Dear Reviewer:

In accordance with the provisions of the National Environmental Policy Act of 1969, we enclose for your review the Final Environmental Impact Statement (FEIS) for the Generic Essential Fish Habitat Amendment to Spiny Lobster Fishery Management Plan, Queen Conch Fishery Management Plan, Reef Fishery Management Plan, and the Coral Fishery Management Plan for the U.S. Caribbean.

On behalf of the National Marine Fisheries Service (NMFS) the Caribbean Fishery Management Council (CFMC) has prepared the subject FEIS. The FEIS analyzes within each fishery a range of potential alternatives to: (1) describe and identify Essential Fish Habitat (EFH) for the fishery; (2) identify other actions to encourage the conservation and enhancement of such EFH; and, (3) identify measures to minimize to the extent practicable the adverse effects of fishing on such EFH. The FEIS contains the scientific method and data used in the analyses, background information on the physical, biological, human, and administrative environments, and a description of the fishing and non-fishing threats to EFH. Alternatives regarding EFH were developed pursuant to the Joint Stipulation and Order (Joint Stipulation) filed in American Oceans Campaign v. Evans, Civil No. 99-982 (GK) (D.D.C. December 17, 2001). As mandated by the Joint Stipulation, the CFMC has identified a subset of alternatives regarding EFH measures as its range of preferred alternatives in this FEIS.

Additional copies of the FEIS may be obtained by contacting either the CFMC, 787-766-5926 or the NMFS Regional contacts, David Dale, 727-570-5317 or David Keys, 727-570-5301. Comments or questions on the FEIS submitted during the 30-day public comment period must be received by May 24, 2004. Written comments should be submitted by mail to Dr. Roy E. Crabtree, Regional Administrator, National Marine Fisheries Service, 9721 Executive Center Drive North, St. Petersburg, FL 33702. Comments may be submitted by facsimile (fax) to 727-570-5300. Electronic comments may be submitted by e-mail to Caribbean.efh.feis@noaa.gov. A copy of your comments should be submitted to me by mail to the NOAA Strategic Planning Office (PFI/SP), SSMC3 Room 15603, 1315 East-West highway, Silver Spring, MD 20910; by fax to 301-713-0585; or by e-mail to nepa.comments@noaa.gov.

NOAA Fisheries is not required to respond to comments received as a result of the issuance of the FEIS. However, comments received will be reviewed and considered for their impact on the issuance of a record of decision (ROD). The ROD will be made available publicly following final agency action.

Sincerely,

Susan A. Kennedy
Acting NEPA Coordinator

Enclosure
Final Environmental Impact Statement

For The Generic Essential Fish Habitat Amendment to:

SPINY LOBSTER FISHERY MANAGEMENT PLAN
QUEEN CONCH FISHERY MANAGEMENT PLAN
REEF FISH FISHERY MANAGEMENT PLAN
CORAL FISHERY MANAGEMENT PLAN
FOR THE U.S. CARIBBEAN

VOLUME 1: TEXT

March 2004

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This is a publication of the Caribbean Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award No. NA17FC1051.
COVERAGE SHEET

Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to the fishery management plans of the US Caribbean

Draft ( )  Final (X)
Type of Action: Administrative (X)  Legislative ( )

Area of Potential Impact: Areas of tidally influenced waters and substrates of the Caribbean Sea and its estuaries in the U.S. Virgin Islands and Puerto Rico extending out to the limit of the U.S. Exclusive Economic Zone (EEZ).

Agency:  HQ Contact:  Region Contacts:
U.S. Department of Commerce  Steve Kokkinakis  David Dale
NOAA Fisheries  NOAA-Strategic Planning (N/SP)  (727)570-5317
Southeast Region  Building SSMC3, Rm. 15532  David Keys
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Suite 201  Silver Spring, MD 20910-3282
St. Petersburg, FL 33702

ABSTRACT

This Final Environmental Impact Statement (EIS) analyzes within each fishery in the US Caribbean a range of potential alternatives to: (1) describe and identify Essential Fish Habitat (EFH) for the fishery, (2) identify other actions to encourage the conservation and enhancement such EFH, and (3) identify measures to minimize to the extent practicable the adverse effects of fishing on such EFH. The EIS contains the scientific methodology and data used in the analyses, background information on the physical, biological, human, and administrative environments, and a description of the fishing and non-fishing threats to EFH.

Additional copies of this FEIS may be obtained by contacting the Regional Contacts (above) or at the address below.

Roy E. Crabtree, Ph.D.
Regional Administrator
NOAA Fisheries
Southeast Region
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ACRONYMS/ABBREVIATIONS

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<tr>
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<tbody>
<tr>
<td>ABC</td>
<td>Acceptable Biological Catch</td>
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<tr>
<td>AFS</td>
<td>American Fisheries Society</td>
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<tr>
<td>ALARM</td>
<td>Automated Landings Assessment for Responsive Management</td>
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<tr>
<td>AP</td>
<td>Advisory Panel</td>
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<tr>
<td>ASAP</td>
<td>Age Structured Assessment Program</td>
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<tr>
<td>ATCA</td>
<td>Atlantic Tuna Convention Act</td>
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<tr>
<td>BRD</td>
<td>bycatch reduction device</td>
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<td>CFMC</td>
<td>Caribbean Fishery Management Council</td>
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<tr>
<td>CMC</td>
<td>Center for Marine Conservation (now Ocean Conservancy)</td>
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<tr>
<td>ComFIN</td>
<td>Commercial Fisheries Information Network</td>
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<tr>
<td>Council</td>
<td>Caribbean Fishery Management Council</td>
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<tr>
<td>CPUE</td>
<td>catch per unit effort</td>
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<tr>
<td>CZMA</td>
<td>Coastal Zone Management Act</td>
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<tr>
<td>DEIS</td>
<td>Draft Environmental Impact Statement</td>
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<tr>
<td>DNER</td>
<td>Department of Natural and Environmental Resources</td>
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<tr>
<td>DOC</td>
<td>U. S. Department of Commerce</td>
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<td>DOI</td>
<td>Department of Interior</td>
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<tr>
<td>EA</td>
<td>Environmental Assessment</td>
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<tr>
<td>EEC</td>
<td>European Economic Community</td>
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<td>EEZ</td>
<td>Exclusive Economic Zone</td>
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<tr>
<td>EFH</td>
<td>Essential Fish Habitat</td>
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<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
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<tr>
<td>E.O.</td>
<td>Executive Order</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>ESA</td>
<td>Endangered Species Act</td>
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<tr>
<td>F</td>
<td>instantaneous fishing mortality rate</td>
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<tr>
<td>FACA</td>
<td>Federal Advisory Committee Act</td>
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<tr>
<td>FCZ</td>
<td>fishery conservation zone (is now called EEZ)</td>
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<tr>
<td>FERC</td>
<td>Federal Energy Regulatory Commission</td>
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<tr>
<td>FL</td>
<td>fork length</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
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<tr>
<td>FMP</td>
<td>fishery management plan</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>GLM</td>
<td>general linear model</td>
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<tr>
<td>GMFMC</td>
<td>Gulf of Mexico Fishery Management Council</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>GSA</td>
<td>General Services Administration</td>
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<tr>
<td>GSMFC</td>
<td>Gulf States Marine Fisheries Commission</td>
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<tr>
<td>HAP</td>
<td>Habitat Advisory Panel</td>
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<tr>
<td>HAPC</td>
<td>Habitat Areas of Particular Concern</td>
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<tr>
<td>HMS</td>
<td>Highly Migratory Species</td>
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<tr>
<td>HRP</td>
<td>Habitat Research Plan</td>
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<tr>
<td>HSI</td>
<td>Habitat Suitability Index</td>
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SEFSC  Southeast Fisheries Science Center of NMFS
SEIS  Supplemental Environmental Impact Statement
SEP  Socioeconomic Panel
SERO  Southeast Regional Office (NMFS)
SFA  Sustainable Fisheries Act
SMZ  special management zone
SOPPs  Statement of Organization Practices and Procedures
SPR  Spawning Potential Ratio
SSB/R  spawning stock biomass per recruit
SSC  Scientific and Statistical Committee
SSS  Side Scan Sonar
TAC  Total Allowable Catch
TED  Turtle Excluder Device
TL  total length
USFWS  United States Fish and Wildlife Service
USGS  United States Geological Survey
VMS  Vessel Monitoring System
VPA  Virtual Population Analysis
WDC/MGG  World Data Center/Marine Geology and Geophysics
YPR  Yield Per Recruit
Z  Instantaneous Total Mortality Rate
EXECUTIVE SUMMARY

Purpose and need

The purpose of this action is to determine whether to amend the Fishery Management Plans (FMPs) of the Caribbean Fishery Management Council (the Council) pursuant to the mandate contained in section 303(a)(7) of the Magnuson-Stevens Fishery Conservation and Management Act (M-S Act). More specifically, the three-part purpose of this action is to analyze within each fishery a range of potential alternatives to: (1) describe and identify Essential Fish Habitat (EFH) for the fishery, (2) identify other actions to encourage the conservation and enhancement of such EFH and (3) identify measures to prevent, mitigate or minimize to the extent practicable the adverse effects of fishing on such EFH. FMPs must describe and identify EFH for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of that EFH. Councils and NOAA Fisheries have direct management authority over fishing activities in Federal waters of the United States, but not over non-fishing activities or fishing activities in State waters (Figure 2.1). NOAA Fisheries has no authority to manage fisheries of other nations.

In 1999, a coalition of environmental groups brought suit challenging the NOAA Fisheries’ approval of the EFH FMP amendments prepared by the Caribbean and other Fishery Management Councils. The court found that the EFH amendments were in accordance with the M-S Act, but held that the EAs on the amendments were in violation of the National Environmental Policy Act (NEPA). NOAA Fisheries entered into a Joint Stipulation with the plaintiff environmental organizations that called for each affected Council to complete an Environmental Impact Statement (EIS).

This analysis was developed and alternatives presented with full anticipation of, and opportunity for, public participation in the development of alternatives. The Council held scoping meetings throughout the US Caribbean in June 2001.

Analytical methodologies used in the EIS

The data analysis undertaken in the development of this EIS for the four Fishery Management Plans includes spatial analysis of the distribution of habitat types, fish species and fishing effort, development of a database containing information on the habitat associations of managed fish species, and characterization of the sensitivity of specific habitats to impacts by specific fishing gears. The methods and concepts for developing and analyzing the alternatives to be considered are common to all of the FMPs. The methodologies used in this EIS are described in Section 2.1 under four main headings:

- Describing and identifying EFH;
- Identifying HAPCs;
- Addressing adverse effects of fishing on EFH; and
- Evaluating the consequences of the alternatives
Preferred alternatives

EFH Alternatives.

Concept 6. Describe and identify EFH according to functional relationships between life history stages of Federally-managed species and Caribbean marine and estuarine habitats.

- Alternative 6. EFH for the spiny lobster fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by phyllosome larvae – (Figure 2.2) and seagrass, benthic algae, mangrove, coral, and live/hard bottom substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.38), shown in the aggregate as Figure 2.39
- Alternative 6. EFH for the queen conch fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.40), shown in the aggregate as Figure 2.39
- Alternative 6. EFH for the Reef Fish Fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and all substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.41), shown in the aggregate as Figure 2.39
- Alternative 6. EFH for the Coral Fishery in the US Caribbean consists of all waters from mean low water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and coral and hard bottom substrates from mean low water to 100 fathoms depth – used by other life stages – (Figure 2.42), shown in the aggregate as Figure 2.39

HAPC Alternatives.

Alternative 4. Designate HAPCs in the Reef Fish FMP as the following areas based on the occurrence of confirmed spawning locations.

- Puerto Rico
  - Tourmaline Bank/Buoy 8 (Figure 2.26) (50 CFR 622.33(a))
  - Abrir La Sierra Bank/Buoy 6 (Figure 2.26) (50 CFR 622.33(a))
  - Bajo de Sico (Figure 2.26) (50 CFR 622.33(a))
  - Vieques – El Seco (Figure 2.27) (State waters)
- St. Croix
  - Mutton snapper spawning aggregation area (Figure 2.26) (50 CFR 622.33(a))
  - East of St. Croix (Lang Bank) (Figure 2.26) (50 CFR 622.33(a))
- St. Thomas
  - Hind Bank MCD (Figure 2.26) (50 CFR 622.33(b))
  - Gramanic Bank (Figure 2.26)

Alternative 7. Designate HAPC For the Reef Fish FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Reef Fish species.
Puerto Rico
Hacienda la Esperanza, Maniti (Figure 2.31).
Bajuras and Tiberones, Isabela (Figure 2.31)
Cabezas de San Juan, Fajardo (Figure 2.31).
JOBANNERR, Jobos Bay (Figure 2.31).
Bioluminescent Bays, Vieques (Figure 2.31).
Boqueron State Forest (Figure 2.32).
Pantano Cibuco, Vega Baja (Figure 2.31).
Piñones State Forest (Figure 2.31).
Río Espíritu Santo, Río Grande (Figure 2.31).
Seagrass beds of Culebra Island (9 sites designated as Resource Category 1 and two additional sites) (Figure 2.31).
Northwest Vieques seagrass west of Mosquito Pier, Vieques (Figure 2.33).
St. Thomas
Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries (Figure 2.34).
Saba Island/Perseverance Bay, including Flat Cay and Black Point Reef (Figure 2.34).
St. Croix
Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary (Figure 2.36).
Altona Lagoon (Figure 2.36)
Great Pond (Figure 2.36)
South Shore Industrial Area (Figure 2.36)
Sandy Point National Wildlife Refuge (Figure 2.36)

Alternative 8. Designate HAPC for the Coral FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Coral species
Puerto Rico
Luis Peña Channel, Culebra (Figure 2.31).
Mona/monito (Figure 2.31).
La Parguera, Lajas (Figure 2.32).
Caja de Muertos, Ponce (Figure 2.32).
Tourmaline Reef (Figure 2.32).
Guánica State Forest (Figure 2.32).
Punta Petrona, Santa Isabel (Figure 2.31).
Ceiba State Forest (Figure 2.31).
La Cordillera, Fajardo (Figure 2.31).
Guayama Reefs (Figure 2.31).
Steps and Tres Palmas, Rincon (Figure 2.31).
Los Corchos Reef, Culebra (Figure 2.31)
Desecheo Reefs, Desecheo (Figure 2.31)
St. Croix
St. Croix Coral Reef Area of Particular Concern (APC), including the East End Marine Park (Figure 2.36).
Buck Island Reef National Monument (Figure 2.36)
South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36)
Frederiksted Reef System (Figure 2.36)
Cane Bay (Figure 2.36)
Green Cay Wildlife Refuge (Figure 2.36)

Alternatives to address adverse effects of fishing on EFH.

Alternative 3. Establish modifications to anchoring techniques; establish modifications to construction specifications for pots/traps; and close areas to certain recreational and commercial fishing gears (i.e., pots/traps, gill/trammel nets, and bottom longlines) to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots
- Require at least one buoy at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank for these gears – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of gill/trammel nets coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of bottom longlines on coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Reef Fish FMPs
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4.3.2.3 EFH Concept 3. Describe and identify essential fish habitat for managed fish species as all waters of the Caribbean that include submerged aquatic vegetation (SAV), mangroves, algae, plains, reefs, reef-SAV interface, hard/live bottoms, sand, and mud.

4.3.2.4 EFH Concept 4: Describe and identify essential fish habitat based on the known distributions of all the various life stages of all species under management.

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1 INTRODUCTION

1.1 Purpose and need for action

The purpose of this action is to determine whether to amend the Fishery Management Plans (FMPs) of the Caribbean Fishery Management Council (the Council) pursuant to the mandate contained in section 303(a)(7) of the Magnuson-Stevens Fishery Conservation and Management Act (M-S Act). More specifically, the three-part purpose of this action is to analyze within each fishery a range of potential alternatives to: (1) describe and identify Essential Fish Habitat (EFH) for the fishery, (2) identify other actions to encourage the conservation and enhancement of such EFH and (3) identify measures to prevent, mitigate or minimize to the extent practicable the adverse effects of fishing on such EFH. Depending on the selected alternatives identified in this Environmental Impact Statement (EIS), the following FMPs could be amended: Spiny Lobster, Queen Conch, Reef Fish and Coral FMPs. The analysis contained in this document is based upon the best scientific information available and the guidelines articulated in the Final Rule to implement the EFH provisions of the M-S Act (See 50 CFR Part 600, Subpart J).

1.2 Need for action

In the M-S Act, Congress recognized that one of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. To ensure habitat considerations receive increased attention for the conservation and management of fishery resources, the amended M-S Act included new EFH requirements, and as such, each existing, and any new, FMPs must describe and identify EFH for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of that EFH.

In 1999, a coalition of several environmental groups brought suit challenging the agency's approval of the EFH FMP amendments prepared by the Gulf of Mexico, Caribbean, New England, North Pacific, and Pacific Fishery Management Councils (American Oceans Campaign et al. v. Daley et al., Civil Action No. 99-982(GK)(D.D.C. September 14, 2000). The court found that the agency’s decisions on the EFH amendments were in accordance with the M-S Act, but held that the Environmental Assessments (EAs) on the amendments were in violation of the National Environmental Policy Act (NEPA) and ordered NOAA Fisheries to complete new, more thorough NEPA analyses for each EFH amendment in question.

Consequently, NOAA Fisheries entered into a Joint Stipulation with the plaintiff environmental organizations that called for NOAA Fisheries to complete Environmental Impact Statements (EIS) rather than EAs for the action of minimizing adverse effects of fishing to the extent practicable on EFH. See AOC v. Evans, Civil No. 99-982 GK (D.D.C. December 5, 2001). However, because the court did not limit its criticism of the EAs to only efforts to minimize adverse fishing effects on EFH, it was decided that the scope of these EISs could address all required EFH components as described in section 303 (a)(7) of the M-S Act. Further, as the
court invalidated the original EAs, it was also determined that the contents of that analysis should not pre-determine any conclusions in the following EIS. The following EIS therefore analyzes alternatives for the EFH FMP amendments, including the alternative that was adopted by the Council and partially approved by NOAA Fisheries in 1999 and other alternatives.

The Joint Stipulation specified a schedule for completion of the EIS, and specified that NOAA Fisheries would determine in a Record of Decision (ROD) whether to amend the FMPs. While the original settlement stipulation provided 24 months to complete Amendments, if appropriate, a revised stipulation agreement shortened the period for completion to within 17 months of the ROD. The alternatives analyzed in an amendment would be based on the alternatives evaluated in this EIS, but other alternatives could also be considered. Any additional or modified alternatives may require additional NEPA analysis.

1.3 The NEPA analysis and fishery management plan actions

NEPA provides a mechanism for identifying and evaluating the full spectrum of environmental issues associated with Federal actions, and for considering a reasonable range of alternatives to avoid or minimize adverse environmental impacts. NOAA Fisheries and the Caribbean Council will consider any new information and alternatives discussed in the EIS to determine whether changes to the EFH provisions of the fishery management plans previously approved by NOAA Fisheries are warranted. As noted in the court’s decision in AOC v. Daley, the alternatives NOAA Fisheries must consider under NEPA are not restricted to the options originally presented in the fishery management plan amendments submitted by the Council. The following EIS, therefore, considers “Status quo” and “No action” alternatives separately. The “No action” alternatives would describe a scenario in which no action would be taken to comply with the EFH provisions of the M-S Act. The “Status quo” alternatives would constitute the current state of the management regime regarding EFH. By including the “No action” alternative in the following EIS, EFH management regimes currently in place would not necessarily drive the outcomes of this analysis. It should be noted that since the Caribbean Council did not adopt any new measures in the 1999 Generic EFH amendment for preventing, mitigating or minimizing adverse effects of fishing on EFH to the extent practicable, the “No action” and “Status quo” conditions are the same for that specific action in this EIS.

1.3.1 Public participation

This analysis was developed and alternatives presented with full anticipation of, and opportunity for, public participation in the development of alternatives for identifying EFH and Habitat Areas of Particular Concern (HAPC) and measures to prevent, mitigate or minimize adverse effects from fishing on EFH.

NOAA Fisheries published a Notice of Intent (NOI) to prepare a supplemental EIS for the EFH components of the Spiny Lobster, Queen Conch, Reef Fish, and Coral FMPs on March 19, 2001. The public comment period was open until April 18, 2001. NOAA Fisheries and the Council solicited public comment to identify a range of alternatives for identifying and describing EFH and HAPCs, requested information required to assess potential adverse effects of fishing
activities on EFH and HAPCs, and on appropriate management measures and alternatives to minimize, to the extent practicable, any adverse effects of fishing on EFH. NOAA Fisheries and the Council subsequently held 10 public scoping meetings as follows:

- St. John, U.S. V.I., June 12, 2001;
- St. Thomas, U.S. V.I., June 13, 2001;
- St. Croix, U.S. V.I., June 14, 2001;
- Hato Rey, P.R., June 18, 2001;
- Arecibo, P.R., June 19, 2001;
- Mayaguez, P.R., June 20, 2001;
- Ponce, P.R., June 21, 2001;
- Culebra, P.R., June 25, 2001;
- Vieques, P.R., June 26, 2001; and
- Farjado, P.R., June 27, 2001.

The Council received three letters in response to the scoping announcement, and comments at six of the 10 scoping meetings. A summary of the public comments and primary issues raised during the meetings is in the Summary of Scoping Comments (Appendix 6).

NOAA Fisheries published the Notice of Availability for the Draft of this EIS on August 1, 2003 with a 90-day comment period. Copies of the Draft EIS were distributed to the agencies and individuals identified in Section 5.3. Five comment letters were received during the comment period and are included in Appendix 8, along with responses developed by NOAA Fisheries and the Council.

1.3.2 Agency coordination

1.3.2.1 Federal

The Regional Administrator for the NOAA Fisheries’ Southeast Region is a voting member on the Council. In addition, the Council’s Habitat Advisory Panel (HAP) has NOAA Fisheries staff membership. Both the U.S. Fish and Wildlife Service (USFWS) and the U.S. Coast Guard (USCG) have non-voting seats on the Council. USFWS has trust authority for seabird and other avian species in the management areas. Expert USFWS staff provided assistance with this analysis. The USCG has expertise with enforcement, search and rescue, vessel accidents and incidents at sea, and human safety at sea. Expert USCG staff provided assistance with this analysis. The Environmental Protection Agency (EPA) is a reviewing agency for all EISs. Additionally, see Section 5.3 for a complete list of agencies on the distribution list for this EIS.

1.3.2.2 State

Representatives from the Commonwealth of Puerto Rico and the Territory of the US Virgin Islands have voting seats on the Council. Commonwealth and Territory staff members participate on the HAP. Expert staff provided assistance with this analysis. Additionally, see Section 5.3 for a complete list of agencies on the distribution list for this EIS.
1.3.2.3 Contractor

The Council contracted MRAG Americas, Inc., a consulting group with extensive experience in US and international fisheries science and management, and marine resource management systems in general, to produce this EIS.

1.4 Section preview

Based in part on the issues identified during scoping, the EIS discusses a reasonable range of alternatives for identifying and describing EFH and HAPCs. The alternatives include several methods of identifying EFH and HAPCs that would result in different areas being designated as EFH or HAPCs. The EIS evaluates the environmental consequences of the EFH or HAPC designation that would result from each alternative. The EIS also includes an evaluation of the effects of fishing on EFH and an analysis of alternatives to minimize to the extent practicable the adverse effects on EFH from fishing. The EIS considers and evaluates alternatives to minimize adverse effects to the extent practicable. Councils and NOAA Fisheries have direct management authority over fishing activities in Federal waters of the United States, but not over non-fishing activities or fishing activities in State waters. NOAA Fisheries has no authority to manage fisheries of other nations.

The analysis considers the no-action and preferred alternative, along with a range of other reasonable alternatives. Information from the 1998 EA and the generic amendment is reflected in this analysis. However, additional information and the selection of alternatives come from a review of the best scientific information available, including new information made available since the FMP amendments were originally completed.

Section 2 of the EIS describes the methodologies used for obtaining and analyzing information used in the EIS, and describes and contrasts the alternatives, including the preferred alternative, for describing and identifying EFH and HAPCs and for preventing, mitigating or minimizing the adverse effects of fishing on EFH. Section 2 discusses significant issues associated with each alternative including those identified during scoping. For each designation alternative, the EIS discusses the geographic range and habitat types included as EFH and HAPC. The discussion of each alternative for minimizing the effects of fishing on EFH describes the associated fishery management measures. Section 2 concludes with a discussion and explanation of alternatives that were considered but not carried forward for further analysis. The description of alternatives provides a broad summary and comparison of each alternative.

Section 3 of the EIS describes the environment affected by the alternative courses of action. This includes a discussion of the areas and habitat types that would be described as EFH and HAPC for each alternative. The description of the affected environment details the physical and biological resources affected by the alternatives, including the fishery resources, threatened and endangered species and marine mammals, and any other relevant biological resources.

Section 3 also characterizes the socioeconomic environment by describing the geographic extent of the fishery and discussing the number of vessels and gear types used. Section 3 also contains
an analysis of the effects of fishing on fish habitat. This analysis includes an overview of national and international literature on fishing impacts to fish habitat and a more focused and relevant analysis of region/fishery specific impacts. The discussion describes how NOAA Fisheries and the Council manage the fishery under the existing FMP and how the EFH amendment will affect, and be incorporated into, the management of this fishery.

Section 4 details the environmental consequences of each alternative for describing and identifying EFH and HAPCs and minimizing the adverse effects of fishing on EFH. Section 4 contains an analysis of the direct and indirect environmental and socioeconomic effects of each alternative. For each of the EFH and HAPC alternatives, the Section describes the specific environmental consequences in relation to effects on the fishery and other fisheries, protected resources, and non-fishing activities. For each of the fishing impact alternatives, the section evaluates the environmental consequences in relation to effects on EFH, the fishery, other fisheries, and protected resources. The discussion of potential impacts resulting from each alternative is presented in comparative form that clearly distinguishes the environmental consequences of each alternative. The discussion in Section 4 includes a description of the conservation benefits and the adverse impacts of the alternatives.

Section 5 lists the agencies, organizations, and individuals consulted. Section 6 provides a list of the preparers of the EIS. Section 7 contains references. The tables and figures are included as a separate Volume. There are eight appendices, as follows:

- Appendix 1. Life history tables with habitats and ecological functions
- Appendix 2. Habitat suitability index maps for selected species prepared for the Generic EFH Amendment
- Appendix 3. Locations of running ripe fish for selected species of Southwestern Puerto Rico (from NOAA SEAMAP data)
- Appendix 4. Fish distributions for selected species off Southwestern Puerto Rico (from NOAA SEAMAP data)
- Appendix 5. Distributional statistics of benthic habitats from NOS mapping
- Appendix 6. Summary of scoping comments
- Appendix 7. Sources of information
- Appendix 8. Response to public comments
2 ALTERNATIVES

The Caribbean Fishery Management Council (the Council) developed a Generic EFH Fishery Management Plan (FMP) Amendment to address the four fishery management plans and submitted it to NOAA Fisheries in 1998. NOAA Fisheries partially approved the Generic EFH Amendment for the selected species listed in the Generic Amendment, and deferred approval for other species managed by the Council (NMFS 1999a). Additionally, AOC et al. v. Daley et al. determined that the Environmental Assessment for the Generic Amendment was deficient with regard to NEPA requirements and had not appropriately identified alternatives for EFH. Under guidance contained in a memo from Dr. William Hogarth (Hogarth 2001), Assistant Administrator for NOAA Fisheries, NOAA Fisheries committed to preparing an Environmental Impact Statement (EIS) for EFH that may lead to fishery management plan amendments, including an "unbiased evaluation of alternatives" in the EIS.

The Alternatives section is the heart of the EIS. The Council on Environmental Quality (CEQ) regulations for implementing NEPA specifies (Section 1502.14) that alternatives shall:

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives that were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so those reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

Councils and NOAA Fisheries have direct management authority over fishing activities in Federal waters, but not over non-fishing activities or fishing activities outside Federal waters (Figure 2.1). NOAA Fisheries has no authority to manage fisheries of other nations. The Council and NOAA Fisheries, therefore, currently have the ability to implement regulations to reduce the adverse effects of fishing on EFH only in Federal waters (Figure 2.2) unless the Secretary of Commerce exercises his authority to preempt state management authority. However, the Council and NOAA Fisheries can recommend management actions for state waters (Figure 2.3). Under the M-S Act, the description and identification of EFH (which may extend into state waters) permits the Council and NOAA Fisheries to be involved more directly on activities outside its authority that may affect EFH. Although NOAA Fisheries already has the responsibility to
consult on these other federal activities through the Fish and Wildlife Coordination Act, and other statutes, the changes brought about through the 1996 amendments to the M-S Act (Sustainable Fisheries Act) require the responsible Federal agency to respond in writing to NOAA Fisheries with the rationale for taking any actions that would be contrary to NOAA Fisheries recommendations for protecting or conserving EFH. Similarly, a written response to EFH recommendations made by the Council also is required. In addition, the EFH regulations provide an opportunity for higher-level review to reconcile interagency disagreements.

The Caribbean Council FMPs, as amended, contain 322 species or species groups in the management units, three within the Spiny Lobster (Table 2.1), 13 within Queen Conch (Table 2.2), 139 within Reef Fish (Table 2.3), and 167 within Coral (Table 2.4). Species in the management units occur throughout the Caribbean in many different species-specific habitats, at different life stages. Descriptions of the life stages and habitats identified in Section 3.2.11 use the best available scientific information. The level of information available for many species is generally low. Moderate amounts of information are available for some species, and virtually none is available for others. Available information is used in Section 3 to develop a risk analysis that includes issues such as the ranking of habitats for life history functions, (spawning, breeding, feeding, and growth to maturity), the importance of various habitat types to managed species, the sensitivity of the habitat type to perturbation (including fishing), and the degree of spatial overlap between the habitat and fishing activity. The development of the Alternatives and the subsequent analyses do not consider “breeding” as an ecological function for species under the four FMPs of the Council. While breeding and spawning both imply the reproductive process, breeding refers to internal fertilization and live birth, while “spawning” refers to broadcast of eggs and sperm and external fertilization. No species in the fishery management units of the four FMPs have live births. In the special case of corals, which can reproduce either sexually or asexually via “budding,” spawning will be used to refer to both modes of reproduction.

This Section of the EIS includes separate sections to present the range of reasonable alternatives to address each of the three areas relevant to EFH. Section 2.1 describes the methodology used for obtaining and analyzing data and other information and for developing alternatives. Section 2.2 lists the preferred alternatives. Section 2.3 provides alternatives for describing and identifying EFH, Section 2.4 provides alternatives for describing and identifying HAPC, Section 2.5 provides alternatives for preventing, mitigating, or minimizing adverse effects of fishing and fishing gear on EFH to the extent practicable, and Section 2.6 lists the alternatives considered and rejected. The assessment of these alternatives (Section 4 of the full EIS) will identify and consider the potential consequences that these alternatives will have on the various affected environments.

### 2.1 Analytical methodologies

This section describes all the methodologies used in this EIS to develop the alternatives and analyze the consequences of the alternatives.
2.1.1 Introduction

The EFH Final Rule provides regulations and guidance on the implementation of the EFH provisions of the M-S Act. It includes information on the types of information that can be used for describing and identifying EFH, designating HAPCs and mitigating fishing impacts on EFH. The guidelines advocate using information in a risk-averse fashion to ensure adequate protection of habitat for all species in the management units. In essence, the information available for many species in the Caribbean FMPs is minimal. Moderate amounts of information are available for a few species, and virtually none is available for others.

The data analysis undertaken in the development of this EIS includes spatial analysis of the distribution of habitat types, fish species and fishing effort, development of a database containing information on the habitat associations of managed fish species, and characterization of the sensitivity of specific habitats to impacts by specific fishing gears. This EIS covers the four fishery management plans in the US Caribbean region, and the implementation of the preferred alternatives will occur through these fishery management plans. However, the methods and concepts for developing and analyzing the alternatives to be considered are common to all of the FMPs. The methodologies used in this EIS are described in detail below under four main headings:

- Describing and identifying EFH;
- Identifying HAPCs;
- Addressing adverse effects of fishing on EFH; and
- Evaluating the consequences of the alternatives

The methodologies for developing alternatives are described under these headings. There is a concluding section describing the methodologies used to analyze the consequences of the alternatives in all three categories. The results arising from the application of these methods are presented in the latter parts of this section (the alternatives), Section 3 (affected environment) and Section 4 (consequences).

The following section describes the federal requirements affecting the scope of the analysis, which help to put the methodologies used into context.

2.1.2 Federal requirements affecting the scope of the analysis

Various Federal laws and regulations set out requirements for data quality and analysis that are applicable to an EFH EIS. Key among them is the M-S Act, which requires EFH and the Final Rule to implement the EFH provisions in the M-S Act (EFH Final Rule). While the designation of EFH is intended by both the M-S Act and the EFH Final Rule to occur within fishery management plans (FMPs), these actions are currently being contemplated within EISs, and as such, the CEQ NEPA Regulations, are clear on procedural matters, but actual compliance is left up to agency discretion, subject only to judicial review when challenged. Finally, the EIS must take into account the NOAA Information Quality Guidelines, which aim to ensure data quality. The steps taken to comply with these requirements are laid out in the following sections. These
requirements do not specify how analysis should occur. Methodological details of the analyses follow the Federal requirements.

2.1.2.1 Compliance with the M-S Act

The M-S Act requires that FMPs describe and identify EFH (Section 2.3), and requires that management measures be based on the best scientific information available (16 USC 1851(a)(2)). The EFH Final Rule contains guidance regarding the types and levels of information that should be used for describing and identifying EFH, mitigating fishing impacts and designating HAPCs. Where information is sparse, the Final Rule directs that FMPs identify data gaps and recommend research to acquire necessary information. The guidelines also require that information be used in a risk-averse fashion to ensure adequate protection of habitat for all species in the management units. As described in more detail in the following sections, the information available for many fish species in the US Caribbean is minimal. Moderate amounts of information are available for some species, and virtually none is available for others.

2.1.2.2 Compliance with NEPA

NEPA is the basic national charter for protection of the environment. It establishes policy, sets goals and provides means for carrying out the policy. The purpose of the regulations is to instruct federal agencies what they must do to comply with the procedures and achieve the goals of the Act. The President, the federal agencies, and the courts share responsibility for enforcing the Act.

NEPA procedures must ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment.

Because information is incomplete for most species covered in the fishery management units covered by the EIS, the document has inferred distribution of species and life stages from habitat utilization (see Section 2.1.3). The inferences have been applied broadly, in a precautionary manner, to assure inclusion of all utilized habitat. The scientific community deals with this type of data paucity by applying best practices, expert opinion, and inferences from known information such as catch per unit effort and landings data. The inferences on fish distribution made from habitat distribution constitute best practices. The level of uncertainty arising from the absence of this information has been mitigated by development of alternatives that are risk averse.

This EIS was developed under a court-mandated deadline and limited funding that constrained the ability to conduct new studies. Section 4.2 provides a discussion of missing information and the efforts underway to obtain new information useful for the periodic review of EFH provisions, based on information as it becomes available, at least every 5 years. Future work to fill data gaps
that would enhance the ability to describe and identify EFH in the US Caribbean and that could reasonably be undertaken within the next five years include:

- Habitat mapping throughout the EEZ and state waters,
- Fishery-independent surveys to investigate species distribution, abundance and functional relationships related to habitat; and
- The development of models that predict the probability of occurrence of fish based on the distribution of habitat.

Funding levels will likely limit the extent to which this work can be undertaken.

NEPA requires an intensive effort to assure compliance. AOC v Daley provided significant guidance in regard to NEPA deficiencies of the Generic EFH Amendment. AOC v Daley determined that the Caribbean Council (and other Council) Generic Amendment for EFH did not meet NEPA standards.

2.1.2.3 Compliance with the Data Quality Act

Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 directed the Office of Management and Budget (OMB) to issue government-wide guidelines that provide policy and procedural guidance to Federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by Federal agencies to the public. Section 515 is known as the Data Quality Act.

Pursuant to Section 515 of Public Law 106-554 (the Data Quality Act) this information product has undergone a pre-dissemination review by the Southeast Region Habitat Conservation Division. The signed Pre-dissemination Review and Documentation Form is on file in that office.

2.1.3 Describing and identifying EFH

2.1.3.1 Introduction

The M-S Act defined essential fish habitat to mean “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (M-S Act § 3(10)). This defines EFH, but does not specify how to distinguish among various parts of a species’ range to determine the portion of the range that is essential. The EFH Final Rule (50CFR Part 600) elaborates that the words “essential” and “necessary” mean identification of sufficient EFH to “support a population adequate to maintain a sustainable fishery and the managed species’ contributions to a healthy ecosystem.”

The process of distinguishing between all habitats occupied by managed species and their EFH requires one to identify some difference between one area of habitat and another. In essence, there needs to be a characterization of habitats and their use by managed species that contains sufficient contrast to enable distinctions to be drawn, based on available information. This needs
to be a data driven exercise, but in the Caribbean there are very few data with which to make such a determination.

In this context, it should also be noted that if a species is overfished and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species may be considered essential. In addition, certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible may also be considered as essential. Once the fishery is no longer considered to be overfished, the EFH identification should be reviewed and amended, if appropriate (EFH Final Rule CFR 600.815(a)(1)(iv)(C)). Several fish species in the US Caribbean are designated as overfished or experiencing overfishing. Other stocks appear to be below desirable levels of abundance. Fish stocks depleted by overfishing, or by other factors, tend to not use as much of the available habitat as a virgin stock or a stock at optimum biomass would use. The picture is complex, however, because other species may have expanded their range to fill some of these ecological niches.

Habitat characteristics comprise a variety of attributes and scales, including biological, physical (defined as geological for this document), and chemical parameters, location, and time. Ecologically, species distributions are affected by characteristics of habitats that include obvious structure or substrate (e.g., coral reefs, seagrass beds, mangroves) and other structures that are less distinct (e.g., turbidity zones, thermoclines, or fronts separating water masses). Fish habitat utilized by a species can change with life history stage, abundance of the species, competition from other species, environmental variability in time and space and human induced changes. Occupation and use of habitats by fish may change on a wide range of temporal scales: seasonally, inter-annually, inter-decadal (e.g. regime changes), or longer. Habitat not currently used but potentially used in the future should be considered when establishing long-term goals for EFH and species productivity. Habitat restoration will be a vital tool to recover degraded habitats and improve habitat quality and quantity, enhancing benefits to the species and society.

Fish species rely on habitat characteristics to support primary ecological functions comprising spawning, breeding, feeding and growth to maturity. Important secondary functions that may form part of one or more of these primary functions include migration and shelter. Most habitats provide only a subset of these functions. The type of habitat available, its attributes, and its functions are important to species productivity and the maintenance of healthy ecosystems.

According to the M-S Act, EFH must be designated for the fishery as a whole (16 U.S.C. §1853(a)(7)). The Final Rule clarifies that every FMP must describe and identify EFH for each life stage of each managed species. As further clarification, NOAA General Counsel has stated that “Fishery” as used in the M-S Act in reference to EFH refers to the FMU of an FMP. This EIS therefore develops alternatives for EFH based on individual species/life stages aggregated to a single EFH designation for each of the four FMPs for the US Caribbean. In the EIS, a single map is used to describe and identify EFH for each fishery. However, the analysis that produced those maps included the preparation of electronic maps of EFH for as many species and life stages as possible.

Designation of EFH for a fishery is therefore achieved through an accounting of the habitat
requirements for all life stages of all species in the FMU. Prior to designating EFH for a fishery, the information about that fishery therefore needs to be organized by individual species and life stages. If data gaps exist for certain life stages or species, the EFH Final Rule suggests that inferences regarding habitat usage be made, if possible, through appropriate means. For example, such inferences could be made on the basis of information regarding habitat usage by a similar species or another life stage (50 CFR Pt. 600.815(a)(iii)). All efforts must be made to consider each species and life stage in the designation of EFH for the fishery and to fill in existing data gaps using inferences prior to determining that the EFH designation for the fishery does not include the species or life stage in question.

While designation of EFH is carried out at the fishery (FMP) level, the determination of whether an area should be identified as EFH depends upon habitat requirements at the level of individual species and life stages. It therefore takes potentially only one species/life stage in the FMU to result in an area of habitat being designated as EFH for the FMP. Many areas of habitat, however, are likely to be designated for more than one species and life stage. The EFH for FMPs that contain a large number of widely distributed species (such as the reef fish FMP), are likely to result in large areas of habitat being designated as EFH, due to the overlay of multiple species habitat needs. For example, even though the 1998 Generic Amendment based its conclusions on only 17 representative species, it identified virtually all estuarine and marine waters of the US Caribbean as EFH. Some see this as a weakness in the EFH designation process, because if EFH is “everything” then the designation process apparently fails to focus conservation efforts on habitats that are truly “essential.” However, this conclusion fails to take into consideration that the distinction between all habitats occupied by a species and those that can be considered “essential” is made at the species and life stage level. What the designation of EFH at the FMP level does is delineate the reference area for consultation purposes. A consultation process will be triggered when an agency plans to undertake an activity that potentially impacts habitat within the area designated as EFH. The resulting consultations will consider how the proposed action potentially impacts EFH. The detailed characteristics of the habitat in the relevant location will be an important part of this analysis. In this context, it is possible to envision that an area of EFH that has been designated as such for a particularly large number of species and life stages, or is particularly rare, or stressed or vulnerable might be of particular concern. In recognition of this, the Final Rule encourages regional Fishery Management Councils to identify habitat areas of particular concern (HAPC) within areas designated as EFH (600.815(a)(8)).

2.1.3.2 Use of information

The EFH Final Rule explains that the information necessary to describe and identify EFH should be organized at four levels of detail, level 4 being the highest and level 1 the lowest:

- **Level 4** – production rates by habitat are available
- **Level 3** – growth, reproduction, or survival rates within habitats are available
- **Level 2** – habitat-related densities of the species are available; and
- **Level 1** – distribution data are available for some or all portions of the geographic range of the species.
The table below provides additional detail on the meanings to be inferred from this list.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Possible units / information sources</th>
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<tbody>
<tr>
<td>Level 4: Production rates</td>
<td>Overall production rates can be calculated from growth, reproduction and survival rates. However, using this information to describe and identify EFH requires not only that production rates have been calculated, but also that they have been calculated for different patches of habitat that can then be distinguished from each other. According to the EFH Final Rule, at this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.</td>
</tr>
<tr>
<td>Level 3: Growth, reproduction or survival rates</td>
<td>Similar to information on overall production rates, it can be used to describe and identify EFH. Growth, reproduction and survival rates would need to have been calculated for different patches of habitat that can then be distinguished from each other. According to the EFH Final Rule, at this level, data are available on habitat-related growth, reproduction, and/or survival by life stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life stage).</td>
</tr>
<tr>
<td>Level 2: Density</td>
<td>Relative density information may be available from surveys, or it could perhaps be inferred from catch per unit effort data, although only for those areas that have been fished. According to the EFH Final Rule, at this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.</td>
</tr>
<tr>
<td>Level 1: Distribution</td>
<td>Distribution information is available from surveys, catch/effort data, and evidence in the biological literature, including ecological inferences (e.g. - a habitat suitability index, HSI). According to the EFH Final Rule, distribution data may be derived from systematic presence/absence sampling and/or may include information on species and life stages collected opportunistically. In the event that distribution data are available only for portions of the geographic area occupied by a particular life stage of a species, habitat use can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior. Habitat use may also be inferred, if appropriate, based on information on a similar species or another life stage.</td>
</tr>
</tbody>
</table>

The EFH Final Rule requires using the highest level of information (production rates) first (if available), followed by the second highest level (growth, reproduction or survival rates) and so on. The guidelines also call for applying this information in a risk-averse fashion to ensure adequate areas are protected as EFH. The most complete information available should be used to determine EFH for each species and life stage. If higher level information is available only for a portion of the species/life stage range then a decision needs to be made regarding how the information should be used – for example can the knowledge from the portion of the range covered be extrapolated to the rest of the range? In accordance with the requirement to use the highest level of detail available, the highest-level information should be used for the portion of
the species/life stage range for which it is available, or to which the information could be validly extrapolated. Information at lower levels should be used only where higher-level information is unavailable and cannot be validly extrapolated.

If only Level 1 information is available, distribution data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify EFH as those habitat areas most commonly used by the species. Information at levels 2 through 4, if available, should be used to identify EFH as the habitats supporting the highest relative abundance; growth, reproduction, or survival rates; and/or production rates within the geographic range of a species. FMPs should explain the analyses conducted to distinguish EFH from all habitats potentially used by a species. Such analyses should be based on geo-referenced data that show some areas as more important than other areas, to justify distinguishing habitat and to allow for mapping. The data must at least show differences in habitat use or in habitat quality that can be linked to habitat use.

There is an implicit link between the level of information available for species and life stages and the extent of EFH that is likely to be designated (Figure 2.4). As the information used to describe and identify EFH becomes less complex, so the area identified as EFH is likely to grow. For example, a determination based on areas where production rates are highest is likely to result in a smaller area than a determination based on basic distribution data, because production rates are unlikely to be at their highest level throughout the species range. Rather they will be highest where habitat conditions are optimal for the species and life stage in question. This increase in the extent of EFH as the level of available information drops is in accordance with the risk-averse approach required by the EFH Final Rule. However, it is not sufficient to designate a large area of habitat as EFH without adequate justification. As mentioned previously, the EFH Final Rule (600.815(a)(1)(iv)(A)) requires that FMPs explain how EFH for a species is distinguished from all habitats potentially used by that species, in order to improve understanding of the basis for the designations.

If no information for a species/life stage is available at the lowest level (distribution) and it is not possible to infer distribution from other species or life stages, then EFH cannot be identified for that species designated (600.815(a)(1)(iii)(B)). CEQ regulations (1502.22) require agencies to make clear when information is lacking.

2.1.3.3 Available information

There are two main types of information available that can be used to describe and identify EFH:

- **Empirical geo-referenced data on species distributions, densities, and/or productivity rates derived from analyses of surveys and commercial catches. These data are essentially independent of the underlying habitat.**

- **Information about associations and functional relationships between species/life stages and habitat that can be used to make inferences about species distributions, density and/or productivity rates, based on the distribution of habitat.**
Information at all four of the levels of detail described in the EFH Final Rule may exist in both of these categories. Examples of such are provided in the following table:

<table>
<thead>
<tr>
<th>Level 1 – distribution data</th>
<th>Empirical geo-referenced information</th>
<th>Species-Habitat relationship modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2 – habitat-related densities of the species</td>
<td>Survey/fishery related CPUE as proxy for density</td>
<td>Spatial modeling of probability of occurrence, or other forms of HSM</td>
</tr>
<tr>
<td>Level 3 – growth, reproduction, or survival rates within habitats</td>
<td>Tagging data (growth) Fecundity data by area</td>
<td>Spatially discreet stock/recruitment relationships; Bio-energetics models</td>
</tr>
<tr>
<td>Level 4 – production rates by habitat</td>
<td>In situ physiological experiments and mortality experiments</td>
<td>Life history-based meta-population models (Mangel pers com.)</td>
</tr>
<tr>
<td>Level 1 – distribution data</td>
<td>Surveys presence/absence</td>
<td>Simple habitat-species associations</td>
</tr>
</tbody>
</table>

The information available in each of these categories is elaborated in more detail in the following sections. In summary, no data are currently available at levels 2, 3 and 4 that can be used to develop alternatives for describing and identifying EFH in the US Caribbean. To ensure that the highest level of information available was used in preparing this EIS, the Council polled the members of its HAP and SSC to determine if any information higher than level 1 was available. None of the members identified any such information. In the category described above as empirical geo-referenced data, the available data, both fishery-dependent and fishery-independent were too sparse to define boundaries of species distribution and habitat needs within the US Caribbean. As a result, and because of the relatively small size of the area covered by this EIS, distribution of a species/life stage was modeled as its “potential” distribution. This was assumed to be any habitat with which the species/life stage associates, everywhere that that habitat occurs in the US Caribbean.

2.1.3.3.1 Empirical spatial data

*Types of data and their utility*

Empirical spatial data are provided by direct and indirect observations of fish distribution, density, or rates. Fishery-independent surveys such as SEAMAP and fishery-dependent data sets such as port sampling programs most typically provide these types of data. Surveys are inherently geo-referenced, in that all data have an association with a location. Port sampling programs and fishery logbooks may not collect location data, or may collect location data at various scales. Summary data collected by statistical area have a more coarse distribution scale than data collected by latitude and longitude of fishing location (i.e. haul by haul).
Entering geo-referenced data into a Geographic Information System (GIS) allows spatial analysis of information. Ideally, the data collection covers the entire range of a species or life stage (or at least the portion of that entire range that is of interest to the study). As the geographic scale of data collection reduces to small areas, so the extent to which it represents the whole range falls, limiting the conclusions that can be drawn from the data.

Surveys and catch data collection provide potentially useful information for determining the distribution and abundance of fish, but the data they collect can have important limitations when being used to delineate the extent of EFH. Although they are frequently used to indicate the presence of fish and estimate their relative abundance, survey and catch data often provide little or no information on the underlying habitat at the sampling or catch locations (other than perhaps depth). In addition, they tend to target only one life stage (usually the adults) and typically are oriented to commercially or recreationally important species. Commercial data in particular are almost always spatially non-random (focusing only on the areas and times when the fish can be most easily caught), and as such limit the inferences that can be drawn with respect to spatial patterns. Distribution of catch by area may provide an index of density, on the assumption that fishers will target areas with highest density to obtain highest catch rates. However, several factors reduce the utility of this approach. Fishers may preferentially fish closer to port in lower density areas to save transit time and cost. Areas offshore would therefore be under sampled. Also, more abundant/higher density species may have lower value than less dense species. An issue specific to the US Caribbean is that some areas have high incidence of ciguatera poisoning, so fishers might not target or retain susceptible species (Graciela Garcia-Moliner, CFMC, personal communication).

Data used in the analysis

Despite the inherent limitations of some types of data, the project team sought and used as much information as possible to describe the distribution, density and habitat uses of species and life stages over the entire US Caribbean. The team targeted information in a GIS-compatible form (or in a form that could be converted to a GIS format within the time frame of this project).

In summary, no empirical geo-referenced information was found that could be used to set reliable boundaries on the density or distribution of species or life stages in the FMUs of the Council’s FMPs. The project team sought the advice and assistance of the Council’s HAP and SSC in finding spatially explicit information, but no new information was available. Improving the availability of data necessary for describing distributions of species and life stages in the FMUs was not feasible under this project because of the cost in time and resources required (See Section 4.2 Missing Information). As a result, the description and identification of EFH in this EIS relies on information in the second major category: Information about associations and functional relationships between species/life stages and habitat (see Section 2.1.3.3.2).

During the search for available data, the project team discovered that commercial catch and location data in the US Caribbean are not uniformly reported on landing forms. CPUE data in the US Caribbean region are not sufficiently accurate to track relative abundance or abundance
trends (CFMC 2002). For these reasons, catch records were determined to be an unreliable indicator of density.

SEAMAP fishery-independent data exist for the waters around Puerto Rico (Rosario 1998). Reef fish were collected by using baited traps and baited hand lines on the southwest coast of Puerto Rico, queen conch were sampled during diver surveys on the east and west coasts of Puerto Rico, and spiny lobster larval settlement was monitored using Whitman collectors on the west coast of Puerto Rico. Fishers’ perceptions, anecdotal information, and the few socioeconomic studies done suggest that southwest Puerto Rico is an important fishing area (Matos-Caraballo 2002). No surveys have been undertaken in other areas of the US Caribbean that might provide data to compare with the reef fish data from this area. Diver surveys of queen conch on the east and west coast of Puerto Rico found similar density of conch on both coasts. Stratification into conch and no-conch areas found significant differences between strata on the west coast, but nearly identical density between strata on the east coast. While these regions seem comparable for queen conch, no data are available with which to distinguish them from other parts of the US Caribbean. Spiny lobster larval collection found habitat differences and seasonal/lunar cycle differences in larval settlement rates in the survey, but again, no data are available with which to distinguish them from other parts of the US Caribbean.

Some fishery-independent SEAMAP data also exist for the area to the southeast of St. Thomas in the USVI (USVI 2001). Baited traps and baited hand lines were used to sample reef fish and Whitman collectors were used to monitor spiny lobster settlement. The reef fish data have not been analyzed and were not analyzed for this EIS due to time and budgetary constraints. Spiny lobster larval collection data indicate differences between sites and seasonal/lunar cycle patterns in larval settlement rates, but no data are available with which to distinguish the results from other parts of the US Caribbean.

2.1.3.3.2 Spatial and functional relationships between managed species and habitats

Modeling approaches

In cases where some information is available on the associations between species/life stages and their habitats, and there is spatial information on the distribution of habitats, it may be possible to use habitat suitability models (HSM) to infer likely species distributions based on the locations of suitable habitat. Where data on fish abundance and habitat distributions are spatially available, mathematical models may predict fish distribution over the habitats. HSM provides a mechanism to predict the locations of suitable habitat, based on the habitat preferences of individual species or species groups. It may then be possible to infer species distribution (a probability of occurrence) based on the distribution of suitable habitat. Biological, geological and hydrological data, such as substrate, vegetation, temperature, salinity, and depth, are subjected to multivariate analyses to classify the community of fishes associated with various portions of environmental gradients. This methodology has been employed in the US Caribbean region to develop descriptive habitat utilization maps (CFMC 1998). A limited amount of HSM analysis exists for several species in the area around St. Thomas (Appendix 2) and several efforts of limited geographic extent have been undertaken in the Gulf of Mexico region (Sheridan 1996; Rubec et
al. 1998; Gallaway et al. 1999). However, in general, insufficient data currently exist to construct quantitative HSM for most managed species and life history stages in the US Caribbean.

In the absence of quantitative HSM, basic information linking species to habitats can be used with habitat distribution information to infer species distributions and thereby identify EFH. For example, functional relationships between species and habitat can be inferred from a simple cartographic or GIS overlay of a species distribution layer with a habitat distribution layer, even if the respective layers are only available for part of the range of the species (provided, of course, that they do overlap). A species can be considered to be associated with all habitats that occur within the geographic range where it has been found. One can then make the assumption, in a precautionary sense, that a species will use that habitat wherever the habitat occurs within the region being studied.

The HSM approach, whether quantitative or qualitative, would benefit from direct sampling to confirm the predicted associations. A sampling program aimed at ground-truthing would demonstrate errors in the results of the HSM exercise, and would provide information for adjusting the model. More sophisticated models could include seasonal habitat associations, which allow targeting sampling to the most likely time to find the species. Less intensive sampling might be required to support simpler HSM. No comprehensive sampling program currently occurs in the US Caribbean region.

Available data

The available information is in two main forms:

- Use of habitat types by all species at all life stages where information exists (Appendix 1) or could be inferred (Appendix 2).
- Spatial information on the distribution of habitat

The information available on habitat use by managed species is largely qualitative. It may be possible to indicate what functions a species/life stage perform in a particular habitat, but it is not yet feasible to infer growth, reproductive, recruitment or overall production rates based on specific habitat conditions. It may be possible to use bioenergetic models, with growth potential as a proxy for habitat use, to predict production rates in different habitat types (Brandt and Hartman 1993; Ault et al. 1999). Although in situ studies of bioenergetics provide a theoretical framework for relating growth rates (productivity) and feeding ecology to an organism’s habitat and environmental conditions (Adams and Breck 1990), many difficulties arise in developing models for productivity of fish on a habitat basis. Consequently, it has seldom been attempted. Studies of this nature usually require that physiological measurements conducted in the field, be extrapolated in the context of known tendencies or “conventions” established in the laboratory. When the development of bioenergetics models is designed to estimate production, the parameters of ingestion, metabolism and waste must be known or estimated so that growth may be determined. Although the amount of ingested energy is relatively easy to measure, metabolic rates in wild fish are difficult to estimate.
Fish physiology has been studied extensively in the laboratory. Published works by Winberg (1956), Fry (1957, 1971), Elliot and Davidson (1975), Brett and Groves (1979), Jobling and Davies (1980), Adams and Breck (1990), and Jobling (1994), among others, have delineated the factors influencing bioenergetics in fish. Although laboratory studies have established the basic physiological requirements for many species, it is important to note that these studies were conducted under controlled environmental conditions, which limit or eliminate many environmental factors found in an organism’s natural habitat. Additionally, many of the fish observed in these studies were freshwater species or cold-water commercial species outside the US Caribbean and southern Atlantic. Consequently, much of the data may not be applicable to productivity issues for marine species in the US Caribbean. Despite these challenges, a few authors have described aspects of fish physiology based on observations and experiments conducted in the field (Beaver 2002; DeMartini et al. 1994; Soofiani and Hawkins 1982; Polunin and Klumpp 1992).

As might be expected, the availability of information at level 1 is much better than at levels 2, 3 and 4. The 1998 Generic Amendment contains information in text tables on the substrates with which managed species associate and the ecological functions they support, preferences for water depth, salinity, and temperature, dissolved oxygen tolerances; known prey and predators, and qualitative information on geographic range. This information and similar data from other sources were organized in a relational database designed specifically for this EIS. The database was used to help analyze the relative importance of habitats to the various individual FMP species and life stages and the FMU assemblages as a whole. The data are referenced in the database on a species / life stage basis. While there is some information for juvenile and adult life stages, there is a general lack of information existing on some of the earliest life history stages, particularly the postlarval stage. Information is completely lacking for some species. The database contains as much information as could be compiled during the time available for preparation of the EIS. It can also potentially hold level 3 and 4 data however there is currently no quantitative information available on differential growth, mortality, or production among Caribbean habitats for any FMP species.

Data inputs were gathered from a number of sources. Local US Caribbean experts, Dr. Edwin Hernandez and Dr. Kenyon Lindeman provided habitat utilization information based on unpublished data and their personal knowledge to previously available information. The principal previous information source was a series of spreadsheet tables compiled by NOAA Fisheries and the Council for the 1998 Generic Amendment. These tables describe the known life history and ecological requirements of each species by life stage. The information they contain was derived from a comprehensive review of information in the scientific literature. Full citations lists were included with these tables providing a referenced source for most pieces of information. Additional information was obtained from the current FMPs (as amended) for reef fish, spiny lobster, and queen conch. Other important sources were Dr. Joseph Kimmel’s 1985 dissertation on Puerto Rican reef fishes in the vicinity of La Parguera (Kimmel 1985) and Rydene and Kimmel’s census of Dry Tortugas reef fishes (Rydene and Kimmel 1995).

The substrata that make up the habitat were categorized in the database by zone and type (Section 3.2). “Substratum Classification” was divided into estuarine and marine zones.
“Substratum Type” was subdivided into lagoon, reef and plain areas, although these subdivisions were not well represented in the data and were not subsequently used.

The relational database was queried to provide answers to questions about habitat use by FMP species. Queries used for this EIS included:

- A listing of the habitats in which each species/life stage in the FMUs occurs and the ecological functions performed there.
- Known prey of each species/life stage in the FMUs.
- A tally of the number of species/life stages in the FMUs occurring on each habitat type broken down by the ecological functions (i.e. spawning, feeding, growth to maturity) performed in that habitat. This last query is important in the context of evaluating ecological importance in the designation of HAPCs (see Sections 2.1.4.2, 3.1.12)

Tables 2.5, 2.6, and 2.7 present the species-life stage / habitat relationships for each of the five life history stages of the several hundred species and species groups in the lobster, conch, and reef fish FMPs. Species-life stage / habitat tables are not presented for coral species, because coral reefs are the habitat for coral.

In the absence of specific information for a particular species and life stage, proxies, models, or other means that address uncertainty in a risk-averse fashion may be used to extrapolate or infer fish distribution or habitat usage from information on other species. Consultation with regional experts, the Council’s SSC and HAP, provided no other suggestions for extrapolation or inference. Only those species-life stage-habitat relationships identified in the literature or by the regional experts were used in developing alternatives for EFH (Appendix 1).

2.1.3.3.3 Mapping of habitat distribution

To use spatial and functional relationships between managed species and habitats to map species distributions, and hence identify EFH, it is necessary to map the habitats used by managed species. This was done using a geographic information system (GIS) created specifically for the EIS project. A GIS is the most effective and efficient way to use spatial information (see Text Box) and is encouraged by the EFH Final Rule to satisfy the EFH mapping requirement.

The NOAA National Ocean Service (NOS) acquired aerial photographs for the near shore waters of Puerto Rico and the USVI in 1999. These images were used to create maps of the region's coral reefs, seagrass beds, mangrove forests, and other important habitats. The benthic habitat map (Kendall et al. 2001) resulting from this project is searchable at a variety of scales. The maps extend to about the 25 m isobath, the maximum depth for visual identification of habitat from aerial photography.
A Primer on Geographic Information Systems

At its simplest level, a GIS is a sophisticated computer system capable of holding and displaying databases describing places and activities on the earth’s surface to “paint a picture” of complex scenarios. Given that the majority of information pertaining to the marine environment has a spatial component, GIS and related geoprocessing technologies such as the global positioning system (GPS) and remote sensing provide a means to aggregate and analyze the data generated by disparate sources. GIS technology is rapidly replacing the traditional cartographic techniques that have typified most coastal mapping and resource inventory projects, and application to coastal and marine research and management efforts occurs worldwide.

A GIS is not simply a computer system for making maps, although it can create maps at different scales, different sizes, and with different colors and symbols. A GIS does not store a map in any conventional sense, nor does it store a particular image or view of a geographic area. Instead, a GIS stores the data from which the user can draw a desired view to suit a particular purpose. A GIS is also an analytical tool that allows the user to pose very complex questions to the computer, and receive answers in easy-to-interpret map form. The GIS database is a collection of spatial and tabular data depicting the location, extent, and characteristics of geographic features.

A GIS allows users to answer questions that deal with issues of location, condition, trends, patterns, and strategic decision-making, such as Where is it?; What patterns exist?; What has changed since...?; What if...? It comprises layers of information occupying the same space so that users can rapidly analyze multiple conditions over wide areas. However, a GIS cannot generate scales of information that do not already exist in the input data. The scale of information that a GIS can analyze and display is fundamentally limited by the scale of the data that are used to create it.

Standard categories of habitat type were defined on the basis of criteria that include substrate (i.e. bottom type) and vegetation, separated into estuarine and marine zones. Basic habitat data were obtained from Kendall et al. (2001). Kendall et al. described many habitats, including subdivisions of coral reef. Descriptions of the utilization of habitats by species and life stages generally did not include the level of habitat detail provided by Kendall et al. (2001). For the purposes of this EIS, the categories of Kendall et al. were consolidated into the following habitat categories (note, the pelagic category was not used by Kendall et al.):

- Seagrasses (marine and estuarine)
- Mangroves (marine and estuarine)
- Benthic algae (marine and estuarine)
- Reefs (marine)
- Sand/Shell bottoms (marine and estuarine)
- Soft bottoms (marine and estuarine)
- Pelagic
- Hard bottoms (marine)
- Artificial habitat

Artificial structures represent man-made structure not naturally occurring in the marine environment. These “pinpoints” are spread over the geographic space of the US Caribbean, rather than distinct parcels of habitat that could be portrayed as habitat polygons on a map. Artificial structures have not, however, been identified as a separate habitat type in the EFH analysis. Although there are maps available of the location of examples of artificial structures (Figures 2.6 to 2.15), they are not mapped in the GIS as potential EFH. Artificial structure will not be subject to specific EFH consultation, but would remain subject to the existing NOAA Fisheries consultation process and other relevant Federal regulations.
Beyond 25 m depth, there was no information on habitat distribution. It was therefore decided to map the area of potential habitat occurrence, which was considered to extend from the most-shallow depth to the maximum depth on the shelf that a habitat could occur. The area of potential habitat occurrence was mapped out to the 100-fathom isobath (representing the shelf break). The maximum depth of seagrass distribution is considered to be 20 fathoms (Fonseca et al. 1992). All other habitats were considered to have a maximum depth of 100 fathoms. Mapping out to this depth limit was considered likely to cover the habitats used by federally managed species.

Several sets of maps describe the habitats in the region. The first set consists of a mosaic of maps modified from NOS (Kendall et al. 2001), which were derived from aerial photography, and present habitats sufficiently visible for identification (with diver confirmation), to depths of around 25 m. Figure 2.5 presents an index of the mosaic maps with all habitats included to give an overview. Figures 2.6 to 2.15 break the US Caribbean into 10 sections. These maps show habitats in less detail than the numerous grids of Kendall et al. (2001).

The second set of maps (Figures 2.16 to 2.21) presents distribution of coral (reef), hard bottom, seagrass, algae, sand, and soft bottom habitats that may extend to depths greater than surveyed by NOS. These maps contain the distribution of each habitat as determined by NOS, and a potential distribution based mostly on minimum and maximum depths at which the habitats occur. For the coral and seagrass maps, additional surveyed sites are also shown (Jose Rivera, private contractor, personal communication). The generalized distribution includes areas in which the specified habitats could, but may not occur, and are intended to provide information to NOAA Fisheries, other Federal agencies, territorial and commonwealth agencies, fishers, proponents of development activities, and interested citizens. Mangrove habitats do not appear in this set of maps because the NOS maps describe the limits of the distribution. Overall, the non-pelagic habitats occur on the shelf, mapped in the previous figures as the 100-fathom contour.

Calculations of bottom area within jurisdictional boundaries from the GIS indicates that approximately 85% of the shelf occurs in state waters, 12.3% occurs in the EEZ adjacent to the USVI, and 2.6% occurs in the EEZ adjacent to Puerto Rico (Figure 2.22).

In the 1970s through the early 1990s, the US Geological Survey (USGS) conducted a project to map the surficial sediment of the entire insular shelf of Puerto Rico at a scale of 1:40,000 (e.g., Schlee et al. 1999), based on collection of seismic-reflection profiles and bottom sampling with a bottom grab. The USGS surveys described geological features, but did not collect or analyze information on seagrass, marine algae, or mangroves, and did not consistently separate coral reefs from hard bottom areas. Not all maps were completed, due to funding limitations (K. Scanlon, USGS, personal communication). To use the USGS data to map habitat for use in this EIS would require a substantial analytical effort. There are 37 paper maps completed to date and five more still in development needing funding. These maps have been prepared using standard (manual) cartographic techniques and are only readily available in paper format. Once the maps are completed, in order to use them in the analysis for the EIS they would need to be converted into a GIS format. This would require scanning each relevant hardcopy map page to a high resolution (300dpi) TIFF image. Each digital image would then undergo a registration process called geo-rectification. This process associates several locations on the image to known coordinates in the GIS. Geo-rectification allows an image to be displayed within a GIS.
environment in its correct geographic position (e.g., the shoreline of the image aligns with the shoreline in the GIS). Once georectified, the polygonal data would be digitized from the images to create digital distribution data for each substrate type. Once the digitized polygons were converted to GIS layers (ESRI Shapefiles), they could be incorporated into the GIS for further analysis. Completing the maps and converting to GIS formats would take several years, a schedule not possible within the time frame of the EIS preparation. Therefore, data from the USGS maps were not used in this EIS.

2.1.3.4 Developing alternatives for EFH

EFH must be described and identified for each of the four FMPs of the US Caribbean: Spiny Lobster, Queen Conch, Reef Fish, and Coral. NEPA requires consideration of a broad range of alternatives for each of these FMPs. Although the FMPs cover quite different fisheries with different species and hence different habitat requirements, the principles on which EFH will be identified in each are broadly similar. In order to take advantage of this similarity and to avoid unnecessary and cumbersome duplication of information under each FMP, a two-stage approach was adopted in developing EFH alternatives. Several conceptual approaches to identifying EFH were identified. Each concept describes the general basis for developing alternatives under each of the FMPs. Specific alternatives for each FMP are therefore elaborated and mapped under each concept. These concepts were reviewed by the Council, and some were considered and rejected at the concept stage.

No information was identified that could be used to distinguish between the total distribution of species/life stages and subsets of the distribution with sufficient contrast to indicate that one part of a species/life stage distribution should be identified as EFH and another should not. Due to the paucity of this type of information in the US Caribbean, for the purposes of this EIS, the distribution of species/life stages in the US Caribbean was assumed to be the distribution of all habitats that the species/life stage was known to associate with, based on all available information (as organized in the habitat use database). No information was available from other sources to distinguish habitat utilization in one region of the US Caribbean from another. All habitat used by a species/life stage was considered of equal value.

2.1.3.4.1 Concepts for describing and identifying EFH

The number of viable conceptual approaches was limited to a large extent by the available information. As described previously, virtually no information exists at levels 2, 3, or 4 for managed species in the US Caribbean. In all, eight concepts for describing and identifying EFH were developed. These are described in detail below.

2.1.3.4.1.1 Concept 1. No Action – Roll back to pre-EFH designation

The first concept is “no action” which is used to develop the no action alternatives required by NEPA. When applied to the four FMPs, this would create four alternatives under which no EFH
would be designated. Apart from providing one potential option for the Council to adopt, the consequences of these alternatives provide a baseline against which the consequences of the other alternatives can be considered.

The *AOC v. Daley* lawsuit challenged the environmental analyses that led to the current EFH designations, and the settlement required a broader range of alternatives. The No Action Alternatives would roll back the Council’s designation of EFH from the 1998 Generic Amendment. The existing status-quo designations (see Alternative 2 from the Generic Amendment) should not pre-suppose any changes to EFH designation the Councils may wish to take as a result of analysis in this EIS. Therefore, it is necessary to consider alternatives that do not result in any EFH designations. Under the No Action alternatives, no EFH can be mapped.

Justification for taking no action is sometimes based on the lack of information necessary to show what action should be taken. However, the M-S Act requires the Council to identify EFH for species under management by an FMP. Alternatives under this concept, while useful for providing a baseline against which to judge the consequences of the other alternatives, would not meet the requirements of the M-S Act.

Even if the no action alternative was adopted under one or more FMPs (assuming it was a viable alternative), protection of fish habitat in the US Caribbean region would still occur under existing and possible future regulatory actions. Many Federal and state laws and regulations require evaluation of the consequences of projects proposed for the marine (and other) environments. NOAA Fisheries already has the ability to recommend, through Fish and Wildlife Consultation Act consultations, mitigation or minimization of adverse impacts on those habitats important to fisheries resources. The Council and NOAA Fisheries have a wide range of management authority, which includes the ability to manage fishing activities and protect fish habitats to ensure healthy stocks and sustainable fisheries. The Council and NOAA Fisheries have taken a variety of measures in past management plan amendments that protect fish habitat. In some cases, the habitat protection occurred as direct action for habitat, while in other cases the habitat protection occurred as a benefit of management measures directed for other purposes.

Direct protection has resulted from prohibitions on the use of explosives and chemicals, prohibitions on anchoring in sensitive areas, designations of some areas as marine protected areas (MPAs), and restrictions on use of some fishing gear. The Council has currently protected certain habitat areas important to life stages, e.g. a no take area for a spawning aggregation site for red hind and a proposed no take area for yellowfin grouper. Indirect protection has occurred from management actions that required gear modifications, harvest limits, license and permit limitations, prohibitions of fishing activities, time/areal restrictions, designation of MPAs and fishing gear restrictions. The Council has established a Habitat Advisory Panel (HAP) for advice on habitat-related issues. Thus, the Council and NOAA Fisheries could continue current activities to protect fish habitat and could continue to address impacts of fishing on fish habitat without designation of EFH. Prior actions by the Council to protect habitat are provided in the Section 2.1.5.2.
2.1.3.4.1.2 Concept 2. Status Quo

The second concept is status quo. This provides alternatives under each FMP that are the same as the preferred alternative from the 1998 Generic EFH Amendment. The Generic Amendment specified the most commonly used habitat for 18 selected indicator species across all four FMPs (see below).

The Generic Amendment identified and described EFH for various life stages of the following species and the coral complex managed under FMPs:

<table>
<thead>
<tr>
<th>FMP</th>
<th>Species Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common name</td>
</tr>
<tr>
<td>Reef Fish</td>
<td>Coney</td>
</tr>
<tr>
<td></td>
<td>Red hind</td>
</tr>
<tr>
<td></td>
<td>Nassau grouper</td>
</tr>
<tr>
<td></td>
<td>Mutton snapper</td>
</tr>
<tr>
<td></td>
<td>Schoolmaster</td>
</tr>
<tr>
<td></td>
<td>Gray snapper</td>
</tr>
<tr>
<td></td>
<td>Silk snapper</td>
</tr>
<tr>
<td></td>
<td>Yellowtail snapper</td>
</tr>
<tr>
<td></td>
<td>White Grunt</td>
</tr>
<tr>
<td></td>
<td>Banded butterfly fish</td>
</tr>
<tr>
<td></td>
<td>Queen triggerfish</td>
</tr>
<tr>
<td></td>
<td>Squirrelfish</td>
</tr>
<tr>
<td></td>
<td>Sand tilefish</td>
</tr>
<tr>
<td></td>
<td>Redtail parrotfish</td>
</tr>
<tr>
<td></td>
<td>Trunkfish</td>
</tr>
<tr>
<td>Spiny Lobster</td>
<td>Spiny lobster</td>
</tr>
<tr>
<td>Queen Conch</td>
<td>Queen conch</td>
</tr>
<tr>
<td>Coral and Coral Reefs</td>
<td>Coral and coral reefs</td>
</tr>
</tbody>
</table>

NOAA Fisheries partially approved the Generic EFH Amendment. While EFH was approved for the selected species, NOAA Fisheries determined that the Council did not sufficiently justify how the EFH of the selected species related to EFH of other species. Approval for other species in the Management Unit was deferred pending further justification or description of EFH for all species. The AOC v. Daley court decision found that the EFH amendments complied with the M-S Act, but were inadequate with regards to NEPA. The Memorandum Opinion and Order, filed September 14, 2000 remanded the EFH amendments and enjoined NMFS from enforcing the EFH amendments until new and thorough NEPA analyses were completed. The Joint Stipulation and Order, filed December 17, 2001 dissolved the injunction set forth in the Court’s Memorandum Opinion and Order.

The Generic EFH Amendment described and identified EFH based on areas where various life stages of 18 selected species and the coral complex occur. The Council used available
information to describe and identify EFH as “everywhere that the managed and selected species commonly occur.” Because the life stages of these species (including pelagic stages) collectively occur in all habitats of the US Caribbean, EFH under the Generic Amendment included all waters and substrates (e.g., mud, sand, shell, rock, and associated biological communities), including coral habitats (coral reefs, coral hard bottoms, and octocoral reefs), sub-tidal vegetation (seagrass and algae) and adjacent intertidal vegetation (wetlands and mangroves), and pelagic waters. Therefore, EFH included virtually all marine waters, substrates (mud, shell, rock, coral reefs), and associated biological communities. Because of the patchy distribution of these habitats and lack of information with which to map all habitats, the boundary enclosing these categories of EFH extends from the shoreline to the seaward limit of the EEZ, including bays, estuaries, and intertidal areas. Information does not exist to precisely map all of these substrates and habitats as now required by NOAA Fisheries, but they all fall within the boundaries of the EEZ.

2.1.3.4.1.3 Concept 3: List specific habitat types

Under Concept 3, each alternative would list specific habitat types that would be designated as EFH. This makes the assumption that the known range of the habitats listed in the alternatives would at least cover the area that should be designated as EFH for each managed species and life stage, but it does not specifically link species and life stages to habitats. This concept would encompass all waters of the Caribbean that include SAV, mangroves, algae, plains, reefs, reef-SAV interface, hard/live bottoms, sand, and mud, the main habitats used by FMP species. Because the species of each FMP may not use all of these habitats, an alternative under this concept would specify only the habitats used by the species/life stages of that FMP.

2.1.3.4.1.4 Concept 4: Known distributions

Under Concept 4, EFH would be designated on the basis of available empirical distribution data. As with Concept 3, no explicit link can be made between the distribution information and the underlying habitat other than designating the total distribution of species and life stages as EFH. However, as described previously, there are no empirical distribution data of this type available for the US Caribbean.

2.1.3.4.1.5 Concept 5: Habitat-related densities

Concept 5 would make use of information on density distributions of managed species. If different levels of density were known within the overall range of a species and life stage, then it may be possible to use these levels as the basis of designating a portion of the total range as EFH.

This concept would expand the delineation of EFH as described in the 1998 Generic Amendment from the various life stages of the 18 representative species to include the life stages of all managed species in the four FMPs. This concept could be used for those species and life stages...
for which quantitative data (i.e., density or relative abundance) are available for the habitats they occupy. Density information would be used to identify EFH as the habitats supporting the highest relative abundance within the geographic range of a species. Under this concept, EFH would be defined as the area where the density or relative abundance of a species life stage is above a threshold level. The threshold should be identified through research so that the area designated as EFH meets the intention of the guidance in the EFH Final Rule: sufficient to “support a population adequate to maintain a sustainable fishery and the managed species’ contributions to a healthy ecosystem.” In practice, it is likely that the data would limit the options for selecting threshold levels, and levels would be selected by the Council on the basis of an analysis of practicability.

As noted in the EFH Final Rule (50 CFR Part 600), because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

Because this concept selects an area with density above a certain threshold (assumed to be greater then zero), it would result in less area being designated as EFH for individual species/life stages than under alternatives developed under Concepts 2 or 6. These latter concepts use the entire known distribution of species and life stages (i.e. density > 0). However, aggregation of individual species/life stage EFH may result in the overall extent of the composite EFH for a fishery being similar in size to that under Concepts 2 and 6.

Data on density distributions of managed species in the US Caribbean are not currently available. CEQ regulations (1502.22) require agencies to make clear when information is lacking. Therefore, alternatives under this Concept, while they would meet the requirements of the EFH Final Rule, could not be developed and mapped with available information.

2.1.3.4.1.6 Concept 6: Functional relationships between species and habitats.

Concept 6 specifies functional relationships for life stages and habitat types that might be regarded as meriting special attention for their importance to managed species. The M-S Act defined EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” These are the functions that marine and estuarine habitats support. Under this concept, the distribution of species and life stages is inferred from information on these the functional relationships. It may be possible to use information on ecological relationships to infer that some portions of the distribution range are more important than others for the sustainability of the species.

This Concept expands commentary and analyses to incorporate all managed fish species, not just those included in the Generic EFH amendment. This addresses the partial approval by NOAA Fisheries for the 18 indicator species of the Generic Amendment.
Functional relationships are modeled on the basis of utilization and degrees of utilization of habitats by species and life stages. This alternative requires information on both habitat utilization and the location and extent of habitats in order to map EFH. Density and growth, survival, or production rate information all relate to the functional relationship and can be incorporated into the analysis of the degree of habitat utilization. Empirical data on species distribution and density, where available are used to verify the results of the modeling exercise. This alternative therefore incorporates all available information for describing and identifying EFH for all managed species. All available information will be assessed to describe EFH for all managed species. However, little information exists on relationships between habitat, abundance and distribution for many of the life stages of managed species in the US Caribbean. Therefore, where practicable, proxy information will be used for those species where information is lacking. This means that attempts will be made to use certain criteria (e.g. taxonomy, similar behaviors, prey preferences) to match the life stages of data-poor species with species for which information is available that could act as proxies.

Lack of information might prevent precise mapping of the various habitats, habitat-related densities, or other ecological information covered under this concept. Confining EFH designation to only mapped habitat areas would omit areas of habitat yet to be identified, and leave undesignated and without the protection afforded by EFH provisions, areas that may be essential to fish production. However, potential habitats can be mapped using maximum depth limits as boundaries. For practical purposes, and in accordance with the precautionary approach, describing and identifying EFH under this concept will be applied as broadly as possible. For each FMP, the habitats used by species and life stage are presented in Tables 2.5 to 2.7 and Appendix 1. Table 2.8 presents each habitat and the species and life stages that use that habitat. Tables 2.5 to 2.7 and Table 2.8 are built from information in Appendix 1. Mapping of the habitats occurs as described in Methodology Section 2.1.3.3.3.

2.1.3.4.1.7 Concept 7. Spatial data

Concept 7 would use spatially explicit, qualitative or quantitative information that link fish distributions and habitat to describe and identify EFH. Spatially explicit information would result in alternatives under each FMP that would be intermediate between Alternatives 6 and 8. However, the spatially explicit information required to implement the concept is not currently available.

CEQ regulations (1502.22) require agencies to make clear when information is lacking. Spatial explicit information may exist as unpublished data or reports. However, fishery scientists and administrators familiar with this concept have not indicated sources of such material. It is not known if it such material exists in a GIS-compatible form or over a wide enough scale to allow comparison among areas. This Concept is not feasible at this time because of the cost in time and resources to mount an extensive search, to perform necessary data processing, and to conduct analyses.
2.1.3.4.1.8 Concept 8. Habitat Suitability Models

Concept 8 is a more sophisticated version of Concept 6. It uses habitat suitability modeling (HSM) prepared by NOS to infer information about species distribution, and possibly relative density (i.e. assuming that habitats with a higher suitability support greater abundances of a species life stage).

The National Ocean Service (NOS) has developed a prototype procedure of HSM for the US Caribbean that integrates distribution of habitats with the species affinity for each habitat, using a geographic information system (CFMC 1998) to help explain species abundance. Biological and hydrological data, such as temperature, salinity, and depth, are subjected to multivariate analyses to classify the community of fishes associated with various portions of environmental gradients. The analysis used the habitats mapped by NOS (Kendall et al. 2001), limited to about 25 m depth. Suitability index modeling is undertaken to define which portions of environmental gradients are most important in explaining species abundance (Rubec and McMichael 1996). In general, insufficient data currently exist to construct HSMs for most managed species and life history stages.

For the Caribbean region, depth, shelf zone, and substrate type were the most important determinants of species distribution. However, depth could not be accurately linked to substrate data, and was not used at the time of development of the prototype procedure. To accomplish the linkage between life history table and habitat data, coverage of habitat zones (leeward, windward, crest relative to reefs, and shorelines) and structures (seagrass, reefs, mangroves, algae, sand, and mud) were converted to individual grids.

This methodology is being employed in the US Caribbean region to develop descriptive habitat utilization maps (CFMC 1998), and several limited efforts have been undertaken in the Gulf of Mexico region (Sheridan 1996; Rubec et al. 1998; Gallaway et al. 1999). The habitat identified as EFH in Concept 8 is less than would be identified under Concepts 2 and 6. The information available is limited to 14 species (one life stage of each) and covers only the waters around St John to a depth of 25 meters (Appendix 2).

2.1.3.4.1.9 Considered and rejected concepts

The Council reviewed the above concepts in March 2002, and considered and rejected Concepts 3, 4, and 7 (see also Section 2.6 – considered and rejected alternatives). The Council agreed with recommendations from the HAP and SSC that:

- Concept 3 provided only a list of habitats that, while important, did not use information for the ecological function of species and life stages of habitats
- Concept 4 was considered and rejected because Concepts 4 and 6 describe the same EFH, and Concept 6 contains all the elements of Concept 4 and better meets the requirements of the M-S Act.
- The Council recommended that Concept 7 should be held for future consideration when more information becomes available.
2.1.3.4.2 Applying the concepts to the FMPs

Each of the EFH concepts that the Council agreed to consider further was used to develop specific alternatives under each of the FMPs. These Alternatives are presented in Section 2.3. These alternatives explain in detail how EFH is described and identified in each case. In addition, for each FMP where possible, they present maps that show the composite EFH for all species and life stages under each FMP.

The 1998 Generic EFH Amendment designated EFH as areas where species commonly occur, which amounted to all pelagic waters and benthic habitats of the US Caribbean; mapping of Alternative 2 for each FMP used the GIS to depict the waters of the EEZ. Mapping of the Alternatives 6 and 8 for each FMP used GIS methodology to combine maps of habitat distribution and information on species habitat utilization, which are both described in the preceding sections. Each map of EFH under each Alternative 6 (one map for each FMP) is a composite of the EFH for all individual species and life stages within that FMP. These maps required extracting habitat use information for all species and life stages in the FMU of an FMP from a species/life stage/habitat-use database. EFH was described and identified as the full distribution of the habitats used in each FMP. Habitats with known locations (from Kendall et al. 2001) were combined with locations of potential habitats using GIS technology, and presented in the Generic EFH Amendment. The maps of EFH under Spiny Lobster, Queen Conch, and Reef Fish FMP for Alternative 8 are based on the Kendall et al. (2001) maps.

No alternatives were developed under Concepts 3, 4 and 7 because these were considered and rejected by the Council. Therefore no maps were drawn. No maps were drawn for the alternatives developed under Concept 1 because this concept does not describe and identify EFH. Alternatives developed under Concept 5 required maps that build composite EFH from the EFH of species and life stages under those FMPs for which density information exists. However, because no US Caribbean-wide density data are available, no maps could be drawn. Alternatives under Concept 2, the status quo alternatives, are from the 1998 Generic Amendment. While the Generic Amendment did not provide maps of EFH, alternatives under this Concept were mapped as the entire EEZ. Maps were drawn for alternatives developed under Concept 6. These maps build a composite EFH for each FMP from the individual EFH of all species and life stages under each FMP for which information on the functional relationship of species/life stages and habitat is available. Concept 8 requires a map for each FMP that builds a composite EFH from the EFH of all species/life stages for which HSM information is available.

2.1.4 Designating HAPCs

2.1.4.1 Introduction

The EFH regulations encourage regional Fishery Management Councils to designate habitat areas of particular concern (HAPC) within areas identified as EFH in order to focus conservation priorities on specific habitat areas that play a particularly important role in the life cycles of
federally managed fish species. EFH potentially encompasses a very broad range of habitat used by fish species, and without additional distinctions would not identify or attempt to add additional protection for the areas of habitat that are most important to the survival and productivity of the species. Identifying the few most important habitat areas or types as HAPC provides additional focus for conservation recommendations developed through the consultation process, and encourages a higher level of scrutiny of activities proposed in designated areas. This will afford those habitats extra protection, to promote recovery where needed, and give the fish species an extra buffer against adverse impacts that could otherwise lead to declines in abundance and productivity and/or changes in distribution.

The Council and NOAA Fisheries presently have the authority to manage fisheries and fishing gear within Federal waters and can, therefore, evaluate and restrict fishing gear as necessary on a case-by-case basis. Implementation of fishery-related restrictions applied to EFH and/or HAPC designated outside of Federal waters would require consultation and agreement with the relevant state agencies. Proposed alternatives for minimizing impacts of fishing on habitat are presented in Section 2.5. Identification of HAPC also gives the Council and NOAA Fisheries added opportunity to influence non-fishing activities that may adversely affect habitat.

Many fish species require very specific physical and/or biological conditions for certain critical life history functions. Obligatory areas often exist for spawning or recruitment, without which these vital processes would be severely impacted. These obligatory areas may act increasingly as a limiting factor to fish production – as the areas diminish in size or are otherwise adversely affected, the production may also start to diminish. For example, a fish species may spawn only on a special type of habitat in a limited geographic area and/or under specific physical conditions, such as temperature, tide, etc. A nursery area may consist of a particular type of vegetation or bottom type, or fish feeding may occur on other species that have specific habitat requirements.

2.1.4.2 Habitat conditions for designating HAPC

Whereas EFH must be described and identified for each species and life stage in the FMUs, HAPCs are identified on the basis of the condition of the habitat. The Final Rule lists the following considerations in the designation of HAPCs (50 CFR 600.815 (a) (8)):

- The importance of the ecological function provided by the habitat;
- The extent to which the habitat is sensitive to human-induced environmental degradation;
- Whether and to what extent development activities are or will be stressing the habitat; and
- The rarity of the habitat type.

Musick (1999) proposed using three principles – utilization, availability, and vulnerability – to determine important habitat areas. DeAlteris (2002) advanced this concept by recommending priorities for habitat conservation inversely related to availability (comparable to the concept of rarity in the above list) and directly related to utilization (comparable to ecological importance) and vulnerability (comparable to sensitivity and stress). DeAlteris quantified these principles in
evaluating effects of mobile fishing gears for the NE United States in making recommendations for prioritizations of fish habitat.

The designation of HAPCs is intended to identify to anyone considering actions that might be potentially threatening to habitat those areas of EFH considered to be of the highest importance in the life cycles of managed species and most in need of protection. An HAPC is expected to be a localized area of EFH that is especially ecologically important, sensitive, stressed, or rare when compared to the rest of EFH.

2.1.4.2.1 Ecological importance

In the context of this EIS, the ecological importance of a habitat stems from the function that it provides to the managed fish species. However, the Final Rule is not explicit regarding the metrics that should be used for measuring ecological importance. Caribbean fish utilize many types of habitat. For example, most reef fish spawn in offshore waters of the Caribbean where they produce pelagic eggs, eggs may drift inshore where juveniles use estuarine, shallow water, or near shore areas as nursery grounds, and move offshore as adults to live on demersal habitats. Other species spend the entire life cycle in open waters. In no case, does enough information exist to definitively determine levels of ecological importance for the managed fish species.

A variety of approaches are envisioned that could be used, including

- Habitats that support the ecological activities of a larger number of managed species life stages;
- Habitats that support important ecological functions of managed species (bottlenecks); and
- Habitats that support species that play an important role in the food web (e.g. forage species)

The use of a habitat by a managed fish species that is depleted or overfished would not in and of itself result in establishment of an HAPC. Species status would influence the designation of HAPC only if one or more of the habitat considerations identified in 50 CFR 600.815 (a) (9) is met.

An important aspect of measuring ecological importance for the purpose of identifying HAPCs is that the metric used provides sufficient contrast to enable local areas to be distinguished from one another. Preferably this is done quantitatively rather than qualitatively. The first approach listed above (habitats that support the ecological activities of a larger number of managed species’ life stages) readily lends itself to quantification, and the necessary information is available in the habitat use database described in Section 2.1.3.3.2. The rationale for this approach is that greater number and variety of species and life stages that rely on the habitat for completing their lifecycle, the more ecologically important that habitat is likely to be and the greater the ecological benefit that is likely to be derived from protecting it (and conversely the greater the ecological cost of adversely affecting it).
Each life history stage can use the habitats on which it is found for one or more of the three ecological functions (spawning, feeding or growth to maturity). Of the three possible functions, eggs can only perform “growth to maturity.” Larvae, postlarvae, early juveniles, and late juveniles can perform “growth to maturity” and also possibly “feeding.” Adults, by definition, are already mature, and so can only perform “feeding.” Finally, spawning adults can perform “spawning” and also possibly “feeding” (although this is rarely documented). If adults of a species are known to occur in a habitat, but feeding activity has not been documented, the ecological function was listed as “unknown.” The “unknown” designation was not used for the other life stages. For stages less developed than adults, if there was no other documented function, then they were recorded as using the habitat for “growth to maturity.” For spawning adults, if there was no other documented function, then the function was listed as “spawning.”

Using the habitat use database, the number of managed species’ life stages occurring in particular habitat types were tallied separately for each ecological function, under each FMP. The habitat use scores resulting from this analysis are presented and discussed in Section 3 of the EIS.

In order to use this information in a spatial context, to identify locations of potential HAPCs, it is necessary to have knowledge of the distribution of the habitat types, and preferably some information on the geographic extent of the species distribution. This would enable accurate representation of the number of species and life stages potentially using habitats for the various functions in local areas. However, mapping of habitat in the US Caribbean is only available down to 25 m depth, and there is a lack of spatial information on fish distribution other than knowing that the species in the habitat use database occur at least somewhere in the region. This data limitation therefore prevented describing habitat use by managed species on a local scale suitable for identifying HAPCs.

2.1.4.2.2 Sensitivity to human-induced environmental degradation

Human induced environmental degradation can result from both fishing activities and non-fishing activities such as coastal development and pollution. Methods used to evaluate and assess these types of impacts to EFH are described and evaluated in this section. The types and extent of fishing and non-fishing impacts are presented in detail in Section 3.5 of this EIS.

An evaluation of fishing impacts is important both in the identification of potential sites of HAPC and to provide guidance on the types of impacts that need to be prevented, mitigated, or minimized under the requirements of the EFH Final Rule (600.815(a)(2)). In addition to providing a metric for identifying HAPCs, the evaluation of non-fishing impacts contributes to the evaluation of the likely benefits of possible modifications to fishing activity by providing information about cumulative impacts.
Different fishing gears affect habitats to different degrees. Mobile gears, such as bottom trawls and dredges, have a potential to affect habitat over a wide area, because the gear is in direct contact with and moves across the substrate and any biogenic structures. However, such gears are not typically used in Caribbean fisheries. Non-mobile gears fish primarily in a fixed location, so their direct effects on habitat are generally confined to that location or “footprint.” The damage from a single encounter in either case can range from negligible to severe. However, the adverse effects on EFH of fishing that are to be prevented, mitigated, or minimized relate to the functional relationship between habitat and fish. At this time, only limited information exists to relate fishing activities to habitat damage (Rester 2000, Barnette 2001, Johnson 2002, NRC 2002), and there is no basis yet for a quantitative link between habitat damage and habitat function. Therefore only a speculative, qualitative evaluation of the degree of impairment of the function of the habitat for fish species and life stages that results from these impacts can be made. Nevertheless, attempts have been made to combine these concepts – the likely degree of damage from a single standard encounter, and the resulting impaired function for fish – to create a scale of potential habitat damage that will be called the fishing gear sensitivity:

- **High (3 or +++):** Capable of severe damage to a wide swath of habitat during a single encounter. Seriously impairs the function (for fish) of the impacted habitat.
- **Moderate (2 or ++):** Capable of severe damage to habitat in a “footprint” of the gear during a single encounter; or capable of moderate damage to habitat over a swath. Impairs the function (for fish) of the habitat.
- **Minor (1 or +):** Capable of moderate damage to habitat in a limited area during a single encounter. May impair the function (for fish) of the habitat.
- **Negligible (0):** Does not typically cause damage. No perceptible impairment to the function (for fish) of the habitat.

Damage in the high category would involve widespread and severe damage from a single encounter that seriously impairs the ecological function of that habitat for managed fish species, while ‘negligible’ indicates no appreciable impairment to the ecological function of the habitat.

*A fishing gear sensitivity* score is allocated to each combination of habitat type and fishing gear, and presented as a cross tabulation of the standard habitat types and all the fishing gears that are potentially used under the FMPs (Section 3.5.1.2). These relative measures result from modifications of rankings developed during a 1999 NMFS workshop on gear impacts on essential fish habitat in the NMFS Southeast Region (Hamilton 2000, Barnette 2001).

The NMFS workshop did not specify all gear-habitat interactions encountered in the US Caribbean. Section 3.5.1.2.13 designates separate categories, coral, mangrove, benthic algae, and drift algae, not included in the workshop list. Benthic algae habitats were given the same score as seagrasses. Coral habitats were given the same score as hard bottom, except that gill/trammel nets scores were increased from 1 to 2 based on advice from HAP/SSC members: careless use of
nets set by SCUBA divers causes nets to drag over and damage coral. The NMFS workshop did not score beach seines on hard bottom, but Section 3.5.1.2.13 scored coral and hard bottom as a 2 based on advice from HAP/SSC members that beach seines drag over nearshore coral structures and damage vertical structure. The HAP/SSC and the Council reviewed and commented on the table of fishing gear sensitivity, and the scores reflect their comments.

2.1.4.2.2.2 Sensitivity of habitats to non-fishing impacts

A number of non-fishing impacts to EFH occur throughout the US Caribbean region, and include a variety of physical, water quality, and biological effects. The majority of these impacts are directly related to anthropogenic activities (especially dredge and fill) and these vary throughout the region. The relative measures of these effects (activities) are an important factor in determining all of the potential anthropogenic impacts on EFH in the US Caribbean. Therefore, an analysis of non-fishing effects and their relative intensity would ideally be performed and used in concert with fishing impacts for the EFH risk analysis for assessing cumulative impacts.

Non-fishing impact types are described in detail in Section 3.5.2. Quantitative information of the kind needed to assess the intensity and spatial distribution of non-fishing impacts are not available at present. Therefore, in this EIS, such impacts have been assessed only on a very general and qualitative basis. However, the reefs that ring Puerto Rico are threatened because of their proximity to stresses from coastal development (Puerto Rico DNER 2000). Turgeon et al. (2002) rated levels of concern over non-fishing activities for coral reef managers of the US and Pacific Freely Associated States.

2.1.4.2.3 Stress from development activities

Assessing the extent to which development activities are or will stress areas of habitat requires knowledge of the spatial distribution of those activities in the past, present and possible future in relation to local habitats. To obtain a measure of the risk for areas that are or will be stressed by development activities, the areal distribution of these activities must be coupled with information on the sensitivity of habitats in the area to the development activities. For the purposes of this component of the EIS, “development activities” were considered to include all human induced non-fishing activities that might lead to impacts on EFH.

There is no information currently available that describes the geographic distribution of non-fishing impacts in the US Caribbean. Information on amounts of non-fishing activities in different locations is available only in the form of project proposals reviewed by the NOAA Fisheries Habitat Conservation Division (HCD) of the Southeast Region (See Section 3.5.2). This information does not adequately represent the actual distribution of impacts, but does provide an overview. Therefore, a quantitative assessment could not be made of the relative stress from development activities on a scale suitable for identifying HAPCs.
2.1.4.2.4 Rarity

Musick (1999) recommended considering availability in evaluating habitat, and DeAlteris (2002) recommended an inverse relationship between availability (equivalent to a direct relationship with rarity) and habitat protection. If a habitat is ecologically important, and it is also rare, then the benefit of protecting it from adverse impacts will likely be greater than if it is either less ecologically important, or more common. It is likely that the same proportion of loss of a more rare or less rare habitat will have similar consequences for production of species that use the habitat. However, a unit loss of the more rare habitat will cause a higher proportion of habitat loss that same unit loss on a less rare habitat, and thus likely cause a proportionately higher loss in production for the species using that habitat.

However, insufficient habitat mapping exists in the US Caribbean to do this. NOS mapping extends only to depths of approximately 25 m, which leaves the majority of waters unmapped. Using this limited mapping would give a potentially misleading representation of habitat rarity. As a result of data limitations, no distinction between habitats in the US Caribbean could be made on the basis of rarity. This condition was therefore not used to identify HAPCs.

2.1.4.2.5 HAPC considerations not used in the analysis

Data limitations prevented utilization of several metrics developed for quantifying considerations for evaluating HAPC. These metrics are presented here as an example of how the analysis of information relating to HAPC could proceed as data become available.

2.1.4.2.5.1 Ecological importance

If sufficient information were available, the analysis of ecological importance could be expanded by weighting the habitat use of species and life stages differently, to cover factors such as ecological bottlenecks or forage species. For example, increased weight could be given to habitats that fulfill a larger number and variety of ecological functions for managed species (i.e. spawning, breeding, feeding, growth to maturity), which might therefore represent bottlenecks. Similarly, the life stages of keystone prey species could be given additional weighting (rather than simply counting each as 1). Lack of information on bottlenecks and keystone species precluded weighting the habitat use. Additionally, lack of habitat mapping beyond 25 m depth and lack of spatial information on fish distribution would not allow applying this concept to specific local areas.

2.1.4.2.5.2 Sensitivity to non-fishing impacts

If the information necessary to quantitatively estimate sensitivity to non-fishing impacts were available, analysis might proceed along the following steps. Sensitivity involves an evaluation and weighting of each of the non-fishing impact types for a given habitat based on best scientific judgment and literature reports. The analysis used to develop these weighting factors would follow approaches similar to those used recently used in habitat and ecological stressor...
evaluations in the Tampa Bay, Florida area (Kurz et al., 2001; Kurz et al., 2002). Different non-fishing activities affect habitats to different degrees. Some activities have a potential to affect habitat over a wide area, while other activities are more static and their effects are generally confined to the location of the activity. The damage from a single non-fishing activity in either case can range from negligible to severe. Combining these concepts – extent of a single activity, degree of damage from a single activity, and impaired function for fish – would lead to a ranking of potential habitat damage equivalent to the sensitivity index described above for fishing impacts. However, insufficient information is currently available to develop such an index.

Different habitat types can be more or less sensitive to impacts from non-fishing activities that threaten the capacity of the habitat to maintain (or restore) its ecological function for managed species. If sufficient information were available, sensitivity to non-fishing impacts would be measured on a relative scale similar to the measurement of the fishing sensitivity (see below). Weighting factors for each of the habitats and effects would be scored based on the potential severity of a given activity/effect on a specific habitat. These scores would use the quartile approach used elsewhere in this document (see Section 2.1.5.3.3), and would range from 0 (no effect) to 3 (large effect).

2.1.4.2.5.3 Stress from development activities

Ideally, spatial distribution of non-fishing (development) activities would be available in a GIS-compatible format to allow overlay mapping on habitats. In this way, a single nominal quantity denoting the risk would be allocated to each area of habitat for each non-fishing activity. To quantify non-fishing impacts, GIS data on non-fishing activities should be gathered from various sources throughout the US Caribbean region and used in this analysis, using relevant, spatially accurate databases with a continuous coverage throughout the US Caribbean region. Ideally, these data would be analyzed separately for different fishing zones throughout the US Caribbean and further separated by a depth zone (estuarine versus marine). Since the data would probably vary by units (some data might be points, others might be in miles or acres), the values for a given activity/effect could be reduced to a value based on a quartile distribution (see Section 2.1.5.3.3.) of those data throughout the region. These values would then be tabulated in the format of a habitat/effect matrix, and would represent a measure of habitat stress. The relative stress imposed on the EFH parcels will be determined based on the extent to which the habitat has been or is expected to be stressed by development activities (more stress = higher ranking) that adversely affect its capacity to maintain its ecological importance. Stress will be measured according to standard criteria, such as distance from potentially stressing activities (e.g. outfalls, centers of industry, population etc), or actual data on pollution load, turbidity etc.

Risk of habitat stress depends on the sensitivity of the habitat to non-fishing (development) activities, and the intensity of those activities on a local scale. For each habitat type and gear type:

\[ \text{risk of habitat stress} = \text{sensitivity to non-fishing impact} \times \text{intensity of non-fishing activity} \]
These data could be condensed by summing the total effects values for each habitat type by zone and plotting them on maps to show the relative distribution of scores throughout the US Caribbean. These data would represent the relative non-fishing effects values for each zone and depth (estuarine and marine). Insufficient information exists to implement this approach at this time.

2.1.4.2.5.4 Rarity

Calculation of habitat rarity would require subdivision of the total area into parcels of contiguous patches of a single habitat type, characterized, for example, by substrate type, depth, temperature and possibly some geographic range such as a pre-defined ecological sub-region. The parcels would need to be of the same sort of local scale as that envisioned in the Final Rule. The relative rarity of a habitat parcel could be calculated on the basis of the spatial extent of the parcel (and all other parcels with the same characteristics) compared to the overall extent of the area being studied, and the distance between this parcel and its nearest neighbor parcel with the same characteristics. Such a calculation could be implemented relatively easily in a GIS.

2.1.4.2.6 The importance of scale

The discussion of HAPC and application of the conditions set out in the EFH Final Rule depends to some extent on the scale of the area under consideration. If one were considering the US Caribbean shelf in the context of EFH in the entire US EEZ, it could be argued that the entire insular shelf of the US Caribbean makes a good candidate for an HAPC, by meeting all the four conditions set out in the EFH Final Rule (Section 2.1.4.2), and representing a discrete area, as envisioned in the guidelines. Looking at the US Caribbean EEZ in isolation, however, the shelf does not appear to be a discrete area and is not of the scale envisioned in the guidelines.

The US Caribbean shelf contains a mosaic of coral, live/hard bottom, marine vegetation, and other habitats used by the managed species of the four FMPs (Section 3.2). The entire shelf therefore meets the condition of ecological importance. Puerto Rico has lost approximately 66% of its mangrove forests, and USVI has lost significant portions of mangroves, due to development (Martinez 1994). Mangroves are necessary to maintain the health of coral and seagrasses. Coral reefs show an overall decline in health mainly from land use impacts. Seagrass beds decrease steadily from coastal development. These habitats therefore meet the conditions of sensitivity to human-induced environmental degradation and undergoing stress from development activities. Coral reefs and associated ecosystems make up a small fraction of the world ocean, and the US coral reefs make up a small fraction of the US EEZ. These habitats can therefore be considered to be rare.

For the purposes of this EIS the idea of designating the entire insular shelf of the US Caribbean as an HAPC has not been considered further; however, it is recommended that this issue of scale be kept under review.
2.1.4.3 Developing alternatives for HAPC

2.1.4.3.1 The range of HAPC alternatives

Seven alternatives were originally considered for designating HAPCs. These are described individually in more detail in Section 2.4. In summary, they were as follows:

- Alternative 1. No action (roll back)
- Alternative 2. Status quo
- Alternative 3. Ecological bottlenecks
- Alternative 4. Spawning sites
- Alternative 5. Nursery grounds
- Alternative 6. Migratory routes
- Alternative 7. Sites of special interest

As with EFH, the no action alternative is required under NEPA. The Council has previously taken action to designate only one site-specific HAPC (Hind Bank), as well as several general habitat types (see Section 2.4). No action would therefore represent a “roll back” in that this HAPC would no longer be designated under the EFH provisions of the M-S Act. The status quo alternative would leave this HAPC intact, but designate no others. Alternatives 3 to 6 were all considered to represent various aspects of ecological importance. As described in the previous section, due to the low level of information available regarding the geographic locations of habitats and the activities that impact them in the US Caribbean, the methods described for providing quantitative metrics for the four HAPC conditions (including ecological importance) could not be used. Instead, development of alternatives focused on using expert knowledge to select areas that could be justified as meeting one or more of the conditions for HAPC designation on qualitative grounds. The intention of alternatives 3 to 6, therefore, was to delineate sites, on the basis of expert opinion, that are important for spawning, early life stage development, or migration, or that represent an ecological bottleneck for one or more of these or other reasons. Alternative 7 was intended to capture expert opinion on the other three conditions for HAPC: sensitivity to degradation, stress level and rarity.

No information was available that could reasonably be used to delineate HAPCs under alternatives 3, 5 and 6, even on qualitative grounds. There is, however, some information on the location of spawning sites for some species that can be used to identify these as HAPC on the grounds of ecological importance (see Section 2.4). The Council therefore agreed to retain Alternative 4, but to consider and reject Alternatives 3, 5 and 6 (see Section 2.6).

The Council’s HAP and SSC jointly provided a list of specific sites recommended for consideration as HAPC. These sites most commonly comprise locations of coral or mangroves habitat. As with other actions under the EFH provisions, sites of HAPC must be designated through the process of amending one or more FMPs. To designate HAPCs in an efficient manner, it was envisioned that for each potential HAPC a choice would need to be made as to which FMP it would be designated under. Sites with predominantly coral habitat were aligned with the Coral FMP. Coral is both a habitat and a managed species (as defined for management purposes). It also serves as habitat for species and life stages that are managed under other FMPs,
however, a designation under the Coral FMP was considered to be an appropriate course of action. Sites with predominantly mangrove habitat were aligned with the Reef Fish FMP. Mangrove habitats rank higher in ecological importance for reef fish than for species in other FMPs. Therefore, the original Alternative 7 was split into two alternatives (see Section 2.4):

Alternative 7. Reef fish sites of special interest (Reef Fish FMP)
Alternative 8. Coral sites of special interest (Coral FMP)

Under these alternatives, qualitative information on the four HAPC conditions is considered as it relates specifically to the reef fish and coral FMPs.

2.1.4.3.2 Mapping HAPC alternatives

All mapping of the HAPC alternatives was conducted using a GIS developed exclusively for this EIS.

Alternative 1 requires no maps, because no HAPCs are designated under this alternative.

Alternative 2 simply maintains the designation of HAPC as that made under the 1998 Generic Amendment, but there were no maps of HAPC produced in that document. After 1998 nearshore coral and hard bottom were mapped by NOS and are presented in Figures 2.5 to 2.15. Hind Bank is shown in Figure 2.23. Estuaries are shown in Figure 2.24 and 2.25.

No maps could be drawn for Alternatives 3, 5, and 6, which were consequently considered and rejected.

Alternative 4 requires a map showing spawning areas. Locations of most known spawning areas are available either from the Council, which closed or partially closed them to fishing, or in the literature. Sites that can be mapped are proposed as HAPCs under Alternative 4 are shown in Figures 2.26 to 2.27.

A panel of experts recommended HAPC sites for Alternatives 7 and 8. Members of the panel provided the site locations via the Council and these locations are mapped in Figures 2.31 to 2.36.

2.1.5 Addressing adverse effects of fishing on EFH

2.1.5.1 Introduction

Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature. Each FMP must therefore be amended, as necessary, to prevent, mitigate, or minimize to the extent practicable adverse effects from fishing on EFH, including EFH designated under other Federal FMPs (600.815(a)(2)(ii)). In addition,
Federal agencies must consult with NOAA Fisheries on Federal projects that may adversely impact EFH. These requirements recognize that both fishing and non-fishing actions may adversely affect fisheries productivity through a variety of impacts on EFH.

Gears allowed in the US Caribbean EEZ are limited to trawls, traps/pots, gill/trammel nets, vertical gear (hook and line, rod and reel, hand line, bandit gear), longline, power head, dip net, hand harvest, slurp gun, cast net (50 CFR 600.725). However, not all of these gears are authorized for use under the Council’s FMPs. Although few studies have been conducted specifically in the Caribbean, information on potential impacts of fishing gears used in US Caribbean fisheries have been reviewed and documented by Hamilton (2000) and Barnette (2001). Appeldoorn et al. (2000) provided site-specific information on trap/pot damage to benthic habitat. Authorized fishing gears used in the Caribbean region that are documented to have potentially adverse impacts on habitat are longlines and fish traps/pots. Vertical gear and some nets could also adversely impact habitat (see Section 3.5.1). However, insufficient information exists to draw conclusions on the full impacts of all fishing gears on all habitats. The physical effects on EFH/HAPCs from the use, or cumulative use, of specific fishing gears in specified areas have not been well studied in the Caribbean. The allowable fishing gears for FMP and non-FMP fisheries in the US Caribbean are identified in Section 3.5.1.3 and for FMP fisheries in Table 2.9.

Barnette’s (2001) report for NOAA Fisheries also reviews the limited information regarding habitat recovery from gear impacts, and existing management or policy recommendations in use for protecting EFH. In general, the goal of minimizing fishing impacts on EFH is to protect the biological function of the EFH. Additionally, mitigation methods may be useful in restoring ecological function to EFH previously damaged. Although it is possible to quantitatively document habitat recovery, it is very difficult to quantitatively measure the functional or biological benefits to species of fish, due to the effects of many other variables.

The EIS considers the consequences of specific alternatives to address adverse fishing impacts. It also considers in a general way the consequences of anthropogenic, non-fishing impacts and natural impacts. The practicability of the fishing impacts alternatives is considered with regard to the economic and ecological costs and benefits of the resulting management measures, within the overall context of the fishing and non-fishing and natural impacts (see Section 2.1.6.4). The benefits of taking action under the EFH mandate also need to be considered in light of existing and reasonably foreseeable future Council actions that protect habitat. To provide a baseline against which to develop alternatives for new action, the following section describes existing Council actions in detail.

2.1.5.2 Caribbean Council habitat protection policies

As with EFH and HAPC alternatives, NEPA requires there to be a no action alternative for addressing fishing impacts. However, unlike with EFH and HAPC, the no action alternative in this case does not imply that there is no opportunity for actions envisioned under the EFH mandate. The Council has in the past and will continue to take action to protect habitat from fishing and other impacts under its existing management frameworks.
Since the creation of the Council in 1977, habitat issues have been discussed as an integral and essential part of the development of all FMPs. The Council has, since the 1980s, included specific sections on the habitat and distribution of the species under management in its FMPs. For example, the Spiny Lobster FMP (1981) included an extensive description of the habitat area suitable for *Panulirus argus*, one of the most important species landed in the US Caribbean. Habitat conservation and management measures implemented by the Council to date, include actions that eliminate or minimize physical, chemical, or biological alterations of the substrate; loss of, or injury to, benthic organisms, prey species, their habitat; and impacts to other components of the ecosystem.

Throughout the early 1980s, the Council discussed and prepared documents such as the FMP for the Fishery Resources of the Puerto Rican and Virgin Islands Geological Platform (1983). At the same time, there were ongoing efforts to map each habitat type in the US Caribbean from the shoreline to the deepwater reefs in the EEZ.

In September 1983, the Council adopted a unanimous motion to cooperate in the habitat protection conservation policy being developed.

In 1984, the Generic FMP was developed to accommodate the view that the overall potential of the coralline plateaus should be considered instead of fish stocks as separate from habitat. The draft document entitled “The Ecological Basis of Fishery Yield of the Puerto Rico-Virgin Islands Insular Shelf” (Jacobsen and Browder) was prepared in 1987.

In June 1988, the Council adopted a new habitat policy and created three Habitat Panels to address the ecosystems of St. Croix, St. Thomas and St. John in the USVI and Puerto Rico. The Council began discussions on marine protected areas early in its inception and formed advisory panels to help with recommendations on this matter. These efforts resulted in the establishment of seasonal area closures in the EEZ and later on in the establishment of seasonal area closures shared between the State and the Federal governments.

The issues with habitat conservation were regularly discussed at the open meetings with the user groups, especially with the commercial fishers. The Council attempted to bring together the other agencies with interests in habitat issues to participate in the advisory panels. Significant cooperation has existed between the USFWS and the Council and a number of commercial fishers from both Puerto Rico and the USVI.

The Habitat Advisory Panel has recommended to the Council, among many other actions, seasonal area closures, the establishment of no-take areas, the restriction of destructive gears and the need to map and assess habitat in the US Caribbean. These recommendations, also reviewed by the Scientific and Statistical Committee and the Advisory Panel (composed primarily commercial and recreational fishers) resulted in the following FMPs, Amendments and Actions:

1. Reef Fish FMP Amendments (1990, 1993, 1996 Amendments) that resulted in 6 seasonal area closures;
(2) The Coral FMP (1994) that resulted in the total prohibition on the take of coral from the EEZ and thus resulted in full compatibility among the state and Federal waters;
(3) Prohibitions on the use of destructive gear to harvest spiny lobster and reef fish or reef associated invertebrates;
(4) The establishment of the no-take area southwest of St. Thomas (1999);
(5) The EFH Generic Amendment to all the FMPs (1998); and
(6) The completion of the mapping efforts of the shallow water benthic habitats of Puerto Rico and the USVI.

The most important result of the policy on habitat adopted by the Council is probably the establishment of the first no-take marine protected area in all of the US EEZ, known as the Marine Conservation District (MCD). The MCD is approximately sixteen square nautical miles, and located southwest of St. Thomas, USVI (Figure 2.23), in which all fishing has been prohibited since 1999. The MCD was established under Amendment 1 to the Coral FMP and has resulted in not only the protection of coral, one of the most important habitats for the reef fish species, but also in the protection of known grouper spawning aggregation sites, as well as large and diverse complex of reef species, shellfish and sharks.

The open policy of discussion maintained by the Council has resulted in numerous public meetings, orientation meetings, and workshops. The required scoping meetings and public hearings ensure full participation of user groups and enhance their understanding of the concept of no-take. This increases the potential level of compliance with the establishment of the MCD. The history of the development of the MCD is contained in Amendment 1 to the Coral FMP.

When it established the MCD, the Council requested from NOAA Fisheries the development of a Monitoring Plan for the no-take zone (Beets 1999). The Monitoring Plan identified research priorities to monitor and evaluate the impact of a total prohibition on fishing on habitat, fish stocks and users, and recommended mapping and characterizing the area within the MCD as a first priority.

The Council, in cooperation with NOS and many other partners, pioneered the mapping of benthic habitats and has produced the first complete set of shallow water (<30 m) habitats maps, classification and areal extent for Puerto Rico and the USVI. The maps are available at http://biogeo.nos.noaa.gov.

Recent efforts have resulted in near shore benthic habitat maps for the US Caribbean. These maps are the first available to cross reference with fish abundance data that are available for State waters (Generic EFH Amendment). The information will be available for the State governments to establish, for example, area closures for the protection of juvenile fish (including conch and spiny lobster in, for example, seagrass areas) or other area closures to protect spawning adults at times other than the peak spawning seasons.

These habitat maps are already being used to determine potential areas for the protection and conservation of important habitat, such as seagrass beds associated with clean sandy areas, which are essential habitat for juvenile queen conch, and other reef fish (e.g., Burke et al. 2002). The Council has discussed under the Amendment to the Queen Conch FMP (October 2001) the
following recommendation for the protection of queen conch habitat: (1) to establish no-take zones to protect areas of juvenile conch (near shore) and (2) to establish no-take zones in clean coral sand with low organic content, where queen conch lay egg masses. Furthermore, the Council has recommended that there be increased enforcement of the laws and regulations in place that protect marine habitats from sediment run off, contamination from raw sewage, illegal dumping, uncontrolled development, uncontrolled placement of pipes or cables, and from other activities that can adversely impact queen conch resources (e.g., EFH Generic Amendment 1998; Queen Conch Amendment 2 2001).

2.1.5.2.1 Mapping efforts

Habitat information has been obtained from a number of sources throughout the years. In 1983, the Council contracted for the first attempt at large scale mapping of the marine benthic habitats of Puerto Rico and the USVI. This original work was done using the satellite remote sensing technology available at the time. This initiative resulted in amendments to the Spiny Lobster and Reef Fish FMPs and allowed for quantification of benthic habitats and mangroves.

Significant information has also become available from agencies other than NOAA, such as the USGS (1980s, 1990s), EPA (1992) as well as from Universities and Research Centers. The EFH Generic Amendment (1998) included most of these references. Although attempts had been made to obtain benthic maps for the US Caribbean it was not until 1998 that efforts began to obtain these baseline maps. The NOS (Mark Monaco, NOS) and the Council collaborated with over seventeen other agencies, institutes, universities and individuals to prepare a large scale map of the benthic habitats of the US Caribbean (http://biogeo.nos.noaa.gov).

Among other concurrent efforts to obtain more detailed information, especially for those areas from which data other than presence or absence of species was available, included the efforts of SEAMAP-Caribbean. SEAMAP-Caribbean recently began mapping the benthic habitats of the sampling areas (i.e., West Coast of Puerto Rico and South Coast of St. John). SEAMAP-Caribbean, a fishery-independent program, has been continuously sampling for fish since 1989 and more recently for queen conch and spiny lobster. The data include identification of species, distribution and abundance as well as identification of reproductive activity of commercially important species. Through this Program the red hind spawning aggregation grounds have been identified and monitored. The details of the habitat will become available through the use of side scan sonar and deep-water video cameras in the near future.

The Council has collaborated with various agencies\(^1\), local and Federal, to work on EFH related projects such as:


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\(^1\)NOAA/NMFS, PR Department of Natural and Environmental Resources, USVI Department of Planning and Natural Resources, PR CZMP, USVI CZMP, NOS, UVI, UPR, Sea Grant Program, SEAMAP-Caribbean, US Department of Interior/FWS, US Geological Survey, US Corps of Engineers.
2. Side-scan sonar mapping of the Southwest coast of Puerto Rico (UPR).
3. SEAMAP-Caribbean side-scan sonar mapping of the SEAMAP areas (West Coast of Puerto Rico and south coast of St. John, USVI).
4. NOAA Fisheries’ study on the effect of trap fishing on habitat in coral reefs ecosystems (PR, USVI and Florida; Hill et al., ongoing).
5. Collection of economic data from commercial trap fishers (NOAA Fisheries).
6. Evaluation of marine reserves as management tools (movement patterns and spawning habitat of red hind grouper in no-take zone (Nemeth, ongoing, personal communication); queen conch (Hernandez, ongoing, personal communication).
7. Demographics (adult population, larval settlement) of red hind (Sabat et al., ongoing, personal communication).
8. Hydro acoustic biomass stock assessment surveys of fish spawning aggregation sites (PRDNER, NOAA Fisheries).
9. Monitoring of MCD no-take zone fish spawning aggregations and other seasonal areal closures (Nemeth).
11. SeaBED autonomous underwater vehicle for benthic imaging (UPR/WHOI)

These research projects will provide, in the near future, detailed information on habitat that will support the better characterization of EFH and HAPCs, specific locations of these habitats, information on the health of the habitats and provide basic knowledge for future research.

2.1.5.2.2 History of Council actions to protect habitat

In 1990, both the Spiny Lobster and the Reef Fish FMPs were amended to include “an extensive description of habitat” (Federal Register 56(80): 19008) of the stocks comprising the management units. These habitat sections identified habitats of particular concern (HPC), habitat threats, and habitat information needs. The priority was and has been the complete mapping of the marine habitats around Puerto Rico and the USVI. Emphasis has also been placed on the health status determination of the habitats mapped and EFH/HAPCs identified.

The harvest of spiny lobster was also restricted, in 1984 (Federal Register 49(249): 50049-50053), to non-destructive gear. The prohibited gears included the use of poisons, explosives, drugs or other chemicals to harvest lobster because of their obvious impact on coral reefs and other habitats. The Council banned the use of explosives, poisons and chemicals to prevent damage to coral reef habitat. Federal regulations in 50CFR 622.31(a), (b), and (e) prohibit use of explosives, toxic chemical and plants, and poisons and drugs. An explosive (except an explosive in a powerhead) may not be used to fish in the Caribbean EEZ. A vessel fishing in the EEZ for a species governed in this part, or a vessel for which a permit has been issued, may not have on board any dynamite or similar explosive substance. A toxic chemical may not be used or possessed in a coral area, and a chemical, plant, or plant-derived toxin may not be used to harvest a Caribbean coral reef resource in the Caribbean EEZ. A poison, drug, or other chemical may not be used to fish for Caribbean reef fish in the Caribbean EEZ.
The Council developed a Coral FMP (implemented in December 1995) that protected coral reef resources by prohibiting the harvest of coral (Federal regulations in 50 CFR 622.32 (b)(1)), prohibiting the possession or sale of stony corals, gorgonians, and live rock from the EEZ (622.45(a)(1)), and by prohibiting the use of chemicals, plant or plant-derived toxins or explosives to harvest reef associated species (Federal regulations in 50 CFR 622.31(a), (b), and (e)). However, a Federal permit may be issued to take or possess Caribbean prohibited coral as scientific research activity, exempted fishing, or exempted educational activity (622.4(a)(3)(iv)). Federal regulations in 50CFR 622.31(f) and (g) prohibit use of powerheads and power-assisted tools. A power-assisted tool may not be used in the Caribbean EEZ to take a Caribbean coral reef resource. A powerhead may not be used in the Caribbean EEZ to harvest Caribbean reef fish. The restrictions on the use of chemicals to collect reef-associated organisms specifically protect corals and coral reefs. Quinaldine, the most commonly used chemical to harvest live organisms from reefs is a coal tar derivative used in the manufacture of explosives and dyes. Quinaldine has been shown to damage coral. Restrictions on harvest and gear respond to the need to protect coral heads or reef habitat that would be overturned or destroyed during harvest. The Council banned the use of explosives, poisons and chemicals to prevent damage to coral reef habitat in 1984 (Federal Register 50(167): 34850-34855).

The first seasonal area closure (Table 2.10) to protect a spawning aggregation of the most commonly landed grouper in the US Caribbean, the red hind, *Epinephelus guttatus* was established by the Council in 1990. The area seasonally closed is known as the “Hind Bank” or grouper bank (Federal Register 55(213): 46214-46216). Spawning aggregations occurring at the same sites every year lend themselves to being managed through seasonal closures. These sites are not as productive or fished so intensively at other times of the year. These seasonal closures have two very important characteristics, the protection of the spawning population as well as the protection of the particular habitat used annually for spawning. These areas, fish spawning aggregation sites, are generally heavily fished with traps, hook and line, and by divers (spearfishing). The aggregations tend to occur over a small area and the fishing is carried out while at anchor when the aggregation is found. Establishing these seasonal area closure, with the adequate buffer zone, prevents fishers from deploying unusual amount of gear (traps), prevents anchoring (since the burden of proof is on the fisher to show that while at anchor in the closed area they were not fishing) in the habitat critical for spawning for a number of species in the fishery management unit (FMU). These efforts offer protection to the EFH of the reef fish resources of the US Caribbean and to the fish stocks therein. To date the red hind have apparently benefited from this closure, as monitoring and comments from the commercial fishers at public meetings have indicated that size and numbers of fish have increased. These results are also extended to the areas outside the no-take zone. Federal regulations in 50CFR 622.33 (a) and (b) establish seasonal and permanent area closures (Figure 2.26). Seasonal fishing closures include the mutton snapper spawning aggregation area, red hind spawning aggregation areas east of St. Croix, west of Puerto Rico at Bajo de Cico, Tourmaline Bank, and Abrir La Sierra Bank, and the entire EEZ to queen conch fishing during the spawning seasons. Amendment 1 to the Coral FMP (December 1999) established the first no-take zone (Marine Conservation District or MCD) in Federal waters (Figure 2.23), in the EEZ southwest of St. Thomas, USVI. A permanent fishing closure and prohibition of anchoring by fishing vessels occurs at the MCD.
In October 1993, Amendment 2 to the Reef Fish FMP restricted the collection of marine aquarium fishes to hand-held dip nets and slurp guns (50CFR622.41(b)); closed, to all fishing, two additional red hind spawning aggregation areas from December through February every year; and closed a spawning aggregation area, to all fishing, for mutton snapper (*Lutjanus analis*) from March through June each year in St. Croix, USVI.

In December 1996, a regulatory amendment to the Reef Fish FMP was implemented in accordance with framework procedures for adjusting management measures, that adjusted the boundary of the existing red hind spawning aggregation seasonal area closure in the EEZ off western Puerto Rico and added two red hind spawning aggregation seasonal area closures.

Amendments to the Reef Fish FMP also included trap/pot mesh size restrictions, requirement of degradable panels, and degradable fastening material for the trap/pot doors. These management measures indirectly contribute to the protection of habitat since the removal of juveniles and various adult species is prevented. By preventing removal of these species the changes in community structure are lessened and the impacts on habitat caused by, for example, the removal of herbivores decreases.

The 1998 EFH Generic Amendment was partially approved on March 29, 1999. This Generic FMP identified EFH and adverse impacts from fishing and non-fishing activities. The Council has been working with NOS and a number of other agencies and parties to prepare benthic habitat maps of the US Caribbean (http://biogeo.nos.noaa.gov/projects/mapping/caribbean) (see Section 2.1.5.2.1).

Fish are part of their habitat, and indirect protection has resulted from actions that restrict fishing effort, limit harvest of fish, limit harvest of small fish (that are allowed to grow or provide prey for other species), or improve administration of the fisheries.

- 622.6(b) requires marking of pots/traps. A fish trap or spiny lobster trap used or possessed in the Caribbean EEZ must display the official number specified for the vessel by Puerto Rico or the USVI so as to be easily identified. A buoy that is attached to a trap or pot must display the official number and assigned color code. An unmarked Caribbean spiny lobster trap or fish trap, or a buoy deployed in the EEZ where such trap, pot, or buoy is required to be marked is illegal and may be disposed of in any appropriate manner by the Assistant Administrator or an authorized officer.
- 622.32(b)(1) prohibits harvest of fish species. Foureye, banded, and longsnout butterflyfish; jewfish; Nassau grouper; and seahorses may not be harvested or possessed in or from the Caribbean EEZ. Egg-bearing spiny lobster in the Caribbean EEZ must be returned to the water unharmed.
- 622.37 sets minimum size limits for harvest of yellowtail snapper, spiny lobster, and queen conch. These species must be landed intact (622.38).
- 622.39(e) sets a bag limit for queen conch, except that a commercial trip limit for queen conch applies (622.44(e)).
- 622.40(a)(1) and (b)(1) prohibit unauthorized hauling of pots and traps and require escape panels for pots and traps.
2.1.5.3 Evaluation of fishing impacts on EFH

This EIS evaluates the relative risk of impacts to EFH resulting from fishing activities. This provides the basis for developing alternatives to prevent, mitigate, or minimize adverse effects of fishing on EFH. The evaluation occurs in several steps (Figure 2.37):

1. Prepare habitat maps and identify EFH;
2. Determine sensitivity of the EFH to fishing activity (sometimes referred to as the context of the impact);
3. Determine the extent of the fishing activity, preferably by geographic location (sometimes referred to as the intensity of the impact – this is fishing effort in this context); and
4. Combine sensitivity and extent of the fishing activity into a measure of fishing impacts to the EFH from, preferably by geographic location.
5. Using advice from local experts and professional judgment, develop alternatives that potentially reduce the probability of impacts and thereby prevent, mitigate, or minimize adverse effects of fishing on EFH.

The evaluation depicted in Figure 2.37 also goes beyond the stage at which the alternatives are developed and illustrates the types of considerations that comprise the analysis of environmental consequences and the practicability of the alternatives, particularly in the context of cumulative impacts (see Section 2.1.6.3).

Steps 1 and 2 in the list above were completed under the EFH and HAPC components of the EFH mandate respectively. Section 3.2 (Affected Environment) describes the species managed under the Caribbean FMPs, their known prey, and the habitat used by those species for the four ecological functions (spawning, breeding, feeding, and growth to maturity), to the degree known. As described in Section 2.1.3.3.3, mapping of habitat was limited to depths less than about 25 m, the maximum depth for visual identification of habitat from aerial photography. Beyond this depth, there was no information on habitat distribution. It was therefore decided to map the area of potential habitat occurrence, which was considered to extend from the most-shallow depth to the maximum depth on the shelf that a habitat could occur. The area of potential habitat occurrence was mapped out to the 100-fathom isobath (representing the shelf break). The maximum depth of seagrass distribution is considered to be 20 fathoms (Fonseca et al. 1992). All other habitats were considered to have a maximum depth of 100 fathoms. Because most species in the Caribbean Council FMUs and fishing for those species occur on or near the insular shelf, mapping out to this depth limit was considered likely to cover the habitats used by federally managed species.

The evaluation of the sensitivity of habitats to impacts from fishing resulted in a matrix of fishing gear sensitivity (Section 3.5.1.2.13). While these sensitivities are somewhat subjective in nature, they are essentially a function of two components: the sensitivity of the habitat to perturbation and the nature of the fishing impact. This sensitivity is independent of the actual
intensity of the impact to which the habitat is subject. This intensity is provided by data on fishing effort.

2.1.5.3.1 Fishing effort

The fisheries in the US Caribbean are multi-species, multi-gear, artisanal in nature, and principally coral reef-based (Sections 3.3, 3.5.1). Traps/pots, vertical line gear, and gill/trammel nets catch the majority of species in both state waters and the EEZ. Bottom longlines, hand harvest, spears, slurp guns, and dip nets are also used in state waters and the EEZ. Beach seines, powerheads, and cast nets are used only in state waters.

To show spatial contrast in the probability of impacts from fishing, it is necessary to have fishing effort data broken down by location on as fine a scale as possible. Ideally, spatial distribution of fishing effort would be available in a GIS-compatible format to allow effort maps to be overlaid on maps of habitat. The units of fishing effort should be expressed in terms that enable quantification of the amount of contact between the gear and the habitat, so that impacts of gears can be evaluated individually and cumulatively in absolute rather than relative terms. For example, if the threat to habitat arises from the action of a beach seine being hauled over the seagrass, then effort needs to be in terms of swept area (distance hauled x seine width). It is also important to know the distribution of hauls – i.e. for a given number of hauls, what overall seagrass area is impacted – because some hauls will likely cover the same area more than once; if the threat is from a pot landing on a substrate, then effort needs to be in terms of number of sets and the footprint of pots. In this case it would also be important to have information about movements of the pots over the substrate while they are deployed. This is likely to be closely linked to weather conditions – particularly wind, waves and water currents. In reality the units of effort are often on a very broad level, possibly as coarse as the presence/absence of fishing activity for some gears/areas.

Fishing effort data for fisheries in the US Caribbean are not sufficiently accurate to map spatial distribution (CFMC 2002). Some information is available on the number of fishing trips, but this is incomplete, has no spatial resolution and there is great uncertainty about the validity of the data due to missing gear codes and use of multiple gears on a single trip. According to the South East Fisheries Science Center, the data are currently being reviewed. It was therefore decided that these data should not be used for the purposes of estimating gear use on habitats in the US Caribbean at this time.

As a substitute, landings data from Puerto Rico were used to estimate relative use of gears among habitats. Total landings were calculated for all gears and averaged over the period 1998-2000 (Table 2.11). The average landings values were used to rank overall gear usage into three categories: high (3), moderate (2) and low (1). The landings data did not indicate the habitats on which each gear was used; however, some qualitative information was available on the general areas and habitats that fishers would target with each of the gears. This information was used to create a relative ranking of gear use by gear and habitat. A gear was given its maximum ranking on habitats where the gear is most commonly used and a lower rating on habitats where it is less commonly used. The maximum rank a gear could have on any habitat was the overall rank it was
given based on the average landings. For example, hand harvest ranked as a moderate landing total, while pots/traps ranked as a high landing total. Therefore, the rank for hand harvest used on the habitat on which it is most commonly used is 2, whereas the rank for traps and pots on which they are most commonly used is 3. Habitats on which these gears are less commonly used would be ranked 2 or 1 as appropriate. A “not used” category was created for habitats on which a particular gear was not used. In the case of pots/traps, hard bottom, algal plains, and sand/mud were the most commonly used habitats, while coral was moderately used. Therefore, hard bottom, algal plains, and sand/mud received a rank of three, and coral received a rank of 2. The overall rank therefore has potential rank scores of 0 (not used), 1 (low usage), 2 (moderate), and 3 (high). The actual value assigned to relative use for a gear/habitat combination was based on a best professional judgment on how commonly a gear is traditionally used in a particular habitat (Section 3.5.1.2). The distribution of gear use within a habitat type was assumed to be uniform, because no spatially explicit fishing effort distribution was available for mapping.

2.1.5.3.2 Fishing impact index

All fishing has an effect, to varying degrees, on the marine environment, and thus on its associated habitats. This is true even if one considers only the effects of removal of fish. The nature and magnitude of habitat effects depend greatly on the type and intensity of fishing activity and the physical and biological characteristics of the fished area.

The fishing impact index for habitat caused by fishing activity is a function of the habitat sensitivity and the fishing effort; these are the context and the intensity of the impacts respectively. Values from the index of sensitivity, which ranged from 0 to 3 (Section 3.5.1.2.13), were multiplied by their counterpart values from the fishing effort index, which also ranged from 0 to 3 (Section 3.5.1.2.13), to arrive at an index of the relative probability of fishing impacts (fishing impacts index) for each gear on each habitat. The potential range of the impacts index was from 0 (0x0=no adverse impacts) to 9 (3x3=highest possible adverse impacts). The values of this index were used to direct the development of alternatives for preventing, mitigating, or minimizing adverse effects of fishing. Essentially, gear/habitat combinations with a higher score were considered to be a higher priority for attention than those with lower scores. As required by the Final Rule, however, alternatives for Council consideration were developed for all fishing activities that adversely affect EFH in a manner that is more than minimal and not temporary (see Section 2.5).

2.1.5.3.3 Limitations of the analysis

One of the major aims in the analysis of data for the US Caribbean is to find ways to show contrast in the probability of impacts from one location to another. Demonstrating contrast enables managers to focus their attention on the areas most at risk and most in need of protection. This concept is central to the process of identifying EFH and HAPC. It applies equally to the identification of adverse impacts from fishing. However, major difficulties were encountered in achieving this aim because the level of information available, particularly on a geographic scale, was generally very low. This is demonstrated very clearly by the poor resolution in the fishing
effort data, which was a major constraint to the analysis. Fishing impacts on habitat could not be mapped due to a lack of spatial information on fishing effort, and lack of habitat distribution (below 25 m).

In many cases, the process for examining adverse fishing impacts uses information with a high degree of uncertainty. However, in the absence of estimates of that uncertainty, the calculations described in this section treated the available data deterministically. The calculations that develop sensitivity and effort indices, and then multiply these to calculate the probability of impacts, for example, propagate and compound unknown errors at each step.

This analysis has recognized the existence of uncertainty by grouping data and results of calculations into categories. Quartiles were used, for example for the sensitivity and fishing effort indices. These were selected to provide enough contrast among the categories for the analysis to be useful, but did not want to imply an unrealistic level of precision in the analysis. Whether this balance has been achieved is impossible to tell, because the true level of uncertainty is presently unknown. Ideally, additional development of this methodology would specifically deal with the uncertainty through development of stochastic procedures. It is possible, however, that the small contrast shown by the deterministic analysis would be lost if the true levels of uncertainty were represented. There would then be little basis at all for selecting one course of action over another when selecting alternatives.

2.1.5.4 Developing alternatives to prevent, mitigate, or minimize the adverse effects of fishing on EFH

2.1.5.4.1 The potential scope of Council action

The Council and NOAA Fisheries can directly implement regulations to modify actions only in federal waters, unless the Secretary of Commerce elects to use his authority to preempt state management. However, much of the habitat that potentially will be designated as EFH is in state waters. In order to extend actions that protect EFH into state waters, the Council will need to establish a cooperative arrangement with Puerto Rico and the USVI, or it can make strong recommendations to these States to address adverse impacts from fishing gears on EFH in their jurisdiction. Because many fishery resources occur in state waters, some fishery management programs have extended to the shoreline. However, not all regulations are fully consistent between federal and state waters.

The habitat types that potentially will be described and identified as EFH for one or more species managed by the four FMPs include:

- Seagrasses (marine and estuarine)
- Mangroves (marine and estuarine)
- Benthic algae (marine and estuarine)
- Reefs (marine)
- Sand/Shell bottoms (marine and estuarine)
- Soft bottoms (marine and estuarine)
• Hard bottoms (marine)
• Pelagic

2.1.5.4.2 More than minimal and not temporary

The EFH Final Rule (50 CFR 600.815(a)(2)(ii)) establishes a threshold for determining which fishing activities warrant analysis to prevent, mitigate, or minimize to the extent practicable the adverse effects of fishing on EFH:

“Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature, based on the evaluation conducted pursuant to paragraph (a)(2)(i) of this section and/or the cumulative impacts analysis conducted pursuant to paragraph (a)(5) of this section.”

As discussed in the preamble to the EFH Final Rule at 67 FR 2354, management action is warranted to regulate fishing activities that reduce the capacity of EFH to support managed species, not fishing activities that result in inconsequential changes to the habitat. The “minimal and temporary” standard in the regulations, therefore, is meant to help determine which fishing activities, individually and cumulatively, cause inconsequential effects to EFH.

In this context, temporary effects are those that are limited in duration and that allow the particular environment to recover without measurable impact. The following types of factors should be considered when determining if an impact is temporary:

• The duration of the impact;
• The frequency of the impact.

Minimal effects are those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions. Whether an impact is minimal will depend on a number of factors:

• The intensity of the impact at the specific site being affected;
• The spatial extent of the impact relative to the availability of the habitat type affected;
• The sensitivity/vulnerability of the habitat to the impact;
• The habitat functions that may be altered by the impact (e.g., shelter from predators)
• The timing of the impact relative to when the species or life stages need the habitat.

There has been some considerable debate regarding how to determine specifically whether a particular impact can be described as minimal and temporary. For some interactions it is likely to be quite obvious that the effects of fishing are negligible; for example, the effects of vertical gear on sand/shell bottoms (see Section 3.5.1.1). Similarly there are some interactions that are quite obviously not minimal and more than temporary; for example various kinds of traps on coral reefs (e.g. see Section 3.5.1.1). However, there are likely to be some impacts for which the determination is very difficult to make without considerable supporting data, which for the most
part are currently not available. The view is therefore taken in this EIS that any interactions that cause impacts which cannot be considered to be obviously minimal and temporary, based on existing knowledge of fishing gear sensitivities and fishing effort, will need to have alternatives developed for them.

The method for implementing this in practice was to use the fishing impacts index, calculated as described in Section 2.1.5.3. All gear/habitat interactions that had fishing impacts index scores in the lowest category (0) were considered to fall below the threshold of “minimal and temporary.” Alternatives were therefore not developed for these interactions. While gear/habitat interactions at higher levels may also fall below the minimal and temporary standard, available information does not allow determination at the higher levels, and alternatives were developed for interactions above the 0 category.

Of the fishing gears that are known to operate in Federal waters of the US Caribbean and have potential impacts on fish habitat that may be more than minimal and not temporary are indicated in the table below as having alternatives developed. Hand harvest scored higher than 0 for coral, but this score was based on direct harvest of coral. This designation for hand harvest did not apply to harvest of other species – reef fish, lobster and conch. Beach seines and cast nets have scores greater than zero in the fishing impacts index, but are used only in state waters. Trawls and powerheads have scores greater than zero in the fishing impacts index, but are currently prohibited in the EEZ by Council FMPs, but not for non-FMP fisheries. Trawling does not currently occur in the US Caribbean, but the potential exists for its use in the future. Recommendations for approaches to mitigating impacts caused by these gears are provided in Section 4.7 (Conservation Recommendations).

<table>
<thead>
<tr>
<th>Gear Type</th>
<th>Alternatives developed</th>
<th>Conservation recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAV</td>
<td>Coral Reef</td>
</tr>
<tr>
<td>Trawl</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trap/pot</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Gill/trammel</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hand harvest</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Beach seine</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Bottom longline</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vertical gear</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Powerheads</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spears</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Cast net</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

2.1.5.4.3 Possible Council actions

The impacts of fishing gears on fish habitat in the southeastern US and the US Caribbean have been described in Hamilton (2000) and Barnette (2001). In most cases, limited data preclude
definitive conclusions on the impacts of fishing gears on specific habitats in the Caribbean. However, these papers indicate the types of habitat most likely to suffer damage from each gear. Table 2.12 provides a list of possible actions the Council might take to protect the habitats most likely to be impacted by fishing.

This section describes a suite of gear modifications and gear prohibitions that can be developed to mitigate possible adverse impacts by a gear on a habitat. Many different actions are possible for each gear, and the possible actions presented below have a wide range of effectiveness. The alternatives to prevent, mitigate, or minimize fishing impacts were selected from among these possible actions for each gear to develop an effective strategy for each habitat. The discussion of alternatives presents justifications for selection of each measure. While these possible actions could be applied on habitat in any jurisdiction, the alternatives described in Sections 2.5.2-2.5.6 apply only to waters of the EEZ.

2.1.5.4.3.1 Trap/pot gear

The Council and NOAA Fisheries could select among the following possible actions to restrict trap/pot gear in EFH or HAPCs to minimize habitat damage during fishing activities.

- Restrict fish traps/pots to a single gear per buoy (prohibit trap lines).
- Require buoys on all traps/pots.
- Require vessels to transport all traps from the fishing ground to land-based storage at the completion of each fishing trip.
- Reduce fishing effort by some amount.
- Establish time or areal closure that restricts fishing activity by some amount.
- Prohibit fish traps/pots on coral, live/hard bottom, or SAV habitat.
- Prohibit fish traps/pots within a buffer zone around coral, live/hard bottom, or SAV habitat.
- Prohibit fish traps/pots in the Caribbean EEZ.

Discussion: Barnette (2001) identified fish traps as one of the fishing gears used in the Caribbean most likely to damage fish habitat, specifically coral and hard bottom with gorgonians and sponges, or SAV (Section 3.5.1). However, traps/pots are the only relatively well-studied Caribbean gear in terms of habitat impacts, and other less-studied gears may actually have the potential to do greater habitat damage (Lisa Marie Carrubba, NOAA, personal communication). The trap lines connecting traps and pots can cause damage by sweeping across fragile vertical coral and gorgonian structures, and from grappling for lost or un-buoyed traps/pots (Appeldoorn et al. 2000; Barnette 2001). Minimizing the use of trap lines could potentially reduce the damage. Transporting traps/pots to a land-based storage at the completion of a fishing trip would reduce loss from untended pots. However, few vessels can carry more than several traps/pots at a time.

A single trap/pot can cause damage to fragile vertical relief on reefs or live bottom. Repeated use of a pot and multiple pots will cause aggregated damage. The total amount of damage currently done by fish traps in the Caribbean is not known. Fish traps damage corals, gorgonians and sponges by direct physical impact. Traps sitting on SAV can cause seagrass mortality by shading.
and crushing after a period of time. Some fishers do not attach traps to buoys, and retrieve the traps by grappling (Appeldoorn et al. 2000; Barnette 2001), which can cause damage greater than that caused by trap impact alone. Lost traps also have a greater potential for habitat damage.

2.1.5.4.3.2 Gill and trammel nets

The Council and NOAA Fisheries could select among the following possible actions to restrict gill and trammel net gear in EFH or HAPCs to minimize habitat damage during fishing activities.

- Prohibit mechanical net haulers on coral habitat.
- Require setting and retrieving nets with SCUBA divers
- Prohibit setting and retrieving nets with SCUBA divers
- Reduce fishing effort by some amount.
- Establish time or area closure that restricts fishing activity by some amount.
- Prohibit bottom gill and trammel nets on coral habitat.
- Prohibit gill and trammel nets on coral habitat.
- Prohibit gill and trammel nets in the Caribbean EEZ.

Discussion: Barnette (2001) noted that available studies indicate that habitat degradation from gillnets/trammel nets is minor, except for potential impacts on coral reef communities. Bottom gillnets set over coral may cause negative impacts if any part of the net entangles with branching or foliaceous corals, which then break as the net is retrieved. Mechanical net haulers can increase the damage to corals. Gill/trammel net fishers may use SCUBA to set and retrieve the nets among coral structures, and drive the fish into the nets by making noise and disturbances. Damage to coral can occur if nets wrap around the coral or if fishers pound on the coral to make noise (Burke et al. 2002).

Lost nets will ghost fish for a period of time. Marine organisms may quickly cover the nets (Barnette 2001). The nets tend to roll up into balls and the biota that grow on the nets fill in meshes. On hard bottom and coral, the nets become incorporated into the reef. Barnette (2001) suggests that gillnets and trammel nets cause more problems with ghost fishing and entanglement of marine life than as a hazard to habitat.

2.1.5.4.3.3 Bottom longline gear

The Council and NOAA Fisheries could select among the following possible actions to restrict bottom longline gear in EFH or HAPCs to minimize habitat damage during fishing activities.

- Limit bottom longline gear on coral or hard/live bottom habitat to a shorter length than currently used.
- Limit bottom longline gear to a shorter length than currently used.
- Prohibit heavy groundlines for longline gear.
- Reduce fishing effort by various proportions from current level.
• Establish time or areal closure that restricts fishing activity by various proportions from current level.
• Prohibit longline gear on coral or hard/live bottom habitat.
• Prohibit bottom longline gear in the Caribbean EEZ.

**Discussion:** Barnette (2001) identified bottom longlines as one of the fishing gears used in the Caribbean most likely to damage fish habitat, specifically coral and hard bottom with gorgonians and sponges (See Section 3.5.1). Pelagic longlines are designed to fish in surface to mid-water depths, and do not interact with the bottom. Bottom longlines used in the Caribbean reef fish fishery typically are 700 feet long. A single unit of shorter length of longline will likely do less habitat damage during each set than a unit of longer length. Avoiding or reducing bottom longline effort on corals, gorgonians, or sponge habitat will minimize risk of habitat damage to these areas.

Barnette (2001) did not document any studies on longline damage to habitat in the Caribbean, and the amount of damage currently done by bottom longline gear in the Caribbean is not known. Barnette (2001) described habitat damage from the Alaskan bottom longline fishery for Pacific halibut. Halibut longline gear generally consists of 5/16-inch nylon or polyester rope as groundline with 3-4 foot long twine gangions (branch lines) spaced at 3-18 feet. To the degree that Caribbean longlines differ in construction from the Alaskan longlines, potential damage will also differ. The Alaskan marine ecosystem is much different from that in the Caribbean. While the specific damage assessments in Alaska would not apply directly to the Caribbean, the shearing action of the longlines under tension would have similar results on sensitive vertical structure.

2.1.5.4.3.4 **Vertical gear**

The Council and NOAA Fisheries could select among the following possible actions to restrict vertical gear in EFH or HAPCs to minimize habitat damage during fishing activities.

- Require use of circle hooks on all vertical gear.
- Require the use of buoys on anchor lines to retrieve anchors, so that retrieval would be straight up.
- Reduce fishing effort by some amount.
- Establish time or areal closure that restricts fishing activity by some amount.
- Prohibit anchoring while fishing with vertical gear on coral or live/hard bottom habitat.
- Prohibit vertical gear on coral or hard/live bottom habitat.
- Prohibit vertical gear in the Caribbean EEZ.

**Discussion:** Barnette (2001) notes that vertical gear (recreational or commercial) may damage hard-bottom habitats. Misplaced anchors or dragging anchors could impact hard bottom and associated coral and gorgonian biota. However, most commercial vertical gear fishing in the US Caribbean is drift fishing, as is most recreational vertical gear fishing for pelagic fishes (Lisa Marie Carrubba, NOAA, personal communication). Few studies have focused specifically on the potential affects of vertical gear to habitat, and the total amount of damage currently done by
vertical gear in the Caribbean is not known. While individual encounters by vertical gear generally would not cause major impacts, significant cumulative impacts may occur (see Section 3.5.1). Vertical gear fishers rely on finding concentrations of fish within the range of attraction of the few hooks on vertical gear. Concentrations of many managed fish species are higher on hard bottom areas than on sand or mud bottoms.

The Council and NOAA Fisheries have the authority to regulate anchoring of commercial or recreational fishing vessels in the EEZ, but not for other vessels. Negative impacts from vertical gear include entangled fishing lines and hooks that break, foul, or otherwise degrade coral and gorgonian habitat, and anchoring that damages coral and gorgonian habitats.

2.1.5.4.3.5 Spears

The following actions restrict spears in EFH or HAPCs to minimize habitat damage during fishing activities.

- Reduce fishing effort by some amount.
- Establish time or areal closure that restricts fishing activity by some amount.
- Prohibit the use of spears while fishing.
- Prohibit use of SCUBA while spear fishing.
- Prohibit spears on coral or hard/live bottom habitat.
- Prohibit spears in the Caribbean EEZ.

Discussion: Barnette (2001) notes that use of spears by divers (recreational or commercial) may result in coral breakage, but described the damage as generally minor (See Section 3.5.1). Potential negative impacts include broken coral, touching reefs, and re-suspended sediments, although few studies have focused on the potential affects of spears to habitat. Touching coral removes a protective coating, and makes the coral more susceptible to disease and infection. Impact of lines from the spear gun attached to the spear can cause additional damage. Sedimentation buildup can smother corals. These impacts can lead to susceptibility to coral diseases, infections or overgrowth of algae. Use of SCUBA while spear fishing allows divers to stay submerged longer, and to have a higher potential for adverse interactions with sensitive habitats. It should be noted, however, that touching and re-suspended sedimentation result from actions of divers that may occur in the absence of spears. In general, habitat damage from spear fishing is thought to be a greater problem among recreational spear fishers than commercial fishers (Lisa Marie Carrubba, NOAA, personal communication).

Spear fishing is a minor activity in terms of total effort and total harvest compared to vertical gear or longline gear. The amount of total damage caused by fishermen with spears in the Caribbean is not known. Spear fishers rely on finding concentrations of fish within the spearing range. Concentrations of many targeted fish species are higher on hard bottom areas with relief than on sand or mud bottoms.
2.1.5.4.4 Structure of the fishing impacts alternatives

The suite of possible management measures for gears and habitats in the previous section represents an impractical range of choices and potential mixtures of actions for analysis of consequences. Rather than develop each possible action as an alternative, this EIS presents alternatives that consist of a package of several possible management actions (see Section 2.5). The actions in each alternative are intended to offer logical groupings of measures to address impacts as a plausible scenario for the Council to consider. This range of alternative actions spans four concepts: no action, gear modifications, time/area management, and full prohibition of the activity causing the impact. These concepts are described in more detail in the table below. The alternatives arising from these concepts comprise specific actions to be implemented under FMPs that have been organized so that, in general, successive alternatives offer more severe restrictions. Each successive alternative tends to incorporate but add to the measures included in its predecessor (see Section 2.5).

The alternatives were constructed to provide a reasonable range within which to consider the consequences of plausible groupings of measures. This is not intended in any way to restrict the Council’s choices, but rather to enable them to make informed decisions. The Council is free to select a different grouping of measures. If this different grouping is close to one or other of the alternatives analyzed in this EIS then the likely consequences of the Council’s preferred grouping will be relatively easy to determine. If, however, the preferred grouping is very different in its structure then it will be necessary to take this alternative and consider its consequences as part of a separate analysis.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No action</td>
<td>As explained previously, no action alternatives are required by NEPA in part to provide a baseline for the consequences analysis, against which the consequences of all the other alternatives can be compared. Under this concept, no new measures for preventing, minimizing or mitigating adverse effects of fishing on EFH would be introduced. To adopt this concept as the fishing impacts alternative, the Council would have to show that existing management measures adequately minimize, mitigate, or prevent potential adverse fishing impacts for all gears in all FMPs, to the degree practicable using best available scientific information (see Section 2.5.1 for a more complete rationale for the Alternative).</td>
</tr>
<tr>
<td>Gear modifications</td>
<td>Under this concept, alternatives are developed for modifications to the design and/or use of specific fishing gears that have a high potential of preventing, minimizing, or mitigating the adverse fishing impacts they cause. Fishing gears to which coral habitat is sensitive are identified and several alternatives for gear modifications to reduce adverse impacts are proposed.</td>
</tr>
</tbody>
</table>
2.1.6 Evaluating the consequences of the alternatives

This section forms the scientific and analytic basis for the comparisons of alternatives for the EIS. It consolidates the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion includes the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. The effects of missing information in assessing the environmental consequences of the EFH alternatives are specifically discussed in Section 4.2.

This section of the EIS provides an analysis of potential environmental impacts that may result from the implementation of the NO ACTION ALTERNATIVE and the ALTERNATIVES, including the PREFERRED ALTERNATIVE, presented in Section 2.2 of this document. Elements such as climate, physiography, and geology are not generally affected by localized activities, although they are presented here as required. As described in Section 2 Essential Fish Habitat Alternatives, this section is presented as three main parts:

- 4.3 Consequences of alternatives to describe and identify EFH;
- 4.4 Consequences of alternatives for preventing, mitigating, or minimizing the adverse effects of fishing; and
4.5 Consequences of alternatives to define and establish HAPC.

Within each of these sections, the discussion is further broken down into physical, biological, human, and administrative environments.

2.1.6.1 EFH and HAPC Alternatives

The direct and indirect consequences of the EFH and HAPC alternatives were considered in the context of the physical, biological, human and administrative environments. The direct and indirect impacts of each alternative are discussed qualitatively and compared across alternatives in Sections 4.3 to 4.5.

Indirect impacts will occur due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal and state agency actions (both fishing and non-fishing actions) that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. If state actions do not require Federal involvement (e.g. Federal permits), the Council and NOAA Fisheries can still make recommendations to the states. However, the states are not required to respond to the recommendations under these circumstances.

Each alternative was qualitatively evaluated for likely effects on consultations and for likely effects on the process for developing management measures for addressing adverse fishing impacts.

2.1.6.2 Fishing impacts alternatives

The direct and indirect consequences of the fishing impacts alternatives were considered in the context of the physical, biological, human and administrative environments. The results are presented in Section 4 of the EIS. The specific methodologies employed in these analyses are described below.

2.1.6.2.1 Biological environment

The fishing impacts alternatives are intended to reduce the risk of adverse impacts to habitat that adversely impact the productivity of managed species. The consequences of the alternatives therefore need to be considered in the context of this risk. Below the methodology used to assess the risk for the purposes of this EIS is explained.

There are two elements to the assessment of risk. The first is the fishing impacts index, which was evaluated for the purposes of developing the fishing impacts alternatives (see Section 2.1.5.3). The second is the utility of the habitat for managed species. The utility of a piece of habitat is a measure of the potential ecological cost of losing that habitat. In the absence of any
other suitable metric for utility, the index of ecological importance of the piece of habitat (measured as the level of habitat use – see Section 2.1.4.2) was used².

The fishing impacts index and the utility index of habitat provide a mechanism to calculate the relative risk to fish production from the effects of fishing activity by habitat and gear. The utility index (the same as the ecological importance in this analysis) has a potential range of 1 to 4 (see Section 2.1.4.2). Multiplying this by the fishing impacts index results in a total possible range of 0 to 36 (4 x 9). This range was divided into quartiles (see Section 2.1.5.3.3):

- Category 1, from 27-36,
- Category 2, from 18-26
- Category 3, from 9-17
- Category 4, from 0-8

The results of this analysis are presented in Section 4.5. Category 1 comprises the upper quartile of the risk index. This level of risk suggests that the Council should consider regulatory, corrective action because these impacts may be limiting on fish production and the consequences of action for the biological environment (in terms of fish production) are likely to be good. In category 2, the risk is moderate to high, suggesting that regulatory action might produce benefits, but the case for action is less clear than in category 1. In category 3, the risk is considered to be low to moderate, which suggests that regulatory action will provide probably only small benefits for fish production. In category 4, the risk is at the lowest end of the range, indicating that regulatory action will provide minimal benefits for fish production.

2.1.6.2.2 Human environment

Previous Council FMPs and FMP amendments contained most of the information available for the human environment. Consultation with NOAA Fisheries Southeast Fisheries Science Center (Juan Agar) and scientific literature supplemented the information in the Council documents.

The limited socio-economic information precludes extensive analysis of the impacts of alternatives on fishers and fishing communities, and allows only qualitative discussions of these impacts.

2.1.6.2.3 Administrative environment

NOAA Fisheries, and especially the SERO, will have responsibility for implementing measures in this EIS. Consultation with Sustainable Fisheries, Habitat Protection, and Enforcement Divisions provided information for use in evaluating the Administrative Environment.

² It was originally planned to use the concept of habitat rarity in the calculation of utility. It was reasoned that the more rare a habitat is, the greater its utility value, because if a piece of habitat is both ecologically important, and also rare, then the risk of impacts that affect the productivity of managed species is higher, because an impact affecting a rare habitat is likely to affect a larger proportion of that habitat. Unfortunately, due to the lack of spatial information on the area and distribution of different habitat types, it was not possible to calculate rarity.
2.1.6.3 Cumulative effects

2.1.6.3.1 Cumulative effects of alternatives

"Cumulative effect" is the effect on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (CEQ regulations Sec. 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

To the extent feasible and practicable, FMPs should analyze how fishing and non-fishing activities influence habitat function on an ecosystem or watershed scale (§ 600.815 (a) (6) (i)). This analysis should describe the ecosystem or watershed; the dependence of the managed species on the ecosystem or watershed, especially EFH; and how fishing and non-fishing activities, individually or in combination, impact EFH and the managed species; and how the loss of EFH may affect the ecosystem. Section 4.6 addresses the cumulative and synergistic effects of multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts), and an assessment of the ecological risks resulting from the impact of those threats on the managed species' habitat. The effects of describing and identifying EFH and designating HAPC are primarily secondary, resulting from consultation and management of fishing gears. While Section 4.6 addresses these effects, the Section focuses on effects of addressing adverse fishing impacts to EFH, on effects of catch on fish productivity, and effects on anthropogenic non-fishing effects. For the purposes of this analysis, cumulative effects are impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions. Cumulative effects can result from individually minor, but collectively significant actions taking place over a period of time.

Approaches to assessment of cumulative threats to EFH will vary (NMFS 1998) depending on several factors, including:

- the types of habitats under consideration;
- characteristics of the ecosystem;
- the nature and extent of identified threats;
- the availability and quality of data; and
- available resources and expertise.

Information relating to the first three items is presented in Section 3, the affected environment. The last two items are addressed in Sections 2.1.3 to 2.1.5.
2.1.6.3.2 Evaluating non-fishing impacts

Evaluation of non-fishing impacts uses the procedures described above (Section 2.1.4.2). Available information allows only a qualitative assessment and a relative comparison of impacts. At this time, the qualitative nature of the non-fishing impacts does not allow mapping.

2.1.6.4 Practicability

The EFH provisions at 16 U.S.C. §§ 1853(a)(7) state that each FMP shall identify EFH and "minimize to the extent practicable adverse effects on such habitat caused by fishing...." In this context, "practicable" was interpreted to mean "reasonable and capable of being done in light of available technology and economic considerations." In other words, a gear modification is "practicable" if the technology is available and effective, and will not impose an unreasonable burden on the fishers.

The EFH regulations at 50 CFR 600.815(a)(2)(iii) provide guidance on evaluating the practicability of management measures:

“In determining whether it is practicable to minimize an adverse effect from fishing, Councils should consider the nature and extent of the adverse effect on EFH and the long and short-term costs and benefits of potential management measures to EFH, associated fisheries, and the nation, consistent with national standard 7. In determining whether management measures are practicable, Councils are not required to perform a formal cost/benefit analysis.”

In evaluating the practicability of the identified management measures, the EIS considered and informally compared the economic and ecological costs and benefits of those measures (Section 4.5, 4.6) in accordance with the EFH Final Rule (50 CFR 600.815(a)(2)(iii)). The socio-economic costs of management measures are difficult to determine but can be relatively estimated based on the given the costs of gear modifications and expected changes in allowable catch and effort. However, the ecological costs and benefits (of not taking or taking action) are substantially harder to evaluate. In essence, the benefits of specific actions to protect or restore habitat are not readily quantifiable in the same units as the socio-economic costs. Therefore making direct quantitative comparisons and giving specific quantified answers to questions of practicability is difficult because of the uncertainty in the direct effects of fishing gears on habitat function and the lack of information on the relationships between habitat function and the managed species productivity (see Section 2.1.3).

Identifying ecological value has been recognized and studied by several authors (e.g. Costanza et al. 1997) through attempts to estimate the value of various “ecosystem services,” including those provided by EFH. Such studies tend to agree that this ecosystem service valuation is difficult and fraught with uncertainties. It also seems likely that any estimates that are calculated will be minimum estimates at best, or more likely under estimates. Costanza et al. (1997), however, agree that quantification of the value of the ecosystem is a worthwhile objective, citing among other benefits, the value of such estimates in project appraisal, i.e. in the preparation of EISs such as this one. Quantitative information would allow summation of the various components of benefits in comparable units to the costs, leading to a determination of the net costs or benefits of
one alternative relative to another. This would provide one objective basis for the choice of preferred alternatives by the Council.

No quantification of the economic value of the fish habitat of the U.S. Caribbean has been undertaken and such an analysis is outside the scope of the EIS, for reasons of both available time and cost. Without quantified benefits to balance against the costs, decisions about practicability of one alternative relative to another become largely subjective. This does not necessarily mean that science is excluded from the process. Qualitative information may be scientific in nature. However, deciding on what is practicable and what is not will depend on how the components of costs and benefits are weighted. Without a detailed quantification of the trade-offs, it is difficult to develop a strictly scientific basis for how to weigh the information. Interpretation of the quantitative and qualitative information provided in this EIS will involve judgment by decision makers. This EIS presents the best available scientific information to resource managers to support informed decision making, to the extent that this is possible at this stage.

Modifying, restricting, or prohibiting the use of fishing gear will result in some incremental change to the environment from the current situation. Benefits may be considered as primarily biological, leading to environmental conditions that better support sustainability. If previously impacted fish productivity recovers, then higher catches in the future may lead to secondary economic benefits for the human environment in the long-term. However, the economic benefits for fishers that might arise from this are likely to be dissipated in an open access environment (e.g. Freeman 1993), such as that which exists in the U.S. Caribbean. In addition, continuing adverse impacts on habitat from non-fishing activities such as coastal development and pollution (Sections 3.5.2 and 4.3 to 4.6) may limit the scope of improvements in productivity that can be achieved by modifying fishing activity alone. The corollary of this is that in addition to direct biological costs of not taking action, there may be secondary, future economic costs for the human environment, arising from declines in productivity. Nevertheless, the primary, direct, short-term consequences of the alternatives for the human and administrative environments are likely to be in the form of economic costs. Costs for the human environment arise from the cost of modifying fishing gear, relocating fishing effort, or reduced catches, and costs for the administrative environment arise from the need for increased surveillance and enforcement.

The EIS used specific practicability factors relevant to EFH Final rule requirements to evaluate these concepts. The practicability factors used for the US Caribbean consist of the five items listed below.

<table>
<thead>
<tr>
<th>Practicability Factor</th>
<th>Relevance to 50 CFR 600.815(a)(2)(iii):</th>
<th>Description</th>
</tr>
</thead>
</table>
| Net economic change to fishers | • The long and short-term costs and benefits of potential management measures to:  
  • associated fisheries,  
  • the nation, | Changes in short-term and long-term economic conditions of fishers as a result of fishing impacts alternatives |
<p>| Effects on enforcement, management, and | • The long and short-term costs and benefits of potential management | Changes in requirements or effectiveness of enforcement, |</p>
<table>
<thead>
<tr>
<th>Practicability Factor</th>
<th>Relevance to 50 CFR 600.815(a)(2)(iii):</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>administration</td>
<td>measures to:</td>
<td>management, and administration as a result of fishing impacts alternatives</td>
</tr>
<tr>
<td></td>
<td>• associated fisheries,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• the nation,</td>
<td></td>
</tr>
<tr>
<td>Changes in EFH</td>
<td>• The nature and extent of the adverse effect on EFH and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The long and short-term costs and benefits of potential management measures to:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• EFH</td>
<td>Future improvement or degradation in the extent, quality and/or function of EFH resulting from fishing impacts alternatives</td>
</tr>
<tr>
<td>Population effects on</td>
<td>• The nature and extent of the adverse effect on EFH and</td>
<td></td>
</tr>
<tr>
<td>FMU species from</td>
<td>• The long and short-term costs and benefits of potential management measures to:</td>
<td></td>
</tr>
<tr>
<td>changes in EFH</td>
<td>• EFH,</td>
<td>Magnitude and direction of productivity changes resulting from changes in EFH</td>
</tr>
<tr>
<td></td>
<td>• associated fisheries</td>
<td></td>
</tr>
<tr>
<td>Ecosystem changes</td>
<td>• The long and short-term costs and benefits of potential management measures to:</td>
<td></td>
</tr>
<tr>
<td>from changes in EFH</td>
<td>• EFH,</td>
<td>Improvement or degradation of ecosystem function resulting from changes in EFH</td>
</tr>
<tr>
<td></td>
<td>• associated fisheries</td>
<td></td>
</tr>
</tbody>
</table>

These factors were chosen to help identify the costs and benefits to EFH, the fisheries, and the nation. The first factor addresses burdens on fishers, and the remaining four factors address technological availability and effectiveness. Section 2.5 contains a comparison of the practicability factors for each alternative, and the sections discussing consequences of the alternatives (Section 4.5) contain an analysis of the practicability of each alternative.

2.2 Preferred alternatives

These Preferred Alternatives are discussed further in Sections 2.3 (EFH), 2.4 (HAPC) and 2.5 (Fishing Impacts), and the consequences of these and other alternatives are evaluated in Sections 4.3 (EFH), 4.4 (HAPC), and 4.5 (Fishing Impacts).

2.2.1 EFH

Concept 6. Describe and identify EFH according to functional relationships between life history stages of Federally-managed species and Caribbean marine and estuarine habitats.

- Alternative 6. EFH for the spiny lobster fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by phyllosome larvae – (Figure 2.2) and seagrass, benthic algae, mangrove, coral, and live/hard bottom
Alternative 6. EFH for the queen conch fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.40), shown in the aggregate as Figure 2.39.

Alternative 6. EFH for the Reef Fish Fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and all substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.41), shown in the aggregate as Figure 2.39.

Alternative 6. EFH for the Coral Fishery in the US Caribbean consists of all waters from mean low water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and coral and hard bottom substrates from mean low water to 100 fathoms depth – used by other life stages – (Figure 2.42), shown in the aggregate as Figure 2.39.

2.2.2 HAPCs

Alternative 4. Designate HAPCs in the Reef Fish FMP as the following areas based on the occurrence of confirmed spawning locations.

Puerto Rico
- Tourmaline Bank/Buoy 8 (Figure 2.26) (50 CFR 622.33(a))
- Abrir La Sierra Bank/Buoy 6 (Figure 2.26) (50 CFR 622.33(a))
- Bajo de Sico (Figure 2.26) (50 CFR 622.33(a))
- Vieques – El Seco (Figure 2.27) (State waters)

St. Croix
- Mutton snapper spawning aggregation area (Figure 2.26) (50 CFR 622.33(a))
- East of St. Croix (Lang Bank) (Figure 2.26) (50 CFR 622.33(a))

St. Thomas
- Hind Bank MCD (Figure 2.26) (50 CFR 622.33(b))
- Gramanic Bank (Figure 2.26)

Alternative 7. Designate HAPC For the Reef Fish FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Reef Fish species.

Puerto Rico
- Hacienda la Esperanza, Maniti (Figure 2.31).
- Bajuras and Tiberones, Isabela (Figure 2.31)
- Cabezas de San Juan, Fajard (Figure 2.31).
- JOBANNERR, Jobos Bay (Figure 2.31).
- Bioluminescent Bays, Vieques (Figure 2.31).
- Boquerón State Forest (Figure 2.32).
- Pantano Cibuco, Vega Baja (Figure 2.31).
- Piñones State Forest (Figure 2.31).
- Río Espiritu Santo, Río Grande (Figure 2.31).
Seagrass beds of Culebra Island (9 sites designated as Resource Category 1 and two additional sites) (Figure 2.31).
Northwest Vieques seagrass west of Mosquito Pier, Vieques (Figure 2.33).
St. Thomas
Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries (Figure 2.34).
Saba Island/Perseverance Bay, including Flat Cay and Black Point Reef (Figure 2.34).
St. Croix
Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary (Figure 2.36).
Altona Lagoon (Figure 2.36)
Great Pond (Figure 2.36)
South Shore Industrial Area (Figure 2.36)
Sandy Point National Wildlife Refuge (Figure 2.36)

Alternative 8. Designate HAPC for the Coral FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Coral species
Puerto Rico
Luis Peña Channel, Culebra (Figure 2.31).
Mona/Monito (Figure 2.31).
La Parguera, Lajas (Figure 2.32).
Caja de Muertos, Ponce (Figure 2.32).
Tourmaline Reef (Figure 2.32).
Guánica State Forest (Figure 2.32).
Punta Petrona, Santa Isabel (Figure 2.31).
Ceiba State Forest (Figure 2.31).
La Cordillera, Fajardo (Figure 2.31).
Guayama Reefs (Figure 2.31).
Steps and Tres Palmas, Rincon (Figure 2.31).
Los Corchos Reef, Culebra (Figure 2.31)
Desecheo Reefs, Desecheo (Figure 2.31)
St. Croix
St. Croix Coral Reef Area of Particular Concern (APC), including the East End Marine Park (Figure 2.36).
Buck Island Reef National Monument (Figure 2.36)
South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36)
Frederiksted Reef System (Figure 2.36)
Cane Bay (Figure 2.36)
Green Cay Wildlife Refuge (Figure 2.36)

2.2.3 Preventing, mitigating or minimizing adverse effects of fishing on EFH

Alternative 3. Establish modifications to anchoring techniques; establish modifications to construction specifications for pots/traps; and close areas to certain recreational and commercial
fishing gears (i.e., pots/traps, gill/trammel nets, and bottom longlines) to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots
- Require at least one buoy at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank for these gears – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of gill/trammel nets coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of bottom longlines on coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Reef Fish FMPs

2.3 FMP alternatives for EFH

Applying the concepts identified in Sections 2.1.3.4 to individual FMPs results in specific alternatives for EFH. The Council may apply a different concept for each FMP, which would result in identifying different alternatives for the FMPs. The Council has the option of amending each FMP separately or developing a generic amendment to amend all FMPs at the same time. In either case, alternatives are identified for each FMP.

2.3.1 Spiny Lobster FMP

Designation of EFH has no direct environmental impact, but is likely to result in indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. Table 2.13a summarizes and compares the Spiny Lobster alternatives.

2.3.1.1 Alternative 1. (No Action-Roll Back) Do not describe and identify EFH in the US Caribbean for the spiny lobster FMP.

This alternative would violate the requirements of the M-S Act. Analysis of the No Action alternative is required by NEPA. Under the No Action alternative, no EFH would be described
and identified for the spiny lobster species. EFH considerations would be removed from the FMP. Loss or degradation of spiny lobster habitat may occur at a faster rate than under the action alternatives, because this alternative fails to make the link between habitat and productivity of managed species a more explicit component of the assessment and management process. The roll back of EFH would likely receive support from individuals and organizations that wish to simplify regulations and reduce the administrative burden of restrictions on modification of habitat. Conversely, those interests that supported development of the EFH provisions would oppose this action.

Consultations on development projects would occur as before the 1998 Generic EFH Amendment, and project proponents would not have to comply with the stricter requirements of the SFA that amended the M-S Act. Federal agencies may reduce costs compared to other alternatives as a result of conducting less extensive EFH consultations. Under Alternative 1, the Council and NOAA Fisheries would generically amend all FMPs together, or amend each FMP separately, to remove designation of EFH.

2.3.1.2 Alternative 2. (Status Quo) EFH for the spiny lobster fishery consists of areas where various life stages of the spiny lobster commonly occur.

This Alternative is based on EFH Concept 2, status quo. The Generic EFH Amendment listed habitat preferences for spiny lobster, but not for the other two lobster species in the Spiny Lobster FMP. Larvae are found in pelagic waters, and drift with the currents; lobster larvae drift into the US Caribbean EEZ from other jurisdictions (FAO/Western Central Atlantic Fishery Commission 2001). Pelagic waters from Mean High Water to the EEZ make up the EFH for larvae of the spiny lobster. EFH for juvenile spiny lobster occurs in mangrove, seagrass, algae, sand/shell, reef, and hard bottom habitats. EFH for adults occurs on seagrass, benthic algae, reef, and hard bottom habitats, and EFH for spawning adults occurs on reefs. The Generic EFH Amendment described but did not map spiny lobster EFH.

While the spiny lobster EFH will likely apply to the other lobsters, the Generic Amendment does not justify extending EFH of indicator species to all other species. However, these distinctions will have no direct impacts. The widespread EFH also allows addressing adverse fishing impacts on EFH on a wide scale. Consultation for non-fishing impacts would be limited to the EFH identified for spiny lobster, and would not explicitly consider EFH for the other species.

This Alternative would likely generate nearly an opposite response from Alternative 1, receiving support from those interests wishing to require the widest possible requirements for consultations, and opposition from those objecting to restrictions on modification of habitat. The lack of EFH designation for non-indicator species and the lack of maps have an indirect impact on consultations by providing less information with which to justify NOAA Fisheries recommendations (Section 4.3). The expansive EFH throughout the EEZ provides indirect impacts as the maximum extent on which NOAA Fisheries could implement management measures to address adverse fishing impacts on EFH.
Federal agencies will incur costs as a result of conducting EFH consultations, since time and resources will be required to develop EFH Assessments, exchange correspondence, and engage in other coordination activities required for effective interagency consultation, but will not add additional costs to the current situation. Alternative 2 will not require an amendment to the FMPs.

[Alternatives 3-4 were not developed because the Council considered and rejected the corresponding concepts from further analysis. See Section 2.6]

[Alternative 5 was not developed for the Spiny Lobster FMP because no density distribution data were available for lobster species and life stages. See Section 2.6]

2.3.1.3 Alternative 6. (Preferred Alternative) EFH for the spiny lobster fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by phyllosome larvae – (Figure 2.2) and seagrass, benthic algae, mangrove, coral, and live/hard bottom substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.38), shown in the aggregate as Figure 2.39

This Alternative is based on EFH Concept 6, functional relationships of species life stages and habitats. Table 2.5 summarizes the information currently available for habitats used by each life history stage of the lobster species in the FMP, and Appendix 1 presents the functional utilization of the habitats by the life stages of each species. Less is known about the other species than about the spiny lobster, but available information is included in the table and Appendix 1. Maps of each habitat provide specific distributions from aerial photography and generalized distribution based on potential occurrence within depth limits. The boundaries of the distributions for the habitats used by the lobster species and life stages are poorly known for most of the habitats. The known distributions of habitats are plotted in Figures 2.5 to 2.15. To maintain a risk-averse approach, potential habitat is added to known habitats in Figures 2.16 to 2.21.

The combination of Table 2.5, Appendix 1, and Figures 2.5 to 2.21 describes and identifies EFH for the individual lobster species and life stages, where such information is available or can be inferred. EFH for the pelagic phyllosome larval life stage is the waters of the EEZ and state waters (Figure 2.2). The pueruli post larval and subsequent life stages live on benthic habitat, within the insular shelf. EFH for species and life stages that use mangroves (Table 2.8) is bounded by the mean high water lines and limited to areas around the shoreline and cays, and shown in Figures 2.5 to 2.15. EFH for species and life stages that use seagrass (Table 2.8) is limited to water depths less than 20 fathoms, and is shown in Figure 2.19. EFH for species and life stages that use coral (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.16. EFH for species and life stages that use live/hard bottom (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.17. EFH for species and life stages that use benthic algae (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.20. EFH for species and life stages that use sand/shell (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.21. The composite of the benthic habitats described above comprises the non-larval component of EFH for the Spiny Lobster FMPs.
(Figure 2.38), which encompasses a much smaller and more defined area than the area used by
the phyllosome larval stage.

Because no information was available with which to distinguish habitat utilization by species or
life stages in one region of the US Caribbean from another and because the larval life stage uses
all habitats, EFH for all species and life stages of lobster is described, consistent with the EFH
Final Rule, as the area bounded by mean high water and the outer boundary of the EEZ. The
composite of these areas (Figure 2.39) makes up the EFH for the spiny lobster fishery.

Alternative 6 describes and identifies EFH for lobster species not included in the Generic
Amendment. However, the composite distribution of EFH in Alternative 6 will not change from
Alternative 2 because the information known about the other lobster species will add no new
habitat for the composite. However, this Alternative uses all available information for all life
stages of the lobster species, making it the most appropriate Alternative from the standpoint of
linking spiny lobster ecological functions to habitats. In addition, this Alternative provides maps
of spiny lobster EFH.

Alternative 6 leads to the same composite EFH as results from Alternative 2. However,
Alternative 6 describes and identifies EFH for more species and life stages than identified by
Alternative 2, and relates the functional relationship of species/life stages to the habitats.

While the indirect impacts of EFH are expected to benefit managed species, the indirect impacts
may also benefit protected species.

The economic consequences are likely to be very similar to those of the alternatives in
Alternative 2, because the composite extent of EFH is similar in both cases. The widespread
EFH of Alternative 6 provides an opportunity for consultation and NOAA Fisheries
recommendations for nearly all Federal-agency projects in the US Caribbean. However, the
justification for EFH is greater in Concept 6 because it involves more species and life stages, and
provides maps of EFH, maps of habitat distribution, and tables of habitat use for all species and
life stages with available information. This will have an indirect impact on consultations by
providing more information with which to justify NOAA Fisheries recommendations (Section
4.3). Indirect impacts on adverse fishing measures will be similar to those of Alternative 2. The
level of controversy is likely to be similar to Alternative 2 because of the similar extent of EFH.

Federal agencies will incur additional costs compared to other alternatives as a result of
conducting EFH consultations, since time and resources will be required to develop EFH
Assessments, exchange correspondence, and engage in other coordination activities required for
effective interagency consultation. Alternative 6 will require a generic amendment to all of the
FMPs or amendment to each FMP separately.

[Alternative 7 was not developed because the concept was considered and rejected from further
analysis. See Section 2.6]
2.3.1.4 Alternative 8. EFH for spiny lobster consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.44)

This Alternative is based on EFH Concept 8, HSM. The habitat use predicted by HSM for spiny lobster is shown in Appendix 2. This distribution of potential habitats is less than for Alternatives 2 and 6, does not specify life stage, and includes only the area around St. John. Spiny lobster EFH for Alternative 8 consists of a discontinuous band in water depths less than 25 m around the island of St. John. It does not include other lobster species, other areas of the US Caribbean, or deeper waters that lobster are known to inhabit.

Alternative 8 will have no direct impacts. No indirect impacts will occur as a result of addressing adverse fishing impacts because EFH does not extend into the EEZ. Consultations for non-fishing impacts would encompass a smaller area of EFH than for Alternatives 2 or 6, as EFH extends discontinuously around St. John at depths less than 25 m. As a result, individuals and organizations with interests in comprehensive identification of EFH will likely find this Concept inadequate, while those wishing to restrict EFH will likely prefer it to Alternatives 2 or 6. This Concept may result in a level of controversy intermediate between Concept 1 and Concepts 2 and 6.

2.3.2 Queen Conch FMP

Designation of EFH has no direct environmental impact, but is likely to result in indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. Table 2.13b summarizes and compares the Queen Conch alternatives.

2.3.2.1 Alternative 1. (No Action – roll back) Do not describe and identify EFH in the US Caribbean for the queen conch FMP.

This alternative would violate the requirements of the M-S Act. Analysis of the No Action alternative is required by NEPA. Under the No Action alternative, no EFH would be described and identified EFH for queen conch. The no action alternative for the Queen Conch FMP would have consequences similar to those of Alternative 1 of the Spiny Lobster FMP.

2.3.2.2 Alternative 2. (Status Quo) EFH for the queen conch fishery consists of areas where various life stages of the queen conch commonly occur.

This Alternative is based on EFH Concept 2, status quo. The Generic EFH Amendment listed habitat preferences for queen conch, but not for the other conch species in the Queen Conch FMP. EFH for queen conch eggs occur on seagrass, algal plain, and sand habitats. Larvae occur in pelagic waters, and drift with the currents. Pelagic waters from Mean High Water to the EEZ make up the EFH for larvae of the queen conch. Juvenile queen conch EFH occurs in seagrass
and sand/shell habitats. Adult EFH occurs on seagrass, benthic algae, reef, sand, and hard bottom habitats. EFH for spawning adults occurs on seagrass, benthic algae, and sand habitats. The Generic EFH Amendment described but did not map queen conch EFH.

The status quo alternative for the Queen Conch FMP would have consequences similar to those of Alternative 2 of the Spiny Lobster FMP (Section 2.3.1.2).

[Alternatives 3-4 were not developed because the concepts were considered and eliminated from further analysis. See Section 2.6]

[Alternative 5 was not developed for the Queen Conch FMP because no density distribution data were available for conch species and life stages. See Section 2.6]

2.3.2.3 Alternative 6. (Preferred Alternative) EFH for the queen conch fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.40), shown in the aggregate as Figure 2.39

This Alternative is based on EFH Concept 6, the functional relationship of species life stages and habitats. Table 2.6 presents the information currently available for habitats used by each life history stage of the conch species in the FMP, and Appendix 1 presents the functional utilization of the habitats by the life stages of each species, where such information is available or can be inferred. Less is known about the other species included in the FMP than about the queen conch, but available information is included in the table. Maps of each habitat provide specific distributions from aerial photography and generalized distribution based on potential occurrence within depth limits.

The combination of Table 2.6, Appendix 1, Table 2.2, and Figures 2.5 to 2.21 describes and identifies EFH for life stages of the conch species. EFH for pelagic larval life stages is the waters of the EEZ (Figure 2.2). EFH for species and life stages that use seagrass (Table 2.8) is limited to water depths less than 20 fathoms, and is shown in Figure 2.19. Subsequent life stages live on benthic habitat, within the insular shelf. EFH for species and life stages that use coral (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.16. EFH for species and life stages that use live/hard bottom (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.17. EFH for species and life stages that use benthic algae (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.20. EFH for species and life stages that use sand/shell (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.21. The composite of the benthic habitats described above comprises the non-larval component of EFH for the Queen Conch FMP (Figure 2.40), which encompasses a much smaller and more defined area than the area used by the larval stage.

Because no information was available with which to distinguish habitat utilization by species or life stages in one region of the US Caribbean from another and because life stages use all habitats, EFH for all species and life stages of conch is described, consistent with the EFH Final
Rule, as the area bounded by mean high water and the outer boundary of the EEZ. The composite of these areas (Figure 2.39) makes up the EFH for the queen conch fishery.

Alternative 6 describes and identifies EFH for conch species not included in the Generic Amendment. However, the composite distribution of EFH in Alternative 6 will not change from Alternative 2 because the information known about the other conch species will add no new habitat for the composite.

Alternative 6 for the Queen Conch FMP would have consequences similar to those of Alternative 6 of the Spiny Lobster FMP (Section 2.3.1.3).

[Alternative 7 was not developed because the concept was considered and eliminated from further analysis. See Section 2.6]

2.3.2.4 Alternative 8. EFH for the queen conch consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.45)

This Alternative is based on EFH Concept 8, HSM. The habitat use predicted by HSM for queen conch is shown in Figure 2.45 and Appendix 2. This distribution of potential habitats is less than for Alternatives 2 and 6, and includes only the area around St. John. The HSM does not distinguish among the life stages of conch. Conch EFH consists of a discontinuous band in water depths less than 25 m around the island of St. John. It does not include other conch species, other areas of the US Caribbean, or deeper waters that conchs are known to inhabit.

Alternative 4 for the Queen Conch FMP would have consequences similar to those of Alternative 4 of the Spiny Lobster FMP.

2.3.3 Reef Fish FMP

Designation of EFH has no direct environmental impact, but is likely to result in indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. Table 2.13c summarizes and compares the Reef Fish alternatives.

2.3.3.1 Alternative 1. (No Action-Roll Back) Do not describe and identify EFH in the US Caribbean for the reef fish FMP.

This alternative would violate the requirements of the M-S Act. Analysis of the No Action alternative is required by NEPA. Under the No Action alternative, no EFH would be described and identified for reef fish.
The no action alternative for the Reef Fish FMP would have consequences similar to those of Alternative 1 of the Spiny Lobster FMP.

2.3.3.2 Alternative 2. (Status Quo) EFH for the reef fish fishery consists of areas where various species and life stages of reef fish commonly occur.

This Alternative is based on EFH Concept 2, status quo. The Generic EFH Amendment listed habitat preferences for 13 reef fish species, but not for the other reef fish species in the Reef Fish FMP. At least one species life stage of these 13 representative species uses at least part of the Caribbean fish habitats. Cumulatively, species-life stage habitat use by the selected species (from the Generic EFH Amendment) corresponds to all pelagic waters and benthic habitats in the US Caribbean. The Generic EFH Amendment described but did not map reef fish EFH.

The status quo alternative for the Reef Fish FMP would have consequences similar to those of Alternative 2 of the Spiny Lobster FMP (Section 2.3.1.2).

[Alternatives 3-4 were not developed because the concepts were considered and rejected from further analysis. See Section 2.6]

[Alternative 5 was not developed for the Reef Fish FMP because no density distribution data were available for reef fish species and life stages. See Section 2.6]

2.3.3.3 Alternative 6. (Preferred Alternative) EFH for the Reef Fish Fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and all substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.41), shown in the aggregate as Figure 2.39

This Alternative is based on EFH Concept 6, the functional relationship of species life stages and habitats. Table 2.7 presents the information currently available for habitats used by each life history stage of the reef fish species in the FMP, and Appendix 1 presents the functional utilization of the habitats by the life stages of each species, where such information is available or can be inferred. Maps of each habitat provide specific distributions from aerial photography and generalized distribution based on potential occurrence within depth limits.

The combination of Table 2.7, Appendix 1, and Figures 2.5 to 2.21 describes and identifies EFH for the reef fish species. EFH for pelagic egg and larval life stages is the waters of the EEZ (Figure 2.2). Subsequent life stages live on benthic habitat, within the insular shelf. EFH for species and life stages that use mangroves (Table 2.8) is limited to areas around the shoreline, and shown in Figures 2.5 to 2.15. EFH for species and life stages that use seagrass (Table 2.8) is limited to water depths less than 20 fathoms, and is shown in Figure 2.19. EFH for species and life stages that use coral (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.16. EFH for species and life stages that use live/hard bottom (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.17.
life stages that use benthic algae (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.20. EFH for species and life stages that use soft bottom (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.18. EFH for species and life stages that use sand/shell (Table 2.8) is limited to water depths less than 100 fathoms, and is shown in Figure 2.21. The composite of the benthic habitats described above comprises the non-egg and -larval component of EFH for the Reef Fish FMP (Figure 2.41), which encompasses a much smaller and more defined area than the area used by the egg and larval stages.

Because no information was available with which to distinguish habitat utilization by species or life stages in one region of the US Caribbean from another and because life stages use all habitats, EFH for all species and life stages of reef fish is described, consistent with the EFH Final Rule, as the area bounded by mean high water and the outer boundary of the EEZ. The composite of these areas (Figure 2.39) makes up the EFH for the reef fish fishery.

Alternative 6 describes and identifies EFH for many reef fish species not included in the Generic Amendment. However, the composite distribution of EFH in Alternative 6 will not change from Alternative 2 because the information known about the other reef fish species will add no new habitat for the composite.

Alternative 6 for the Reef Fish FMP would have consequences similar to those of Alternative 6 of the Spiny Lobster FMP (Section 2.3.1.3).

[Alternative 7 was not developed because the concept was considered and rejected from further analysis. See section 2.6]

2.3.3.4 Alternative 8. EFH for the reef fish consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.46).

This Alternative is based on EFH Concept 8, HSM. The habitat use predicted by HSM for squirrelfish, coney, red hind, Nassau grouper, sand tilefish, mutton snapper, schoolmaster, gray snapper, silk snapper, yellowtail snapper, white grunt, banded butterfly fish, and queen triggerfish is shown in Appendix 2. This distribution of potential habitats is less than for Alternatives 2 and 6, and includes only the area around St. John. The HSM does not distinguish among the life stages of the reef fish species. The gray snapper predicted distribution represents a composite for the 13 HSM species (Appendix 2). EFH for reef fish species consists of a discontinuous band in water depths less than 25 m around the island of St. John (Figure 2.46). It does not include other reef fish species, other areas of the US Caribbean, or deeper waters that reef fish are known to inhabit.

Alternative 8 for the Reef Fish FMP would have consequences similar to those of Alternative 8 of the Spiny Lobster FMP.
2.3.4 Coral FMP

Designation of EFH has no direct environmental impact, but is likely to result in indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. Table 2.13d summarizes and compares the Coral alternatives.

2.3.4.1 Alternative 1. (No Action-Roll Back) Do not describe and identify EFH in the US Caribbean for the coral FMP

This alternative would violate the requirements of the M-S Act. Analysis of the No Action alternative is required by NEPA. Under the No Action alternative, no EFH would be described and identified EFH for corals.

The no action alternative for the Coral FMP would have consequences similar to those of Alternative 1 of the Spiny Lobster FMP (Section 2.3.1.1).

2.3.4.2 Alternative 2. (Status Quo) EFH for the coral fishery consists of areas where various life stages of the coral commonly occur.

This Alternative is based on EFH Concept 2, status quo. Coral species and life stages use coral and hard bottom habitat in the depth range from mean low water to the 100-fathom contour. Larvae drift throughout the EEZ. While each coral species will have specific requirements for depth, light, current, etc., data do not provide the detail for mapping species distributions. The Generic EFH Amendment described but did not map coral EFH.

The status quo alternative for the Coral FMP would have consequences similar to those of Alternative 1 of the Spiny Lobster FMP.

[Alternatives 3-4 were not developed because the concepts were considered and rejected from further analysis. See Section 2.6]

[Alternative 5 was not developed for the Coral FMP because no density distribution data were available for coral species and life stages. See Section 2.6]
2.3.4.3 Alternative 6. (Preferred Alternative) EFH for the Coral Fishery in the US Caribbean consists of all waters from mean low water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and coral and hard bottom substrates from mean low water to 100 fathoms depth – used by other life stages – (Figure 2.42), shown in the aggregate as Figure 2.39

This Alternative is based on EFH Concept 6, the functional relationship of species life stages and habitat. Hard and soft coral larvae (plannulae) drift in pelagic waters for several days to weeks, and could use the entire EEZ and state waters (Figure 2.2). Larvae settle on coral (Figure 2.16) and hard bottoms (Figure 2.17). While corals spawn regularly on a seasonal basis, colonies of juvenile hard corals are rare. Adult coral is its own habitat (Figure 2.16). Adult soft corals live on hard bottom (Figure 2.17). The distribution of adult hard coral is the same as for Alternative 4 (considered and rejected), but Alternative 6 adds soft corals and larval and juvenile stages of both hard and soft corals. The composite of the benthic habitats described above comprises the non-larval component of EFH for the Coral FMP (Figure 2.42), which encompasses a much smaller and more defined area than the area used by the plannulae larval stage.

EFH for species and life stages of coral is the coral habitat, which may extend from the shoreline to less than 100 fathoms depth (Figure 2.16). EFH for larval coral is coral (Figure 2.16) and bare hard bottom (Figure 2.17) and pelagic waters.

Because no information was available with which to distinguish habitat utilization by species or life stages in one region of the US Caribbean from another and because the larval life stage uses the pelagic habitat, EFH for all species and life stages of coral is described, consistent with the EFH Final Rule, as the area bounded by mean low water and the outer boundary of the EEZ (Figure 2.39). The composite distribution of EFH in Alternative 6 will not change from Alternative 2 because the information known about the other coral species will add no new habitat for the composite.

Alternative 6 for the Coral FMP would have consequences similar to those of Alternative 4 of the Spiny Lobster FMP.

[Alternative 7 was not developed because the concept was considered and rejected from further analysis. See section 2.6]

[Alternative 8 was not developed for the Coral FMP because no HSM modeling was done for coral.]

2.4 Alternatives to designate HAPC

The alternatives presented for HAPCs are not mutually exclusive, and the Council could choose one or more of them as means of designating HAPCs (Table 2.14). The Council did not designate HAPC by FMP in the Generic EFH Amendment. The Council has the option of amending each FMP separately or developing a generic amendment to amend all FMPs at the same time.
2.4.1 Alternative 1: (No Action-Roll Back) Do not identify any HAPCs

NOAA Fisheries regulations encourage but do not require designation of HAPCs. The No Action Alternatives would roll back the Council’s designation of HAPC from the 1998 Generic Amendment. This alternative is the ‘no-action’ alternative as required by NEPA. The existing status-quo designations (see Alternative 2 from the Generic Amendment) should not pre-suppose any changes to HAPC designation the Councils may wish to take as a result of analysis in this EIS. Therefore, it is necessary to consider alternatives that do not result in any HAPC designations. Under the No Action alternatives, no HAPC can be mapped.

Note that if any of the EFH Concepts 2, 4, or 8 is chosen, the Council could still decide not to designate HAPCs and, if so, the impacts of this Alternative (i.e. of not identifying additional HAPCs) would be the same as for those Alternatives. Even if the Council chooses not to identify or establish HAPCs, it could establish HAPCs subsequently through an FMP amendment. Under EFH Concept 8, EFH would be limited to waters of approximately 25 m depth around St. John, and could not extend into the EEZ.

Prior to the EFH Generic Amendment, the Council had designated the Hind Bank (under Amendment 1 to the Coral FMP), an area southwest of St. Thomas, as an HAPC due to its importance for red hind spawning. Under this Alternative, the Council would not identify additional HAPCs. Under Alternative 1, no heightened conservation focus would occur based on importance of the ecological function, extent of habitat sensitivity, stress from development activities, or habitat rarity.

Consultations on development projects would occur as before the 1998 Generic EFH Amendment, but project proponents and NOAA Fisheries would not have additional conservation focus on specific areas. Federal agencies will reduce costs compared to other alternatives as a result of conducting less extensive EFH consultations. Under Alternative 1, the Council and NOAA Fisheries would generically amend all FMPs together, or amend each FMP separately, to remove designation of HAPC.

2.4.2 Alternative 2: (Status Quo) Designate HAPC as nearshore reefs, nearshore hard bottom, and estuaries.

This Alternative contains no new action and is, therefore, the status quo Alternative. In the 1998 Generic Amendment, the Council identified general types of HAPCs and specific HAPCs based on the four criteria outlined in Section 2.1.4. General HAPCs that were identified include:

1. All Puerto Rico and USVI estuaries;
2. All near shore reefs and hard bottom; and
3. Hind Bank
The Council generically identified Puerto Rico and the USVI estuaries as HAPCs because of their importance to many fishery species, particularly as nursery grounds. The Council generically identified near shore reefs and other hard bottom areas as HAPCs because of their fishery value. The Council had previously identified the area southwest of St. Thomas USVI, an area known as the “Hind Bank,” as an HAPC. Amendment 1 to the Coral FMP established a no-take marine conservation district in this area. The area was already seasonally closed to protect the red hind spawning aggregation. The year-round closure is intended to protect corals and associated flora and fauna.

The 1998 Generic Amendment did not map the HAPCs. Puerto Rico and USVI estuaries are mapped in Figures 2.24 and 2.25, and nearshore reefs and hard bottom are mapped on Figures 2.16 and 2.17. The Hind Bank is mapped on Figure 2.23.

This Alternative would not identify or establish additional HAPCs at this time. While HAPCs are not required, they are highly recommended. With this in mind, however, the identified general HAPC designations for all estuaries and reefs and hard bottom appear to be much broader than the intent of the EFH Final Rule that encourage more discreet use of HAPCs as a tool to single out priority areas for conservation and management. NOAA Fisheries is encouraging that HAPCs should be very specific sites.

2.4.3 Alternative 3: Describe and identify HAPC as all habitat areas obligatory to a species life history (considered and rejected).

This Alternative was considered and rejected because no information is available to determine or map obligatory areas (i.e. areas that a species must inhabit and utilize to complete its life cycle). Obligatory areas are included in the rationale for selection of specific sites recommended in Alternatives 7 and 8. See Section 2.6.

2.4.4 Alternative 4: (Preferred Alternative) Designate HAPCs in the Reef Fish FMP as the following areas based on the occurrence of confirmed spawning locations:

- **Puerto Rico**
  - Tourmaline Bank/Buoy 8 (Figure 2.26) (50 CFR 622.33(a)(2)(ii)(B))
  - Abrir La Sierra Bank/Buoy 6 (Figure 2.26) (50 CFR 622.33(a)(2)(ii)(C))
  - Bajo de Sico (Figure 2.26) (50 CFR 622.33(a)(2)(ii)(A))
  - Vieques – El Seco (Figure 2.27) (State waters)
- **St. Croix**
  - Mutton snapper spawning aggregation area (Figure 2.26) (50 CFR 622.33(a)(1))
  - East of St. Croix (Lang Bank) (Figure 2.26) (50 CFR 622.33(a)(2) (i) )
- **St. Thomas**
  - Hind Bank MCD (Figure 2.26) (50 CFR 622.33(b)(1))
  - Gramanic Bank (Figure 2.26)

The spawning sites identified under this alternative are all from species in the Reef Fish FMP. Reef fishes spawn over a broad range of habitats and depths (Appendix 1). Specific spawning
locations have not been identified for many of these species. Several studies have located spawning sites for several reef fish species.

Nassau grouper, goliath grouper, and yellowfin grouper are known to form spawning aggregations (Olsen and La Place 1978; Beets and Friedlander 1992; Domeier and Colin 1997). Rock hind and Warsaw grouper are suspected to aggregate for spawning (NOAA 2000; Gilmore, pers. comm.). The Council established five seasonal closures (Figure 2.26) to protect red hind spawning and one seasonal closure to protect mutton snapper spawning. These areas were closed to protect vulnerable spawning aggregations from heavy exploitation and would become designated as HAPCs under this Alternative. Yellowfin grouper spawning aggregation areas are identified at Gramanic Bank (Figure 2.26), adjacent to the MCD. Tiger grouper spawning aggregation areas are identified in an area east of Vieques (Figure 2.27).

These sites proposed as HAPC under Alternative 4 are inferred to contain coral and live/hard bottom habitats, sensitive to fishing and non-fishing impacts, because red hind, mutton snapper, and yellowfin grouper typically spawn on that type of habitat. Thus, the HAPCs are designed to protect the habitat used for spawning. Spawning areas identified as HAPCs under this Alternative would meet HAPC considerations for important ecological function and sensitivity to human-induced degradation.

These sites – Tourmaline Bank, Bajo de Seco, Abrir La Sierra Bank, the mutton snapper spawning aggregation area, Lang Bank, Hind Bank MCD, Gramanic Bank, and El Seco – have documented spawning sites. Alternatives to address adverse fishing impacts on these sites are prepared in Section 2.5, except for Hind Bank that is permanently closed to fishing and El Seco that is in state waters.

The Council considered three potential spawning aggregations for designation as HAPC: locations with concentrations of fish along the southwest to the southeast coast of Puerto Rico identified from hydroacoustic surveys (Figure 2.28), the sites with running ripe fish in the SEAMAP area of southwest Puerto Rico (Figure 2.29), and several suspected spawning sites around St. Thomas (Figure 2.30). However, spawning at the sites had not been confirmed, so the Council chose to remove these sites from the list for HAPC. The Council confirmed its intent to consider areas inferred as coral or live/hard bottom from confirmed spawning aggregations as HAPC. If future research confirms spawning, the sites may be reconsidered as HAPC. If information were available to determine if spawning occurs at these sites, then the designation of HAPC on this basis would add additional area to HAPC. Increasing the amount of HAPC to incorporate these additional areas would benefit the fish through higher production, but would add short-term costs to fishers and non-fishing development if more restrictive management were developed for the sites. Management measures proposed in Fishing impacts alternative 2.5 and 3 suggest that the Council would recommend closure of the sites to selected gears. The distance from shore – near the shelf edge – of these sites suggests that non-fishing development would be minimally impacted.

Coral, and species living in and around coral, spawn on coral reefs. However, coral spawning is not localized, and does not meet the NOAA Fisheries guideline for selecting HAPC as discrete
Coral reefs have experienced degradation and are vulnerable to future damage. Figures 2.5 to 2.15 present the locations of nearshore coral reefs.

2.4.5 Alternative 5: Describe and identify HAPC as those habitat areas used by early life stage development of each species in the management units (considered and rejected).

This Alternative was considered and rejected because no information is available to map nursery areas. Nursery areas are included in the rationale for selection of specific sites recommended in Alternatives 7 and 8. See Section 2.6.

2.4.6 Alternative 6: Describe and identify HAPC as those habitat areas used by managed species as migratory routes (considered and rejected).

This Alternative was considered and rejected because no information is available to map migratory routes. Migratory routes are included in the rationale for selection of specific sites recommended in Alternatives 7 and 8. See Section 2.6.

2.4.7 Alternative 7: (Preferred Alternative) Designate as HAPCs in the Reef Fish FMP the following natural reserves or sites

Puerto Rico
- Hacienda la Esperanza, Maniti (Figure 2.31).
- Bajuras and Tiberones, Isabela (Figure 2.31).
- Cabezas de San Juan, Fajardo (Figure 2.31).
- JOBANNERR, Jobos Bay (Figure 2.31).
- Bioluminescent Bays, Vieques (Figure 2.31).
- Boqueron State Forest (Figure 2.32).
- Pantano Cibuco, Vega Baja (Figure 2.31).
- Piones State Forest (Figure 2.31).
- Río Espiritu Santo, Río Grande (Figure 2.31).
- Seagrass beds of Culebra Island (9 sites designated as Resource Category 1 and two additional sites) (Figure 2.31).
- Northwest Vieques seagrass west of Mosquito Pier, Vieques (Figure 2.33).

St. Thomas
- Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries (Figure 2.34).
- Saba Island/Perseverance Bay, including Flat Cay and Black Point Reef (Figure 2.34).

St. Croix
- Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary (Figure 2.36).
- Altona Lagoon (Figure 2.36).
- Great Pond (Figure 2.36).
South Shore Industrial Area (Figure 2.36)  
Sandy Point National Wildlife Refuge (Figure 2.36).

Under this Alternative, sites of special importance were proposed by an expert group, the HAP and SSC, to which the Council delegated the responsibility of providing a list of special sites. Many reserves and parks designated by Federal, Commonwealth, and Territorial governments have significant vulnerabilities or ecological benefits for fish species managed by the Council. Other, undesignated, sites may have similar benefits or vulnerabilities. Area-specific published information on habitat use of Caribbean fishes is limited, and the use of an expert panel provides access to information otherwise unavailable. These sites are all in state waters, and no alternatives were developed for addressing adverse fishing impacts.

Most of these sites include multiple habitats used by multiple resources. For ease of description, each site has been aligned with a single FMP that offers the most correspondence to the predominant habitat or resource. However, the extra scrutiny that occurs with HAPC sites will not be limited to the species of the single FMP, but may also include species from other FMPs. The natural reserves areas or sites identified in this alternative have primary ecological importance to Caribbean reef fish because of the importance of mangroves in these areas. These sites meet the HAPC considerations for ecological importance, and most meet the sensitivity and stress considerations. Further descriptions occur in Section 3.2.

Hacienda la Esperanza (Figure 2.31)

Hacienda la Esperanza was designated as a Natural Reserve in 1987. This reserve is part of the estuary system of Rio Grande de Manatí. DNER has designated the area as one of the most important rivers in Puerto Rico, as critically important to wildlife, and as critical to mangroves. All four species of mangrove occur in the reserve. Red mangrove wetlands in the area support many recreationally and commercially important fish species, particularly as nursery grounds. Over 50 families and 145 species of marine fishes have been identified as benefiting from Puerto Rico estuaries. PRNDER identified impacts on mangroves as cut and fill in mangrove wetlands for housing construction, use as cattle pasture, and discharge of untreated sewage into wetlands, which lead to designation as critical status due to threats from human activities. Hacienda la Esperanza meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Bajuras and Tiberones (Figure 2.31)

The submarine cave system off Bajuras and Cueva de los Tiburones, Isabela (Figure 2.31) have abundant coral growth over basement limestone in an area known for submarine springs and caves. An associated underground network of aquifers captures most of the surface runoff. Other than Bajuras, the rapidly sloping, very high-energy coastline of the region is largely devoid of reef-like habitats. This site extends off shore from 18 31.367’ N, 67 05.424’ W in the northeast to 18 31.196’ N, 67 07.073’ W in northwest, from the 10 fathom bottom contour to the shoreline. This unique marine habitat in Puerto Rico is home to a large variety of marine vegetation, hard and soft corals, reef fishes, marine turtles, and manatees. Large snapper and grouper and queen conch have declined to low abundance in recent years. Smaller reef fish still occur at the site.
Acropora palmate, A. cervicornis, Porites porites, and several Montastrea are abundant coral species at Bajuras, although at lower abundance than in the past. Marine vegetation is abundant throughout the region.

Bajuras and Tiburones are currently under great fishing pressure due to their accessibility and proximity to the shoreline. Non-fishing impacts result from recreational activities, the collection of coral and live rock, increased population density, and the exploitation and disappearance of the sand dune system bordering the shoreline. Bajuras and Tiburones meet HAPC considerations for ecological importance, sensitivity to human-induced degradation, and threats from development activities.

Cabezas de San Juan (Figure 2.31)

Cabezas de San Juan was designated a Natural Reserve in 1986. It contains two lagoons, Laguna Grande and Lagunda de Aguas Prietas, ranked by DNER among the most important lagoons in Puerto Rico. Only one, Laguna Grande, is in the Reserve. The Reserve is characterized by numerous fish species, healthy coral reefs, dense seagrass beds, and intact mangrove forests. PRDNEP designated the mangrove forests associated with Cabezas de San Juan as critical. Local fishers report Laguna de Aguas Prietas as one of the most important nursery areas for marine organisms, including for species in the Council’s FMUs. Groupers, snappers, and snook are the most important fish harvested in the lagoon. Laguna Grande has importance as nursery area for lobster and other crustaceans. Cabezas de San Juan is part of Puerto Rico’s Northeast Ecological Corridor because of the ecological importance of the coastline. Lack of marina facilities in the area has limited the amount of boat traffic. The Northeast Corridor is under intense developmental pressure with a series of resorts planned for construction. A campground adjacent to Laguna de Aguas Prietas encroaches on and threatens the lagoon. Cabezas de San Juan meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and threats from development activities.

JOBANNERR (Figure 2.31)

Jobos Bay was designated as a National Estuarine Research Reserve in 1981, to protect coastal mangroves of singular value and the related estuarine habitats. The Bay is considered one of the most important littoral zones along the southern coasts of Puerto Rico, with a complex matrix of mangrove forests, coral reefs, salt flats, and seagrass beds. DNER considers Mar Negro, part of the Reserve, as on the most important wildlife areas in Puerto Rico. DNER designated the mangrove forest, in particular that associated with Mar Negro, as a critical mangrove area. The Reserve contains over 260 fish species, anemones, hard corals, and soft corals in the keys surrounding the Bay, and 240 species of invertebrates dominated by crustacean, mollusks, sea urchins, sponges, and sea stars within the Bay. Lobster and conch are fished within the Bay. The area has been impacted by illegal fill of wetlands for housing, development of a marina that eliminated mangrove areas, construction of a landfill along the coast, agriculture with irrigation systems, and construction of a power plant that discharges on top of a now-destroyed coral reef. DNER has identified adverse runoff patterns from encroachment on Mar Negro and degraded water quality from discharge of untreated sewage. Jobos Bay meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.
Bioluminescent Bay (Figure 2.31)

The Bioluminescent Bay Reserve was created in 1983 by an MOU between Puerto Rico and the US Navy. DNER designated the area as a primary critical wildlife area due to the complex of marine, aquatic, and upland forest systems that support a great diversity of organisms. It designated the area as a critical mangrove area because of the importance of the four species of mangrove as wildlife habitat. Snappers represent one of the dominant fish species in the Bay. The area has suffered from excessive sedimentation resulting from upland erosion caused by construction of roads and other development. The DNER has identified a clandestine landfill north of the mangroves as a significant threat. Bioluminescent Bay meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Boquerón State Forest (Figure 2.32)

Boquerón State Forest contains a complex of fringing mangroves, salt flats, coastal lagoons, and adjacent coral reefs. Laguna Rincón, within the Forest, is an important nursery area for various fish species. *Ruppia* and *Naja* dominate the submerged aquatic vegetation in the area. DNER designated the area as a primary critical wildlife area and as a critical mangrove area. Local fishers catch snook, tarpon, mullet, jacks, and the invasive exotic tilapia, and harvest mangrove oysters. Dolphins, sharks, and manatees are common in the lagoons and Boquerón Bay. Boquerón State Forest is part of the Southwest Special Planning Area, designated to protect the ecologically and economically important southwest sector of Puerto Rico. The area is under heavy pressure from urban and tourism/recreational development, a municipal landfill along the coast, and construction of dikes for agricultural land management. Boquerón State Forest meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Pantano Cibuco (Figure 2.31)

Pantano Cibuco, the estuary of the Cibuco River, contains regions that dynamically vary from mangrove forests to open water to cattails to freshwater ferns on a regular basis, apparently in response to changes in freshwater inflow. The Cibuco River and its mangroves are identified as among the most important on Puerto Rico; the mangrove forest contains all four mangrove species. Some of the oldest and largest red mangrove trees on Puerto Rico occur in this region within the well-developed fringing mangrove forest. Over 50 families and 145 species of marine fish have been identified as benefiting from the estuaries of Puerto Rico. DNER has designated the area as a primary wildlife area. Cutting and fill of mangroves, wetland drainage, construction of housing in wetlands, use of wetlands as pastureland, and discharge of untreated sewage in mangrove wetlands threaten and degrade the Pantano Chibuco. Pantano Chibuco meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.
Piñones State Forest, (Figure 2.31)

DNER designated Piñones State Forest as a critical wildlife area for a large variety of organisms to safeguard its important ecological, physical, and geographical characteristics. It contains the largest remaining mangrove forest in Puerto Rico, with all four species present. The Forest is part of the estuarine system of the San Juan Bay Estuary, the largest estuary in Puerto Rico, which is part of the National Estuary Program and an estuary of national importance. The Forest serves as habitat for at least 38 species of fish. The lagoons of the area serve as nursery areas for schoolmaster, lane snapper, and gray snapper, which subsequently move to the nearshore reefs along the coast. Snook, tarpon, liza, mojarra, mullet, and the invasive exotic tilapia use the area. A variety of invertebrates use the rocky shores and mangrove lagoons. The San Juan metropolitan area surrounds the Forest, and development has encroached on the mangroves and lagoons. Large-scale development has been proposed for areas still privately owned. Marina development, housing, discharge of untreated wastewater, and San Juan International Airport have adversely affected water quality and eliminated wetland in the area. Piñones State Forest meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Río Espíritu Santo (Figure 2.31)

DNER designated Río Espíritu Santo as a critical wildlife area because of its ecologically important mangrove forests and herbaceous wetlands associated with the Río Espíritu Santo estuary, designated its mangroves as a critical mangrove forest, and designated the river as one of the most important in Puerto Rico because of the richness of marine life there. Commercially-important snappers and groupers use the estuary. Sharks and crabs harvested by local fishers contribute to the economy. DNER considers the area one of the most imperiled mangrove forests on Puerto Rico because of development pressure. Cutting and filling mangroves, boat use, expansion of beach projects, construction of roads that affect hydrology, and the use of off road vehicles adversely affect the area. Río Espíritu Santo meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Seagrass beds of Culebra Island (Figure 2.31)

The Culebra archipelago consists of about 25 offshore islands, cays, and rocks in the Caribbean Sea. Cayo Luis Peña, Culebrita Island, and parts of Culebra were designated as the Culebra National Wildlife Refuge in 1909. The low rainfall and no permanent streams allowed the extensive development of pristine seagrass beds over shallower substrates to depths of 18m or more in many localities. The Culebra seagrass beds are still in relatively pristine condition, unlike those found around the main island of Puerto Rico and other Caribbean islands. The first nine seagrass beds listed below are designated as Resource Category 1 by FWS.

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3 The USFWS established four Resource Categories to guide recommended mitigation of project impacts (Federal Register/Vol. 46, No. 15/January 23, 1981). Category 1 habitat has a high value for species selected for impact analysis, is unique and irreplaceable on a national basis or in the ecoregion, and has a goal of no net loss (although projects with insignificant changes that do not result in adverse impacts on habitat value may be acceptable provided they will have no significant cumulative impact).
Culebra seagrasses provide foraging habitat for many different species. Commercially important queen conch (*Strombus gigas*) and coral reef bony fishes (*Osteichthyes*) including parrotfish (*Sparisoma* spp.), grunts (*Haemulon* spp.), and porgies or sea breams (*Archosargus rhomboidealisis*) graze in or on seagrasses. These meadows are also the feeding grounds of several species of commercially important cartilaginous fishes (*Chondrichthyes*), the West Indian manatee, and green turtle.

Culebra’s seagrass beds are being threatened by commercial, housing, and recreational development. By-products of these activities include decreased water transparency from eroding soils and raw waste material and increased water turbidity from boating activities. The seagrass beds of Culebra are important for the preservation of biodiversity around the Culebra archipelago, Puerto Rico, and the U.S. Virgin Islands. These pristine meadows are crucial to the continued survival of wildlife and fisheries populations, as well as the local economy. These seagrass beds meet HAPC considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

Locations of the beds are given in the list below:

1. The seagrass beds located on the northwest coast of Cayo Luis Peña, located approximately at 18° 19' North, 65° 20' West, and extending 0.8 km.
2. The small seagrass beds located northwest of Punta Tamarindo Grande on Culebra at approximately 18° 19' North, 65° 20' West. These extend north for about 0.3 km.
3. All the seagrass beds extending from Punta Melones to Punta Tamarindo Grande along the west coast of Culebra Island. These seagrass beds run parallel to the shore forming a thick band from shallow water to about 9-12 m deep. These are the principal seagrass beds of the island. These meadows extend at least 3.1 kilometers and cover approximately 62 hectares.
4. The seagrass beds located on the southern coast of Culebra, southeast of Punta Maguey. These extend for 0.5 km and are located at approximately 18° 17' North and 65° 18’ West.
5. The seagrass beds on the western side of Punta del Soldado. This small meadow extends for 0.3 km and is located at approximately 18° 17’ North and 65° 17’ West.
6. All the seagrass meadows on the eastern side of Punta del Soldado north to Punta Colorada. These meadows are major nursery habitats for inshore reef fishes.
7. All the seagrass beds within Bahía Mosquito on the southeast coast of Culebra. These beds include fringing turtle grass beds as well as deeper offshore seagrass patches and are grazed extensively by green sea turtles, sea urchins and conches.
8. All seagrass beds within Puerto del Manglar on Culebra’s east coast. These seagrass beds consist principally of *Thalassia testudinum* and *Halodule wrightii*. Although the water is turbid all year long, these narrow meadows support a local green turtle population and numerous commercial fish species.
9. All the seagrass beds of Isla Culebrita, particularly those situated between Piedra del Norte and Laguna del Molino. The other seagrass beds located around the coast of Culebrita are scattered patches that are very dynamic and may change in areal extent and
species’ composition throughout the year. Green turtles and several commercial fish and invertebrate species are found within these meadows year round. 

10. The seagrass communities located at Fulladosa Cove between Punta Colorada and Punta Aloe. The sites are major nursery grounds of the juvenile stages of over 50 fishery target species, including Federally-managed species under the Reef Fish, Coral, Queen Conch and Lobster FMPs. Also, there is a resident population of the endangered Green Turtle, *Chelonia mydas*. These seagrass communities are not designated as Resource Category 1.

11. The seagrass communities located at Ensenada Honda between Punta Carenero and Punta Cabras. The sites are major nursery grounds of the juvenile stages of over 50 fishery target species, including Federally-managed species under the Reef Fish, Coral, Queen Conch and Lobster FMPs. Also, there is a resident population of the endangered Green Turtle, *Chelonia mydas*. These seagrass communities are not designated as Resource Category 1.

Ceiba State Forest (Figure 2.31)

Ceiba State Forest is characterized by extensive mangrove forests dominated by fringing red mangrove and basin black mangrove, interspersed with salt flats and shallow ponds. Some portions of the Forest also have dense seagrass beds and coral reefs in excellent condition. The Forest is part of the Fajardo River estuary, and supports a large number of native stream fish and shrimp. The estuary serves as nursery habitat for reef fish such as snappers, as well as snook and tarpon. Queen conch is heavily fished in areas of the Forest, and they may spawn in the area. The Forest is under threat from development in the area of Fajardo. A proposal to cut off a meander of the Fajardo River could lead to destruction of mangrove forest and estuarine wetlands for development. Unauthorized wastewater discharge and sedimentation from development have impacted the River. While some wetlands have been impacted, the Forest is mostly in good condition. Ceiba State Forest meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Northwest Vieques seagrass beds west of Mosquito Pier

The seagrass meadows of the northwestern end of Vieques west of Mosquito Pier have a mixture of lush turtle grass, manatee grass, shoal grass, and macroalgae intermingled with sandy bottom. The area is subject to naturally-occurring blowouts, but the seagrass shows signs of rapid recovery. These seagrass beds serve as valuable spawning and nursery areas for many marine fish, spiny lobster, and other invertebrates. The seagrasses are in close proximity to coral reefs; many reef fish such as grunts, snappers, and squirrelfish migrate from the reefs to the seagrass at night to feed. Bucktooth parrotfish dominate the seagrass fish complex. The diverse fauna of the seagrass beds consists of sea urchins, starfish, sea cucumbers, solitary corals, polychaetes, shrimps, mollusks, and fishes. Manatees frequently graze in the seagrass. The Mosquito Pier seagrass beds meet the HAPC consideration for ecological importance and sensitivity to human-induced degradation.

Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries
The USVI government has designated the mangrove lagoon and adjacent cays as an area of particular concern. These areas contain the most extensive mangrove forest on St. Thomas. Mangroves are important habitat for many marine species. Many species of grouper and snapper use mangroves as nursery habitat. Extensive mangrove habitat has been lost to development throughout St. Thomas. The area is adjacent to the only landfill on St. Thomas, several marinas, and a boat repair yard. These areas meet HAPC considerations for ecological importance, sensitivity to human-induced degradation, and ongoing development activities that stress the habitat.

Salt River Bay submarine canyon and Salt River estuary

Salt River was designated in 1960 as a National Historic Landmark (five acres) due to its cultural significance as a site for pre-Columbian development. The Nature Conservancy established Triton Bay, the eastern arm of Salt River Bay, as a Wildlife Sanctuary in 1971. In 1979, Salt River was designated an Area Of Particular Concern and an Area for Preservation and Restoration by the Virgin Islands Coastal Zone Management Program. In 1980, the National Historic Landmark designation was expanded in Salt River to 600 acres due to its historical importance as the landing site of the second voyage of Christopher Columbus in 1493 and subsequent colonization by the English, Spanish, French, Knights of Malta and Dutch. Salt River was included as a site for protection under the Coastal Barriers Resources Act in 1990. In 1992, the Department of Interior, National Parks Service, and the Government of the Virgin Islands formed a partnership to manage the area jointly as the Salt River Bay National Historical Park and Ecological Preserve in 1995, the Government of the Virgin Islands designated Salt River as a Marine Reserve and Wildlife Sanctuary. Salt River estuary is composed of an outer bay (Salt River Bay) and two parallel inner bays (Triton Bay to the east and Sugar Bay to the west). Salt River contains the largest remaining mangrove forest in the Territory of the Virgin Islands. Salt River estuary is a nursery area for many commercially and recreationally important finfish and shellfish species, including spiny lobsters. Numerous endangered species, including hawksbill, green and leatherback sea turtles are found within the park. The park contains a unique continuum of protected uplands, estuary and coral reef ecosystems. The estuary contains a fringing mangrove forest, extensive shallow seagrass beds and a unique submarine canyon with numerous coral species on nearly vertical sides of the canyon. Salt River Bay National Historical Park and Ecological Preserve meets HAPC considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

Altona Lagoon

Altona Lagoon is a semi-enclosed, mangrove-lined pond east of and adjoining Christiansted Harbor. Altona Lagoon is within the Christiansted Harbor Area of Particular Concern and Area for Preservation and Restoration, designated by the Coastal Zone Management Program in 1979. In 1990, Altona Lagoon was listed as a site designated for protection under the Coastal Barriers Resources Act. Altona Lagoon’s fringed red mangrove community provides a substrate for the attachment and colonization for numerous invertebrates and algae. The shallow lagoon contains extensive seagrass beds. Altona Lagoon is a nursery area for many finfish and shellfish species, including the southern pink shrimp *Peneaus notialis*. Altona Lagoon meets HAPC.
considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

Great Pond

Great Pond was designated as an Area for Preservation and Restoration in 1960. Great Pond was designated an Area of Particular Concern and a Significant Natural Area by the Virgin Islands Coastal Zone Management Program in 1979. In 1990, Great Pond was designated as a site for protection under the Coastal Barriers Resources Act. Great Pond was included in the formulation of the East End Marine Park in 2003. Great Pond, an 1165-acre coastal salt pond, is the second largest in the Virgin Islands, located on the south coast of St. Croix. Great Pond is fringed by red and black mangroves and contains numerous red mangrove islets. Water exchange into Great Pond is restricted to a three-meter wide channel heavily colonized by red mangroves. Great Pond is an important nursery area for commercial and recreational fish and shellfish species, including permit, snook, bonefish, snapper, blue crab and southern pink shrimp (*Penaeus notialis*). Great Pond contains the greatest species and abundance of avifauna on St. Croix. Great Pond serves as an important sediment trap, containing upland runoff from reaching the seagrass and coral communities of Great Pond Bay. Great Pond meets HAPC considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

South Shore Industrial Area

The South Shore Industrial Area is the Territory’s most significant industrial complex in terms of size, capital investment and importance to the local and territorial economies. The developed shoreline area extends from Canegarden Bay westward to Long Point, approximately five miles in length. The first three miles comprise Limetree Bay and Krause Lagoon, which were industrialized in the 1960’s. Krause Lagoon was the largest mangrove lagoon in the Territory of the Virgin Islands, occupying approximately 1.5 square miles of shoreline on the south coast. Krause Lagoon and Canegarden Bay were subsequently developed for the construction of a deepwater port facility for an alumina processing plant, an oil refinery and a containership facility. Development expanded westward with the Anguilla Sewage Treatment Plant and Landfill, Henry E. Rohlsen Airport and Virgin Islands Rum Industry Limited (VIRIL). Valuable fishery resources and coral reefs were compromised with the development of the South Shore Industrial Area. However, due to the mangrove mitigation planting efforts of the alumina refinery, viable fringing red mangrove communities and vestiges of original communities exist, and in conjunction with extant adjacent seagrass communities, form valuable nursery and forage habitat for fish and shellfish species. Krause Lagoon is also listed as an Area of Particular Concern under the Coastal Zone Management Program in 1979. Krause Lagoon and Canegarden Bay were designated as sites afforded protection under the Coastal Barriers Resources Act of 1990. The South Shore Industrial Area meets HAPC considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.
Sandy Point National Wildlife Refuge

Sandy Point became a National Natural Landmark site in 1962. The U.S. Fish and Wildlife Service designated Sandy Point in 1978 as critical nesting habitat for endangered leatherback sea turtles. The National Marine Fisheries Service designated the waters adjacent to Sandy Point as critical habitat in 1978. In 1979, the Government of the Virgin Islands designated Sandy Point as a Significant Natural Area. The U.S. Fish and Wildlife Service purchased 398 acres of Sandy Point in 1984 and established the Sandy Point National Wildlife Refuge. Sandy Point was listed as a site afforded protection under the Coastal Barriers Resource Act of 1990. The Coastal Zone Management Program designated Sandy Point an Area of Particular Concern in 1993. Sandy Point is a peninsula of approximately 500 acres located at the southwest tip of St. Croix. The three-mile stretch of beach at Sandy Point is the longest beach in the Virgin Islands. The 1.6-mile nesting beach for leatherback sea turtles is the largest and most important nesting site for leatherback sea turtles in the United States and its territories. Sandy Point National Wildlife Refuge also contains the largest salt pond in the Virgin Islands, Westend Salt Pond. The Westend Salt Pond provides important habitat for avifauna and functions as a sediment trap for upland runoff, protecting coral reef habitat offshore.

2.4.8 Alternative 8: (Preferred Alternative) Designate as HAPCs in the Coral FMP, the following natural reserves or sites

Puerto Rico
- Luis Peña Channel, Culebra (Figure 2.31).
- Mona/Monito (Figure 2.31).
- La Parguera, Lajas (Figure 2.32).
- Caja de Muertos, Ponce (Figure 2.32).
- Tourmaline Reef (Figure 2.32).
- Guánica State Forest (Figure 2.32).
- Punta Petrona, Santa Isabel (Figure 2.31).
- Ceiba State Forest (Figure 2.31).
- La Cordillera, Fajardo (Figure 2.31).
- Guayama Reefs (Figure 2.31).
- Steps and Tres Palmas, Rincon (Figure 2.31).
- Los Corchos Reef, Culebra (Figure 2.31).
- Desecheo Reefs, Desecheo (Figure 2.31).

St. Croix
- St. Croix Coral Reef Area of Particular Concern (APC), including the East End Marine Park (Figure 2.36).
- Buck Island Reef National Monument (Figure 2.36).
- South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36).
- Frederiksted Reef System (Figure 2.36).
- Cane Bay (Figure 2.36).
- Green Cay Wildlife Refuge (Figure 2.36).
Under this Alternative, sites of special importance were proposed by an expert group, the HAP and SSC, to which the Council delegated the responsibility of providing a list of special sites. Many reserves and parks designated by Federal, Commonwealth, and Territorial governments have significant vulnerabilities or ecological benefits for fish species managed by the Council. Other, undesignated, sites may have similar benefits or vulnerabilities. Area-specific published information on habitat use of Caribbean fishes is limited, and the use of an expert panel provides access to information otherwise unavailable. These sites are all in state waters, and no alternatives were developed for addressing adverse fishing impacts.

Most of these sites include multiple habitats used by multiple resources. For ease of description, each site has been aligned with a single FMP that offers the most correspondence to the predominant habitat or resource. However, the extra scrutiny that occurs with HAPC sites will not be limited to the species of the single FMP, but may also include species from other FMPs. The natural reserves areas or sites identified in Alternative 8 have primary ecological importance to Caribbean coral. These sites meet the HAPC consideration for ecological importance, and most meet the considerations for sensitivity and stress. Further descriptions occur in Section 3.2.4.

Luis Peña Channel (Figure 2.31)

DNER designated Cayo Luis Peña in 1976 as a priority area for preservation and restoration because of the importance of its coral reefs and mangroves. DNER designated offshore reefs, mangrove forests, and beaches of Culebra as geographical areas of particular concern. The area serves as nursery and adult habitat for crustacean and fish species in the Council’s FMU. Conch spawn in the area and are caught by commercial fishers. Luis Peña Channel is the first no-take marine protected area in Puerto Rico (9/30/1999, Administrative Order 99-15). The local Commercial Fishermen’s Association proposed the reserve to replenish reef fish and protect coral reefs and seagrass beds in the area. Commercial and recreational fishers from Culebra and Vieques, Puerto Rico and the USVI use the waters in the area. Declining reef fish abundance and degradation of coral reefs and seagrass have been documented, likely caused by pollution, sedimentation, overuse by boaters, and overfishing. Luis Peña Channel meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Mona/Monito (Figure 2.31)

DNER considers Mona/Monito as a region of incalculable ecological value because of the diversity of fauna and flora, and because of its isolated location that reduces human encroachment. DNER designated the mangroves on the island as a critical mangrove forest. A large reef platform borders the southern portion of Mona Island. Barrier reefs protect the eastern and western coasts of the island from wave energy and enclose shallow coastal lagoons. The reefs in the area contain a large variety of hard and soft coral. The habitats of Mona are in good conditions with the exception of reef damage from two large ship groundings and hurricanes. Areas inside the reefs, especially seagrass, serve as nurseries for a variety of reef fish. The area is considered as overfished because of extensive pressure from commercial and charter fishers. Large snappers and groupers that dominated fish populations in the 1980 to mid 1990s rarely
occur in catches. Wrasses and parrotfish now dominate. Conch, once abundant in the seagrass, have declined in abundance. Mona/Monito meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

La Parguera (Figure 2.32)

DNER has designated La Parguera as a critical wildlife habitat and as a critical mangrove forest. The area of Parguera has the richest coral reef resources on Puerto Rico. The reserve contains more than 30 common species of coral, mangrove wetlands, seagrass beds, and salt flats that make the area important for fishery resources. Red mangroves dominate the mangrove forests, but the other three species are present. The reserve extends to the shelf edge, which includes an extensive coral reef system. A minimum of 28 commercially and recreationally important species frequent the reefs of Parguera. The mangroves and associated channels serve as important juvenile habitat for numerous reef species, especially snappers. The shelf edge reef is an important spawning area for commercially important species such as red hind and snappers. The seagrass beds of the area are important nursery areas for conch and lobster, and queen conch are harvested locally. DNER has identified recreational activity in the mangroves, construction along the shoreline that requires cut and fill of mangroves, fill of salt flats, and intense boat traffic as the greatest threats to the mangrove forests, coral reefs, and seagrass beds. La Parguera meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Caja de Muertos, Ponce, Puerto Rico (Figure 2.32)

DNER has designated Caja de Muertos as a primary wildlife area. It contains the largest emergent reef system on the southern coast of Puerto Rico, and includes Cayo Berbería and Isla Morrillitos. Coral reefs, hard bottom, seagrass beds, macroalgae, mangrove forests, sandy beaches, and rocky shorelines are the main ecological systems within the reserve. Coral reefs, fringing coral, and coral colonies occur in the reserve. Turtle grass and manatee grass occur in dense stands. The area contains diverse fish species, including wrasses, doctorfish, parrotfish, squirrelfish, grunts, snappers, and groupers. Commercial and recreational fishers harvest red hind, coney, and lane snapper. The area remains fairly pristine because it is largely inaccessible except by water. The reefs, mangrove forests, and seagrass have changed little over time. Fish populations, however, have shifted from many large predators to primarily herbivores and small predators. Some impacts to fish habitat have occurred from boating. Caja de Muertos meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Tourmaline Reef (Figure 2.32)

The Tourmaline Reef Reserve is the most ecologically important coral reef resource on the west coast of Puerto Rico, because of the diversity of coral and fish species, and the most economically important because of the importance to commercial fishers. The reserve was established in part for management as a nursery area and as a refuge for commercially important species. The Reserve contains three seasonally closed spawning areas for red hind. The seagrass beds contain calcareous algae that contribute calcium carbonate to the system. The seagrass beds and sandy areas also harbor many invertebrates including queen conch. Commercial fishers
harvest queen conch, lobster, and snappers and groupers. Tourmaline Reef meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Guánica State Forest (Figure 2.32)

DNER has designated Guánica State Forest as a primary critical wildlife area because of the importance of complex coastal habitats. The area contains healthy expanses of coral reef, seagrass beds, mangrove forests, sandy and rocky beach and hard bottom. The reefs at Punta Vendana are some of the oldest and most extensive on Puerto Rico. The reefs extend to the shelf edge where dense coral colonization occurs. Yellowtail snappers and barracuda predominate the large fish of the area, and juveniles of snappers and groupers are common. Local fishers harvest lobster, conch, and various reef fish. Rapid development of the town of Guánica has brought development to the edge of the forest with construction of tourist facilities and private homes along the shoreline. DNER has restricted entry to part of the area to limit boat traffic. Sedimentation associated with runoff from development has reduced coral cover in some areas. Cut and fill has reduced the extent of the mangrove forests. Increased boating near developed areas has impacted seagrasses. Guánica State Forest meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and ongoing development activities that stress the habitat.

Punta Petrona (Figure 2.31)

DNER has designated Punta Petrona, part of the Aguirre State Forest, as a critical wildlife area and as a critical mangrove forest. It contains one of the most impressive coral reef systems of the southern coast of Puerto Rico. The reefs are primarily composed of hard corals, as wave action limits soft coral. Mangrove forests are interspersed with ponds, meandering channels, and various cays. Tranquil waters surrounding the mangroves contain turtle grass and coral reefs. Limited access to the area has allowed the reserve to remain in a relatively pristine state. Punta Petrona produces substantial commercial and recreational catches of snappers, groupers, trunkfish and lobster. Some encroachment on the mangrove forest has occurred from the Playa de Santa Isabel community, and boaters have caused some damage to corals and seagrass. Punta Petrona meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

La Cordillera (Figure 2.31)

DNER has designated La Cordillera as a primary wildlife area because of numerous marine species and seabird breeding colonies in the area. The reserve is characterized by well-developed reefs, diversity of marine life, calm transparent waters, and beautiful beaches. Rock reefs are the most common and prominent formation on the windward side of the reserve. Patch reefs are common on the leeward side of larger islets. Fringing reefs are best developed in the lee of islets on the northern boundary of the reserve. Expanses of seagrass beds, mainly turtle grass, occur in shallow water. Commercially and recreationally important fish such as schoolmaster, yellowtail snapper, red hind, and barracuda occur in the area, and are fished by local fishers. Catches of large fish have declined, and fishers harvest mostly juvenile fish. Sea turtles and manatees forage
in the area. La Cordillera meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Guayama Reefs (Figure 2.31)

The Guayama Reefs reserve contains a great diversity of corals, including branching and rose corals and sea fans. The reef flat is fragmented into small buttresses with fire, elkhorn, and finger coral on the tops. The reef serves as protection for areas of small coral reefs and extensive seagrass beds. The area is known for the large extent of the reef and for a diversity of fish. The reef complex is inhabited by a great variety of fish and other marine organisms, many of commercial value. Lobsters and conch were commonly fished in the area, but are now difficult to find, likely due to overfishing. Manatee forage on the seagrass beds. Development in the area causes heavy discharge of sediments into the sea. The Guayama reef is affected to some degree by sedimentation, which may result from sediment discharge or the natural force of southeast swells. Guayama Reefs meet HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Steps and Tres Palmas (Figure 2.31)

The coastal habitats near Steps and Tres Palmas in Rincon (Figure 2.31), support endangered and threatened wildlife and contain one of the few remaining healthy stands of elkhorn coral (*Acropora palmata*) left in Puerto Rico (Bruckner 2002). The Steps and Tres Palmas reefs also represent some of the best-developed fringing coral reefs off the west coast of Puerto Rico. The success of these stands appears to result in part from fast growth rates, persistence of injured adults by rapid wound healing, and high rate of asexual recruitment of fragments. Because *A. palmata* exhibits limited ability to recruit sexually, damaged populations are unlikely to recover unless a local source of branches remains following a disturbance. Populations of elkhorn coral formerly existed on reefs surrounding Mayaguez Bay to the south, but these have largely disappeared as a result of poor water quality.

The high structural complexity produced by the branches of elkhorn coral colonies provide essential fish habitat. Studies from Florida and the Virgin islands have shown that a higher number of lobsters, snappers, grunts, parrotfish and other large reef fish occur in areas with live stands of elkhorn coral. In many locations, elkhorn colonies have died, but erect skeletons (standing in place) may remain for 10-20 years. The skeletons are rapidly overgrown with algae and benthic invertebrates, and fish communities become dominated by schools of herbivorous fish like surgeonfish due to increased biomass of algae. Over time, the skeletons eventually collapse, eliminating high-relief topography and habitat for predatory fish and motile invertebrates.

Potential large-scale development projects in the fields immediately fronting Steps Reef are likely to cause substantial run-off and sedimentation during and after construction, and elevated nutrients and pollutants once the establishment is operational (as a result of increased sewage production and pesticides and fertilizers used on the surrounding grounds). Rincon’s reefs are affected by poor water quality conditions during the rainy season in summer due to run-off, but murky conditions generally persist for short periods and water clarity improves after a few days.
In winter, high wave action prevents the accumulation of sediment on branches. Clearing of the land adjacent to Steps Reef would likely have a significant impact on the exceptional local elkhorn coral populations. If populations of *A. palmata* were seriously damaged near Rincon, there is no other site within close proximity that could serve as a site for new recruits. Steps and Tres Palmas meet HAPC considerations for ecological importance, rarity, and sensitivity to human-induced degradation.

Los Corchos Reef (Figure 2.31)

Los Corchos Reef is a linear reef system located at approximately 1.5 km east-southeast of Culebra Island, and just south of Culebrita Island. This is the easternmost linear reef system of the Puerto Rican archipelago, with living coral cover values that reach 70-90% in some areas of its forereef zone. It supports well-developed and clearly defined reef zones, including a 25-40 m deep forereef slope and an extensive 10-25 m deep forereef terrace that includes well defined *Montastraea annularis* biotopes and extensive thickets of the candidate endangered species *Acropora cervicornis*. This is the largest known stand of *A. cervicornis* of the eastern Puerto Rican platform. A total of 70 coral species have been preliminarily listed from this site, including 45 scleractinians, 4 hydrocorals and 21 octocorals. In addition, over 200 fish species have been documented from Los Corchos, including all Federally-managed species within the Reef Fish FMP.

Major anthropogenic stressors to this site are recreational boat impacts, anchoring, overfishing and occasional turbid water flows from the coast. These have caused substantial localized destruction of *Acropora palmata* frameworks. Also, anchoring is creating significant localized destruction of *Acropora cervicornis* frameworks on the forereef and backreef zones. Fishing activities by artisanal and recreational fishers is increasing and fish populations of target species are rather low in comparison to the nearby Luis Peña Channel No-Take Natural Reserve (Hernández-Delgado, undergoing studies). Murky runoff waters flowing from Ensenada Honda, Mosquito Bay and Puerto de Manglar after heavy rainfall can reach Los Corchos Reef with tidal flushing of the bays, sending turbid waters and nutrient pulses over the reef. Las Corchos Reef meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Desecheo Island (Figure 2.31)

Puerto Rico designated the waters and habitats within one mile of Desecheo Island as a marine reserve, in part because the quality of the reefs equal or exceed any in Puerto Rico. Coral reefs are found approximately one quarter mile from shore in waters as deep as 100 feet. Coral reef formations begin on the southwestern island shelf and continue down to the southern part of the island. They offer a high level of biodiversity and hard coral bottom cover. A total of 21 species of hard coral was reported on the Desecheo Island reefs, and hard coral bottom cover exceeded algae bottom cover. Overall, an average of 91% of the coral colonies were reported as healthy, 5% were reported bleached and 4% were reported sick. Waters surrounding Desecheo Island are clear and contain low nutrient levels. The waters around Desecheo Island are not impacted by runoff from the island, because no rivers are present on Desecheo Island.
Recreational diving, sport and commercial fishing, snorkeling, occasional pleasure boating, and most recently whale watching are all common in the area. The waters around the island are so deep that many boats are forced to anchor in the shallow water where the coral reefs are located or in deeper water where the boaters cannot see the bottom, and anchor damage to coral is reported. While no fish census is available for the area off Desecheo Island, data available for the northwestern Puerto Rico waters show a lack of top predator fishes like snappers and groupers, and fishing activities may have caused depletion of fish resources. The Desecheo Island reefs meet HAPC considerations for ecological importance and sensitivity to human-induced degradation.

Saba Island/Perseverance Bay (Figure 2.34)

Saba Island/Perseverance Bay is not managed under US or USVI rules or regulations. The area consists of coral reef areas, seagrass beds, sand flats, and rhotolith pavement areas with algal cover. Coral reef and seagrass are important marine habitats that support various life stages of many species under the Council’s FMUs. DFW surveys in 2002 found higher conch abundance in the seagrass in this area than in other St. Thomas areas. Saba Island/Perseverance Bay meet HAPC considerations for ecological importance and sensitivity to human-induced degradation.

St. Croix Coral Reef Area of Particular Concern including the Eastend Marine Park (Figure 2.36)

The St. Croix Coral Reef Area of Particular Concern (APC), designated in 1979 by the Coastal Zone Management Program, is comprised of the three-mile Territorial Sea portion of the insular shelf platform extending around St. Croix. The widest part of the platform (9 miles) extends eastward onto Lang Bank and narrows to the southwest (< 3 miles). Width of the platform decreases markedly off the north coast (<0.25 mile). The APC contains extensive coral reefs, including the only barrier reefs in the eastern Caribbean, shelf-edge reefs and fringing reefs. The East End Marine Park was established in 2003 by the Government of the Virgin Islands and represents the first Territorial Park in the U.S. Virgin Islands. The park extends from Punnett Point on the northeast coast out to the three-mile Territorial Sea limit, around East Point and back to the shoreline at Milford Point on the south coast. The East End Marine Park encompasses more than 27 square miles of submerged lands containing extensive inshore seagrass beds, mangroves, salt pond, patch reefs, a unique bank-barrier reef system and deep reefs. The diversity of habitats includes important nursery grounds, forage and habitat for numerous commercially important finfish and shellfish species, including conch and lobster. Nearly all of the coastline of the park contains linear or patch reefs. Seagrass beds distributed throughout the park are most common in subtidal areas but also occur in intertidal areas. Turtle grass, shoal grass, manatee grass, and calcareous green algae all occur. One of the three remaining significant mangrove forests on St. Croix occurs in the park. Hard bottom colonized by soft corals and sponges occur in the park. The East End Marine Park meets HAPC considerations for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.
Buck Island Reef National Monument (Figure 2.36)

Presidential Proclamation #3443 in 1961 established Buck Island Reef National Monument (BIRNM) for the protection and preservation of submerged lands and coral reef around Buck Island. BIRNM boundary was expanded by 18,135 acres in 2001. Barrier reefs, deep reefs, patch reefs, extensive hard bottom communities of gorgonids and sponges, unique elkhorn coral formations called “haystacks” and extensive seagrass beds, characterize the area. BIRNM meets HAPC considerations for ecological importance and sensitivity to human-induced degradation.

South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36)

An extensive patch reef system and well-developed deep reef system is present extending from Canegarden Bay to Sandy Point. The patch reefs inshore and the deep reef offshore have been and continue to be stressed by the development and activities of the south shore industrial complex. These activities include oil and alumina refinery processes, commercial vessel traffic to the refineries and the containership port, leachate from the landfill, sewage discharge and rum effluent discharge. Water quality in this area is degraded. The South Shore Industrial Area Patch Reef and Deep Reef System meet HAPC consideration for sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

Frederiksted Reef System (Figure 2.36)

The Frederiksted Reef System north and south of the Frederiksted Pier to Sprat Hole is largely a monotypic reef system dominated by mountainous star coral *Montastrea annularis*. The Virgin Islands Port Authority has designated this area as an anchorage area for commercial vessels. Corals have been crushed by the impact of anchors. Vertical relief on portions of this reef has been reduced to less than one-half meter in height by commercial vessel anchor drag and chain swing. Water quality is degraded by the production of calcium carbonate dust produced by the pulverization of corals. Coral coverage in areas not impacted by vessel anchors or chain drag at the seaward slope is greater than 70%. The Frederiksted Reef System meets HAPC consideration for ecological importance, sensitivity to human-induced degradation and undergoing development activities that stress the habitat.

Cane Bay (Figure 2.36)

The northwest coast of St. Croix includes a coral reef and wall that stretches from the bluffs at La Vallee to Ham’s Bluff and Bay at the extreme NW tip of the island. The area includes Cane Bay and Davis Bay, plus the rocky shoreline embayments from Carambola to Ham’s Bluff, with adjacent oceanic waters. Cane Bay, a complex of coral reefs and associated shallow-water environments on the northwest coast of St. Croix, includes an important concentration of essential fish habitats, including shallow-water gorgonian beds (and formerly acroporid coral beds, just beginning to redevelop). These waters serve as important spawning and nursery grounds for many juvenile reef fishes and other managed species.
These coral reefs have are increasingly threatened by increasing fishing pressure and by shore-based water quality degradation. Underwater observations indicate a marked recent decline in the abundance and diversity of managed reef fishes, and heavy siltation on sponge surfaces and sponge necrosis. In addition, the region wide coral bleaching events which hit the Caribbean in recent years had a significant impact on these reefs. Some beach dredge-and-fill activities have degraded shallow-water reefs. Westerly long-shore drift in this area often brings silt and pollutant-laden waters from the east during and after storm events. Cane Bay meets HAPC considerations for ecological importance, sensitivity to human-induced degradation, and undergoing development activities that stress the habitat.

Green Cay Wildlife Refuge (Figure 2.36)

Green Cay is a 14-acre island located three miles east of Christiansted. The island was designated Green Cay National Wildlife Refuge under the Endangered Species Act by the U.S. Fish and Wildlife Service in 1977 to protect the rare and endangered St. Croix Ground Lizard *Ameiva polops*. Green Cay and its offshore seagrass beds and fringing reef provide habitat for many terrestrial and marine species, including nesting sea turtles. Green Cay Wildlife Refuge meets HAPC consideration for ecological importance and sensitivity to human-induced degradation.

2.5 Alternatives to prevent, mitigate, or minimize adverse effects of fishing on EFH

Six alternatives for preventing, mitigating, or minimizing adverse effects of fishing on EFH are presented. Each alternative represents a package of several individual measures that affect the use of fishing gears allowed under the Reef Fish FMP and the Spiny Lobster FMP. Each alternative has a different set of consequences (Table 2.15) on the Affected Environment described in Section 3. Gear used under the Queen Conch FMP (hand harvest only) is not considered to have adverse impacts. No harvest of coral is allowed under the Coral FMP.

These Alternatives present options for preventing, mitigating, or minimizing all adverse impacts on EFH by federally managed fishing gears in the US Caribbean that are considered to be more than minimal and not temporary (see Section 2.1.5.4). They were developed from the following four conceptual approaches to preventing, mitigating, or minimizing adverse effects of fishing (see also Section 2.1.5.3):

- No action
- Gear modifications
- Time/area closures
- Prohibitions on the use of gears

For some impacts, there may be several options for mitigation spanning all four of these categories. For others, due to the nature of the impact and/or the gear there are essentially only two options: no action or total prohibition. Each alternative includes some or all of the individual measures from the preceding alternative, to which are added additional measures. Successive alternatives are therefore increasingly restrictive. The gear modifications in Alternative 2 would probably be relatively easy to implement, without substantial cost or loss of efficiency to the
fishery. However the time/area closures in Alternatives 3 and 4, while having greater potential for preventing, mitigating, or minimizing impacts, are likely to result in a greater restriction on fishing activity and therefore carry a greater burden for the fishers. Total prohibition of gears is the most restrictive management measure that could be imposed. Alternatives 2 through 5 are therefore mutually exclusive.

The analysis of the consequences of these alternatives (Section 4.5) provides information to enable managers to make informed decisions about necessary management actions. The rationale for each alternative presented in the following sections contains a summary of the consequences analyzed in Section 4.5. The cumulative impacts (Section 4.6) also consider the effects of the fishing on habitat with non-fishing impacts and demonstrate that the latter probably affects fish habitat and production to a much greater extent (Table 2.16). A practicability analysis (Section 4.5.3.4, 4.5.4.4, 4.5.5.4, 4.5.6.4, and 4.5.7.4) uses information evaluated in Sections 4.5 and 4.6 to compare and contrast the benefits to fish habitat and fish production and the costs to society of the alternatives (Table 2.17).

As stated in Section 2.1.5.4.4, the alternatives presented below are not intended to restrict the Council’s choices, but rather to enable it to make informed decisions. If the Council decides to amend any or all FMPs to address adverse fishing impacts on EFH, the individual management actions could be recombined into an alternative package different from those presented. If such a new alternative falls within the range of scenarios presented here, the analysis of consequences in Section 4 will provide some guidance on the likely consequences of that new alternative. However, to understand fully the likely consequences of a new package will require additional analysis. The extent of the modification will determine the extent of the requirement for new analysis during preparation of any FMP Amendments.

2.5.1 Alternative 1. (No Action, status quo). Use existing regulations to prevent, mitigate, or minimize adverse fishing impacts in State and Federal waters of the US Caribbean

**Rationale:** Under this Alternative, no new actions would be introduced. Existing management measures put in place by the Council and NOAA Fisheries that contribute to preventing, mitigating, or minimizing adverse effects of fishing on EFH would remain in place. The Council and NOAA Fisheries would address future management actions on a case-by-case basis within the existing FMP management framework.

In some cases, habitat protection has resulted from Council and NOAA Fisheries management action aimed directly at habitat protection, while in other cases habitat protection occurred as an ancillary benefit of management measures designed for other purposes. Direct protection of habitats used by fish has resulted from prohibitions on the use of explosives and chemicals, designations of some areas as marine protected areas (MPAs), prohibitions on anchoring in sensitive areas, and restrictions on use of some fishing gear. Specific Council and NOAA Fisheries actions are presented in Section 2.1.5.2.

Degradation of fish habitat has occurred throughout the US Caribbean, caused mainly by natural events and non-fishing activities. Many fish species appear heavily fished and at lower than
desirable abundance levels. Direct adverse fishing impacts on habitat account for a small proportion of degraded habitat or decreased abundance. Under Alternative 1 any current direct impacts fishing on the physical, biological, human, or administrative environments will continue. All current commercial and recreational fishing practices would continue unchanged until changes in fishing regulations occur under the existing FMP management framework.

Calculations of bottom area within jurisdictional boundaries from the GIS indicates that of the shelf habitats in less than 100 fathoms depth, approximately 15% occurs in the EEZ and 85% occurs in state waters (Figure 2.22). Most of the shelf in the EEZ occurs off the USVI. Most commercial fishing occurs in state waters, and more likely occurs in the EEZ around the USVI than off Puerto Rico. According to MRFSS data, most recreational fishing in the EEZ around Puerto Rico occurred for dolphin and tuna, while most bottom fishing occurred in state waters. Similar information is not available for USVI, but the higher amount of EEZ off USVI probably means more recreational fishing in the EEZ of the USVI.

The Council concluded that adverse impacts occur from fishing activities, and that practicable measures exist to address these impacts.

2.5.2 Alternative 2. Establish modifications to anchoring and pots/traps for recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots under the Spiny Lobster and Reef Fish FMPs
- Require at least one buoy at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ under all FMPs

**Rationale**: Although fishing gears have different impacts on different habitats, this Alternative applies gear modifications irrespective of which habitats the gears are being used on. Only a limited amount of coral habitat has been mapped in the EEZ, and the bottom substrate of other areas is not clearly identified. Thus this alternative is precautionary and will mitigate impacts on known coral areas and the entire EEZ (potentially other habitat types) as described below. Under this Alternative, EFH would be determined to be adversely impacted by fishing activities (Section 3.5.1.2) that occur in the EEZ, and that low-level gear modifications are necessary to prevent, mitigate, or minimize these impacts. This fishing gear Alternative is applicable only for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ.

Requiring a buoy on individual pots/traps or a buoy on each end of a trap line would significantly reduce the need for fishers to retrieve pots and traps by grappling. While grappling probably causes most damage on coral and hard bottoms, it could also cause damage to seagrass and benthic algae. Illegal fishing with un-buoyed pots/traps in closed areas causes enforcement
difficulties in addition to habitat damage from grappling. About 4% of all trap/pot retrievals would occur on coral. However, it would seem difficult to grapple on coral, because the grapple hook would tend to hang up on the physically complex coral habitat.

While Barnette (2001) did not consider anchors as fishing gear, he recognized that vessels often anchor while fishing. Dropping or dragging anchors on sensitive habitat may cause substantial damage to EFH. Fishers do not typically use anchors on coral habitat, but they are sometimes deployed there by accident or miscalculation. US Caribbean commercial vertical line fishers tend to drift fish, as do recreational fishers who target pelagic fishes (Lisamarie Carrubba, NOAA Fisheries, Puerto Rico, personal communication). A trip line reduces the likelihood that an anchor lodged in coral or hard bottom will subsequently require breaking the substrate to release the anchor. A trip line consists of a long length of line sufficiently strong to retrieve the anchor tied to the crown (the point where the anchor shank meets the flukes) and attached to a surface buoy with sufficient flotation to remain at the surface during anchoring (Rousmaniere 1999). Anchors with trip lines are more likely to be retrieved with minimal damage and adverse impacts when snagged in irregular bottom than anchors without them, particularly on fragile coral and hard bottoms.

The measures listed under this Alternative would not cause a reduction in harvest, unless they caused an increase in costs (see Section 3.3) and forced some fishers to drop out of fisheries. A requirement for buoys on traps/pots may indirectly cause more trap hauls due to retrieval by the rightful owners and by robbers. Trap/pot buoys cost about $2-4 apiece, and the cost of requiring buoys will depend on the number of buoys needed. The type of buoy and amount of trip line for an anchor retrieval system depend on depth of anchoring. A small (13 pound flotation) mooring buoy coast approximately $15, and 600 feet of line costs $17 for ¼ inch polypropolene, $39 for ¼ inch nylon, $66 for ½ polypropolene, and $138 for ½ inch nylon.

Pots/traps have a fishing impacts index score of moderate (6) on coral, seagrass, and benthic algae and a moderate risk index, but observations suggest lower impacts (Section 4.5.1). Vertical gear ranks in the low category of the fishing impacts index on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category of the risk index for coral.

In the absence of effective control of fishery harvest and anthropogenic non-fishing impacts, the fishers would pay the primary cost of activities to minimize loss or damage to EFH. The immediate potential benefits to habitat and to fish production from restricting fishing on EFH are small compared to the potential benefits of controlling fishery harvest and managing non-fishing impacts. However, maintaining conditions for sustainable fisheries requires healthy habitats.

Two gear modifications that might mitigate adverse impacts by longlines were considered: shorter groundline length and use of monofilament groundlines. However, these were not proposed in this Alternative because neither measure would provide much reduction in the minor adverse impacts from longlines. The impacts of longlines are addressed by alternatives 3, 4 and 5.

The potential for applying the gear modification concept to spear fishing was also considered. For example, it would be possible to prohibit the use of gas-propelled spear guns while allowing
non-gas propelled spears to be used. However, the main cause of impacts from spear fishing is not the spears themselves, but the divers operating the spears. Therefore, this was not considered to be a reasonable alternative for mitigating the impact. Nothing other than a prohibition on the use of SCUBA equipment was considered to have a reasonable likelihood of mitigating the impact from this gear. This management action is included in Alternative 4.

The Council concluded that the management measures in this Alternative are practicable (See Section 4.5.3.4).

2.5.3 Alternative 2.5 Establish modifications to anchoring and pots/traps and close areas to pots/traps for recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots under the Spiny Lobster and Reef Fish FMPs under the Spiny Lobster and Reef Fish FMPs
- Require at least one buoy that floats on the surface at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ under all FMPs
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented reef fish spawning areas (Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs

This Alternative includes all measures described in Alternative 2 – buoys on traps/pots and buoys on trap lines, require anchor retrieval systems – and additionally prohibits fishing with pots/traps in currently seasonally-closed areas and on Gramanic Bank (Figure 2.26), that contain coral/hard bottom inferred from reef fish spawning. The seasonally-closed areas are Bajo de Sico, Tourmaline Bank, Abrir la Sierra Bank, east of St Croix (Lang Bank), and the Mutton Snapper spawning aggregation area. Pot/trap fishing has the potential to cause the adverse impact to coral habitats.

The closures would remove adverse fishing impacts by pots/traps on sensitive habitats from the spawning areas. This alternative would likely result in a tradeoff of no effort by pots/traps on sites of known ecological functions for increased effort in sites without known functions. Fishers could shift from pots/traps to other gear on these areas.

Closing the areas would require pot/trap fishers to move to other areas, change gears, or not fish. This Alternative could likely cause a decrease in harvest, but the amount of decrease cannot be predicted. Only gears in the Reef Fish and Spiny Lobster FMPs are identified as having potential adverse impacts on these habitats.
In the absence of effective control of fishery harvest and anthropogenic non-fishing impacts, the fishers would pay the primary cost of activities to minimize loss or damage to EFH. The immediate potential benefits to habitat and to fish production from restricting pot/trap fishing on EFH on these sites inferred as coral are small compared to the potential benefits of controlling fishery harvest and managing non-fishing impacts. However, maintaining conditions for sustainable fisheries requires healthy habitats. As most anthropogenic non-fishing impacts occur in state waters (Section 3.5.2), any fishing impacts in the EEZ occur at some distance from the non-fishing impacts. On a local scale in the EEZ, fishing is often the primary impact on fish habitat.

The Council concluded that the management measures in this Alternative are practicable (See Section 4.5.4.4).

2.5.4 Alternative 3. (Preferred Alternative) Establish modifications to anchoring techniques; establish modifications to construction specifications for pots/traps; and close areas to certain recreational and commercial fishing gears (i.e., pots/traps, gill/trammel nets, and bottom longlines) to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots
- Require at least one buoy at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank for these gears – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of gill/trammel nets coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of bottom longlines on coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Reef Fish FMPs

**Rationale:** This Alternative includes the measures described in Alternative 2.5 – buoys on traps/pots, an anchor retrieval system, and a prohibition of traps/pots on inferred coral and hard bottom – and additionally prohibits fishing with gill/trammel net and bottom longlines on the same coral/hard bottom inferred from reef fish spawning as described in Alternative 2.5 (Figure 2.26). While the gears have different impacts on different habitats, this alternative contains measures that apply to all habitats in the EEZ and measures that apply to specific habitats. Only a limited amount of coral habitat has been inferred from documented spawning aggregations in the
EEZ. Unique conditions attract reef fish spawning aggregations, which could include habitat configuration. Thus this alternative to protect habitat in spawning areas is precautionary. Under this Alternative, adverse fishing impacts (Section 3.5.1.2) would be determined to occur in the EEZ, and moderate gear modifications and area closures are necessary to address these impacts.

The prohibition of gill/trammel and longlines on seasonally closed areas (50 CFR 622.33(a)) and Gramanic Bank would extend the benefits discussed for pots/traps in Alternative 2.5 to gill/trammel nets and longlines – gears with likely adverse impacts. The amount of gill/trammel net or longline fishing on coral on these sites is not known.

The closures would reduce fishing on spawning aggregations and remove adverse fishing impacts from the sensitive habitats of the spawning area. This alternative would likely result in a tradeoff of lower fishing effort on sites of known ecological functions for increased effort in sites without known functions. Closing the areas would require gill/trammel net and bottom longline fishers to move to other areas, change gears, or not fish. This Alternative would likely cause a decrease in harvest as catch rates tend to be higher on spawning aggregations, but the amount of decrease cannot be predicted. Fishers may increase effort to make up for closed areas, which would increase costs, with participants fishing more for less income.

This Alternative sets precedent for extending prohibitions on fishing as new coral and hard bottom areas are located. The additional enforcement required for a prohibition of traps/pot, gill nets, trammel nets, and longlines on inferred habitats would further strain enforcement capabilities in the US Caribbean. Only gears in the Reef Fish and Spiny Lobster FMPs are identified as having potential adverse impacts on these habitats.

Pots/traps have a fishing impacts index score of moderate on coral, seagrass, and benthic algae and a moderate risk index, but observations suggest lower impacts (Section 4.5.1). Gill/trammel nets have a fishing impacts index score of moderate for coral, but some observers suggest that these gears have the highest potential impact of gears used in the US Caribbean (HAP/SSC Meeting, April 2003). Gill/trammel nets score low for other habitats. Vertical gear ranks in the low category of the fishing impacts index on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category of the risk index for coral. Longlines rank in the minor category of the fishing impacts index on coral and live/hard bottom habitats.

In the absence of effective control of fishery harvest and anthropogenic non-fishing impacts, the fishers would pay the primary cost of activities to minimize loss or damage to EFH. The immediate potential benefits to habitat and to fish production from restricting gill/trammel net and long line fishing from inferred coral areas and prohibiting trap lines are small compared to the potential benefits of controlling fishery harvest and managing non-fishing impacts. However, maintaining conditions for sustainable fisheries requires healthy habitats. As most anthropogenic non-fishing impacts occur in state waters (Section 3.5.2), any fishing impacts in the EEZ occur at some distance from the non-fishing impacts. On a local scale in the EEZ, fishing is often the primary impact on fish habitat.

The Council concluded that the management measures in this Alternative are practicable (See Section 4.5.5.4).
2.5.5 Alternative 4. Establish modifications to anchoring and pots/traps, and close additional 
areas to pots/traps, gill/trammel nets, bottom longlines, and fishing with SCUBA, for 
recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing 
impacts in the EEZ:

In addition to the measures listed under Alternative 3:

- Prohibit all pots/traps for use in fishing or on board vessels fishing on mapped coral areas 
  (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit gill and trammel nets for use in fishing or on board vessels fishing on mapped 
coral areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit SCUBA for use in fishing or on board vessels fishing on mapped coral areas 
  (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit bottom longlines for use in fishing or on board vessels fishing on mapped coral 
  areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit trap lines linking traps/pots for all fishing vessels that fish for or possess 
  Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the 
  Spiny Lobster and Reef Fish FMPs

**Rationale:** The gears used in the EEZ that can cause adverse fishing impacts on fish habitat are 
pots/traps, gill and trammel nets, spears, and bottom longlines. If the measures in Alternatives 1, 
2, or 3 do not adequately address adverse fishing impacts, management can eliminate these gears 
from mapped areas of coral (Figure 2.47) and prohibit trap lines on pots/traps throughout the 
EEZ. Coral is one of the most sensitive of habitats, even though only a small amount of habitat is 
mapped in the EEZ. Including all adversely impacting gears in the closure, without considering 
the relative impacts of each gear, increases enforcement effectiveness, as fishing with a 
prohibited gear cannot occur under the guise of fishing with a legal gear. Under this Alternative, 
adverse fishing impacts (Section 3.5.1.2) would be determined to occur in the EEZ, and that 
moderate gear modifications and total closures of coral habitats are necessary to address these 
impacts.

Prohibitions on the use of pots/traps, gillnets, trammel nets, and longlines on mapped coral/hard 
bottom habitat would eliminate those gears with the most potential for habitat damage. As an 
indirect consequence of this Alternative, overall catch in the fisheries would likely decrease, 
which would directly benefit overfished stocks using those areas. In general, increased 
enforcement requirements for gear prohibitions on mapped EEZ coral for traps/pots, gill nets, 
trammel nets, spears, and longlines would further strain current enforcement capabilities.

The prohibition on trap lines would prevent damage to primarily coral and hard bottom habitats 
that results from dragging trap lines during pot/trap retrieval. Lines under tension during retrieval 
could cause shearing and could drag pots across sensitive habitat. Prohibiting gill and trammel 
 nets and bottom longlines from coral and hard bottom areas that are inferred from spawning 
locations would greatly reduce any adverse impacts from these gears on these specific sites that 
are considered to be of high ecological importance. Fishers state that they don’t use pots/traps on
coral because of damage to traps, but surveys (Section 3.5.1, 4.5, 4.6) find traps/pots on coral. Less than 4% of trap/pot fishers would likely grapple on coral bottom (Section 4.5.3.1). Because grapples tend to hang up on the irregular coral bottom, fishers would likely use a retrieval method other than grappling on coral. Floating trap lines and slack in line between pots/traps minimize these problems. Prohibiting trap lines would reduce adverse impacts from the small proportion of fishers that grapple on coral, but would prevent fishers from using trap lines on habitats that do not experience adverse impacts.

This alternative is more likely to affect USVI gill net and trammel net fishers who use SCUBA to set nets in coral areas than Puerto Rico gill net and trammel net fishers who do not usually set nets near coral. Prohibiting fishing on mapped coral implies that future mapping would lead to closures as more coral is documented, and to decreased catch and increased costs to fishers.

The additional management measures proposed in this alternative apply only to coral because only coral habitats have been mapped in the EEZ and because of the sensitivity of coral habitat to damage. This Alternative retains the requirements described in Alternative 3 that include gear modifications that would reduce impacts on all habitat types.

Pots/traps have a fishing impacts index score of moderate (6) on coral, seagrass, and benthic algae and a moderate risk index, but observations suggest lower impacts (Section 4.5.1). Vertical gear ranks in the low category of the fishing impacts index on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category of the risk index for coral. Longlines rank in the minor category of the fishing impacts index on coral and live/hard bottom habitats, and in the minor category of the risk index.

In the absence of effective control of fishery harvest and anthropogenic non-fishing impacts, the fishers would pay the primary cost of activities to minimize loss or damage to EFH. The immediate potential benefits to habitat and to fish production from prohibiting fishing with pots/traps, gill/trammel nets, longlines, and spears on EFH are small compared to the potential benefits of controlling fishery harvest and managing non-fishing impacts. However, maintaining conditions for sustainable fisheries requires healthy habitats. As most anthropogenic non-fishing impacts occur in state waters (Section 3.5.2), any fishing impacts in the EEZ occur at some distance from the non-fishing impacts. On a local scale in the EEZ, fishing is often the primary impact on fish habitat.

The Council concluded that the management measures in this Alternative are not practicable (See Section 4.5.6.4).
2.5.6 Alternative 5. Establish total prohibitions on selected recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ by the following actions:

Prohibit the use of the following gears for fishing throughout the EEZ

- Pots/traps
- Gill and trammel nets
- Vertical line gear
- Spears
- Bottom longlines

**Rationale**: The fishing gears listed in this alternative are all those that are considered to have impacts on EFH that are more than minimal and not temporary. The Council convened workshops throughout the US Caribbean in May 1999 to explore with fishers the implications of prohibiting fishing gears, and received very high opposition. Under this alternative, a determination would be made that no measures other than prohibiting the use of pots/traps, gill and trammel nets, SCUBA, and bottom longlines for fishing throughout the EEZ would adequately address adverse impacts from fishing gears.

This Alternative would nearly eliminate reef fish and lobster catch from the EEZ and provide an opportunity for rebuilding in species with lower than desirable abundance. Calculations of bottom area within jurisdictional boundaries from the GIS indicates that approximately 15% of all US Caribbean EFH less than 100 fathoms depth occurs in the EEZ. This breaks down to about 2.6% from Puerto Rico and about 12.3% from the USVI. If fishing were distributed evenly across the shelf, the elimination of fishing in EEZ EFH in Puerto Rico might result in a loss of 2.6% of landings and value. The EEZ prohibition would, however, be likely to cause more intense fishing in state waters. Fishers would also be excluded from habitats in the EEZ that have low or no sensitivity to fishing gear. The effect would be greater for USVI fishers than Puerto Rico fishers because proportionately more of the USVI shelf in occurs in the EEZ.

A closure of the EEZ to traps/pots, gill/trammel nets, longlines, vertical line gear, and spears provides protection to sensitive habitats at the expense of eliminating a substantial portion of the US Caribbean to fishers.

Pots/traps have a fishing impact index score of moderate on coral, seagrass, and benthic algae and a moderate risk index, but observations suggest lower impacts (Section 4.5.1). Vertical gear ranks in the low category of the fishing impacts index on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category of the risk index for coral. Longlines rank in the minor category of the fishing impacts index on coral and live/hard bottom habitats, and in the minor category of the risk index. Spears rank in the low category of the fishing impacts index on coral and live/hard bottom habitats, and in the minor category of the risk index.

In the absence of effective control of fishery harvest and anthropogenic non-fishing impacts, the fishers would pay the primary cost of activities to minimize loss or damage to EFH. The immediate potential benefits to habitat and to fish production from restricting fishing on EFH are
small compared to the potential benefits of controlling fishery harvest and managing non-fishing impacts. However, maintaining conditions for sustainable fisheries requires healthy habitats. As most anthropogenic non-fishing impacts occur in state waters (Section 3.5.2), any fishing impacts in the EEZ occur at some distance from the non-fishing impacts. On a local scale in the EEZ, fishing is often the primary impact on fish habitat.

The Council concluded that the management measures in this Alternative are not practicable (See Section 4.5.7.4).

### 2.6 Alternatives considered but eliminated from the study

During the development of this EIS, the Council reviewed a variety of potential alternatives or concepts for alternatives to describe and identify EFH, designate HAPC, and address adverse fishing impacts on EFH. The Council considered and eliminated from further consideration some of these concepts and alternatives as described below.

#### 2.6.1 EFH

**2.6.1.1 Concept 3.** Describe and identify EFH for managed fish species as all waters of the Caribbean that include submerged aquatic vegetation (SAV), mangroves, algae, plains, reefs, reef-SAV interface, hard/live bottoms, sand, and mud.

Concept 3 specifies habitats (Figure 2.5-2.21) that fish species are generally known to occupy, but it does not link identification of EFH to the use of habitat at the level of individual species-life stages. The selected habitats are similar to the habitats listed in Alternatives that are developed from Concept 2 (Status quo). Concept 3 does not describe or identify EFH for any species and life stages, but the composite distribution of EFH under this Concept would not differ substantially from EFH under Concept 2. However, any habitats not listed under this Concept would not be described and identified as EFH. If a species-life stage from any of the four FMPs used a habitat that is not listed, then a portion of its habitat that might be important for its life cycle would not be identified as EFH. This Concept does not fulfill the requirements of the EFH Final Rule for any of the four FMPs because it does not specify species life stages and is not based on the four levels of information.

**2.6.1.2 Concept 4:** Describe and identify EFH based on the known distributions of all the various life stages of all species under management.

This Concept describes and identifies EFH in the same manner as Concept 6. However, this Concept does not link identification of EFH to the ecological functions listed in the M-S Act (spawning, breeding, feeding, growth to maturity). It also makes no attempt to distinguish between EFH and all the habitats occupied by all the species and life stages in the FMPs. The alternatives of Concept 6 use all the distribution information that would be used under Concept 4, plus all available information about the ecological relationships between managed species and the habitats they occupy. Concept 4 was therefore considered but rejected.
2.6.1.3 Concept 5: Describe and identify essential fish habitat based on habitat related densities of all life stages of all species under management.

If density information were available, then it would represent a higher level of information compared to the information used under other concepts (Section 2.1.3.2). Adequate density information is not available for species in any of the four FMPs, so no alternatives could be developed for describing and identifying EFH under this concept. This Concept was therefore not developed into specific alternatives in this EIS. However, the Council emphasized that Concept 5 should be re-considered in future EFH EISs as new information becomes available.

Habitat-related density information would help to better define EFH for species and life stages in the US Caribbean. Only limited density information presently exists for some managed species in very limited geographic areas of the US Caribbean. Given the small amount of background information that now exists, it is not currently possible to model this type of information and apply to the entire US Caribbean. New research efforts to obtain habitat-related density information for managed species across the US Caribbean would entail multi-year collections of fishery and fishery-independent data. Funding and time constraints preclude obtaining this information for inclusion in the EIS. Because complete mapping of habitat-related density information throughout the US Caribbean is unlikely to become available for any species in the near future, density mapping on discrete habitats representative of the entire area may allow inferences of density distributions using HSM techniques (Section 2.1.3.3.2). Available density data would probably result in a smaller overall area being identified as EFH than under Alternative 6 at the species/life stage level (Figure 2.4), but it is by no means certain that this would carry through into the composite EFH for each FMP. Nevertheless, “higher” density areas when added together over all the species in each FMP might not encompass the entire EEZ. Future updates of EFH by the Council should incorporate specific alternatives from such analyses presented to the Council.

2.6.1.4 Concept 7. Describe and identify EFH as all marine waters and substrates indicated on maps produced by spatially explicit, qualitative or quantitative information that link fish distributions and habitat.

No spatially explicit, qualitative or quantitative information linking fish distributions and habitat was available for the US Caribbean region. Due to lack of information, this concept was considered but rejected, and no alternatives were developed.

Spatially explicit information would allow development of alternatives using geo-referenced data (Section 2.1.3.3), but no such analyses are currently available for consideration for any of the four FMPs. Inquiries to local experts, universities, management agencies, or other researchers did not produce any such information, and did not produce suggestions for other sources of spatially explicit information. The compilation of such information, if it does exist, would require considerable time, effort, and money; beyond the constraints of the current funding and deadlines for the EIS. New research efforts designed to collect such information for the entire US
Caribbean would require surveys of fish and habitat in coordinated manner throughout the region. At a minimum, the surveys would be conducted on representative habitats to allow extrapolation to unsurveyed areas. Ideally, the surveys would include all areas. Such surveys would take several years and require substantial funding. Therefore, no specific alternatives can be developed using this Concept at this time. Future research may allow use of HSM techniques (Section 2.1.3.3.2) to quantify the ecological function-habitat link for species in the FMUs. If so, this concept could improve upon the alternatives under Concept 6, which infers distribution based on habitat use and upon alternatives under Concept 8, which applies HSM to a limited area and limited data set. If such spatially explicit information provided ranges of usage across habitats (information at levels 2 and above), then reduced areas of EFH would result. Smaller amounts of EFH would mean less area protected, but higher likelihood for effective protection. Future updates of EFH by the Council can incorporate specific alternatives from such analyses presented to the Council.

2.6.2 HAPCs

2.6.2.1 Alternative 3. Describe and identify HAPC as all habitat areas obligatory to a species life history.

Obligatory habitat areas for managed species are not presently known. Identification of such areas would require information at Levels 3 or 4, which does not currently exist for US Caribbean species. This alternative was therefore considered but rejected.

Determining obligatory areas would require laboratory and field research to determine the ability of species and life stages to utilize alternate habitats for ecological functions. Given the level of quantitative information that exists, it is not possible to model the degree on dependence of species on these habitats US Caribbean-wide. Collection of such information via new research efforts would require more funding and time than is currently available for inclusion in this EIS, but could be incorporated into future HAPC assessments. Because Alternative 3 cannot specify or map particular sites that meet the obligatory criterion, it does not meet the requirements of the NOAA Fisheries Final EFH rule.

Obligatory habitat areas might represent bottlenecks in the life history of one or more managed species. In terms of the concept of using “bottlenecks” as HAPC, the identification of a “bottleneck” implies finding a limiting factor in terms of fish production. These obligatory habitats might be limited and very specific habitat areas, which function as spawning grounds, migration routes, nursery grounds, etc., and are necessary to maintain levels of fish production. If information was available which allowed a quantitative distinction to be made among the US Caribbean habitats in various zones of the region, as far as their capacity to support the ecological functions for each life stage of managed species, then obligatory areas could be identified as those habitat areas that alone could support a particular function for a species. Such areas could be designated as HAPC. If information were available to determine which of these areas was most at risk from human activities, then the designation of HAPC on this basis might be narrowed even further. Narrowing the amount of HAPC to incorporate the most important areas would benefit the fish, fishers, and developers by focusing conservation attention on the areas that support highest fish production and minimizing restrictions in other areas.
The Council wanted to use obligatory areas information to the degree possible, so chose to combine this with other general information from Alternatives 7 and 8. The Council placed this in the category of recommended for future consideration. Future updates of HAPC by the Council can incorporate specific alternatives from such analyses presented to the Council. If complete information on the four considerations listed in the Final Rule for identifying HAPC (ecological importance, habitat sensitivity to human-induced degradation, extent of stress on habitats from development activities, and rarity of the habitat) were available, then these considerations could be used to develop alternatives for HAPC as described in Section 2.1.4.2.5. This would allow quantitative scaling of these considerations to evaluate concepts and sites proposed for HAPC. With more information, considered and rejected HAPC alternatives 3, 5, and 6 could be reevaluated using an objective procedure.

If sufficient information were available, the analysis of ecological importance could be expanded by weighting the habitat use of species and life stages differently, to cover factors such as ecological bottlenecks (Alternative 3), important early life history areas (Alternative 5), or migratory routes (Alternative 6).

Rarity could be considered with complete mapping of habitats, which would allow calculation of habitat rarity using a subdivision of the total area into parcels of contiguous patches of a single habitat type. The relative rarity of a habitat parcel could be calculated on the basis of the spatial extent of the parcel (and all other parcels with the same characteristics) compared to the overall extent of the area being studied, and the distance between this parcel and its nearest neighbor parcel with the same characteristics.

Sensitivity to human-induced degradation occurs for both fishing and non-fishing activities (Section 2.1.4.2.2). Different habitat types can be more or less sensitive to impacts from non-fishing activities that threaten the capacity of the habitat to maintain (or restore) its ecological function for managed species. If sufficient information were available, sensitivity to non-fishing impacts would be measured on a relative scale similar to the measurement of the fishing sensitivity (Section 2.1.5.3). Weighting factors for each of the habitats and effects would be scored based on the potential severity of a given activity/effect on a specific habitat. These scores would use the quartile approach used elsewhere in this document, and would range from 0 (no effect) to 3 (large effect).

The extent of stress from development activities could be calculated if spatial distribution of non-fishing (development) activities were available in a GIS-compatible format to allow overlay mapping on habitats. Since the data would probably vary by units (some data might be points, others might be in miles or acres), the values for a given activity/effect could be reduced to a value based on a quartile distribution (see Section 2.1.5.3.3.) of those data throughout the region.
2.6.2.2 Alternative 5. Describe and identify HAPC as those habitat areas used by early life stage development of each species in the FMUs.

Many species of marine organisms aggregate on specific types of habitat which function as nursery areas. Others disperse over a wide range of habitats. Larval and juvenile stages are sensitive to stressors such as temperature and pollution. A qualitative assessment of nursery areas is available for many Caribbean species. However, quantitative information on habitat areas used for early life stage development by managed species are not presently mapped or modeled. Collection of such information via new research efforts would require surveys of likely habitats at times of the year when they function as nursery areas for the FMU species over several years. Nursery grounds for some species in the FMPs may be generally known, but not in sufficient spatial detail for mapping. Because Alternative 5 cannot specify or map particular sites that meet the early life stage development criterion, it does not meet the requirements of the NOAA Fisheries Final EFH rule. This alternative was therefore considered but rejected. Use of additional data would proceed as described in Section 2.6.2.1.

Habitat areas that serve as nurseries for managed species might represent “bottlenecks” in the life history of one or more managed species. If quantitative information was available which indicated that nursery areas were “bottlenecks” for some managed species, and represented a limiting factor in terms of fish production, then nursery habitats could be identified as HAPC. These nursery habitats might be limited and very specific habitat areas, which are necessary to maintain levels of fish production. If information was available which allowed a quantitative distinction to be made among the US Caribbean habitats in various zones of the region, as far as their capacity to support the growth to maturity function (nursery function) of managed species, then nursery areas could be identified as HAPC. This might be based on a single species with very narrow requirements for its nursery habitat or the requirements of multiple species. If information was available to determine which of these areas was most at risk from human activities, then the designation of HAPC on this basis might be narrowed even further. Narrowing the amount of HAPC to incorporate the most important areas would benefit the fish, fishers, and developers by focusing conservation attention on the areas that support highest fish production and minimizing restrictions in other areas.

The Council wanted to use nursery ground information to the degree possible, chose to combine this with other general information from Alternatives 7 and 8, which also uses other, perhaps limited, information to select specific areas for HAPCs. Thus, Alternatives 7 and 8 use an array of information on ecological functions within a mapped area, even if the information is qualitative. The Council placed this in the category of recommended for future consideration. Such information could be incorporated into future HAPC assessments as it becomes available.

2.6.2.3 Alternative 6: Describe and identify HAPC as those habitat areas used by managed species as migratory routes that are most in need of protection (to be determined).

Many species migrate from place to place using particular routes as they develop from one life stage to another, or as they transition from one ecological function to another. Perturbations of these routes could delay or divert fish, at the cost of future production. Specific spatial
information on the migratory routes used by managed species does not yet exist at a level of
detail that would allow mapping. Present constraints on funding and time do not allow new
research delineating migratory routes to be done in time for inclusion in this EIS. However, such
information could be incorporated into future EFH assessments as the information becomes
available. Migratory routes for some species in the FMPs may be generally known, but not in
sufficient spatial detail for mapping. Because it is not possible to map particular sites that meet
the early life stage development criterion to support Alternative 6, it does not meet the
requirements of the EFH Final Rule. Use of additional data would proceed as described in
Section 2.6.2.1.

Migratory routes utilized by managed species, might be seen as “bottlenecks,” if human
activities can disrupt the use of these routes and cause a decline in fish production. If information
was available on the location of these migratory routes and additional quantitative information
on human activities (fishing and/or non-fishing) indicated that habitat alteration by one or more
activities disrupted the habitat’s use as a migratory route, then these migratory routes could be
designated as HAPC. This might be based on a single species with very specific migratory route
requirements or more general routes used by multiple species. If information were available to
determine which of these areas was most at risk from human activities, then the designation of
HAPC on this basis might be narrowed even further. Narrowing the amount of HAPC to
incorporate the most important areas would benefit the fish, fishers, and developers by focusing
conservation attention on the areas that support highest fish production and minimizing
restrictions in other areas.

The Council wanted to use migratory route information to the degree possible, so chose to
combine this with other general information from Alternatives 7 and 8, which also uses other,
perhaps limited, information to select specific areas for HAPCs. Thus, Alternatives 7 and 8 use
an array of information on ecological functions within a mapped area, even if the information is
qualitative. The Council placed Alternative 6 in the category of recommended for future
consideration.

2.6.3 Actions to prevent, mitigate or minimize the effects of fishing on EFH

2.6.3.1 Limit longline gear to 300 or 500 feet in length on coral, gorgonian, or sponge habitat.

The Council determined that limiting the length of longline gear to protect habitat is not feasible
without also limiting the number of sets. The enforcement cost of such a measure is not
reasonable for the amount of habitat protection that is likely to result. This actions was
considered but rejected and was therefore not include in any of the bundles that constitute the
alternatives to prevent, mitigate or minimize the effects of fishing on EFH.
2.6.3.2 Require buoyancy on fish traps/pots on coral, gorgonian or sponge habitat.

The rational for this action was to reduce the impact of fish traps and pots on sea-floor habitat by reducing the velocity with which they hit the bottom when first deployed. However, buoyancy might also cause traps to bounce along the bottom while they are fishing due to the action of water movement from tides and waves. It is likely that the additional damage caused by trap movements would outweigh the reduction in damage on first impact with the bottom. This action was therefore not included in any of the bundles that constitute the alternatives to prevent, mitigate or minimize the effects of fishing on EFH.

2.6.3.3 MOU with commonwealth and territorial governments

The Council chose to work informally with Commonwealth and Territorial governments on EFH issues rather than establish a more formal arrangement such as an MOU. An MOU would not be binding to the governments, the Council, or NOAA Fisheries. The composition of the Caribbean Council, made up primarily of senior fishery agency staff and private citizens from Puerto Rico and USVI, offers an excellent opportunity for cooperation among the state and federal agencies and the Council. Council members discuss important issues, and decide which to make high priorities. Council members employed by fishery agencies can immediately transmit Council decisions and policies to the agencies. Council staff members work directly with agency staff members to implement projects jointly supported by the Council and the state governments. The cooperation among the various agencies including NOAA Fisheries (Habitat Conservation, Enforcement, Sustainable Fisheries), the Caribbean Council, Sea Grant and the PR-DNER and USVI-DPNR has been very successful and included discussion and joint projects for fishery regulations, description of habitat, habitat form and function, and the impact of fishing or other human related activities on fisheries and fisheries habitats (e.g., anchoring, trampling, fishing).

The creation of the Marine Conservation District represents an example of the Council, Puerto Rico, the USVI, and federal agencies cooperating to convert policy (protecting heavily fished spawning aggregations and spawning habitat) into management action (no-take closed area). Puerto Rico and USVI fishery agencies are currently evaluating appropriate management for similar areas in state waters.

The Council actively encourages joint habitat and other research among state and federal agencies and universities in Puerto Rico and the USVI, and widely distributes funding notices to local scientists, NGOs, fishers (e.g. CRP) and state agencies that can and do apply for funding. The Council encourages state participation in federal research in support of Council-requested research. NOAA Fisheries has worked closely with the state fishery agencies to address management alternatives such as prohibiting traps in certain areas, banning the use of traps and to develop measures of socio-economic impacts of management actions. NOAA Fisheries also works closely with the states and the Council in support of SEAMAP research. Extensive joint research has occurred and is continuing for mapping to determine what habitats are available, where they are located, how much of each there is, and what function they serve for fish species.
2.6.3.4 VMS for fishing vessels

The Council has previously considered VMS for fishing vessels, but costs and logistic concerns led the Council postpone further consideration.

2.6.4 Framework Alternatives

2.6.4.1 Alternative 1. Do not modify the framework process.

2.6.4.2 Alternative 2. Establish a framework procedure for each Council FMP to provide the Council with a mechanism to add to or adjust EFH measures, as the Council receives new information to justify new measures.

When new information becomes available, a framework procedure would allow the Council and NOAA Fisheries to add to or adjust EFH measures without the need for a full FMP amendment. The framework would be especially useful as a means of implementing future actions to add to or modify EFH, prevent, mitigate or minimize adverse fishing impacts on EFH, or add to or modify HAPCs that the Council selects during this process. However, frameworks require an analysis of foreseeable situations to which the framework will apply and the analysis-in-advance is not practicable for EFH. The complexity of the issues and lack of information restrict analysis of current circumstances, which makes analysis of future events too speculative for implementing a framework process.
3 AFFECTED ENVIRONMENT

3.1 Physical environment

The crust of the earth consists of a series of plates that are in motion, propelled from earth’s core by inner forces of pressure and heat (Rudder no date). Where plates are in contact with each other there may be a wide range of outcomes, most spectacularly earthquakes and volcanoes as regularly recorded in the history of the Caribbean. The main archipelago of Caribbean islands formed along the area where the American Plate is being subducted beneath the thicker Caribbean Plate. Earthquakes have been common through recorded history, caused as plate material has submerged, heated and melted and then pushed violently upwards to burst out initially as submarine volcanoes then later as emergent islands. A volcanic island platform that includes Puerto Rico and the Virgin Islands was formed at the leading edge of the Caribbean plate as the Puerto Rico Trench subduction zone developed (Morelock et al. 2001). Limestones filled in between volcanic flows to form Puerto Rico about 40 million years ago. Puerto Rico and the U.S. Virgin Islands (USVI) are mountainous with central highland areas, and rise to a maximum altitude of about 4,400 feet above sea level in Puerto Rico and about 1,100, 1,560, and 1,280 feet above sea level on St. Croix, St. Thomas, and St. John, respectively (Olcott 1999). Composition of the coastlines can be categorized as: 1) hard (resistant) composed of limestone or igneous rock; 2) semi durable composed of eolianite or beachrock which is less cemented and more erodible than the first group; 3) erodible unconsolidated deposits such as beach, alluvial fan, alluvial plain, or dune (Morelock et al. 2001). Another category, mangrove shorelines, lies between group 2 and 3, and often shows accretion.

3.1.1 Puerto Rico

The island of Puerto Rico is almost rectangular in shape, about 35 by 110 miles, and is the smallest and the most eastern island of the Greater Antilles (CFMC 1998, Morelock et al. 2001). Its coast measures approximately 700 miles and includes the adjacent islands of Vieques and Culebra. To the north and south, seascapes measure 8.525 m for the Grave of Puerto Rico and 5.000 m for the Grave of Tanner. In addition to the principal island, the Commonwealth includes the islands of Vieques, Culebra, Mona, Monito, and various other isolated islands. Deep ocean waters fringe Puerto Rico. The Mona Passage, which separates the island from Hispaniola to the west, is about 75 miles (120 km) wide and more than 3,300 feet (1,000 meters) deep. Off the northern coast is the 28,000 foot (8,500 meters) deep Puerto Rico Trench, and to the south the sea bottom descends to the 16,400 foot (5,000 meters) deep Venezuelan Basin of the Caribbean.

The territory is very mountainous (cover 60 percent). There is a coastal plain belt in north, mountains reaching right up to the west coast, and sandy beaches along most coastal areas (CFMC 1998). The Cordillera Central, the Sierra de Luquillo, and the Sierra de Cayey generally are oriented east-west and dominate the mountainous southern two-thirds of the island (Olcott 1999). An area of gently dipping limestone that has been deeply dissected by dissolution forms a wide band of karst topography along most of the north coast. Flat-lying coastal plains and alluvial valleys compose a discontinuous belt around much of the periphery of the island. The
coastal plain is especially prominent along part of the south coast where adjacent streams deposited coalescing fan deltas to form a broad, continuous plain.

Drainage on each of the islands characteristically consists of short, deeply incised streams that have steep gradients in the upper reaches (Olcott 1999). Drainage generally is radial from the central highlands to the sea. Few of the streams along the southern coast of Puerto Rico, its offshore islands, or the USVI are perennial, but flow only after major precipitation and during sustained wet periods. Many small rivers and high central mountains ensure land is well watered; the south coast is relatively dry; and a fertile coastal plain belt is found to the north. Of the 1,200 bodies of water on Puerto Rico only 50 are classified as rivers (CFMC 1998). In addition, there are many surface water bodies that are either part of the estuarine system of these rivers, or have their own outlet to the Caribbean Sea or Atlantic Ocean. Numerous rivers flow down from the mountains to distinct coastal plains. The Central Range divides the north (Atlantic) and south (Caribbean) watersheds. The northern rivers are long, rich and tranquil waters in comparison to the southern rivers, and the coast is wet and green. The major rivers are Grande de Loíza (65 km), Bayamón (40 km), La Plata (80 km), and Grande de Arecibo (55 km). To the west and the east are the river basins that form the water systems, and these rivers are Culebrinas (45 km), Grande de Añasco (65 km), and Guanajibo (36 km). Subterranean streams are abundant, especially toward the northwest. Puerto Rican rivers are not navigable except near the coast, but they provide electrical power generation and irrigation.

Precipitation in Puerto Rico and the Virgin Islands is highly variable, both seasonally and areally (Olcott 1999). Seasonally, a dry period begins in December and ends in March or April. This is usually followed by a period of intensive rainfall in April and May. A period of diminished rainfall in June and July is followed by the wet season that extends from August through November during which about 50 percent of annual rainfall occurs. Hurricane recurrence studies to 1998 reported more than 130 hurricanes in the Tropical Atlantic zone with 21 coming within 60 miles of Puerto Rico (Morelock et al. 2001). About 30 hurricanes passed less than 400 kms south or north of San Juan from since 1940.

3.1.2  U.S. Virgin Islands (USVI)

The USVI are part of the Virgin Islands, a group of about 90 small islands and cays in the West Indies (CFMC 1998). Most of the USVI are uninhabited. All of them are considered part of the Leeward Islands and the Lesser Antilles. They cover an area of about 195 sq. miles with a coastline of about 175 miles. St. Croix is entirely surrounded by the Caribbean Sea. The shores of St. Thomas and St. John open onto the Atlantic Ocean to the north and the Caribbean Sea to the south.

The hilly peaks of the USVI formed from volcanoes over a period of 25 million years (CFMC 1998). They are all peaks of submerged mountains, most of them now extinct volcanoes, rising from a submarine plateau. In St. Thomas, flat, low-lying areas are limited to the Charlotte Amalie area and a few narrow beaches (Olcott 1999). St. John is similar to St. Thomas but has even less flat land; flat land is limited mostly to the Cruz Bay and Coral Bay areas. The
northwestern and eastern parts of St. Croix are characterized by low mountains and rugged hills. The central and southwestern parts of the island are low-lying to gently rolling hills.

St. Croix, the largest of the islands, is about 28 miles long and covers an area of 82 sq. miles (CFMC 1998). It is about 40 miles south of St. Thomas and St. John. St. Thomas consists of a range of hills and has little level land. It covers an area of 32 sq. miles. Magens Bay in the center of the north coast has more than 3,500 ft of white sand beach and is one of the finest beaches in the Caribbean. St. John, the smallest of the three, has an area of about 20 sq. miles. It is the most easterly of the islands and is only half a mile to the west of the British Virgin Islands.

Rainfall in the USVI also varies with season, with periods of peak precipitation occurring from September through November, followed by a dropoff in rainfall in December.

3.1.3 Ocean water characteristics

The following description of water movements and marine habitats is derived from summaries provided by UNEP/IUCN (1988), Appeldoorn (1993), Morelock et al. (2001), Capella et al. 2003, and Gyory et al. (2004). The following currents and associated hydrologic features transport pelagic larvae and other planktonic organisms in the US Caribbean.

Hydrologic patterns link the waters of the US Caribbean with the Florida Keys and southeastern Florida. To the north of Puerto Rico and the USVI, there is a westward flow of the North Equatorial current and to the south is the Caribbean current. The waters of the westward flowing North Equatorial Current primarily influence the marine waters of the US Caribbean. The North Equatorial Current is the predominant hydrological driving force in the Caribbean region. It flows from east to west along the northern boundary of the Caribbean plateau and splits at the Lesser Antilles. The North Equatorial Current flows westward along the north coasts of the islands. North of the Mona Channel it splits, with one branch flowing north of Silver and Navidad Banks, past Turks and Caicos to form the Bahamas Current. The southern branch parallels the north coast of Hispaniola about 30 km offshore. A small gyre has been documented off the northwest corner of Puerto Rico resulting in an easterly flow nearshore in this area.

The north branch of the Caribbean Current flows west into the Caribbean Basin at roughly 0.5 meters (1.7 feet) per second. It is located about 100 km south of the islands, but its position varies seasonally. During the winter it is found further to the south than in summer. Flow along the south coast of Puerto Rico is generally westerly, but this is set-off by gyres formed between the Caribbean Current and the island. The Antilles Current flows to the west along the northern edge of the Bahamas Bank and links the waters of the Caribbean to those of southeastern Florida.

The Caribbean current flows at an average speed of 0.5 to 1 knot, and it is located about 100 km to the south of the Islands. The westward flow of nearshore water along the south coast of Puerto Rico has been reported by Yoshioka et al. (1985), Colin and Clavijo (1988). The westward flow of nearshore waters along the north coast is “interrupted” by a gyre off the northwest coast of Puerto Rico that results in an eastern flow in the area.
This general description omits much of the intricate and complex nature of the smaller scale flows of the area. For example, in the Mona Passage – still a large-scale flow – the net surface flow is to the northwest, especially during the summer. Alongside the Mona Passage there is a strong southwest flow into the Caribbean and countercurrents have been described for the area.

The circulation in the Caribbean experiences much variation in both space and time, some of it in the form of mesoscale eddies and meanders (Gyory et al. 2004). Researchers have proposed several physical processes to explain this variation. Dominant processes depend on bottom topography, wind forcing, current width and shear, and the collision of North Brazil Current rings with the Antilles. Eddies often appear near bottom topographic features, but the large number of topographic features has caused uncertainty whether the topographic features cause eddies, or coincidentally exist near them. Wind stress appears to modify eddies and meanders. However, similar drift patterns surface and sub-surface drifters and simulation that replicate drifter patterns models without wind input indicate that wind is not the primary cause of the variation.

The Guiana Current enters the Caribbean along the northern coast of South America (Gyory et al. 2004). The current is significantly influenced by freshwater discharges from the Amazon and Orinoco Rivers. Several rivers exert intermittent but important influence on the waters of the Caribbean Basin including the Amazon, the Orinoco, the Magdelana, and the Columbian. The plume from the Orinoco River, for example, can carry with it high concentrations of suspended particles, unique chemical properties, and biota up past the Lesser Antilles and along the Greater Antilles, to near the south coast of Puerto Rico. The plume, therefore, can be responsible for events of high turbidity and algal blooms that often occur in the Caribbean Basin in October.

Coastal currents around PR-USVI are mainly tidally and wind driven (Capella et al. 2003). The narrow and shallow shelf is in most places directly exposed to the open ocean, especially along the north coast. With the exception of bays and lagoons, coastal flows are steered by the coastline-shelf topography and are therefore east-west along the north and south coasts, north-south in Mona Passage, and variable on the shallow Virgin Islands platform.

Suspended matter contributes to light attenuation, especially near shore. Other factors, such as non-point sources can also reduce the transparency of the water and reduce the amount of photosynthetic active radiation reaching autotrophic species such as seagrasses and corals. Seagrasses require 10-20% of photosynthetic active radiation reaching the surface; branching corals require 60% and massive corals about 40% of photosynthetic active radiation.

It is believed that no upwelling occurs in the waters of Puerto Rico or the USVI (except perhaps during storm events) and, since the waters are relatively stratified, they are severely nutrient-limited. However, upwelled waters from the north coast of South America are advected into the US Caribbean region, principally in the autumn (Morelock et al., 2001). In tropical waters nitrogen is the principal limiting nutrient. Primary productivity rates in the area range between 55-90 gC/m²/yr with rates in the south varying between 37-55 gC/m²/yr.
The Caribbean Sea is highly stratified in the upper 1200 m of the water column (Gyory et al. 2004). The structure and composition of the Caribbean Surface Water exhibit a well-defined seasonal pattern (Capella et al. 2003). In the northeastern Caribbean Sea, the depth of the thermocline reaches a maximum of 100 m in the spring (January – March) and a minimum of 25 m in the fall (September – October). Density, temperature, and salinity follow the same seasonal patterns with temperatures and salinities ranging from 26 to 30 °C and from 34 to 36.3 ppt, respectively. The large range in offshore surface salinities is due to the northwards advection-mixing of South American riverine outflow in the eastern Caribbean Sea, especially from the Orinoco River.

Oceanic currents flow from east to west on both coasts of Puerto Rico, although there is a periodic reversal on the north coast. The north and east coasts are exposed to winds and waves from the Atlantic Ocean striking the island from the east and northeast. The Cordillera Central, oriented east-west across the island, causes a considerable reduction in rainfall from northeast to southwest. Average rainfall varies from over 5,000 mm in the Sierra de Luquillo to less than 1,000 mm on the south coast. There are two rainy seasons, one between July and November (the hurricane season) and one in May. Tropical storms and hurricanes develop with easterly air streams and are accompanied by torrential rain and high seas. Occasional cold fronts during the winter months bring torrential rain for several days and cause extensive flooding. Average temperatures vary very little from 28.1°C in September to 25.5°C in February.

Sea surface temperature (SST) ranges from a minimum of 25EC in February-March to a maximum of 28.5EC in August-September. Inshore temperatures may be higher (e.g., 30EC) due to shallower depths or may be influenced by thermal plumes from generator plants (see below). Attempts have been made to correlate SST to changes in the marine biota under the surface (i.e., at depths greater than 3 meters, for example) but as reviewed by Quinn and Kojis (1994) these works show no consensus specifically when dealing with rising SST and coral bleaching. Changes in SST associated with coral bleaching are reviewed in detail in the Coral FMP. Quinn and Kojis (1994) best summarize the importance of long-term and high-resolution sea temperature (both surface and subsurface) data sets in assessing environmental changes and the effects on marine organisms. Also, these authors summarize the meaning of these long-term data sets to the coastal areas (e.g., global warming, and sea level rise). There is no doubt that there are some long-term data sets (e.g., USVI Department of Planning and Environmental Resources/Division of Environmental Protection) on water quality for a number of specific sites but in terms of temperature most information available are surface measurements. Sea surface temperature is recorded from the upper 3 meters of water while very seldom is subsurface temperature recorded (Quinn and Kojis 1994).

There are differences in the tidal regimes between the north and south coasts with the fluctuations being highest on the north coast (where waves are also larger). The fluctuations range from a diurnal tide of about 10 cm on the south coast to a semi diurnal regime of between 60 and 100 cm along the north coast (Kjerfve, 1981). Tidal range is slight (0.18-0.34 m) and tides are normally semidiurnal except on the south coast where these are diurnal.

There are no perennial streams in the USVI. The extensive alteration of the islands' ecosystems, through burning, mono-crop agriculture (sugar cane), and the subsequent regrowth of scrub
vegetation have eliminated free flowing streams. During the periods of intensive rainfall, up to 6 inches in 24 hours, runoff through “guts” can produce serious lowland flooding and a temporary lowering of coastal water quality. As a general condition, the coastal waters are exceptionally clear due to the lack of sediments and nutrients from rivers (USVI Coastal Zone Management Plan).

3.2 Biological environment

The National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) acquired aerial photographs for the nearshore waters of Puerto Rico and the USVI in 2000. These images were used to create maps of the region’s coral reefs, seagrass beds, mangrove forests, and other important habitats. The benthic habitat map (Kendall et al. 2001) resulting from this project is searchable at a variety of scales, however the mapping was done at the scale of one acre, which limits the level of detail.

Twenty-one distinct benthic habitat types within eight zones were mapped directly into a geographic information system (GIS) using visual interpretation of orthorectified aerial photographs. Benthic features were mapped that covered an area of 1600 km$^2$ in Puerto Rico and 490 km$^2$ in the USVI. In Puerto Rico, 49 km$^2$ of unconsolidated sediment, 721 km$^2$ of submerged vegetation, 73 km$^2$ of mangroves, and 756 km$^2$ of coral reef and colonized hard bottom were mapped. In the USVI, 24 km$^2$ of unconsolidated sediment, 161 km$^2$ of submerged vegetation, 2 km$^2$ of mangroves, and 300 km$^2$ of coral reef and hard bottom were mapped. Overview maps from Kendall et al. (2001) are presented in Figures 2.5 to 2.15. Table 3.1 presents areal extent of marine biotopes for coastal areas of Puerto Rico and the USVI prepared for the Generic Amendment, with updated summaries from recent NOS mapping. Table 3.2 classifies habitats used in this document into estuarine and marine environments.

About eighty different bottom types are found around Puerto Rico and the USVI (CFMC, 1984; CFMC 1994). The bottom types vary with depth and consist of combinations of gravel, rock, sand, mud, and clay. The bottom types greatly influence which organisms are found in each habitat. In turn, some organisms residing in different bottom types may also modify those substrates (as ecosystem engineers), and be an intimately associated with the habitats and their ecological function (Coleman and Williams 2002). Ecosystem engineers include organisms whose physical morphology adds complexity to the habitat they occur in (autogenic engineers: wetland plants, mangroves, seagrasses, benthic algae, corals, coralline algae) and those which live in habitats and modify them by their behaviors and actions (allogenic engineers: burrowing, boring, and foraging organisms).

Many of the hard bottom areas consist of coral and non-coral reefs. Nearshore, coral reefs are common. Inshore of the reefs, the dominant habitats are seagrasses and tidal wetlands, primarily mangrove wetlands. Acting together these coastal areas provide food, habitat, and water quality maintenance functions that support the areas’ important fisheries.

The coastal habitats (i.e., reefs, seagrasses, and mangroves) are all interconnected physically, chemically and biologically providing mutual support and operating as one system (CFMC
For example, the reefs are efficient at dissipating wave energy and provide the quiescence required for establishment and maintenance of seagrass and mangrove habitats. Mangrove fringes trap fine sediments that would otherwise be carried into reef areas and smother sensitive corals. Seagrasses bind and stabilize the sediments that could also damage the reefs. Seagrass beds and reefs are also important sediment sources in areas where external sediment inputs are very small (Cintrón, 1987). Each of these habitats is used in turn by various ontogenetic stages of fishery species and their prey. Coral reefs, seagrass beds, and mangrove wetlands are the most productive of the habitat types found in the Caribbean, but other areas such as soft-bottom lagoons, algal plains, mud flats, salt ponds, sandy beaches, and rocky shores are also important in overall productivity. The use of these habitats has been reviewed for preparation of this document based on the use of these habitats by managed species. The habitats that make up these subsystems are briefly described for the specific species managed by the Council; references to the species that utilize these habitats are included. General distributions of these habitats are included in the sections that follow.

The marine waters of the Caribbean are relatively nutrient poor and as such have low rates of primary and secondary productivity, but the inshore waters of the Caribbean islands display some of the greatest diversity of any part of the US South Atlantic region. Highly diverse and highly abundant concentrations of biota are found in these areas.

3.2.1 Tidal wetlands and marshes (Estuarine)

Wetlands are classified on the basis of their hydrology, vegetation, and substrate. Coastal (emergent) wetlands can occur in either the estuarine or marine systems. Estuarine emergent wetlands are described as tidal wetlands in low-wave-energy environments, where the salinity is greater than 0.5 parts per thousand (ppt) and is variable owing to evaporation and the mixing of seawater and freshwater. Marine emergent wetlands are described as tidal wetlands that are exposed to waves and currents of the open ocean and have a salinity of greater than 30 ppt. Although many types of coastal wetland ecosystems are found and provide habitat for managed species in the US Caribbean, two types predominate. These are (1) mangrove wetlands (estuarine/marine intertidal forested and shrub) in Puerto Rico and (2) intertidal salt flats in Puerto Rico or salt ponds in the Virgin Islands. Additionally, tidal salt marshes (estuarine/marine intertidal emergent) provide habitat functions for some managed species.

A guide to Puerto Rico’s wetlands published by the US Army Corps of Engineers (1978) further divided wetlands into 9 types based on salinity conditions and the flora present: saltwater aquatic, saltwater coastal flat, saltwater marsh, saltwater swamp, freshwater aquatic, freshwater flat, freshwater marsh, and freshwater swamp. Detailed descriptions of these Puerto Rican wetland types are contained in the 1978 guide.

Tide, salinity, nutrients, and temperature influence structure and function of a saltmarsh. The saltmarsh can be a stressful environment to plants and animals, with rapid changes occurring in these abiotic variables (Gosselink 1980; Gosselink et al. 1974). Although species diversity may be lower than in other systems, the salt marshes are some of the most biologically productive ecosystems in the world (Teal and Teal, 1969). The high primary productivity that occurs in the
marsh, and the transfer of detritus into the estuary from the marsh, provide the base of the food web supporting many marine organisms.

Many salt marshes are drained by an intricate network of tidal creeks. These tidal creeks and the adjacent marsh function as nursery areas for larval and juvenile finfish, crustaceans, and mollusks, and as an important habitat for adult fisheries species. Many of the species landed both in commercial and recreational fisheries in the US Caribbean utilize wetlands during some portion of their life cycle. The marsh provides food, structure, and refuge from predators to various life stages of fishery organisms. In addition to its function as an essential fish habitat, the marsh plays a vital role in the health and water quality of the estuary and coastal areas by regulating the amounts of freshwater, nutrient and sediment inputs into the estuary. The position of salt marshes along the margins of estuaries and coastlines and their dense stands of persistent plants make them valuable for stabilizing shoreline and for storing floodwaters during coastal storms.

Estuarine marshes (emergent wetlands) are uncommon in Puerto Rico. They usually form a narrow transition zone between mangrove-dominated wetlands and adjacent freshwater wetlands. Plant species in estuarine marshes typically include sawgrass, cattails, and leather ferns. Although marshes may develop in sandy sediments, especially in high-energy areas, marsh development typically leads to sediments with fine particle-size (mud) and high organic matter content. In most physical settings, marshes can accrete sediments, and thus maintain their elevation in relation to the rising sea level. Salt marshes persist longest in low-energy protected areas where the rate of sediment accretion is greater than or equal to the rate of subsidence (Mitsch and Gosselink, 1986).

3.2.2 Mangroves (Estuarine and Marine)

Low energy depositional environments within the tropics are colonized by an assemblage of salt tolerant trees or bushes that have received the collective designation "mangroves" (Cintron, 1987). These all share similar adaptations and growth habits that allow them to colonize waterlogged oxygen deficient and saline soils. These grow as trees or shrubs along most tropical estuaries and sheltered shores. Although worldwide there are more than 56 mangrove species, only four are found in the USVI and Puerto Rico. These are red mangrove, *Rhizophora mangle*; black mangrove, *Avicennia germinans*; white mangrove, *Laguncularia racemosa*; and the buttonwood, *Conocarpus erectus* (Cintron, 1987). NOS prepared maps with distribution of mangrove fringe areas for Puerto Rico (CFMC 1998). NOS updated the distributions (Kendall *et al.* 2001) using aerial photography. Of the total 5009 km$^2$ of benthic habitat mapped by NOS in Puerto Rico, 73 km$^2$ (1.4 %) was mangrove fringe. The buttonwood, although frequently referred to as a mangrove, does not meet the strict mangrove definition proposed by Tomlinson (1986). In some instances all four species may be present in a location and segregate among themselves and other wetland plants based on elevation, salinity, substrate suitability, availability of sediments and nutrients, and seed source availability. Exposed and sheltered mangrove shorelines are common throughout the US Caribbean (Armstrong 1983).
Mangroves represent a major coastal wetland habitat in the southeastern United States, occupying in excess of 200,000 hectares along the coastlines of all Gulf coast states, Puerto Rico, and the U. S. Virgin Islands. Mangrove wetlands are the dominant type of emergent wetlands in Puerto Rico. Mangroves inhabit low energy intertidal areas in Puerto Rico and the USVI (Cintrón, 1987). Suman (1994) provided a review of the management and conservation of mangrove ecosystems.

NOS prepared maps of mangroves and other nearshore habitats from 1984 NOS/HAZMAT data (CFMC 1998) and further updated mangrove distributions (Kendall et al. 2001, Figures 2.5 to 2.15).

The PR/DNER prepared a final document (April 1997) that constitutes the management plan for mangroves. This document, and its appendices, review the literature available for the mangrove forests in Puerto Rico, reviews the inventories of mangrove forests, establishes the functional criteria of mangroves and the need for conservation and appropriate management of development of these areas that are in need of special preservation efforts. The PR/DNER document establishes definitions of mangrove areas that need to be preserved and conserved as areas of great ecological significance, uniqueness, and great ecological sensitivity. These mangrove areas are recognized as important substrates for nursery grounds, protection, and feeding areas of marine organisms. These areas sustain important populations of fish and shellfish important in the commercial and recreational catch. The flux of nutrients (organic and inorganic matter) from mangrove areas creates the link.

In general, mangroves tend to form fairly uniform forests dominated by a single species. In some instances all species may be present in a location and form banded stands, which are known as "banding" or "zonation," due to a series of factors. The forests dominated by mangrove trees support a very complex assemblage of marine plants and animals and can be highly productive.

Mangrove forests are open; they receive significant energy input from the land by river flow and runoff and from the sea by tides, current, and waves. The materials received from these sources favor the maintenance of high photosynthetic rates. In addition, mangroves are considered "plastic;" these can adapt to the particular mix of environmental factors in a given location. The degree of growth and development they reach will be a function of all the environmental factors that characterize the site. If one of these environmental factors does not lead to the development of mangrove forests, other non-mangrove systems, such as seagrass beds or coral communities may emerge.

There are a number of environmental factors which impact size and areal coverage of mangroves. These include the following:

1. Suitable topography meaning flat terrain and where salt water can reach inland
2. Saline water that eliminates many plant species that would otherwise compete for space and eventually excludes mangroves
3. High tidal range which causes flooding by salt water
4. Moist or wet climates; where rainfall exceeds evaporation
(5) Availability of shelter for seedlings and mature trees, which are vulnerable to uprooting by waves and current scour, which is often reduced by offshore reefs, shoals and other structures, such as behind sand dunes or storm built coral ramparts

(6) Availability of external sources of sediments; terrestrially derived sediments that are rich in nutrients and are used by plants and which also provide sediment inputs that are essential for land building and encroachment.

Mangroves are highly productive structures; a significant amount of the net production is incorporated into woody tissues and roots and a large proportion goes into the production of leaf tissues and fruits. Part of this yield is exported and eventually routed into the food web. The abundance of shellfish and finfish in these areas, as well as the diversity and abundance of the other associated fauna, is an indicator of the utilization of part of this productivity.

Leaf tissues and fruits are constantly being produced and fall to the forest floor at the rate of upwards of 2 grams per square meter per day, more than 7 tons per hectare per year. The freshly fallen material is quickly broken down into fine fragments by the activity of grazing organisms such as amphipods. In the earlier stages of breakdown organic materials are released which microbial populations in the water column may also utilize. As the leaf material decomposes it is transformed into microbial protein. Microscopic examination of this material reveals that the leaf substrate is permeated by fungi, and covered by attached bacteria, protozoans, and microalgae. These "enriched" fragments become a valuable food source and energy base for a complex food web (Odum and Heald, 1975 in Cintrón, 1987).

Mangrove roots are a very complex community containing numerous organisms belonging to diverse groups; burrowing organisms consume dead wood, underwater mangrove is eaten by Teredo worms. Filter-feeding mollusks, sponges, and tunicates receive shelter and food from mangrove roots. Mangrove roots are used by many organisms as nurseries because these provide shelter and concentrations of food sources. These export high quality protein to coastal areas in the form of the living tissue of animals that migrate offshore after completing their early development in mangrove areas. Massive migrations of mullets and shrimps, among others, are well known. These migrations link mangroves directly to other coastal systems like coral reefs and seagrass beds.

Since mangroves are an important component of our coastal landscape, it is important to assess their response to stresses of various types. A stress is a condition that drains energy, which could be used to do useful work, away from a system. The stressor, the force impinging on the system, may operate in a sustained manner (chronically) or in a brief, transient episode (acutely). A chronic stressor will impede a system from attaining its full development, while an acute stressor causes only a relatively brief period of energy loss. Stressors may be the result of natural events, or man-made.

A significant amount of the plants’ net production is incorporated into woody tissues, roots, leaf tissues, and fruit. Part of this productivity is exported as detritus material and eventually enters the marine food web. In mangrove areas where access for fish and invertebrates is available, considerable nursery and forage habitat is provided. Diurnal migrations into and out of
mangroves are well known. These migrations link mangroves directly to other coastal systems such as coral reefs, and seagrass beds. Important inhabitants of mangrove wetlands are invertebrates (sponges, crabs, tunicates, bivalves (oysters), and lobsters, fish (grunts, snappers, parrotfish, barracuda, eels, surgeonfish, doctorfish, tangs), and algae, (particularly red and green algae). Gilmore and Snedaker (1993) provided syntheses of most recent available information on fishery organism use, in terms of presence in mangrove habitats; information prior to about 1981 on faunal use is provided by Odum et al. (1982). Based on these publications and references cited, there is little doubt that mangrove habitats provide nursery, feeding and growth, and refuge for both recreationally and commercially important fishery organisms and their food resources when flooded. Mangroves serve as an intermediate nursery habitat that may increase the survivorship of young fish (Mumby et al. 2004). Mangroves in the Caribbean strongly influence the community structure of fish on neighboring coral reefs. In addition, the biomass of several commercially-important species is more than doubled when adult habitat is connected to mangroves.

Spiny lobsters (Panulirus argus) are the most important commercial and recreational invertebrates commonly found among the prop roots of mangroves. Snook (Centropomus undecimalis), goliath grouper (Epinephelus itajara), leatherjacket (Oligoplites saurus), gray snapper (Lutjanus griseus), dog snapper (L. jocu), sailor’s choice (Haemulon parra), bluestriped grunt (H. sciurus) also are common to this habitat, using it as refuge and as a ready source of food. Collections in both seagrass beds and mangroves suggest that there is an integral link between these habitats with tripletail, snook, gray snapper, and goliath grouper, for example, occurring over seagrass beds or other adjacent bottoms as adults or large juveniles but using the mangrove prop-root during juvenile stages.

Mangroves are considered resilient and display characteristics of some “pioneer species” in that they have broad tolerances to environmental factors, rapid growth and maturity, continuous or almost continuous flowering and propagule production, high propagule outputs in a wide range of environmental conditions, and adaptations for short and long distance dispersal by tides (Cintrón-Molero 1992). Even with these pioneer (or “r-strategist” species) characteristics mangroves are both sensitive and vulnerable to disturbance. Odum et al. (1982) point out, however, that one of the adaptations of mangroves--the aerial root system, is also one of the plant’s most vulnerable components because of their susceptibility to clogging, prolonged flooding, and boring damage from invertebrates. Any process that coats the aerial roots with fine sediments or covers them with water for long periods has the potential of being a destructive agent. Diking, impounding and long term flooding as has occurred in mosquito control situations have caused considerable damage, as have spraying of herbicides and inundation by oil spills. Gilmore and Snedaker (1993) provide good discussions of the impacts of urbanization, impoundment, and flood control.

Salt ponds, common in the USVI, are formed when mangroves or fringing coral reefs grow or storm debris is deposited, effectively isolating a portion of a bay. The resulting "pond" undergoes significant fluctuations of salinity with changes in relative evaporation and runoff. The biotas associated with salt ponds are, therefore very specialized, and usually somewhat limited. Salt ponds are extremely important in trapping terrestrial sediments before they reach the coastal waters.
3.2.3 Seagrasses (Estuarine and Marine)

In Puerto Rico and the USVI, seagrasses occur in both the estuarine and marine zones. Puerto Rico has one of the most diverse seagrass floras of the north Atlantic Ocean with seven species recorded: *Thalassia testudinum* (turtle grass), *Halophila decipiens, H. baillonis, H. engelmannii* (paddle grass or sea vines), *Halodule wrightii* (shoal grass), *Syringodium filiforme* (manatee grass) and *Ruppia maritima* (widgeon grass) (Vicente, 1992). Turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and shoal grass (*Halodule wrightii*) are the three most abundant species. The NOS maps of benthic habitat for Puerto Rico and the USVI (Figures 2.5 to 2.15 and 2.19) provide the most current distribution of seagrasses. Of the total 5009 km$^2$ of benthic habitat mapped by NOS in Puerto Rico, 625 km$^2$ (12.5 %) was seagrass. NOS mapped 485 km$^2$ of benthic habitat in the USVI, 160 km$^2$ (33 %) was SAV. Data from St. John indicate a loss of previously present dense seagrass beds, particular at popular anchorages. An overall decline was seen in all St. John bays monitored and studied (Turgeon et al. 2002).

Seagrass beds are highly productive ecosystems that are quite extensive in the Caribbean and often occur in close association with shallow-water coral reefs. Seagrasses are true flowering plants that spread through the growth of roots and rhizomes or sexual reproduction. Collectively, this group of submersed aquatic vascular plants (SAV) will be referred to as seagrasses.

Seaweeds (macro-algae) are often mistakenly referred to as “grasses.” Despite the fact that these frequently co-occur and provide similar ecological services, these two plant taxa have distinctly different growth forms and contrasting life requirements.

Seagrasses are the only vascular plants able to complete their life cycle fully submerged in the marine environment. These have a high rate of net primary production that provides a large supply of organic matter. To obtain light for growth these require shallow, or clear deep, water. The biomass of turtle grass is, for example, lower in more polluted environments (Fonseca et al. 1992). Sea vines (*Halophila* spp.), on the other hand, do not usually occur in mixed species beds but may be found in shallow turbid water, in silty muddy substrates, or to depths of 50 m in clear water because they are adapted to low light intensity (Ogden, 1980). These characteristically occur as pure strands but may be mixed with *Syringodium filiforme* and are eaten by a variety of fishes and the queen conch, *Strombus gigas*. Sea vines occur widely in the tropical western Atlantic (Colin, 1978). Manatee grass has cylindrical grass blades and a dense mat of rhizomes about 5 cm deep. It often occurs with turtlegrass in mixed stands and is eaten by various herbivorous fishes and the queen conch.

*Thalassia testudinum*, the turtle seagrass is the most abundant and important seagrass found in tropical waters (Buesa, 1974). These plants grow on sand or mud bottoms, from the shoreline to depths of 20 to 30 feet, depending on the species and sunlight penetration (Stephens, 1966). In the clear waters of the USVI, turtlegrass beds have been found at depths of 43 feet (Randall, 1965). *Thalassia testudinum* has a horizontal rhizome, buried as much as 25 cm deep in the sediment, which gives rise to erect, flattened green grass blades (Colin, 1978). In Puerto Rico, male and female turtle grass flowers may be found from March-June in the shallow subtidal zone (Vicente, 1992). Turtlegrass beds exposed to high wave energy, sand burial, poor water quality and heated effluents do not reproduce sexually (Vicente, 1992).
**Thalassia** (seagrass) blades are the primary source of food for a wide range of organisms that include fishes, sirenians, turtles, urchins, and gastropods. This great number of species, which feed exclusively or nearly so on *Thalassia testudinum* blades or the epiphytes on them, makes them a unique resource (Ogden, 1976; in Medina et al). Turtlegrass leaves provide a substrate for more than 100 species of algae and other organisms (crustaceans, hydrozoans, snails) that live on the blades. The beds themselves provide shelter and nursery grounds for larvae and juveniles of several fish and invertebrate species such as grunts, wrasses, parrotfish and snappers and conch (Stephens 1966). More than one hundred species are known to rely on turtlegrass beds for protection and food (Croz et al. 1975).

*Thalassia* grass blades provide a substrate for more than 100 species of algae that live as epiphytes on them. Other organisms (crustaceans, snails) live encrusted on the blades. Seagrass beds also provide shelter and nursery grounds for larvae and juveniles of several fish and invertebrate species. Also, small fishes and invertebrates use the area as their habitat where these can hide and camouflage between the leaves (Stephens 1966 in Medina et al.; Fonseca et al. 1992).

The overall depth distribution of 50 m (about 20 fathoms) represents the maximum potential distribution of seagrass habitat (Figure 2.19).

The multi-species invertebrate and plant assemblages which form the backbone of reef and seagrass communities constitute an array of habitats and microhabitats, which are the very basis of a wealth of natural resources exploited by humans. Although reef and seagrass communities may be distinguished relatively easily, these are not distinct entities. These are intimately interconnected with each other and with other marine and terrestrial habitats (Cintrón and Schaffer-Novelli, 1983). Seagrass beds serve as secondary feeding grounds for many coral reef animals (e.g. haemulid fishes) and protect coral reefs by trapping sediment and lowering the potential for sediment resuspension and transport. Reef environments, including both coral and rocky reefs, dissipate wave energy, protect seagrasses and provide shelter for many animals that feed in seagrass areas (Tetra Tech, 1992). There is also an important interchange between seagrass beds and reefs by animals such as grunts and snappers that migrate between the two habitats (Helfman et al. 1982). When they return to the reef after feeding, these fishes deposit organic compounds in the form of feces that become available to detritivores and are thereby introduced into the food web. The ecological relationships and interdependencies both within and between these two communities are thus wide-ranging and complex.

High species diversity and abundance are associated with seagrass meadows, especially in tropical areas. Many vertebrates and invertebrates, including a substantial number of commercial importance, occur in seagrass beds at some phase in their life history. Juveniles utilize this habitat as a nursery area for food and shelter, and both adults and young graze on the detritus and organisms attached to the blades, such as numerous shrimp, amphipods, mysids, snails and small fish. These, in turn, are preyed upon by larger carnivores (Thayer et al. 1978). Macroalgae are foraged extensively by a large assemblage of herbivores and the prey of many commercial species may be found in these meadows (e.g., conch clams, parrotfish, snappers and grunts, among many others) (Thayer et al. 1978; Fonseca et al. 1992). Postlarvae of shrimp and spiny lobster recruit into seagrass beds and lobster reside in these areas for their first 9-12 months, then
migrate to deeper water from which they return at night to feed. More than one hundred species of organisms are associated with the *Thalassia* beds for protection and food (Croz *et al.* 1975; in Medina *et al.*).

Seagrasses provide canopy and substrate for attachment and refuge (Fonseca *et al.* 1992) and have a high rate of net production that provides a large supply of organic matter. It is also of note, that one threatened and one endangered species heavily depend on seagrass meadows for forage in the region; both adults and juveniles of the threatened green turtle, *Chelonia mydas*, feed almost exclusively on seagrasses and extensively on the younger portions of seagrass blades throughout the wider Caribbean area (Fonseca *et al.* 1992; Vicente *et al.* 1992). The endangered manatee, *Trichechus manatus*, excavates the sediment in grass beds and feeds on roots, rhizomes and leaves.

Besides being a food resource and substrate for the attachment of several plants and animals, seagrass meadows are important in controlling and reducing erosion by trapping and consolidating bottom sediments with their extensive root and rhizome network. They also promote the accumulation of organic matter for further utilization by the resident population. All these conditions support the extensive fauna and productivity that is characteristic of *Thalassia testudinum* beds (Ferguson 1967; in Medina *et al.*).

Vicente (1992) stated that, “previous research has shown that seagrass beds are difficult to establish artificially and are slow to recover from damage. Essentially they are irreplaceable.” The seagrass beds of Culebra have been given a Resource Category 1 Designation in a document titled The Seagrass Beds of Culebra, Puerto Rico, signed by the Regional Director (Region 4) of the US Fish and Wildlife Service. Category 1 means that areas are considered unique and irreplaceable and that loss of this system is not acceptable. Thus, protection of these beds is afforded since Federal permits required by Section 404 of the Clean Water Act and Section 10 of the River and Harbor Act are required for development in these areas. The strong Federal interest in protecting these areas will be relayed to the permitting authorities (e.g., Corp of Engineers) by agencies such as the National Marine Fisheries Service and US Fish and Wildlife Service as part of the permit review process.

Of great importance in the conservation of seagrass beds is the maintenance of the successful hydrophilic pollination. Pollen grains produced at the time of reproduction have a floating capacity, making them more susceptible to poor water quality. Under poor water quality conditions flowering, and thus pollination, are interrupted.

One of the most important functions of seagrass beds is the entrapment of large amounts of sediment, which can eventually modify the shorelines. Specifically, water quality is maintained because the leaves of the seagrasses help in the precipitation of suspended matter, prevent resuspension of anoxic sediments and transform nutrients into biomass. The root system and rhizomes hold the sediment in place.

Seagrass habitats sustain populations of turtles, manatees and fish (including shellfish). The relationships vary from serving as food (e.g., leaves are eaten by green turtles), and as foraging habitat (e.g., fish use them as hunting grounds) (see Section 3.2.11), to providing surface area for
egg laying by fish (e.g., leaves of *Thalassia*) or habitat for reproductive purposes (e.g., nurse shark, *Ginglystoma cirratum*). A few of the many species which forage either on the blades/rhizomes of the seagrasses themselves or on organisms in the meadows (foraging for invertebrates, epiphytes, etc.) are: queen conch, *Strombus gigas*; parrotfish, *Sparisoma* spp.; *Haemulon* spp.; nurse sharks; West Indian manatees and green turtles (both endangered species), as well as the brown pelican (*Pelecanus occidentalis*, also endangered).

These meadows are intricately associated with green algae (also in the Coral FMP’s FMU) species such as *Caulerpa*, *Halimeda* and *Penicillus* spp. (Phylum Chlorophyta). These green algae are of importance in stabilizing disturbed bottoms.

The autotrophic nature of seagrasses sets the depth limits at between 30 cm and 20 m. The shallower limit might be set by tidal considerations (exposure) and sediment load (buried meadows). The deeper limit might be set by water transparency, allowing the required amount of PAR to reach deeper in the water column. Width of insular shelf, depth and the patchy distribution of non-optimal bottom (rocky substrate) limit the areal extent of seagrass beds.

Vicente (1992) reported that in Puerto Rico, primary production and biomass of seagrasses are very high (6,898 gC/m²/yr and 2,260 gC/m², respectively). Seagrasses and coral reefs are among the highest primary production systems in the tropics.

Fish and lobster pots and traps cause the primary fishing threat to seagrasses through shading. Vertical hook and line gear and gill/trammel nets may cause minor damage. Among the non-fishing threats to seagrasses are: (1) raw sewage disposal (specifically in areas where there are no sewage treatment plants) since raw sewage delivers high concentrations of nutrients into the environment; (2) construction of ramps, piers, docks, and other construction on the coast (shading of large portions of the beds); (3) telephone, water and electricity underwater pipes (specially those not held in place); (4) anchoring, scarring, and groundings; (5) any upland development in Puerto Rico and the USVI, which generates sediment erosion and run off to the nearshore environments; (6) deforestation (ibid.; increased turbidity); (7) storms and hurricanes (sand burial and also mangroves damage, since after destruction of the mangrove forest, there is sediment resuspension and redistribution and increased turbidity); (8) diseases; (9) sea level rise which threatens seagrass beds indirectly since the effects of increased turbidity and poor water quality may prevent vertical accretion of seagrasses as sea level rises; (10) dredging for navigational purposes or to remove seagrasses to create sandy bottoms adjacent to resort beaches.

3.2.3.1 Seagrasses and their function as fish habitat

As in terrestrial grasslands, individual seagrasses and associated species form recognizable biological and physical assemblages known as seagrass meadows. The meadows are usually defined by a visible boundary delineating unvegetated and vegetated substrate, and vary in size from small, isolated patches of plants less than a meter in diameter, to a continuous distribution of grass tens of square kilometers in area. Seagrass meadows are dynamic, spatial and temporal features of the coastal landscape (Patriquin 1975). Some of the smaller species have been shown
to be capable of establishing meadows annually in the seasonal waters of the South Atlantic. Alternatively, meadows formed by the larger bodied species, that have either limited or irregular sexual reproduction, may require decades to reach full maturity. When turtlegrass is compared to its congeners, *H. wrightii* and *S. filiforme*, it has the slowest rate of vegetative expansion (Fonseca *et al.* 1987). Depending on the environmental conditions, rates of vegetative expansion for *H. wrightii* and *S. filiforme* are normally 4 to 10 times faster than *T. testudinum*. Thus, *T. testudinum* meadows form more slowly than any of the other species, yet if the environmental conditions allow the full development of a turtlegrass meadow its biomass and productivity will usually exceed any other seagrass (Zieman 1982).

Regardless of developmental stage or species composition, differential growth and mortality can cause small seagrass patches and entire meadows to shift spatially over time, the rate of which may vary on a scale of hours to decades. These dynamic spatial and temporal features of seagrass meadows are important aspects of fishery habitats. Seagrass habitats must be recognized as including not only continuously vegetated perennial beds but also patchy environments with the unvegetated areas between patches as part of the habitat. In fact, available data show that patchy habitats provide many ecological functions similar to continuous meadows (Murphey and Fonseca 1995, Fonseca *et al.* 1996). Also, the absence of seagrasses in a particular location does not necessarily mean that the location is not viable seagrass habitat. It could mean that the present conditions are unfavorable for growth, and the duration of this condition could vary from months to years.

Because seagrasses are rooted, they can become nearly permanent, long-term features of coastal marine and estuarine ecosystems coupling unconsolidated sediments to the water column. No other marine plant is capable of providing these properties of seagrasses. Seagrass meadows provide substrate and environmental conditions that are essential to the feeding, spawning and growth of several managed species (see Zieman 1982, Thayer *et al.* 1984). The specific basis of seagrass as fishery habitat is recognized in four interrelated features of the meadows: 1) primary productivity, 2) structural complexity, 3) modification of energy regimes and sediment and shoreline stabilization, and 4) nutrient cycling. High rates of primary production lead to the formation of complex, three-dimensional physical structures consisting of a canopy of leaves and roots and rhizomes buried in the sediments. The presence of this physical structure provides substrate for attachment of organisms, shelter from predators, frictional surface area for modification of water flow and wave turbulence, sediment and organic matter deposition, and the physical binding of sediments underneath the canopy. Linked together by nutrient absorbing surfaces on the leaves and roots and a functional vascular system, seagrass organic matter cycles and stores nutrients, and provides both direct and indirect nutritional benefits to thousands of species of herbivores and detritivores.

### 3.2.3.2 Specific examples of seagrass as fish habitat

Experiments and observations have shown that juvenile and adult invertebrates and fishes as well as their food sources utilize seagrass beds extensively (e.g. Randall 1965; Pollard 1984; Duarte 2000). In fact, the habitat heterogeneity of seagrass meadows, the plant biomass, and the surface area enhance faunal abundances. Predator-prey relationships in seagrass beds are influenced by canopy structure, shoot density, and surface area. Blade density interferes with the efficiency of
foraging predators and the reduction of light within the leafy canopy further conceals small prey, which includes young-of-the-year of many ecologically and economically important species. High density of seagrass shoots and plant surface area can inhibit movement of larger predators, thereby affording shelter to their prey. Additionally, some organisms can orient themselves with the seagrass blades and camouflage themselves by changing coloration. Food available to juvenile stages of managed species may be extremely high. These attributes are particularly beneficial to the nursery function of seagrass beds, and while there is continuing debate and research on whether refugia or trophic functions are most important (when and to which organisms), there is little debate that these are important functions provided by this habitat type.

The spiny lobster (*Panulirus argus*), has a strong reliance on seagrass habitats including seagrass-supported trophic intermediaries. There have been few studies dealing with larval fish settlement and use of seagrass habitats, while there have been numerous publications listing juvenile and adult fishes collected in seagrass meadows. Seagrass beds are important for the brooding of eggs and for fishes with demersal eggs. Many fish reside only temporarily in grass beds, to forage, spawn, or escape predation. Economically important species which use these habitats for nursery and/or spawning grounds include: grunts (haemulids), snook (*Centropomus* spp.), tarpon (*Megalops atlanticus*) and several species of snapper and grouper.

For the most part, the organisms discussed above utilize the grass bed structure and trophic elements associated with the bed, but many species of herbivorous invertebrates (e.g., urchins *Lytechinus variegatus*, *Tripneustes ventricosus*), birds (e.g., black brant *Branta bernicla*), fishes (e.g., pinfish *Lagodon rhomboides*, parrotfish *Sparisoma radians*), the green turtle (*Chelonia midas*) and the manatee (*Trichechus manatus*) feed directly upon coastal and estuarine seagrasses.

### 3.2.4 Benthic algae (Estuarine and Marine)

NOS prepared maps with distribution of macro-algal dominated areas for Puerto Rico (CFMC 1998). NOS updated the distributions (Kendall *et al.* 2001) using aerial photography. Of the total 5009 km² of benthic habitat mapped by NOS in Puerto Rico, 97 km² (1.9%) was macro-algal dominated areas. Benthic algae is likely underrepresented because mixed algal/seagrass areas were classified as seagrass in the mapping process.

Puerto Rico harbors 473 species of benthic algae, which is generally characterized by a lack of vascular tissue, simple organ differentiation, and naked reproductive structures. Among Puerto Rico’s benthic algal species, 57% are Rhodophytes, 14% are Phaeophytes, and 29% are Chlorophytes (Ballantine and Aponte 1997). Benthic algae occurs in both estuarine and marine environments, and is used as habitat by managed species, such as the queen conch and early life history stages of spiny lobster. Threatened sea turtles utilize some benthic algae species directly as food. This habitat is also inhabited by invertebrate species including mollusks and crustaceans, which are eaten by various fishes. A more in-depth discussion is included in the algal plains section.
3.2.5 Drift algae (Estuarine and Marine)

Consists of parts of benthic algae, such as *Acanthophora* and *Laurencia*, which have broken off and become free-floating. They sometimes become entangled in attached benthic entities, like seagrasses, for short periods of time, but otherwise are moved about by local water currents. The importance of drift algae as an ephemeral habitat for fishes has become better appreciated in recent years (Rydene and Matheson, 2003). Drift algae have been found to harbor relatively high densities of invertebrate forage species. It also appears to enhance dispersal of some organisms within the estuary (Brooks and Bell 2001).

3.2.6 Sand/shell and soft bottoms (Estuarine and Marine)

Throughout the US Caribbean, both rocky shores and sandy beaches are common. While many of these beaches are high-energy and extremely dynamic, buffering by reefs and seagrasses allows some salt-tolerant plants to colonize the beach periphery. Birds, sea turtles, crabs, clams, worms, and urchins use the intertidal areas. Over 190 species of fishes, almost all occurring in US Caribbean, have been recorded from nearshore hard bottom reefs of Southeast Florida (Lindeman and Snyder 1999).

The sand/mud subsystem includes all non-live bottom habitats or those with low percent cover (< 10%) to 183 m. Sandy and mud bottom habitats are widely distributed, found in coastal and shelf areas, and include inshore, sandy areas separating living reefs from turtle grass beds and shorelines; rocky bottoms near rocky shorelines; and mud substrates along mangrove shorelines (VIERS 1969). Kendall *et al.* (2001) presented the distribution of mud bottom areas in depths sufficiently shallow for aerial photography interpretations (Figures 2.5 to 2.15 and 2.18).

Mollusks and gastropods are typically found in sandy and muddy habitats. Queen conch and milk conch occur in soft-bottom euphotic habitats and on sandy bottoms with coral rubble and macroalgae (Appeldoorn 1985). Other species commonly found in these habitats include spiny lobsters, stingrays, gerreids, goatfishes, lizardfishes, yellowtail snapper, coney, doctorfish, parrotfish, and the silk snapper (*Lutjanus vivanus*), as well as numerous pelagic species found in the waters overlying these sand/mud bottoms. Burrowing fishes, like yellowhead jawfish and garden eels, occupy sandy areas. Schooling fishes also travel through these unvegetated areas, and striped mullet (*Mugil cephalus*) feed on muddy organic-based bottoms. Ocean triggerfish reproduce and guard young in sandy areas.

Mud plains have been shown to become a dominant bottom type at depths greater than 183 m (CFMC 1994). Although it has been reported that dramatic changes have taken place in nearshore areas, no information is available at this time, except for the identification of this habitat type as related to species in the EFH tables (see Section 3.2.11).

Table 3.1 shows the areal extent of marine biotopes, including shallow sand. The extent and characterization of these habitats is unknown. Sand/shell habitat is utilized for foraging by abundant fishes, such as mojarras. Sand has been shown to be important in association to a number of marine species most significantly the sand tilefish (*Malacanthus plumieri*). The
distribution of sandy habitats can be estimated from the presence or absence of this species. Kendall et al. (2001) present distribution of sandy bottom areas in depths sufficiently shallow for aerial photography interpretations (Figures 2.5 to 2.15 and 2.21).

Sandy and soft bottoms are inhabited by various infauna (e.g. worms and crustaceans) and epifauna (e.g. sea pens) which act as ecosystem engineers and modify these habitats by the presence of their physical structure or burrowing in the substrate. As such, they can be considered an integral part of the habitats they occur in. Activities which directly or indirectly kill or remove ecosystem engineer species may substantially alter the nature of these habitats.

3.2.7 Pelagic (Estuarine and Marine)

The pelagic subsystem explicitly includes the habitat of pelagic fishes, while the benthic component of these areas, including demersal fishes, is included in other subsystems (Jacobsen and Browder 1987). In general, primary productivity in this zone is low, and patchily distributed. Pelagic productivity is higher in nearshore areas than in offshore “blue water” areas (Thurman 1988). Information on the fishes inhabiting the pelagic zone is sparse. Some pelagic fishes, such as dolphin and young flying fishes congregate beneath objects floating at or near the surface, such as Sargassum or Thallasia debris. The pelagic system is inhabited by the eggs and larval stages of many reef fishes, highly migratory fishes, and invertebrates, some of which, like the spiny lobster are commercially important. Some fish, such as billfishes, tunas, mackerels, jacks and excoetids occur in the pelagic environment as adults, as well. Cartilaginous fishes including sharks such as the shortfin mako and pelagic rays like the Atlantic manta live in this zone also.

3.2.8 Algal plains (Marine)

Offshore, between the seagrass beds and the coral reefs and in deeper waters, sandy bottoms and algal plains dominate. These areas may be sparsely or densely vegetated with a canopy of up to 1 m of red and brown algae. Algal plains are not areas of active sand transport. These are algal-dominated sandy bottoms, often covered with carbonate nodules (i.e. rubble), primarily in deep water (>50 feet or 15 meters) and account for roughly 70% of the area of the insular shelf of the USVI. Kendall et al. (2001) present distribution of algal plain areas in depths sufficiently shallow for aerial photography interpretations (Figures 2.5 to 2.15 and 2.20). Algal plains support a variety of organisms including algae, sponges, gorgonians, solitary corals, mollusks, fish, and worms. Algal plains may serve as critical juvenile habitat for commercially important (and diminishing) species such as queen triggerfish and lobsters.

Algal plains are sandy-bottom habitats, with a diverse community benthic flora and fauna covering 60-85% of the bottom (Dahl 1973). Species composition of the community undergoes periodic changes under the influence of strong tidal currents and winds (Kimmel 1985). Algal plains occur in a wide range of water depths, near coral reefs and in areas of strong currents around small islands. Sediments of the algal plain are coarse sand and coral rubble, providing little vertical relief except for an occasional patch reef, coral head, empty conch shell, or sand mound (Kimmel 1985).
Sediment-stabilizing algal species include *Halimeda, Udotea, Caulerpa, Anadyomene, Agardhiella,* and *Gracilaria* spp., and species such as *Laurencia, Halymenia, Dasya,* and *Condria* are found attached to shells and rubble.

Managed species that use algal plains include queen conch, spiny lobsters as well as various gorgonians and macroalgae that are managed under the Coral FMP. Most fishes in this zone are relatively small species of little commercial value, but some commercial species may use this habitat as a nursery area. Burrowing fishes (e.g. yellowhead jawfish, hovering goby) are common here (Kimmel 1985).

### 3.2.9 Coral reefs and hard bottoms (Marine)

Corals, as defined by the M-S Act, are both fish and habitat. NOS prepared maps with distribution of coral for Puerto Rico and the USVI (CFMC 1998). NOS updated the distributions (Kendall *et al.* 2001) using aerial photography (Figures 2.5 to 2.15). Of the total 5009 km² of benthic habitat mapped by NOS in Puerto Rico, 756 km² (15.1%) was coral reef and colonized hard bottom. NOS mapped 485 km² of benthic habitat in the USVI, 298 km² (61%) was coral reef and colonized hard bottom. Puerto Rico has 93 coral taxa including 43 scleractinian corals, 42 octocorals, 4 antipatharians, and 4 hydrocorals (Turgeon *et al.* 2002). In Puerto Rico, the main island has coral growth along much of the insular shelf, but reef development is mostly restricted to the eastern, southern, and western coasts as a result of physical, climatic and oceanic conditions. In the USVI, fringing reefs, deep reefs, patch reefs, and spur and groove formations occur on all 3 islands, but only St. Croix has well-developed barrier reefs (Turgeon *et al.* 2002).

The following is a general summary from the Coral Reef FMP. The locations of emergent reefs (described below) are found in most nautical charts available to the general public. Coral reefs and other coral communities are one of the most important ecological (and economic) coastal resources in the Caribbean. These biogenic habitats act as barriers to storm waves, and their architecture provides habitats for a wide variety of marine organisms including most of the economically important species of fish and shellfish, are the primary source for carbonate sand, and serve as the basis for much of the tourism (Dayton *et al.* 2002). Coral reefs are built upon the accumulation of calcium carbonate produced by living animals, coral polyps, in symbiosis with a dinoflagellate, zooxanthellae.

Coral reef communities or solitary specimens exist throughout the geographical areas of authority of the Council. This wide distribution places corals in many variable habitats, from nearshore environments to continental slopes and canyons, including the intermediate shelf zones. Shelf-edge reefs are the best developed, but least studied of the reef systems in this area, with live coral cover ranging from 10-50%, and living coral occurring as deep as 40 m (Bruckner 1999; Morelock *et al.* 2001). Coral reefs are among the most productive and diverse tropical marine habitats. Although highly productive, they develop best in shallow, well-lighted tropical waters that are usually poor in nutrients such as nitrates, ammonia and phosphates. Coral reef environments have among the highest rates of photosynthetic carbon fixation, nitrogen fixation, and limestone deposition of any ecosystem (Goureau *et al.* 1959).
The ecological importance of coral reefs is well-documented (Goenaga and Cintrón, 1979). Many fish species and crustaceans of commercial and recreational value depend on coral reefs during some or all of their life stages. They provide a buffer against shoreline erosion and influence the deposition and maintenance of sand on the beaches that they protect. The sand in these beaches originates principally from the reefs.

Rock reefs are also of importance in some areas, such as the western and northwestern coasts of Puerto Rico, where they may provide fishes and macroinvertebrates with the only structure with topographic relief (Garcia et al. 2001). Rock reef habitats are often colonized by turf algae and other encrusting biota, but very little coral. Flat eolianite reefs occur off the northern coast of Puerto Rico and have a high cover of turf algae, sponges, and encrusting corals.

Although attempts have been made to generalize the discussion into definable types, it must be noted that the continuum of habitats includes many more than the varieties discussed here.

Well-known areas of pinnacles are found in southwestern Puerto Rico (specifically to the southeast of Turromote Reef and also near San Cristobal Key in La Parguera), and are reported from an area south of St. John, USVI. These structures are submerged and extend from depths of about 20 meters to about 5 meters from the surface. Genera associated with these structures are Dendrogyra (pillar coral) and or Montastrea (boulder star coral). These are live corals and constitute very attractive sites for recreational diving.

3.2.10 Coastal and shelf summary

The characterization of the shelf features is incomplete. The US Geological Survey has collections of sediment maps for most of the areas around Puerto Rico (mostly in hard copies) and some for the USVI. These however do not include details, except for the bathymetry information, of the submerged structures on the shelf.

The following description of the US Caribbean insular shelf and coastal features (UNEP/IUCN 1988) serves two main purposes: (1) allowing access to the information, (2) allowing for comparisons to be made when EFH is identified and mapped.

Puerto Rico and the USVI contain a wide variety of coastal marine habitats, including coral and rock reefs, seagrass beds, mangrove lagoons, sand and algal plains, soft bottom areas, and sandy beaches. These habitats are interspersed among each other and function together to form the coral reef ecosystem complex. Nearshore waters range from 0 to 20 meters in depth and outer shelf waters range from 20 to 30 meters in depth, the depth of the shelf break. Along the north coast the insular shelf is very narrow (2-3 km wide), seas are generally rough, and few good harbors are present. The coast is a mixture of coral and rock reefs and sandy beaches. The east coast has an extensive shelf that extends to the British Virgin Islands. Much of the bottom is sandy, commonly with algal and sponge communities and depth ranges from 18 to 30 m. The southeast coast has a narrow shelf (8 km wide). About 25 km to the southeast is Grappler Bank, a small seamount with its top at 70 m depth. The central south coast broadens slightly to 15 km
and an extensive seagrass bed extends 9 km offshore to Caja de Muertos Island. Further westward, the shelf narrows again to just 2 km before widening at the southwest corner to over 10 km. The whole of the southern shelf is characterized by hard or sand-algal bottoms with emergent coral reefs, grassbeds, and shelf edge. Along the southern portion of the west coast the expanse of shelf continues to widen reaching 25 km at its maximum. A broad expanse of the shelf is found between 14 and 27 m; habitats are similar to those of the south coast. To the north, along the west coast, the shelf rapidly narrows to 2-3 km.

3.2.10.1 Puerto Rico

García et al. (2001) concluded that the healthiest coral reefs in Puerto Rico were located on protected sections of shelf, which were furthest away from shore and major river discharges. Reefs had been killed by combinations of anthropogenic activities (e.g. dredging, ship traffic, sewage output, industrial discharges) in semi-enclosed areas.

Although corals grow around much of Puerto Rico, physical conditions result in only localized reef formation. On the north coast, reef development on the narrow shelf is almost non-existent along the western two-thirds, possibly as a result of one or more of the following factors: high rainfall; high run-off rates causing erosion (mechanical abrasion) and silt-laden river waters and nutrient loading; intense wave action (especially in winter) which removes suitable substrate for coral growth; and long shore currents moving material westward along the coast (Morelock et al. 2001). This coast is steep, with most of the island's land area draining through it. Reef growth increases towards the east due to its location upstream of major river discharges and a wider shelf, which is somewhat protected by a series of emergent rock reefs occurring between the main island and Culebra in an east-west alignment (Morelock et al. 2001). On the wide insular shelf of the south coast, small reefs are found in abundance where rainfall is low and river influx is small. The greatest development and diversity occurs in the southwest where waves and currents are strong and the climate is dry. These conditions allowed the development of many emergent and submerged reefs, with subsequent development of seagrass beds and fringing mangroves (Morelock et al. 2001). Submerged reefs with high coral cover and diversity fringe a large proportion of the shelf edge in the south and west; these appear to have been emergent reefs 8000-9000 years ago, which failed to keep pace with rising sea levels (Goenaga 1985). Reefs on the west coast are limited to small patch reefs or offshore bank reefs and may be dying due to increased sediment influx, higher water turbidity and lack of strong wave action (Almy and Carrión-Torres, 1963; Kaye, 1959).

Fringing reefs once occurred close to shore in Puerto Rico in areas with low rainfall, where hillsides were stabilized by heavy vegetation. These reef have now mostly disappeared due to clearing of natural vegetation and a subsequent increase in terrigenous inputs (Morelock et al. 2001).

Goenaga and Cintrón (1979) provide an inventory of mainland Puerto Rican coral reefs and the following is a brief summary of their findings. On the basis of topographical, ecological and socioeconomic characteristics, Puerto Rico's coastal perimeter can be divided into eight coastal sectors -- north, northeast, southeast, south, southwest, west, northwest, and offshore islands.
These are used in the following descriptions of habitat distributions. The southwest and the northeast sectors stand out as particularly rich in natural systems of importance to fishery production.

3.2.10.1.1 North coast: Rio Grande de Arecibo (Arecibo) to Boca de Cangrejos (Carolina)

**Setting.** The San Juan Metropolitan Area, in the eastern part of the north coast sector, is the largest of the Island's urban areas and a major port. Topography in the north coast sector is practically level with extensive karst hillocks toward the interior. The fertility of these level lands has favored the intensive cultivation of sugar cane (32 tons to the acre) and pineapple (15.5 tons to the acre).

**Coastal features.** The north coast sector contains the rivers with the greatest volume of flow on the island and the largest system of subterranean aquifers. Two major non-mangrove wetlands along the north coast, Caño Tiburones and Laguna Tortuguero, are susceptible to tidal flooding and are populated principally by freshwater biological communities. Laguna Tortuguero is the only natural freshwater lagoon in the Island. It possesses a wide variety of plant species (600), of which 35 are endemic and unique to the lagoon. Faunal diversity is also remarkable. In studies by the Puerto Rico Department of Natural Resources, 18 molluscan genera, 21 species of fish, and 39 species of birds were identified. Because of its biological diversity and recreational potential, Laguna Tortuguero is one of a number of areas requiring special management attention to insure that its values are preserved and protected.

With its exposure to heavy wave action, the north coast is highly susceptible to natural erosion, a condition aggravated in several locations by man-made activities. Wave action on the coastline has resulted in the creation of numerous tombolos and lunate bays. However, most of the north coast beaches consist of thin deposits of sand covering a rocky lower foreshore. During the winter storm period, these sands may move offshore temporarily as part of the natural erosion cycle.

**Coral reefs.** There is little reef development on the north coast except for patchy coral growth and narrow linear "reefs" consisting of coral communities covering fossil sand dunes formed during lower sea levels. North of Isla Verde and in several other places these ridges are exposed as small rocky islets. There are several minor coral assemblages at Arecibo and submerged patch reefs off Camuy and Puerto de Tortuguero. An extensive, but highly stressed, reef fringes the shore at Dorado. The reef flat (1-3 m deep) has abundant gorgonians, and the predominant corals are *Diploria strigosa* and *D. clivosa*. The reef front has many dead corals overgrown by algae and other corals; seaward of this reef are small patch reefs at 25 m with abundant fish life. East of San Juan, there is a poorly developed and heavily stressed discontinuous chain of rock reefs trending in an east-west direction and extending 1.5 km off shore. These consist of a thin coral veneer over a shallow platform that, in some cases, such as Isla Piedra, east of San Juan, and Isla Cancora, rise above the water (Kaye, 1959). Patch reefs are found off Punta Las Marias that are typically mound-like and rise to within a couple of meters of the surface. The tops are covered with head corals bordered by *A. palmata*; the lower slopes are covered with gorgonians.
3.2.10.1.2 Northeast coast: Boca de Cangrejos (Carolina) to Rio Demajagua (Ceiba)

**Setting.** This coastal sector includes the Island's most extensive mangroves (approximately 4,850 acres), and various salt water lagoons (approximately 941 acres). Together with the mangroves that surround them; these lagoons are nursery areas for sport and commercial fish. The wide insular shelf toward the east, favors the proliferation of coral reefs that culminate in a chain of small islands (La Cordillera) ending in Culebra and Culebrita.

Coral and rock reefs protect these coasts, causing tranquil waters and creating conditions favorable to the formation of abundant sandy beaches that border 78 percent (45.8 kilometers) of the coastline. The extensive insular shelf and the presence of reefs and mangroves support abundant marine life, making this portion of the coast very attractive for aquatic recreational activity.

Topography is predominantly level from Boca de Cangrejos to Punta Percha in Luquillo. East of Punta Percha, extensions of the Sierra de Luquillo come down to the coastline creating hills and valleys. The rain forest of the Caribbean National Forest locally called El Yunque and the chain of small islands known as La Cordillera augment the attraction of this area for tourism.

**Reefs.** A well-developed reef system used to lie in clear waters northwest of Boca de Cangrejos with extensive coral growth from the surface to 10 m depth. This has been virtually destroyed by sedimentation due to extensive dredging and organic pollution from sewage treatment plants in Torrecilla Lagoon. Currently, almost no living coral is found deeper than 1.5 m. The reefs in the region of Punta Vacia Talega are described in detail in Goenaga and Cintrón (1979). Stony corals are present on rock reefs and beach rock platforms as encrusting forms and are most abundant along the northern side of the inner reef. *Millepora complanata* is the most abundant species near the surface, and *Diploria* and *Isophyllia* are common in deeper areas. Soft corals are present in sheltered areas. Scattered patch reefs breaking the surface are found between Punta Iglesias and Punta San Agustin, east of Punta Vacia Talega; although these do not form a continuous barrier, they provide an effective wave energy absorbing structure. Water quality is characterized by high levels of suspended particles and low visibility, and reef patches adjacent to the shore are dead, probably as a result of siltation. Water quality and coral health improves offshore but corals are only present in depths of 1-3 m on the outermost reefs.

Reef development improves east of the easternmost major river, Espíritu Santo. Fringing reefs, about 0.5 km wide, border the north and west sides of Punta Miquillo and the north and east sides of Punta Picua. Both headlands were probably once sand cays, but are now connected to the mainland by a broad marsh and narrow sand tombolos. The reefs have poor coral development, especially at Punto Miquillo where there may be damage from the dredging of a channel parallel to the shoreline.

Punta Percha, to the west, forming part of the same system, has similar reefs but slightly higher living coral cover. Ensenada Comezón, between Punta Miquillo and Punta Picua, has numerous patch reefs, more than 2 m high, which lack distinct zonation. Algae are dominant, and the surrounding waters are generally very turbid, but a number of corals occur here. Two large, roughly circular (300-500 m diameter) patch reefs occur off the mouth of Río Mameyes, each
with an exposed shoal of coarse sand. Coral diversity is low, probably due to siltation from the river.

To the east is a complex of barrier, fringing and patch reefs, which are responsible for the formation of Luquillo Beach at Punta Percha. The fringing reefs surrounding the northern and eastern end of the beach have deteriorated on the seaward edge where growth is limited to the upper 3 m. East of Luquillo, water transparency increases gradually and the reefs have slightly higher living coral cover. East of Río Juan Martín, there is a series of patch and fringing reefs with low coral diversity, which have been described by Torres (1973). Siltation appears to be the main factor limiting coral growth. West of Cabeza Chiquita to Cabo San Juan, there is a fringing reef system, also in a poor state of health.

Conditions on the shallow platform east of Puerto Rico are ideal for coral development. The best reef development on the northeast coast is the fringing reef system around the La Cordillera islets and the islets of Isla Ramos, Isleta Marina and Cayo Ahogado between the mainland and La Cordillera. These have reefs on their eastern shores, with the degree of reef development, apparently related to distance from the mouth of Río Fajardo. The islands are susceptible to occasional drastic wave erosion (Goenaga and Cintrón, 1979). The reefs at Cordillera, Culebra and Vieques are upstream of east coast river discharges and generally still have high coral diversity and cover.

On the mainland, persistent high levels of turbidity affect nearshore waters. An extensive, but dying, fringing reef is found from northeast Cabo San Juan to the north end of Punta Sardinera, protecting the entrance to Bahía Las Croabas. There are no coral reefs from Playa Sardinera to Punta Barrancas, presumably because of the influence of Río Fajardo although narrow reefs project eastward about 450 m from Punta Barrancas and Mata Redonda. Between these two headlands, there is a shallow but small reef in the north of Bahía Demajagua (McKenzie and Benton, 1972).

La Cordillera (18°22'N, 65°32'W) is a shallow, narrow submarine ridge approximately 18 miles (29 km) long, trending east-southeast and supporting a number of islets with high quality fringing reefs. The islets, especially Icacos, the westernmost and largest, are composed of oolitic eolianite, deposited and partially submerged some time previous to the development of the reefs (Kaye, 1959). Most of the islands are high and vegetated. On Icacos, rock reef fringes two thirds of the north shore (Goenaga and Cintrón, 1979); in the northwest the beaches consist of loose, white, calcite sand whereas in the southeast they are formed of consolidated beach rock. Island vegetation changes from low scrub in the northwest to sea grapes and white mangrove in the southeast (Almy and Carrión-Torres, 1963). The Palominos complex and Cayo Largo are situated on the same platform, south of the main line of La Cordillera reefs. Palominitos, the top of a submerged hill, has ridges which continue south and east as large submerged banks. Palominitos was formed by wave-deposited sand and coral fragments on the reef platform and has a maximum altitude of less than 3 m (Goenaga and Cintrón, 1979). The waters in this area are affected by severe storms, tsunamis and waterspouts, and the region is seismically active.

Fringing reefs surround most of the islands in this area. Many of the reefs around Icacos and Palominitos have a similar formation that is probably typical of the northeast coast (Pressick,
Reefs along the east, north and northeast sides of Cayo Icacos are most well known (Almy and Carrión-Torres, 1963). In the north, corals cover less than 50% of the available surface area (McKenzie and Benton, 1972), and very little growth is observed behind the northwest reef (Almy and Carrión-Torres, 1963). The southwestern shore is more protected and has higher coral cover, particularly to the north and south where the currents pass round the ends of the island. Almy and Carrión-Torres (1963) discussed general aspects of the reefs on this coastline and listed 21 coral species collected from the reef.

The zonation of a 420 m long reef in the southeast, between Icacos and Audry Rock, is described by Pressick (1970). The shore zone extends in a gradual slope to about 1.6 m, and scattered living corals are found at about 20 m from the shore line. The lagoon extends out about 195 m from the shore zone. The sandy slope has patches of coral, with *Thalassia testudinum* gradually becoming more abundant. *Manicina areolata* is common among the seagrass. The bottom of the lagoon is sandy with sparsely scattered *Acropora cervicornis* and *A. palmata*. Gorgonians are abundant. The rear zone (seaward slope of the lagoon) rises sharply to form the reef flat and has a rich coral covering including massive colonies of *Montastrea annularis*, *Diploria* and *Porites asteroides*. The reef flat is about 50 m wide and is generally exposed at low tide. *A. palmate* and *Millepora complanata* predominate, and *Astrangia solitaria* forms attractive tiny red colonies throughout the zone. At the edge of the reef flat there is a 3 m drop-off with massive heads of *Montastrea annularis* and abundant *Agaricia agaricites*. This zone gives way to an *Acropora palmata* zone. Colonies of this species spread to diameters of 3-5 m and are interspersed with small, scattered *Diploria* heads. An *A. Diploria* zone extends down to depths greater than 4 m.

The south coast reef on Palominitos is described in Goenaga and Cintrón (1979). The reef crest and *A. palmata* zones intermix and are dominated by *A. palmata*. *Millepora complanata* is common as well as *D. clivosa*, *Favia fragum*, *Dichocoenia stokesii*, *A. cervicornis* and *P. asteroides*. Coral cover is high although many colonies are broken. The mixed zone descends to about 6 m and is dominated by gorgonians and *M. annularis*, *P. porites* and *A. cervicornis* are also common. This zone is very diverse and has a small spur and groove system of about 2.5 m in relief. At 6 m, large colonies of *A. palmata* are abundant. The steep reef slope is dominated by *Agaricia agaricites* and has several other species in abundance.

Cayo Largo is a relatively untouched reef and needs further study (Goenaga and Cintrón, 1979). The reef crest and *A. palmata* zones intermix and are dominated by *A. palmata*. *Millepora complanata* is common as well as *D. clivosa*, *Favia fragum*, *Dichocoenia stokesii*, *A. cervicornis* and *P. asteroides*. Coral cover is high although many colonies are broken. The mixed zone descends to about 6 m and is dominated by gorgonians and *M. annularis*, *P. porites* and *A. cervicornis* are also common. This zone is very diverse and has a small spur and groove system of about 2.5 m in relief. At 6 m, large colonies of *A. palmata* are abundant. The steep reef slope is dominated by *Agaricia agaricites* and has several other species in abundance.

The area is inhabited by spiny lobster, octopus, helmet shells, and a variety of reef fish. Numerous Queen Conch *S. gigas* occur in the *Thalassia* bed adjacent to Cayo Largo (Goenaga and Cintrón, 1979).
3.2.10.1.3 Southeast coast: Rio Demajagua (Ceiba) to Rio Grande de Patillas (Patillas)

**Setting.** The southeastern coastline is an alternation of rocky headlands, partly shaped by marine erosion, and valleys of alluvial material that, as a result of wave action and marine deposition, form broad beach plains. North of Punta Lima, the coastline consists of mangroves, rocky headlands, and a few small beach plains and pocket beaches. This end of the island is bordered by an insular shelf, with abundant coral and marine organisms, that extends eastward to the neighboring Virgin Islands.

Average annual rainfall is high, with a range of 1.4 to 2.0 m (55 to 80 inches). Rivers and streams are abundant and meander through narrow V-shaped valleys. The most dramatic example of these is the Maunabo Valley situated between the Cuchilla de Panduras and the Sierra de Guardarraya, which reaches to the water's edge. These two formations and their forested landscapes harbor an important wildlife habitat.

**Reefs.** Isla Pineros off Medio Mundo, Ceiba, has moderate coral growth on its north and east coasts. Cabeza de Perro, an islet to the south, was used by the US Navy for bombing practice and lacks marine benthic life. South to Punta Lima, the coast is mainly bordered by *Thalassia* seagrass beds with occasional small fringing and patch reefs. Most of the latter lie on a 6-7 m deep platform, many patch reefs not reaching intertidal level. Some probably lie on sand or mud formations, judging from their location at the edge of tidal swamps (Kaye, 1959).

Southwest of Punta Lima, turbidity increases due to sediment-laden rivers and creeks. Several islets such as Cayo Santiago and Cayo Batata have coral growth in shallow waters and south facing areas, open to the sea, with dense 90% living *A. palmata* stands intermingled with gorgonian and head corals close to the surface. Submerged shoals with sparse coral growth occur occasionally off Humacao, as at Bajo Parse, which has numerous gorgonians, small head corals and extensive patches of the encrusting sponge *Anthosigella varians*. Further south, there is little coral growth in Yabucoa Bay (apart from an annular reef in the southern part of the bay with a few living corals) presumably because of river outflow (Díaz-Piferrer, 1969; Seiglie, 1969). About 5.5 nautical miles (10.2 km) east of Yabucoa Bay, La Conga reef is probably part of the submerged barrier reef bordering most of the southern shelf of Puerto Rico.

At Maunabo, the insular shelf is only 1 km wide; the associated high energy wave conditions and reversing tides flush Sergeant Reef, south-east of Punta Tuna, clean of river sediments (see separate account). A fringing reef extends almost continuously for four miles (6.4 km) between Cabo Mala Pascua to Puerto Patillas; this is exposed at low tide and protects a sandy apron at the foot of the Sierra de Guardarraya. Arrecife Guayama, lying 0.6-0.9 km off Punta Figueras and nearly 5 km in length, is well developed but is now affected by siltation; the *A. palmata* zone has low coral cover and many dead colonies.

Sergeant Reef, on the southeast coast, 0.3 km southeast of Punta Tuna, extends 1.08 km in length and is 0.1 km wide at its widest point. The reef flat has abundant *A. cervicornis* thickets. Further seaward there is an area of reduced *A. palmata* growth with high encrusting algal cover; this zone gives way to one of dense *Porites* growth, with patches larger than 100 sq. m in some places, alternating with *A. palmata* colonies. Seaward of this, is a zone of dense 100% *A.
palmata, which thins out with depth, until gorgonians predominate (Goenaga and Cintrón, 1979). The reefs protect the shoreline in the vicinity of Punta Tuna from the southeast swell (Goenaga and Cintrón, 1979).

3.2.10.1.4 South coast: Rio Grande de Patillas (Patillas) to Rio Tallaboa (Peñuelas)

The arid south coast sector is a low lying alluvial plain, except for a short stretch between Tallaboa and Punta Cuchara, where the mountains extend to a coastline shaped by wave erosion and fringing reefs. The rest of the coastline is either beach plain or mangrove. Ponce, located in the western part of this sector, is the second largest metropolitan area, and second largest port city on the island.

Reefs. Off Arroyo, the Corona and Algarrobo patch reefs appear relatively healthy and little affected by siltation. Arrecife Las Mareas, south of Las Mareas, Guayama, is almost devoid of living coral.

Southwest of Punta Pozuelo, a fringing barrier reef, Cayos Caribes, extends for about 2.5 km forming an arc with Cayos de Barca and Cayos de Pájaros and protecting the entrance of Bahía de Jobos. Living coral cover is moderate and increases westward. On the lee side of the reefs are a number of narrow sand cays fringed by mangrove vegetation. The Ponce basin contains very turbid water, with a bottom of silt and clay. About 2.5 km south of Ponce, reefs are found at Baja Tasmanian, on a two-tiered platform, the northern level 6-12 m deep, and the southern level 18-24 m deep. A. cervicornis is particularly abundant at the lower level with large shingle-like growths of various massive corals at the shelf edge (Beach, 1975). Numerous offshore cays with healthy coral cover occur off Salinas, Santa Isabel and Ponce.

Bahía de Jobos is an area on the south coast, in the municipalities of Salinas and Guayama, including Cayos de Pájaros (17E55' N, 66E15' W), Cayo Morrillitos (17E55' N, 66E15' W), Cayos de Ratones (17E56', 66E17'W - not to be confused with Cayo Ratones described in a separate account), Arrecife Media Luna, Cayo Alfeñique, Cayos de Caracoles, Cayo Cabuzazos and Cayos de Barca.

The surrounding land is largely flat with a few hills rising only to 50 m. The climate is characterized by short periods of heavy rain, which may produce flash floods, most of which discharge into the sea. Annual rainfall averages 1086 mm/year. Temperatures range from 22 to 31EC with an annual average of 26.5EC. The dry season extends from January to April, and the wet season from June to November. The area includes a wide variety of habitats such as estuaries, mangroves, salt marshes, coral reefs and seagrass beds, and has been described by Beach (1975) and Diaz et al. (1983).

Szmant-Froelich (1973) studied the zonation and ecology of the Bahía de Jobos reefs and found 13 coral species. Profiles for some of these areas are given in Goenaga and Cintrón (1979). Cayos de Pájaros has an M. complanata-dominated reef crest fragmented into buttresses about 3 m high, a well-developed A. palmata zone, and a mixed zone and slope typical of other reefs in
the area. Cayo Morrillos has a very wide *M. complanata* reef crest with 2 m high buttresses and much coralline algae; the *A. palmata* zone and slope was similar to Cayos de Pájaros.

On Cayos de Ratones, *A. palmata* is common on the *M. complanata*-dominated reef crest. Seaward of this, there is an abrupt slope leading to a bare sand area with scattered isolated small head corals. Beyond this, depth increases rapidly to an area where mounds topped with *M. complanata* are found. The *A. palmata* zone is found at greater depth, followed by a mixed zone with gorgonians dominant on the upper part, and massive corals dominant near the reef base. *Mycetophyllia* and *Oculina* are also common.

Cayo Alfeñique is crescent-shaped with the same three zones, although these are less well defined on the east side of the reef, and the *A. palmata* zone was not nearly as well developed as on other nearby reefs. A spur and groove system is found east of the reef slope, with north-south orientation (parallel to the reef crest). Gorgonians dominated the spurs and bare sand was found on the bottoms of the channels. The lagoon had sparse *Thalassia* and dead *Porites*.

On Cayo Cabuzazos, small *D. clivosa* and *D. strigosa* formed an important component of the *M. complanata*-dominated reef crest. Calcareous algae and *Palythoa* were common. Beyond the *A. palmata* zone, the mixed zone consisted of *A. cervicornis*, gorgonians and other corals. The reef slope was dominated by *A. agaricites* and gorgonians, with other corals and sponges. The reef flat was a well-developed *Porites* biotope, with a *Thalassia* bed mixed with *Porites* on the shoreward side.

More recent studies have shown that the reefs have significantly changed since 1973. Diaz et al. (1983) describe the current status of reefs at Arrecife Las Mareas-Guayama, Cayos Caribe, Cayos de Barca, Cayos de Pájaros, Cayo Morrillos, Cayos Ratones, Punta Colchones and Punta Puerca, and Cayo Media Luna. Szmant-Froelich (1973) found that reef diversity increased towards the east, but currently reef diversity is highest in the west at Cayos de Pájaros and Cayo Morrillos; these changes are probably due to hurricane damage.

Bahía de Jobos is an important wetland site with the second largest mangrove swamp in the country, brackish and saline lagoons and one of the best areas in Puerto Rico for migratory shorebirds (Diaz et al. 1983; Scott and Carbonell, 1986). All the cays, except Media Luna, have mangroves in various stages of development (Goenaga and Cintrón, 1979). Bahia de Jobos is the most important area in Puerto Rico for the Caribbean Manatee *T. manatus*, and is a feeding area for the Hawksbill Turtle *E. imbricata* and Green Turtle *C. mydas* (Groombridge, 1982; Scott and Carbonell, 1986). The fish fauna has been well documented, with over 260 species having been recorded in the bay and among the cays, including many commercially important species (Diaz et al. 1983). The rich invertebrate fauna includes large populations of spiny lobsters *Panulirus sp.*, and the mollusks *Crassostrea rhizophorae, Isognomon alatus* and *Brachiodontes exustus* (Scott and Carbonell, 1986). Diaz et al. (1983) described the mammal, bird, reptile and amphibian faunas.
3.2.10.1.5 Southwest coast: Rio Tallaboa (Peñuelas) to Punta Guaniquilla (Cabo Rojo)

The topography of this area is generally hilly, with the exception of level areas near Tallaboa, Guayanilla, Guanica, Pole Ojea, and Boquerón. Precipitation is low – 89 cm (35 inches) annually -- which gives rise to the xerophytic (desert-type) vegetation that abounds along the coast. The absence of alluvium and the relatively wide extension of the insular shelf along the southwest coast have permitted the proliferation of coral reefs and bioluminescent waters -- natural systems sustaining a food chain that contributes to the southwest's fisheries resources, which are abundant compared to those of the rest of the island.

The dry forest of Guanica (9,582 acres); the mangroves of La Parguera, Boquerón, and Pitahaya (1,681 acres); the reefs of Margarita and Turromote; the beaches of Caña Gorda, Bahía de la Ballena, El Combate, Caleta Salina, Punta Ventana, and Boquerón; the bird reserves of the Cabo Rojo National Wildlife Refuge and the Commonwealth's Boqueron Bird Refuge (970 acres) are examples of the natural wealth of the southwestern coast.

Reefs. Off Tallaboa and Bahía de Guayanilla, living coral cover is negligible, due to industrial development, although some isolated heads of *A. palmata* and *M. complanata* still survive on the seaward side. Over the last four years, coral cover has declined from 10-20 % to less than 1 %. A few areas of high coral cover and diversity still occur, for example, on the walls of the Guayanilla submarine canyon (Goenaga in litt., 7.3.86). The reef off Punta Verraco, on the west of Guayanilla Bay, has an extensive *Thalassia* and *Syringodium* bed on its reef flat. Stony coral cover on the shallow front reef is very reduced, but the deeper fore reef has an extensive and quite healthy community of soft corals and gorgonians. An extensive submerged reef extends from Punta Vaquero to Punta Ventana, where it breaks the surface first as a fringing reef and later as a barrier reef protecting Playa Tamarindo, Bahía de la Ballena and Playa de Cana Gorda just west of Guánica. This reef is almost totally devoid of living coral and has huge carpets of the fast-growing colonial anemones *Zoanthus* and *Palythoa* lying over the dead coral framework. Quinn (1972) has described surge channels on the southwest coast.

West of Punta Jorobado, reefs become more prolific and complex, due to limited rainfall, minimal soil run-off and low wave action, and are described in the account for La Parguera (Goenaga and Cintrón, 1979). Around Cabo Rojo, the reefs are small and often do not break water although coral growth is fairly abundant. In the small bay west of Cabo Rojo Lighthouse, patches of coral alternate with *Thalassia* grass beds, and are described in Almy and Carrión-Torres (1963). Bajo Gallardo is a well-developed, relatively untouched reef about 13 km west of Punta Aguila, Cabo Rojo; with luxuriant *A. palmata* growth and abundant fish life. Roca Ola, a patch reef in Bahía Sucia, Cabo Rojo; has large colonies (more than 3 m diameter) of *M. annularis* (Goenaga in litt., 73,96).

The Caja de Muertos complex on the south coast includes Caja de Muertos (17E55'-17E54'N, 66E33'W, 8.5 km off the coast and west of Santa Isabel), Cayo Berberia (17E55'N, 66E27'Wg 5.5 km to the north-east) and Cayo Morrillitos at the tip of Caja de Muertos. Villamil et al. (1980) gave a detailed description of the area, including climate (data from Santa Isabel airport), geology and physicochemical characteristics of the water. Aspects of marine geology are described by Beach and Trumbull (1980), and sedimentation by Beach (1975). Both cays are
vegetated. Villamil et al. (1980) mapped the marine communities of the area; seagrass beds cover 1110 ha and coral reefs cover 519 ha, a variety of other types making up the remaining area.

Cayo Berberia had an extensive (3 km) fringing reef on the eastern and southern shores. Coral development reached a maximum on the southern shore where the A. palmata zone reached 95% cover prior to Hurricanes David and Frederick in 1979. The reef was described in more detail by Villamil et al. (1980), who considered it to be richer and more diverse than the reef at Caja de Muertos. The reef crest was a low relief zone which, with the exception of some M. complanata and small A. agaricites and F. fragum colonies, was devoid of coral growth and dominated by alga with much coral rubble. The A. palmata zone now appears as a low-relief barren platform with sand filled depressions, and only a few small colonies of A. palmata and other hermatypic corals. P. astreoides is the most abundant species and coral cover is 11.6%. Beyond this zone, the reef slopes down to a depth of 12 m at an average angle of 35°. Coral cover and diversity increase considerably on the fore reef slope. The dominant coral is M. annularis and coral cover averages 21.7%. Southeast of Berberia is a small, submerged reef called Las Cervezas, which had extensive A. palmata coverage and dense gorgonian stands. Fish life was especially abundant.

On Caja de Muertos, greatest reef development is found on the northeastern shore. This reef is particularly noticeable for its complex high relief lagoon that supported a variety of benthic and nektonic fauna (Goenaga and Cintrón, 1979). It was described by Canals et al. (1980) and Villamils et al. (1980). Four zones were identified: a) a lagoonal zone, b) a reef crest, dominated by Millepora spp. and zoanthids, c) an A. palmata-dominated zone and d) and a fore-reef (4-7 m deep), where gorgonians and octocorals predominate. Twenty-six species of coral were recorded. Coral cover was highest (34-37%) on the fore reef and only 2-11% in the A. palmata zone.

Villamil et al. (1980) gave a detailed description of noteworthy flora and vegetation of the cays. Mangroves are found on the two major cays and there is a large expanse of seagrass. Villamill et al. (1980) provide species lists for echinoderms, crustaceans, mollusks and fish (69 species). The reef at Cayo Berberia has a higher diversity of fish than that at Caja de Muertos. Juvenile spiny lobsters P. argus and the queen conch S. gigas have been recorded. Large numbers of marine turtles may nest on the beaches of Caja de Muertos, although it is not recorded in Bacon et al. (1984). The area is also visited by the Caribbean Manatee Trichechus manatus.

Hurricanes David and Frederick caused greater damage at Caja de Muertos than at Cayo Berberia and affected the A. palmata zone, resulting in increased algal cover in this area.

CAYO RATONES PROPOSED PROTECTED AREA

Geographical Location. South coast, about 1.1 nm (2.03km) south of Ponce; 17°57'N, 66°40'W. Physical Features. One of the numerous mangrove islets fringed by coral reefs, which lie off Ponce (other islets include Isla de Frio, Isla de Cardona, and Cayo Cardona). Waters are moderately silt-laden (Goenaga and Cintrón, 1979). Tidal range at Ponce is 0.18 m (Velazco-Domínguez et al. 1985)
Reef. A fringing reef borders the south coast of the island (Goenaga and Cintrón 1979). The reef crest was dominated by *M. complanata*, with occasional colonies of *A. palmata* and abundant *Palythoa*. In the *A. palmata* zone, living cover increased seaward; many dead colonies were found shoreward. Large buttresses, about 3 m in relief, were topped with *A. palmata*, scattered gorgonians and *M. annularis* colonies. *A. palmata* cover decreased towards the mixed zone, which was dominated by gorgonians, for a width of about 100 m; *M. annularis*, *M. cavernosa* and *Siderastrea* were also common, as well as dead *A. cervicornis* colonies. On the reef flat, *Thalassia* and *Syringodium* were found, but the *P. porites* biotope was not well developed. Ferrer Hansen (in litt., 12.5.86) reports that the fore reef is now dominated by *M. cavernosa*, and that the encrusting gorgonian *Erythropodium caribaeorum* is the most dominant species.

Mangroves grow on the reef flat (Goenaga and Cintrón, 1979). The Caribbean manatee *T. manatus*, hawksbill turtle *E. imbricata*, and leatherback turtle *D. coriacea* may occur in this area.

LA PARGUERA

Geographical Location. Southwest coast, 28 km south east of Mayagüez; 17E58' N, 67E 04'W; the area includes the following islands and cays: Cayo San Cristóbal, Cayo Laurel, Cayo Media Luna, Cayo Mario, Cayo Enrique, Cayo Turrumote, Cayo Corral, Isla la Gata, Cayo Caracoles, Cayo Majimo and Cayo Caballo and Ahogado. Bahía Fosforescente, a mangrove-bordered bay on the mainland, is situated to the east of La Parguera, and Isla Magueyes is situated just south of the town.

Area, Depth, Altitude: Wetland area covers 400 ha.

Physical Features. The coast forms a broad landward indentation at the fishing village of La Parguera, and is fringed with mangroves, intertidal mudflats, natural salt flats and shallow saline lagoons. The insular shelf is about five miles (8 km) wide at this point, and supports two elongated reef systems aligned approximately east to west. Goenaga and Cintrón (1979) discuss their possible origin. The outer line of reefs (Turrumote, Media Luna and Laurel) are situated about 3 km offshore, each reef facing the incoming waves from the east-southeast. The inner reefs (Enrique, La Gata complex, Caracoles, Majimo) are closer (1 km) to shore, forming an arc which is convex to the south. Most of the reefs are small, but they increase in length westwards, and Arrecife Margarita reaches a length of two miles (3.2 km). They are considered to be poorly formed barrier or ribbon reefs. Channels between the reefs are 50-70 ft (15.2-21.3 m) in depth and have sandy bottoms. Between the inner reef line and shore are small patch reefs; their rapid growth combined with the spread of mangroves is causing the shelf in this part to become shallower.

Hydrographic conditions in the waters off La Parguera are described by Coker and Gonzales (1960) and summarized by Almy and Carrión-Torres (1963). The climate is semi-arid with an average rainfall of 30 in. (762 mm), and an annual evaporation rate of 80 in. (2030 mm). Salinity averages 35.4 ppt and surface temperatures range from 25.5 to 32.0°C. The temperature-salinity characteristics are indicative of a mild hydrographic climate (Glynn, 1973). Winds are from the south-east or east-southeast and tend to freshen in the forenoon. Currents are from east to west...
and flow parallel to the coast. A continuous surface current flow over the reef, and a maximum daily tidal range of only 40 cm prevents marked temperature and salinity differences.

**Reef Structure and Corals.** The majority of the larger reefs have a broad (up to 50 m wide) shallow reef flat. Of the outer reefs, Cayo Turrumote has the greatest variety of species although it is comparatively short. It is formed from large coral boulders thrown up by waves to an average height of about 1 m, but reaching 2-3 m on the eastern end. The exposed part of the reef has maximum dimensions of 100 x 1000 ft (30 x 300 m) and is topped with white mangroves. Seaward of the exposed part, the shallow fore reef flat is covered with a *P. porites* pavement, scattered with *M. complanata*, *A. palmata* and *A. prolifera*. The pavement is unusually narrow, about 60 ft (183 m) wide, and at a depth of 2 ft (0.6 m) gives way to a dense growth of *A. palmata* in the surf zone. At 5-10 ft (1.5-3 m) *M. complanata* is found intermixed with *A. palmata*, with large massive boulders of *M. annularis*. Beyond 30 ft (9.1 m), coral density decreases although diversity increases. Coarse sand patches occur among the gorgonian patches.

On the shoreward side of Cayo Turrumote, an open lagoon extends to a steep slope along the north edge of the reef. *P. porites*, *F. fragum* and *S. radians* floor the shallow parts of the lagoon and give way to sand and widely spaced coral colonies in water deeper than 2 ft (0.6 m). At the north edge of the reef, the gently sloping lagoon floor drops from 15 ft (4.6 m) to a sand covered bank at 35 ft (10.7 m) depth. *A. palmata* is abundant along the edge of the drop-off and a variety of corals are found on the slope (Almy and Carrión-Torres, 1963). A buttress zone of very high relief, "The Pinnacles", so-called because of the large colonies of *M. annularis* which have grown in pyramid-like form (Nash pers. obs., 1983), has an abundant fish fauna (Goenaga and Cintrón, 1979). Cayo Laurel is described by Glynn (1973). The reef flat has a high population density of *P. furcata*, usually oriented in patches parallel to the longitudinal axis of the reef. Six zones were identified down to 3 m depth. The shoaling seaward slope, with no spur and groove structure, is dominated by *A. palmata*, and gives way to a rigid framework of *M. complanata*, which forms a sill on the seaward edge of the reef flat. This has abundant dead coral colonies, and is often exposed at extreme low water. On the leeward side, *P. furcata* and coral rubble predominate, the former appearing in dense stands in depths of 1.5 m. The deep edge of this *P. furcata* belt, grades abruptly into a smooth sandy bottom, beyond which *Thalassia testudinum* is abundant.

The other outer reefs are similar, built of coral boulders, with *P. porites* dominating the fore reef flat and parts of the lagoon, and abundant *A. palmata* in the surf zone. A steep slope, usually borders the seaward edge of each reef, beginning at 15-20 ft (4.6-6.1 m), and dropping to a trough at 65 ft (20 m), which tends to be particularly well developed along the fronts and east ends of the longer reefs. Where the trough is less evident on long reefs, a buttress formation may be present. There seems to be a slight variation in the faunal assemblages of each reef (Almy and Carrión-Torres, 1963).

Cayo Enrique is the best known of the inner reefs and is described by Almy and Carrión-Torres (1963), Armstrong (1981) and Morelock et al. (1977). It is located 1.5 km south of La Parguera, and is approximately 1.4 km long and 0.4 km wide at its widest point, aligned almost parallel to the shore (Armstrong, 1981), but oriented to the incoming waves and currents. It forms an apron
reef with a shallow (0.5-3 m) area of sand deposition leeward of the reef flat. *T. testudinum* areas occur at both ends of the sandy lagoon and on the reef flat, and patch reefs are found in the middle and western parts of the lagoon. The reef flat is composed mainly of living *Thalassia*, *Zoanthus*, *Porites* and occasionally *Halimeda clumps* (Armstrong, 1981). The reef crest is dominated by *M. complanata*, and the zooanthid *Palythoa caribbea* is found encrusting dead corals near the reef crest.

At the eastern end, the fore reef of Cayo Enrique is relatively broad and gradually slopes to a depth of 20 m. It gets narrower and steeper towards the west. The reef lacks a spur and groove formation, but has a well-defined coral zonation. *A. palmata* occurs seaward of the crest to a depth of 3 m, followed by *A. cervicornis* to 5 m. A zone of massive corals occurs from 5 to 15 m, and is composed mainly of *Montastrea*, *Diploria* and *Agaricia*. The lagoonal patch reefs are dominated by *M. annularis*, in addition to numerous sponges and gorgonians. Other corals present include *A. cervicornis*, *S. siderea* and *D. labyrinthiformis*. Dead coral heads covered with algae are common in this area (Armstrong, 1981).

The reef flat at La Gata reef complex has been divided into seven zones: a) a latticework of *M. complanata* and encrusting calcareous red algae; b) a pool with dead coral debris; c) an emergent reef flat; d) a mixed *Thalassia* - coral rubble zone; e) sand; f) massive clumps of the alga *Acanthophora spicifera*; and g) a sandy leeward lagoon (Glynn, 1968).

Goenaga and Cintrón (1979) give brief descriptions of reef zonation at San Cristóbal, Cayo Enrique, Cayo Laurel, Turrumote, Isla La Gata, Margarita, Las Pelotas, Cayo Ahogado, Cayo Media Luna, La Conserva, and Collado. San Cristóbal, a small reef 4-5 km southwest of La Parguera, has a high relief *A. palmata* zone with an abundant fish fauna. Cayo Laurel is a large, well-developed reef. Cayo Caballo Ahogado is situated shoreward of Cayo Enrique and is described briefly by Almy and Carrión-Torres (1963) and Morelock *et al.* (1977).

The main differences between the inner and outer reefs are the extensive red mangroves *R. mangle* on the former, mainly on the east and west ends, and the well-developed mud flats and *Thalassia* beds in the lagoons (Almy and Carrión-Torres, 1963). The patch reefs north of the inner line of reefs, have mangrove thickets in various stages of development and a restricted coral fauna compared with the other reefs. *P. porites* is abundant in shallow areas, and there is a poorly developed *A. palmata* zone on the seaward side. *P. porites* is the main constituent of the coral assemblages fringing the coastline, and also around the non-coral island Isla Magueyes. Almy and Carrión-Torres (1963) provide a checklist of coral species found in the La Parguera area, which has the greatest recorded number (54) in Puerto Rico. The productivity of the reefs is described in Odum *et al.* (1959); Rogers (1979a and 1983) studied productivity and sedimentation on San Cristóbal Reef.

Mangroves *R. mangle*, *L. racemosa* and *A. nitida* are found on the cays and along the shoreline throughout the area (Almy and Carrión-Torres, 1963; Armstrong, 1981; Glynn *et al.* 1964; Odum *et al.* 1959). The importance of the area as a wetland is described by Scott and Carbonell (1986). The Caribbean manatee *T. manatus*, the green turtle *C. mydas*, the hawksbill turtle *E. imbricate* and the leatherback turtle *D. coriacea* are found within the La Parguera area. The haemulid (grunt) fishery is described by Appeldoorn and Lindeman (1985). The area is a popular
recreation site; Cayo Enrique is visited frequently by pleasure boats that stay up to 3-4 days anchored in the calm, sandy lagoon (Armstrong, 1981). La Parguera is being used increasingly as a weekend resort by families from further inland and increasing numbers of "casetas", houses on stilts, built over the waters bordering the mangroves (Nash pers. obs., 1983). The iguanas resident on Isla Magueyes are a popular tourist attraction with special boat trips to the island to "feed the iguanas" and Bahia Fosforescente is a further attraction.

Hurricanes are the main destructive agents. Glynn et al. (1964) documented the effects of Hurricane Edith in 1963. Although extensive coral destruction on the outer reefs was observed, Cayo Enrique and other inner reefs suffered only 10 to 50% Acropora destruction, and there was slight damage to the mangroves. The topography of many of the outer cayos was considerably altered. Hurricane Beulah had a major impact in 1969. Hurricane David in 1979 passed 160 km to the south of Ponce and caused significant damage with boulder rampart accumulation on the reef flat at Cayo Enrique (Goenaga 1982a).

Changes on Cayo Enrique, from 1936 to 1979, were studied using aerial photo-analysis (Armstrong, 1981). A two-fold increase in lagoonal seagrass areas occurred over this period. Mangrove areas increased fifteen times between 1936 and 1978, but an area of 1560 sq. m was destroyed by Hurricane David. Mass destruction of reef biota was recorded in 1965 as a result of extreme midday low tides. The impact was felt most strongly by echinoids (Glynn 1968).

3.2.10.1.6 West coast: Punta Guaniquilla (Cabo Rojo) to Rio Culebrinas (Aguada)

The west coast, like the southeast, is characterized by valleys defined by mountain chains that come down to the coastline. This stretch of the coast receives the largest amount of rainfall – from 65 to 90 inches annually. The abundance of water makes the principal valleys of the area – Añasco, Culebrinas and Guanajibo – of great agricultural value.

In the southern portion of this sector, beach plains predominate. However, north of Punta Guanajibo, there are a variety of coastal characteristics: rocky shorelines, mangrove stands, and fringing reefs. Mayaguez, located midway between Punta Guaniquilla and Rio Culebrinas, is the Island's third largest urbanized area, and the third largest port city (after San Juan and Ponce).

Reefs. Between Cabo Rojo and Mayaguez, there is high water turbidity near shore, unusually low wave action and heavy land drainage. The broad bank that lies immediately offshore minimizes wave action, limiting water circulation and the removal of land drainage pollution. The coral patches and assemblages generally have few stony corals, often covered by mats of macro-algae, but there are spectacular, dense stands of gorgonians (Kolehmainen, 1974). Bahía de Boquerón is very turbid, its reefs surrounded by mud, but nevertheless there is a dense covering of corals, particularly gorgonians.

Reefs to the north include Escollo Negro and Arrecife Tourmaline (see separate account), Las Coronas, Escollo Rodríguez, Cayo Fanduco, Manchas Interiores, Manchas Exteriores, Arrecife Peregrina and Gallardo. Las Coronas is a shallow (2-4 m) sand shoal colonized principally by large-sized gorgonians and occasional massive corals, extending east to Cayo Fanduco. Manchas
Interiores, Manchas Exteriores and Arrecife Peregrina have low-relief spur and groove systems sloping more or less abruptly westward, giving way to a dense black coral-dominated fauna. Encrusting coral growth with large pillar corals and gorgonians dominate the shallow depths. Escollo Rodríguez, situated about 1.6 km west of Cayo Corazones, consists of a series of elongated patch reefs, which lack the distinct zonation found in the other reefs. There is abundant fish life, but the reefs appear to be affected by siltation from the Guanajibo River (Morelock et al. 1983; Schneidermann and Morelock, 1973).

A study of reef fish was carried out on a 25 sq. km reef tract, about 9.5 km off the west coast from an underwater habitat (Parish, 1982; Parish and Zimmerman, 1977). This area consisted of a shallow bank, 3-6 m deep, with a steeply sloping face of living coral on the seaward side to 16.5 m depth. The reef has a variety of living hexacorals and octocorals, growing on an open porous structural framework of dead coral, with a diverse assemblage of other sessile invertebrates and low, encrusting filamentous algae.

North of Arrecife Peregrina to Punta Higuero, the insular shelf is less than 1 km wide and has well-developed reefs at its outer edge, where the bottom slopes steeply. Stony corals, unusual gorgonians and black corals are abundant at depths of 15-40 m but water transparency is quite variable, being influenced by river discharge. Poorly developed fringing reefs, consisting mainly of partially dead *A. palmata* and scattered gorgonians occur on the north side of the Rincón Peninsula from Punta Higuero to Punta del Boquerón.

Arrecife Tourmaline and El Negro (Escollo Negro) (18E5'-18E10'n, 67E17'-67E19'W) lie off the west coast, approximately 10 km west of Punta Ostiones, and are two of the offshore reef areas on the west coast north of Boquerón. Currents flow mainly north-south or south-north, the northerly flow predominating (Loya, 1976). Visibility at El Negro is poor according to Loya (1976), although Goenaga and Cintrón (1979) mention high water transparency. East and West Reefs rise vertically on Escollo Negro from an average depth of 20 m to about 7 m; West Reef is a flat patch reef.

Escollo Negro is characterized by a low relief spur and groove system, with high living coral cover and diverse, encrusting coral growth. The system diminishes shorewards and gorgonian cover increases (Goenaga and Cintrón, 1979). East Reef has a reef flat at 6-8 m depth, dominated by *A. cervicornis*, which provides 45% coverage, *M. annularis* accounting for 28%. The upper fore-reef is at 9-17 m depth and the lower fore-reef at 18-20 m depth. At greatest depths, *M. cavernosa* is the main reef builder. At West Reef, the four commonest species, *M. cavernosa*, *S. radians*, *S. siderea* and *D. strigosa*, cover 73%. At East Reef, the four commonest species, *M. cavernosa*, *M. annularis*, *Agaricia agaricites* and *S. siderea* cover 62%. Twenty-one coral species have been recorded at El Negro (Loya, 1976).

Turbidity and sedimentation, produced by resuspension of local fine calcareous sediments during heavy, long-period ground swells originating in the Atlantic Ocean mainly during winter months, are the most important factors affecting reef growth in this area (Cintrón et al. 1973; Kolehmainen, 1974; Loya, 1976). Terrigenous suspended sediments and domestic pollution from Rio Guanajibo, and the presence of seston and plankton in the water column, also affect
turbidity. *M. cavernosa* is the dominant coral in areas most seriously affected by sedimentation, *S. siderea* suffering high mortalities.

3.2.10.1.7 Northwest coast; Rio Culebrinas (Aguada) to Rio Grande de Arecibo (Arecibo)

This sector – the tableland of the northwest – is characterized by a hilly interior and rocky cliffs along the coast. These cliffs, some as much as 300 feet high, are a tourist attraction because of their dramatic scenic beauty. Nevertheless, since the coastline is exposed to direct wave action of the sea, the potential for aquatic recreation is limited. The sand dunes on the coastline are an important resource, and submarine sand deposits off the coast of Isabela are important potential resources. The limestone bluffs of the northwest coast have been shaped by wave erosion. Along much of the coast, the bluffs extend several hundred meters or more back from the shoreline, with beach plain between the bluffs and the water. In the Jobos Beach area in Isabela, an extensive system of sand dunes exists. These pose a major coastal issue because of extensive mining, which threatens the resource. East of Isabela, beaches are generally narrow, consisting of thin layers of sand over a rocky shoreline. Despite numerous rocky headlands that separate these beaches, adjacent sand dunes supply most of the beach sands by landward erosion and littoral migration.

Reefs. North of Punta del Boquerón, only scattered, undeveloped coral growth occurs. There is an underwater cave system off Bajura, Isabela, with dense coral growth, especially *Agaricia*, on the outer walls and ledges.

3.2.10.1.8 The offshore islands: including Culebra, Vieques, Mona, and others

The principal offshore islands of Puerto Rico are Vieques (33,970 cuerdas), Culebra (7,180 cuerdas), and Mona (13,900 cuerdas). The topography of the first two is similar, characterized by small hills. Rainfall on these islands is light. Vegetation is the same as that of the semi-arid south coast of Puerto Rico. Portions of the coasts are bordered by mangroves, and some of the bays are bioluminescent. The clarity of coastal waters contributes to the presence of coral reefs in the near-shore waters. These waters also provide favorable conditions for marine life and recreational boating. Economic activity on Vieques and Culebra is limited.

Mona is predominantly a limestone tableland surrounded by cliffs interrupted sporadically by bands of beach. Low rainfall and the extreme porosity of its soils result in a vegetation typified by dry coastal forest. The island is uninhabited; its flora and fauna include a large number of endemic species. The principal value of this island is as a natural reserve.

The other small islands, the majority of coral origin, are uninhabited and reflect natural conditions similar to the islands previously described. The many fringing islands of the south coast of Puerto Rico are also very important in numerous coastal processes.
THE ISLAND OF CULEBRA

Setting. The island of Culebra lies approximately 17 miles east of Puerto Rico, 12 miles west of St. Thomas, and 9 miles north of the island of Vieques. Its total area, including surrounding keys, is 7,700 acres. It is characterized by irregular topography with hills of low elevation, the tallest being Monte Resaca with an elevation of 650 feet.

Due to Culebra's small size and low elevation, it does not force precipitation from the trade winds to any great degree. This accounts for the island's limited rainfall. As a result, the climate of Culebra is slightly xeric; mean annual rain-fall is only 0.9 m (36 inches), varying from 0.4 m (16 inches) in the drought year of 1967, to as high as 1.5 m (59 inches) in 1942. There are no permanent fresh water streams on Culebra. Such conditions are favorable for a profuse coral growth in the surrounding clear littoral waters where sedimentation is reduced to a minimum.

Due to its long and intricate shoreline, Culebra presents a series of bays, peninsulas, and bars, some of which end in abrupt cliffs, sandy shores, or mangrove forests. The principal harbor is Ensenada Honda, which is considered one of the most secure hurricane harbors in the Leeward Islands.

Turtlegrass beds: Turtlegrass beds are found around most of the islands, in waters shallower than 9.1 m, usually interspersed with stretches of sandy bottom, or coral reefs. The north and northwest sides of the islands are the exceptions because of heavy surf action caused by swells from the Atlantic Ocean.

Mangrove shores: Mangrove forests cover much of the shoreline in Ensenada Honda, and to varying degrees, the southeastern coasts of the islands. Most of the animals encrusted on mangrove roots are flat tree oysters and, to a lesser extent, edible mangrove oysters. Important mangroves are also present behind the following beaches: Flamencó, Resaca, Brava, and Larga.

Reefs. There is no information readily available for the reefs of Culebra and Culebrita Islands. The shallow-water sublittoral benthos is described by Cerame-Vivas et al. (1971). Ensenada Honda on Culebra has been described by Cintron et al. (1974). Communities of Porites furcata are found along the southeast coast (Glynn, 1973). These corals form extensive monotypic stands that extend from the leeward reef through the reef crest and into the reef front. This is quite uncommon in other reefs where large, monotypic stands of this coral are restricted to the leeward reef sections.

THE ISLAND OF VIEQUES

Located 18 km east of Puerto Rico (18E06’ N, 65E 24’ W). The special area is situated on the southern coast of the island between Punta Negra and Punta Jalova. The seaward boundary is delineated by the 50 m isobath, which is the edge of the island's coral shelf and is situated 2.6-4.5 km from shore (Anon., 1982).

The island of Vieques is approximately 9 miles southeast of Puerto Rico. It covers approximately 33,000 hectares, of which 26,156 hectares are Federal lands.
Setting. There are no permanent fresh water streams on Vieques Island, and precipitation is minimal. Vegetation in Vieques is similar to that of the semi-arid region of southwest Puerto Rico. The coast is fringed by mangrove wetlands and bays that exhibit the phenomenon of bioluminescence, such as Puerto Mosquito, Bahia Tapon, Puerto Ferro, and Puerto del Manglar. Many coral reefs are found in Vieques, and the broad insular shelf provides favorable conditions for proliferation of marine life. The most important natural areas in Vieques include its beaches, like Sun Bay, which has complete facilities; and mangrove systems like the ones in Laguna Kiana, Ensenada Honda, Bahia Tapon, Bahia Mosquito, Playa Grande, Bahia Ferro and Bahia Chiva, all of which are of great importance for Puerto Rico’s wildlife.

The most important coral reefs bordering the coastal waters near Vieques are Ensenada, Cana Honda, Punta Vaca, Isabel Segunda, Caballo Blanco, Mosquito and Corona. These corals are of varied shapes and colors, and several species of fish are associated with them.

The eastern part of the island (within the Navy Base), exhibits numerous swamps and the adjacent hills of Mt. Pirata, as well as Kinani Lagoon, all of them natural areas of importance to Puerto Rico’s wildlife.

Reefs. Numerous fringing, patch and offshore bank barrier reefs are found around the coast of Vieques, including reefs at Punta Este on the eastern point, Peñasco Fosil, Punto Gato, Gato Afuera, Isla Yallis and Punta Icacos around Bahía Icacos on the north coast, Cerro Indio, Pena Roja, Bahía Salinas, Punta Salinas, Cerro Matias, and Roca Alcatraz on the south coast (Antonius and Weiner, 1982; Dodge, 1981; Maclntyre et al. 1983). Brief descriptions of these reefs are given in Antonius and Weiner (1982). Those off the eastern end are well known, as a result of a series of studies carried out for the US Navy in 1978. The area has been used as a practice range for air-dropped bombs and ships gunnery, but the Navy ceased operations on Vieques in May 2003.

Raymond (1978) carried out an ecological survey of the shallow reefs fringing the promontories on the eastern, western and northern shores of Bahía Salina del Sur. Two extensive sand beaches border the northeastern and northwestern corners. The fringing reef off the west side of the bay consists of a well-developed A. palmata community, and banks and mounds of P. porites occur around two distinct promontories on the north coast (MacIntyre et al. 1983). The fringing reef on the eastern side of the bay consists of Montastrea, Siderastrea and Diploria coral heads. Another reef juts out from the promontory and has zonation typical of shallow water Caribbean reefs: a reef crest and shallow forereef dominated by A. palmata and a mixed coral community at depths greater than 4 m, which includes M. annularis, D. strigosa and S. siderea. The seaward slope levels off at a depth of 8 m, grading into the sediment floor of the bay. The backreef, shoreward of the reef crest, is composed of large colonies of M. annularis on rubble and pavement.

Maclntyre et al. (1983) describe the results of core drilling and give estimates of accumulation rates for this reef. Roca Alcatraz, an island 1 km south of the bay, is surrounded by an A. palmata reef.
Reefs outside the range area include Mosquito Reef, some distance off the northwest coast, and Ensenada Honda off the south coast (Dodge, 1981), which falls within a proposed marine sanctuary area.

**Physical features:** The seabed within the proposed area is a gradually sloping limestone and coral shelf, sheared off at the edge by volcanic activity. Beyond 50 m depth, the bottom plunge sharply to 900 m within the 4.8 m territorial water boundary, finally reaching a depth of 4 km, at 24 km from shore. Fine-grained sands overlay the hard coral bottom. The shoreward boundary is fringed by mangroves and sandy beaches. The clarity of the water contributes to the luxuriousness of the reefs. Several phosphorescent bays occur in the western portion of the proposed area, outside Federally restricted water (Anon., 1982).

**Reef structure and corals:** No detailed information is available, although there is a reef at Ensenada Honda. The reefs are probably similar to those of Culebra, and almost certainly similar to those at the eastern end of Vieques, which have been intensively studied.

Mangroves fringe the coast. The Caribbean manatee may be found here occasionally. Green turtle *C. mydas*, Hawksbill *E. imbricata* and Leatherback *D. coriacea* turtles nest sparsely on Vieques (Bacon *et al.* 1984; Groombridge, 1982).

The area's relative isolation makes it an ideal site for research, particularly into the nature and ecological relationships of phosphorescent bay habitats (Anon., 1982). Despite the intensive work carried out at the eastern end of Vieques, particularly at Bahia Salina del Sur, the reefs of this area do not seem to have been surveyed.

**THE ISLANDS OF MONA AND MONITO**

Geographical Location 67E57'W, 18E10'N; the islands are about 3 miles (4.8 km) apart, about 50 miles (80 km) west of Puerto Rico, half way between Puerto Rico and the Dominican Republic, in the middle of Mona Passage.

**Area, Depth, Altitude**
- Monito = 500 m x 300 m; maximum altitude 60 m;
- Mona = 14,000 cuerda (5486 ha); maximum altitude 90 m.

**Physical features:** Both islands are surrounded by high vertical cliffs which drop to 100 ft (30 m) below sea level, and are undercut by caves at sea-level. They are the furthest offshore islands in Puerto Rico and are surrounded by clear seas, with visibility up to 200 ft (60 m). The current in Mona Passage, where depths reach 500 fathoms (915 m), is generally to the southwest, but sometimes to the northeast. Winds are mainly from the northeast and southeast, and high seas often make access difficult; there are occasional hurricanes. The climate is semi-arid with a mean temperature of 79EF (26.1EC) and mean annual rainfall of 32 in. (813 mm). There is no water supply other than rain. Monito is roughly rectangular and covered with xeric scrub vegetation. Mona is a carbonate island with a very flat, gently sloping upland surface, composed mainly of pitted limestone and dolomite, with caves that contain phosphorite deposits. The upland area is bordered by a narrow coastal lowland plain around the southern edge of the island from Punta...
Este to Punta los Ingleses, and from just west of Punta Caigo o no Caigo, almost to Punta el Capitan on the west. The north has high sheer sea cliffs. Sandy beaches extend for five miles (8 km) on the south. Vegetation consists of low cacti and shrubs or is absent (Anon., undated).

The marine communities of Mona are described by Goenaga (1982b) and Cintrón and Thurston (1975). Reefs are found on the less exposed southeast, south and west sides of the islands, and are considered to be in good condition. The north coast of Mona descends vertically as a wall to 90-100 ft (27-30 m) depth with abundant soft corals, fish and turtles. The southwest coast is fringed by reef. Black coral is present. A barrier reef, south of Cabo Barrio Nuevo, protects a shallow lagoon with coral.

The green turtle *C. mydas*, leatherback turtle *D. coriacea*, and hawksbill turtle *E. imbricate*, are known to nest on Mona Island (Bacon *et al.* 1984; Groombridge, 1982; Olson, 1985). Surrounding waters are visited by humpback whales *Megaptera novaeangliae*, pilot whales *G. macrorhynchus*, and large fish such as tuna, shark and blue marlin. A total of 270 fish species have been recorded. Ghost and Hermit crabs are common on the Mona beaches. There is a small area of mangrove. Turtlegrass is not extensive (Anon. undated).

3.2.10.2 US Virgin Islands

General description: The USVI consists of three main islands: St. Thomas and St. John (88 km east of Puerto Rico) in the north and St. Croix, 40 n. mi. (74 km) to the south, and about 90 small islands and cays. St. Thomas (8.3 sq. km) and St. John (5.2 sq. km) lie on the same submerged bank as Puerto Rico and the British Virgin Islands and the earliest volcanic deposits of the northwest Caribbean lava flows are visible in many places. St. Croix is the largest island (22 sq. km) and, unlike others in the Lesser Antillean chain, is primarily sedimentary in origin, and lies on a submerged bank separated from the other islands by a 4000-m deep trench. The geology of St. Croix is described by Adey *et al.* (1977). The islands are hilly with peaks rising to 474 m; the original forest is largely destroyed and existing forest and scrub is secondary.

The major wind and wave patterns affecting the Virgin Islands are related to westerly trade wind circulations to the north. Severe winds occur in the winter and hurricanes in the autumn. Average temperatures vary little between winter (25EC) and summer (28EC). The climate of St. Croix is described in Adey *et al.* (1977). Annual rainfall varies between 750 and 1250 mm, with heavy autumn and winter rains having profound effects on local marine sedimentation (Hubbard *et al.* 1981). Tides on St. Croix vary between diurnal and semidiurnal with a spring-tidal range of 0.24 m. Climatic conditions on St. John vary from the drier, windward (eastern) exposures to the moist mountain top.

A general description of the marine environments of the USVI is given in Island Resources Foundation (1977). The fringing reefs on St. John are said to be poorly developed (Randall, 1963); those within the Biosphere Reserve, which covers over two thirds of the island, are described in a separate account. Outside this area, in Coral Bay, a more-mature reef profile is found at Lagoon Point. Randall (1963) compared fish populations on an artificial and two natural reefs.
St. Croix has the most extensive reefs, with many miles of bank-barrier reefs, often with algal ridges, extending in an almost unbroken line from Coakley Bay on the north coast, around the eastern tip to Great Pond Bay on the south coast. There are also numerous fringing and patch reefs. On the north coast, the eastern shelf is up to several kilometers wide and is rimmed by emergent Holocene reefs, considered to be the best developed on the island. The western portion is less than 0.2 km wide and is traversed by two small submarine canyons; in the Salt River and Cane Bay areas, the edge of the shelf drops precipitously into great depths and the reefs form a vertical wall supporting abundant growths of black coral. The south shore has a shelf up to 4 km wide (Hubbard et al. 1981). The reef zonation of the entire island has been mapped from aerial photographs for the Bureau of Land Management.

A number of reef areas have been recommended for protection and are described in the following accounts:

- Southeastern St. Thomas, including Cas Key and the mangrove lagoon in Great St. James Bay
- Saba Island/Perseverance Bay, including Flat Key (St. Thomas)
- Salt River Submarine Canyon and Salt River Estuary (St. Croix)
- St. Croix Coral Reef Area of Particular Concern (APC), including the marine park.

Cane Bay, off the north coast of St. Croix, towards the west end, is also of conservation interest because of its popularity with divers and tourists and its scientific interest.

3.2.10.2.1 St. Thomas

**Geographical location:** Southeast St. Thomas, 7 km south-east of Charlotte Amalie; 68°48‘-64°54‘W, 18°16‘-18°19‘N. This area comprises Mangrove Lagoon, Benner, Jersey and Cowpet Bays and the waters surrounding nine offshore islands and cays: Bovoni Cay 50 acres (20 ha), Buck Island 42 acres (17 ha), Capella Island 22 acres (9 ha), Cas Cay 14 acres (6 ha), Dog Island 12 acres (5 ha), Patricia Cay 33 acres (13 ha), Rotto Cay 2 acres (1 ha), Great St. James 157 acres (64 ha) and Little St. James 69 acres (28 ha).

Bovoni, Patricia and Cas Cays, interspersed with reefs, separate Mangrove Lagoon from Jersey Bay. The uninhabited offshore islands are similar to each other in ecology and appearance, being volcanic in origin, and covered with thin stony soil. Cas and Patricia Cays have precipitous south and east windward sides, but are flatter to leeward where the headlands are dominated by cedar and mangroves (Anon., 1982). Other islets in Jersey Bay include several groups of rocks such as Cow and Calf, the Stragglers, Welk, and Dog and Fish Cay. Salt ponds are found on Great and Little St. James, Dog, Patricia and Capella Islands.

The rest of the area is dominated by fine sandy substrate with transitional seagrass beds of turtlegrass *T. testudinum* and *Halimeda* algae; 15 different biotic associations of calcareous algal plains, zones of rock and rubble, and open-ocean waters have been identified, as well as a series of shallow fore-reefs, deep reefs and back-reefs. Seaward of the reef community is the
characteristic sand zone which typically separates Caribbean reefs from the deep-water algal association. Most of the offshore areas below 15 m depth are covered by a rich and diverse algal plain which is extremely productive and is frequented by a variety of crustaceans, mollusks and fish (Olsen et al. 1978; Wells and Olsen, 1973). In the extreme eastern portion of Benner Bay there are two well-defined zones of sabellariid worms.

Reefs: A. palmata dominates the shallow fore-reef along with a variety of other corals including massive formations of Siderastrea, Montastrea and Diploria and some A. cervicornis, Agaricia and Millepora. The reef communities surrounding the offshore islands and cays are variable and include several species of sponges and soft coral assemblages in the shallower waters. In deeper waters gorgonian forests are found, characterized by Pterogorgia, Pseudopterogorgia, Eunicea, Plexaura and sponges.

Well developed coral reefs dominated by the Montastraea genera occur along the shoreline of St. Thomas and most of the small offshore cays in 1 to 20m depth. The best developed near-shore reefs of St. Thomas occur along the eastern shoreline of northern-facing embayments (e.g. Megens Bay, Hull Bay, Caret Bay, Botany Bay) and protected headlands (e.g. Vluck Point) or on both shorelines and headlands of southern facing embayments (e.g. Brewers Bay, Sprat Bay, Benner Bay). The best developed reefs on the off-shore cays typically occur on the leeward side of most islands (e.g. Flat Cay, Saba Island, Savana Island, Buck Island). Cover of living coral on these near-shore reefs ranges from 5 to 40% (Nemeth unpublished data). Well developed, but largely unmapped, coral reefs also occur on mid-shelf areas of the insular platform south of St. Thomas in 20 to 30m depth and along the southern shelf edge in 30 to 50m depth (Nemeth, personal observation). These deeper reefs are dominated by Montastraea franksi and faviolata but also M. cavernosa. Cover of living coral on these mid-shelf and shelf edge reefs ranges from 40 to 80% (Nemeth unpublished data). Acropora palmata and A. cervicornis reefs are showing signs of recovery from extensive mortality in the 1970s and 1980s from disease and hurricanes. Primary areas of recovery include Inner Brass Island, Caret Bay, Flat Cay, and Coculus Point.

Noteworthy fauna and flora: The area including Jersey Bay, Mangrove Lagoon and Benner Bay with Bovoni Cay, Cas Cay and Patricia Cay, contains the most extensive red mangrove R. mangle system remaining in the Virgin Islands. The cays of Mangrove Lagoon (Rotto Cay, Manglar Cay, Cas Cay, Patricia Cay and Bovoni Cay) support a unique and simple community of red, white and black mangroves. Sea Grape Coccoloba uvifera, cactus Cephalocereus and Opuntia, Saltwort Batis maritima, Bay Bean Ipomoea pescaprae and Sea Spinach Sesuvium portulacastrum are found along the beaches of the mainland. Further inland, White Frangipani Plumeilia alba, palms Cocos nucifera and Coccothrinax alta, Agave sp. and Casha Acacia farnesiana are found. The vegetation of the offshore islands is primarily mixed grasses, scrubby thorn woods and cactus, which is often extremely dense.

More than 76 species of algae, 46 mollusk species, 15 sponge species, 58 echinoderm species, numerous cnidarian, annelid and crustacean species, 243 fish species, five marine turtle species, 100 shore bird species and three whale species have been recorded within the proposed sanctuary area. The green turtle C. mydas, Hawksbill E. imbricata, leatherback D. coriacea, olive ridley Lepidochelys olivacea and loggerhead Caretta caretta have been recorded. They are no longer common but there are still two or three nesting sites of hawksbills on the beaches of Great St.
James, Dog Island and Great Bay (Bacon et al. 1984). Turtles are often sighted at the precipitous underwater cliffs at Little St. James. The waters to the north and east of the sanctuary area serve as one of the many migrational paths for the humpback whale *M. novaengliae*, as it enters the Caribbean from the Atlantic.

**SABA ISLAND AND PERSEVERANCE BAY AREA**

The southwest coast of St. Thomas (18E20'N, 64E59'W), including Perseverance Bay, Brewers Bay, a portion of South-west Road, and waters surrounding Saba Island, Dry Rock Cay, Turtledove Cay and Flat Cay. Covering approximately 14 sq. km.

Perseverance Bay is the largest bay on the south-west coast of St. Thomas and is naturally protected from waves driven by the prevailing northeast trade winds. The mainland shores are primarily sand and cobble pocket beaches situated between rocky promontories. Below 15 m depth, algal plains predominate. In shallower depths, seagrass beds, sand and coral formations cover the bottom (Anon., 1982). Saba Island and Flat Cay are uninhabited cays 3.6 and 2 km SSW of Truman Airport runway. The area is described in detail by Rogers (1982), and the hydrology by Island Resources Foundation (1977b).

**Reefs.** Extensive fringing reefs are found in western and eastern Perseverance Bay, central and western Brewers Bay and along the eastern shores of Saba Island and Flat Cay (Anon., 1982). Perseverance Bay has a submerged barrier reef. Brewers Bay has submerged barrier reefs in the western and central portions, the smaller western reef being separated from the central one by a distinct sand channel. *P. porites* and *M. annularis* are abundant; *Agaricia sp.* is abundant at Perseverance and Brewers West, and *Millepora* is abundant at Perseverance and Flat Cay (Rogers, 1982).

Seagrass beds intermixed with algae cover much of the sandy substrate of Perseverance and Brewers Bays. Mangroves are found around salt ponds on the mainland shore. Perseverance Bay Pond is briefly described in Scott and Carbonell (1986). Fighting conch *S. pugilis* are found on the algal plains. 136 fish species have been recorded (Anon., 1982).

3.2.10.2.2 St. John area

**VIRGIN ISLANDS NATIONAL PARK**

Virgin Islands National Park covers approximately 3/5 of St. John, and nearly all of Hassel Island in the Charlotte Amalie harbor on St. Thomas (NPS 2003). Within its borders lie protected bays of crystal blue-green waters teeming with coral reef life. The health of these reefs is closely tied to its component plants and animals as well as adjacent non-coral marine environments such as sandy bottoms, seagrass beds, and mangrove forests. Also the effects of waves and currents and the impacts of human use and nearby development directly affect the wellbeing of the reef. The Park includes steep, verdant hillsides, rising from rocky shores that are interspersed with coral sand beaches, numerous bays and cays with clear, warm waters, fringing reefs, seagrass beds, mangroves and natural salt ponds.
VIRGIN ISLANDS CORAL REEF NATIONAL MONUMENT

The interim rule that went into effect on May 5, 2003 created Virgin Islands Coral Reef National Monument (VICRNM). The VICRNM encompasses 5,145 ha of marine habitat within a 3-mile belt off St. John and contains all the elements of a Caribbean tropical marine ecosystem including mangroves, seagrasses, coral reefs, octocoral hard bottoms, sand, mud, and algal plains. Most marine bottoms south of St. John are deep algal plains with scattered areas of raised hard bottoms. Habitats within VICRNM are utilized by numerous reef fishes and invertebrates (e.g. spiny lobster, queen conch, Nassau grouper) as well as marine mammals, birds, and sea turtles. Additionally, the area contains spawning migration routes and reef fish spawning sites (e.g. snapper and grouper species).

Hurricane Hole, which lies within VICRNM, is an important marine nursery area and has the most extensive and well-developed mangrove ecosystem on St. John. Hurricane Hole consists of a series of bays and coves within larger bays, which are contained within a still larger bay. Some of these bays are described in the following text.

Borck Creek

Lying in the western end of Hurricane Hole, it is a small bay with a well-protected cove to the east. Water depths can reach 9 m in the south-central portion. The bay's northern side is dominated by seagrass. Large mature red mangroves line the southern shoreline.

Princess Bay

Located in the north central region of Hurricane Hole, it is the largest bay and contains small inlets in its east, north, and western portions. Water depths up to 12 m occur in the south-central area of the bay. The southern portion is generally shallow with patchy seagrasses and a narrow fringe of shoreline mangroves. Mangroves along the rest of the bay occur as a wider band.

Otter Creek

This relatively small bay has inlets to the east, north, and west with a narrow mangrove fringe and scattered seagrasses. Water depths in the south-central portion may reach 12 m.

Water Creek

The whole shoreline is lined with extensive mangroves with steep hillsides immediately landward. The area also contains a small, well-protected bay in its southern portion. Water depths in the central portion reach 12 m.
3.2.10.2.3 St. Croix

St. Croix Coral Reef. Located mainly along the northeast and southeast coasts of St. Croix; 17E45N, 64E33’W.

The mainland shore consists largely of segments of sandy beach interspersed with low and steep rocky areas. Coral reef formations are distributed throughout the area with numerous reefs fringing the shore (Anon., 1982). Seagrass beds are found in shallow lagoon areas in association with patch reefs.

The east end of St. Croix is fairly dry with an annual rainfall of 30 in. (760 mm), much of this concentrated in the rainy season from June to December. Occasional very heavy rains may reduce salinity below 35 ppt near shore where intermittent streams enter the lagoons. In the vicinity of the reefs and ridges, salinities probably only rarely go below 34 ppt. Offshore sea temperatures range from 25°C in February to 28°C in July; lagoonal temperatures behind the reef are in the range 23-30°C. Easterly trade winds are very constant. Water clarity is usually largely dependent on wave action and the resulting suspension of fine carbonate sediment. In rough weather visibility is about 4-6 m; in calm weather visibility may reach 15-20 m. Visibility is poorest in the summer when plankton density is at its highest. The tidal pattern is diurnal with a range of 30-35 cm during spring tides and 10-15 cm during neap tides when a semi-diurnal pattern may occur (Aden, 1975). Tropical storms or hurricanes occasionally pass to the south during the autumn and tsunamis have been recorded (Anon., 1982).

Reefs. The shallow coral reef and algal ridge systems on the eastern shelf of St. Croix are described and mapped by Adey (1975). The insular shelf is relatively shallow (10-15 m) at its western ends, both in the western Buck Island Channel on the north, and along the south shore from Krause Lagoon west. Further east, on the south coast around Grassy Point, the shelf lies at about 15-18 m under the reef, and 20 m outside. To the north, off Boiler Point, a shallow shelf in the bay, slopes to about 20 m just offshore and has given rise to a triple-reef complex. At East Point, outside the reef, the shelf is about 24 m deep.

The reefs on the inner shelf, extending eastward to East Point, from Pull Point in the north and Long Reef in the south, show a general pattern of decreasing maturity. Reef flats are relatively broad to the west, becoming narrower towards the east; they are fragmented off Boiler Bay in the north and Grapetree Bay in the south, and are virtually absent from Isaac Point around East Point to Lamb Point (Aden, 1975). In many places they have become so shallow, that coral growth is less prolific now than it used to be. West of the southern ship channels, there are a few reefs that are generally poorly developed, with narrow or patchy reef flats. Abundance of live A. palmata decreases from east to west; in the east, shallow reefs are dominated by impressive living and dead stands (Aden et al. 1981).

The reef flats are generally dominated by A. palmata, a large part of the pavement surface being constructed of dead branches coated with crustose coralline algae. The outer edge or crest of the flat tends to have a high proportion of M. complanata. The back-flat sections, as they deepen into the lagoon (2-6 m), frequently have abundant Montastrea annularis, Diploria spp., P. porites and the small form of A. cervicornis.
The *A. palmata* forereef extends to about 13 m depth at East Point, the lower boundary gradually rising to the west, probably because of decreasing light due to turbidity and lessened wave action. Further west on the north shore (on the Teague Bay Reef, on the south side of Buck Island Channel and on the western parts of the South Shore), the lower depth limit is 5-8 m (Adey, 1975). The bank barrier off Teague Bay, has about 5 m relief off the shoreward edge, and is approximately 90 m wide. It is dominated by *A. palmata*, but an indistinct zonation is found around the inner edge of the reef, where the base is characterized by *M. annularis*, the edge by *A. palmata* and large mounds of *P. porites* (up to 2.5 m high and 4.5 m wide), and the top by *A. palmata, Diploria* and *Millepora*. The seaward slope drops off to 14 m depth (Dahl *et al.* 1974). The reef at Teague Bay and Knight Bay is described in several publications including Gladfelter (1979) and Ogden and Ehrlich (1977). Candlelight Reef, at the end of the northern bank reef forming the seaward margin of Coakley Bay, is a large patch reef, slightly separated from the main reef by a boat channel. The reef flat is partly algal turf. The reef, which supports sparsely vegetated Sand Cay, is dominated by *A. palmata*, with small amounts of *Porites, Montastrea* and *Diploria* present.

Several patch reefs northeast of Buck Island, rising from a sandy shelf at a depth of about 10-12 m, appear to be anastomosing thickets of *massive A. palmata* from top to bottom (Adey, 1975). A deep patch reef directly east of Buck Island, consists of mainly *A. palmata* and has a relief of 8-9 m. It is covered with large heads of *M. annularis, Diploria* sp., *M. cavernosa* and is surrounded by a great abundance of alcyonarians (Dahl *et al.* 1974). Reefs immediately around Buck Island are described in a separate account.

In the relatively quiet Buck Island Channel, an irregular band of *P. porites* often extends from the base of the *A. palmata* fore-reef to the sand channel floor at a depth of 10-12 m. Further east and on the south shore, this zone is usually occupied by *A. cervicornis*. The *A. cervicornis* band can be extensive, or may consist of only scattered patches. From the lower end of the *A. palmata* fore-reef to the sandy shelf, the dominant coral is usually *M. annularis*, with interspersed *Diploria* sp., *A. cervicornis* and *A. palmata*. Occasionally a marked, spur and groove pattern occurs in the lower fore-reef. The lower boundary of the deeper fore-reef is sometimes marked by an abrupt drop of 1-2 m to the sediment interface. A flat sandy shelf is found directly below the *Montastrea-Diploria* deep fore-reef that generally extends almost to the reef margin (Adey, 1975).

Between East Point and Lang Bank, the sand band is narrow and the shelf beyond is coated with a pavement or hard ground. The dominant coral here is *M. meandrites*, although *M. cavernosa, S. siderea, D. strigosa, D. stokesii* and *Zoanthus* sp. also occur. Approximately 75% of the surface is coral-bare pavement with abundant sponges and gorgonians (Adey, 1975). Lang Bank is the best example of an inactive reef, the predominant reef-type of St. Croix. It is situated at the eastern shelf edge at 9-18 m depth, and is ideally located for active barrier reef growth. However, an interlocking reef framework is lacking, and the bank is largely a rubble-covered carbonate pavement with abundant alcyonarians, sponges and large sand patches with only scattered coral heads and very little *A. palmata* (Adey *et al.* 1977; Dahl *et al.* 1974).
Isaac Reef on the eastern tip, extending from Cudejarre Point to Isaac Point, is a relatively young reef with narrow reef flats. The crest is broken by numerous channels, there is high living *A. palmata* cover, and the reef breaks the surface in a discontinuous fashion. Off Robin Bay, on the southeast coast a strongly developed mature reef, with a nearly continuous crest and a moderately deep reef flat, blocks most of the shore from Rod Bay to Great Pond Bay. It has a wide and relatively shallow back-reef. Living *A. palmata* is an important constituent, but there is only 20% cover. Further west off Halfpenny Bay, there is a continuous reef with a broad and shallow reef flat, and few living acroporids (Adey *et al.* 1981).

A reef (known in some publications as Long Reef) forms a barrier between the sea and Krause Lagoon, opposite the Hess Refinery on the south coast. Two channels have been cut across the reef to provide access to the lagoon. The waters are relatively turbid. The reef appears to consist of a rather loose aggregation of coral fragments, although this may be a result of blasting in the channel (Adey, 1975). Further west, Channel Reef is the remains of a reef between the Hess Refinery and the Martin Marietta Bauxite plant channels, and Airport Reef is a patch-like structure lying west of the ship channels (Adey *et al.* 1981). The back-reef areas of Airport Reef do not correspond to the normal pattern but appear to be a series of relatively young, elongate patches.

Off open shores, the reefs develop algal ridges at the surface (Adey, 1975). *Lithophyllum congestum*, *Porolithon pachydermum* and several Neogoniolithon species are the primary algal ridge builders. All of the known algal ridges occur east of Canegarden Bay on the south coast. The westernmost ridge is on the south shore at Vagthus Point, but most of the ridges lie east of Great Pond Bay. Small ridges are found on the north side of Buck Island, on the south shore outside Spring Bay, and at East End Bay. Algal cup reefs are found around Cottongarden Point. These have pronounced rims and overhang, with a relief of about 2 m. Their upper surfaces are covered by fleshy algae including *Sargassum* ssp. and a few flat colonies of *P. astreoides* (Dahl *et al.* 1974). The main ridges, however, are found off the South Shore at Fancy Mountain, Robin Point, Isaac Bay, and at Boiler Bay at the eastern end.

The algal ridges at Fancy Mountain are relatively low and are degenerating as a result of wave blocking by the *A. palmata* ridge forming on the outside. The algal ridge complex off Robin Point lies on a southwesterly projection of the reef system. It is open to the easterly sea and almost perpendicular to the wave direction, and is generally the roughest and most active of the ridges. In the outer line, there are small individual boilers or cup reefs, 2-3 m in diameter, with well-developed raised rims and marked central depressions. Others are up to 30 m in diameter, with highly raised rims on the seaward margins only. The relatively deep (1 m) central basins in this case often have large *Diploria* heads. Such structures are formed by fused individual boilers. Robin Ridge lies landward and northwest of the actively growing *A. palmata* reef. The waters immediately around these high algal ridges are often relatively deep (3-6 m), and in addition to rubble and sand patches in some of the channels, the pavements often support a community of scattered but large *Diploria* ssp., *Millepora* and *M. annularis*.

Beach Algal Ridge, between Grassy and Grapetree Points, is the longest (over 0.5 km), straightest, and probably the oldest Holocene ridge. It is being blocked by an off-lying reef system that has already developed a reef flat in the eastern part. Isaac Algal Ridge off Isaac Point
is one of the smallest, but being quite exposed, it has high rims. The developing *A. palmata* reef here is still relatively deep (3-4 m). The Boiler Bay Algal Ridge is described in detail by Adey (1975). The surfaces of the boilers are infested with *Echinometra*, their burrows occupying about 30%. Crustose corallines occupy about 30% of the remaining surface, interspersed with algal-bored, dead coralline pseustellid crusts, *Homotrema* and the crusts or filamentous bases of abundant fleshy-leaf algae.

Marine algaees of this area are described by Adey *et al.* (1981). Fish communities have been studied at a number of sites by Gladfelter *et al.* (1980) and Ogden and Ehrlich (1977). The halos formed around West Indian patch reefs by the echinoid *Diadema antillarum* have been studied at Knight Bay (Ogden *et al.* 1973), 1 km west of Cottongarden Bay. Hawksbill *E. imbricata*, Green *C. mydas* and leatherback *D. coriacea* turtles, nest at a number of sites in this area (Bacon *et al.* 1984). Scott and Carbonell (1986) describe several important wetland sites including Altona Lagoon, Southgate Pond (4 km north-east of Christiansted), Coakley Bay Pond and Great Pond.

The 4,000-year old eastern and southeastern bank barrier reef of St. Croix is one of the best-developed reef systems in the tropical Atlantic Caribbean area and is the most extensive reef on the Puerto Rican-Virgin Islands shelf (Adey *et al.* 1981). It has long been of considerable scientific interest, partly because it is relatively untouched, but also because the many subtypes of reef which exist in the one complex, serve as a baseline for comparison with others throughout the Caribbean. The south shore reefs are particularly interesting, as all reef geographical and ecological successional stages, young to old, are present.

The *Meandrina* hard ground off East Point is in need of extended study because of its possible importance to shelf building in the Antilles (Adey, 1975).

**BUCK ISLAND REEF NATIONAL MONUMENT**

**Geographical location.** Area: 71 ha terrestrial 7,340 ha marine.

Buck Island (17°45'N, 64°45'W) is a small cay located 6 mi. (10 km) north-east of Christiansted, St. Croix, 2 km off the eastern shore covered with vegetation, with beaches on the south and west shores. A bank barrier reef surrounds the east and north of the island, 12 m high in places along its outer perimeter. The water is extremely clear, since there is no freshwater run-off (Randall and Schroeder 1962). An interim rule which took effect May 5, 2003 extended the area of Buck Island Reef National Monument and added “haystack” formations of elkhorn coral, barrier reefs, patch reefs, spur and groove coral formations, and deep reefs.

**Reefs.** The reef extends from the middle of the southern coast where it joins the shore, around the eastern tip of the island and along the north shore. To the northeast, it breaks up into large patch reefs. It lies approximately 200 ft (60 m) from the southern shoreline, where the lagoon has clear water, a clean sandy bottom and a patch reef system. At the eastern tip of the island and along the north shore, the lagoon has many patch reefs reaching the surface. The barrier reef in the Underwater Trail area has complex back-reef topography, with 2-3 m vertical relief of crevices and caves within the reef structure. Although separated from the shore by a narrow sandy belt, it can be considered a form of fringing reef (Dahl *et al.* 1974). The front of the reef
comprises a solid stand of *A. palmata* and *A. cervicornis*, which shelves off steeply from the surface to the bottom at 35 ft (11 m) where sand alternates with coral patches. On the lagoon side, the reef is composed mainly of *Millepora* and *Diploria* with some *Montastrea, Agaricia* and *Isophyllia*. The reef off the northwest end at West End is different, having a broad area of patch reefs in 10-30 ft (3-9 m) of water with rich coral growth. There is a barren pavement area with scattered eroded dead coral heads with little algal cover.

Ninety-three of the 250 species known from St. Croix waters were recorded within the Monument. The gorgonian fauna is poor, with only a few colonies and less than half a dozen species. Sea anemones, including *Stoichactus, Palythoa* and *Zoanthus* are abundant (Adey et al. 1977). *S. gigas*, the whelk *Cittarium pica*, the spiny lobster *Panulirus argus*, moray eels and many fish such as the foureye butterfly fish *Chaetodon capistratus*, smooth trunkfish *Lactophrys triqueter*, porkfish *Anisotremus virginicus*, *Pomacanthus paru*, queen angelfish *Holacanthus ciliaris* and blue angelfish *H. bermudensis* are found. Larger fish include sharks, snappers, baracudas and tarpon. Dolphins occur in these waters. The marine habitat of Buck Island Reef National Monument includes spawning migration routes and reef fish spawning sites (e.g. for grouper and snapper species). The island has hawksbill *E. imbricata*, leatherback *D. coriacea* and green turtle *C. mydas* nesting sites (Bacon et al., 1984). St. Croix has been affected by the mass mortality of *Diadema*, which occurred throughout much of the Caribbean (Carpenter, 1985).

**SALT RIVER SUBMARINE CANYON**

**Geographical location** 17E47' N, 64E 45' W; north coast, St. Croix. The 8 sq. km. area includes the Salt River Estuary and shoreward portion of the Salt River Submarine Canyon.

**Physical features**. There is virtually no shelf outside the mouth of the estuary. The canyon floor shelves gently northward from the apex for about 200 m, at which point it drops precipitously to 3500 m through cemented, carbonate sand terraces towards the deep Virgin Islands basin that lies between St. Croix and St. Thomas. The west wall is very steep, with overhanging cliffs cut by sediment-filled tributaries. An algal/coral reef forms a bar across the mouth of the estuary (Anon., 1982). The area is described in Adey et al. (1977). Water within the estuary flows only intermittently seawards and the waters in the inner portions of the estuary are poorly mixed. Salinities in the southern portion may reach 38 ppt during extended periods of low rainfall. The tidal range is about 0.3 m.

**Reefs**. *Siderastrea* corals occur along the southern shoreline of the estuary (Anon., 1982). Other reefs are briefly described in Adey et al. (1977) and Rogers et al. (1984). The upper lip of the canyon has a dense covering of hard coral and gorgonian fans (Adey et al. 1977). The east wall has a raised flange of *A. palmata* extending along its margin. The west wall is composed of carbonate rocks of coral reef origin, with overhanging cliffs cut by sediment-filled tributaries. Dead coral is common at 9 m depth. Highest living coral cover occurs at a depth of 18 m and is about 6-24% on the east wall and 5-24% on the west wall. At 9 and 18 m depths, the dominant corals are *A. agaricites, M. decactis* and *M. cavernosa*. *A. lamarcki* is the most abundant species at 27 m and 37 m depths on both walls (Rogers et al. 1984).
The estuary is lined by white, black and red mangroves, and is described in Anon (1982) and Scott and Carbonell (1986). Seagrasses occur over much of the shallow bottom. Juvenile fish are common in the estuary and sharks are reported to occur quite frequently in the central portion (Anon., 1982; Scott and Carbonell, 1986).

Several sponges in the genus *Verongia*, and the gorgonian *Iciligorgia schrammi*, occur in the canyon but are unknown or rare elsewhere on St. Croix. Hawksbill *E. imbricata* and green *C. mydas* Turtles nest at Salt River (Bacon et al. 1984).

The reefs of the USVI have suffered a variety of forms of natural damage. Tropical Storm Klaus caused damage in 1984 (Rogers, 1985). Implications of the *Diadema* die-off on St. Croix are described by Carpenter (1985). High *Diadema* mortalities were also observed at St. Thomas and St. John (Lessios et al. 1984), and are probably due to a water-borne pathogen that caused Caribbean-wide mortality of this species. Outbreaks of white band and black band disease have been reported (Rogers, 1985).

### 3.2.11 Fishery resources under FMPs

Fishery statistics data indicate declining abundance of fishery resources in waters around Puerto Rico (Matos Caraballo and Rivera Alvarez 1994; Turgeon et al. 2002). The following measures provide evidence of the decline:

- Decrease in number of pounds landed (Appeldoorn et al. (1992) reports 69% decrease between 1979 and 1990);
- Declining catch per unit effort;
- Recruitment failures;
- Marketing of species without prior commercial value;
- Large proportion of harvest made up of sexually immature individuals; and
- Change from harvesting with traps and diving, to more efficient hook and line and nets.

The decline in large fish and the massive die-off of the long-spined urchin may have caused a major shift in community structure of many Puerto Rico reefs from coral- to algal-dominated communities. The lack of large herbivorous and predatory fishes have stimulated a proliferation of small fish. Damselfish, in particular, harm reefs because they bite and kill coral polyps to promote algal growth for their young. In addition, smaller herbivorous scarids, scrape algae off of reef structures and cause bioerosion estimated at 160 g of sand m$^{-2}$ year$^{-1}$ in the US Caribbean (Opitz 1996). In addition, persistent and increasing fishing of the spiny lobster in Puerto Rico has substantially reduced the densities of this predator on shallow reefs. Consequently, there has been a proliferation of one of its favorite prey groups, the corallivorous gastropods (Turgeon et al. 2002). Such indirect effects of overfishing lead to an acceleration of coral reef degradation, which in turn will hamper the ability of the fisheries to recover in the future.

In the USVI, the composition and size of reef fish assemblages have changed markedly (Rogers and Beets 2001), although the exact factors producing these changes are difficult to separate and quantify. Fishers tend to target top level predatory fishes rather than forage species, remove the largest egg-producing individuals, and may alter sex ratios of sex-changing species (Dayton et
Overfishing, deterioration of coral reefs, mangroves, and seagrass beds have all undoubtedly contributed to alterations of USVI coral reef communities. As an example, the average number of traps fished per full-time fisherman increased from 4 in 1930, to 8 in 1967, to greater than 100 in 1997 (Fiedler and Jarvis 1932; Dammann 1969; W. Tobias pers. comm.) The maximum number of pots fished by a single fisher was 30 traps in 1930, it was 3000 traps in 1997 (Fiedler and Jarvis 1932; Downs et al. 1997).

Up through the 1960s, groupers and snappers were abundant and dominated USVI fishery landings. As fishing technology improved, fishers set more traps and began to target spawning aggregations, which are particularly vulnerable to overexploitation (Dayton et al. 2002; Turgeon et al. 2002). By the 1970s, several spawning aggregations of Nassau grouper had been depleted and local populations of the species crashed (Olsen and LaPlace 1978). Nassau grouper are still scarce in the USVI (Wolff 1996; Garrison et al. 1998). After depleting the larger species of groupers, fishers began targeting smaller aggregating species like red hind, leading to “sequential overfishing” (Murawski 2000). This practice may cause the decline of entire assemblages. Today on St. Croix there is active targeting of mutton snapper aggregations on the southwest side of the island. While groupers and snappers have decreased, herbivorous species have increased in relative abundance (Beets and Rogers in press). Predator removals may create trophic opportunities for other species which may subsequently increase in abundance, due to the disrupted food web (Tasker et al. 2000). The nature and magnitude of these disruptions vary from predator to predator. Removal of predators may lead to an accelerated decline due to a feedback loop, where predator removal causes an increase in prey species, and these abundant prey eat the juveniles of their predator (Dayton et al. 2002). Overfished species may be more susceptible to environmental variability. While some species are resilient and able to recover, others are not. If a depleted species is replaced by an alternative species, the possibility of recovery is even less likely (Dayton et al. 2002).

Several studies have documented the failure of existing territorial regulations to protect reef fishes or reverse declines in the abundance of preferred species (Beets 1996; Garrison et al. 1998; Wolff 1996; Beets and Rogers in press). Lack of enforcement of existing regulations is one problem. Garrison et al. (1998) found that over 50% of the fish traps examined had no functioning biodegradable panels to allow fish to escape if the traps were lost, leading to “ghost fishing.” Even with better enforcement and full compliance, it is unlikely that existing regulations would be adequate to reverse the alarming trends seen in USVI fisheries (Turgeon et al. 2002).

3.2.11.1 Ecosystem engineers

Many of the organisms discussed in this document may be considered ecosystem engineers. These are species which create more complex habitats 1) via their own morphological structures or 2) through behavioral actions which alter existing habitats (Coleman and Williams 2002). In the first group are species such as corals, mangroves, and seagrasses whose own structure creates complex habitat for fishes and invertebrates (e.g. mineralized reefs, networks of prop roots, or vegetative canopies). Corals are unique among this first group, in that they are both a habitat for many managed species and are managed species themselves. In the second group are a number
of federally managed and non-federally managed species whose actions physically modify the habitats they occupy. These actions primarily involve excavations of substrate such as those conducted by tilefish to create burrows, but also include the less noticeable modifications of bottom habitats by invertebrate infauna (e.g. marine worms, crabs).

The importance of these ecosystem engineers, in terms of the maintenance of community structure, function and diversity has begun to be recognized, as well as the potential consequences to an ecosystem if engineer species are removed by fishing activities (Coleman and Williams 2002). In the US Caribbean, the most obvious examples of ecosystem engineers exploited by fishing activities would be tilefishes and epinepheline groupers (e.g. yellowedge grouper) which inhabit and modify shelf edge and slope biotopes. Their excavation activities produce complex habitats which are utilized by other managed fish (e.g. snowy grouper, vermilion snapper, black grouper) and invertebrate species (e.g. spiny lobster). Burrowing activities also affect biogeochemical cycling and the decomposition of organic matter in the substrate (Coleman and Williams 2002). In addition, because both tilefish and groupers require a relatively long time to reach maturity, they do not recover quickly once they have been overexploited (Coleman and Williams 2002). As they are top-level predators their removal may cause additional problems such as trophic cascades and fishing down the food web (Sala et al. 1998, Pauly et al. 1998, Steneck 1998). Because of the importance of ecosystem engineers, they may be good candidates to be indicator species of ecosystem health in the future.

3.2.11.2 Spiny Lobster FMU

3.2.11.2.1 Status of Stocks

The species managed under the Spiny Lobster FMP is *Panulirus argus*. The FMU however includes two other species of the family Palinuridae: the spotted spiny lobster, *Panulirus guttatus* and the smoothtail spiny lobster, *Panulirus laevicauda*. There are no separate landings and no stock assessments for either of these other species of lobster.

*P. argus* provides most of the landings. The Spiny Lobster FMP (CFMC 1981) set an optimum yield (OY) from the fishery as all the nonberried (ones that do not carry eggs) lobsters having a carapace length (CL) of 3.5 inches (89mm) or greater that can be harvested on annual basis. In 1981, this amount was estimated to range from 582,000 pounds to 830,000 pounds annually. This level of harvest was established as optimum from a biological, social, and economic standpoint, to provide the greatest overall benefit to the nation. Carapace length means a head-length measurement taken from the orbital notch inside the orbital spine, in a line parallel to the lateral rostral sulcus, to the posterior margin of the cephalothorax.
The last stock assessment and fishery evaluation (SAFE) report for the Caribbean spiny lobster dates to 1991 (Bohnsack et al. 1991). The conclusions of the SAFE report were that: (1) the spiny lobster fishery in the USVI appeared healthy at the levels of current fishing effort (data reviewed up to the year 1989) and fishing practices and (2) of particular concern was the nine-year decline in total landings and the large number of undersized lobster landed in Puerto Rico. Growth overfishing appears to be a significant problem in Puerto Rico. Recruitment overfishing does not appear to be a problem under present levels of fishing effort (before 1992) based on calculated levels of spawning potential. Little information is available on the recruitment patterns of the spiny lobster. The most recent information was revised and included in CFMC (2000) and CFMC (1998) and it is not duplicated here.

The assessment team concluded that the most obvious management action to increase the productivity of the spiny lobster fishery would be to increase compliance with minimum size restrictions in Puerto Rico. Matos-Caraballo (1995a) reported that during 1992-1994, approximately 43% of the spiny lobster harvested in Puerto Rico were below the minimum size (36% of the spiny lobster males and 48% of the female lobsters were undersized). Compliance appeared acceptable in the USVI.

The SAFE (Bohnsack et al. 1991) recommended a 20% SPR for the overfishing definition as a conservative measure. Spawning potentials, based on mean total fecundity, of 55.9% were calculated for Puerto Rico (in comparison to an unfished population in the Dry Tortugas) and of 142% and 197% for St. Croix and St. Thomas, USVI, respectively. The most recent data need to be analyzed to determine changes in the population since 1989. The Spawning Potential Ratio (SPR), the ratio of eggs produced between a fished and unfished population, was calculated from fishery dependent data according to methods used by Gregory et al. (1982). Spawning potential was based on total mean fecundity, defined as the total number of eggs potentially produced divided by the total number of females.
An updated assessment of spiny lobster harvest in waters of St. Croix suggests that the spiny lobster resource is overfished (Mateo and Tobias 2001). Yield per recruit analysis, using growth and mortality parameter estimates and catch curve analysis, demonstrated that average exploitation rates for spiny lobster exceeded an optimum rate of 0.5. St. Croix spiny lobster harvest exceeded the 15,500 kg per year MSY (calculated using Schaeffer and Fox model) in four years from 1990-1991 to 1998-1999 (Mateo and Tobias 2001). While the results may contain errors as a consequence of biases in the data and violations of assumptions during analysis (Mateo and Tobias 2001), the yield per recruit analysis shows that fishing pressure should be reduced considerably in waters around St. Croix. The different conclusions on the status of spiny lobster stocks in St. Croix compared to the conclusions in Bohnsack et al. (1992) suggests that other fishery management agencies update spiny lobster assessments.

The United Nations Food and Agriculture Organization (FAO) (1997) reports that the spiny lobster is considered to be overexploited throughout much of its range. Fisheries throughout the Western Central Atlantic have experienced a substantial decrease in catch per unit effort over the years, suggesting that this species has declined in abundance throughout at least a portion of its range (Bowen 1980; Marx and Herrnkind 1986; Quinn and Kojis 1997). NMFS (1999a) has expressed a need to identify the actual sources of all stocks (both U.S. and foreign) and to establish an international management regime to prevent overfishing.

In its 2001 report to Congress on the status of U.S. fish stocks, NOAA Fisheries reports that the Caribbean spiny lobster is neither overfished nor approaching an overfished condition, and that overfishing is not occurring on this species. These determinations are based on definitions of overfished and overfishing that were approved under pre-SFA guidelines. Under these definitions, a spiny lobster stock or stock complex is overfished when it is below the level of 20% of the Spawning Potential Ratio (SPR). When a spiny lobster stock or stock complex is overfished, overfishing is defined as the harvesting rate that is not consistent with a program that has been established to rebuild the stock or stock complex to the 20% SPR. When a spiny lobster stock or stock complex is not overfished, overfishing is defined as a harvesting rate that, if continued, would lead to a state that would not allow harvest at optimum yield (OY) on a continuing basis (NMFS 2002). The SFA Working Group classified the status of the spiny lobster as “unknown.”

3.2.11.2.2 Habitat Use by Species in FMU

During its six distinct life history stages, the spiny lobster uses three distinct habitats (Herrnkind no date): open ocean; the shallow, vegetated coastal zone; and coral reefs. The spiny lobster larvae spend months in the pelagic plankton, and may travel large distances. Postlarvae migrate to nearshore areas and settle to the bottom. Postlarvae molt to juveniles that live in algal beds or among mangrove roots, and subsequently move to crevices in shallow areas. Sub adults and adults live on reefs. The spotted spiny lobster has generally similar habitats as the spiny lobster, but is smaller in size, and has a more shallow distribution (Tewfik et al. no date).
3.2.11.2.2.1 Eggs

Most spiny lobster mate in spring and early summer along outer reefs near the shelf edge (CFMC 1998, Herrnkind no date). Male spiny lobsters deposit sperm packets on the underside of the female. The fertilized eggs stick to the swimmerets beneath her tail and hatch in about four weeks. Therefore, the eggs utilize the habitat used by the females.

3.2.11.2.2.2 Larvae

Egg hatching occurs in deeper waters with strong water movements (Herrnkind no date) to release transparent phyllosome larvae. The larval stage of spiny lobster is long (6-12 months) and spent in the open ocean. Numerous planktonic larval stages occur. The horizontal distribution of spiny lobster phyllosomes collected from 6 to 46 km from the southwest Puerto Rico coastline indicated that early stage larvae stay on the insular shelf, while older larvae were distributed offshore (Sabater and Garcia Sais, 1998). While larvae were available all year, abundance peaked in May.

Spiny lobster phyllosomes molt to puerulus postlarvae in the open ocean near the continental shelf edge (Herrnkind no date). The postlarvae move to nearshore habitats in the upper meter of the water column during the night. During the day, the postlarvae settle to the bottom. The postlarvae become benthic (settle) at about 6 mm carapace length and use algal habitats (Herrnkind no date).

Post-larval recruitment has been scantily assessed in the US Caribbean (i.e., Monterrosa, 1986; USVI SEAMAP-Caribbean Program). The Puerto Rico SEAMAP-Caribbean Program is currently assessing post-larval recruitment on the West Coast of Puerto Rico. Pueruli have been collected in Acanthophora clumps and Thalassia beds but were never found in coral rubble (Monterrosa, 1986). All these habitats reported from very shallow areas. Temperature tolerance for post-larvae is high ranging from 10 to 35 degrees C.

3.2.11.2.2.3 Juveniles

Herrnkind (no date) reports that postlarvae molt to an algal-phase juvenile shortly after settlement. Juveniles also use sea urchin spines and mangrove root habitats. The algal phase lasts for several months. Juveniles use the algae for protection from predation and for feeding. As the juveniles grow too large for algal habitats, they move to nearby crevice shelters at about 15-20 mm carapace length. The juveniles hide in crevices during the day and feed at night. Acosta (1999) found that rubble fields acted as a barrier to benthic dispersal, and that vegetated substrates may function as migratory corridors for juvenile lobster. Lobsters were more abundant around coral/mangrove islands surrounded by seagrass, than similar islands surrounded by rubble fields, and juveniles were relatively more rare around islands without seagrass.
The most important Caribbean habitats for juvenile lobster appear to be *Thalassia* beds and mangroves (CFMC 1998). Additional juvenile habitat includes sea urchins, algal mats (plains), and rock crevices.

### 3.2.11.2.2.4 Adults

About a year after settlement, subadult lobster (50-75 mm carapace length) expand their range to 3-10 m deep banks with abundant food (Herrnkind no date). They forage nocturnally on benthic invertebrates and hide during the day around the bases of sea whips and large sponges, rock ledges, seagrass rhizome mats, or coral heads. In mid autumn, in response to seasonal storms, subadults mass-migrate in single-file queues from shallow banks to 10-20 m deep rock and coral shelters and disperse into sheltered waters.

About two years after settlement, 75-cm carapace length lobsters mature and move seaward for mating and spawning (Herrnkind no date). Adult lobsters live individually or communally in rock or coral crevices, caves, and ledges. Adult lobster forage at night on seagrass beds and algal plains (CFMC 1998). Herrnkind (no date) reports that spiny lobster in the Florida Keys move offshore in autumn in response to storms and in spring for mating.

Off Honduras, Tewfik *et al.* (no date) found that spiny lobster and spotted spiny lobster co-occurred on only one of 22 transects with positive sightings, suggesting that the two species use the habitat differently. The spiny lobster had highest abundance on rock habitat in water deeper than 15 m while spotted spiny lobster was found no deeper that 9.1 m depth on rock and coral. The spotted spiny lobster is known to be common on shallow reefs down to 12 m hiding under coral heads, ledges, and in crevices of the roof of caves (Tewfik *et al.* no date).

### 3.2.11.2.2.5 Prey Species

*Panulirus argus* depends on the healthy condition of seagrass beds were most of the adult feeding activities take place. Spiny lobsters are nocturnal predators and locate slow-moving, sedentary prey via chemosensory setae located on their antennules and walking legs (Marx and Herrnkind 1986). Among the prey items identified for spiny lobster are gastropod and bivalve mollusks, crustaceans, echinoderms, annelids, and sponges (Table 3.3). These prey species inhabit the same habitats as the species in the spiny lobster FMU, and therefore would also benefit from any habitat protection measures adopted by the Council (Appendix 1).

### 3.2.11.3 Queen Conch FMU

#### 3.2.11.3.1 Status of Stocks

Queen conch was designated as overfished in the 2000 Report to Congress on the Status of US Fisheries. Most who have studied queen conch resources in the Caribbean believe overfishing has been a significant problem since the late 1960's. In many areas, fishers themselves have acknowledged overfishing as a serious problem, and indicated that the resource is noticeably
declining (Appeldoorn 1987). Rhines (2000) reports that their numbers are declining now more than ever. In the Bahamas, for example, it is believed that deep water populations sustain the smaller shallow water populations.

A management program designed to restore overfished conch resources through a reduction in fishing effort may have the support of the fishing industry. Nearly every nation in the Caribbean has acknowledged that overfishing has led to decreased harvest levels and has taken actions to reduce effort and subsequent fishing mortality. Opitz (1996) stated that the high levels of natural predation pressure on queen conch (and also spiny lobster) leave the resource particularly vulnerable to additional exploitation by fishers. Various Caribbean nations have imposed restrictions that include seasonal closures to protect spawning populations; shell or meat size limits or flared-lip restrictions to protect immature conch; limited access and quotas on allowable catch; prohibitions on the use of SCUBA gear to protect deep-water reproductive populations; seasonal and areal closures to rebuild populations and guard against local stock declines; and, in some areas, the initiation of mariculture programs to rear conch to sizes suitable for replenishing impoverished areas. The Council is considering an amendment to the Conch FMP that would prohibit the harvest and possession of conch in the US Caribbean EEZ.

The queen conch was listed in Appendix II of CITES on November 6, 1992, which means this species is protected through regulation of international trade in live specimens, parts and derivatives. Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled.

According to Appeldoorn (1993), conch fisheries in the northern fringe areas of the range (i.e., Florida and Bermuda) have shown little or no improvement despite total closure for many years. Fisheries in Bonaire and Cuba also have been closed for extended periods because of severe overfishing (Berg and Olsen 1989). Appeldoorn (1993) reported that in the absence of management, spawning potential ratio (SPR) for the queen conch stock could be expected to decline below the 20 percent level. In the mid-1980's off La Parguera, Puerto Rico, fishing mortality was estimated at 1.14 with an SPR value of 0.09 or less than one-half the recommended value of 0.2 (20 percent), and landings declined 80 percent during that period. There is no evidence that such high fishing mortality rates are unique to this area of Puerto Rico, or that mortality rates have since declined; therefore, it is likely that the SPR for queen conch is below the recommended value of 0.2 or 20 percent, throughout much of the management area. Closures may be an aid to restoring conch populations in areas where local overfishing is known to occur, and there are provisions in the Queen Conch FMP to institute such closures should the recommended management program prove ineffective.

The CFMC hosted a Queen Conch Stock Assessment Workshop in 1999 to determine the status of the stock(s) in the US Caribbean and the wider Caribbean Region (CFMC,CFRAMP 1999). Limited information for the Virgin Islands allowed application of a Schaefer catch/effort model to calculate MSY as 35,000 pounds for St. Croix. The 1997-1998 harvest of about 73,000 pounds approximately doubled the estimated MSY.

Friedlander (1997) observed that the abundance of queen conch in 1996 around St. John was relatively lower than during the early 1980s, and that a 5-year moratorium (1988-1992) on conch
harvest and implementation of bag limits, minimum size, and closed seasons did not lead to a
rebuilding of abundance. He concluded that present regulations are inadequate to ensure
rebuilding. However, compliance with existing harvest regulations for shell length by
commercial fishermen is poor, lacking an enforcement presence (CFMC 2000).

Stoner and Ray-Culp (2000) found in the Exuma Cays, Bahamas, that queen conch mating never
occurred at densities less than 56 conch/ha, and that spawning never occurred at densities less
than 48 conch/ha. Friedlander (1997) reported average adult queen conch densities in August of
14.71/ha and 32.19/ha for St. John and St. Thomas, respectively, with only one site on each
island that exceeded the minimum mating density found by Stoner and Ray-Culp. For the east
and west coasts of Puerto Rico, Appeldoorn (1996) reported average queen conch density from
October to March peaked in the 51-70 ft depth range at 15.07/ha, and in the 61-80 ft depth range
at 4.87/ha, respectively. Only one sampling station exceeded the minimum density for mating or
spawning. The St. Thomas/St. John sampling occurred during the spawning season, while the
Puerto Rico sampling occurred at the end and after peak spawning.

Concern with the status of the stock encouraged the Caribbean Council and NOAA Fisheries to
analyze the queen conch landings statistics and to review and implement fisheries-independent
surveys to assess stock abundance, age, and size composition, and fishing effort (Valle-Esquivel
2002a). In addition, various international meetings have been held to discuss approaches for the
assessment and management of this species, including the Queen Conch Stock Assessment and
Management Workshop hosted by the Caribbean Council in 1999 (CFMC, CFRAMP 1999).
The results from these studies have revealed that the resource is indeed heavily exploited (Valle-
Esquivel 2002b).

Valle-Esquivel (2002b) used fishery-dependent catch and effort data from 1983-2001 to develop
relative indices of abundance for queen conch in the U.S. Caribbean. That report concludes that
the queen conch resource in the U.S. Caribbean is experiencing overfishing, but is only just
approaching an overfished condition. But the author indicates this conclusion is very optimistic,
noting that the time series used in the assessment was constrained by the available data and that
"the first years of the assessment do not represent, by any means, the early part of the fishery,
when indeed, population levels relative to the virgin biomass must have been high." She
indicates that, had the assessment accurately reflected the status of the stock in 1983, it would
likely have generated a finding of overfished (Valle-Esquivel 2002b). In addition, that
assessment did not consider recreational landings, which were estimated to be about 50% of
commercial catch (Valle-Esquivel pers. comm.).

In its 2001 report to Congress on the status of U.S. fish stocks, NOAA Fisheries reports that the
queen conch is overfished and that overfishing is occurring on this species. These
determinations are based on definitions of overfished and overfishing that were approved under
pre-SFA guidelines. Under these definitions, a queen conch stock is overfished when it is below
the level of 20% of the spawning stock biomass per recruit (SSBR) that would occur in the
absence of fishing. When a queen conch stock is overfished, overfishing is defined as harvesting
at a rate that is not consistent with a program that has been established to rebuild the stock to the
20% SSBR level. When a queen conch stock is not overfished, overfishing is defined as a
harvesting rate that, if continued, would lead to a state of the stock or stock complex that would not at least allow a harvest of OY on a continuing basis (NMFS 2002).

3.2.11.3.2 Habitat Use by Species in FMU

Little information exists for 12 of the 13 species in the queen conch fishery management unit. Only queen conch has sufficient information available to describe habitat use. The Academy of Natural Sciences of Philadelphia (2002) has summarized the geographical and depth ranges for the other queen conch FMU species except *Astrea tuber* (Table 3.4).

The Queen Conch FMP indicates that degradation and loss of essential habitat for juvenile settlement and development may result in reduced productivity and contribute to the species being in an overfished state. There is information presented in the Queen Conch FMP and the EFH Generic Amendment (1998) that clearly states the importance of seagrass beds found near coral reefs as nursery grounds for queen conch. Protection and conservation of these essential habitats is of critical importance. The value of the commercial fisheries (for all species including the queen conch) might be used as an indicator of the value of the habitat (for example seagrass beds) since most commercial species use seagrass beds during some part of the life cycle.

No area estimates for the USVI queen conch habitats are available. Preliminary information for Puerto Rico indicate that of the area covered by the habitat mapping project (2001), sand areas covered 11.14 squared kilometers; seagrass beds covered 449.79 squared kilometers; and algal plains about 69.05 squared kilometers. The information obtained from these habitat maps may contribute to the rebuilding of the queen conch populations by providing information on the possible sites to consider as marine reserves for the protection of, for example, juvenile queen conch. Two projects are currently underway to assess habitat areas for queen conch using geographic information system techniques (Barreto *et al.* 2002) and an evaluation of a marine fishery reserve as a management tool to restore shallow water populations of queen conch (Hernandez 2002).

The following discussion for queen conch comes primarily from CFMC (1996), supplemented with additional material.

3.2.11.3.2.1 Eggs

Queen conch spawn eggs masses in clean coral sand with low organic content but spawning has also been reported from seagrass beds (historical information) (CFMC 1996). Females cover the egg mass with sand grains. The production of egg masses has been correlated to temperature and weather conditions (highest temperatures and longer photoperiods increase number of egg masses while stormy weather conditions decrease the number of egg masses laid. Incubation period is about 5 days. The peak spawning season occurs from mid-May to mid-November in waters of Puerto Rico, and February-March to November-December in waters of the USVI (CFMC, CFRAMP 1999).
3.2.11.3.2.2 Larvae

The larvae (known as veligers) of the queen conch are pelagic. Substrate conditions to metamorphose and settle to the bottom seem critical, but unfortunately at present the requirements are largely unknown (CFMC 1996). No additional information is available to the Council at this time. The laboratory data could be applied to environmental gradients in the field once these have been identified.

Larvae have been found offshore in the middle of the eastern Caribbean Sea and in the North Atlantic Drift (extension of the Gulf Stream) (CFMC 1999). Larvae can be transported up to 26 miles per day (i.e., 540 miles during the 3-week larval period) but the average extent of larval dispersal in the range of 10s to 100s of km (Posada and Appeldoorn 1994, Stoner and Davis 1997). Posada and Appeldoorn (1994), however, conclude that even when larvae are found offshore most larvae are retained within the area where they spawned. Smith and Pitts (2002) found larvae are transported along the shelf, primarily by wind-driven flow, to the mouths of inlets where they are drawn onto Great Bahama Bank by tidal currents. Combining average flow rates with the time the larvae spend in the water column indicates that local juveniles are recruiting from spawning stocks located no further than about 50 km (36 miles) upstream of the nursery areas.

3.2.11.3.2.3 Juveniles

Conch settle in areas of soft sand, and remain buried during the first year (CFMC, CFRAMP 1999). The burial depth changes with size (CFMC 1996). Conch 35-54 mm are found buried 3-4 cm in the sand. Predation is very high at this early stage (e.g., 50% survival reported by Sandt and Stoner 1993). Information is available from laboratory and hatchery-reared juveniles that includes a complete description of development, growth, and stocking densities. Field releases of juvenile conch reared in the laboratory have not been as successful as expected.

In the Bahamas, Stoner et al. (1994) found that areas of strong tidal circulation contain a higher number of juveniles. "The occurrence of sandbars, where larval settlement may occur, adjacent to seagrass meadows as nursery areas is potentially significant" at least in Lee Stocking Island (Stoner et al. 1994). Stoner and Waite (1990) suggested that seagrass biomass, as well as seagrass shoot density were critical features in these nursery habitats. However, areas with optimal seagrass biomass did not contain the populations of conch expected. A possible explanation is the lack of adequate numbers of larvae available for recruitment to prime settlement grounds. Smith and Pitt’s (2002) analysis of water temperature data showed that conch nurseries from Exuma Cays receive a regular flushing of oceanic water from Exuma Sound, while habitats that appeared suitable for conch, but were devoid of the animals, were rarely flushed. It also may be speculated that other more important aspects of the habitat needed for settlement were absent. Among these, are the overall condition of the habitat (e.g., increased sedimentation, sediment size and type, water quality, etc.), the availability of a required food, and the number of juveniles already present in the area. Davis and Stoner (1994) showed that for laboratory-cultured conch, larvae metamorphose in response to algae, epiphytes, and sediments.
found in natural nursery grounds. However, they reported that no conch metamorphosed when exposed to conspecifics.

Required habitat for juvenile conch includes a delicate balance between seagrass beds and the surrounding sandy areas. Juveniles require red algae for feeding. The degradation of these habitats worsens the problem of overfishing, since for juvenile settlement the presence of other juveniles seems to be required (Stoner and Ray, 1993).

3.2.11.3.2.4 Adults

Queen conchs are found on insular shelf areas with sandy bottoms that support the growth of seagrasses and epiphytic algae upon which they feed. They also occur on gravel, coral rubble, smooth-hard coral, or beach rock bottoms.

Queen conch commonly occur on sandy bottoms that support the growth of seagrasses, primarily turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and epiphytic algae upon which they feed (Randall 1964). They also occur on gravel, coral rubble, smooth hard coral or beach rock bottoms and sandy algal beds. They are generally restricted to waters where light can penetrate to a depth sufficient for plant growth. Queen conch are reported from depths greater than 200 feet. Queen conch are often found in sandy spurs that cut into offshore reefs.

Conch fishermen reported that the east and west coasts of Puerto Rico comprise the main areas of Puerto Rican conch distribution (Rosario no date). The wide insular shelves in these areas provide extensive conch habitat. The east coast islands of Culebra and Vieques and the west coast islands of Desecheo, Mona, and Monito appear to be centers of distribution. The south coast has a more narrow shelf, and follows behind the east and west coasts in importance to fishermen. The narrow, high-energy north coast has few, smaller areas of conch abundance. Rosario (no date) did not report similar results for the USVI.

Appeldoorn (1996) found densities of queen conch similar for the eastern (7.28 conch/ha) and western (5.86 conch/ha) shelf areas. Stratification on conch and no-conch areas based on fishermen reports were effective for the western shelf, but not for the eastern shelf. In both areas, most conch occurred in seagrass areas, while mud had the lowest densities.

3.2.11.3.2.5 Prey Species

The queen conch is one of the largest of the herbivorous gastropods, and uses its highly extendable proboscis to graze algae and seagrasses (Yonge, 1932). In general, Randall (1964) found that the dominant plants within the community where conchs occur tend to be the principal foods. Although seagrasses, such as *Thalassia* and *Halophila*, are consumed to a certain extent, various species of algae appear to be the main components of the diet of *S. gigas*. Robertson (1961) observed conchs grazing on epiphytic algae on *Thalassia*, but did not find leaves of *Thalassia* in stomach samples. He noted that algae of the genera *Cladophora*, *Hypnea*, and
Polysiphonia, in particular, were ingested (Table 3.3). Conch accidentally may ingest considerable quantities of sand and small benthic animals while feeding on filamentous and unicellular algae. Randall (1964) reported queen conch feeding during the night. Immature conch, in particular, tend to feed most actively at night, often spending most or all of the day buried in the sand. Queen conch larvae (veligers) feed on small plankton. These prey species inhabit the same habitats as the species in the queen conch FMU, and therefore would also benefit from any habitat protection measures adopted by the Council (Appendix 1).

3.2.11.4 Reef Fish FMU

3.2.11.4.1 Status of Stocks

The last Stock Assessment and Fishery Evaluation (SAFE) report for the Caribbean Reef Fish Fishery dates to 1992 (Appeldoorn et al. 1992). The conclusions of the SAFE report were that (1) insufficient data are available from the US Caribbean to properly characterize biological parameters for most reef fish, (2) many species are overexploited, and (3) no yield per recruit analysis could be conducted due to lack of growth and other essential biological information: “although there are insufficient data available from the US Caribbean to calculate these [SSBR] ratios, there is reasonable evidence to suggest that many [reef fish] species continue to be overexploited.”

The 2000 Annual Report on the Status of the Fisheries of the United States lists the status of most reef fish species in the US Caribbean as unknown. The 2000 Annual Report on the Status of Fisheries of the United States and the CFMC Reef Fish FMP list two Caribbean reef fish species as overfished, Nassau grouper and goliath grouper. The harvest of Nassau grouper and goliath grouper has been prohibited in Federal waters since 1990 and 1993, respectively. There is no evidence of recovery in these fisheries at present (see letter from Dr. Kemmerer dated 1998 SFA Amendment Appendix 14.3.) According to Amendment 2 (1993) to the FMP for the Reef Fish Fishery of Puerto Rico and the USVI, page 25, “The Nassau grouper and goliath grouper are currently considered overfished. Although a quantifiable SSBR cannot be determined because of the paucity of available data, total landings have declined to the point where these once abundant species rarely occur in the landings. The harvest of Nassau grouper was prohibited under Amendment 1 to the Shallow-Water Reef Fish FMP, and will remain so until the species has recovered to a level of 20% SSBR. Amendment 2 prohibits all further harvest of goliath grouper. This is the most restrictive action possible to restore these drastically impoverished stocks.” Nassau and goliath groupers are fully protected by the Council.

Evidence of overexploitation of some Puerto Rican reef fish resources began to appear during the late 1970s and early 1980s from analyses of length-frequency data (Stevenson 1978; Dennis 1988). Appeldoorn and Lindeman (1985) used catch and effort data for the haemulid fishery off La Parguera, Puerto Rico to derive two surplus-production models, and concluded the fishery was overexploited. The level of exploitation at the time was estimated to be 250% greater than that predicted to result in maximum yield. A 1992 fish trap study compared catch rates from near La Parguera, Puerto Rico with those reported from Puerto Rico in the 1970s and from under and overfished areas elsewhere in the Caribbean, and concluded that stock abundance in Puerto Rico...
had declined significantly (Appeldoorn and Posada 1992). A preliminary yield-per-recruit analysis for red hind in Puerto Rico and St. Thomas in 1992 indicated that fishing levels at the time were 50% and 20% greater, respectively, than theoretically optimum levels of fishing, as defined by $F_{0.1}$ criteria (Sadovy and Figuerola 1992). The authors recommended that fishing pressure on red hind in Puerto Rico be reduced substantially, and be reduced to a lesser extent in St. Thomas, if harvest equivalent to fishing at $F_{0.1}$ was to be achieved. Beets and Friedlander (1992) analyzed 1984-1988 red hind landings from St. Thomas and reported a significant decline in average size and an apparent loss of larger size classes from the fishery. Additional analyses of landings data from a known spawning aggregation concluded that a trend toward smaller average size and a skewed sex ratio (a 15:1 female to male ratio with a predominance of gravid females) was evidence of a possible shortage of males and increased potential for spawning failure (sperm limitation) in this protogynous species (Beets and Friedlander 1992; Bannerort et al. 1987). In 1990, a spawning aggregation closure was enacted for this location. Beets and Friedlander (1999) reexamined this same red hind spawning aggregation in 1997, and reported an increase in average length (from 295 mm TL in 1988 to 365 mm TL in 1997) and an increase in the proportion of males, resulting in a 4:1 female to male ratio. Nemeth (in review) who studied this same red hind aggregation found that the average size of red hind increased to 391 cm TL by 2001 and that the density of spawning red hind increased from 4.5 fish /100 m$^2$ in January 1997 (Beets & Friedlander, 1999) to 23 fish /100 m$^2$ in January 2001), a 500% increase in four years (Nemeth in review). Moreover, Whiteman et al. (in review) found that the overall female to male sex ratio was 2.92: 1 during the 2003 spawning season. Acosta and Appeldoorn (1992) used length-frequency data to estimate growth parameters, mortality, and yield per recruit for lane snapper. The Beverton-Holt yield-per-recruit model they generated indicated that at that time the fishery was harvesting approximately 91% of the potential yield. They recommended against any increase in fishing effort to avoid future stock-recruitment problems.

The SFA Working Group (WG) found in February 2003 the following reef fish sub-units, in addition to Nassau and goliath groupers, at risk and in need of rebuilding, and NOAA Fisheries found queen conch overfished in 2001:

1. Snapper Unit 4: yellowtail snapper
2. Grouper Unit 4: red, yellowedge, misty, tiger, yellowfin
3. Nassau grouper
4. Goliath grouper
5. Queen conch

In 1996, the World Conservation Union (IUCN) assessed hogfish and mutton snapper as vulnerable to extinction, but the SFA WG considered the subunits containing these species as not at risk.

Nassau Grouper Rebuilding. Quantitative data on fishing mortality rates and biomass levels are lacking; however, it is understood that Caribbean US Nassau grouper are severely depressed due to lack of occurrence in sampling and catches (prior to moratorium); thus, using this qualitative information, this stock can be classified as being below MSST. Fishing mortality rates are currently near zero (retention in catches are no longer allowed).
Although quantitative information on biomass (B) is not available for Nassau grouper, it is expected that current biomass is much less than MSST. It is unlikely that recovery could occur within 10 years with no fishing. Generation time for Nassau grouper is probably from 10 to 30 years (Legault and Eklund 1998). Generation times were examined using a range of likely M’s and spawning production. The determination that $B_{\text{now}}$ is less than MSST is qualitative, based upon occurrence in samples (or lack thereof).

Goliath Grouper Rebuilding.

Quantitative data on fishing mortality rates and biomass levels are lacking; however, it is understood that Caribbean US goliath grouper are severely depressed due to lack of occurrence in sampling and catches (prior to moratorium); thus, using this qualitative information, this stock can be classified as being below MSST. Fishing mortality rates are currently near zero (retention in catches are no longer allowed).

Although quantitative information on biomass (B) is not available, it is expected that current biomass is much less than MSST. It is unlikely that recovery could occur within 10 years with no fishing. Generation time for goliath grouper is estimated to be 15 to 40 years (Legault and Eklund 1998). Generation times were examined using a range of likely M’s and spawning production. The determination that $B_{\text{now}}$ is less than MSST is qualitative, based upon occurrence in samples (or lack thereof).

Goliath grouper in the US Caribbean are especially vulnerable to fishing due to their availability and due to their low productivity. Little quantitative assessment information is available (CFMC 1993).

3.2.11.4.2 Habitat Use by Species in FMU

US Caribbean ichthyofauna has been characterized as being composed by three groups (in terms of energetics): large, fast-swimming pelagic apex predators with loose reef affiliations, strongly reef-associated carnivores, and reef-associated herbivores (Opitz 1996). While reef-associated carnivores represent 70-80% of reef fish species in the US Caribbean and herbivores only 10%, the herbivores comprise around 40% of total fish biomass. However, large to intermediate-sized herbivores are not a preferred prey for the larger piscivorous fishes (Opitz 1996). Much of the literature that has been reviewed includes listing of species “seen” in the study areas but fail to provide information of the life stage of the individuals seen. Often there are no data on the size of the fish, an important variable in determining whether the fish are juveniles or adults.

Appendix 1 summarizes the available information on utilization of habitats by life history stages of species in the FMU for the Spiny Lobster, Queen Conch, and Reef Fish FMPs.
3.2.11.4.2.1 Eggs

Except for general descriptions there is little information on the distribution of reef fish eggs. All of the 15 species selected for discussion in the Generic EFH Amendment (CFMC 1998) have planktonic eggs, the distribution of which is unknown. Most of the information available for these stages is, except for a few exceptions, only known at the family level.

The seasonality of the presence or absence of eggs was based primarily on the spawning seasonality of the species. The information on distribution in terms of distance from shore, depth, temperature, and other environmental factors that might affect egg survival is not yet available for the US Caribbean. At present, information is being gathered in the area of La Parguera, Puerto Rico regarding fish egg distribution.

3.2.11.4.2.2 Larvae

Little information exists on the distribution of reef fish larvae, the development of larvae, or the settling and subsequent development of fish larvae. Presence or absence of larvae has also been determined from the available information on the spawning seasonality of the species. The information on distribution in terms of distance from shore, depth, temperature, and other environmental factors that might affect larval survival is not yet available for the US Caribbean. In general, newly settled stages tend to occur at depths of 0-10 m, and primarily at 5-10 m (Lindeman et al. 2000). At present information is being gathered in the area of La Parguera, Puerto Rico regarding larval fish distribution.

Grouper species may be less likely than snapper species to have local larval retention due to their longer larval duration. Bases on their size and age at settlement, grunts may be considered one of the reef fish groups most likely to exhibit local retention. However, larval duration may not be the only factor involved in determining the amount of local retention, as factors such as seasonal variations in current patterns and larval behaviors may also be important (Lindeman et al. 2000).

3.2.11.4.2.3 Juveniles

Many species of reef fishes utilize seagrass and mangrove habitats as juveniles, and then migrate to reef areas as they grow larger (Murphy 2001; Christensen et al. 2002; R. Appeldoorn, University of Puerto Rico, pers. comm. See Table below). In southwestern Puerto Rico, grunts and snappers were found to occur in seagrasses as juveniles (0-5 cm FL), then shift to mangroves as sub-adults (5-10 cm FL), and finally inhabit reef areas as adults (> 15 cm FL) indicating an ontogenetic migration pattern (Christensen et al. 2002). The same study found juvenile sparids and Mullids in seagrasses, but adults in coral reef habitats. Murphy (2001) also found that many species known to use reefs as adults were abundant in seagrasses and mangroves as juveniles. Rooker and Dennis (1991) suggests that offshore mangrove keys may serve as intermediate staging areas for species, such as French grunts, when they are making the transition from inshore nursery habitats to offshore reefs used by adults. Over 68% of the demersal stages of South Florida reef fish species examined in Lindeman et al. (2000) exhibited a cross-shelf
migration to deeper waters as ontogeny progressed. Some reef fishes have been found to use shallow reef areas as juveniles, and then move to deeper reef areas as they mature.

Some species of juvenile grunts are reported to use the spines of urchins (*Diadema antillarum*) during the early stages, 20-40 mm in length, and an age of 1 to 2 months. These juveniles also use *Acropora cervicornis* among other branching corals. The use of urchin spines has been explained as offering protection from predation by moray eels, Nassau and other groupers, snappers, and barracuda. Branching corals occur dispersed over sand bottoms, seagrass beds, around reefs (emergent or submerged), etc. and are used by both early and late juveniles. Among the snapper-grouper complex species, “strict estuarine dependence is a rare life history strategy, although more species have an opportunistic association” (Lindeman *et al.* 2000).

Nursery grounds for red hind, at present the most important grouper in the commercial harvest, are still unknown. These have been seen in habitats described as shallow sand (less than 10 m) and coral rubble areas (Sadovy per. obs.), and in areas with the same characteristics but at 20-30 m depths (J. Beets). In the US Virgin Islands juvenile red hind (<15 cm) occur more frequently than expected in two habitat types: (1) coral mounds formed by living *Porites porites* or dead *P. porites* covered in macroalgae and (2) sand/rock substrates dominated by seafans, gorgonians and sponges (E. Whiteman, personal observation). Both these habitat types appear to afford these small individuals protection from predation, either through hiding within the complex structure created by the coral fingers and/or camouflage. Interestingly more than 95% of juvenile red hind observed were seen on the North coast of St. Thomas (E. Whiteman, personal observation). This may be a reflection of greater larval supply or a lack of suitable habitat in other nearshore areas. The large coral mounds, living or dead, created by *P. porites* are rare if not absent on the south coast of St. Thomas. More work is needed to clarify the causes of this pattern. Finally, subadults appear to expand from these nursery habitats into a greater range of habitat types including patch reefs, reefs and bedrock habitats.

Nursery grounds for red hind, at present the most important grouper in the commercial harvest, are still unknown. These have been seen in habitats described as shallow sand (less than 10 m) and coral rubble areas (Sadovy per. obs.), including beer cans (per. obs.) and in areas with the same characteristics but at 20-30 m depths (J. Beets).
Reef fishes showing ontogenetic migration from inshore seagrass (Sg) and mangrove (Mg) habitats to reefs (R).
Ch = Channel, sh = shallow.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Settlement / Juvenile Habitat</th>
<th>Adult Habitat</th>
<th>Juvenile Habitat Dependency?</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthurus bahianus</td>
<td>surgeonfish</td>
<td>sh R/Sg</td>
<td>R</td>
<td>Opportunistic</td>
<td>8,13</td>
</tr>
<tr>
<td>Acanthurus chirurgus</td>
<td>doctorfish</td>
<td>Mg/Sg</td>
<td>R</td>
<td>Mg/Sg</td>
<td>1,6,8,9,10,13</td>
</tr>
<tr>
<td>Chaetodon capistratus</td>
<td>butterflyfish</td>
<td>Mg</td>
<td>R</td>
<td>Not Mg</td>
<td>1,9,10,13</td>
</tr>
<tr>
<td>Epinephelus striatus</td>
<td>Nassau grouper</td>
<td>sh Algae</td>
<td>R</td>
<td>Mg/Ch/</td>
<td>3</td>
</tr>
<tr>
<td>Gerres cinereus</td>
<td>yellowfin mojarra</td>
<td>Mg</td>
<td>R</td>
<td>Possible Mg</td>
<td>9,13</td>
</tr>
<tr>
<td>Haemulon flavolineatum</td>
<td>French grunt</td>
<td>Sg/Mg/R</td>
<td>R</td>
<td>Sg/Mg</td>
<td>3</td>
</tr>
<tr>
<td>Haemulon parra</td>
<td>sailors choice</td>
<td>Mg</td>
<td>R</td>
<td>Opportunistic</td>
<td>5,10</td>
</tr>
<tr>
<td>Haemulon plumieri</td>
<td>while grunt</td>
<td>Sg (Mg?)</td>
<td>R</td>
<td>Opportunistic</td>
<td>4,5,6,9,11,13</td>
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<tr>
<td>Haemulon sciurus</td>
<td>bluestriped grunt</td>
<td>Sg to Mg</td>
<td>R</td>
<td>Sg/Mg</td>
<td>5,6,7,9,10,11,13</td>
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<td>Mg/Sg</td>
<td>R</td>
<td>Possible Sg/Mg</td>
<td>5,9,11,13</td>
</tr>
<tr>
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<td>schoolmaster</td>
<td>Mg/Sg</td>
<td>R</td>
<td>Probable Mg/Mg</td>
<td>3</td>
</tr>
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<td>gray snapper</td>
<td>Mg/Ch</td>
<td>R</td>
<td>Possible Mg/Mg</td>
<td>1,5,8,9,10,11,13</td>
</tr>
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<td>Mg</td>
<td>R</td>
<td>Possible Mg/Mg</td>
<td>5,11</td>
</tr>
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<td>Mg/sh R</td>
<td>R</td>
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<td>R</td>
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<td>R</td>
<td>Mg/Sg</td>
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<td>R</td>
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<td>R</td>
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<td>9,10,13</td>
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<td>R</td>
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<td>Scarus taeniopterus</td>
<td>princess parrotfish</td>
<td>Mg/Sp</td>
<td>R</td>
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<td>8</td>
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<td>Sparisoma rubripinne/chrysopterum</td>
<td>yellowtail/redtail parrotfish</td>
<td>Mg/Ch</td>
<td>Ch/R</td>
<td>Not Mg/Sg</td>
<td>6,9,10,13</td>
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<td>Sparisoma viride</td>
<td>stoplight parrotfish</td>
<td>some Mg</td>
<td>R</td>
<td></td>
<td>13</td>
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<tr>
<td>Sphyraena barracuda</td>
<td>great barracuda</td>
<td>Mg</td>
<td>R</td>
<td>Possible Mg</td>
<td>1,6,9,10,13</td>
</tr>
</tbody>
</table>

Literature Source:

1. Dennis (1992)
4. Appeldoorn et al. (1997)
5. Lindeman (1997a)
6. Murphy (2001)
7. Recksiek et al. (2001)
8. Cochere et al. (2002)
3.2.11.4.2.4 Adults

Most commercially important reef fish in the Greater Caribbean area (e.g. groupers and snappers) migrate to specific places at specific times to reproduce in spawning aggregations (SPAGs) (Heyman et al. 2002). Many documented SPAG sites occur largely at reef promontories, and/or the seaward extension of reefs near deep water (Heyman et al. 2002). In regions where no SPAG fishing has been documented, locations of promontories and reef extension may predict the location of SPAG. Reef fish spawning sites tend to occur near the edge of outer reefs or reef passes over hard sand bottom at depths around 20-50 m (Claro and Lindeman 2003). However, among similar shelf edge sites, some support SPAGs while others do not (Lindeman et al. 2000). Beets and Friedlander (1999) observed red hind along the insular shelf in St. Thomas forming aggregations only in structurally complex habitats, which they suggest may be uncommon habitat along the shelf. Concentrations of fish along the southwest to the southeast coast of Puerto Rico identified from hydroacoustic surveys (Figure 2.28) may be SPAG sites for red hind or other reef fish (Jose Rivera, private contractor, Puerto Rico, pers. comm.), but spawning has not yet been definitely confirmed. If a correlation exists between complex habitat and red hind spawning, management strategies may be possible based on habitat type.

SPAG sites likely possess unique characteristics that attract spawning fish. For example, spawning aggregations of schoolmaster snapper, tiger grouper, black jacks and queen triggerfish have been observed in the same general location as the red hind spawning aggregations on St. Thomas and St. Croix (Nemeth, personal observation). Yellowfin grouper and possibly Nassau grouper have been observed to aggregate on another well developed reef south of St. Thomas called the Gramanic Bank. This same location also supports a large cubera snapper SPAG (Nemeth, personal observation). Habitat likely plays a substantial but unknown role in defining SPAGs. Regulatory actions that protect snappers and groupers from overexploitation on SPAGs also reduce fishing effort, which may subsequently reduce adverse fishing impacts. The primary red hind SPAG on Lang Bank St. Croix is also on coral habitat but other small satellite red hind SPAGS on Lang Bank and in the British Virgin Islands occur on hard bottom habitats providing only small crevices, gorgonians and sponges for cover (Nemeth personal observation).

SPAGs, once discovered by fishers, are often heavily exploited. Heavy fishing on SPAGs and spawning migration routes can have detrimental effects on population stability rebuilding efforts, and ecosystem complexity (Claro and Lindeman 2003). Interannual variations in SPAG formation may occur, especially among those that are heavily fished (Lindeman et al. 2000). In some cases, SPAGs may become so depleted that they no longer form. For example, Nassau grouper SPAGs have disappeared from approximately one-third of all known SPAG sites in the wider Caribbean region. These include sites in Belize, Mexico, Honduras, Puerto Rico, the USVI, Florida, the Dominican Republic and Bermuda (Heyman et al. 2002). If management-conservation intervention occurs before complete collapse, spawning aggregations have the potential to recover. SPAGs are critically important in the life cycle of many reef fishes and reproduction at these sites often represents the total annual reproductive output for specific stocks of a species (Heyman et al. 2002).
SPAGs provide substantial economic benefits to subsistence and commercial fisheries and may play a significant role in the marine tourism industry, e.g., dive tourism. Among commercially important species that form spawning aggregations, grouper populations have drastically declined in the Caribbean (Heyman et al. 2002).

Spawning areas for red hind have been identified in federal and state waters, and some are already under management. Amendment Number 1 to the Coral FMP (dated May 1998) established a no-take zone in what is known as the “Hind Bank.” The Hind Bank SPAG south of St. Thomas was established as a Marine Conservation District (MCD) in 1999 and is permanently closed to all fishing. The area had been under a seasonal closure established in 1990 specifically to protect the red hind spawning aggregation, a management measure that has been shown to be successful. The red hind SPAG on Lang Bank St. Croix is under a seasonal closure to protect the red hind spawning aggregation. The Regulatory Amendment to the Reef Fish FMP (dated August 1996) protects two additional sites off the West Coast of Puerto Rico. Still, there is no detailed description of these areas. The best description available to the Council is that of the Hind Bank on the southwest of St. Thomas (e.g., Beets and Friedlander 1997, 1999; Olsen and LaPlace 1978). The red hind aggregations take place in areas of high relief (apparently uncommon in the USVI platform) with large colonies of *Montastrea franksi* and *faviolata* (Nemeth, unpublished data). The data are not available at this time, to determine if the same is true for the other already protected and unprotected aggregations.

The fisheries for Nassau grouper and goliath grouper are closed in the EEZ; a closure for goliath, but not Nassau grouper occurs in state waters of the USVI; the state waters of Puerto Rico are not closed to either species. Historical spawning areas and nursery grounds are known, but all of these areas continue to be fished for other species, which appear to have replaced these larger groupers. Of the other groupers, the red hind, rock hind, and graysby support the grouper fishery in the US Caribbean. Several known spawning areas have been closed during the spawning season, but others continue to be fished. However, the Council has identified and inventoried a number of old maps (e.g., 1958-1959; 1971; 1982-1983), which describe the communities at that time, and which could be digitized to determine changes in area and perhaps “migration” of some habitat types. Very little is known of the deeper reefs around the USVI, especially in areas that may support critical grouper and snapper spawning aggregation sites along the shelf edge (Goenaga and Boulon 1992).

A comparison of protogynous porgies in protected vs. exploited areas found that porgies from exploited areas had higher growth rates and were more female biased (Buxton 1993). Nassau groupers from low density aggregations had courtship and color patterns which were less intense than in denser aggregations, suggesting that successful spawning may require a minimum density of fishes (Colin 1992). Females and males have been observed swimming rapidly upward from near the substrate, then turning sharply to release gametes at the peak, before rapidly swimming back down to the substrate (Colin 1982).

Size at sexual reproduction, which until recently has been largely unknown for reef fish in the US Caribbean, has served as the basis for the first steps in trying to identify specific juvenile and adult areas.
3.2.11.4.2.5 Prey species

Table 3.3 shows some of the known prey organisms consumed by reef fish in the FMU, with an emphasis on the prey of groupers, snappers, and grunts. Among the FMU species there are both prey and predators. For example, the Nassau grouper feeds on small grunts as juveniles and on spiny lobster as adults (among other prey items), the red hind feeds on squirrelfish, the mutton snappers also feed on spiny lobsters as adults, the yellowtail snapper feeds on planktonic organisms as juveniles and prey on fish eggs and larvae as adults. Most finfish have a varied diet of fish, shrimp, copepods, amphipods, cephalopods, stomatopods and crabs among many other organisms.

Several reef fish species feed on sponges, and *Zoanthus* (a colonial anemone) is a food source of major importance for at least 16 species of fishes in 7 families (Randall, 1967). In this study, polychaetes were among the most important food items of 62 West Indian reef-fish species in 24 families and were surpassed as preferred foods only by crustaceans (copepods, barnacles, amphipods, stomatopods, shrimps, crabs and lobsters). Ophiuroids (brittlestars) were food for 33 fish species and 16 species fed on benthic tunicates. Larger predators such as groupers and snappers feed on fish (e.g., cubera snapper feeds on red hinds).

The trunkfish feed primarily on sponges and tunicates; queen triggerfish mostly feeds on echinoids (primarily *Diadema antillarum*) and the redtail parrotfish mostly feed on algae and seagrass (Randall 1967). All of the above prey species inhabit the same habitats as their predator species in the reef fish FMU, and therefore would also benefit from any habitat protection measures adopted by the Council (Appendix 1).

3.2.11.5 Coral FMU

3.2.11.5.1 Status of Stocks

The resources contained in the Coral FMP are considered to be distinctive habitats of limited distribution, the greatest value of which is perceived to be as habitat for reef-associated and reef-dependent organisms, as a buffer against coastal erosion, and having an aesthetic significance for tourism and related activities. Given the limited distribution and slow regeneration rates of the majority of these species, they are considered to be non-renewable resources, for which an OY of zero is the only level which can reasonably be expected to ensure no net loss. Although current harvest of corals and live-rock is low, there is considerable concern over increasing pressure to harvest these resources, and over the growing intensity of anthropogenic stresses to which they are being subjected. The socioeconomic impact associated with this level of OY is considered to be negligible at the present time. The amount taken recreationally for personal use is not known but is believed to be a fraction of that taken commercially.

Information is not available regarding natural abundance, sustainable harvest levels, or current harvest of other reef-associated invertebrates included in the Coral FMP management unit. The
estimated numbers of organisms exported provides only a minimum estimate of harvest in Puerto Rico, as on-island trade is completely unaccounted for, and has yet to be assessed. Because of insufficient data, no level of OY can be set until further information is obtained. However, since there is valid concern that harvest will increase, and that from experience elsewhere, heavy uncontrolled harvest has the potential to reduce the abundance of certain species in the reef ecosystem (as has occurred with the Bahamas starfish in Florida, and the starfish *Acanthaster planci* in Sri Lanka) (Wood 1985), every effort must be made to collect sufficient data to estimate OY and MSY as soon as possible. Information is urgently needed on reef-associated invertebrates to determine abundance, current and sustainable harvest levels and capture-induced mortalities to permit establishment of OY, especially for more heavily exploited species in the FMU such as *Condylactis* and brittlestars; quotas have been established for several invertebrate species harvested for the marine aquarium trade in Florida's Marine Life Rule because of concerns over excessive harvest. The recommended data collection program to accompany permitting for harvest of components of the FMU, and research initiatives, will enable OY to be determined.

3.2.11.5.2 Habitat Use by Species in FMU

“Reef corals represent a peculiar situation since, in most cases, they are the main constructors of their own habitat, the coral reef. Therefore, their condition reflects the condition of their habitat. If corals are dead or dying, the coral reef is likely to degenerate. Many other organisms, however, do depend to different extents on the condition of the coral reef. These include commercially important species that utilize corals, directly or indirectly, for shelter, food and as spawning sites” (Goenaga and Boulon 1992).

3.2.11.5.2.1 Eggs

Corals exhibit sexual and asexual reproduction. Many coral species mass-spawn (UVI no date). Most corals have well defined seasonal patterns of sexual reproduction (Szmant 1986). Within a 24-hour period, all the corals from one species and often within a genus release their eggs and sperm at the same time. This occurs in related species of *Montastraea*, and in other genera such as *Montipora, Platygra, Favia*, and *Favites* (Wallace and Willis 1994). In some *Montastraea* and *Acropora* species, the eggs and sperm are released in a sack. They float to the surface where they separate and fertilization takes place. Mass spawning raises the possibility of hybridization by congeneric species (Wallace and Willis 1994).

Some species of coral brood their larvae (UVI no date). The sperm fertilizes the egg before both are released from the coral. The larvae float to the top, settle, and become another colony. Species of *Acropora* release brooded larvae.

Corals also reproduce asexually. The coral colony expands in size by budding. Budding may be intratentacular, in which the new bud forms from the oral discs of the old polyp, as in *Diploria*, or extratentacular in which the new polyp forms from the base of the old polyp, as in *Montastraea cavernosa*.
Corals commonly reproduce by fragmentation. Forms with branching morphology and high growth rates (e.g., *Acropora palmata* and *A. cervicornis*) can disperse through breakage during storms (e.g., Highsmith, 1982). Broken pieces of corals that land on a suitable substrate may begin growing and produce a new colony (UVI no date).

### 3.2.11.5.2.2 Larvae

Sexual reproduction results in the formation of minute larvae (plannulae) that spend a variable amount of time in the water column as plankton (from days to weeks), eventually settling on an appropriate substrate (CFMC 1996). If reproduction is asexual, larvae are brooded in the gastric pouch of the parent and released when ready to settle (UVI no date). Larval capacity for substrate selection is unknown for most species but is likely to vary among them (CFMC 1996). After settling, larvae develop a skeleton and, if colonial, start budding additional polyps that will eventually form an adult colony. Individuals of some species delay sexual reproduction and use the available energy for asexual growth until a colony size safe from predation has been attained (Szmant 1986).

Rock and dead coral surfaces are also vital substrates for the settlement of larval phases of benthic organisms that cannot settle onto living coral. Suitability of substrate is one of the major factors controlling the distribution of many species. For example, natural, rough, substrate covered with other living organisms, presence of other larvae, and absence of certain organisms are all necessary for octocoral settlement. Many other coral species also have specific substrate requirements for larval settlement. Natural substrate cleared of other organisms had no appreciable octocoral colonization even after six months (Wheaton 1989; Kinzie 1971). Other factors that influence the settlement of sessile organisms include total surface area available for settlement, conditioning period of substrate, surface relief including crevices and ridges, substrate orientation, and substrate composition (Wheaton 1989). Thus, both physical and biological complexity are essential for the development of the reef ecosystem. Coral reefs and live-rock habitats form the backbone of this complex.

### 3.2.11.5.2.3 Juveniles

Even though *Montastrea annularis* is one of the most abundant corals off La Parguera, and in many reefs off Mayaguez, juvenile colonies of this species have not been commonly reported. Very small colonies of this species can be frequently observed in La Parguera. However, Goenaga and Boulon (1992) report that upon close inspection, it can be seen that these are remnants of larger colonies that have undergone partial mortality and the rest of their skeleton have been covered by other organisms such as filamentous algae. While this is generally true for the USVI as well, very small, apparently juvenile colonies have been observed in certain localities (e.g. Salt River submarine canyon (Boulon, 1979; Beets, pers. comm.)).
3.2.11.5.2.4 Adults

Because corals are sessile organisms, the habitat used for larval settlement is the habitat used by adults. Larvae require biologically and physically complex substrates for settlement (see section above for larvae). Adult corals extend their habitat asexually through budding and fragmentations. In all cases, the coral becomes its own habitat. However, specific requirements are not usually known.

It is not the intention of the Council and NOAA Fisheries to reproduce in this document the contents of the FMPs it has in place, but to identify what is missing from these documents, and set forth the direction of research. The Coral FMP (1995) (a fishery management plan for invertebrates, plants and reef associated species) indicates that fisheries are dependent on these organisms as habitat (also food, shelter, to form spawning aggregations, etc.). Most importantly, that management of reef-building corals needs to focus on habitat rather than on individual organisms (Goenaga and Boulon, 1992). Therefore, the lack of available information on their requirements for suitable substrate, temperature, light and water conditions prevents any other action from the Council than to prohibit harvest of all corals (stony, sea fans and gorgonians, any species in the FMU) as determined in the Coral FMP.

Most information available is for organisms found in emergent coral reefs (those that break the surface).

3.2.11.5.2.5 Prey species

The following text is from Goenaga and Boulon (1992) from a report submitted to the Council.

Cnidarian, skeleton forming animals are well equipped to capture and eat living animal prey. They possess tentacles loaded with batteries of nematocysts. These are stinging cells that serve to paralyze and kill zooplankton. Hermatypic corals (scleractinians and, possibly, hydrocorals and gorgonians), however, are considered polytrophic organisms (Muscatine and Porter 1977). This means that they can feed at multiple levels in the food web. These modes of feeding include (a) dissolved and suspended organic matter (auxotrophic), (b) photosynthesis from zooxanthellae (primary consumers), and, (c) zooplankton (secondary consumers). In addition, their capacity to photosynthesize, as a symbiotic unit with zooxanthellae, makes them a very special case of primary producer, in which production exceeds consumption in many cases. Hermatypic gorgonians have abundant zooxanthellae in their tissues. The extent to which different species depend on their zooxanthellae for nutrition is, to a large extent, unknown.

Black corals do not contain zooxanthellae. Their tentacular muscles are not well developed and tentacular contraction and retraction are slow. Even so, when presented in the laboratory with living zooplankton they exhibit an efficient preying response. Living food is rapidly engulfed with the aid of ciliary currents inflowing through the pharynx into the gastrovascular cavity. These prey species inhabit the same habitats as the species in the coral FMU (Appendix 1).
3.2.12 Summary of habitat use by managed species

The use of habitats by managed species was summarized using the habitat use database (see Section 2.1.4.2.1). A habitat use score was calculated as the total number of species/life stages using habitats for the designated ecological functions (score one per species/life stage/function). The habitats were ranked for each ecological function from highest use (most species/life stages) to lowest use. The most-used habitat was given a score equal to the total number of habitats used by that FMPs species. The second most-used habitat was given a score of total habitats minus one, and so on (See Table 3.5a for an example). Habitats that tied for number of uses were all given the same score. Following a tie, the score started again with the number for the next habitat. Habitats that had no reported use, received a score of zero. For example, if an FMP had 16 habitats, then the most used habitat would score a 16, the second would score a 15. If three habitats tied for third, all three would score a 14, and the next habitat would score an 11. The least-used habitat would score 1, except for unused habitats that would score 0. The habitats also received a rank for each ecological function (Table 3.5 b,c,d), in which the habitat with the highest score ranked 1, the second highest score ranked 2, and so on. Habitats not used for a function received “not applicable” rather than a rank. After each habitat had been scored for each of the three designated ecological functions, an average score was calculated by taking the mean of the three scores (Table 3.6). The habitats were then ranked again according to their mean scores.

The ecological importance of a habitat was labeled “high” for a given ecological function, if it ranked in the upper quartile range (Table 3.5). If several habitats tied for the final upper quartile position, all were included in the upper quartile and received a high importance designation. The habitats in the two middle quartiles were given a moderate importance designation, and habitats in the bottom quartile were characterized as having low importance for the ecological function in question. An ecological importance was also calculated from the mean scores. As before, the habitats in the upper quartile received an overall high ecological importance, those in the two middle quartiles received a moderate importance, and those in the bottom quartile received a low importance (Table 3.6).

Of the substrata identified as habitat for Caribbean species (Table 3.2), marine seagrasses, coral reefs, hard/live bottom, sand/shell bottoms and pelagic waters ranked as high ecological importance for at least one of the FMPs (Table 3.6). Spawning by species in the Fishery Management Units occurred on relatively few substrata (marine reefs, marine hard bottom, marine sand/shell, and marine seagrasses) for any of the species in the FMPs (Table 3.5b). Feeding occurred on more diverse habitats, with 16 habitats represented among the management plans (Table 3.5c). Growth to maturity had a similar diversity to feeding (Table 3.5d).

3.2.13 Fishery resources not under Council FMPs

3.2.13.1 Highly migratory species

The US pelagic longline fishery for Atlantic Highly Migratory Species (HMS) primarily targets swordfish, yellowfin tuna, or bigeye tuna in various areas and seasons. This HMS section is
summarized from NMFS (2002b). Secondary target species include dolphin, albacore tuna, pelagic sharks including mako, thresher, blue sharks and porbeagle, as well as several species of large coastal sharks. In the Caribbean this gear usually targets swordfish, yellowfin tuna, dolphin, and bigeye tuna. Although this gear can be modified (i.e., depth of set, hook type, etc.) to target either swordfish or tunas, like other hook and line fisheries, it is a multi-species fishery. These fisheries are opportunistic, switching gear style and making subtle changes to target the best available economic opportunity of each individual trip. Longline gear sometimes attracts and hooks non-target finfish with no commercial value, as well as species that cannot be retained by commercial fishermen, such as billfish. Pelagic longlines may also interact with protected species such as marine mammals, sea turtles and sea birds, and have thus been classified as a Category I fishery with respect to the Marine Mammal Protection Act. Any species (or undersized animal of permitted species) that cannot be landed due to fishery regulations is required to be released, whether dead or alive.

Commonly caught non-target species that can be kept include blacktip, sandbar, dusky, shortfin mako, oceanic whitetip, spinner, and silky sharks. Bigeye thresher, blue, tiger, and lemon sharks can also be kept, but are usually discarded. In addition, great hammerheads can also be kept, but the whole fish must be retained. As the fins are the only highly valued part, it is not worthwhile keep the whole fish just for fins, so they generally are discarded. Night, Caribbean reef, Caribbean sharpnose, smalltail, bignose, and sand tigers sharks are also caught, but possession of these is prohibited, so they are discarded. Caribbean observer studies did not document incidental capture or injury of marine mammals due to pelagic longline encounters. Sea turtles are also sometimes caught, but many are released alive, including loggerhead, leatherback, green, hawksbill, and Kemp’s Ridley turtles.

Pelagic longline gear is composed of several parts. The primary fishing line, or mainline of the longline system, can vary from five to 40 miles in length, with approximately 20 to 30 hooks per mile. The depth of the mainline is determined by ocean currents and the length of the floatline, which connects the mainline to several buoys and periodic markers with radar reflectors and radio beacons. Each individual hook is connected by a leader to the mainline. Lightsticks, which contain chemicals that emit a glowing light, are often used. When attached to the hook and suspended at a certain depth, they attract baitfish that may, in turn, attract pelagic predators. When targeting swordfish, the lines generally are deployed at sunset and hauled in at sunrise to take advantage of the nocturnal near-surface feeding habits of the large pelagic species (Berkeley et al. 1981). In general, longlines targeting tunas are set in the morning, deeper in the water column, and hauled in the evening. Except for vessels of the distant water fleet which undertake extended trips, fishing vessels preferentially target swordfish during periods when the moon is full to take advantage of increased densities of pelagic species near the surface. Those sets targeting dolphin are set in the daytime near the surface, with shorter longlines and shorter soak time.

Secondary hook and line gear is permitted onboard pelagic longline vessels. Longliners use harpoons for safer handling of larger fish, and for the occasional harvest of free-swimming fish that approach the vessel during haul-back. Using a technique known as "green sticking," fishermen may use a long pole to extend several longline leaders and hooks behind the vessel. Typically, this line is trolled while hauling the primary gear or while the vessel is moving on the
fishing grounds. "Jigging machines" are a type of bandit gear used for trolling drift handlining HMS. Many pelagic longliners troll regular rod and reel gear while drifting to determine what species are available in the area they are passing through.

Annual permits are required for US commercial vessels fishing for swordfish, and for those commercial vessels fishing for sharks in the US EEZ. There is a two-tiered limited access permit system for directed and incidental longline fishing for swordfish, sharks, and BAYS (bigeye, albacore, yellowfin, and skipjack) tunas based on current and historical participation in these fisheries. The limited access program requires pelagic longline vessels targeting tuna or swordfish to have tuna, shark, and swordfish permits (either directed or incidental). Longline vessels targeting sharks must have a shark permit (either directed or incidental). The limited access program is intended to stabilize the fleet size and provide an opportunity for NMFS to collect data, conduct studies, and work cooperatively with constituents to develop a flexible, and permanent, effort control program.

During 1996, 264 pelagic longline vessels fishing for Atlantic swordfish deployed approximately 10.2 million hooks. Based on the eligibility criteria selected in the limited access system, NMFS estimates that about 198 and 218 vessels are eligible for a directed and incidental swordfish permit, respectively, and that approximately 416 vessels are eligible for a BAYS longline permit.

Reported effort, in terms of number of vessels fishing, has fluctuated in recent years but has not shown obvious trends in the distant water, southeast coastal, and northeast coastal areas. However, there appears to be a trend towards decreasing numbers of vessels fishing in the Caribbean and the Gulf of Mexico. In all areas, the reported number of hooks per set has increased. Although swordfish appear to have remained the primary target species in the Caribbean, distant water, and southeast coastal fishery areas, the proportion of swordfish in the reported landed catch has decreased in both the distant water and southeast coastal areas. In the case of the distant water fishery, an increasing proportion of the reported landings consist of yellowfin, albacore, bigeye and/or skipjack tunas. Coastal shark and reported dolphin landings have increased in the southeast coastal area. The largest decreases in targeting and landing of swordfish were in the northeast coastal area (Cramer and Adams, 1998). The Gulf of Mexico, which has historically been primarily a yellowfin tuna fishery, has had an increase in reported targeting and landing of swordfish in recent years (Cramer and Scott, 1998).

The pelagic longline fishery sector is comprised of five relatively distinct segments with different fishing practices and strategies, including the Gulf of Mexico yellowfin tuna fishery, the south Atlantic-Florida east coast to Cape Hatteras Swordfish fishery, the mid-Atlantic and New England swordfish and bigeye tuna fishery, the US distant water swordfish fishery, and the Caribbean Islands tuna and swordfish fishery. Each vessel type has different range capabilities due to fuel capacity, hold capacity, size, and construction. In addition to geographical area, segments differ by percentage of various target and non-target species, gear characteristics, bait, and deployment techniques. Some vessels fish in more than one fishery segment during the course of the year.
3.2.13.1.1 The Caribbean tuna and swordfish fishery

This fleet is similar to the southeast coastal fishing fleet in that both are comprised primarily of smaller vessels that make short trips relatively near-shore, producing very high quality fresh product. Both fleets also encounter relatively high numbers of undersized swordfish at certain times of the year. Longline vessels targeting HMS in the Caribbean set fewer hooks per set, on average, fishing deeper in the water column than the distant water fleet off New England, the northeast coastal fleet, and the Gulf of Mexico yellowfin tuna fleet. This fishery is typical of most pelagic fisheries, being truly a multi-species fishery, with swordfish as a substantial portion of the total catch. Yellowfin tuna, dolphin and, to a lesser extent, bigeye tuna, are other important components of the landed catch. Principal ports are St. Croix, USVI and San Juan, Puerto Rico. Many of these high quality fresh fish are sold to local markets to support the tourist trade in the Caribbean.

3.2.13.1.2 Vessel permitting

Currently all commercial vessels that hold HMS permits are required to display the official number of the vessel so as to be clearly visible from an enforcement vessel or aircraft. NMFS does not intend to amend these regulations, as they are useful for enforcement purposes. Vessel permits for commercial and recreational vessels targeting Atlantic tunas (Atlantic bluefin, yellowfin, bigeye, albacore, skipjack, and bonito [commercial only]) must be renewed on an annual basis. NMFS has issued approximately 20,000 Atlantic tuna vessel permits under an automated permitting system that was implemented in 1997.

Annual permits are also required for US commercial vessels fishing for swordfish and for those commercial vessels fishing for Atlantic sharks in the US Exclusive Economic Zone (EEZ). The HMS FMP implements a two-tiered limited access permit system for directed and incidental longline fishing based on current and historical participation in these fisheries. The limited access program will require pelagic longline vessels targeting tunas or swordfish to have tuna, shark, and swordfish permits (either directed or incidental.) Longline vessels targeting sharks must have a shark permit (either directed or incidental.) The limited access program is intended to stabilize the fleet size and provide an opportunity for NMFS to collect data, conduct studies, and work cooperatively with constituents to develop a flexible, and permanent, effort control program.

3.2.13.1.3 Observer coverage

Scientific observer coverage of the US pelagic longline fleet was initiated by the NMFS in 1992. Contracted and NMFS observers collect catch data aboard pelagic longline vessels fishing in the waters of the northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. An International Commission for the Conservation of Atlantic Tunas (ICCAT) recommendation requires five-percent observer coverage of vessels fishing for yellowfin and bigeye tunas. Selection of US vessels is done randomly, with selection based on the fishing vessel performance information provided through mandatory pelagic logbooks. The NMFS’ Southeast Fisheries Science Center and NMFS’ Northeast Fisheries Science Center successfully recorded effort from 652 sets during
1994, 699 sets during 1995, 362 sets during 1996, and 460 sets during 1997. Observers from the NMFS’ Southeast Fisheries Science Center have recorded over 50,000 fish (primarily swordfish, tunas, and sharks), marine mammals, turtles, and seabirds during this time period.

3.2.13.1.4 Management

The reauthorization of the Magnuson-Stevens Act (M-S Act) came with a new emphasis on the precautionary approach. The fishery, which targets highly migratory species, presents a challenging management scenario, because it is fished by many different nations. Many of the species in the fishery are identified as “overfished” (e.g. bluefin tuna, bigeye tuna, swordfish, and large coastal sharks), but the implementation and enforcement of management regulation is inconsistent among nations. The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the multi-national cooperative management body that provides scientific information and management recommendations for stocks of Atlantic tuna, swordfish, and billfish. In the US, whenever possible, regulations are implemented dually through the authority of the Atlantic Tunas Convention Act (ATCA) and the M-S Act. There is no international management of sharks at present, but the Global Plan of Action from the 1999 FAO Consultation on Shark Conservation and Management took steps to improve shark conservation.

The United States fisheries for Atlantic HMS are managed by NMFS, acting for the Secretary under authority of ATCA and the M-S Act. Since 1966, ICCAT has been responsible for international conservation and management of tuna and tuna-like fishes. ICCAT's stated objective is to "cooperate in maintaining the populations of these fishes at levels which will permit the maximum sustainable catch for food and other purposes." All of the Atlantic HMS including tunas, swordfish and billfish, with the exception of the shark species, are currently subject to ICCAT management authority. Data collection and research recommendations for sharks are considered by ICCAT's Subcommittee on Bycatch. Atlantic sharks in the US are managed under the HMS FMP directly by NMFS under the authority of the M-S Act.

The conservation and management recommendations of ICCAT include total allowable catches, sharing arrangements for member countries, minimum size limits, effort controls, time/areal closures, trade measures, and monitoring and inspection programs. If the United States accepts an ICCAT recommendation, ATCA provides the Secretary with the necessary authority to implement these binding ICCAT recommendations in the United States. However, no regulation promulgated under ATCA may have the effect of increasing or decreasing any allocation or quota of fish or fishing mortality level to which the United States agreed pursuant to a recommendation of ICCAT.

HMS are defined to be tuna species, marlin (Tetrapturus spp. and Makaira spp.), oceanic sharks, sailfishes (Istiophorus spp.), and swordfish (Xiphias gladius). Tuna species are further defined as albacore tuna (Thunnus alalunga), bigeye tuna (Thunnus obesus), bluefin tuna (Thunnus thynnus), skipjack tuna (Katsuwonus pelamis), and yellowfin tuna (Thunnus albacares). Thus, the Secretary currently has the authority to manage directly those species listed above without a Regional Fishery Management Council’s FMP.
Swordfish are separated from other billfish for purposes of management because the swordfish fishery is primarily a commercial one, while the domestic billfish fishery is a recreational one. Thus, billfish other than swordfish, are managed under a separate FMP. Nevertheless, measures in the two FMPs are designed to be complimentary.

These fisheries are managed through: quotas, gear restrictions, limiting access to the fishery, areal closures, time closures, size limits, retention limits, anti-finning rules, increasing observer coverage, logbook requirements, and permit requirements.

The management of HMS (including billfish) may effect the management of other fisheries managed by an FMP under one or more of the five Fishery Management Councils with authority in the Atlantic Ocean. A reduction in recreational effort directed toward Atlantic billfish may result in increased activity targeting other pelagic species (e.g., dolphin, king mackerel, wahoo). Conversely, management of the dolphin fishery may affect the management of HMS, including Atlantic billfish. The SAFMC, in conjunction with the Mid-Atlantic and New England Councils, received approval in 2004 on a fishery management plan for dolphin and wahoo.

How might pelagic longlines and their associated HMS fisheries impact the habitat of the managed Caribbean species considered in this EIS? Since the gear does not interact with the substrate, the principal concern comes over how removing these large apex predators, might affect the abundance of potential prey abundance species utilized by managed Caribbean fishes.

3.2.13.2 Fisheries in state waters

The description of fisheries and fishers in the Human Environment (Section 3.3) applies to fisheries in state waters. The fisheries occur across the insular shelf in both state waters and the EEZ. The majority of fishing occurs in state water, although no breakout of catch or effort is available. Applying the GIS to the habitat maps (Section 2.1.3.3.3) provides a calculation that about 85% of the shelf occurs in state waters, and 15% in the EEZ (Figure 2.22). In addition to the gears in the EEZ, beach seines and cast nets (Section 3.5.1) are used in the state waters.

3.2.14 Marine Mammals and Protected (Threatened and Endangered) Species

3.2.14.1 Mammals

Marine mammal species found in the US Caribbean include: from Suborder Mysticeti, Family Balaenopteridae; from Suborder Odontoceti, Family Physeteridae (whales); from Suborder Odontoceti, Family Ziphiidae (beaked whales); from Suborder Odontoceti, Family Delphinidae (dolphins); from Order Carnivora, Suborder Pinnipedia, Family Phocidae (seals); from Order Sirenia, Family Trichechidae (manatees). At present, a total of 17 species of whales and dolphins have been reported from Puerto Rican and US and British Virgin Island waters (Mignucci-Giannoni 1999). There are four baleen (blue, fin sei, and humpback) whales, one toothed (sperm) whale, and one sirenian (West Indian manatee) species with occurrence in the Caribbean that are listed as endangered. The Caribbean monk seal is also listed as endangered but may be extinct, as no confirmed sightings have occurred since 1952.
Under section 118 of the MMPA, NOAA Fisheries must publish, at least annually, a List of Fisheries that places all U.S. commercial fisheries into one of three categories based on the level of incidental serious injury and mortality of marine mammals that occurs in each fishery. The commercial and recreational fisheries under jurisdiction of the Caribbean Council are all listed in the 2003 List of Fisheries (68 FR 41725) as Category III fisheries, the category with the lowest level of serious injury and mortality to marine mammals. However, interactions of fishing gears with marine mammals are poorly documented. Interactions of marine mammals and gill and trammel nets in the US Caribbean may occur at a higher level, based on analogy with other fisheries, but sufficient information is not available. A study of cetacean strandings in Puerto Rico and the Virgin Islands found that entanglement was the cause in 28.6% of the cases, although the study did not specify what percent involved entanglement in fishing gears (Mignucci-Giannoni 1999). The Southeast Regional Office may reevaluate the Caribbean gill and trammel net fisheries in subsequent List of Fisheries. Pelagic longline fisheries interactions with marine mammal in the U.S. Caribbean are believed to be very limited, based data from observers (NMFS 1999b).

A summary of the biology and status of endangered marine mammals found in the U.S. Caribbean is included below. Additional information on these species and on the other marine mammals and their occurrence in the U.S. Caribbean may be found in Mignucci-Giannoni et al. 1988 and 1999 (see references) and Schwarts et al. 2001 publications. More general information on the biology and status of marine mammals may be found in on NOAA Fisheries' website: http://www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/individual_sars.html.

3.2.14.1.1 Blue Whale (*Balaenoptera musculus*)

The distribution of the blue whale in the western North Atlantic generally extends from the Arctic to at least mid latitudes (Waring *et al.* 2001). The blue whale is best considered as an occasional visitor in US Atlantic EEZ, which may represent the current southern limit of its feeding range (NMFS 2002c). Yochem and Leatherwood (1985) summarized records that suggested an occurrence of this species south to Florida and the Gulf of Mexico, although the actual southern limit of the range is unknown. The Navy’s Sound Surveillance System (SOSUS) program has tracked blue whales in much of the North Atlantic, including subtropical waters north of the West Indies (Clark 1995; NMFS 2002c). However, Mignucci-Giannoni (1998) did not report any blue whales occurrences in Puerto Rico or the USVI, and states that the only known Caribbean record is from a cervical vertebrate found in Panama in 1922.

Little is known about the population size of blue whales, except for limited information in the St. Lawrence area (NMFS 2002c). The status of blue whales relative to optimum sustainable population (OSP) in the US Atlantic EEZ is unknown, but the species is listed as endangered under the ESA (Waring *et al.* 2001). Data are insufficient to determine population trends (NMFS 2002c). The total level of human-induced mortality and serious injury is unknown, but believed to be insignificant and approaching zero.
3.2.14.1.2 Fin Whale (*Balaenoptera physalus*)

Fin whales are common in the US EEZ, principally north of Cape Hatteras (Waring *et al.* 2001; NMFS 2002c). Preliminary results from the US Navy SOSUS program suggest a substantial migration to deep-water areas (Clark 1995). The whales likely make migrations to subtropical and tropical waters (Waring *et al.* 2001). However, there is no evidence to support the idea of a distinct large-scale annual migration, such as that undertaken by some other mysticetes (NMFS 2002c). Mignucci-Giannoni (1998) reported limited sightings of fin whales from Puerto Rico and the Virgin Islands. These whales are usually seen over the shelf in small groups of up to 5 individuals, with single whales or pairs being most common. Large rorquals in Puerto Rico have only been reported north of Mona Island and south of Cayo Ratones in Salinas, but most sightings occur around the Virgin Islands. US and British Virgin Island sightings usually occur north of Whale Banks, off Anegada, Virgin Gorda, Tortola, south of St. John and St. Thomas, and west and east of St. Croix (Mignucci-Giannoni 1998). However, most sightings have not distinguished between fin whales and the very similar sei whales (*B. borealis*). The majority of Caribbean sightings occur in the winter, which coincides with the fin whale breeding season (December-January). In the spring the whales move north to feeding grounds north of Long Island (Mignucci-Giannoni 1998).

The status of fin whales relative to optimum sustainable population (OSP) in the US Atlantic EEZ is unknown, but the species is listed as endangered under the ESA (Waring *et al.* 2001). Data are insufficient to determine population trends (NMFS 2002c). The total level of human-induced mortality and serious injury is unknown, but ship strike and fishing related injuries or death are reported as far south as Georgia (Waring *et al.* 2001; NMFS 2002c).

3.2.14.1.3 Humpback Whale (*Megaptera novaeangliae*)

The Gulf of Maine humpback whale stock is indigenous to the Northeast United States, and is apparently genetically separate from other north Atlantic stocks (Waring *et al.* 2001). In winter, whales from the Gulf of Maine and other stocks mate and calve primarily in the West Indies, especially in waters of the Dominican Republic (e.g. Blanco de la Plata, Silver Bank, Navidad Bank, Samana Bay). Humpback whales have been reported to occur in lower densities in other waters of the Caribbean, including those of Puerto Rico (Mignucci-Giannoni 1998; NMFS 1999b; Waring *et al.* 2001; NMFS 2002c). However, a recent visual and passive acoustic survey of the area found winter aggregations of humpbacks around Cabo Rojo and the northern shore of Mona Island that appear to be as dense as those of the Dominican Republic waters (Swartz *et al.* 2001a). Swartz *et al.* (2001a) also reported that humpback whales were the most commonly encountered cetacean in both visual surveys and passive acoustic transects around the Puerto Rico/Virgin island area in the winter. A population estimate of 532 whales (95% CI from 260-1,088) was made for the Puerto Rico/Virgin Island insular shelf based on the visual survey data, although this is likely a substantial underestimate (Swartz *et al.* 2001 a, b). It is probable that not all whales migrate from the north to the West Indies every winter.

Studies of cetaceans off Puerto Rico and the US and British Virgin Islands found that the highest concentrations of humpbacks in the US Caribbean occurred along the northwestern coast of
Puerto Rico (especially Punta Higuero and Punta Agujereada), around Cabo Rojo and Mona Channel, near Saba Bank, the northern Virgin Islands (especially off northeastern St. John), and off the east end of St. Croix in waters less than 200 m deep (Mignucci-Giannoni 1998; Swartz et al. 2001a). Humpback whales in the US Caribbean congregate in small groups of 1-4 individuals, but usually singly or in pairs. Mother and calf groups occurred closer inshore, and humpbacks were generally found to be more common in areas with low sea floor relief, which may have to do with reproductive requirements (Mignucci-Giannoni 1998). Humpbacks occur seasonally in tropical waters between November and May with a peak during February/March (Debrot 1998; Debrot et al. 1998; Mignucci-Giannoni 1998).

Recent estimates indicate population growth for the North Atlantic and Gulf of Maine humpback whale stocks (Waring et al. 2001), although the stocks may be below the OSP, and are listed as endangered under the ESA. Substantial injuries and death result from ship strikes and fishing-related activities. One serious fishery-related injury was observed near the Florida Keys, but the origin of the actual injury is unknown.

3.2.14.1.4 Sei Whale (Balaenoptera borealis)

The sei whale occurs primarily in waters off the northeast US and eastern Canada (Waring et al. 2001). Reports occur north from Cape Hatteras and as far south as the northeastern coast of Venezuela (Mignucci-Giannoni 1998). Limited sightings of sei whales have been reported from the US Caribbean. Groups of up to 5 whales have been seen, but single individuals or pairs are most common. Sei whales are seen both inshore, and offshore near the shelf edge. However, most sightings of Balaenoptera spp. from the US Caribbean do not differentiate between sei whales and fin whales, which are difficult to separate visually in the field. Such large rorquals are seen in Puerto Rico north of Mona Island and south of Cayo Ratones. In the US and British Virgin Islands they have been sighted north of Whale Banks, off Anegada, Virgin Gorda, Tortola, south of St. John and St.Thomas, and west and east of St. Croix (Mignucci-Giannoni 1998). Sei whales movement patterns are believed to be linked to the movements of their prey, with a bimodal occurrence pattern reported for the southern portion of the western North Atlantic (February-March and July-October; Mitchell and Kozicky 1974).

The status of this stock relative to OSP is unknown in the Atlantic EEZ, but the whale is listed as endangered under the ESA. Data are insufficient to determine population trends (NMFS 2002c). The total level of human-induced mortality and serious injury are unknown, but rarity of reports indicates rates are near zero (Waring et al. 2001; NMFS 2002c).

3.2.14.1.5 Sperm Whale (Physeter macrocephalus)

The distribution of sperm whale in the US EEZ extends over the continental shelf edge, over the continental slope, along ocean trenches, and into mid-ocean regions (Mignucci-Giannoni 1998; Waring 2001; NMFS 2002c), possibly associated with the Gulf Stream edge. Historical whaling records suggested an offshore distribution, off the southeastern US coast. The whales that occur in the US EEZ likely represent a fraction of the total stock (Waring 2001).
Both large and small adults and calves and juveniles occur in the southeastern Caribbean, where they have been observed in groups of up to 30 individuals, although the majority of groups have been 10 or less animals (Mignucci-Giannoni 1998; NMFS 2002c). Sperm whales observed in the southeastern Caribbean appear drawn to areas where sound scattering organisms are concentrated directly above the 80-90 m thermocline (Mignucci-Giannoni 1998). They are sometimes reported occurring close to land near upwelling areas, and also in deeper waters where they hunt larger cephalopods. Most Caribbean sightings are from the leeward sides of islands. Sightings in Puerto Rico and the US and British Virgin Islands have been recorded from Mona Island, Mona Passage, off Rincon, off San Juan and Lo za, south of Ponce, south of Isla de Vieques, north of St. Croix, along the southern shelf edge of the northern Virgin Islands, between St. Thomas and St. Croix, and off Anegada (Mignucci-Giannoni 1998). Swatz et al. (2001a) detected sperm whales acoustically in deep waters southwest of Puerto Rico and in Mona Channel southwest of Mona Island. Sperm whales were found to have higher than expected occurrences near areas of high bottom relief.

Sperm whales are reported in the northeastern Caribbean, beginning in the late fall and remaining through the early spring, with a peak occurrence in February. They are rarely seen in the US Caribbean from April through September (Mignucci-Giannoni 1998). Their seasonal distribution is believed to be related to migratory movements, which differ between bachelor and breeding groups. In addition, while females and juveniles are usually located in tropical and subtropical waters, males are more wide-ranging and occur at higher latitudes (NMFS 2002c).

The status of this stock relative to OSP is unknown in the Atlantic EEZ, but the whale is listed as endangered under the ESA (NMFS 2002c). Data are insufficient to determine population trends. The total level of human-induced mortality and serious injury are unknown, but are considered insignificant and approaching zero (Waring et al. 2001; NMFS 2002c).
3.2.14.1.6 Caribbean Monk Seal (*Monachus tropicalis*)

The Caribbean monk seal was listed as endangered by the USFWS throughout its range on March 11, 1967 (USFWS 2000), before the passage of the ESA. NOAA Fisheries listed the monk seal under the ESA as endangered throughout its range on April 10, 1979 (NMFS 2001). The last reliable sighting of a Caribbean monk seal occurred in 1952. None were seen in aerial surveys in 1973, and no confirmed sightings have been reported since then. Many scientists believe that the species has been extinct since the early 1950s. The Caribbean Monk Seal was formally declared extinct in the 1996 IUCN red list of threatened animals. No recovery effort is currently being made for this species.

3.2.14.1.7 West Indian manatee (*Trichechus manatus*)

The West Indian manatee occurs in the Atlantic Ocean (UNEP-WCMC 2003). In the western Atlantic, this species ranges as far north as Georgia (USA), southward to coastal areas of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, this species is known to occur around the southern and eastern end of Puerto Rico and around nearby Vieques Island. In Puerto Rico, where the manatee population numbers about 60-100, the primary cause of mortality seems to be entanglement in gill nets (FWS 2003a). According to 68 FR 41725, the incidental take of at least one manatee in Caribbean gillnet fisheries has been documented. The incidental take of this marine mammal by Caribbean haul/beach seines has been documented as well (68 FR 41727). Collisions with boats and illegal killing of manatees for food may also be affecting the Puerto Rican population to some extent, but supporting data are limited (FWS 2003a). Except for rare sightings, manatees seem to be absent from the Virgin Islands at present, but fossils have been found in middens on St. Croix (USFWS 2003a).

3.2.14.2 Sea Turtles

The U.S. Caribbean provides nesting, foraging, and developmental habitat for three species of sea turtles listed as endangered or threatened under the ESA: the leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and green (*Chelonia mydas*) Loggerhead sea turtles (*Caretta caretta*) are only occasionally seen, but are transitory (Hillis-Star et al., 1998). Rare olive ridleys (*Lepidochelys olivacea*) have been reported in the area only twice (Caldwell and Erdman 1969, Diez pers. comm. In Flemming 2001). The Kemp’s ridley never has been reported in the Caribbean region.

Interactions of sea turtles with fishing gear are poorly documented. Hook and line gear, including longlines and vertical lines, and gill and trammel nets are the gears most likely to catch sea turtles (NMFS 2001j). Sea turtle interactions have been reported in the US Caribbean from incidental hook and line capture, boat strikes (unknown if the strikes came from fishing or non-fishing vessels), entanglement in fishing gear, incidental net capture, and incidental fish trap capture (NMFS 2001j). SCUBA divers setting and retrieving gill/trammel nets in the USVI have reportedly released turtles from the nets (R. McAullife Fishermen’s United Services Cooperative...
of St. Croix, personal communication), but dead turtles consistent with mortality in gill/trammel nets have been reported (W. Tobias, USVI DPNR, personal communication).

3.2.14.2.1 Green Sea Turtle

Green sea turtles are distributed circumglobally mainly in the waters between the 20 °C isotherms (Hirth 1971). Green turtles were traditionally highly prized for their flesh, fat, eggs, and shell. Fisheries in the United States and the Caribbean are largely to blame for the decline of the species. In the southeastern United States, green turtles are found around the USVI, Puerto Rico, and the continental US from Texas to Massachusetts (NMFS 2001b). The primary nesting sites in US Atlantic waters are along the east coast of Florida, with additional sites in the USVI and Puerto Rico. In the US Caribbean, green sea turtle nesting occurs on Vieques, Mona, and Culebra, and on the main island of Puerto Rico; and also on St. Croix. Mating occurs in the waters off nesting beaches. Important foraging areas include the Culebra archipelago and other Puerto Rican coastal waters.

Total population estimates for the green turtle are unavailable, and trends are particularly difficult to assess because of wide year-to-year fluctuations in numbers of nesting females, difficulties of conducting research on early life stages, and long generation time (NMFS 2001b). The population is listed as threatened, except endangered in Florida. Populations in Surinam, and Tortuguero, Costa Rica, may be stable, but there is insufficient data for other areas to confirm a trend. The recovery team for the green turtle concluded that the species status has not improved appreciably since listing.

The known sources of impacts to green turtles include both domestic and international trawl, gillnet, hook and line, pelagic longline, pound net, long-haul seine, and channel net fisheries; as well as non-fishery impacts from power plants, marine pollution (ingestion of tar balls and plastic, entanglement, degradation of foraging grounds), oil and gas exploration, development, transportation, underwater explosions, dredging, offshore artificial lighting, marina and dock construction and operation, boat collisions, and poaching. On their nesting beaches in the U.S., green turtles are threatened with beach erosion, armoring, and renourishment; artificial lighting; beach cleaning; increased human presence; recreational beach equipment; exotic dune and beach vegetation; poaching; and predation by species such as fire ants, raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus*), and opossums (*Didelphus virginianus*). A more thorough description of anthropogenic mortality sources is provided in the Turtle Expert Working Group (TEWG) reports (1998, 2000). In the Caribbean, gill nets and longlines may cause sea turtle injuries and mortalities (Dayton et al. 2002).

Critical habitat for the green sea turtle is designated as the waters extending seaward three nautical miles (5.6 km) from the mean high water line of Culebra Island, Puerto Rico and its associated keys.
3.2.14.2.2 Hawksbill Sea Turtle

The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. The species is widely distributed in the Caribbean Sea. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the USVI (NMFS 2001c). Nesting within the southeastern United States occurs principally in Puerto Rico and the USVI, the most important sites being Mona Island and Buck Island. Nesting also occurs on other beaches of St. Croix, and on Culebra Island, Vieques Island, mainland Puerto Rico, St. John and St. Thomas. The coral reef habitat and cliffs around Mona Island and nearby Monito Island are important feeding grounds for all sizes of post-pelagic hawksbills.

The hawksbill turtle's status has not changed since it was listed as endangered in 1970. It is a solitary nester, and thus, population trends or estimates are difficult to determine (NMFS 2001c). Most researchers accepted a decline of nesting populations.

Hawksbills are threatened by all the factors that threaten other sea turtles, including exploitation for meat, eggs, and the curio trade, loss or degradation of nesting and foraging habitats, increased human presence, nest predation, oil pollution, incidental capture in fishing gears, ingestion of or entanglement in marine debris, and boat collisions (Lutcavage et al. 1997; Meylan and Ehrenfeld 2000). On Buck Island, nest predation by mongoose is a serious problem. Historically, the decline of the species has been attributed to exploitation for its beautifully patterned tortoiseshell scales (Parsons 1972). International trade in tortoiseshell is now prohibited among all signatories of the Convention on International Trade in Endangered Species, but some illegal trade in both signatory and non-signatory countries still continues.

The critical habitat for the hawksbill sea turtle is designated as the waters extending seaward three nautical miles (6.5 km) from the mean high water line of Mona and Monito Islands, Puerto Rico. Mona Island receives protection as a Natural Reserve under the administration of the Puerto Rico Department of Natural Resources and Environment.

3.2.14.2.3 Leatherback Sea Turtle

The leatherback turtle's range extends from Cape Sable, Nova Scotia, south to Puerto Rico and the USVI (NMFS 2001d). Critical habitat for the leatherback includes the waters adjacent to Sandy Point, St. Croix, USVI, up to and inclusive of the waters from the hundred fathom curve shoreward to the level of mean high tide with boundaries at 17°42'12" N and 64°50'00" W. Nesting occurs from February - July with sites located from Georgia to the USVI. During the summer, leatherbacks tend to be found along the east coast of the US from the Gulf of Maine south to the middle of Florida.

In the Atlantic and Caribbean, the largest nesting assemblages are found in the USVI, Puerto Rico, and Florida (NMFS 2001d). Nesting data for these locations have been collected since the early 1980's and indicate that the annual number of nests is likely stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking. The population
is listed as endangered. Nesting populations of leatherback sea turtles are especially difficult to discern because the females frequently change beaches.

Threats to leatherbacks include domestic and international trawl, gillnet, hook and line, pelagic longline, fish trap, lobster pot, whelk pot, long-haul seine, and channel net fisheries; as well as non-fishery impacts like marine pollution, marine debris (e.g. ingestion of plastic; entanglement), harvest of eggs and adults in foreign countries, oil and gas exploration, development, transportation, underwater explosions, dredging, offshore artificial lighting, marina and dock construction and operation, boat collisions, and poaching. On their nesting beaches in the U.S., leatherbacks turtles are threatened with beach erosion, armoring, and renourishment; artificial lighting; beach cleaning; increased human presence; recreational beach equipment; exotic dune and beach vegetation; poaching; and predation by species such as fire ants, raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus*), and opossums (*Didelphus virginianus*). A more thorough description of anthropogenic mortality sources is provided in the TEWG reports (1998, 2000).

Of the Atlantic sea turtles species, leatherbacks seem to be more susceptible to entanglement in fishing gears such as lobster gear lines and and longline gear, as opposed to swallowing hooks. This susceptibility may be the result of attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, and perhaps to light sticks used to attract target species in the longline fishery. Leatherbacks are exposed to a series of longline fisheries while circumnavigating the ocean basin. According to observer records, an estimated 6,363 leatherbacks were caught by just the U.S. tuna and swordfish longline fisheries between 1992-1999, of which 88 were released dead (NMFS 2001h).

Leatherbacks may be more susceptible to marine debris ingestion than other species due to their pelagic existence and the tendency of floating debris to concentrate in convergence zones which adults and juveniles use for feeding areas and migratory routes (Lutcavage et al. 1997; Shoop and Kenney 1992). Investigations of stomach contents of leatherbacks revealed that a substantial percentage (44%) contained plastic (Mrosovsky 1981). The presence of plastic debris in the digestive tract suggests that leatherbacks may not be able to distinguish between prey items and plastic debris (Mrosovsky 1981). Balazs (1985) speculated that the object may resemble a food item by its shape, size, color, or even movement as it drifts about, and induces a feeding response.

Critical habitat for the leatherback sea turtle is designated as the waters adjacent to Sandy Point, USVI, up to and inclusive of the waters from the hundred fathom curve shoreward to the level of mean high tide with boundaries at 17°42’12”N and 64°50’00”W

3.2.14.2.4 Loggerhead Sea Turtle

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters (NMFS 2001e). In the Atlantic, the loggerhead turtle's range extends from Newfoundland to as far south as Argentina.
Nesting is not reported for the US Caribbean. The recovery team has concluded that nesting trends in the eastern US are generally declining, although increases in some areas have occurred (NMFS 2001e). Western Atlantic loggerhead populations in Honduras, Mexico, Colombia, Bahamas, Cuba, and Panama have been declining. Loggerheads are listed as threatened. Human impacts include disturbing nesting activities, direct mortality for food or shells, bycatch in fishing activities, and development and pollution.

3.2.14.3 Fish

3.2.14.3.1 Goliath Grouper

The goliath grouper was added to the candidate species list in 1991 (NMFS 2001f). In 2001, the American Fisheries Society changed the official common name from jewfish to goliath grouper. Historically, goliath grouper were found in tropical and subtropical waters of the Atlantic Ocean, both coasts of Florida, and from the Gulf of Mexico down to the coasts of Brazil and the Caribbean. Most adults are found in shallow waters, the deepest being about 150 feet. Spawning occurs at aggregation sites in July through September over full moon phases. Fish may move up to 100 km from inshore reefs to the offshore spawning aggregations in numbers of up to 100 or more on ship wrecks, rock ledges, and isolated patch reefs along the southwest coast of Florida. Aggregations declined in the 1980's from 50-100 fish to less than 10 per site. Since the harvest prohibition, aggregations have rebounded somewhat to 20-40 fish per site. When goliath grouper are not on their spawning aggregations, they are dispersed along shallow reefs. Historically, they were abundant in very shallow water, often associated with piers and jetties along the Florida Keys and southwest coast of Florida. They are no longer abundant in these shallow areas.

Juvenile goliath grouper have been found along shallow mangrove shorelines, underneath mangrove prop roots (NMFS, 2001f). Their historical center of abundance is in the Ten Thousand Islands area of southwest Florida. Although goliath grouper are very vulnerable to cold waters and red tide, they are one of the only groupers that can live in brackish waters. Fish taken from an exploited population were aged from 0-37 years, but it is likely that goliath grouper live much longer than 40 years, if left unexploited.

The most likely cause of drastic declines was the heavy fishing pressure on aggregations (NMFS, 2001f). When large numbers of normally dispersed fish are concentrated at predictable areas and times, they are highly vulnerable to overexploitation. Fishing on spawning aggregations also removes many reproductive individuals before they have had the opportunity to spawn. Many goliath grouper were caught between the ages of 9-15 years, meaning that individuals only lived through only a few reproductive years before being captured. Their slow growth rate, long lives, and large size at sexual maturation has made them especially susceptible to overfishing. Finally, their genetic diversity could be impacted when the fishing mortality rate is greater than the natural mortality rate.

Quantitative data on fishing mortality rates and biomass levels are lacking. Goliath grouper are especially vulnerable to fishing due to their availability in aggregations and due to their low
productivity. The fishery has been closed in the US Caribbean since 1993; consequently, fishing mortality rates are currently near zero.

3.2.14.3.2 Nassau Grouper

The Nassau grouper was an addition to the 1991 candidate species list. It is a tropical western Atlantic serranid that is an extremely popular food fish, resulting in its declining status (NMFS 2001g). The Nassau grouper grows to about 100 cm (3 ft) and 25 kg (55 lbs.). They are top-level predators found from inshore to about 100 m. Adults are generally found near shallow high-relief coral reefs and rocky bottoms to a depth of at least 90m.

Quantitative data on fishing mortality rates and biomass levels are lacking. Nassau grouper are especially vulnerable to fishing due to their availability in aggregations and due to their low productivity. The fishery has been closed in the US Caribbean since 1990; consequently, fishing mortality rates are currently near zero. Caribbean Nassau Grouper are considered severely depleted due to lack of occurrence in sampling and catches prior to the moratorium.

3.3 Human Environment

The Council and NOAA Fisheries have jurisdiction over the federal waters off the Virgin Islands and Puerto Rico. The following section covers a description of the social and economic features of the fisheries, including commercial and recreational fishing activities, and a description of Caribbean fishing communities. This discussion is followed by a description of each fishery with references to specific FMPs including the number of vessels involved, the type and quantity of fishing gear used, the species of fish involved and their location, analyses of the cost incurred in management, and actual and potential revenues from the fishery.

A lack of social and economic data in the US Caribbean severely limits the inferences and conclusions that may be made for assessing impacts of the alternatives for EFH, HAPC, and addressing adverse fishing impacts. However, some general socio-economic features that likely apply to the US Caribbean region may help to strengthen the inferences and conclusions drawn for the alternatives. Combining economic models with stock assessment models helps determine the optimum levels of harvest and stock size (Freeman, 1993). Because current harvests and costs depend on past harvest practices and resulting resource abundance, managing a fishery for economic objectives a dynamic process. Freeman (1993) presents methods to address an economic objective to maximize the present value of the net economic return from a fishery over time, within biological constraints. Maximizing economic returns usually requires private ownership or public management with measures to achieve economic optima. Under such conditions, a higher harvest and lower price would result. The fisheries of the US Caribbean are open access with little economic-based regulation. Management measures that increase stock productivity in an open access, whether from improved habitat (Freeman 1993) or increased growth through restrictions (CFMC 1990), tend not to provide long-term increased benefits to fishers. As with optimum management, quantities initially increase and prices initially decrease, leading to increased profits for fishers. However, increased benefits attract more fishers or more
effort. Over a longer term, benefits disappear as fishers’ costs increase and net revenues decline to original or lower levels (CFMC 1990).

Standard economic considerations do not take into account the value that ecosystem services contribute directly to local, regional, and international economies (Costanza et al. 1997). Of the diverse list of ecosystem services, several have direct implications for EFH in the US Caribbean:

- Biological control – Trophic-dynamic regulations of populations, keystone predator control of prey species, reduction of herbivory by top predators
- Refugia – Habitat for resident and transient populations, nurseries, habitat for migratory species, regional habitats for locally harvested species
- Food production – The portion of gross primary production extractable as food, production of fish, subsistence fishing
- Recreation – Providing opportunities for recreational activities, sport fishing

Costanza et al. (1997) address the marginal changes (the estimated rate of change of value compared with changes in ecosystem services from their current levels) in the quantity or quality of various types of ecosystem services may impact human welfare. On a global basis, Costanza et al. (1997) estimate that the average annual value of ecosystem services is US$33 trillion, or 1.8 times the global gross national product. They acknowledge the difficulty and uncertainly of calculating ecosystem value, but contend that choices about ecosystem use (or change) occur through the process of valuation, even if not made explicitly. Use of the preliminary valuation provides an opportunity to give explicit weight to the ecosystems that produce the services against the benefits of proposed projects that cause ecosystem damage, such that ecosystem services lost are not ignored or undervalued.

3.3.1 Description of the fisheries

The fisheries in the US Caribbean are multi-species, multi-gear, artisanal in nature, and principally coral reef-based. Division of fishing activity into specific fisheries by species or gear is artificial, but general characterizations are presented in this section. The US Caribbean fisheries cannot be set apart from the fisheries in the wider Caribbean region. The species targeted in the US waters are also available in other countries and regions, and recruitment of these species may derive from areas distant from the area of the fishery. The Council participates in pan-Caribbean management efforts. Each FMP has an objective of pan-Caribbean management for the species covered by the FMP, including conch, lobsters, and reef fish.
3.3.1.1 Commercial fishing activity

Fleets

Before 1959, the Puerto Rican fleet was composed mainly of open wooden sailboats (average 27 feet in length) and open wooden rowboats. In 1959, the Puerto Rico Department of Agriculture, the Economic Development Bank, and the Agricultural Credit Corporation began extending loans to the commercial fishers to “motorize” the fleet; by 1979, 75% of the commercial fishing fleet had outboard engines. In 1975, there were 865 commercial fishing vessels in Puerto Rico, the size distribution of which is shown in Table 3.7 (Suárez Caabro, 1979).

At present, the artisanal commercial fishing fleets of Puerto Rico and the USVI are fairly uniform, in that, the fleets consist of small-sized, open wood or fiberglass fishing boats, which on average are 20 feet in length. There were 4,112 officially registered commercial fishing vessels in Puerto Rico in 1996 (Table 3.8), but the number of vessels actually fishing commercially in Puerto Rico was probably closer to 1,500 (Table 3.9), and most of these boats (61%) were between 16-21 feet long (Matos-Caraballo 1997). Only 1% of the fleet was greater than 30 feet long. Average horsepower for Puerto Rican commercial vessels was 43 h.p., and 1,218 motors were reported in 1996 (Matos-Caraballo 1997).

There are 342 registered commercial vessels in the USVI (Table 3.10). In St. Thomas, most boats are “small vessels”, 16-19 feet long and of wooden construction, with a much smaller number of “large vessels” (8-9 vessels) greater than 30 feet long. In St. Croix, the larger vessels are used for the trap-based fisheries (as opposed to the gillnet-, vertical gear-, and dive-based fisheries) due to space requirements for traps and machinery (Tobias, 2001). Registration fees increase with vessel size for commercial and recreational vessels (Table 3.11).

Data on the number and size of US Caribbean fishing vessels are summarized in Tables 3.7-3.10. These tables include the size frequency distributions for fishing vessels for 1988 and 1995-1996 for Puerto Rico, and 1991-1992 for the USVI. The tables help describe the capacity and the nature of the fleet. However, the vessel information cannot be distributed to specific fisheries.

Fishers

Commercial fishers are required by local laws to have a fishing license in both the USVI and Puerto Rico. In 1975, there were 1,230 commercial fishers in Puerto Rico, but this had increased to an estimated 1,758 active commercial fishers in 1996 (1,262 full-time and 496 part-time) with ages ranging from 38-63 and an average age of 46 years old (Matos-Caraballo 1997). In 1996, Matos-Caraballo (1997) concluded that while the number of Puerto Rican commercial fishers was relatively stable, the amount of fishing effort was increasing. Matos-Caraballo (2002) predicted that the latest information from the pending Puerto Rico Fishery Census would show a loss of approximately 500 fishers since 1996. However, more recent data showed 1,973 fishers in 2000 and 2,023 in 2001 (NMFS 2002a).

In addition to issues related to overfishing, storms and hurricanes (e.g. Hurricane Georges) have had a negative impact on Puerto Rican fishers in the recent past (Matos-Caraballo 2001). In
1996, the west coast of Puerto Rico supported the highest number of fishers (461), with Cabo Rojo having the largest number of fishers among municipalities (213). In 1996, the percentage of Puerto Rican fishers belonging to fishing associations had increased to 62%, indicating a greater willingness to unify in order to procure more fishing and social benefits (Matos-Caraballo 1997).

Matos-Caraballo (1997) census of Puerto Rican fishers reported 3,613 nets, of which 7% were beach seines, 38% were gillnets, 24% were trammel nets, and 31% were cast nets. In the line category 9,805 units were recorded, of which 9% were longlines, 69% were hand lines, 10% were trolling lines, and 12% were rod and reel. The census recorded 15,481 traps, of which 72% were fish traps and 28% were lobster traps, while 396 winches were used to haul traps. SCUBA divers (n=598) and skin divers (n=281) used 2,170 units of various fishing gear, of which 23% were spears, 61% were gaffs, 11% were snares, and 5% were conch-lifting baskets.

Puerto Rican commercial fishers typically exploit more than one fishing zone and fishery (Matos-Caraballo 1997), with effort occurring on the shoreline (31%), on the shelf (70%), on the shelf edge (43%), and in oceanic waters beyond the shelf edge (46%). These fishers pursue multiple species including reef fish, lobster, and conch (74%); pelagic species (68%); deep-water snappers (53%); and baitfish (23%). Fishing trips are generally a half-day long (Matos-Caraballo 2002).

In Puerto Rico, traps are still one of the primary fishing methods, although the most recent data shows traps landings now place second behind line-based fisheries (Matos-Caraballo 2002). Puerto Rico’s trap fishers have recently shown a trap reduction trend, altering the previous historical increase in numbers of traps per fisher (Scharer et al., in press). The proportion of Puerto Rico’s catch derived from fish traps decreased from 72% in 1974, to 67% in the early 1980s, to 34% by 1988 (Rolon 1975; Stevenson 1978; Appeldoorn and Posada (1992). Presently, the number of traps/fisher in Puerto Rico ranges from 10 to 300, with an average of 67 traps/fisher. Decreases in trap effort may be due to competition with other gears such as lines, trammel nets, gillnets, and diver-based fishing (Griffith and Valdés-Pizzini 2002).

Sheridan et al. (2003) reported that fish traps are utilized throughout Puerto Rican waters, but are most frequently deployed in the southwest (Cabo Rojo, Lajas), south-central (Guayama), and east coasts (Culebra and Naguabo). Spiny lobster traps are deployed principally off the east (Vieques and Culebra) and south (Juana Diaz) coasts. In Puerto Rico, 77% of trap fishers target reef fish and spiny lobster, 13% of trap fishers target only reef fish, and 10% target only lobster (Scharer et al., in press). According to Puerto Rican trap fishers, habitats targeted for setting traps include areas surrounding coral reefs such as sand, algal plains, seagrasses, and especially low- to medium-relief hard bottom (known as “rastreal” and preferred by 38% of fishers); but the coral reefs themselves are not targeted (Scharer et al., in press). Most trap hauling is done via winches or other mechanical means (68%), with the remainder being done by hand. Puerto Rican fishers stated that they pull traps straight up off the bottom to avoid dragging traps on the bottom and losing or damaging them (Scharer et al., in press). Traps are set on the insular shelf in depths ranging from 9-181 m, with a mean depth of 40-62 m, but varying from one region of the island to another. The distribution of traps in a particular area also varies seasonally, based primarily on changing sea conditions and associated safety considerations (Valdés-Pizzini et al. 1997; Jean-Baptiste 1999). Although trap fishery areas in Puerto Rico have typically been concentrated in
the shallow nearshore zone, some fishers are now exploiting offshore areas because of depleted resources and habitat degradation (caused by habitat destruction, water pollution, sedimentation, and eutrophication) in the nearshore (Scharer et al., in press). Among trap types, wooden pots (i.e. cajones) are used for spiny lobster, while wire-mesh traps (i.e. nasas) are used for fish and lobsters (Scharer et al., in press). Only 1 of 47 Puerto Rican trap fishers interviewed used GPS technology to navigate and locate traps; while local knowledge and landmarks were the principal techniques used by all other fishers.

Among Puerto Rican trap fishers, 53% set traps singly and 47% set a series of 2-6 traps connected by a trap line. Among trap line trap fishers, 68% used buoys to mark the trap string and 32% did not use buoys at all, a technique known as “ahogado” or drowned traps (Scharer et al., in press). Predominant methods of trap recovery include grappling (34%) or diving (32%). Thus, about 5% of the fishers grapple for trap lines. The drowned trap technique is used to deter theft, but makes traps harder to recover, especially in areas where human activities have reduced water clarity.

In the USVI, there is presently a moratorium on issuing new commercial fishing licenses. In the USVI during 1991-1992 there were approximately 427 commercial fishers. St. Thomas has both full- and part-time fishers who use traps, handlines, and float fishing methods (Downs et al. 1997). In St. John, there are very few full-time fishers (approximately 2-10), with most fishers being of the part-time variety, who work other jobs and fish to supplement their income (Downs et al. 1997). St. John fishers are concentrated in the Cruz Bay and Coral Bay areas of the island and are primarily West Indian, with some “continental” fishers from the mainland US participating in the fishery as well (Downs et al. 1997). Each of these ethnic groups tends to target different fish species and use different techniques, with West Indians using traps and handlines/floatlines to capture reef species, while “continentals” tend to troll for pelagic species. USVI trap fishers most frequently deploy traps off southwestern St. Croix and southern and western St. Thomas and St. John (Sheridan et al. 2003).

Based on St. Croix data (Tobias 2001), both reef fish and lobster fishers fish approximately 5 hours per day and market their catch the same day. Fishing with traps, gill nets, diving, and the majority of vertical gear occurred over the insular shelf (< 72 m deep), while additional vertical gear fishing for deepwater snapper occurs seaward of the shelf edge.

An estimated 30-40 full-time trap fishers operate out of St. Thomas/St. John, and another 30-40 out of St. Croix (Sheridan et al., in review). Recent estimates by Sheridan et al. (in review) put the overall number of traps fished in the USVI at around 8,500, with about 1,500 fished off St. Croix and 7,000 fished off St. Thomas/St. John. Traps are fished most frequently off southwestern and northeastern St. Croix, and southwestern and southeastern St. Thomas. Sheridan et al. (in review) reported that while fishing multiple traps connected by trotlines (buoys on each end) is common among St. Thomas fishers, it is rare among St. Croix fishers who typically fish single traps with a single buoy attached. Additionally, St. Thomas trap fishers use mechanical pot haulers, fish their traps in deeper water (< 183m with a mean of 48m), and grapple off the bottom to snag buoyant trap lines and recover lost traps. St. Croix fishers generally pull traps by hand, fish in relatively shallow water (< 30m with a mean depth of 18m), and dive to locate missing traps (Sheridan et al., in review). However, the habitat makeup of
waters deeper than 30 m is largely unknown (Sheridan et al., in review). These authors also stated that coral damage from traps may be more prevalent in St. Croix where reef habitat dominates, than in St. Thomas/St. John where macroagal plains are more common. Recent dive surveys observed that pots on coral habitat in the USVI typically had no markings required of legal pots, indicating that pot damage may occur primarily from illegal fishers (Roger Uwate, William Tobias, DFW, USVI, pers. comm.).

Markets

In Puerto Rico, fishers may market their catch using two or more strategies including selling their catch to a fish buyer (33%), to an association (40%), to a restaurant (10%), selling it themselves on the street (41%), or selling the catch through their own business (13%), which is usually a fish store or eatery (Matos-Caraballo 1997). As of 1996, Puerto Rican fishers were still using poor catch management strategies, with 51% gutting their catch at sea but only 1% utilizing ice.

St. Thomas fishers sell their fish at markets, to restaurants and hotels, and to residential customers. Local demand exceeds local supply, so there is no exporting of fish from St. Thomas. St. John fishers also sell their fish at informal markets, to restaurants and hotels, and to residential customers (Downs et al. 1997). In St. Croix, fishers sell their catch at landing sites, along road sides, or to hotels and restaurants (Tobias 2001).

Catch data

Commercial fishers report their catches voluntarily in Puerto Rico, although the government does provide economic incentives to encourage reporting. Puerto Rican landings are reported by species or species groups such as red hind, mutton snapper or groupers, snappers, etc. Between 1/1998 and 12/2001, port samplers collected data from 42 coastal municipalities and 88 identified fishing centers in Puerto Rico (Matos-Caraballo 2002). During this 4-year period a total of 13,620,481 pounds of fish and shellfish with a market value of about $27,407,302 were reported landed in Puerto Rico (no correction factor applied). The west coast of Puerto Rico produced the greatest catch (with 34% of the total landings) and Cabo Rojo was the most productive municipality (with 18% of the total landings). The major fish and shellfish species in Puerto Rico as far as percentage of total commercial landings were: spiny lobster (9%), deepwater snappers (principally Lutjanus vivanus and Etelis oculatus, 9%), queen conch (8%), yellowtail snapper (7%), lane snapper (7%), mackerels (Scomberomorus cavalla and Scomberomorus regalis, 5%), various tunas (5%), various grunts (principally Haemulon plumieri, 4%), dolphin (4%), groupers (mostly Epinephelus guttatus, 4%), parrotfishes (3%), and trunkfishes (3%). A trend noticed since the early 1990s has been the retention and marketing of fish and shellfish species that in the past were usually discarded, such as squirrelfishes (holocentrids), surgeonfishes (acanthurids), angelfishes (pomacanthids), and crabs (Carpilius corallinus and Myitrax spp.). These species formerly had little to no market value, but now fetch a reasonable market price (Matos-Caraballo 2001, 2002) due to depletion of preferred species.

From 1998-2001, Puerto Rican total commercial landings, including non-FMU species such as shark and tuna, broke down as follows (after correction factors were applied): 1998 landings
were estimated at 4,427,467 pounds and valued at $8,946,870; 1999 landings were estimated at 4,265,435 pounds and valued at $8,795,880; 2000 landings were estimated at 5,756,130 pounds and valued at $11,793,159; and 2001 landings were estimated at 5,233,859 pounds and valued at $10,800,657 (Matos-Caraballo 2002). During 1998-2001, line-based fisheries (handlines, rods and reels, trolled lines, and longlines) accounted for the highest percentage (40%) of the total commercial catch in Puerto Rico, followed by traps (fish and lobster traps) at 21%, nets (trammel nets, beach seines, gill nets, and cast nets) at 20%, and diver-based fisheries (SCUBA and skin-diving) at 19%. Commercial CPUE for Puerto Rico during 1998-2001 (pounds caught per individual fishing trip) ranged from 53-71 pounds per trip. This compares with estimates of 63-80 pounds per trip for 1994-1997, and contrasts with the 123 pounds per trip estimate for 1979-1982 (Collazo and Calderon 1988; Matos-Caraballo 2002). Prices paid per pound for fish and shellfish during 1998-2001 varied among municipalities in Puerto Rico (Matos-Caraballo 2002).

Catch data for species in the FMUs of the FMPs were updated in a draft amendment, known as the SFA Amendment, to address required provisions of the M-S Act (CFMC in prep.). Landings of the FMU species average about 2.2 million pounds annually (Table 3.12).

Trap-based fisheries in Puerto Rico accounted for 22% of the overall catch in 2001 (Scharer et al., in press). As is the case for US Caribbean fisheries in general, because of lower trap-based catch of preferred species like groupers and snappers (“primera”), trap fishers in Puerto Rico (and the USVI as well) are catching and marketing less desirable species (“segunda”) like parrotfishes, goatfishes, triggerfishes, and grunts (Scharer et al., in press; Garrison et al. 1998). Studies in the La Parguera area (SW Puerto Rico) found that spiny lobster was most abundant species in the trap catch (Jean-Baptiste 1999; Appeldoorn et al. 2000). Soak times in Puerto Rico are longer (about 5-7 days) than they were historically (about 1-3 days), most likely due to the effects of overfishing and low catch rates forcing fishers to extend soak times (Juhl and Suarez-Caabro 1973; Appeldoorn et al. 2000; Scharer et al., in press).

In the USVI, reporting is required by law to obtain or renew commercial fishing licenses. In the USVI, landings are reported by categories - for example pot fish or net fish. With the exception of queen conch and spiny lobster, which are reported separately, it is difficult to describe specific fisheries in the USVI, and to determine how many fishers are involved. Most commercial fishers use a multiple number and type of gears - fish traps, hook and line, nets, and SCUBA, among others, which makes them non-specialized harvesters. An exception might be participants in the queen conch fishery. Conch are hand-harvested by a relatively small number of fishers using SCUBA primarily. Conch fishers harvest not only conch, but also lobster and fish while diving. Catch statistics are not available for the USVI, but the CFMC Draft SFA Amendment estimated the landings as 1.4 million pounds (Table 3.12), based on a percentage of the Puerto Rico landings.

St. Croix biostatistical data on the commercial reef fish and spiny lobster fisheries collected during 1997-2000 indicated a 10% decrease in average weight of reef fish and a 12% decrease in the average weight of lobster specimens measured during the study period (Tobias, 2001). Also, the mean number of fish/ trap haul and weight of fish/trap haul decreased (drops of 19% and 13% respectively from 1997/98 to 1998/99, and of 40% and 47% respectively from 1998/99 to 1999/2000). Hurricanes Georges and Lenny had a deleterious effect on the St. Croix fisheries,
especially trap fisheries, during the study period, because of lost traps and vessel damage. Due to
the reduction of trap effort, almost ten times more spiny lobster were landed by divers than by
traps from 1997-1999 (Tobias et al. 2000). Sheridan et al. (in review) also reported that most St.
Croix trap fishers had reduced the number of traps they fished, with many switching to gill nets.
However, trap fishing effort among St. Thomas fishers was did not show a similar shift and was
relatively stable.

Traps (fish and lobster) are still the most productive gear in St. Croix, with vertical gear taking
second place. While traps represented 71% of the landings in 1985, they represented only 41-
46% of the landings from 1997 through 1999 (Appeldoorn et al. 1992; Tobias et al. 2000). Fish
traps in St. Croix landed mostly parrotfish followed by surgeonfish, snappers, and grunts (Tobias
2001; Sheridan et al., in review). In St. Thomas/ St. John the catch from traps was dominated by
triggerfish then by parrotfish, snappers, and groupers (Sheridan et al., in review). Trap fishers in
St. Croix appear to operate fewer traps (mean = 32) then trap fishers in St. Thomas (mean =
231). Mean soak time for traps and pots appears to be shorter in St. Croix (mean = 3.2 days) than
in St. Thomas (mean = 7.2 days).

The use of gillnets in the USVI has increased over the past 10 years, where they are used in
conjunction with SCUBA divers to catch parrotfish (Tobias et al. 2000). Divers set nets in sandy
offshore areas (between reefs at the shelf edge) where schools of fish congregate just before
dark. The highest catches are made during peak spawning times (Tobias 2001). Between 1997-
1999, parrotfish represented 74-78% of total net landings in St. Croix (Tobias et al. 2000). Gill
nets appear to compete with fish traps for similar reef fish resources.

Commercial catch statistics were recently reviewed by NOAA Fisheries’ Southeast Fishery
Science Center. Based on the review, DFW has begun error checking and corrections of the data
set, and verification of the data against original catch reports. Analysis of a provisional data set is
underway. Catch records through 2001 for categories of major species are presented in Table
3.12, from the Council’s Draft SFA Generic Amendment (in preparation).

3.3.1.2  Recreational Fishing Activity

Boats

All recreational vessels in Puerto Rico must be registered with the DNER. There are a number of
charter boats (trolling and bottom fishing), diving boats, shoreline fishers, and recreational
fishing boats (privately-owned vessels) but information on fishing effort, catch, or other
information is largely not known. Most of the information available from the recreational fishing
sector deals with tournament data on species such as marlin and dolphin fish.

The total number of recreational boats registered in Puerto Rico in 1995 (DNER 1995
unpublished data) was reported as 35,931 registered vessels – including personal watercrafts (jet
skis). The total number of boats registered in Puerto Rico during 1996 was 44,049 (Table 3.8),
indicating an increase of 8,118 boats in one year.
Eastern Caribbean Center (2002) reported 2,462 registered boat owners in the USVI, with 566 of these from St. Croix and 1,896 from St. Thomas/St. John. However, the number of recreational vessels registered in the USVI in 1997 was estimated to be 5,000 (L. Roberts, USVI/DPNR Division of Environmental Enforcement, personal communication). In addition, numerous other recreational vessels are reported in transit through the USVI. Average USVI recreational boat length is 22.8 feet, with most (81.6%) less than 30 feet, while only 5% were 40 feet or greater in length (Eastern Caribbean Center 2002). The boat registration fees are presented in Table 3.11.

Downs et al. (1997) found eight charter fishing businesses operating in St. Thomas and two in St. John run mostly by “continentals” from the mainland US, with vessel sizes ranging from 25-48 feet long. None of these vessels was licensed to carry more than six passengers, and the larger vessels were crewed by a captain and mate. These charter vessels tended to target pelagic fishes and sharks, and the catch not retained by customers was sold to restaurants and hotels.

García-Moliner et al. (2002) found that fishing charter activity has increased in the US Caribbean since the survey by Downs. In 2000, a survey identified 46 year around charter-fishing operations, 27 in the USVI and 19 in Puerto Rico. The operations included 60 vessels. Additional seasonal operations exist during the June-September blue marlin fishery. Most of the charter vessels fish off shore and target pelagic species, but some offer inshore and reef fish trips. The charter industry considered reef fish availability as “fair.” Charter and head boats are not required to maintain records and there is no information available to describe activities of these groups targeted at species under Council authority. Establishment of needed socioeconomic research is necessary to improve data with regard to charter and head boat fisheries.

Of over 100 dive-charter operations in the US Caribbean, 37% of those in Puerto Rico and 21% of those in the USVI allowed fishing (García-Moliner et al. 2000). Fishing during dive trips targeted lobsters (hand harvest) and fish (spear fishing) García-Moliner et al. (2000) found that a likely maximum number of 4,700 (3%) divers in the USVI and 58,800 (30%) divers in Puerto Rico fished while on chartered dive trips.

Fishers

Presently, recreational fishers are not required to have a license or permit. Information on the recreational fleet, charter fleet, and fishing enterprises other than bona-fide commercial fleet is scant. Queries run on the NOAA Fisheries MRFSS dataset indicate that Puerto Rico had 222,128 recreational fishers in 2001, and 28,757 of these were from out-of-state. In contrast, Schmied (1989) reported only 81,000 resident marine recreational fishers (from about 23,000 boats) for Puerto Rico. A creel census of 132 recreational shoreline anglers and 20 boat-based anglers was conducted in the area of Guanica State Forest between 10/1997 and 9/1998 (Silva et al. no date). The age of anglers was not dominated by any one group, but the 41-50 year old group (24.4%) was the most common. Shoreline-based angler effort was highest in August, June, and October; and lowest in January and March. Recreational anglers in Puerto Rico made approximately 1.4 million fishing trips in 2001 (NMFS 2002a), of which 0.9 million were from shore, 0.5 million were from private boat, and 11,000 were from charter boat.
A telephone survey of a subset of USVI registered boat owners (n=120) who used their vessels for recreational fishing was conducted in 2000 (Eastern Caribbean Center 2002). Based on that survey the number of boat-based recreational fishers was estimated at 2,509 for the USVI (712 from St Croix and 1,797 from St. Thomas/St. John). These fishers were predominantly male (96.7%), with a mean age of 47.5 years old, and were of various ethnic heritages, education levels, and income levels. The number of recreational fishers in the USVI (boat-based and shore-based fishers) was estimated to be around 11,000 people in 1999, about 9.2% of the population, which is roughly the same proportion that Jennings (1992) found in 1986 (see Mateo 1999; Eastern Caribbean Center 2002). A survey of 312 boats taken at boat ramps stated that only 41 vessels (13%) reported fishing as one of their activities (Appeldoorn and Valdés-Pizzini 1996). Of these 41 vessels, 80% used hook and line/rod and reel gears.

A total of 814 recreational anglers were counted on St. Croix, of which 404 were interviewed (ECC 2002). The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur. The USVI Division of Fish and Wildlife, Department of Planning and Natural Resources (DPNR) is currently assessing the recreational fishery of the USVI.

The Eastern Caribbean Center survey (2002) found that trolling was reported as the most common boat-based fishing method in the USVI (59.7%), followed by bottom fishing (22.7%). However, Jennings (1992) states that bottom fishing (70%) was more common than trolling (20%) in 1986. Eastern Caribbean Center (2002) found that about half (53.3%) the USVI recreational fishers fished in territorial waters (< 3 miles from shore), while 46.7% fished in Federal waters. The most preferred fish group was snappers, followed by dolphin and tuna, and the majority of the catch (72.9%) was used for personal consumption. On average USVI boat-based fishers make two fishing trips a month and fish about 4 hours per trip (Eastern Caribbean Center 2002). The total USVI boat-based recreational fishing hours in 2000 was estimated to be 320,204 hours.

The average cost of a USVI recreational fishing trip was $125.11 for things such as gear, bait, ice, refreshments, food, fuel, launching fees, lodging, auto transportation, and charter and guide fees, among others (Eastern Caribbean Center 2002). Most gear was purchased in the USVI (77%), but about half of the electronics were bought outside the USVI. Average USVI boat ownership costs were about $2,104.13 annually. Total boat-based recreational fishing expenditures in the USVI in 2000 were approximately $5.9 million, with St. Thomas/St. John contributing about $4.8 million to the total.

Catch

The Marine Recreational Fisheries Statistical Survey (MRFSS) was expanded to Puerto Rico at the end of 1999. The total recreational catch reached 2.8 million fish in 2000, and 1.7 million pounds in 2001 (Table 3.13). Of this, about 860,000 fish in 2000 and 720,000 fish in 2002 (Council Draft SFA document), or about 31 and 42%, were from the Reef Fish FMU. Total recreational finfish catch for Puerto Rico was 46.57% of commercial finfish landings. For Puerto Rico, the majority of catch occurred in state waters (Table 3.13). “Other Fishes” (not identified
in the MRFSS data set) and snappers make up the majority of the recreational landings in state waters. Dolphin fish and tuna dominated the recreational catch (Table 3.13). Recreational landings of spiny lobster in Puerto Rico reached 128,000 in 2000 and 143,000 in 2001 (Council Draft SFA document). Recreational landings of queen conch in Puerto Rico reached 140,000 in 2000 and 124,000 in 2001 (Council Draft SFA document).

A survey of catch from 41 Puerto Rican recreational fishing vessels (Appeldoorn and Valdés-Pizzini 1996) found that, aside from clupeids taken for use as bait, the most caught species were silk snapper, *Lutjanus vivanus*; barracuda, *Sphyraena barracuda*; red hind, *Epinephelus guttatus*; and lane snapper, *Lutjanus synagris*. Most trips targeted groupers and snappers. A creel survey of shore-based recreational anglers at Guanica State Forest recorded 33 species, and 203 specimens were examined by interviewers, who found that white grunt, *Haemulon plumieri*; mutton snapper, *Lutjanus analis*; slippery dick, *Halichoeres bivittatus*; schoolmaster, *L. apodus*; and yellowtail snapper, *Ocyurus chrysurus* were caught most often (Silva *et al.* no date). Except for MRFSS data for 2000 and 2001, there is little collection of recreational fishing data for local Puerto Rican waters.

Appeldoorn and Valdés-Pizzini (1996) conducted a three-month survey targeting Puerto Rican recreational boat users who trailered their boats. A total of 312 boats were surveyed; 41 reported fishing and four of these reported fishing for queen conch while snorkeling. They also sampled finfish during the survey and showed that many of the fishes harvested by the recreational sector were juveniles.

The USVI is not yet part of the MRFSS program, but is in the process of being included. Applying the ratio of recreational catch to commercial catch in Puerto Rico to the commercial catch in the USVI led to an estimate of 627,000 reef fish, 88,000 lobster, and 76,000 queen conch (Council Draft SFA document). Two on-going projects in the USVI collect recreational data. One collects information from the logbooks voluntarily filled out by offshore recreational fishers, and the second collects information from nearshore recreational fishers. The offshore fishers target primarily blue marlin, dolphin fish and wahoo. Of 563 recreational nearshore anglers interviewed in the USVI between 1995 and 1998, fishers most frequently reported catch of french grunts, jacks, and yellowtail snappers (I. Mateo, USVI/DPNR).

The first quantitative report on the shoreline recreational fishery of St. Croix shows that the two (out of a total of 48 species reported) of the most frequently caught fishes (mojarras and anchovies) were primarily used as bait for barracuda and yellowtail snapper (Adams 1997). It also suggests that the shoreline fishery is declining, with CPUE (number of fish caught per hour of fishing) values declining since 1995 with increased effort every year. Among the species landed were red hinds, yellowtail snapper, seven other species of snappers, grunts, etc. These were caught using hook and line and nets.

Jennings (1992), from a telephone survey conducted in 1986, estimated fish harvest by recreational fishers in the USVI at 24,648 kg-fish annually (54,226 lbs./year). The most frequently reported species were yellowtail snapper and red hind, in addition to mackerels and tunas reported specifically from St. Croix. In the mid-1980s, 10% of the residents of the USVI fished recreationally. Jennings (1992) indicates that the proportion of anglers fishing from the
shoreline in St. Croix was higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

3.3.1.3 Spiny Lobster

The spiny lobster fishery in waters around Puerto Rico and the USVI occurs with gill and trammel nets, pots and traps, hand-harvest and beach seines. No stock assessment has been conducted for spiny lobster, but Tobias (2001) suggests that the spiny lobster resource is overfished based on growth and mortality parameters. Most of the commercial harvest occurs in state waters, but fishery statistics do not allow accurate separation of harvest in the EEZ from harvest in state waters.

Puerto Rico

Although three species of spiny lobsters occur in the management area, landings of only Caribbean spiny lobster (*Panulirus argus*) are of significance, and the management system described is restricted to that species. The Council Draft SFA document presented estimates of a 290,554-pound annual average for commercial lobster landings for 1997-2001 in Puerto Rico. The current landings represent about a third of those from 1979, but about 90% of the commercial landings reported by Bohnsack *et al.* (1991). Recreational lobster harvest estimated by MRFSS for 2000-2001 amounted to 54,253 pounds for Puerto Rico.

Matos-Caraballo (2002) reported commercial lobster landings from Puerto Rico during 1998 to 2001 as follows: 1998 landings were 298,389 pounds with an average price of $5.24/pound and a market value of $1,563,558.30; 1999 landings were 326,914 pounds with an average price of $5.27/pound and a market value of $1,722,836.70; 2000 landings were 258,154 pounds with an average price of $5.05/pound and a market value of $1,303,677.70; 2001 landings were 285,018 pounds with an average price of $5.50/pound and a market value of $1,567,599.00. Spiny lobster represented 9% of the total commercial fishery landings in Puerto Rico during 1998-2001. During 1998-1999, the south and west coasts of Puerto Rico reported the highest lobster landings. During 2000-2001, the south and east coasts reported the highest lobster landings, as the west coast experienced a significant decrease in landings (Matos-Caraballo 2002).


Among Puerto Rican trap fishers, 77% were found to target both lobster and reef fish, while only 10% target lobster alone (Scharer et al., in press). Wooden traps were used primarily for lobster, but wire mesh traps were used for both lobster and reef fish. Biodegradable panels are required for all traps, but fishers have not always followed this regulation.

Spiny lobster have been protected by federal and state management plans for 18 years, but fishing pressure has remained intense. Biostatistical sampling of Puerto Rican lobsters caught during 1998-2001 found that 18% were under the minimum state and federal size limit (89 mm carapace length), which is an improvement over the 36% found undersized during 1994-1997 (Matos-Caraballo 2002).

USVI


On St. Croix, Mateo and Tobias (2001) reported a steady increase in average landings from 7,800 pounds during the 1980s to 29,600 pounds in the 1990s. However, mean carapace length in St. Croix exhibited a decrease between 1997 and 2000, going from 107.78 mm in 1997/1998 to 102.46 mm in 1999/2000, and the in the USVI overall, the mean size of landed lobsters is decreasing, as are landings (Tobias et al. 2000; Bolden 2001). However, Tobias (2001) found that a greater number of lobster were being taken per trap haul in St. Croix from 1997 to 2000, but that these lobster were smaller (12% decrease in weight). Tobias (2001) suggests that the spiny lobster resource is overfished based on growth and mortality parameters. Divers accounted for about 85% of total landings from 1990 to 1998. On St Croix from 10/1997 to 12/2000, divers landed 74,976 pounds of lobster, while traps caught only 8,300 pounds (Tobias 2001). Total commercial USVI lobster landings averaged 36,534 pounds for St. Thomas/St. John, and 7284 pounds for St. Croix between 1980 and 1988, and appeared relatively stable (Bohnsack et al 1991).

Among lobster fishers using traps in the USVI, mean crew size was 2-3 individuals, soak times were about 7 days, and vessels utilized ranged in length from 28-35 feet. In contrast, USVI fishers harvesting lobster by diving, used vessels ranging from 18-20 feet in length (Tobias 2001).
The overall average of 361,270 pounds for the entire US Caribbean is approximately 44% of the MSY estimated in the FMP. Traps accounted for the majority of landings during these years, but the proportion harvested by divers increased through the 1980s: diver harvest represented less than 15% of trap harvest in 1977 and 1978, but represented 83% of trap harvest in 1988 and 42% in 1989.

There were 1,723 licensed fishermen in PR and USVI in 1979 and the ex-vessel value of their lobster catch was reported as $1,947,940 (CFMC 1981). Spiny lobsters were an important resource in PR and USVI that year and comprised about 8% (797,856 pounds) of the total estimated landings from the inshore fishery (includes all landings except those from the distant water tuna fishery). Lobsters were harvested by hand and spear (12-13%) and traps (83%).

**Regulations**

Concurrent regulations for spiny lobster apply in the EEZ and in territorial waters of Puerto Rico and the USVI. The minimum size limit specifies a 3.5-inch carapace length. Current regulations prohibit harvest of lobster with spears or other piercing devices. Gaffs are often used to pin the animals down, but regulations prohibit piercing the lobsters. The use of poisons or explosives is also prohibited. Lobsters must be landed whole, and while berried females may be kept in traps, they may not be kept onboard of vessels. It is illegal to pull another fisher’s trap without his express permission (except authorized officers). Traps must be fitted with a biodegradable panel and fasteners. Buoy, boat, and trap identifications and markings must be as displayed according to specifications.

### 3.3.1.4 Queen Conch

The queen conch fishery in waters around Puerto Rico and the USVI occurs with hand-harvest only. Over-harvest of queen conch in shallow, nearshore waters since the use of SCUBA in the 1970s, has led to commercial harvest primarily in waters with depths of 15-30 m (45-95 ft), although harvest can occur in depths in excess of 37 m. The queen conch fishery in the US Caribbean is considered overfished and undergoing overfishing (Powers 2001). A 15-year rebuilding plan is proposed under the current draft SFA plan. Most of the commercial harvest occurs in state waters, but fishery statistics do not allow accurate separation of harvest in the EEZ from harvest in state waters. Most (92%) conch fishers fish within 9 nm of the coast and 60% within 3 nm. The average conch fishing trip lasts four hours and 60% of the daily trip catch is in the 100-150 pound range (Rivera 1999).

The Council is promoting the pan-Caribbean management of queen conch, *Strombus gigas*. This is an international effort to evaluate the status of the conch stocks, and develop regional management measures for the sustainable fisheries of the species.
Puerto Rico

Rivera (1999) reported that Puerto Rico had 209 commercial conch fishers, and 16 of them fished Federal waters. Half of the Puerto Rico conch fishers were from the Peñuelas/Cabo Rojo area on the south/southwest coast, another 25% were from the southeast coast (Naguabo, Ceiba, Fajardo, and Vieques Island), with a much smaller number of north coast fishers (Rivera 1999). A conch biometry survey found that 24% harvested from state waters in Puerto Rico were under the Federal size limit (Rivera 1999).

The Council Draft SFA document estimated average annual queen conch commercial landings at 249,237 pounds for 1997-2001 in Puerto Rico. During 1998-2001 queen conch made up 8% of the total commercial landings for Puerto Rico. Matos-Caraballo (2002) reported commercial queen conch landings from Puerto Rico during 1998 to 2001 as follows: 1998 landings were 260,990 pounds with an average price of $2.22/pound and a market value of $579,397.80; 1999 landings were 213,739 pounds with an average price of $2.25/pound and a market value of $480,912.75; 2000 landings were 281,702 pounds with an average price of $2.23/pound and a market value of $628,195.46; 2001 landings were 328,467 pounds with an average price of $2.44/pound and a market value of $801,459.48. The west coast of Puerto Rico exhibits the highest landings, followed by the east coast, and then the south coast, with only minimal landings from the Puerto Rican north coast. The southwest corner of Puerto Rico produced the largest catches, and 58% of Puerto Rico’s commercial conch landings have come from the municipalities of Lajas, Cabo Rojo, and Mayagüez since 1983-2000 (Valle-Esquivel 2002). Almost all landings are made by SCUBA divers (between 92-99% from 1998-2001), followed by skin divers (between 1-6% from 1998-2001) in Puerto Rico (Matos-Caraballo 2002).

Historically, Puerto Rican commercial queen conch landings increased from 60,000 pounds in the 1970s to a 440,000 pound peak in 1983, than declined thereafter to around 100,000 pounds through the early 1990s, with an increase since to 290,000 pounds in 2001 (Valle-Esquivel 2002). Densities of queen conch in Puerto Rico have decreased from 8.11 conch/hectare in 1987 to 5.68 conch/hectare in 1996. Pounds of conch meat landed per trip has also decreased from 160 pounds/trip in the mid 80s to 72 pounds/trip for 1988-2001 (Valle-Esquivel 2002).

Annual recreational conch harvest estimates by MRFSS for 2000-2001 amounted to 52,848 pounds for Puerto Rico. Statistics on recreational conch catches are not recorded by the Puerto Rican Research Laboratory, however, Appeldoorn and Valdés-Pizzini (1996) interviewed recreational fishers at boat ramps (71 sites). Only 4 of 41 boats who reported fishing as an activity, were recreationally fishing for conch (10 %), and all of these were free-diving. Most conch were caught for personal consumption. Sixty specimens were examined, 73% were juveniles, and 55% of these had shell lengths less than 19 cm (the approximate minimum size for retention by commercial fishers).

USVI

Rivera (1999) reported no full-time conch fishers and 23 part-time from St. Thomas and St. John, with none of these fishing in Federal waters. St. Croix had 16 full-time and 12 part-time fishers, with two of these working in Federal waters. A conch biometry survey found that 92% of conch
harvested from state waters in St. Thomas and St. John were under the Federal and Territorial size limit, while in St. Croix 21% were undersized (Rivera 1999).

The Council Draft SFA document estimated annual average queen conch commercial landings in the USVI at 151,773 pounds for 1997-2001. Absolute catch of queen conch is considerably higher in St. Thomas/St. John than in St. Croix. Proportionally, queen conch is more important in St. Croix making up 5% of total commercial landings there, but only 0.4% of commercial landings in St. Thomas/St. John (Valle-Esquivel 2002). St. Croix commercial landings peaked in 1979 at 60,000 pounds, but have decreased since then to around 20,000-30,000 pounds per year. Annual recreational conch harvest estimates by MRFSS for 2000-2001 amounted to 75,885 pounds in the USVI.

USVI fishery independent surveys conducted between 1981 and 1996 have found progressive decreases in queen conch densities from 40.87 conch/hectare (in 1981) to 14.71 conch/hectare (in 1996). In St. Croix, the average number of pounds of conch meat caught per commercial trip went from 83 pounds/trip in the 1980s, down to 57 pounds/trip in the 1990s, when effort nearly quadrupled (Valle-Esquivel 2002). In general, conch fishers in the US Caribbean believe that search times are longer and that more offshore/deep water fishing has become necessary. In others words, they are spending more time to get less conch (Valle-Esquivel 2002).

Regulations

Federal regulations apply in the EEZ, outside of state waters of Puerto Rico. Federal regulations for queen conch set the minimum size limit at 9 inches for shell length or a lip thickness of more than 3/8 of an inch. Conch must be landed whole (in the shell). There is a closed season from July 1 through September 30. Recreational (non-commercial) fishers may land up to 3 conch per day with a limit of 12 conch/boat. Commercial fishers may land up to 150 conch per day. Use of hookahs to harvest conch is prohibited.

Regulations in USVI territorial waters are the same as those for Federal waters, except that the harvest for recreational fishers is 6 conch/day with a limit of 24 conch/boat. There are no queen conch regulations in Puerto Rico state waters except for the July through September seasonal closure.

3.3.1.5 Reef Fish

It is difficult to describe specific fisheries in the US Caribbean, and to determine how many fishers are involved. Most commercial fishers use multiple number and types of gears – fish traps, hook and line, nets, SCUBA, among others – that make them non-specialized harvesters. Additionally, divers collect aquarium trade species in Puerto Rico, principally in state waters.

Commercial landings data in the US Caribbean have been collected since 1969 in Puerto Rico, and since 1970 in the USVI. In Puerto Rico and the USVI, trap fishing has been the traditional and most productive fishing method used (CFMC 2001). In the late 1980s, hook and lines (hand, trot, etc.) became the most productive gear in Puerto Rico.
Puerto Rico

In Puerto Rico from 1998-2001, the commercially-caught fishes with the highest landings were snappers, mackerels, tunas, groupers, dolphin, grunts, jacks, parrotfishes, and trunkfishes (Matos-Caraballo 2002). Looking only at the reef-associated fishes (1998-2001): snappers totaled 3,975,691 pounds, groupers totaled 598,906 pounds, grunts totaled 508,853 pounds, jacks totaled 370,165 pounds, parrotfishes totaled 351,506 pounds, and trunkfishes totaled 336,386 pounds. On a species basis, yellowtail snapper (1,223,895 pounds valued at $2,506,969), silk snapper (932,606 pounds valued at $2,585,211), lane snapper (815,111 pounds valued at $1,664,227), and red hind (251,223 pounds valued at $526,651) were especially important to the commercial fishery (Matos-Caraballo 2002).

In most years, the three main components of the reef fish landings in Puerto Rico have been snappers, groupers, and grunts, from the reef fish complex (CFMC 2001). These species are found in both shallow and deep water. In several years, one pelagic species entered the top three major components of the landings: mackerels (1969, 1981 and 1996) and tunas (1988-1990). For 1995 and 1997, the top three components consisted of two pelagic species and only one “reef-associated” group (dolphin and mackerel, 1990; tuna and mackerel, 1997). Appeldoorn et al. (1992) reported that landings of all demersal fishes in Puerto Rico declined from a peak of 5,296,410 pounds in 1979 to 1,144,395 pounds in 1990.

Shallow-water reef fishery: In Puerto Rico during 1998-2001, the most important commercial shallow-water reef fishes were yellowtail snapper, lane snapper, and red hind (Matos-Caraballo 2002). Other major fish groups taken commercially from reefs on the Puerto Rican platform (besides snappers and groupers) include: grunts, jacks, parrotfishes, and trunkfishes.

In Puerto Rico during 1998–2001 (Matos-Caraballo 2002), the greatest commercial landings of yellowtail snapper were caught by bottom lines (a type of vertical gear; 1,004,955 pounds), fish traps (92,133 pounds), gill nets (57,499 pounds), and longlines (28,996 pounds). The greatest commercial landings of lane snapper in Puerto Rico during 1998–2001 were caught by fish traps (273,430 pounds), bottom lines (253,815 pounds), gill nets (142,358 pounds), and longlines (106,206 pounds). This general pattern holds for the other shallow-water snapper species, except that SCUBA is used to take a substantial portion of some snapper landings (e.g. mutton snapper). The greatest commercial landings of red hind were caught by bottom lines (127,027 pounds), fish traps (58,404 pounds), and SCUBA (53,164 pounds). The highest landings of the other shallow-water grouper species are accomplished using these gears also. Grunts are taken principally by fish traps (196,253 pounds), gill nets (139,598 pounds), bottom lines (67,183 pounds), trammel nets (60,789 pounds), and beach seines (32,647 pounds). Jacks are captured mostly via bottom lines, gill nets, and also beach seines to a lesser extent. Parrotfishes are mostly caught by fish traps (88,063 pounds), gill nets (76,960 pounds), and SCUBA (76,023 pounds). Trunkfishes are caught principally by fish traps (225,528 pounds), SCUBA (33,555 pounds), trammel nets (30,973 pounds), and gill nets (23,170 pounds).
The majority of the commercially caught reef fishes inhabit the insular shelf. The shallow-water reef fishery of Puerto Rico and the USVI occurs within the EEZ, and extends to the shorelines of both territories. This fishery is limited to depths of 40 fathoms or less. Following collapse of the Nassau grouper resource, red hind became an important species in the fishery; however, statistics show a decrease in the number of young fish in the population as concluded by the Stock Assessment Group (Appeldoorn et al., 1992). Whenever possible, the Council relies upon closing aggregation sites during spawning seasons to enhance reproductive capacity. Most species that aggregate during spawning season are highly vulnerable to capture at that time. Fishermen have sometimes asked for the closure of spawning areas. Most commercial fishing occurs by hand-line fishermen in outboard-powered vessels less than 6m in length; however, fish traps and most recently gill nets have been used to harvest mutton snapper in this area. Weather permitting, more than 30 fishing vessels can be seen nightly for one week after the full moon during the months of March through June. Fishing effort is most heavily concentrated at depths of 18-27 m. Mutton snapper appear to be especially vulnerable to harvest when aggregated for spawning.

Deep-water reef fish: The deep-water fishery, primarily for reef fish, ranges from the outer reaches of the shallow-water fishery (approximately 73 m) seaward to depths up to more than 550 m. Fishes inhabiting the deep-water reef areas of the slopes characterized by rocks, ledges, and corals generally are captured with heavy-duty traps, and by electronically-powered reels; bottom long-lines are deployed to a limited extent. Based on numbers of commercially-landed pounds and average price paid per pound in Puerto Rico from 1998-2001 (Matos-Caraballo 2002), market value for the four major deep water snappers and one grouper species can be calculated. From 1998-2001 Puerto Rican silk snapper landings totaled 932,606 pounds valued at $2,585,211; queen snapper landings totaled 303,288 pounds valued at $859,475; vermilion snapper landings totaled 101,106 pounds valued at $237,409; misty grouper landings totaled 23,761 pounds valued at $51,259; and wenchman landings totaled 18,629 pounds valued at $46,574.

In Puerto Rico during 1998-2001 (Matos-Caraballo 2002), the greatest commercially-landed poundage of silk snapper was caught by bottom lines (a type of vertical gear; 641,361 pounds), fish traps (261,597 pounds), and longlines (28,996 pounds). The greatest commercially-landed poundage of queen snapper was caught by bottom lines (227,360 pounds), longlines (70,484 pounds), and fish traps (5,246 pounds). The greatest commercially-landed poundage of vermilion snapper was caught by bottom lines (58,982 pounds), fish traps (40,455 pounds), and longlines (894 pounds). The greatest commercially-landed poundage of misty grouper was caught by bottom lines (15,769 pounds), longlines (3,497 pounds), and fish traps (2,185 pounds). The greatest commercially-landed poundage of wenchman was caught by bottom lines (14,136 pounds), fish traps (2,065 pounds), and gill nets (1,577 pounds).

USVI

Net fishing has been shown to be increasing (e.g., Valdés Pizzini et al. 1992) in Puerto Rico (Figure 3.1). The trend has also been reported for the USVI; in St. Croix nets are fished using SCUBA divers to herd fish into the nets, principally parrotfish (Tobias et al. 2000). The decline in trap fishery is probably the most important factor contributing to the increase in the number
and use of nets (re-direction of the fishery). Reef fishes targeted by nets and traps, parrotfish (scarids) and surgeonfish (acanthurids), were shown to be decreasing in mean size based on 1985-1990 data (Appeldoorn et al. 1992), and a new assessment utilizing 1990-2000 data is needed (Tobias 2001). No net restrictions are in place in the US Caribbean Federal waters.

Pot-caught fish continue to make up the highest percentage of the USVI total catch (Figure 3.2) but some changes have taken place since the late 1990’s, at least in St. Croix. The DPNR has reported (CFMC Meeting) that 54 commercial fishers from St. Thomas-St. John District were fishing 4,574 fish traps and 1,655 lobster pots, for a total of 6,229. The number of traps per fishermen ranged from a minimum of 1 to a maximum of 350, with 33% having less than 20 traps. The data available for the landings in the USVI (DPNR 1997) for the year 1995/1996 indicate that there were 182 commercial fishers registered of whom 149 reported landings from 4,909 trips made during the year. The average reported total catch per year for potfish in St. Thomas-St. John (1993-1996) was 367,788 pounds of fish and 64,668 pounds of lobster. The catch per trap (using the average for the last three years reported by DPNR) was 80 pounds per fish trap and 39 pounds of lobster per lobster pot, a combined average of 69 pounds per fish/lobster trap. However, mean catch per trip was reported to be of 110 pounds from 1993 through 1996. The estimated landings reported (over a million pounds per year from average for 3 years), result in an average of 130 pounds per trap. In the 1980s the CFMC had estimated the catch per trap to be less than 120 pounds. CPUE showed little variation through the 1980s and 1990s. The number of registered fishers that did not report landings has consistently been decreasing since 1986-87 for St. John, and 1981-82 for St. Croix. There has been no in-depth analysis by gear type for the fisheries of the US Caribbean.

Marine aquarium trade fishes: The CFMC prohibits the harvest of butterflyfish, seahorses, and juvenile red hind and mutton snapper for the aquarium trade (Reef Fish FMP Amendment 2, 1993). In state waters, both the Puerto Rico and USVI fishery agencies manage the take of aquarium trade species through a permit system, with associated reporting requirements. In USVI state waters, collection for the commercial aquarium trade species is prohibited, but unpermitted collection of aquarium fishes can be made by individuals for their personal aquaria. Collection for educational purposes is authorized by permit. At present, only two permits are active in the USVI, both for educational facilities. Little activity is reported from USVI federal waters (CFMC 2002). In Puerto Rico, the status of many species of marine aquarium fishes has not been determined, but some are uncommon while others are heavily exploited without restriction. The trade and shipping lists for 1990/91 indicate that over 150 species of fish (105 finfish) and invertebrates (45) were exported from Puerto Rico. Many of the species collected are the young of those that are valued as adults in other fisheries, some of which are regulated. About 100 people are engaged in the marine aquarium trade in Puerto Rico. Most collectors are exporters; however, some collectors sell to exporters or to local shops. Major collectors have their own equipment, and collect from 3-4 days to 7 days a week depending on weather and demand. Collectors visit specific areas and generally rotate collecting sites to avoid over-fishing an area. Collection are commonly made by SCUBA down to 20 m, but occasionally to 40 m for certain species; mask and snorkel are commonly used in shallow waters. Most collectors are based out of the northwest and southwest coastal regions; with Isabela Aquadilla, Rincon, Cabo Rojo, La Parguera, and Ponce as the primary collecting areas (Ojeda-Serrano et al. 2001). The only allowable fishing gears for capturing aquaria-trade fish are hand-held dipnets and slurp
The use of poisons, drugs, other chemicals, and explosives is prohibited. Puerto Rico has also identified allowable species for harvest, and implemented a four-fish daily limit, per species (CFMC 2002).

From 1998-2000, 10 species accounted for 76% of all aquaria-trade fish exported from Puerto Rico, with the Royal Gramma (Gramma loreto) alone accounting for 42%. Other species on the list include yellowhead jawfish, blue chromis, redlip blenny, rock beauty, greenbanded goby, blue tang, longhorn blenny, bluehead wrasse, and cherubfish (Ojeda-Serrano et al. 2001). Most of the aquaria-trade exports (99.3%) during 1998-2000 went to the continental US.

Diver harvest in Federal waters is probably limited to a small area of shelf-extension off southwestern Puerto Rico, while some deep water ornamentals may be taken by traps and also incidentally by commercial fishers in Federal waters.

3.3.1.6 Coral

The Coral FMP establishes regulations to restrict the taking of coral reef resources in or from the exclusive economic zone (EEZ) around Puerto Rico and the USVI. It prohibits the harvest or possession of stony corals, soft corals, sea fans, gorgonians and any species in the fishery management unit if attached or existing upon live-rock; it prohibits the sale or possession of any prohibited species unless fully documented as to point of origin; it prohibits the use of chemicals, plants or plant derived toxins, and explosives for harvest (consistent with the Council's Reef Fish FMP); and it limits harvest of other invertebrates to dip nets, slurp guns, by hand and other non-habitat destructive gear. The local governments also prohibit the harvest of corals from state waters.

Most harvest of species under the Coral FMP goes to the aquarium trade. The description in the Reef Fish section of the aquarium trade applies to invertebrates of the Coral FMP.

Amendment 1 to the Coral FMP established a no-take Marine Conservation District (MCD) in an area known as the “Hind Bank” southwest of St. Thomas, USVI. The area is closed to all fishing and harvesting activities, protecting populations of groupers, snappers, other reef fish, and spiny lobster from fishing mortality and protecting coral from fishing activities.

3.3.2 Fishing communities

The information available to describe commercial fishing communities has been reviewed in the Council’s FMPs. There is no continuous program that collects information to describe these communities in great detail. Sporadic and targeted surveys are conducted in the US Caribbean to answer specific questions. Caribbean commercial fisheries are complex and harvest multiple species with a variety of gears and seasonal harvesting patterns. This complexity has not been analyzed in sufficient detail.

Matos-Caraballo (1997) provided the latest commercial fishing census (1995) for Puerto Rico and detailed information concerning regional landings, US census information, and fishing
participants in various fisheries by region. The 1,758 full and part time fishermen were distributed fairly evenly around Puerto Rico: 428 on the North Coast, 427 on the East Coast, 442 on the South Coast, and 461 on the West Coast. Only two communities reported more than 100 fishermen: Cabo Rojo (213) and Humacao (108). The total number of active commercial fishermen reported by the PRFRL has fluctuated without long-term trend since 1974 (Matos-Caraballo 1997).

No comparable document is available for the USVI, although Downs and Petterson (1997) obtained information for USVI during evaluation of a proposed Marine Conservation District at St. John. They reported that the two traditional fishing communities of St. Thomas are Hull Bay on the north side and Frenchtown on the south side; however, northside fishermen tend to keep vessels in the east or south coast areas. Most St. Thomas fishermen are of French descent. On St. John, fishermen cluster in Cruz Bay on the west end and in Coral Bay on the east end. Most St. John fishermen are recent arrivals, or of West Indian descent.

The Heinz Center (2000) report on roundtable discussions for improving federal fisheries management both nationally and for the Caribbean specifically, calls for enhanced social science research including the development of long-term, comprehensive social science data collection programs. In the US Caribbean, the panel recommended more proactive use of social and economic information in the fishery management process and providing transition assistance to displaced fishers. Emphasis was placed on the need for long-term research to collect information on community infrastructure, how fishers learn and produce knowledge, cultural perceptions and politics, socioeconomic development of fishing communities, gender issues, fishery histories, ethnic composition and background of fishery participants, rules and regulations, and systems of jurisdiction and conflicts. They also suggested moving away from surveys to gather data and towards the idea of getting fishers to participate more extensively in the data collection and assessment process. The panel believed that Puerto Rico and the USVI should have both commercial and recreational socioeconomic research programs.

3.4 Administrative environment

3.4.1 Fishery management under the FMP

The M-S Act was originally passed by Congress in 1976. Section 302 of the Act (§ 302) created eight regional fishery management councils, including the Caribbean Council, to develop Fishery Management Plans (FMPs) to regulate fisheries in an effort to prevent overfishing. Councils prepare FMPs for each fishery under its jurisdiction, and submit these plans to the Secretary of Commerce for final approval.

Membership on Councils includes the directors of state fishery organizations, the Regional Director of NOAA Fisheries, and knowledgeable citizens appointed by the Secretary of Commerce as voting members and representatives from the US Fish and Wildlife Service, Coast Guard, regional Marine Fisheries Commission, and Department of State as nonvoting members.
During the process of developing FMPs, the M-S Act directs the Councils to conduct public hearings to provide opportunities for input from the affected public. The M-S Act also establishes a Scientific and Statistical Committee to assist with statistical, biological, economic, social, and other scientific information, and Advisory Panels to provide information, and to assist in development and review of management plans and plan amendments.

When a council approves a plan, it forwards the plan to NOAA Fisheries for review and approval. NOAA Fisheries, NOAA, and NOAA General Counsel (GC) assure that the plan or amendment meets various federal requirements. Following this internal review, the plan or amendment continues on a two-part track. One part leads to approval of the management plan or plan amendment, and the other leads to a final rule that establishes regulations.

For the management plan or plan amendment, NOAA Fisheries publishes a Notice of Availability that starts a 60-day public comment period. Following the comment period, NOAA Fisheries and NOAA GC conduct a final evaluation, and usually the plan is approved, disapproved, or partially approved at the national level. In rare cases the Regional Administrator (in the case of Caribbean Council plans, the Southeast Regional Administrator) takes over this function.

To implement a plan or amendment, NOAA Fisheries develops a Proposed Rule (PR) that also goes through NOAA Fisheries, NOAA, NOAA GC, and public review. After internal review, NOAA Fisheries publishes the PR in the Federal Register to start a 45-day public comment period. The Regional Administrator responds to the public comments, and then completes a rulemaking package for the Final Rule (FR). The FR undergoes further federal review and approval by NOAA Fisheries, and gets published in the Federal Register.

### 3.4.2 Fishery management by states

The governments of the Commonwealth of Puerto Rico and the Territory of the USVI have the authority to manage their respective state fisheries. As a Commonwealth, Puerto Rico has an autonomous government, but is voluntarily associated with the United States. The USVI is an unincorporated territory with a semi-autonomous government and its own constitution.

Puerto Rico has jurisdiction over fisheries in waters extending nine nautical miles from shore. Those fisheries are managed by the Fisheries Research Laboratory of Puerto Rico's Department of Natural and Environmental Resources (PR-DNER). Section 19 of Article 6 of the Constitution provides fishery rules and regulations.

The USVI has jurisdiction over fisheries in waters extending three nautical miles from shore. The Department of Planning and Natural Resources' Division of Fish and Wildlife (DFW) is the USVI's fishery management agency. Rules and regulations for USVI fisheries are codified in the Virgin Islands Code, primarily within Title 12.

Each state fishery management agency has a designated seat on the Council. The purpose of state representation at the council level is to ensure state participation in Federal fishery
management decision-making and to promote the development of compatible regulations in state and Federal waters. But, while the states have adopted compatible regulations for some stocks, many fishery regulations remain inconsistent. For example, both state agencies prohibit the take of corals from state waters, consistent with Federal regulations. But neither agency prohibits, or even regulates, catches of Nassau grouper, which have been prohibited in Federal waters since 1990. The lack of compatible regulations in state waters makes Federal regulations difficult to enforce and hinders the Council's ability to achieve Federal management objectives. This is particularly true in state waters of Puerto Rico, which contain the vast majority of habitat that supports Federal fisheries.

The PR-DNER recently made significant progress in aligning federal and local fishery management goals through the initiation of Puerto Rico Law 278. That law would require the Commonwealth to adopt for its waters most of the fishery management measures implemented by the Council. But the successful implementation of that law is uncertain, as it has been under review since 1998 (The Heinz Center 2000).

3.4.2.1 Marine resource and fisheries management in the USVI

Regulatory authority

There are various rules and regulations regarding the management of marine resources and fisheries within the USVI. Within territorial waters (less than 3 miles from shore), rules and regulations are codified in the Virgin Islands Code (VIC), primarily within Title 12.

Territorial marine reserves

VIC, Title 12, Chapter 1. Marine reserves and wildlife sanctuaries. Various marine reserves have been designated in the VIC. They are as follows:

1. Compass Point Pond Marine Reserve and Wildlife Sanctuary (St. Thomas)
2. Cay Cay/Mangrove Lagoon Marine Reserve and Wildlife Sanctuary (St. Thomas).
4. Small Pond Wildlife and Marine Sanctuary (Frank Bay, St. John).

Additional marine reserve designations and more detailed regulations have been promulgated by the Commissioner of DPNR

1. Compass Point Pond, a salt pond, at Benner Bay as a marine reserve and wildlife sanctuary (9/24/92).
2. Salt River Bay Marine Reserve and Wildlife Sanctuary at Salt River Bay, St. Croix (7/19/95).
3. Cas Cay/Mangrove Lagoon Marine Reserve and Wildlife Sanctuary and St. James Marine Reserve and Wildlife Sanctuary” at Cas Cay and Mangrove Lagoon, and in Jersey...
Bay, St. James Bay and St. James Cut as marine reserves and wildlife sanctuaries (9/16/94).

Endangered species

Local protection of indigenous, endangered and threatened fish, wildlife and plants is covered in VIC, Title 12, Chapter 2). This regulation prohibits the harvest of goliath grouper, but not Nassau grouper. The Federal regulation regarding endangered species is in 16 USC 1538.

Territorial beaches and shorelines

Obstruction of shorelines is prohibited (VIC, Title 12, Chapter 10). In addition, horses and motor vehicles are prohibited from recreational areas including beaches (VIC, Title 32, Section 26).

Fishing in territorial waters

Commercial and recreational fishing is covered in VIC, Title 12, Chapter 9A. It includes the following:

1. Regulation on the fishing of spiny lobsters, traps, sea turtle catches, and ban on lobster fishing with explosives, poisons, drugs, chemicals, spears, hooks or similar devices. Size regulations for lobsters are the same in territorial waters as in the EEZ.
2. Regulations for conch and whelk harvesting. Harvest regulations for conch are the same as the federal regulations, except that recreational harvest is higher (6 per fisher and maximum 24 per boat).
3. Rules and regulations for fish traps (mesh size). Mesh size regulations are the same on St. Croix as CFMC (1 ½ inch hex mesh). Larger mesh size (2 inch square or hex mesh) is required on St. Thomas.
4. Limited closed season for mutton snapper (St. Croix).

The promotion of commercial fishing is covered in VIC, Title 11, Chapter 27. Included in this chapter are the following:

1. Formation of the fisheries advisory committees,
2. Fishermen’s loan fund,
3. Duties of the Commissioner,
4. Rules and regulations,
5. Powers and authority of conservation officers,
6. Ownership of navigable waters,
7. Registration, certification and licensing of commercial fishers,
8. Rules for non-resident fishers,
9. Fish and game fund,
10. Reporting requirements of fishers,
11. Closed seasons,
12. Scientific research,
13. Protection of marine turtles, nests and eggs,
14. Lobster regulations,
15. Freshwater fishing regulations,
16. Fishing gear regulations,
17. Fishing with explosives,
18. Contamination of fishing waters,
19. Sale of local seafood

Specific regulations regarding baitfish harvest were enacted by the Commissioner of DPNR (2/9/89).

Territorial boating regulations

Rules and regulations for mooring and anchoring of vessels and houseboats are covered in VIC, Title 25, Chapter 16. Additional rules and regulations for operating personal watercraft and other thrillcraft in the USVI were formalized in VIC, Title 3, Chapter 35.

Protection of marine mammals

There are no specific local regulations regarding marine mammal protection. Marine mammal protection is covered in the Federal Marine Mammal Protection Act of 1972 (16 USC 1361-1407). Local regulations protect any species listed as endangered or threatened by the federal or territorial governments.

Management structure within the USVI

Fisheries and marine resource management suggestions can come from a variety of sources including local government agencies, the public, commercial fishermen, and the local Fisheries Advisory Committees. In recent years, most suggestions for the management of marine resources and fisheries have been initiated by the local Fisheries Advisory Committees (that is composed of representatives from government, marine scientists, commercial and recreational fishers, charterboat fishers, and dive operators). For example, the recent initiative to limit issuance of new fishing licenses was a St. Croix FAC initiative.

The suggestion reaches the Commissioner of DPNR (usually from the local FAC). The Commissioner typically requests a public hearing on the issue. This allows the public to provide input into the management suggestions. Based on the results of the public hearing, the advice of local government agencies (especially the Division of Fish & Wildlife and the Division of Environmental Enforcement) and the limited authority of the Commissioner, the Commissioner may either issue a regulation or may suggest amendments or adjustments to the VI Code.
The role of the Division of Fish and Wildlife is quite varied and includes:

1. to advise and support the local Fisheries Advisory Committees,
2. to conduct appropriate research to assess the fisheries and marine resources,
3. to review scientific literature and provide guidance based on the best available information, and
4. to advise the Commissioner on fisheries and marine resource issues and management options.

It is not the role of DFW to enforce regulations. That role is the responsibility of the Division of Environmental Enforcement.

3.4.3 National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA) requires all Federal actions to be evaluated for potential environmental and human environment impacts, and for these impacts to be assessed and reported to the public. As it applies to the formulation of fishery management plans, the NEPA process should ensure that the potential environmental ramifications of actions determined necessary to manage a fishery, are fully considered. Thus, proposed regulations that may set size or bag limits, limits on the number of permits or vessels, quotas, allowable gears, closed seasons or areas and any other measure, is reviewed for its potential affect on the broader marine environment, in addition to its affect on the specific fishery being managed.

Councils initially prepare an Environmental Assessment (EA), which is a concise statement that determines whether the FMP (and subsequently any proposed amendment to the plan) will have a significant impact on the environment. If there is no potential significant impact, a “Finding of No Significant Impact,” or FONSI, is issued.

Determination that the action will result in a significant impact to the quality of the human environment requires a full Environmental Impact Statement (EIS). In this determination, the Council must consider the context and intensity of the action or activity, both short term and long term effects, impacts that may be beneficial or adverse, and effects on locality and society as a whole. Generally, the EIS is drafted concurrently with the FMP and it lays out the proposed action(s), alternatives to the proposed action(s), and the environmental consequences for each alternative. The Draft EIS is sent to the EPA for a 45-day review period, and subsequently its availability is announced in the Federal Register. The public is afforded an opportunity to comment on it, generally concurrently with the public comment period for the FMP itself. The EIS is submitted to the Secretary of Commerce along with the FMP for final approval.

3.4.4 Endangered Species Act (16 U.S.C. Section 1531 et seq.)

The Endangered Species Act (ESA) of 1973 (16 U.S.C. Section 1531 et seq.) provides for the conservation of species which are in danger of endangerment or extinction throughout all or a significant portion of their range and the conservation of the ecosystems on which they depend. "Species" is defined by the Act to mean a species, a subspecies, or, for vertebrates only, a distinct population. The ESA requires that federal agencies use their authorities to conserve endangered
and threatened species and that they ensure actions they authorize, fund, or carry out are not likely to harm the continued existence of those species or the habitat designated to be critical to their survival and recovery. The ESA requires NOAA Fisheries, when proposing a fishery action that “may affect” critical habitat or endangered or threatened species, to consult with the appropriate administrative agency (itself for most marine species, the U.S. Fish and Wildlife Service for all remaining species) to determine the potential impacts of the proposed action. Consultations are concluded informally when “may affect but are not likely to adversely affect” endangered or threatened species or designated critical habitat. Formal consultations, including a biological opinion, are required when proposed actions may affect and are “likely to adversely affect” endangered or threatened species or designated critical habitat. If jeopardy or adverse modification is found, the consulting agency is required to suggest reasonable and prudent alternatives.

A section 7 consultation will be conducted on any proposed agency action stemming from this EIS prior to its implementation for its possible effects on species and critical habitat designated under the ESA. Information on endangered and threatened species in the Caribbean is presented in section 3.2.14. Information is also presented on two fish species in the Caribbean that are on NOAA Fisheries candidate list of species for possible future listing.

3.4.5 Marine Mammal Protection Act (16 U.S.C. 1361 et seq.)

The Marine Mammal Protection Act (MMPA) established a moratorium, with certain exceptions, on the taking of marine mammals in US waters and by US citizens on the high seas, and on the importing of marine mammals and marine mammal products into the United States. Under the MMPA, the Secretary of Commerce (authority delegated to NOAA Fisheries) is responsible for the conservation and management of cetaceans and pinnipeds (other than walruses). The Secretary of the Interior is responsible for walruses, sea and marine otters, polar bears, manatees and dugongs.

Part of the responsibility that NOAA Fisheries has under the MMPA, involves monitoring populations of marine mammals to make sure that they stay at optimum levels. If a population falls below its optimum level, it is designated as "depleted," and a conservation plan is developed to guide research and management actions to restore the population to healthy levels.

In 1994, Congress amended the MMPA, to govern the taking of marine mammals incidental to commercial fishing operations. This amendment required the preparation of stock assessments for all marine mammal stocks in waters under US jurisdiction, development and implementation of take reduction plans for stocks that may be reduced or are being maintained below their optimum sustainable population levels due to interactions with commercial fisheries, and studies of pinniped-fishery interactions.

The MMPA requires all commercial fisheries to be placed in one of three categories, based on the relative frequency of incidental serious injuries and mortalities of marine mammals in each fishery. Category I designates fisheries with frequent serious injuries and mortalities incidental to commercial fishing; Category II designates fisheries with occasional serious injuries and mortalities; Category III designates fisheries with a remote likelihood or no known serious
injuries or mortalities. Under the 2003 List of Fisheries, Caribbean fisheries under the jurisdiction of the Council fall under Category III. The large pelagics longline fishery is listed under Category I (68 FR 41275).

3.4.6 Non-fishery management laws & regulations

The implementation of a number of federal, state, and local laws, regulations, and policies have a direct effect on habitat and waters that may be considered essential habitat or habitat of particular concern to the fish species managed under the Caribbean FMPs. The designation of EFH allows the Council and NOAA Fisheries to intervene in decisions on non-fishing activities that may affect essential habitat, and requires other federal agencies with responsibility for proposed non-fishing actions to consult with NOAA Fisheries on projects with potential adverse impacts on EFH. The responsible federal agency must respond in writing to NOAA Fisheries with the rationale for whatever mitigation it authorizes.

The following laws and regulations are those that permit non-fishing activities for which the Council and NOAA Fisheries may potentially intervene. Brief descriptions of the intent of the law are provided. Much of these descriptions have been taken from A Guide to Protecting Wetlands in the Gulf (Goldberg et al. 2001).

3.4.6.1 Federal

3.4.6.1.1 The Clean Water Act (33 U.S.C. Section 1251 et seq.)

In 1972, Congress passed the Clean Water Act (CWA) - also known as the Water Pollution Prevention and Control Act - to protect the quality of the nation’s waterways including oceans, lakes, rivers and streams, aquifers, coastal areas, and aquatic resources. The law sets out broad rules for protecting the waters of the United States; Sections 404 and 401 apply directly to waters and aquatic resources protection.

3.4.6.1.1 Section 404 of the Clean Water Act

Section 404 of the Clean Water Act (often referred to as “Section 404” or simply “404”) forbids the unpermitted "discharge of dredge or fill material" into waters of the United States. Section 404 does not regulate every activity in aquatic resources or coastal areas, but requires anyone seeking to fill any area to first obtain a permit from the Army Corps of Engineers (ACOE). Constructing bridges, causeways, piers, port expansion, or any other construction or development activity along a waterway or in aquatic resources generally requires a 404 permit. When a fill project is permitted, there may be mitigation required to replace lost aquatic resources.
3.4.6.1.2 Section 401 of the Clean Water Act

Section 401 of the Clean Water Act requires that an applicant for a Section 404 permit obtain a certificate from their state’s environmental regulatory agency (if the state has delegated such authority to the agency) that the activity will not negatively impact water quality. This permit process is supposed to prevent the discharge of pollutants (pesticides, heavy metals, hydrocarbons) or sediments into waters, that may be above acceptable levels, because decreased water quality may endanger the health of the people, fish, and wildlife. However, acceptable pollutant levels have not been established for many aquatic resources, which makes it difficult for state agencies to fully assess a project’s impact on water quality.

3.4.6.1.3 National Estuary Program

The National Estuary Program, established by Congress in 1987 by amendments to the Clean Water Act, identifies estuaries of national significance and establishes a management conference to develop a comprehensive management plan for the estuary. The management conference often involves representatives from NOAA and/or NOAA Fisheries. It is given the responsibility to: assess and characterize trends in water quality, pollutants, natural resources, uses of the estuary, and causes of environmental problems; develop a comprehensive conservation and management plan (CCMP) that recommends priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the estuary, including restoration and maintenance of water quality, and a balanced indigenous population of shellfish, fish, and wildlife.

Implementation of the CCMP is completely voluntary, rather than regulatory, but the process allows consideration and incorporation of many issues such as protection or restoration of EFH. Additionally, similar to the language in the Coastal Zone Management Act, the management conference is supposed to review all Federal financial assistance programs and development projects in accordance with the requirements of Executive Order 1372, as in effect on September 17, 1983, to determine whether such assistance program or project would be consistent with and further the purposes or objectives of the CCMP.

3.4.6.1.2 Section 10 of The Rivers and Harbors Act (33 U.S.C. Section 403)

The Rivers and Harbors Act was created in 1899 to prevent navigable waters of the United States from being obstructed. Section 10 of the Act requires that anyone wishing to dredge, fill, or build a structure in any navigable water and associated wetlands obtain a permit from the ACOE. An activity affecting wetlands may require a Section 404 and Section 10 permit, thus both sections are often included together in a permit notice. When these activities are permitted, and there is direct loss of submerged habitat, such as seagrasses, then mitigation is often required to compensate for this loss.
### 3.4.6.1.3 The Coastal Zone Management Act (16 U.S.C. Section 1456(c))

In 1972, Congress passed the Coastal Zone Management Act (CZMA) to protect the Nation’s coasts by helping states regulate activities in the coastal zone. The CZMA encourages states to develop a Coastal Zone Management Plan (CZMP) in which they define permissible land and water uses within the state’s coastal zone. The coastal zone generally extends 3 miles seaward (state waters) and inland as far as necessary to protect the coast. In the Caribbean, state waters for Puerto Rico extend 9 nautical miles, and in the USVI they extend 3 nautical miles, except in areas where they are very close to the British Virgin Islands (e.g. only half a mile from the coast of St. John to the British Virgin Islands). The program is administered at the federal level by the Coastal Programs Division (CPD) within NOAA’s Office of Ocean and Coastal Resource Management (OCRM). States with approved CZMPs receive federal funding to help them protect and improve the quality of their coastal areas.

The CZMA requires that any applicant for a federal permit obtain a determination from the state that the activity is consistent with its CZMP, if the activity may affect the natural resources in the coastal zone. This process is called a “consistency determination.” Thus, a Section 404 permit that may affect a state’s coastal zone cannot be issued unless the state certifies that the activity is consistent with its CZMP. Each state has a procedure for obtaining CZMP consistency determinations and includes an opportunity to obtain comments from state and local agencies, as well as the public. If a state fails to act on an application for a consistency determination within 6 months, it is presumed that the activity is consistent with the CZMP.

#### 3.4.6.1.3.1 National Estuarine Research Reserves System

The National Estuarine Research Reserves System was established by the Coastal Zone Management Act of 1972, as amended. It is a network of 25 protected areas that represent different biogeographic regions of the United States. It helps to fulfill NOAA’s stewardship mission to sustain healthy coasts by improving the nation’s understanding and stewardship of estuaries.

Each reserve is a "living laboratory" in which scientists conduct research and educators communicate research results. Reserve staff members work with local communities and regional groups to address natural resource management issues, such as nonpoint source pollution, habitat restoration and invasive species. One NERR is established in the Caribbean: Jobos Bay in Puerto Rico.

### 3.4.6.1.4 The Coastal Wetlands Planning, Protection, and Restoration Act (Public Law 101-646, Title III)

The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) of 1990 sets aside millions of dollars every year for voluntary wetland restoration projects in coastal states. Agencies and citizens can take part in the CWPPRA process by proposing projects of local concern and providing input on proposed restoration projects. Local ACOE district offices and
regional Fish and Wildlife Service offices maintain information on projects being funded under CWPPRA.

3.4.6.1.5 The Fish and Wildlife Coordination Act (16 U.S.C. 661, 666c)

The Fish and Wildlife Coordination Act protects the quality of the aquatic environment needed for fish and wildlife resources. The Act requires consultation with the Fish and Wildlife Service and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" by any agency (except TVA) under a Federal permit or license. NOAA Fisheries was brought into the process later, as these responsibilities were carried over, as a result of Reorganization Plan Number 4 of 1970 that created NOAA. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources", and to ensure that the environmental value of a body of water or wetland is taken into account in the decision-making process during permit application reviews. Consultation is most often (but not exclusively) initiated when water resource agencies send the FWS or NOAA Fisheries a public notice of a Section 404 permit. FWS or NOAA Fisheries may file comments on the permit stating concerns about the negative impact the activity will have on the environment, and suggest measures to reduce the impact.

3.4.6.1.6 Title III of the Marine Protection, Research and Sanctuaries Act of 1972

The National Marine Sanctuaries Program was created in Title III of the Marine Protection, Research and Sanctuaries Act of 1972. Today, there are 13 national marine sanctuaries protecting some 18,500 square miles of ocean and coasts.

Staff from the NOAA Fisheries are involved in the federal management teams that develop the sanctuary management plans to ensure coordination with regard to fisheries management, and protection of vital fishery resources and fishery habitats.

3.4.6.2 State laws and policies

States often have their own permitting processes for any activities that may affect wetlands, waters, and other environmentally-sensitive habitats and ecosystems. States have the ability to be more stringent than federal laws on the same issue. Additionally, states may have their own land/water protection program with defined designations such as aquatic preserve, marine reserve, wildlife refuges, and wild and scenic river, to name a few. Each state sets its own parameters, with regard to the types of activities or development that may occur in these designated areas, and will usually require that proposed activities be reviewed to ensure that they will not cause environmental harm. Some states require that a permit be obtained before the activity can proceed. However, there is no process for the Council or NOAA Fisheries to provide comments or review of state permitting activities to ensure adequate safeguards to protect EFH, unless there are concurrent federal actions required.
3.4.6.3 Local land use regulations and policies

The manner in which land and waterways are used, maintained, and developed is an important component in promoting and ensuring the integrity of natural resources. Many areas throughout the Caribbean have, and continue to experience, significant declines in water quality and substantial losses of important wetlands and coastal areas due to growth and development pressures. Much of this loss can be attributed to the failure of local communities to sufficiently plan for growth by ensuring that development occurs in a way that protects important natural resources.

Local land-use zoning regulations, ordinances, and growth management policies direct the way land is developed by designating areas suitable for business, residential, and industry, and by establishing appropriate management practices for construction activities. Regulations can also prohibit business development in certain areas, identify unique open space areas that should be protected and remain undeveloped, or require establishment of easements and natural corridors around wetlands or along waterways, in order to protect water quality and fish and wildlife habitat. Thus land use regulations have a major impact on the quality of environmental resources.

Just as with state activities, there is little opportunity and no designated process for input from the Council or NOAA Fisheries, unless there are concurrent federal permits required.

3.5 Threats to Habitat

3.5.1 Fishing impacts

3.5.1.1 National and international studies and literature

As part of an effort to identify fishing impacts on fish habitat from the gears used in the Gulf of Mexico, South Atlantic, and Caribbean Regions, Rester (2000a; 2000b) completed an annotated bibliography that compiled a listing of papers and reports that addressed fishery-related habitat impacts. The bibliography included scientific literature, technical reports, state and federal agency reports, college theses, conference and meeting proceedings, popular articles, memoranda, and other forms of nonscientific literature, but did not include studies that pertained to the ecosystem effects of fishing (e.g. changes in the biological community structure). While recognizing that fishing may have many varying impacts on EFH, the bibliography focused on the physical impacts of fishing activities on habitat.

Hamilton (2000) summarized a December 1999 workshop concerning gear impacts on EFH attended by NOAA Fisheries scientists and managers. The workshop participants examined existing studies on gear impacts, and examined which factors made gear impact studies relevant to the Southeast region. The criteria included whether the specified gear was utilized in the Southeast Region, whether it was utilized in the same manner (similar fisheries), and whether the habitat was similar. This review recognized that in many instances numerous epifaunal and
infaunal species are an integral part of benthic habitat. Such species act as ecosystem engineers and modify the habitats they occupy through burrowing activities (Coleman and Williams 2002). Therefore, studies that document impacts (i.e., reduction in biomass or species diversity) to benthic communities have been included in this section. Recommendations were made concerning future research needs, and a table of the relative impacts of various fishing gears on different habitats was developed.

Barnette (2001) used the over 600 papers compiled by Rester (2000a, 2000b, 2001) to examine fishing impacts in the Southeast Region. The following section is largely excerpted from Barnette (2001). Barnette found a paucity of readily available information on the numerous types of gear utilized within the Caribbean, South Atlantic, and Gulf of Mexico. While there have been hundreds of studies published on gear impacts worldwide, the majority of these focus on mobile gear such as dredges and trawls. Furthermore, in addition to the approved gears within the various FMPs, there are other gears utilized within state and territorial waters that also needed to be evaluated because EFH may extend into coastal and estuarine waters. However, there are few, if any, habitat impact studies that have been conducted on many of these gear types.

Johnson (2002) also reviewed literature (through May 2002) dealing with the effects of fishing gears on benthic habitats. The document focused on mobile gears, such as trawls and dredges, which are not typically used in Caribbean fisheries, but also contained some information on traps, pots, longlines, and gill nets.

Morgan and Chuenpagdee (2003) reviewed literature on gear impacts, summarized these findings and presented them to an expert panel of fishers, scientists, and managers who then ranked habitat impacts for 10 fishing gears commonly used in U.S. fisheries. In this instance, gear impacts considered physical habitat damage, bycatch, and potential ghost fishing together. Based on the results of the panel workshop, a questionairre was developed to assess fishing impacts, which was circulated among a broad range of marine fisheries experts. Results from the questionairres were analyzed to rank fishing gear impacts and categorize gears as having high, medium, or low impacts. The report states that bottom trawls, bottom gillnets, dredges, and midwater gillnets have relatively high impacts; pots/traps, pelagic longlines, and bottom longlines have medium impacts; while midwater trawls, purse seines, and hook and line have relatively low impacts. Based on the Morgan and Chuenpagdee (2003) report, the gear impacts for gears used in Caribbean fisheries from high to low would be: bottom gillnets (high); pots/traps, bottom longlines, pelagic longlines (medium); hook and line (low).

The Council prohibited explosives and poisons due to the documented habitat damage associated with those methods, but the methods are briefly reviewed because of their historical use. While trawls are not used within the region, they are allowed for non-FMP fisheries (50 CFR 600.725).

Habitat impacts, recovery metrics, and management recommendations were extracted from the studies listed in Rester (2000), Barnette (2001), and Johnson (2002), and included in this section.

DeAlteris et al. (1999) stated that fishery-related impacts to fish habitat need to be compared to natural causes, both in magnitude and frequency of disturbance. Fishing can be adjusted or eliminated to complement particular habitats, whereas natural conditions continue unabated.
Depending on the intensity and frequency of fishing, its impacts may well fall within the range of natural perturbations. However, Hall (1999) pointed out that while it is important to appreciate the range of natural variation in disturbance from currents, wind, and waves so that fishing can be put into context, the fact that the natural range is large provides no basis for arguing that the additional perturbation imposed by fishing is inconsequential. Marine communities and their associated habitats have adapted to natural variation. Fishing impacts may introduce a variable that is beyond the range of natural impacts, potentially resulting in dramatic alterations in habitat or species composition. For example, Posey et al. (1996) suggested that deeper burrowing fauna are not affected by severe episodic storms, though fishing may still impact them. The study site was at a depth of 13m and samples were collected to a depth of 15cm below the substrate. “Deeper burrowing” was not defined, but it implies fauna living at a depth of 7 - 15cm (Jennings and Kaiser 1998) which is well within the depths disturbed by trawls and dredges (Krost and Rumohr 1990). Regardless, information from studies that include comparisons of fishery-related impacts to natural events have been included in the scope of this review.

All fishing has an effect on the marine environment, and therefore the associated habitat. Fishing has been identified as the most widespread human exploitative activity in the marine environment (Jennings and Kaiser 1998). Fishing impacts range from the extraction of a species, which skews community composition and diversity to reduction of habitat complexity through direct physical impacts of fishing gear. In addition, some gears kill or remove ecosystem engineer species, which may compound the impact that the gear has on the habitat (Coleman and Williams 2002).

The nature and magnitude of the effects of fishing activities depend heavily upon the physical and biological characteristics of a specific area in question. There are strict limitations on the degree to which probable local effects can be inferred from the studies of fishing practices conducted elsewhere (North Carolina Division of Marine Fisheries 1999). The extreme variability that occurs within marine habitats confounds the ability to easily evaluate habitat impacts on a regional basis. Obviously, observed impacts at coastal or nearshore sites should not be extrapolated to offshore fishing areas because of the major differences in water depth, sediment type, energy levels, and biological communities (Prena et al. 1999). Marine communities that have adapted to highly dynamic environmental conditions (e.g., estuaries) may not be affected as greatly as those communities that are adapted to stable environmental conditions (e.g., deep water communities). While recognizing the pitfalls that are associated with applying the results of gear impact studies from other geographical areas, due to the lack of sufficient and specific information within the US Caribbean it is necessary to review and carefully interpret all available literature in hopes of improving regional knowledge and understanding of fishery-related habitat impacts.

Various types of fishing gear and how each is utilized on various habitat types affect the resulting potential impacts. For example, longlines vary in length and line thickness, as well as their impacts to the seabed. Additionally, the intensity of fishing activities needs to be considered. Whereas a single incident may have a negligible impact on the marine environment, the cumulative effect may be much more severe. Within intensively fished grounds, the background levels of natural disturbance may have been exceeded, leading to long-term changes in the local benthic community (Jennings and Kaiser 1998). Collie (1998) suggested that, to a
large extent, it is the cumulative impact of bottom fishing, rather than the characteristics of a particular gear, which affects benthic communities. Unfortunately, a limitation to many fishing-related impact studies is that they do not measure the long-term effects of chronic fishing disturbance. Furthermore, one of the most difficult aspects of estimating the extent of fishing impacts on habitat is the lack of high-resolution data on the distribution of fishing effort (Auster and Langton 1999).

The effects of fishing can be divided into short-term and long-term impacts. Short-term impacts (e.g., sediment resuspension) are usually directly observable and measurable while long-term impacts (e.g., effects on biodiversity) may be indirect and more difficult to quantify. Even more difficult to assess would be the cascading effects that fishery-related impacts may have on the marine environment. Additionally, various gears may indirectly impact fish habitat. Bycatch disposal and ghost fishing are two of the better documented indirect impacts to fish habitat (Dayton et al. 2002). While recognizing that these are serious issues that pertain to habitat, this review does not attempt to discuss these due to the secondary nature of the impacts.

The majority of existing gear impact studies focus on mobile gear such as trawls and dredges. On a regional scale, mobile gear, such as trawls, impact more of the benthos than any other gear. However, other fishing practices may have a more significant ecological effect in a particular area due to the nature of the habitat and fishery. Yet there are few studies that investigate other gear types, especially static gear. Rogers et al. (1998) stated that there are few accounts of the physical contact of static gear having measurable effects on benthic biota, as the area of seabed affected by each gear is almost insignificant compared to the widespread effects of mobile gear. Regardless, static gear may negatively affect fish habitat and, therefore, must be considered.

The exact relationship that particular impacts have on the associated community and productivity is not fully understood. While it is clear that fishing activities impact or alter fish habitat, the result of those impacts or the degree of habitat alteration that still allow for sustainable fishing is unknown (Dayton et al. 1995; Auster et al. 1996; Watling and Norse 1998). Hall (1994) noted that not all impacts are negative. A negative effect at one level may sometimes be viewed as a positive effect at a higher level of biological organization – particular species may be removed in small-scale disturbances yet overall community diversity at the regional scale may rise because disturbance allows more species to coexist.

A “Symposium on Impacts from Fishery Activities to Benthic Habitats” was held in Tampa, Florida on November 11-15, 2002. The following is a summary of the meeting prepared by SSC member R. Boulon for the Council.

The driving force for this symposium was the question of the relationship of EFH and impacts to benthic habitats by fishing activities. This requirement was instrumental in the development of three questions that were defined as the goals for this symposium:

1. What have we learned about fishery impacts?
2. What more do we need to know?
3. What do we know enough about to act on right now?
While the vast majority of the habitat impact presentations dealt with trawling impacts to deep water soft bottom habitats in either the north Atlantic or north Pacific, there were a number of issues discussed that answered the above questions and would be generally applicable to us here in the Caribbean.

While considerable information exists on the actual physical impacts attributable to different fishing activities, little information on the long-term ecological and indirect effects of those impacts is available. For example, if a reduction in biomass as a consequence of fishing occurs, is it known if it is related to a reduction in animals or a reduction in body size? It has been found from various trawling studies that body size of benthic invertebrates in heavily trawled areas were 9 to 31% smaller than in untrawled areas. An indirect effect example comes from the North Sea where it has been found that Organotin and TBT in antifouling paints from fishing boats is producing high rates of imposex whelks (presence of male testes in females). This has caused a collapse of the whelk populations that in turn has caused a reduction in hermit crab populations as the whelk shells have become unavailable for use as homes. In general, the linkages between cause and effect, such as trophic cascades, are poorly understood when it comes to impacts from fishing activities. One presenter made it clear that if the geologic features of a habitat are destroyed and carrying capacity depends on these structures, changes in abundance and community composition may be permanent (irreversible).

There was one poster dealing with lobster trap impacts to seagrasses in which the authors found that soak times in excess of six weeks caused a reduction in seagrass densities. It was also noted that shrimp trawling significantly affected _Oculina_ coral reefs off Florida through destruction caused by the gear. Some very preliminary data was presented on impacts of traps to coral reefs in the Virgin Islands. Due to the preliminary nature of this data, it was difficult to ascertain the quantitative impacts. Some data was also presented on impacts to coral reef organisms such as sponges and soft corals from hook and line activities.

It was heard a number of times that the eventual goal should be ecosystem management with managers taking a broader view to protect the benthos. Some of the problems faced by managers attempting to do this include; first, generally too much fishing capacity (fishing presently goes on just about everywhere), second, cost-benefit analyses tend to work against managers (it’s very difficult to prove “long-term gain for short-term pain”), and third, sustainability is very complex, involving combinations of biological, ecological, economic and social factors.

However, the greatest need (and where very little information exists beyond nearshore, shallow-water areas) is accurate mapping of benthic habitats. Without knowing what exists and where it is, management measures to protect or conserve benthic habitat cannot be developed. The next step is identifying the level and distribution of fishing activities relative to our benthic habitats. Once mapped, habitats can be classified based on their availability (how much there is), their vulnerability (which is based on frequency of natural disturbance) and their risk (measured by frequency of disturbance from fishing activities).

A number of mapping methods were discussed, including digital side scan sonar, multibeam sonars, hyperspectral methods, and autonomous underwater vehicles. Each method has its own
strengths and weaknesses. In reality, a number of different methods should be used to exploit each method’s strengths so as to provide as complete a picture as possible.

In general, very little is known. Information is needed regarding where EFH is, what HAPCs exist, information on indirect effects of fishing activities, information on ecological linkages (functional relationships) within and between habitats and a number of other things. In some ways, the Caribbean region may have a somewhat better handle on impacts and effects than other locations where major fisheries occur in deep water.

With the current level of knowledge concerning impacts to habitats and the effects on populations of animals, it is clear that fisheries should be at least managed to ensure that disturbance is patchy within habitats. This primarily applies to soft-bottom habitats that have fairly rapid recovery rates and would not work in most hard bottom habitats. There was also mention of such things as zoned application of fishing gear and conservation engineering of fishing gear (reduction of “ecological footprint”).

However, the general consensus among presenters was that a considerable amount is known concerning what happens within no-take Marine Protected Areas (MPAs) and these probably represent the simplest and best effort for restoring populations of marine organisms and conserving representative habitats for the future. Although there is still limited information on what the effects are in waters surrounding MPAs, the preliminary information coming from places with MPAs is encouraging. In general MPAs should cover a broad range of habitats covering the habitats used by various ontogenetic stages of the most critical species (Lindeman et al. 2000).

3.5.1.2 Determination of identifiable adverse fishing effects

The following sections come primarily from Barnette (2001), supplemented with additional material.

3.5.1.2.1 Longline

Longlines use baited hooks on offshoots (gangions or leaders) of a single main line to catch fish at various depths, depending on the targeted species (Figure 3.3). The line can be anchored at the bottom in areas too rough for trawling or to target reef associated species, or set adrift, suspended by floats to target swordfish, tuna and sharks. Longlines are widely utilized in numerous fisheries throughout the Southeast Region, but to a limited degree in the US Caribbean. Benthic, or bottom, longlines have the greatest potential to adversely impact EFH, because they directly encounter bottom substrates. Pelagic longlines drift in midwaters, are not intended to contact the bottom, and therefore should not impact any benthic habitats.

Impacts
When a vessel is retrieving a bottom longline, hooks and line may be dragged across the bottom for some distance. The substrate penetration, if there were any, would not be expected to exceed
the breadth of the fishhook, which is rarely more than 50mm (Drew and Larsen 1994). The anchors or weights attached to the line may also impact the substrate (ICES 2000; Johnson 2002), but would probably have a small footprint. Based on these observations, it is logical to assume that longline gear would have a minimal impact on sandy or muddy habitat areas. More important is the potential effect of the bottom longline itself, especially when the gear is employed in the vicinity of complex vertical habitat such as sponges, gorgonians, and corals. Environmental factors such as strong currents and inclement weather may also affect the degree of impact to habitats (Hamilton 2000). Observations of halibut longline gear off Alaska included in a North Pacific Fishery Management Council Environmental Impact Statement (NPFMC 1992) provide some insight into the potential interactions longline gear may have with the benthos. During the retrieval process of longline gear, the line was noted to sweep the bottom for considerable distances before lifting off the bottom. It snagged on whatever objects were in its path, including rocks and corals. Smaller rocks were upended and hard corals were broken, though soft corals appeared unaffected by the passing line. Invertebrates and other lightweight objects were dislodged and passed over or under the line. Hooked fish were observed to move the groundline numerous feet along the bottom and up into the water column during escape runs, disturbing objects in their path. This line motion has been noted for distances of 15.2m (50ft) or more on either side of the hooked fish.

Bottom longline gear in the Caribbean is substantially lighter (often with monofilament groundlines) than the halibut longline gear (generally 5/16\textsuperscript{th} inch nylon or polyester rope as groundline) in Alaska described by Barnette. The Alaskan marine ecosystem is much different from that in the Caribbean, so specific damage assessment in Alaska may not directly apply to the Caribbean. Due to the vertical relief that hard bottom and coral reef habitats provide, it would be expected that longline gear might become entangled, resulting in potential impacts to habitat. Shearing actions of longlines under tension during hauling will have similar results whether monofilament or rope groundlines.

Lost or abandoned longline gear potentially causes two problems not discussed by Barnette (2001): ghost fishing and grappling to retrieve gear. Fishermen generally maintain as much control as practicable over the gear to prevent losses. However, gear sometimes becomes lost because of weather or accidents, and may be abandoned by fishermen in closed areas, when trying to avoid detection by enforcement. Longline gear continues to catch fish and possibly catches sea turtles if bait or fish parts remain on the hooks, and self-baits if captured fish subsequently attract and catch other fish. The gear stops fishing when all hooks are bare. Cumulative effects of lost longline gear could be significant. Retrieval of lost or abandoned gear typically occurs by dragging a grappling hook across the bottom to snag the line. Grappling would cause minimal habitat damage to soft or unstructured bottom, but could cause severe local damage to fragile habitat such as coral. The magnitude of the potential problems from lost gear has not been evaluated in the Caribbean.

Pelagic longlines do not impact benthic habitats except by accident. In most cases, pelagic longlines are set in water too deep for the lines to reach bottom. Lines and hooks will not adversely impact the water through which they float.
3.5.1.2.2 Vertical gear

Hook and line, handline, bandit gear, and rod and reel are widely utilized by commercial and recreational fishermen over a variety of estuarine, nearshore, and marine habitats. Hook and line may be employed over reef habitat or trolled in pursuit of pelagic species in both state and Federal waters.

Impacts
Few studies have focused on physical habitat impacts from these gear types. Although individual impacts may be low, there is concern over vertical gears due to the sheer numbers of fishers using them, especially in the recreational sector (Hamilton 2000). Also effort with vertical gears may be concentrated over favorite fishing areas, such as reefs, and anchor damage may occur as an associated impact (Hamilton 2000). Impacts may include entanglement and minor degradation of benthic species from line abrasion and the use of weights (sinkers). Schleyer and Tomalin (2000) noted that discarded or lost fishing line appeared to entangle readily on branching and digitate corals, and was accompanied by progressive algal growth. This subsequent fouling eventually overgrows and kills the coral, becoming an amorphous lump once accreted by coralline algae (Schleyer and Tomalin 2000). Lines entangled amongst fragile coral may break delicate gorgonians and similar species. Due to the widespread use of fishings weights and anchors over coral reef or hard bottom habitat and the concentration of effort over these habitat areas from recreational and commercial fishermen, the cumulative effect (from coral breakage) may lead to significant impacts resulting from the use of these gear types.

Anchoring practices by vertical gear vessels potentially causes a problem not discussed by Barnette (2001). If vertical gear fishermen anchor up-tide of a spot holding or expected to hold fish, the anchor set could occur on a reef or hard bottom. Some fishers may not pull up the anchor between sets. If so, they typically steam ahead, the anchor normally pops out of the sediment, and flies in mid water above the bottom because the anchor flukes act as a hydrofoil or wing. The magnitude of the potential problems from anchoring practices has not been evaluated in the Caribbean.
3.5.1.2.3 Traps and pots

Fish traps and pots in the US Caribbean (Figure 3.4) are rigid devices, non-selective, and used to entrap finfish or invertebrates. The traps or pots may be designed or modified, in some cases, specifically for one species (i.e., lobster). Generally baited, and equipped with one or more funnel openings, they are left unattended for some time before retrieval. Vinyl-coated wire traps of heavier gauge wire have a life expectancy of more than five years compared to lighter gauge, uncoated wire traps. Life expectancy can also be increased with the use of zinc anodes. Traps and pots, in most cases, are not are weighted to rest on the bottom. Depending on the commonwealth or territorial regulations, traps may be marked with buoys at the surface (although not always), and are sometimes attached to numerous other traps via one long line, called a trap line. Traps and pots are widely used on a variety of habitats in both state and Federal waters to harvest species such as lobster, snapper, and grouper. Wire-mesh fish traps are one of the principal fishing gears used in coral reef areas in the Caribbean, and the most common type is the Antillean “arrowhead” or “chevron” style weighing about 20 kg (Appeldoorn et al. 2000).

Impacts
Due to their use to harvest species associated with coral and hard bottom habitat, traps and pots have been identified to impact and degrade habitat. US Caribbean fishers who have been interviewed have usually stated that they set traps on habitats near coral reefs (e.g. hard bottom, seagrass, sand, algal plain, rubble), but not on the reefs themselves (Scharer et al., in press; Sheridan et al., in review). Scharer et al. (in press) stated that low-medium relief hard bottom was targeted by 38% of Puerto Rican trap fishers interviewed, while 11% targeted vegetated habitats, 10% targeted the coral reefs, and 12% targeted sand. Among 30 trap fishers from St. Croix and St. Thomas, 20% said that they set a portion of their traps in coral reef habitats and all were from St. Croix where reef habitat dominates (Sheridan et al., in review). The 142 trap reported on coral represented about 3% of the 4900 traps used by surveyed fishers.

Hunt and Matthews (1999) found that lobster and stone crab traps reduce the abundance of gorgonian colonies from rope entanglement. Furthermore, seagrass smothering occurs from trap placement on SAV beds, resulting in SAV “halos.” However, Uhrin et al. (unpublished) found that lobster pots in the Florida Keys caused significant damage only after six weeks on seagrass (Thalassia testudinum and Syringodium filiforme). Manatee grass, T. testudinum, but not turtle grass, S. syringodium, recovered four months after removal of the traps.

Gomez et al. (1987) noted the incidental breakage of corals on which traps may fall or settle, constitutes the destructive effects of this gear. Van der Knapp (1993) noted that fish traps set on staghorn coral in Bonaire, Netherlands Antilles, easily damaged the coral. It appeared that in all observed cases of injury due to traps, the staghorn coral regenerated completely, although the time for regeneration varied from branch to branch. The greatest impact noted from the setting of traps was observed when the point of the trap’s frame ran into coral formations. Several different species of coral were observed to suffer damage from fish traps. Observations of at least one damaged coral specimen noted that algae growth prevented regeneration in the damaged portion of the coral. Additionally, complete deterioration of a vase sponge was observed after it had been severely damaged by a trap. Traps are not placed randomly; rather they are fished in specific
areas, multiple times, before fishing activity moves to other grounds. Therefore, trap damage will be concentrated (cumulative effect) in particular areas, rather than be uniform over all coral reef habitats.

Eno et al. (1996) found pots that landed on, or were hauled through, beds of bryozoans caused physical damage to the brittle colonies. It was noted that several species of sea pens bent in response to the pressure wave created by a descending pot and lay flat on the seabed. When uprooted, the sea pens were able to reestablish themselves in the sediment. A species of sea fan also was found to be flexible and specimens were not severely damaged when pots were hauled over them. Eno et al. (2001) observed effects of pots (creels and three types of crustacean pots) set in water depths ranging from about 14-23 m, over a wide range of sediment types in Great Britain: mud communities with sea pens, limestone slabs covered by sediment, large boulders interspersed with coarse sediment, and rock. Observation demonstrated that sea pens were able to recover fully from pot impact (left in place for 24-48 hours) within 72-144 hours of the pots being removed. Pots remained static on the seafloor, except in cases where insufficient line and large swells caused pots to bounce off the bottom. When pots were hauled back along the bottom, a track was left in the sediments, but abundances of organisms within that track were not affected. This suggests that in some instances the direct contact of certain gears may not be the primary cause of mortality; rather the frequency and intensity may be more important.

Additionally, Sutherland et al. (1983) cited little apparent damage to reef habitats inflicted from fish traps off Florida. The study found four derelict traps sitting atop high profile reefs with four other traps observed within a live-bottom area. There was no visual evidence that traps on the high profile reef, killed or injured corals or sponges. One uprooted gorgonian was observed atop a ghost trap in a live-bottom area. However, these observations were made on randomly located derelict traps. Thus, the primary impacts that may occur during deployment and recovery could not be evaluated.

Appeldoorn et al. (2000) commented that traps physically damage live organisms, such as corals, gorgonians, and sponges, which provide structure and in some cases, nutrition for reef fish and invertebrates. Damage may include flattening of habitats, particularly by breaking branching corals and gorgonians; injury may lead to reduced growth rates or death, either directly or through subsequent algal overgrowth or disease infection. During initial hauling, a trap may be dragged over more substrate until it lifts off the bottom. Traps set with trap lines connecting the pots can cause further damage, from the trap line being dragged across the bottom, potentially shearing off at their base those organisms most important in providing topographic complexity. Traps that are lost or set unbuoyed are often recovered by dragging a grappling hook that sometimes impacts the bottom. This practice can result in dragging-induced damage from all components (grappling hook, trap, trap line). The area swept by trap lines upon recovery is orders of magnitude greater than the cumulative area of the traps themselves. However, fishers typically use floating trap lines, which generally precludes the need to grapple on the bottom for unbuoyed trap strings (Sheridan, Hill, and Kojis, in review; Sharer et al. in press). Additionally, fishers use more line between pots/traps than the water depth and pull pots vertically, which would help in retrieval of a pot without disturbing the next pot (Sheridan, Hill, and Kojis, in review; Sharer et al. in press).
Appeldoorn et al. (2000) documented that single-buoyed fish traps off La Parguera, Puerto Rico, have an impact footprint of approximately 1 m$^2$ on hard bottom or reef. Of the traps investigated in the study, 44% were set on hard bottom or reef (principally in high-relief coral at 18% and low-relief hard bottom at 15%). Traps were also found in sand or mud (45%), sand with invertebrates or macroalgae (9%), and seagrass (2%). Traps set in hardbottom or reef areas resulted in 23% damage to coral colonies (70 cm$^2$ average), 34% damage to gorgonian colonies (56 cm$^2$ average), and 30% damage to sponges, though sponges were less frequently impacted due to their patchy distribution. Trap hauling resulted in 30% of the traps inflicting additional damage to the substrate. Traps constructed of lighter materials like wood or plastic (as opposed to metal traps) may be prone to greater potential for damage habitat because they are moved more readily by swells and currents (Scharer et al., in press). Valdez-Pizzini et al. (1997) and Jean-Baptiste (1999) studied trap distributions off Lajas and reported that the majority of traps were found on algal plains and sand habitats.

Within the Virgin Islands State Park, Garrison (1998) found 86% of the fish traps were set on organisms (live coral, soft coral, SAV) living on the sea floor. Damage to the live substrate has far-reaching negative effects on the marine ecosystem because the available amount of shelter and food often decreases as damage increases. Subsequently, Garrison (1997) found that 82% of traps rested directly on live substrate, with 17% resting on stony corals. Garrison et al. (in press) surveyed 295 traps around St. John, and reported that 16% were located on hard coral reefs, 27% on octocoral hard bottoms, and 31% on algal plains.

In a similar study focusing on fish trap impacts conducted off St. Thomas (Quandt 1999), 40% of 18 traps investigated were found to be resting on reef substrate, which is substantially different (lower %) than Garrison’s (1997, 1998) results. On average, 4.98% of all hard corals and 47.17% of all gorgonians were damaged; tissue damage averaged 20.03% to each gorgonian. On average, a pot damaged about 10 cm$^2$ of coral habitat. Secondary impacts, such as trap hauling and movement due to natural disturbances were not investigated. However, the effects of pulling a string of two or more traps would most likely be much greater than one trap alone. Quandt assumed that a pot was fished each week. USVI fishing records indicate about 5,000 traps in use around St. Thomas and St. Croix (USVI Fish and Wildlife, pers. comm. to Barnette). Projecting 40% of 5,000 traps on reef substrate and a 10-cm$^2$ damage per pot results in an estimate of 104 m$^2$ of reef damage per year for the USVI (Quandt 1999). This estimate is likely an upper limit, as the proportion of traps on coral reefs is considerably less than 40% in most studies reviewed in this Section.

Preliminary results from a multi-year study of trap distributions in the Florida Keys and the US Caribbean used boat-based surveys in conjunction with shallow water NOS habitat maps (<30m depth) to estimate the distribution of traps among habitats (Sheridan et al. 2003). In addition, limited diver surveys were also done. In the Puerto Rico boat-based surveys, 48% of traps were estimated to occur in coral and hard bottom habitats, 47% in unknown habitat, 3% in seagrass, and 2% in macroalgae. Diver surveys corroborated these estimates in Puerto Rico. For boat-based locations of pots in the USVI plotted on the NOS habitat maps, 54% of traps were estimated to occur in coral, 30% in unknown habitat, 11% in seagrass, 5% in macroalgae, 1% in bare substrate, and 0% in sponge/gorgonian (i.e. hard bottom) habitat. However, USVI diver surveys painted a substantially different picture of trap distribution with 32% in bare substrate,
29% in sponge/gorgonian, only 14% in coral, 13% in seagrass, and 11% in macroalgae (Sheridan et al. 2003). This may indicate that the habitat maps used for the boat-based surveys are not of a sufficient resolution to allow determination of the actual habitat that a trap was resting on.

The above US Caribbean studies varied widely in the percentage of traps estimated to be deployed on coral reef habitat, and in many cases, hard bottom gorgonian-sponge habitat was included with coral. Most studies covered small areas, were restricted to one season, or observed a small number of pots. Additionally, the distribution of traps may change seasonally based on the biology of target organisms or weather/sea state factors (Sheridan et al. 2003; Scharer et al. in press; Sheridan et al., in review). Therefore, the results may not be representative of the US Caribbean as a whole. The lack of consistency among studies makes it difficult to reliably determine the level of trap/pot effort in coral reef habitat. Sheridan et al. (in review) concluded that only a small percentage (<20%) of traps set in water shallower than 30 ft actually contacted coral, gorgonians or sponges. Ron Hill (NOAA Fisheries, Galveston TX, pers. comm.) concurred with the results of Sharer et al. (in press) that few pot or trap fishers actually target coral reefs, but that they try to set near the reefs. Most USVI trap fishers interviewed by Sheridan et al. (in review) said that they fished their traps in more than one habitat.

Pot and traps may also cause ghost fishing. Biodegradable panels or fastenings prevent ghost fishing, but only after the biodegradable portions deteriorates and the pot or trap opens, and only if fishers use them. Length of time for deterioration has not been studied in the Caribbean. Garrison et al. (1998) found that over 50% of the fish traps examined had no functioning biodegradable panels to allow fish to escape if the traps were lost, leading to “ghost fishing.”

3.5.1.2.4 Spears and powerheads

Divers use pneumatic or rubber band guns (Figure 3.5) or slings to hurl a spear shaft to harvest a wide array of fish species. Reef species such as grouper and snapper, as well as pelagic species such as dolphin, are targeted by divers. Commercial divers sometimes employ a shotgun or pistol shell known as a powerhead at the shaft tip, which efficiently delivers a lethal charge to their quarry. This method is commonly used to harvest large species.

Impact

Gomez et al. (1987) concluded that spearfishing on reef habitat may result in some coral breakage, but damage is probably negligible. A study that assessed recreational SCUBA activity in the US Caribbean (Garcia-Moliner et al. 2000) concluded that approximately 0.7% of the total recreational divers in the USVI and 28% of the total recreational divers in Puerto Rico are spearfishing. Potential impact would be approximately 4,736 units in the USVI and 220,264 units in Puerto Rico. In this study, impact units consisted of hands and feet (4 units per diver) and impact was broadly defined, as ranging from touching coral with hands to the resuspension of sediment by fins. No assessment of habitat degradation or long-term impacts was discussed. It may be assumed that divers pursuing pelagic species have no effect on habitat due to the absence of any interaction with the benthos.
3.5.1.2.5 Gillnet & trammel net

Gillnets (Figure 3.6) consist of a wall of netting set in a straight line, equipped with weights at the bottom and floats at the top, and is usually anchored at each end. As fish swim through the virtually invisible monofilament netting, they become entangled when their gills are caught in the mesh, hence the name. Gillnets may be fixed to the bottom (sink net) or set midwater or near the surface to fish for pelagic species. A trammel net (Figure 3.7) is made up of two or more panels suspended from a float line and attached to a single lead line. The outer panel(s) is of a larger mesh size than the inner panel. Fish swim through the outer panel and hit the inner panel that carries it through the other outer panel, creating a bag and trapping the fish.

Impacts

Gill nets that are fished mid-water do not contact the substrate and do not impact fish habitat. The majority of the studies that have investigated impacts of fixed gillnets fished on the bottom have determined that they have a minimal effect on the benthos (Carr 1988; ICES 1991; West et al. 1994; ICES 1995; Kaiser et al. 1996b; ASMFC 2000). However, Carr (1988) noted that ghost gillnets in the Gulf of Maine could become entangled in rough bottom. Williamson (1998) noted that gillnets can snag and break benthic structures. Gomez et al. (1987) noted that gill nets set near reefs occasionally results in accidental snarling, often resulting in damage to coral. Bottom gillnets set over coral may cause negative impacts as the weighted lines at the base of the net often become entangled with branching and foliaceous corals. As the nets are retrieved, the corals are broken (Breen 1990; Öhman et al. 1993; Jennings and Polunin 1996; ICES 2000).

Use of SCUBA to set and retrieve gill/trammel nets occurs in waters around St. Croix (W. Tobias, VIDPNR, St. Croix, personal communication). This technique is similar to the muro-ami fishing practice formerly used and now banned in Asian countries. Muro-ami used free divers to set nets in and around coral and to drive fish into the nets by beating on the bottom (Burke et al., 2002). Divers broke and fragmented coral by standing on it to set nets, and by beating on it during the fish drives. Use of SCUBA provides USVI fishers with a mechanism to carefully retrieve gill and trammel nets without damaging coral (Robert McAuliffe, Fishermen’s United Services Cooperative of St. Croix, personal communication), but observations of careless net retrieval has documented damage to coral from gill/trammel nets (William Tobias, VI DPNR, personal communication).

Aside from the potential impacts cited on coral reef communities, the available studies indicate that habitat degradation from gillnets is minor. Several studies note that lost gillnets are quickly colonized by marine species (Carr et al. 1985; Cooper et al. 1988; Erzini et al. 1997). Some netting would contact reef habitat, becoming heavily overgrown and eventually blended into the background. Erzini et al. (1997) noted that the nets eventually became incorporated into the reefs, acting as a base for many colonizing plants and animals. The colonized nets then provided a complex habitat that was attractive to many organisms and may provide a safe haven from predators. Johnson (1990) and Gerrodette et al. (1987) noted that as gillnets tend to collapse and “roll up” relatively quickly, they may form a substrate for marine growths and thereby attract fish and other predators which may get entangled. Therefore, gillnets may be more of a ghost fishing problem and entanglement hazard to marine life than as an impact to habitat.
3.5.1.2.6 Beach seines

Beach seines are active fishing gears consisting of a long fence-like wall of netting, with floats along the top of the net and a series of evenly-spaced weights along the bottom of the net, called a leadline. The wall of netting composing the seine, is meant to stretch from the surface of the water to the bottom. Beach seines are deployed off the shoreline in a semi-circle to trap fish between the shore and the net, the net is then pulled in, and fished while still in the water to release juvenile and undesirable fishes. They are used in state waters.

Impacts
Sadzinski et al. (1996) found that seining had no detectable effects on brackish SAV (Vallisneria and Hydrilla) plant density, height, or species composition in Chesapeake Bay, but did they not assess possible damage to SAV reproductive structures (e.g. – flower shearing). There is a possibility of damage to SAV sites where seines are hauled repeatedly over the same spots over long periods of time (Barnette 2001). Barnette also states that since seines are generally set in flat benthic areas, to avoid net snags and damage, their impact on habitat impact is expected to be minor and temporary.

3.5.1.2.7 Chinchorro

Chinchorros are modified beach seines used in the US Caribbean, that have longer lines used to pull the net to shore. The longer lines allow use of the nets in deeper water further from shore (CFMC 2001). In some cases, boats set the nets further off the shore and encircle the net at sea rather than pull it to shore.

Impacts
Evaluation of this gear has not been reported in the literature. However, it should have impacts similar to those of beach seines, but with a wider extent of impacts because of the wider area of use.

3.5.1.2.8 Cast net

Cast nets are circular nets with a weighted skirt, which are thrown from land or boats over schooling fish. When thrown properly, cast nets spread out and land on the water flat and circular. The weighted perimeter of the net then sinks to the bottom, trapping the fish or invertebrates within. The cast net also has a series of “brail lines” running from the net’s perimeter and up through a large eyelet in the center of the net, where they all meet and connect to a single hand line. Once the cast net has been thrown and sunk, the brail lines can be pulled through the eyelet, causing the bottom of the net to be effectively pursed, so the fish can be landed. These nets are usually used in estuaries and nearshore areas to catch baitfish, mullet, and shrimp.
Impacts
Cast nets can become entangled on encrusted or jagged bottoms with vertically-oriented organisms like sponges, which can be damaged or dislodged in the net retrieval process (Barnette, personal observation; Rydene, personal observation). DeSylva (1954) however found that cast nets had no detrimental effect on habitat.

3.5.1.2.9 Hand harvest

Hand harvest describes activities that capture numerous species by hand. Target species include spiny lobster and queen conch.

Impacts
Impacts may result from divers contact with corals, and re-suspension of sediments, however, there is a lack of scientific investigation on potential impacts to reef fish habitat (Barnette 2001).

There is also a market for calcareous material and attached marine life to decorate marine aquaria. “Live-rock” is an assemblage of living marine organisms attached to a hard substrate such as dead coral or limestone. Harvest of coral and live-rock removes the substrate from the environment at rates faster than natural replenishment. Such harvest in the Caribbean is addressed by the FMP for Coral and Coral Reefs of the Caribbean. Coral reefs, hard corals and sea fans are protected by federal, Puerto Rico, and USVI regulations. Taking or damaging them is prohibited.

3.5.1.2.10 Slurp gun

A slurp gun (Figure 3.8) is a self-contained, handheld device that captures tropical fish by rapidly drawing seawater containing such fish into a closed chamber. Slurp guns are typically employed on hard bottom and coral reef habitat in both state and Federal waters.

Impacts
It is possible that tropical collectors may impact coral or other benthic invertebrates in pursuit of tropical species that are harvested on hard bottom or coral habitat areas. However, due to the limited force applied by a diver in an errant fin kick or hand placement, the likely effects to habitat would be minor.

3.5.1.2.11 Snare, dipnet & bully net

Widely utilized to catch baitfish, crabs, or lobster, varieties of dipnets (Figure 3.9) consist of a long pole with a bag of netting of varying mesh size that are lowered into the water. Dipnets may also be employed to capture tropical reef fish (Figure 3.10), though these utilize a short handle and very fine mesh. Additionally, landing nets or hand bully nets used to capture lobster can be considered a form of dipnet. Varieties of dipnets may be used both in state and Federal waters.
Snares consist of a handle which houses a retractable cable loop, which can ensnare a lobster’s tail.

Impacts
DeSylva (1954) determined that dipnets have no detrimental effect on habitat. However, the use of small dipnets (i.e., tropical fish nets and lobster hand bully nets) may result in minor isolated impacts to coral species as individuals attempt to capture specimens (Barnette personal observation).

3.5.1.2.12 Prohibited gears

Trawls
Trawling is prohibited in fisheries under the FMPs of the Caribbean Council, but allowed for non-FMP fisheries. Fishers do not currently use trawl gear in the US Caribbean region. However, fishers have inquired about using trawls in the areas (R. Nemeth, UVI, personal communication). The following discussion on trawls recognizes a potential for future use of the gear. Otter trawls (Figure 3.11) pursue a variety fish and invertebrate species in the United States. As the most extensively utilized, towed bottom-fishing gear (Watling and Norse 1998), trawls have been identified as the most widespread form of disturbance to marine systems below depths affected by storms (Watling and Norse 1998; Friedlander et al. 1999).

Impacts
The trawl is one of the most studied gear types, thus, there is a wealth of information on its potential impacts to habitat. Jones (1992) broadly classified the way a trawl can affect the seabed as: scraping and ploughing; sediment resuspension; physical habitat destruction, and removal or scattering of non-target benthos. Trawl gear can vary greatly in design, but in general, the various parts of trawl gear that may impact the bottom include the doors, tickler chains, footropes, rollers, and the belly of the net, depending on its operation and towing speeds. Although the passing of one trawl net over a specific bottom site may be relatively minor, the cumulative effect and intensity of trawling may generate long-term changes in benthic communities (Collie et al. 1997; NRC 2002).

Trawling has the potential to reduce or degrade structural components and habitat complexity by removing or damaging epifauna; smoothing bedforms (which reduces bottom heterogeneity), and removing structure producing organisms. Trawling may change the distribution and size of sedimentary particles; increase water column turbidity; suppress growth of primary producers; and alter nutrient cycling The magnitude of trawling disturbance is highly variable. The ecological effect of trawling depends upon site-specific characteristics of the local ecosystem such as bottom type, water depth, community type, gear type, as well as the intensity and duration of trawling and natural disturbances. Trawls used in soft bottoms may remove several centimeters of sediment, and these trawl tracks may still be present more than a year later (Ball et al. 2000). A reduction in coverage; loss of rhizomes; sediment suspension as well as smothering of SAV may occur as a result of otter trawl use (Guillen et al. 1994). Reduction of epifaunal coverage; smoothed bedforms; compression of sediments; sediment suspension (fines); reduction in depth of oxygenated sediments have also been noted to result from the use of otter trawl gear.
(Thrush et al. 1998; Sainsbury et al. 1997; Schwinghamer et al. 1998). Moreover, when chain gear was used, there was loss or damage to epifaunal coverage within sand bottom areas (Smith et al. 1985). Also noted in sand bottoms, well-buried boulders removed and displaced sediment; trawl doors smoothed sand waves and penetrated seabed 0-40 mm (Bridger 1970). When comparing closed areas vs. trawled areas in hard bottoms, there was a reduction in size and density of bryozoan colonies in the trawled areas (Bradstock and Gordon 1983). Trawled areas showed mussel beds of lower structural complexity and less attached epibenthos compared with untrawled areas in hard bottoms (Magorrian 1996). Within muddy sand bottoms otter trawls caused a reduction of epifaunal coverage; smoothed bedforms; compression of sediments; sediment suspension (fines) and a reduction in depth of oxygenated sediments (Thrush et al. 1998; Bridger 1970; de Groot 1984).

No direct relationship exists between the overall amount of trawling effort and the extent of subsequent impacts or the amount of fauna removed because trawling is aggregated and most effort occurs over seabed that has been trawled previously (Pitcher et al. 2000). Yet, several studies indicate that trawls have the potential to seriously impact sensitive habitat areas such as SAV, hardbottom, and coral reefs. In regard to hardbottom and coral reefs, it should be recognized that trawlers do not typically operate in these areas due to the potential damage their gear may incur.

Low-profile, patchy hardbottom or sponge habitat areas are more likely impacted from trawls due to the gear’s ability to work over these habitat types without damaging the gear. In general, trawling in areas with any rigid vertical structure causes a loss of habitat complexity (Auster et al. 1996; NRC 2002), and this loss may lead to a shift toward epibenthic species that prefer open bottom (Sainsbury 1988; Sainsbury et al. 1994). While it may be concluded that trawls have a minor overall physical impact when employed on sandy and muddy substrates, the available information does not provide sufficient detail to determine the overall or long-term effect of trawling on regional ecosystems.

Poison/chemicals
Poisons and chemicals are prohibited in the US Caribbean, but were likely used in the past, and are still thought to be used illegally at present by some fishers. Traditional communities have long used natural poisons to capture fish. However, these practices were typically small-scale and had only incidental consequences. Today, poison fishing is far more damaging (Burke et al. 2002). The divers crush cyanide tablets into plastic squirt bottles of seawater and puff the solution at fish on coral heads. Fish often flee into crevices, obliging the divers to pry and hammer the reefs apart to collect their stunned prey (Barber and Pratt 1997). Collectors of live tropical reef fish commonly employ anesthetics such as quinaldine. Quinaldine (2-methylquinoline, C_{10}H_{9}N) is the cheapest and most available of several substituted quinolines (Goldstein 1973). Bleach is still used in the capture of octopi, and these fishers may cause additional habitat damage by walking on top or reefs to locate an octopus cave.

Impacts
The poison acts as an anesthetic, stunning fish and making targeted fish easier to capture. Other fish are damaged, killed, or left exposed to predation as the poison stuns them. Poisons directly
affect coral. Initial exposure can cause effects ranging from slight to full coral bleaching, and repeated applications of cyanide may cause coral death (Barber and Pratt 1997). Systematic scientific testing of the impact of cyanide on reefs is scanty, but tests show that cyanide kills corals, and its toxic effects on fish are well known. Anecdotal evidence of the poison's lethal effects on the reef comes from countless scuba-diving operators, field researchers, and cyanide fishermen themselves. The process of cyanide fishing itself indisputably wreaks havoc on coral reefs (Barber and Pratt 1997). Short-term impacts of quinaldine include increased flocculent mucus production, retraction of polyps and failure to reexpand with a five-minute observation period, and tissue discoloration in certain species (Japp and Wheaton 1975). Japp and Wheaton (1975) determined that quinaldine exposure resulted in minimal damage to corals.

**Explosives**

Explosives are prohibited in the US Caribbean. The use of explosives for fishing has never been sanctioned by law (Sievert 1999). In the past, the use of explosives to collect fish specimens was allowed in some parts of the world. Explosives assure bigger catches because they are used only when there is a school of fish. Blast fishers often bring along other gear such as hook and line, spear guns, air compressors, poisons, fish pots and a variety of nets (Sievert 1999).

**Impacts**

An underwater explosion makes a series of waves that spreads in the water (Sievert 1999). An initial high-intensity shock wave is generated, followed very closely by less severe pressure waves of diminishing intensity that nonetheless add to the total impact. According to Sievert (1999), fish with air or swim bladders - that is, most bony fishes - are the most vulnerable. The waves of the blast increase the pressure within their bladder, more so when the fish are near the water's surface. Ordinarily, however, fishers are not able to collect all the fish hit by the explosion. The fish affected by the blast may be distributed over a wide area; currents carry some away; others may have sunk to the bottom, too deep for diving even with the use of compressed air (Sievert 1999). Within its relative effective range, the explosion upsets the established community of organisms, as well as their food webs, as the blast also strikes non-targeted, non-commercial species, juvenile fish, plankton, corals, shellfish and other invertebrates, sea mammals, turtles and birds (Sievert 1999). An explosion on or near a coral reef physically alters the reef, leveling and creating a crater, breaking the corals into rubble, reducing its relief and complexity as a habitat and lessening its aesthetic appeal. Blasted reefs support fewer fish species and lower fish biomass, thus resulting in lower fishery production. They also take a long time to recover (Sievert 1999).

**3.5.1.2.13 Summary of impacts**

Different gears affect habitats to different degrees. Mobile gears, for example trawls and dredges, have a potential to affect habitat over a wide area, because the gear moves over the habitat. Other gears fish primarily in a fixed spot, so affect habitat in only that spot. The damage from a single encounter in either case can range from severe to negligible. However, EFH requires a functional relationship between habitat and fish, so habitat is protected for its function for fish, not for its own sake. At this time, no information exists to relate fish production to habitat, so production is not explicitly considered. Combining these concepts – extent of a single contact, degree of
damage from a single encounter, and impaired function for fish – leads to a ranking of habitat damage. These ranks are explained in Table 3.14. Thus, damage in a high category would involve widespread and severe damage from a single encounter that seriously impairs the function of that habitat for fish, while negligible would indicate no damage and no impairment. A high impact gear used with low total effort could lead to less total damage than a moderate or minor gear used at high total effort. The rankings below do not consider the effects resulting from the total effort used. The effects of effort are factored in during a later step.

A December 1999 EFH Workshop attended by NOAA Fisheries scientists and managers, also addressed fishing impacts, and examined which gear impact studies were relevant to the Southeast region (Hamilton 2000, Barnette 2001). The criteria included whether the specified gear was utilized in the Southeast Region, whether it was utilized in the same manner (similar fisheries), and whether the habitat was similar. This review recognized that in many instances numerous epifaunal and infaunal species are an integral part of benthic habitat. To a great extent Table 3.15(a) is based on a table that ranked gear impacts on different habitats, which was generated as part of the aforementioned workshop. While the table from the 1999 workshop included all the gears under consideration in the US Caribbean, some of the Caribbean habitats were not included (mangrove, reef, benthic algae, wetland, drift algae, shoals/banks). For fishing gear/habitat combinations not covered in the workshop table, inferences could sometimes be made relating the effect of the gear to a similar type of habitat (e.g. gear effects on benthic algae would be more or less the same as gear effects on seagrass). In cases where this was not possible, ranks were assigned based on whatever scientific literature was available and best professional judgement.

The NOAA Fisheries EFH Workshop and Barnette (2001) did not consider anchoring as a fishing gear, but recognized that many fishing vessels anchor during the course of fishing. Vessels that move from site to site frequently during a fishing trip, and anchor at each site, may cause substantial damage by dropping anchors on sensitive habitats.

Table 3.15(b), which shows the relative use of gears among habitats, was based on Puerto Rico total landings data by fishing gear for the years 1998-2000 (Matos-Caraballo 2001). These landings data did not give an indication of the habitat each gear was used in, but the landings values were used to show the possible maximum value for use that a gear could have. Total landings were calculated for all gears, gears were then ranked by landings, the ranks divided into quartiles, and each gear assigned one of four potential maximum-use ranks based on the quartile the gear occurred in. The actual value assigned to a gear/habitat combination was based on a best professional judgement on how commonly a gear is traditionally used in a particular habitat.

Of the gears used in the US Caribbean (state and federal waters) pots and traps, longline, vertical gear, and gillnets and trammel nets have the highest individual impact and the greatest potential for adverse damage to fish habitat (Table 3.15). Hand harvest of coral and live/hard bottom, if it were allowed, could also cause substantial habitat damage. Of the habitat types considered in the US Caribbean, coral has the greatest vulnerability to fishing impacts, followed by hard bottom and SAV. Barnette (2001) noted that several gears have negligible or minimal impacts on fish habitat, but that this conclusion was based on limited information. For the Caribbean region, specifically, less information is available than in other regions. Reduction of coral and reef
heterogeneity due to damage or removal of physical structure can seriously impact available
shelter for juvenile fishes and post-settlement larvae, and there is likely a correlation between
topographic relief and fish abundance (Luckhurst and Luckhurst 1978). However, conclusions
drawn on impacts, or lack of impacts, should be made cautiously.

3.5.1.3 Region-specific and fishery-specific information

The authorized gear used in each fishery (Table 2.9) is briefly described below with reference to
the Caribbean habitats where gears are used.

3.5.1.3.1 Caribbean Spiny Lobster FMP

**The trap/pot fishery** primarily targets lobsters in seagrass beds, algal plains and areas adjacent
to coral reefs. Traps or pots are usually of arrowhead or square wood box design. Typically
numerous traps are attached with lines from one to one another and attached at either end to
surface buoys marked with the fisher’s identification. Impacts to habitat can occur if traps are set
on top of or dragged into coral reefs or other fragile habitats.

**The dip net fishery**, using hand held dip nets, targets lobsters in coral reef and seagrass habitats.
Potential impacts include dislodging small coral heads and breaking corals.

**The entangling net fishery**, using gillnets and trammel nets, targets lobsters, most probably in
hard bottom, but there is little information available to the Council regarding the specifics. These
nets are used during the spiny lobster migrations, the only time at which the lobsters are
numerous and in the open areas. These nets are usually 245 m long and 3 m deep with a mesh
size between 0.6 and 15.2 cm, and are fished on the bottom. Impacts include damage to corals
when nets are pulled out of the water in areas with patchy distribution of corals.

**The recreational fishery** utilizes all of the same gears as the commercial fishery – dip nets,
traps, pots, gillnets, trammel nets, snare, and hand harvest – and the potentials for impacts would
be the same as for the commercial fishery.

3.5.1.3.2 Caribbean Reef Fish FMP

**The longline/hook and line fishery** targets reef fish in shallow and deep coral reef, seagrass
lagoon, deep seagrass bed, algal plain habitats. Longlines are typically 213 m long; hook and line
includes hand lines (1 to various hooks per line) and bottom lines (average 11 hooks) lifted either
manually or with an electric winch.

**The trap/pot fishery** harvests reef fish from seagrass, algal plains and areas adjacent to coral
reef habitats. Traps are typically Antillean (or chevron) style fish traps, approximately 1 x 1 m
and ½ m high. Wire mesh of 2 inches is accepted, biodegradable side panels are required to
allow fish to escape and reduce ghost-fishing from lost traps. Numerous traps are typically attached to one another with lines and attached at either end to surface buoys marked with the fisher’s identification. Impacts to habitat can occur if traps are set on top of or dragged into coral reefs or other fragile habitats.

The entangling net fishery targets reef fish using gillnets and trammel net of various configurations. Common gillnets utilize monofilament line with the same average dimensions described for the spiny lobster fishery, as well as for the common trammel nets. They are normally deployed in channels, seagrass beds, encircling mangrove islands on algal plains or near coral reef habitats. They are normally fished for an average 5 hours, but soak time varies greatly. Possible impacts to habitat could include entanglement and breakage of hard and soft corals, trampling of seagrasses, and stirring up fine sediments (short term effect). In addition to direct damage to coral and hard bottom habitats, net use causes indirect damage by accounting for a high proportion of harvest of the herbivorous parrotfish. Declining parrotfish allows increased algae growth on coral and hard bottom areas, and leads to declining coral recruitment, a problem that appears more severe in USVI (William Tobias, USVI DPNR, personal communication) than in Puerto Rico (Daniel Matos, PR DNER, personal communication). Different techniques are typically used in Puerto Rico and the USVI. The USVI net fishery is shifting from gillnets to trammel nets and primarily harvests parrotfish. Fishers use SCUBA to set the nets, usually around vertical structure such as coral and hard/live bottom, and use SCUBA to drive the fish into the nets. While divers also allow careful retrieval of the nets to avoid coral structure (Robert McAuliffe, Fishermen’s United Services Cooperative, St. Croix, personal communication), careless retrieval has caused damage to the coral structures (William Tobias, USVI DPNR, personal communication). These fishers rarely set on benthic algae or seagrass habitats. The Puerto Rico net fishery uses primarily gill nets to target yellowtail snapper and parrotfish, and fishers rarely use SCUBA or set nets in coral areas because of damage that results to the nets from tangling on coral (Daniel Matos, PR DNER, personal communication).

The beach seine-chinchorro fishery occurs fairly near shore; fishers may pull both gears directly onto the shore (CFMC 2001), but chinchorros may be used independently of the shore. In both cases, fishers prefer to fish on smooth bottoms to minimize snagging and damage to the nets. However, beach seines-type gears are used in and damage areas with isolated coral and hard bottom (Miguel Canals, Guanica Reserve, Puerto Rico, personal communication).

The recreational fishery for reef fish is pursued with traps/pots, dip nets, handlines, rods and reels, slurp guns, and spears. Slurp guns are generally tubular in shape and utilize water pressure to capture fish. Both dip nets and slurp guns are used primarily to capture small species and/or juveniles for personal aquaria or for the aquarium trade. Handlines and rod and reels target larger species including snappers, groupers, barracudas, porgies, pelagics, and other species. They are typically fished over or around coral reef habitats. They have the potential to snag or hang on hard and soft corals, rocks, and patchy corals over seagrass beds. Recently concerns have been raised over the use of lead weight, used to control depth at which baits are fished in both salt water and fresh water fishing. This stems from possible increased lead levels from leaching, in habitats with large numbers of lost lead fishing weights. This is believed to be a more serious problem in enclosed freshwater bodies, than in open water marine environments. A greater
concern may be the physical impact of heavy lead weights hitting and breaking the more delicate species of corals in areas where hook and line effort is high.

3.5.1.3.3 Caribbean Coral and Reef Resources FMP:

**The commercial and recreational fisheries** for coral and reef resources permit the use of dip nets and slurp guns such as those described above in the reef fish fishery.

3.5.1.3.4 Caribbean Queen Conch FMP:

**The commercial and recreational fisheries** for queen conch are pursued only through hand capture of conch and related resources. Harvest methods are not regulated in the queen conch fishery and it is allowed everywhere, except for the seasonal closure when all harvesting of queen conch is prohibited. Potential impacts to the habitat include potential trampling and short-term disturbance of sediments by divers.

3.5.1.3.5 Fishing impacts not related to fishing gear

Fishing boats share with non-fishing boats the need for ports, berths, moorings, maintenance, and trash and sewage disposal. These issues are discussed in more detail in a following section on non-fishing impacts. The expansion of ports and marinas for commercial and recreational fishing (and other) vessels has become an almost continuous process due to economic growth, competition between ports, and increased tourism. Maintenance and dredged material disposal to maintain navigable depths for vessels is a major issue at all port facilities and for many marinas. Marinas and other sites where fishing (and other) vessels are moored or operate often are plagued by accumulation of anti-fouling paints in bottom sediments, fuel spillage, and overboard disposal of trash, sewage, and wastewater. The chronic effects of vessel groundings, prop scarring, and anchor damage are generally more problematic in conjunction with recreational vessels. Of particular concern is the threat to seagrass beds from prop scarring. Anchor scarring is often more localized than other physical disturbances associated with vessel operation.

3.5.1.4 Not minimal and more than temporary fishing impacts

3.5.1.4.1 Mangrove habitat

Fishing gears typically reported in the US Caribbean are not suited for use in mangrove areas (Table 3.15). Therefore, no evidence is available that fishing activity from these gears will adversely affect mangrove areas in a manner that is more than minimal and not temporary in nature.
3.5.1.4.2 SAV habitat

Vertical gear, spears, powerheads, slurp guns, and dipnets are not typically used in SAV habitats and for this reason are considered to have minimal and temporary impacts (Table 3.15). Powerheads are prohibited in FMP fisheries of the EEZ. Longline gear and hand harvest occur on SAV, but cause negligible damage, and therefore are also considered to have minimal and temporary impacts (Table 3.15). Pots/traps and gill/trammel nets however, are used in SAV and may adversely affect SAV areas in a manner that is more than minimal and not temporary in nature (Table 3.15).

3.5.1.4.3 Coral reef habitat

Powerheads are not typically used in coral reef habitats (Table 3.15), and are prohibited for FMP fisheries in the EEZ. Slurp gun and dip net gears occur on coral reefs, but cause negligible damage and minimal and temporary impacts (Table 3.15). Pots/traps, longline, vertical gear, gill/trammel nets, spears, and hand harvest techniques are used on coral reefs and may adversely affect coral reef areas in a manner that is more than minimal and not temporary in nature (Table 3.15).

3.5.1.4.4 Sand-shell habitat

Spears, powerheads, slurp gun, and dip net gears are not typically used in sand-shell habitats and therefore have minimal and temporary impacts (Table 3.15). Powerheads are prohibited in FMP fisheries of the EEZ. Pots/traps, vertical gear, and hand harvest occur on sand-shell areas, but cause negligible damage and so are considered to have minimal and temporary impacts (Table 3.15). Longline and gill/trammel nets however, are used on sand-shell habitat and may adversely affect sand-shell areas in a manner that is more than minimal and not temporary in nature (Table 3.15).

3.5.1.4.5 Hard bottom habitat

Powerheads are not typically used in hard bottom habitats, and therefore have minimal and temporary impacts (Table 3.15). Powerheads are prohibited in FMP fisheries of the EEZ. Slurp gun and dip net gears occur on coral reefs, but cause negligible damage and minimal and temporary impacts (Table 3.15). Pots/traps, longline, vertical gear, gill/trammel nets, spears, and hand harvest techniques are used in hard bottom habitats and may adversely affect hard bottom areas in a manner that is more than minimal and not temporary in nature (Table 3.15).

3.5.1.4.6 Benthic algae habitat

Powerheads, slurp guns, and dip nets are not typically used in benthic algae habitats and therefore are considered to have minimal and temporary impacts (Table 3.15). Powerheads are
prohibited in FMP fisheries of the EEZ. Longline, vertical gear, spears, and hand harvest occur on benthic algae, but cause negligible damage and minimal and temporary impacts (Table 3.15). Pots/traps and gill/trammel nets are fished in benthic algae habitats and may adversely affect benthic algae areas in a manner that is more than minimal and not temporary in nature (Table 3.15).

3.5.1.4.7 Soft bottom habitat

Vertical gear, spears, powerheads, slurp guns, and dip nets are not typically used in soft bottom habitats, and so impacts are considered minimal and temporary (Table 3.15). Powerheads are prohibited in FMP fisheries of the EEZ. The remaining gears used on soft bottom cause negligible damage (Table 3.15). Therefore, none of the gears will likely adversely affect soft bottom areas in a manner that is more than minimal and not temporary in nature.

3.5.1.4.8 Wetlands

No fishing gears reported in the US Caribbean are typically used in wetland areas (Table 3.15). Therefore, no evidence is available that fishing activity from these gears will adversely affect wetland areas in a manner that is more than minimal and not temporary in nature.

3.5.1.4.9 Drift algae

No fishing gears reported in the US Caribbean are typically used in drift algae areas (Table 3.15). Therefore, no evidence is available that fishing activity from these gears will adversely affect drift algae areas in a manner that is more than minimal and not temporary in nature.

3.5.1.4.10 Rubble

The gears used on rubble habitat cause negligible damage (Table 3.15). Therefore, no evidence is available that fishing activity from these gears will adversely affect rubble areas in a manner that is more than minimal and not temporary in nature.

3.5.1.4.11 Shoals and banks

Shoals and banks are areas that rise from the sea floor. The substrate on these areas will normally consist of hard bottom, sand-shell, or coral. The substrate types will determine the impact of fishing gears, as discussed in the sections above.
3.5.2 Non-fishing impacts

Under the amended M-S Act, each federal agency is required to consult with NOAA Fisheries regarding any activity that is, or is proposed to be, authorized, funded, or undertaken by the agency, and that may adversely affect EFH. Some state actions may also be reviewed. This language strengthened previous habitat protection measures in the M-S Act and reflects Congress’ increased concern that coastal development, pollution, and other activities threaten the environment, and subsequently the health of fish stocks.

Generally, during the consultation process, NOAA Fisheries staff reviews the proposed action that may affect habitat of a fishery resource. From 1981 to June 2002, NOAA Fisheries Southeast Regional Office (SERO) reviewed 2,674 project proposals for habitat alteration (Table 3.16) in Puerto Rico and the USVI. The SERO reviews from around 40 to 200 permits annually for Puerto Rico and 5 to 40 annually for the USVI, for a total of 50 to 250 annually for the entire area (Table 3.17). Information from the SERO on the distribution of 1174 records of non-fishing activities on Puerto Rico shows that the following "counties" have the greatest amount of activity for approximately 20 years through 2002. These data are insufficient to accurately portray stress from development, but show the limits of available information.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Cabo Rojo</td>
<td>72 actions, 6%</td>
</tr>
<tr>
<td>Carolina</td>
<td>38 actions, 3%</td>
</tr>
<tr>
<td>Culebra</td>
<td>54 actions, 5%</td>
</tr>
<tr>
<td>Fajardo</td>
<td>46 actions, 4%</td>
</tr>
<tr>
<td>Lajas</td>
<td>102 actions, 9%</td>
</tr>
<tr>
<td>Mayaguez</td>
<td>36 actions, 3%</td>
</tr>
<tr>
<td>Ponce</td>
<td>43 actions, 4%</td>
</tr>
<tr>
<td>San Juan</td>
<td>135 actions, 11%</td>
</tr>
</tbody>
</table>

These areas represent about 45% of all actions for which "county" records exist. These, and even the other areas reflecting lesser activity, would seem to show some correlation with population centers.

For the USVI, working from 197 records over the same time frame, the distribution is:

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<tr>
<td>St. Thomas</td>
<td>77 actions</td>
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<tr>
<td>St Croix</td>
<td>65 actions</td>
</tr>
<tr>
<td>St. John</td>
<td>41 actions</td>
</tr>
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</table>

Additionally, Councils are authorized to comment on activities that are likely to substantially affect the EFH of managed species. If information is received that a proposed activity would adversely affect EFH, NOAA Fisheries (through the Secretary of Commerce) must submit recommendations that would conserve the habitat. Within 30 days, federal agencies must prepare a written response to these comments, and must describe how the impact will be avoided, or include a description of the measures or modifications that will be required to mitigate or compensate for the adverse impact of the activity on EFH. When appropriate, the agency’s
response must include an explanation for not following the recommendations of NOAA Fisheries.

This additional scrutiny should provide environmental benefits for the EFH identified by the Council, as regulatory agencies should more fully consider potential EFH impacts. Not all habitats have the same environmental value for fisheries, and some habitats should require higher levels of protection. Thus, the identification of HAPCs will establish more judicious criteria to address, and hopefully alleviate this concern by providing focus on the most critical habitat areas.

Table 3.18 ranks natural and anthropogenic factors which stress reef ecosystems in the US Caribbean according to their level of concern for reef managers (based on Turgeon et al. 2002).

3.5.2.1 Maritime-related factors

3.5.2.1.1 Physical/chemical damage

Physical damage related to navigation can be caused by dredging, anchoring, filling, prop washing, prop scarring, groundings, and certain harvest methods. Dredging activities to remove sand or beach rock, not only result in siltation and increased turbidity, but also cause mechanical damage to reefs. Moreover, waters over dredged areas have significantly more bacteria than neighboring seawater (Galzin 1981). In Benner Bay, St. Thomas, toxic materials (anti-fouling paints) were resuspended into the water column during dredging, leached into the water and adsorbed onto bottom sediments. Metals may be detrimental to corals by impairing their physiological processes and possibly by weakening the structure of the aragonite skeleton (Howard and Brown 1984). If the dredging requires a federal permit, the special conditions of the permit often include a water-quality monitoring requirement during dredging or, at minimum, the placement of sediment curtains or other containment devices. In addition, for dredge disposal in offshore sites, a site management and monitoring plan is required, which dictates that sediments in the area to be dredged, be tested to ensure that they are suitable for ocean disposal.

Heavy recreational boat traffic in some areas can impact seagrasses through scarring, anchoring and groundings. Seagrasses are more susceptible to damage than other habitats because they grow in shallow areas near the coast (Otero and Carrubba 2002). The intensity of an individual scarring event depends on the boat’s draft in relation to water depth, whether it has 1 or 2 propellers, and the boat’s speed. Otero and Carrubba (2002) found that scarring could potentially impact 26-35% of grassbed areas in La Parguera and 1-25% of grassbed areas in Guanica. Most scarring occurred along boat traffic routes and at popular destination areas, however Otero and Carrubba (2002) concluded that the analysis of overflight images and photographs delineated only the most severely impacted areas. Aside from direct seagrass damage, scarring can increase erosion rates, resuspend sediments, change ecosystem nutrient management, fragment grassbeds, alter flow rates and current patterns, change sediment composition, and alter the distribution and diversity of the fauna (Uhrin 2001; Otero and Carrubba 2002). Uhrin (2001) examined individual prop scars in grassbeds of the La Parguera region, and reported higher flow rates near scar edges; a lower percentage of sand and a higher percentage of gravel within scars; a lower abundance of
benthic fauna with closer proximity to scars; lower diversity within scars; and lower abundances of shrimps, crabs, and mollusks within scars. Scarring seemed to have a greater effect on low-mobility fauna and scars may act as barriers for such species. Scars may shift community composition toward bare sand-oriented species and the greater amount of “edge” created could increase predation rates (Uhrin 2001). Damage to coral reef habitat at Lovanco Cay (3 miles east of St. Thomas) due to barge prop wash was reported in January 2002. Approximately 53 m² of habitat was damaged including several live coral colonies (Montastrea annularis and Porites astreoides).

Anchoring on top of corals can severely disrupt coral reef communities, and is a serious concern as boating and tourism increase in reef areas. Between January and March 1987, Rogers and Teytaud (1988) studied anchor damage in several northern and northwestern bays on St. John. Of the 186 boats surveyed, 32 percent were anchored in seagrass and 14 percent in coral. With an estimated 30,000 anchors being dropped in Virgin Islands National Park waters each year, this can result in considerable physical disruption of these areas. Anchor chains can do more damage than anchors as they drag across the bottom. In 1989, a 440-foot sailing cruise ship, the "Wind Spirit" dropped its anchor on a reef off northern St. John and destroyed some 300 m² of coral reef. On May 3, 2002 the vessel Mikaela II dropped anchor north of Frederiksted Pier on a coral reef and caused substantial damage. Extensive tourist activities, including boating and diving, are resulting in considerable damage from anchors and boat groundings. Heavy anchoring from boating activities also occurs in reef areas around La Parguera, southwestern Puerto Rico, off islands of northeastern Puerto Rico, and off the Caja de Muertos Island, south of Ponce.

Groundings also cause considerable reef damage. In 1997, the 326-foot Fortuna Reefer grounded near a Commonwealth of Puerto Rico Natural Reserve off the west coast of Mona Island, creating a 2.75 ha (6.8 acre) grounding site. The vessel injured a fringing reef that extended approximately 10 miles from the eastern end of the island along the southern coast and around to the northwest. The reef was populated with large, branching "old growth" elkhorn corals, which were injured by the grounding. The remoteness of the grounding site hampered salvage efforts and the vessel remained aground for eight days. The grounding and subsequent salvage activities caused a swath of physical damage to the reef surface, measuring approximately 900 feet in length by 50 to 100 feet wide. NMFS initiated an emergency restoration effort in September 1997 that was completed in October 1997. Other large vessel groundings have included the barge Morris J. Berman which grounded on the north coast of Puerto Rico and a Russian cement ship which grounded at the mouth of San Juan harbor.

Smaller vessels have also grounded on reefs. On November 17, 2000 the M.V. Talisman, a 51-foot cabin cruiser, ran aground on Gallows Point reef off Cruz Bay, St. John. Approximately 621.4 m² of reef was damaged including about 29.8 m² of live coral (i.e. 4,723 coral colonies). On December 17, 2000 the catamaran M.V. Native Son Kat ran aground between Cow and Calf Rocks near St. Thomas. This grounding damaged three areas totaling 49.5 m², and consisted mostly of broken and smashed coral and rocks. At Windswept Reef, on the north shore of St. John, an average of five boats per week were striking the reef prior to installation of marker buoys, which considerably reduced the frequency of groundings.
Abandoned vessels can also cause physical and/or toxic chemical damage to US Caribbean habitats. NOAA’s Abandoned Vessels Project reported 64 abandoned vessels and 69 groundings in Puerto Rico, and 95 abandoned vessels and 103 groundings in the USVI, as of July 2002.

Military maneuvers near coral reefs are practiced in Vieques, off eastern Puerto Rico, by the Navy, which controls about 70 % of the island. These activities have resulted in direct physical damage, as well as indirect damage from deposition of coarse sediments on Vieques reefs. Large numbers of unexploded ordnance on these reefs limit their future utilization as fishing or tourist centers. Military activities ceased briefly in 1999, after an accidental death, but resumed in 2000. However, all military activities permanently ended on May 1, 2003.

3.5.2.1.2 Oil pollution

Mangroves are extremely sensitive to oil pollution. Oil fouls the intertidal root region where gas exchange takes place. A heavy coating of oil generally leads to death. In addition to the mechanical damage caused by coating, oil may be toxic and poisonous to the trees. Since the toxic fractions come in contact with the roots, where vital functions take place, toxic products cause rapid mortality. Residual amounts of the spilled product may remain trapped in the sediment for a very long time. As a result, natural recovery may be very slow, if at all. There are no effective ways to clean up mangroves because efforts are labor intensive, costly, and inefficient. Only protection by booming can reduce damages. Corals and SAV may be similarly affected if the oil or constituents within the oil come in contact. Mortality would result and prospects for recovery may be poor or very long term, if the event is severe and the oil persists for a long time.

Two well-known oil spill incidents, the Ocean Eagle and the barge Morris J. Berman, occurred along the north coast of Puerto Rico in 1968 and 1994, respectively. Neither incident resulted in extensive coral or mangrove damage as neither of these habitats is abundant on the north coast. However, widespread mortalities among fishes and benthic invertebrates were noted (Cerame-Vivas 1968; NOAA 1992; NOAA 1995).

NOAA has developed an Environmental Sensitivity Index (ESI) that maps information relevant to oil spill cleanup for much of the US coastline, including Puerto Rico and the USVI (NOAA 2003). This approach systematically compiles information in standard formats for coastal shoreline sensitivity, biological resources, and human-use resources. A main objective of oil spill response in the United States, after protecting human life, is to reduce the environmental consequences of both spills and cleanup efforts. Identification of vulnerable coastal locations before a spill happens helps establish protection priorities and identify cleanup strategies.

3.5.2.1.3 Channelization

This threat is mostly a problem for Puerto Rico. The extensive development on the uplands has resulted in extensive channelization and other alterations of the rivers and streams related to agriculture, flood control, consumptive water uses, etc. Residential and commercial
developments in all physiographic regions of Puerto Rico propose the channelization of rivers, streams, etc. and their use as storm drains. Rampant authorized and unauthorized development in the coastal flood plain of rivers and streams leads to extensive fill of the flood plain, which in turn, brings about “flood control” projects that convert natural channels to concrete sloughs (e.g. the proposed Fajardo River project or the Rio Nuevo flood control project).

While most of these works are located well above the limits of marine fish habitat, the modification of water flows and hydrology often produces serious side effects well downstream, especially in estuaries. An increase or decrease in nutrient flows may be observed; point and non-point source discharges of contaminants to fish habitat may be increased; salinity regimes may be modified and lead to hypersalinity or hyposalinity; and sedimentation may be increased. Channelization may also adversely affect Puerto Rico’s mountain mullet (*Agnostomus monticola*), an anadromous species, which requires freshwater habitats in areas that have been made brackish by channelization.

3.5.2.1.4 Docks, piers, and other structures

The overall biological effects of piers and docks has not been well quantified. However, between 1981 and 1996, the NOAA Fisheries reviewed requests for close to 532 piers and docks from the islands. Accordingly, these represent a substantial feature in Caribbean waters and warrant further attention in the future.

Construction of piers and docks undoubtedly impact fish habitat, but the degree of the impact is not known and would be largely dependent on the size, location, and number of similar structures in a given area. Construction involves jetting of pilings and this has a temporary and localized affect on EFH from increased sedimentation and minor habitat displacement. Sedimentation may exacerbate declines in habitat quality in nearshore systems that are already stressed (e.g. SAV habitats that are already declining or marginal because of low water clarity). The pilings are treated and undoubtedly release chemicals into the water, but this is not perceived to be a large problem because the pilings eventually support the growth of encrusting and fouling organisms. Perhaps the greatest threat arises from shading, and this threat increases in vegetated areas, especially SAV, if a proliferation of piers and docks occur. Where SAV occurs in light conditions that are poor, shading may reduce available light to the point that SAV can no longer survive. Shading has been shown to block the spread of SAV via their rhizomes. It has also been observed that intertidal marsh fails to survive under some of the larger structures. On the positive side, these structures provide some vertical habitat that are usually attractive to various encrusting organisms and fishes. This may provide some habitat diversity, but whether or not this is beneficial is unknown.

A concern over pier and dock construction arises when these structures are placed in shallow water areas that are too shallow, or only marginally so, for navigation. Vessel operation becomes a threat to EFH in these areas due to prop scarring, wake damage, and propwashing. It has been observed that in areas where depths are marginal, habitat damage located around piers and docks may be substantial, and disproportionately large for areas where these structures proliferate (Ludwig *et al* 1997).
3.5.2.1.5 Pipelines

Pipelines have the potential to adversely affect fish habitat directly, especially when placed in mangrove, SAV or coral habitats. Construction techniques may involve laying the pipeline on surfaces, elevated on structures, or in dredged trenches that are subsequently refilled. Pipelines on bottom surfaces may crush coral or destroy the SAV under them. Some pipeline installations have required the destruction of hard bottom habitat via blasting along the entire pipeline corridor, as well as drilling of the shelf edge reef. If structures are placed to support pipelines, they would have the same or similar effects described for piers and docks. If trenches are dredged, impacts similar to those described for navigation would be expected. Secondary effects may arise from pipeline rupture and the release of contents. This would probably be least severe for water and gas pipelines, but most severe for those carrying rum slop, primary sewage, oil, gasoline, or other chemical products.

Between 1981 and 1996, the NOAA Fisheries received only 39 requests to build new pipelines. Although few in number, these projects generally entail a large threat to fish habitat because of their length and because of the sensitive nature of the habitats they must traverse. With regard to secondary effects associated with potential ruptures, most pipelines would pose only a minor risk because, by far, most of them are for water transport. However, pipelines by oil companies were proposed for Yabucoa and Cabo Rojo, Puerto Rico and numerous other pipelines exist where spilled contents would find their way into rivers and streams. All of the pipelines proposed from the USVI appear to have been minor and related to water transport.

3.5.2.1.6 Beach nourishment projects

Threats from beach nourishment include those resulting from the dredging of sand for nourishment and the filling of nearshore habitat. Potential threats of sand dredging include removal of substrates that provide habitat for fish and invertebrates; creation (or conversion) of habitats to less productive or uninhabitable sites such as anoxic holes or silt bottom; burial of productive habitats in the vicinity of the dredging site or in nearshore beach nourishment sites; release of harmful or toxic materials either with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and modification of hydrologic conditions that cause erosion of desirable habitats.

Recent studies on beach nourishment effects along the south Atlantic coast of the US have shown that nearshore hard bottom areas provide developmental habitat for many important commercially and recreationally important marine fish (Lindeman 1997b; Lindeman and Snyder, 1999). After the burial of a 5 ha hardbottom site by a dredging project in Southeast Florida, Lindeman and Snyder (1999) found that fish abundance dropped 30 fold and the number of species dropped 10 fold. The beaches and nearshore waters along the islands probably provide similar habitat and certainly provide habitat for marine turtles.

In the last 15 years there have been 15 proposals to nourish beaches; eight from Puerto Rico and
seven for the USVI. These activities have been mostly small and local such as work associated with a specific resort or hotel. Accordingly, these have not entailed the same degree of threat as observed along the beaches of the US mainland. However, as information continues to develop on nearshore fish habitat and coastal processes, future projects must be carefully evaluated against this information to ensure that EFH is not damaged.

3.5.2.1.7 Navigation projects, ports, marinas, and maintenance dredging

Potential navigation-related threats to fish habitat located within estuarine waters can be separated into two categories: navigation support activities and vessel operations. Navigation support activities include, but are not limited to, excavation and maintenance of channels (includes disposal of excavated materials); construction and operation of ports, mooring and cargo handling facilities; construction and operation of ship repair facilities; and construction of channel stabilization structures such as jetties and revetments. Potentially harmful vessel operations activities include, but are not limited to: discharge or spillage of fuel, oil, grease, paints, solvents, trash, and cargo, grounding/sinking/prop scarring/prop-washing in ecologically or environmentally sensitive locations; exacerbation of shoreline erosion due to wakes; and transfer and introduction of exotic and harmful organisms through ballast water discharge. Most of the physical damage is accidental, but frequent; and some, such as prop-washing, can be intentional.

Navigation in the Caribbean has resulted in the widespread modification of subtidal and intertidal areas in support of commercial vessels and recreational boats. These include the construction and maintenance of ports and marinas and related channels. Several major ports exist, such as the port at San Juan, several commercial fishing-related port facilities, and the cruise ship ports in Puerto Rico and the USVI. There are numerous recreationally-based marinas and basins that have altered fish habitat. Dredged material disposal and disposal of contaminated sediments is a dominant issue. The filling of wetlands and SAV, and the conversion of fish habitat from shallow (e.g. SAV and coral) to deeper water are also threats, as they relate to construction of new facilities or the maintenance and expansion of old ones. In the last 15 years, the NOAA Fisheries has received for review 224 proposals for new navigation projects and maintenance or expansion of existing facilities and channels. Of the 224 proposals, 18 of them involved the alteration of 294 acres of fish habitat.

The most conspicuous navigation-related activity in many estuarine waters is the construction and maintenance of navigation channels and the related disposal of dredged materials. These activities show great annual variation, but have adversely affected and continue to adversely affect fish habitat, by modifying intertidal and subtidal habitats, filling habitat for dredged material disposal and construction of facilities, and in some cases adversely affecting habitat by releasing contaminants and suspending fine sediments. For more extensive dredged features and related disposal sites, hydrology and water flow patterns also have been modified. While channel excavation itself is usually visible only while the dredge or other equipment is in the area, the need to dispose of excavated materials has left its mark in the form of confined and unconfined disposal sites, including those that have undergone human development. Chronic and individually small discharges and disturbances, routinely affect water and substrate, and may be
significant from a cumulative or synergistic perspective. Generally observed effects on fish habitat include: direct removal/burial of organisms as a result of dredging and placement of dredged material; turbidity/siltation effects, including increased light attenuation from turbidity; contaminant release and uptake, including nutrients, metals, and organics; release of oxygen consuming substances; noise disturbance to aquatic and terrestrial organisms; and alteration to hydrodynamic regimes and physical habitat. The relocation of salinity gradients due to channel deepening may, in some cases, be responsible for significant environmental and ecological change.

The expansion of ports and marinas has become an almost continuous process due to economic growth, competition between ports, and increased tourism. Elimination and degradation of aquatic and upland habitats are commonplace, since port and marina expansion almost always requires the use of open water, submerged bottoms, and riparian zones. Vessel repair facilities use highly toxic cleaners, paints, and lubricants that can contaminate waters and sediments. Modern pollution containment and abatement systems and procedures can prevent or minimize toxic substance releases; however, constant and diligent pollution control efforts must be implemented. The extent of the impact usually depends on factors such as flushing characteristics, size, location, depth, and configuration.

Ports facilities serve as the primary route for importing needed goods, supplies, and energy, and exporting local products. The cargo may be diverse, and ranges from highly toxic and hazardous chemicals and petroleum products, to relatively benign materials. Major spills and other discharges of hazardous materials are uncommon, but are of constant concern, since large and significant areas of coral, SAV, and mangrove habitat are at risk.

Maintenance and dredged-material disposal to maintain navigable depths for vessels is a major issue at all port facilities and for many marinas. In many cases, dredged materials are contaminated and disposal sites for these sediments are not readily available. Often offshore sites are proposed for the disposal of clean and contaminated sediments, and such sites have been used. Still, contaminated sediments remain an issue, as does the effects of these materials on offshore systems.

The chronic effects of vessel grounding, prop scarring, and anchor damage are generally more problematic in conjunction with recreational vessels. While grounding of ships and barges is less frequent, individual incidents can have significant localized effects. Propeller damage to submerged bottoms occurs everywhere that vessels ply shallow waters. Direct damage to multiple life stages of associated organisms, including egg, larvae, and juveniles through water column de-stratification (temperature and density), resuspending sediments, and increasing turbidity (Stolpe 1997) has been observed. This damage is particularly troublesome where SAV is found.

Anchor scarring is probably less important than other physical disturbances associated with vessel operation. On coral reefs and other sensitive hard bottoms, however, damage caused by anchoring may be significant (Davis 1977). Dragging or pulling anchors through coral reefs breaks and crushes the coral, destroying the coral formation. Surveys off St. John clearly show damage to benthic resources from anchoring (Link 1997). Virgin Islands National Park has
installed 111 resource protection buoys, and 211 moorings to help prevent anchor damage to benthic habitats, and the entire southern section of the Park is a no-anchor zone.

The effects of vessel-induced wave damage have not been quantified, but may be extensive. The most damaging aspect relates to the erosion of intertidal and SAV wetlands adjacent to marinas, navigation channels, and boating access points such as docks, piers, and boat ramps. The wake erosion in places along navigation channels and elsewhere is readily observable and undoubtedly converts a substantial area of wetlands to unvegetated habitat (e.g., marsh to submerged bottom). In heavily trafficked submerged areas, bottom stability is constantly in flux, and bottom communities may be weakened as a result. Indirect effects may include the resuspension of sediments and contaminants that can modify fish habitat. Where sediments flow back into existing channels, the need for maintenance dredging with its attendant impacts may be increased.

The introduction of exotic species is a problem mostly found with commercial vessel travel. Exotic species have been brought into the US in the bilge waters of vessels. With the introduction of the zebra mussel into the Great Lakes, and its rapid dispersal into other waters, considerable attention is being directed at this problem. According to one estimate, two million gallons of foreign ballast water are released every hour into US waters (Carlton 1985). This possibly represents the largest volume of foreign organisms released on a daily basis into north American ecosystems. The introduction of exotic organisms threatens native biodiversity and could lead to changes in relative abundances of species and individuals that are of ecological and economic importance. This has already been observed in other parts of the world. While fish habitat has not been adversely affected so far, an exotic brown mussel introduction has already occurred in the Caribbean. The effects and extent of this introduction are currently being studied. With the extent of port development and shipping along the Caribbean, this issue must be addressed. It is anticipated that technology such as application of filters or operations such as deep-sea exchange of bilge waters, will mitigate the introduction of exotic species.

3.5.2.1.8 Transmission lines

Transmission lines include cables, structures, conduits, etc., for power distribution and communications. Potential threats range from disturbances associated with the placement of structures, dredging and filling for placement of conduits and transmission lines, and placement of lines directly on water bottoms. These facilities often entail repeated disturbances associated with maintenance, and upgrades. Because these facilities are linear, often crossing large areas of habitat, their impacts can be substantial. This is especially problematic in the Caribbean because of the extensive areas of coral, SAV, and nearshore wetlands such as mangroves. In many areas, it is impossible to run a transmission line without impacting important habitats. In some cases, impacts have been mitigated, but often the destruction of SAV and coral may have permanent or long-term consequences. Installation of a power cable between Vieques and Culebra appears to have created a barrier to the seasonal migration of queen conch in the area.

In the last 15 years, nine proposals (six for Puerto Rico and three for the USVI) were submitted to build power and communications transmission lines in or near important fish habitat. A few of
these were relatively minor. However, for the more extensive projects, often covering large areas between islands, adverse impacts to habitat have been observed. In one of the communications conduits constructed from St. Croix in the USVI, the original project public notice advised that impacts would be minimal. However, it was later learned that the conduit was not placed along the specified alignment and that deeper water plate corals had been damaged as a result. Accordingly, the key to future planning associated with transmission lines must include detailed bottom surveys, careful attention to alignments and construction techniques that minimize threats to fish habitat, the development of techniques to restore damage caused by placement, and adequate oversight to ensure that lines are placed as specified in the review process.

3.5.2.1.9 Mining activities

There have been no mining proposals involving important fish habitat from the USVI within the last 15 years. Four proposals have been submitted for approval from Puerto Rico between 1981 and 1986. Four additional proposals were advertised as part of the US Army Corps of Engineer’s permitting process in 1997. All recent mining proposals involve Puerto Rican rivers that have a bed load of quartz sand, pea gravel, or volcanic fragments. The sediment is generally removed by backhoe and placed in a temporary upland deposit site. From there it is generally screened and sold for commercial purposes, mostly related to construction. The 1997 proposals were for work in the Rio Grande de Manati in Jaquas Ward, the Humacao River in Tejas ward, and the Gurabo River in Celada Ward.

Threats to fish habitat would be similar to those described under the “Navigation” section for mining projects that would directly or indirectly impinge on habitat. These include: direct habitat modification with removal of associated biota; hydrological modifications; increased sedimentation; reduced light transmission; and resuspension and relocation of pollutants. Where mining is proposed for rivers that support the anadromous mountain mullet (*Agnostomus monticola*), this species could be adversely affected.

3.5.2.1.10 Oil and gas development

There are presently no ongoing, related activities in the region involving the exploration of oil and gas resources in the islands. Given that this could change, a brief overview of the potential threats to fish habitat that might result from oil and gas exploration, development, and production on the Outer Continental Shelf (OCS) is provided.

Potential threats to fish habitat include: elimination or damage to bottom habitat due to drill holes and positioning of structures such as drilling platforms, pipelines, anchors, etc; release of harmful and toxic substances from extracted muds, oil, and gas and from materials used in oil and gas recovery; damage to organisms and habitats due to accidental spills; damage to fishing gear due to entanglement with structures and debris; and damage to fishery resources and habitats due to effects of blasting (used in platform support removal); and indirect and secondary impacts to nearshore aquatic environments affected by product receiving, processing, and distribution facilities.
A major oil refinery was built and operates on St. Croix, but there are no immediate plans for additional facilities. Despite this, millions of barrels of crude oil and refined product transit Caribbean waters by tanker vessel every year, and the potential exists for the discharge of thousands of barrels of oil due to vessel collision or sinking. There have, in fact, been several major oil spills in recent years.

3.5.2.1.11 Global warming

Global temperatures may be increasing due to the man-induced release of CO$_2$ into the atmosphere, principally from the combustion of fossil fuels. Global temperature increases of a degree or two can cause sea level rise if melting of the Arctic ice cap follow. Possible effects include: significant loss of coral reefs, salt marshes, and mangrove swamps that are unable to keep up with sea level rise; loss of species whose temperature tolerance ranges are exceeded (this could be especially problematic for corals); elevated nutrient and sediment loading; saltwater intrusion into freshwater ecosystems such as freshwater marshes and forested wetlands; invasion of warmer water species into areas occupied by cooler habitat species; and physical changes that could have much broader implications by altering flows, food chains, and climate (USDC 1997).

In addition, an increase in the intensity and frequency of hurricanes in the Caribbean may result. Given the large number of effects that global warming could have, and the unpredictability of how these effects would interact (possibly synergistically), it is very difficult to assess exactly what specific ecosystem and habitat impacts would occur. The severity of impact on natural resources, including fish habitats, will be determined by the resilience of species and populations to withstand changes in environmental conditions, and the rate of environmental change (USDC 1997).

Consequences of global warming may include rising sea levels and an overall increase in water temperature. Natural heat sinks are decreasing because coral reefs, as well as rain forests, are being destroyed at an increasing rate (Goreau 1992). A major part of human-induced climate change can be controlled by balancing the sources and sinks of atmospheric carbon dioxide (CO$_2$). To balance CO$_2$ flows it will be necessary to restore and protect both these tropical ecosystems and/or to make drastic cuts in fossil fuel use. If this is not done, the rural poor will have little choice but to destroy remaining forests and coral reefs (Goreau 1992). Stabilization of CO$_2$ is technically feasible and cheaper than adapting to climate change. It is also extremely urgent because many coral reef ecosystems may already be near their upper temperature limits.

3.5.2.2 Coastal development and related threats

3.5.2.2.1 Eutrophication

In Puerto Rico, reefs ringing the main island are threatened and at places degraded, primarily because of their proximity to coastal development (Turgeon 2002). In many coastal regions, including the wider Caribbean coastal areas, there is large-scale, and in some cases chronic, eutrophication (Gabric and Bell 1993). In some regions, the link between eutrophication and the
destruction of an ecosystem is obvious, with excessive algal growth and water column anoxia. In other cases, particularly in more fragile ecosystems such as coral reef and seagrass areas, the links are not so obvious, yet the impacts of eutrophication in such regions can be devastating. Eutrophication can have insidious effects, such as contributing directly to the mortality of marine organisms (e.g., through oxygen depletion), and indirectly as disease or death in humans owing to the accumulation of biotoxins in seafood. Increased development and changes in land-use patterns in the coastal zone have increased the loading of diffuse or non-point nutrients. In areas subject to runoff and soil erosion, most of the nutrient load is transported in particulate form. In such cases, the loads of nutrients discharged from crop lands are typically an order of magnitude greater than those discharged from pristine forested areas. Nutrient export from pasture lands, whether these are fertilized or not, is also significantly greater than that from pristine areas, and in many cases, the total loads from such areas are far higher than those from intensively farmed areas. A reduction in nutrient discharges to coastal waters will require careful land use planning. The importance of the particulate fraction in the nutrient load necessitates effective control of soil erosion. The hydrological and nutrient linkage between terrestrial and marine ecosystems must be emphasized. Coordinated management of upland and coastal-zone resources could help remedy a serious and growing problem.

Eutrophication caused by sewage disposal and land drainage in Puerto Rico and the USVI stimulates algal blooms that will outcompete slower-growing organisms, such as living corals. This can result in the proliferation of organisms that compete with, or damage corals (e.g., burrowing bivalves and boring algae and sponges). Sewage pollution is known to stress reefs (Rogers 1985). In Puerto Rico, coral reefs growing close to sanitary discharges show proliferations of green algae. Excessive nutrient enrichment of seagrass beds could result in the replacement of seagrass with benthic algae. In the USVI, the proliferation of residential septic tanks has resulted in high soil loading that, during high rainfall, generates nutrient-rich runoff into the sea. This has caused short-term eutrophic conditions in various bays around St. Thomas and St. Croix. Nutrient levels (total phosphorus, total Kjeldahl nitrogen, ammonia, nitrate and nitrite) were recorded to be generally higher along coastal areas of Puerto Rico than in the USVI (Tetra Tech 1992). The most significant source of nutrients in Puerto Rico was found to be coastal municipal point sources (Tetra Tech 1992).

Nutrient enrichment of the coastal waters, stresses wetlands, mangroves and seagrasses. Coral reefs, however, can be the most seriously impacted. High nutrient concentrations stimulate high phytoplankton productivity as well as high productivity by benthic algae (Birkland 1977), which will favor the establishment of organisms that compete with or damage corals (such as burrowing bivalves and boring algae and sponges). High recruitment by benthic algae would reduce the substrate available for coral larvae settlement and may result in the young corals being overgrown (Birkland 1977).

3.5.2.2.2 Sedimentation

The principal concerns in Puerto Rico and the USVI are erosion and sedimentation following removal of upland vegetation, particularly in areas adjacent to inshore reefs. Sedimentation and turbidity decrease the amount of light, a vital source of energy, available to corals for the photosynthetic fixation and calcium carbonate deposition, reducing growth rates (Lasker 1980).
Sedimentation can also cause the burial of invertebrates and plants. Sedimentation reduces substrate available for the settlement of coral and other larvae.

Sedimentation is an important factor determining the abundance, growth and distribution of corals. Whether natural or man-induced, it is detrimental to corals (Dodge and Vaisnys 1977). Although most corals have effective means of shedding sediments which have fallen on their tissues, sedimentation and turbidity will decrease the amount of light available to the corals for the photosynthetic fixation of calcium carbonate, thereby reducing calcification rates (Lasker 1980). Other than increasing turbidity, sedimentation may limit reef corals by smothering, increasing energy expenditure in particle rejection, increasing potential for bacterial infection, abrasion, creation of conditions unsuitable for larval settlement, alteration of feeding habits, alteration of food supplies such as plankton, and alteration of species composition on reefs.

Turbidity has clearly been shown to influence fish abundance and diversity. In Torrecilla Lagoon, Puerto Rico, sedimentation from dredging and organic pollution from sewage treatment plants almost destroyed reefs northwest of Boca de Cangrejos. Areas of reduced live coral cover occur around Puerto Las Mareas and Ponce, due to terrigenous sediments from rivers (Tetra Tech 1992). The low percent coral cover in Guayanilla Bay was attributed to the resuspension of sediments by local shipping traffic (Morelock et al 1979). High sedimentation, turbidity, and nutrient loading have been associated with coral reef degradation in a number of reef systems off Puerto Rico by different authors (Garcia et al. 1985; Acevedo and Morelock 1988; Castro and Garcia 1996; Garcia and Castro 1997; Hernandez-Delgado 1995).

Nemeth and Sladek Knowlis (2001) evaluated the impacts of sedimentation from shoreline development on coral reefs along the north shore of St. Thomas USVI. Rates of sedimentation, changes in water quality and changes in the abundance and diversity of corals and other reef organisms were measured during a two-year period. Results indicated that sedimentation and total suspended solids increased during large rainfall events, and that sediment load onto adjacent reefs was greatest directly below ravine outlets and in locations where shoreline was sheltered. Visual assessment of coral condition documented that coral pigment loss was associated with the influx of terrigenous sediments. Bleaching of coral colonies during the 1998 bleaching event showed a strong positive relationship with sedimentation ($r^2 = 0.92$). Reef sites exposed to sedimentation rates between 10 to 14 mg cm$^{-2}$ d$^{-1}$ showed a 38% increase in the number of coral colonies experiencing pigment loss (bleaching) than reef sites exposed to sedimentation rates between 4 to 8 mg cm$^{-2}$ d$^{-1}$. Coral cover along the entire reef tract declined about 14% (range: -3.92% to -31.34%). This decline in coral cover from pre- to post-construction surveys showed weak negative associations with sedimentation ($r^2 = 0.52$) and bleaching ($r^2 = 0.48$). This study provides evidence that stress from sedimentation may lead to decline in living coral through secondary effects such as bleaching.

Abdel-Salam et al. (1988) exposed three species of corals, A. palmata, D. strigosa, and M. annularis to the same weight of sediment. Corals were exposed to sediment during daylight and darkness. Oxygen production and consumption were measured by respirometry; sediment removed by corals was collected simultaneously. All corals exposed to sediments showed an increase in respiration rate at night and a decrease in net photosynthesis during the day. Lowered net photosynthesis was due to both light shading and respiratory increase. Integrated 24 hour
“production to respiration” ratios (P/R) for control and sediment-exposed corals were calculated. All control corals had naturally occurring P/R ratios in excess of 1.0, but the sediment treated corals, without exception, had ratios significantly below 1.0, mostly due to high respiration during sediment rejection. *M. annularis* and *D. strigosa* have very high clearing rates relative to *A. palmata*.

Additionally, sedimentation may affect the species composition of coral reef fish communities (Berrios-Diaz *et al.* 1985). Abundances of some fishes, such as scarids and balistids, which are tolerant of high sedimentation rates, tend to be positively correlated with sedimentation. Abundances of other fishes, such as lutjanids and serranids, tend to be negatively correlated with sedimentation rates. In terms of recreational and commercial fishing, sedimentation causes a shift in community composition leading to lower abundances of desirable species and higher abundances of less desirable species (Berrios-Diaz *et al.* 1985).

Sedimentation can also affect mangroves by modifying elevations, resulting in species shifts or conversion of wetlands to upland characteristics. SAV can be adversely affected if light transmission is altered, or if enough sediments are released that SAV is killed. When climax SAV communities, such as *T. testudinum*, are destroyed, the habitat may never reestablish, or will at least require an extensive time period to recover.

A number of examples in both Puerto Rico and the USVI are available regarding the detrimental effects of the removal of upland vegetation without the use of appropriate land conservation practices. In southwestern Puerto Rico, for example, it is not uncommon to observe large sediment plumes after heavy rains where mangroves have been removed and replaced with stilt houses. The pattern of estimated sediment loading from point sources was heaviest on the north coast with the south and west costs running close behind. The lowest estimated point source sediment discharge was for the east coast (Tetra Tech 1992). Nonpoint sources of sediment loading from rivers was greatest on the west coast, followed by the north coast and ranged from 16-59 times greater than sediment loading from point sources in all areas but the north coast (Tetra Tech 1992). Production of sediment may be 10,000 times greater for a construction area than from a vegetation-layered area. For example, the Loiza Basin produces around 115 tons of sediment per square mile, per year and a development area may produce 96,000 tons annually per square mile (Richard Webb personal communication). In the USVI, siltation from heavy housing development on the north coast of St. Thomas is a matter of concern in the area. Mean coastal water turbidity was found to be greater for Puerto Rico than for the USVI (Tetra Tech 1992).

### 3.5.2.2.3 Pollution

Chemical and thermal pollution derive from agricultural, industrial, and residential origin and include toxins, biological pathogens, sediments and thermal inputs (Tetra Tech 1992). This report found that "Fourteen heavy metals were detected rather frequently in the marine and estuarine waters of Puerto Rico. The highest levels of arsenic, cadmium, chromium, cyanide, mercury, nickel, thallium, and zinc were found along the coastal areas of Region 1 (north coast), primarily near San Juan harbor. The highest levels of aluminum, beryllium, copper, lead, and
silver were detected in Region 3 (south coast) ... several of these heavy metals may potentially impair aquatic life and may cause risks to human health from ingestion of contaminated fish.”

The US EPA Office of Water provides access to information about water quality in Puerto Rico. It reports that 99% of the assessed estuarine waters fully support aquatic life use and 95% fully support swimming use. Metals from land disposal and pathogens from unknown sources are responsible for the impaired miles. Industrial and municipal discharges, collection system failures, spills, marinas, urban runoff, and land disposal of wastes also pollute beaches. Puerto Rico also maintains a Permanent Coastal Water Quality Network of 88 stations and the San Juan Beachfront Special Monitoring Network of 22 stations sampled monthly for bacterial contamination.

In 2000, the Puerto Rico Environmental Quality Board (PREQB) used one of EPA’s recommended enterococcus standards to determine whether beach water is safe for swimmers. Three advisories were issued in 2000 when Elevated Bacteria exceeded the standard due to contamination from septic systems. The PREQB does not always issue an advisory or close a beach if the standard is exceeded. The agency reports that monitoring results are posted at the beach and on the Internet and published in newspapers. When an advisory is issued, the PREQB reports that signs are posted at the beach and published in newspapers.

According to Puerto Rico’s 2000 305(b) report, 14% of the 550 miles of coastal water assessed do not fully support aquatic life, and 12% do not support swimming. Pathogens are the major pollutant, a result of urban runoff and sanitary sewer overflows. Of the 175.4 miles of estuaries assessed, 23% fully support aquatic life, 28% fully support swimming, and 70% fully support secondary contact recreation. Low dissolved oxygen concentrations and metals are responsible for the lack of aquatic life support. Major causes of impairment of swimming and secondary recreation at lagoons are pathogens from on-site land disposal, urban runoff, and hydromodifications.

Point source discharges related to urbanization derive mainly from municipal sewage treatment facilities or storm water discharges that are controlled through Environmental Protection Agency (EPA) mandated regulations under the Clean Water Act, and by state water quality regulations. Threats related to these discharges are probably less important than the other factors previously discussed, because efforts are underway to improve treatment. The primary concerns with municipal point-source discharges, involve treatment levels needed to attain acceptable nutrient inputs, and overloading of treatment systems due to rapid development of the coastal zone. In locations where treatment is poor or water conditions unsuitable for adequate dilution of discharges, habitat may be adversely affected. The primary concern would be excessive nutrification of receiving waters, but other concerns such as discussed for non-point-source discharges also apply.

Thermal pollution comes principally from cooling water discharges from power generating facilities. Due to concerns over these discharges, there is now a consent decree between PREPA and EPA to study the impacts of this thermal pollution.
Pollution from the operation of both commercial and recreational vessels also threatens fish habitat. The US EPA (1993) identified: pollutants discharged from boats; pollutants generated from boat maintenance activities on land and in the water; exacerbation of existing poor water quality conditions; pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces; and the physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities, among a suite of possible adverse environmental impacts.

Marinas and other sites where vessels are moored or operate, are often plagued by accumulation of anti-fouling paints in bottom sediments, by fuel spillage, and overboard disposal of trash, sewage, and wastewater. Boating and daily operations at marinas facilities (e.g., fish waste disposal) may lead to lowered dissolved oxygen, increased temperature, bioaccumulation of pollutants by organisms, water contamination, sediment contamination, resuspension of sediments, loss of SAV and estuarine vegetation, change in photosynthesis activity, change in the nature and type of sediment, loss of benthic organisms, eutrophication, change in circulation patterns, shoaling and shoreline erosion. Pollutants that originate from marinas include nutrients, metals, petroleum hydrocarbons, pathogens, and polychlorinated biphenyls (US EPA 1993). In the past, disposal of raw sewage from live-aboard vessels was especially troubling in areas such as La Parguera, Puerto Rico where the number of houseboats had increased dramatically before they were prohibited.

Marina personnel and boat owners use a variety of boat cleaners, such as teak cleaners, fiberglass polish, and detergents; and cleaning boats over the water, or on adjacent upland, creates a high probability that some cleaners and other chemicals will entering the water (USEPA 1993). Copper-based anti-fouling paint is released into marina waters when boat bottoms are cleaned in the water (USEPA 1993). Tributyltin, which was a major environmental concern, has been largely banned except for use on military vessels. Fuel and oil are often released into waters during fueling operations and through bilge pumping. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA 1993).

Increased recreational boating activity may contribute significantly to pollution of Caribbean coastal waters by petroleum products. All two-cycle outboard engines require that oil be mixed with gasoline, either directly in the tank or by injection. That portion of the oil that does not burn is then ejected, along with other exhaust products, into the water. Increased use of personal watercraft such as jet skis adds to the volume of hydrocarbon being introduced into Caribbean waters since the engine exhaust from these vessels is discharged directly into the propellant water jet.

One of the more conspicuous byproducts of commercial and recreational boating activities in coastal environments is the discharge of marine debris, trash, and organic wastes into coastal waters, beaches, intertidal flats, and vegetated wetlands. The debris ranges in size from microscopic plastic particles (Carpenter et al 1972), to mile-long pieces of drift net, discarded plastic bottles, bags, aluminum cans, etc. In laboratory studies, Hoss and Settle (1990) demonstrated that larval fishes consume polystyrene microspheres. Investigations have also found plastic debris in the guts of adult fish (Manooch 1973, Manooch and Mason 1983). Based
on the review of scientific literature on the ingestion of plastics by marine fish, Hoss and Settle (1990) conclude that the problem is pervasive. Most media attention given to marine debris and sea life has focused on threatened and endangered marine mammals and turtles, and on birds. In these cases, the animals become entangled in netting or fishing line, or ingest plastic bags or other materials.

Another major source of point and non-point-source discharges comes from the chemicals used in day-to-day activities, in operating and maintaining homes, for maintaining roads, for fueling vehicles, etc. In addition to chemical input, changes that affect the volume, rate, location, frequency, and duration of surface water runoff into coastal rivers and tidal waters are likely to be determinants in the distribution, species composition, abundance, and health of Caribbean fishery resources and their habitat. In the long-term, impacts of chemical pollution (e.g., petroleum hydrocarbons, halogenated hydrocarbons, metals, etc.) are likely to adversely impact fish populations (Schaaf et al. 1987). Despite current pollution control measures and stricter environmental laws, toxic organic and inorganic chemicals continue to be introduced into marine and estuarine environments (Puerto Rico DNER 2000).

### 3.5.2.2.4 Barriers and impoundments

Between 1981 and 1996, the NOAA Fisheries received for review 31 applications from Puerto Rico and two from the USVI to construct barriers or impoundments. In Puerto Rico, these were mostly projects associated with governmental units such as the Puerto Rico Aqueduct and Sewer Authority, and mainly for municipal and industrial water supplies. In the USVI, the few received were mostly minor works associated with industrial or commercial uses. These activities occurred mostly well inland, and their affect on fish habitat is not well known.

Many impoundments proposed for Puerto Rico are for potable water supplies. In some instances, the amount of water removed leads to near drying of rivers since there are no local standards regarding minimum flow rates to protect aquatic resources. In the case of larger scale projects such as the Northern Superaqueduct Project, the minimum flow rate chosen may still allow significant impacts on estuarine functions if maintained for more than two days. Potential threats to fish habitat from the direct effects of impoundments and other barriers include: removal of habitat, conversion of habitat away from historic usage, alteration of hydrology, and modification of water quality by modification of temperature, salinity, and nutrient and sediment fluxes. Flow regimes often are controlled and differ substantially from pre-impoundment flows. This can adversely affect anadromous fish migration and spawning, as well as, food production for prey species needed by larvae and juveniles.

Unintentional impoundments also can occur when roads or other linear features are built through wetlands and no provision is made to preserve water flows. In the islands, this practice affects mangrove wetlands the most. Impounding may cause water levels to rise, suffocating the trees (Cintron 1987). The effects of impounding are seen rapidly, because tidal range is small and evaporation is high. In some cases when dikes are abandoned, partial recovery may occur.
3.5.2.2.5 Bridges, roads, and causeways

Potential effects to fish habitat include direct destruction, impounding of wetlands, segmenting of habitats, and near and long-term effects on fisheries production by removing nutrient production, and by reducing available habitat. Indirect effects may include the alteration of hydrology and increased non-point-source discharges of materials such as oil, gasoline, and grease from vehicle traffic. New roadways may also increase development and this development can result in the destruction, modification, or reduction in quality of remaining habitats. On St. John, runoff from 56 km of unpaved roads contributes the largest amount of sediment to the coastal waters (Anderson and McDonald 1998).

The NOAA Fisheries received 60 requests since 1981 (59 in Puerto Rico and 1 in the USVI) to build new roadways or improve existing ones. As the population increases, and existing infrastructure ages, the demands to build or expand or improve existing roads, causeways, and bridges will present important threats to fish habitat. These must be evaluated accordingly to ensure that habitat is minimally impacted by new construction and that the adverse effects of old construction be mitigated.

3.5.2.2.6 Housing developments

The coastal areas of the Caribbean are highly sought after as places to live. The amenities of the coast, the water-related activities and the climate produce high population growth rates. As the population increases so does urbanization. People require places to live as well as related services such as roads, schools, water supply facilities, power, etc. These needs often are met at the expense of fish habitat, and they may adversely impact the very values that brought people to the coast. Wetlands and adjacent contiguous lands have been filled for housing and infrastructure. Further, the demand for shoreline modifications (docks, seawalls, etc.) and navigation amenities has further modified the coast. Chemicals produced and used by people also find their way into the waters as point source and non-point source runoff. This has lowered water quality in waters and wetlands adjacent to urban developments. As a result, the quality of fish habitat is often much reduced.

Potential threats include conversion of wetlands to sites for residential and related purposes such as roads, bridges, parking lots, commercial facilities, reservoirs, hydropower generation facilities, and utility corridors; direct and/or non-point-source discharge of fill, nutrients, septic tank overflow, chemicals, cooling water, and surface waters into ground water, streams, rivers and estuaries; hydrological modification to include ditches, dikes, flood control and other similar structures; damage to wetlands and submerged bottoms; and cumulative and synergistic effects caused by association of these and other developmental and non-developmental related activities. Wastewater treatment plants are often non-existent or inadequate to fully accomplish their function.

Wetlands and other important coastal habitats continue to be adversely and irreversibly altered for urban and suburban development. Related activities, such as navigation, are discussed elsewhere. One of the most serious of the adverse effects is filling for houses, roads, septic tank
systems, etc. This can directly degrade fish habitat in the waters near developed uplands. While the total affected area is unknown, it has been extensive in the islands, and its footprint is readily observable. Between 1981 and 1996 the NOAA Fisheries reviewed 2,674 proposals of which requesting to alter fish habitat for housing-related development.

Another major threat posed by housing development is that of point and non-point-source discharges of the chemicals used in day to day activities, in operating and maintaining homes, for maintaining roads, for fueling vehicles, etc. In addition to chemical input, changes that affect the volume, rate, location, frequency, and duration of surface water runoff into coastal rivers and tidal waters are likely to be determinants in the distribution, species composition, abundance, and health of Caribbean fishery resources and their habitat. In the long-term, impacts of chemical pollution (e.g., petroleum hydrocarbons, halogenated hydrocarbons, metals, etc.) are likely to adversely impact fish populations (Schaaf et al. 1987). Despite current pollution control measures and stricter environmental laws, toxic organic and inorganic chemicals continue to be introduced into marine and estuarine environments.

3.5.2.2.7 Commercial and industrial developments

The Caribbean is a prime location for industrial siting. The climate is favorable, economic incentives exist, there is an adequate labor base, and the infrastructure for shipping of supplies and products is well developed. Many industries are heavy water users. Examples of dominant industries include pharmaceutical production, fish processing, and manufacturing.

The hotel and resort industry also is a vital part of the island economies. Most of the Caribbean’s most popular vacation spots are located on or near the coast. Together with the growing coastal population, the demand for coastal recreational opportunities and the stress on natural systems, as a result of increased tourist visits, are expected to grow.

Potential threats from industrial and commercial development include: conversion of wetlands to uplands; discharge of nutrients, chemicals, cooling water, and other pollutants into ground waters, streams, rivers, estuaries and ocean waters; air pollution; hydrological modifications including ditches, dikes, water and waste lagoons; intake and discharge systems. Industrial and commercial development affects fish habitat in a number of ways. The most inexpensive land is usually sought for development near major shipping lanes, such as rivers or ports. These lands usually contain wetlands and these wetlands are generally filled for plant siting, parking, storage and shipping, and treatment or storage of wastes or by-products. These facilities, because of an abundance of hard impervious surfaces, are often a major source of non-point source contaminants. Water, often a vital component of the manufacturing process, serves as a cooling mechanism, and is used to dilute and get rid of wastes or other by-products. While rivers and streams are abundant, at least in Puerto Rico, there is little water in relation to the size of the island’s population and water shortages are becoming commonplace. Many heavy industries produce airborne emissions that often include contaminants. Albeit the islands benefit from their location and the almost constant trade winds, and atmospheric deposition is likely not a large problem yet.
Commercial development along the Caribbean coast has also been extensive. Few coastal areas or barrier islands exist that have not been subject to some form of commercial development, targeting mainly the tourist trade. Past development practices have been especially abusive where, before adequate regulation, it was not uncommon for extensive nearshore modifications to take place for hotel and resort construction. This has now abated, largely because most of the coast has already been developed, and because better information and regulation have exposed the damage to natural resources caused by past practices. However, it remains a fact that fast land is a scarce (and expensive) commodity along the coast, and that the filling of wetlands is viewed as a less expensive alternative. Accordingly, there will continue to be proposals aimed at altering wetlands for commercial development and related infrastructure, and these must be carefully assessed to minimize their impact on remaining fish habitat.

The overall amount of habitat lost to or affected by commercial and industrial development is unknown, but extensive. These form a dominant part of the islands’ landscapes, and are a readily observable feature. More specifically, NOAA Fisheries data showed that between 1981 and 1996, 197 proposals were received for industrial and commercial development. It is expected that wetland conversion has undoubtedly lessened because available land is at a premium, but where industrial and commercial expansion are proposed, they become a prominent part of the landscape and a major commitment of natural resources. Further, expansion of existing facilities poses the same risks. They must, therefore, be carefully assessed to minimize their long-term effects on habitat.

Point-source-discharges from commercial development follow the same risks imposed for urban and suburban development and the discussions under “Housing Development” apply. Industrial point-source-discharges are of greater concern because of their quantity and content. Untreated rum effluent from a St. Croix distillery is discharged on St. Croix’s south shore resulting in a 5-mile long benthic “dead zone”. Each year the Virgin Islands government requests, and has been granted, an exemption from the US Clean Water Act for this discharge. Discharges can alter the diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness of ecosystems, and the communities at the discharge points and further downstream (Carins 1980). Growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites of finfish, shellfish, and related organisms also may be altered. In addition to direct effects on plant and animal physiology, pollution effects may be related to changes in water flow, pH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities (Carins 1980). Some industries, such as paper mills, are major water users, and their effluent dominates the conditions of the rivers where they are located. Changes in dissolved oxygen, pH, nutrients, temperature, and suspended materials often have a great affect on habitat. The direct and synergistic effects of other discharge components such as heavy metals and various chemical compounds are not well understood, but preliminary results of research, is showing that these constituents will be a major concern for the future. More subtle factors such as endocrine disruption in aquatic organisms, and reduced ability to reproduce or compete for food are being observed (Scott et al 1997).

The cumulative effect of many types of discharges on various aquatic systems is not well understood, but attempts to mediate their effects are reflected in various water quality standards
and programs in each state, and within the various water systems. Industrial wastewater effluent is regulated by the EPA through the NPDES permitting program. This program provides for issuance of waste discharge permits as a means of identifying, defining, and controlling virtually all point-source discharges. FWS always provides comments on NPDES permits if they receive a copy of the solicitation. NOAA Fisheries provide comments for CZM Consistency Certificate requests NPDES permits when requested by the Puerto Rico Planning Board CZM Program. The complexity and the magnitude of effort required to administer the NPDES permit program, limit overview of the program. For these same reasons, it is not possible to presently estimate the singular, combined, and synergistic effects of industrial (and domestic) discharges on aquatic ecosystems.

Little is known about non-point-source discharges from industrial activities. Their affects, however, are likely to be at least as important as those from urban and suburban development. In some situations, especially for industries that produce hazardous materials, non-point-source discharges can be traumatic events, especially if there are accidental releases of chemicals. An added concern with industrial operations is contaminants emitted into the atmosphere. The types and levels of contaminants reaching Caribbean surface waters is unknown, but hopefully have a marginal effect because of dispersal by the almost constant trade winds.

3.5.2.2.8 Irrigation, flood control, and drainage related to agriculture, forestry, and urban development

The direct effects of agriculture and forestry in the islands may have some degree of effects on fish habitat. Deforestation of certain lands close to rivers or streams that are being cleared to be used as crop fields, coffee plantations, or other agricultural purposes may have some degree of effect on fish habitat. Presently, the Government of Puerto Rico is undertaking considerable efforts to increase local agriculture production, thereby reactivating an activity which had been relatively static in the past. Major production is derived from the dairy industry. Other major industries include: livestock, vegetables and root vegetables, farinaceous, eggs, poultry, pork, ornamental plants, coffee, and fruits. Direct effects on fish habitat associated with development occur, but are not as important as other threats. In the last 15 years, the NOAA Fisheries received only seven projects under this category for review, and all were in Puerto Rico.

Agriculture and forestry cause direct and non-point-source discharge of fill, nutrients, chemicals, and surface and ground waters into streams, rivers, and coastal waters; hydrological modification to include ditches, dikes, farm ponds and other similar structures and water control devices; and cumulative and synergistic effects caused by association of these and other related activities.

3.5.2.2.9 Mariculture/aquaculture

Aquaculture in the islands has occurred mainly in Puerto Rico, and involved mainly the culture of freshwater species. Culture of saltwater species is in its relatively early stages, where saltwater shrimp, and saltwater species used for the aquarium trade, are being cultured. Mariculture is
obtaining major interest, where one project off the island of Culebra is in operation, and involves the culture of cobias, and mutton snapper. It is not known whether habitat of marine fish species was affected by past aquaculture activities. The blue tilapia (*Tilapia aurea*), red tilapia (*Sarotherodon* sp.) and the freshwater shrimp (*Macrobrachium* sp.) were the primary aquacultured species. Other introduced exotics mainly were associated with reservoirs and farm ponds, or were introduced for aquatic weed control (Erdman 1984). Aquaculture ponds have been built on the coast and there have been observed cases of accidental release during floods. Aquaculture ponds have also been built in the mountainous areas of Puerto Rico. Only the tilapia has found its way into salt water, but is now well-established in some areas. Erdman (1984) believes that these incidental releases have not harmed indigenous species, and that the number of tilapia in salt water is being controlled by marine predators such as snook, tarpon, ladyfish, and jacks.

Proposals have surfaced in the past to culture saltwater penaeid shrimp, but these never went beyond the discussion stage. The first deep water marine fish farm has been put in place off the coast of Culebra and the Puerto Rican government is studying the possibility of putting more of these farms in other locations. However, there is concern over the possibility of escape of non-native fish species and the effects of localized nutrient enrichment from these fish farm cages. Any future culture of marine organisms may involve the alteration of coastal habitats or discharges of wastewater to marine systems. Consequently, they could pose a threat to marine fish habitat.

3.5.2.2.10 Bulkheads, small fills, groins, etc.

Bulkheads are used to protect adjacent shorelines from wave and current action, and may be used to enhance water access. Applications for bulkheads usually specify construction in open water, followed by placing fill material behind the structure. Bulkheads may threaten fish habitat through direct filling; through isolation; and through exacerbation of wave scour. Jetties, groins, and breakwaters can be considered as obstructions to long shore sediment transport, and often accelerate down-drift erosion and scour. Small fills generally include efforts at reclaiming land lost to erosion, but also include efforts related to expanding available uplands, and as small refuse dumps. These may proliferate and convert large amounts of fish habitat to fast land. Further, debris, trash, and floatable objects from small dumps can adversely affect habitat as well and have the potential of releasing containates into adjacent waters.

While most of the projects in this category are considered minor work, they cumulatively are significant, and as such can alter relatively large areas of habitat directly, and secondary affects (e.g., erosion, long-shore drift alteration) associated with these activities may be even more substantial, albeit poorly documented. Evidence for the importance of bulkheads, small fills, groins, etc., as modifiers of fish habitat is evident based on some NOAA Fisheries data. At least 366 proposals in this category were received by the NOAA Fisheries between 1981 and 1996. About 281 acres of fish habitat were proposed for direct alteration by 28 of these proposals.
3.5.2.2.11 Power generating facilities

Power plant siting and power production have the potential to directly impact fish habitat, through modification for facility siting, and construction of cooling water intakes and outlets. These facilities also usually require piers, docks, channels, and related appurtenances for off loading the fuels (e.g., oil) needed to operate the turbines. This often involves dredging and filling, with the threats discussed under “Navigation Projects, Ports, Marinas, and Maintenance Dredging.” Many power plants also require large amounts of water for cooling. Fishery organisms can be entrained within the water intake systems. The water discharge is heated and this impacts fish habitat at the release site. This can be a greater problem in the Caribbean because many aquatic species may already be at their upper tolerance level for temperature. Discharge waters also may contain biocides such as chlorine that are toxic to marine life.

Indirect effects can include non-point-source discharges of contaminants from hard surfaces; release of contaminants in wastewater streams, atmospheric deposition of contaminants such as SO\textsubscript{2}; and the spillage of fuels such as oil during shipping and off loading.

Only three proposals to build or expand power plants, in or near important fish habitat, have been submitted in the last 15 years. All of these were in Puerto Rico. The latest facility, a cogeneration facility in Guayanilla Bay, Puerto Rico, was built by EcoElectrica, L.P. and is operational and includes a marine terminal for unloading liquid natural gas. While there have been relatively few projects, power generating facilities occupy a substantial amount of land and require a large commitment of natural resources. Fish habitat can be seriously threatened by these facilities, with potentially long-term or permanent damage. Accordingly, future requests for new facilities or expansion of old ones must be carefully assessed to ensure that their impacts are fully understood and mitigated.

3.5.2.3 Natural factors

Coastal processes may be dramatically altered by unpredictable, but natural events. These include shorter-term forces such as storms, hurricanes, floods, etc., and longer-term events such as global warming and sea level rise. The latter may also be considered as a result of human activity. Affects vary from potentially positive to catastrophic. For example, a moderate storm may provide badly needed fresh water, flush stagnant systems, and provide a supply of nutrients from upland and high marsh surfaces. Severe events can lead to erosion, destruction of wetlands, subsidence, and severe short-term, and possibly long-range reduction in the ability of habitat to support fishery production. The eventual result of global changes is difficult to predict. However, it is evident that the coast and related wetland systems will change and that the ability of humans to affect this change will largely frame the outcome. With the extensive development along the coastlines, sea level rise can have serious consequences for humans, fish habitat, and the fishery resources that rely on coastal habitats.

Some of the more important natural factors that affect quantity and quality of habitat around the islands are discussed below:
3.5.2.3.1 Tropical disturbances

The passage of storms and hurricanes through mangroves and seagrasses can cause uprooting, mechanical defoliation, and deposition of sediment and other materials. This stress can eliminate vegetation from some areas. For mangroves, following the acute stress, there is a rapid re-establishment of new seedlings on suitable habitats, and the system restores itself. Seagrasses also may recover quickly, if damage is slight and the substrate has not been severely altered. Some storms may have beneficial effects on mangroves such as removing accumulations of materials choking drainage ways, and reopening salt ponds to the sea. Such tropical disturbances are important agents that redistribute materials along the coast. Storms passing within +/- 2° of Puerto Rico have increased in number and intensity since 1990.

Damage to coral reefs in Puerto Rico and the USVI due to natural phenomena has been well documented. A large portion of the Caribbean lies within the hurricane belt and therefore reefs are frequently exposed to severe hurricane related impacts. Hurricanes can modify substantial portions of shallow reefs. Two tropical storms in 1979 (David and Frederic) caused extensive damage on the outer east coast and southern coastal reefs, especially in the shallow Acropora palmata zone, off the eastern point of Vieques and off St. Croix (Goenaga and Cintrón 1979, Rogers 1982). Hurricane Hugo caused a significant reduction in total living scleractinian cover on reefs on the south side of St. John (Rogers et al 1991). It devastated portions of coral reefs and seagrass beds off St. Croix (Rogers et al 1991). Rogers et al (1991) were able to study the effect of Hurricane Hugo that hit the USVI in 1989 Analysis of quantitative data collected before and after the storm allowed documentation of the effects of this powerful storm on coral community structure. The total living cover by scleractinians, including the dominant species, Montastrea annularis, decreased significantly. The amount of substrate available for colonization increased. Cover by macroscopic algae increased dramatically after the storm, later decreased, and then rose again one year later. It appears that the level of herbivory by urchins and fishes is too low to keep the macroalgae in check, and algae are inhibiting coral settlement and growth (Rogers et al. 1997). In spite of the reduction in live coral cover by the dominant coral species, neither diversity nor evenness increased. Hurricane Georges in 1998 was the worst hurricane since San Ciprian in 1932, with sustained winds of 185 km/hour.

On the other hand, hurricanes may also be beneficial by displacing large numbers of fast growing, branching, coral species that monopolize the substrate, thereby freeing space for slower growing, massive species. This appears to result in an increase in species diversity (Connell 1978), in the absence of additional stresses.

3.5.2.3.2 Hypersalinity

In some areas such as salt flats behind fringing mangroves, hypersalinity is a natural phenomena. In other cases, hypersaline conditions have been created by anthropogenic activities which have diminished freshwater flow into the area (e.g. Jobos). Hypersalinity affects mainly mangroves. The accumulation of high levels of salt through evaporation is a chronic natural stressor in dry areas. When evaporation exceeds rainfall throughout the year, tidal action and evaporation accumulate salt in the back areas of the swamp. Eventually the soil salinity increases beyond the
tolerance of mangroves and a barren zone develops. Mangrove coverage in these areas is unstable, with coverage fluctuating between periods of expansions following storms or a succession of very wet years and contraction triggered by drought or silting of drainage ways. During different periods, an area may undergo these changes and subsequently provide a great number of animals with food and other benefits.

3.5.2.3.3 Reef diseases

Diseases represent poorly understood natural phenomena. One factor may be water quality deterioration due to anthropogenic activities, which can reduce an organism’s ability to withstand a disease, or cause a disease organism to proliferate above normal background levels. White-band disease, yellow-blotch disease, white plague II, black-band disease, white plague, and seafan fungus have all affected the coral (Turgeon et al. 2002).

Coral diseases are known to attack reef corals in Puerto Rico and the USVI. The White Band Disease, for example, has caused population declines in A. palmata. Vast stretches of living and healthy A. palmata observed in Cayo Largo, Fajardo, in 1979, were severely decimated, possibly as a consequence of this disease, and it has affected over 5 hectares of the A. palmata reef at Buck Island National Monument, St. Croix (Gladfelter 1982). The Black Band Disease (BBD), caused by photosynthetic cyanobacteria, has been observed to affect corals in reefs of La Cordillera, Fajardo, and at the El Negro reef off the west coast of Puerto Rico, and also on corals in the Virgin Islands National Park on St. John and Buck Island, St. Croix (Peters 1984, Rogers and Teytaud 1988).

Edmunds (1991) determined the effect of BBD among colonies of M. annularis, M. cavernosa, Diploria strigosa, D. labrinthiformis, Siderastrea siderea and Colpophyllia natans at 7 shallow locations in the Virgin Islands. Between September 1988 and November 1988, 0.2 percent of 9204 colonies of these species were infected with BBD in 6,908 sq. meters of reef at 22 randomly chosen areas. Infected colonies were not clumped suggesting that the disease is not highly infectious between colonies. BBD infection rates in areas surveyed 4 times between August 1988 and September 1989 in Greater Lameshur Bay, St. John, USVI, were significantly lower in winter compared to summer. BBDs were found on 5.5 percent of the colonies of D. strigosa) in fall 1988, and 7 out of 12 infected colonies lost > 75 percent of their tissue in 6 months. Low level, chronic BBD infections could convert 3.9 percent of the living cover of D. strigosa to free space per year, thereby creating substrata for successional processes.

Bruckner (1999) determined that incidence of BBD was highly correlated with periods of greatest visibility, lowest wave action, and lowest rainfall. Reefs subject to high levels of runoff (sedimentation) and nutrient loading had lower BBD incidence, possibly because of lower light levels. Bruckner found successful elimination of BBD occurred by 1) removal of bacteria filaments with a syringe and covering the leading edge of the disease with putty or clay; 2) grazing by the sea urchin Diadema; and 3) reduction of natural light. The die off of Diadema has likely contributed to the proliferation of BBD.
Yellow-blotch disease was discovered on several reefs off Mona Island, Desecheo, and La Parguera during 1996-1997, and had spread significantly by 1999, especially among massive boulder star corals (Bruckner and Bruckner 2000). White plague was reported in 1997, as conspicuous white patches of necrotic tissue appearing on scleractinian corals around St. John. Although it does not always lead to total colony mortality, diseased portions never recover, and it has now been confirmed on 14 different coral species, and is the most destructive disease active around St. John (Miller et al. in press). Sea fan disease, caused by the fungus Aspergillus sydowii, occurs on sea fans on St John reefs, and is possibly linked to African dust transported by the wind (Turgeon et al. 2002). Recently, small Porites porites patch reefs in the USVI have been dying from an unknown disease (Turgeon et al. 2002).

Another source of stress to Caribbean reefs is coral bleaching (i.e., expulsion of zooxanthellae or their in situ degeneration), whereby coral growth rates are slowed down, and the capacity to heal from wounds is possibly impaired. A major coral bleaching event occurred worldwide in 1998 including areas of the Caribbean (Australian Institute of Marine Science 1998). Puerto Rico experienced sporadic low-frequency bleaching down to 30 m, primarily affecting the zooanthid Palythoa and Millepora corals. In the USVI, 5 reefs south of St. Thomas experienced bleaching, with 50% of those reefs colonies being affected. Puerto Rico reefs underwent moderate bleaching in 1996 following Hurricane Hortense, but recovered in 1997. Events of this nature also occurred Caribbean-wide in 1987 and 1990 (Williams et al. 1987; Goenaga and Canals, 1990). National Park staff on St. John observed bleaching in several hard coral species and in Palythoa in October of 1987. D. labirinthiformes and D. strigosa were the most affected species and Agaricia lamarcki colonies as deep as 27 m were observed to have been bleached (Rogers and Teytaud 1988). Studies elsewhere in the Caribbean suggest that bleachings have been more severe in polluted areas.

In a study of reef bleaching, Puerto Rican coral reefs were surveyed with photo-transects and remotely-operated vehicles, and permanently tagged individual corals were monitored. Seven of eight phototransects examined between April and October 1988 had bleached or pale colonies of eight species of corals. Between 2.7 and 19 percent of the living coral surface area was affected on transects (Bunkley-Williams et al. 1991). These observations indicate that additional bleaching occurred after the recovery of most photosymbiotic hosts in January 1988. This continued bleaching may represent the longest bleaching event ever recorded. Individual coral colonies that were bleached in October 1987 were permanently tagged and photo-documented in the field. Recovery of some of these colonies took more than 5 months. Some previously living parts of these colonies died and were overgrown by algae by January 1988. Surveys by remotely operated vehicle during 10-13 February 1988 disclosed bleached colonies of Agaricia spp. to a depth of 60 m and unbleached colonies to a depth of 89 m (Bunkley-Williams et al. 1991).

Recently, numerous authors have stated that the most stress results from "abnormally high" seasonal sea surface temperatures (SST) and solar radiation, and have implicated global warming as a cause of coral bleaching. Bleaching usually happens when SST exceeds 1 °C above the long-term average temperature for the hottest months. Such phenomena can be identified by satellite imagery and mapped as "hot spots" where bleaching is most likely to occur. Winter et al. (1998) found that bleaching events in Puerto Rico could be predicted by maximum SST, the number of days where SST exceeded 29.5 °C. or 30 °C.
Observations of increased amounts of wind-borne African dust in the Caribbean Region since the 1970s (Figure 3.12) has led to a hypothesis that the dust has contributed to declines in coral reef health (USGS 2001). Annually, several hundred million tons of red iron-rich soils and clay-rich soils of North African Saharan origin are carried across the Atlantic and deposited on carbonate islands throughout the Caribbean (Muhs et al. 1990). The decline in the health of Caribbean reefs since the 1970s, coincides with peaks in the amount of dust reaching the Caribbean, especially in 1973, 1983 and 1987. Both direct fertilization of benthic algae by iron or other nutrients interacting with NH$_4$ and NO$_2$ + NO$_3$-rich submarine ground water, and broadcasting of bacterial, viral and fungal spores could contribute to reef decline. For example, the fungus affecting sea fans throughout the Caribbean has been identified as a land-based Aspergillus sp., a fungus that does not reproduce in seawater (Smith et al. 1996). The coral die-off corresponded in time with the increased African dust (USGS 2001). The number of fungal colonies in air samples is 10-20 times higher during dust events in the Caribbean. The relationship between African dust deposition in the Caribbean and die off of corals remains only a hypothesis, and requires more research to determine what, if any, link exists.

The relatively recent massive die-offs (1980s) of the long-spined sea urchin, Diadema antillarum, a major herbivore of coral reef systems throughout the Caribbean, have contributed to the modification of corals and the coral reef habitat (Vicente and Goenaga 1984; Lessios et al. 1984). Individuals of this species feed on the substrate, clearing it of fast-growing fleshy and filamentous algae and allowing coral larvae to settle and grow. Algal biomass within coral reefs has increased following the urchin die-offs. If other herbivores do not increase concomitantly, the growth in algal biomass is likely to increase the availability of algal propagules, thereby potentially reducing substrate for coral settlement. This situation is possibly worsened in artificially-eutrophied areas, where algal growth is further stimulated. While numbers of Diadema appear to be increasing at present, estimates put them at only 10% of the population level before the die-off event (Turgeon et al. 2002).

3.5.2.3.4 Bioerosion

Bioerosion also constitutes a significant problem for Caribbean reefs. The proportion of reefs containing boring bivalves per coral head is higher in Caribbean reefs than in coral reefs in the Indian Ocean and in the western Pacific region (Highsmith 1981). Loss of skeletal mass by bioerosion reduces reef growth. Although hard corals, coralline algae, and other marine invertebrates secrete calcium carbonate reef material, natural and man-made forces continue to erode these substrates. If natural erosion and anthropogenic activities such as harvest and accidental damage, outstrip calcium carbonate deposition by corals and other reef-building organisms, a net loss of these resources will occur over time.
4 ENVIRONMENTAL CONSEQUENCES

NOAA Fisheries regards the EFH mandate as a significant opportunity to make a difference in improving the success of sustainable fisheries and healthy ecosystems in waters under US jurisdiction (NMFS 1998). This opportunity, however, depends on effective partnering and cooperation with federal, state and local government agencies, fishing and other industries, conservation groups, academia, landowners, and other members of the general public.

4.1 Overview

This section provides the scientific and analytic basis for the comparisons of the alternatives (Sections 2.3 to 2.5), and describes the probable consequences of the alternatives on the affected environment, as described in Section 3. The methodologies used for obtaining and analyzing information to assess the environmental consequences are described in Section 2.1.

The M-S Act divides the anthropogenic sources of potential adverse effects on EFH into two main groups: fishing activities and non-fishing activities. The Council and NOAA Fisheries have control over fishing activities in Federal waters, and can set regulations as required to balance the needs of the fishing industry, the fish and habitat conservation (Figure 2.1). The Council can use its environmental policy and the designation of EFH to determine appropriate additional measures in the EEZ to limit damage to EFH from fishing gear. The alternatives for describing and identifying EFH, for designating HAPCs, and for preventing, mitigating or minimizing effects of fishing on habitat are described in Sections 2.3 to 2.5.

The Council and NOAA Fisheries have no direct control over non-fishing activities or over fishing activities in state waters (Figure 2.1). NOAA Fisheries has no authority to manage fisheries of other nations. Final decisions on approval and conditions for non-fishing activities remain with the Federal agency with responsibility for the action. That agency will determine if proposed activities must be modified to prevent, mitigate or minimize adverse impacts on EFH. However, NOAA Fisheries and the Council have important input into the process because the responsible agency must initiate a consultation with NOAA Fisheries for activities with potential to adversely effect EFH, and must respond in writing to recommendations made by NOAA Fisheries and the Council.

Impacts on EFH from fishing and non-fishing activities will occur in both state and Federal waters. In the US Caribbean, relatively smaller amounts of EFH occur in the EEZ than in other Fishery Management Council regions. Lack of data limits mapping of habitats that make up EFH in the EEZ (Appendix 5). Potential habitats designated as EFH occur mostly in state waters with a small portion in Federal waters (Figure 2.22).

The lack of information required to quantify both fishing and non-fishing impacts on fishery production, such as Caribbean-wide relative fish abundance or relationships between habitat and production for many fish species, calls for a precautionary approach (see Section 4.2) in designating EFH and HAPCs. Areas designated as EFH are considered to be necessary to
support a population adequate to maintain a sustainable fishery and the managed species’ contributions to a healthy ecosystem, measures to prevent the loss or degradation of EFH would be beneficial, even though the impacts to fishery production may not be quantifiable.

To compound the problems with the analysis of impacts, we cannot predict the results of consultations on non-fishing activities. If a responsible Federal agency implements the recommendations from NOAA Fisheries and the Council during consultation, then, providing these recommendations effectively address possible impacts, EFH presumably will not suffer adverse effects or at least impacts will be offset. However, there may not be sufficient information to always make accurate assessments of risk and loss of EFH may still occur. If the responsible Federal agency does not implement or only partially implements the recommendations, then non-fishing activities may cause habitat losses that accumulate with each project. We cannot predict what habitats will be destroyed or adversely impacted, or the associated rate of decline in fish production. As a range of possibilities for individual projects, EFH and HAPC designations offer a range spanning nearly total protection to no protection at all. However, in the aggregate, past EFH consultations have resulted in the conservation of marine fish habitats. Clearly, the effectiveness of a consultation is likely to be enhanced by information leading to identification and quantification of relationships between fish and habitat.

Of necessity, the analysis of environmental consequences is done with incomplete information and data. The effects of missing information in assessing the environmental consequences of the EFH alternatives are specifically discussed in Section 4.2.

### 4.2 Effects of missing information in assessing environmental consequences

According to NEPA Regulations (CFR Part 1502.22), when an agency evaluates reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information, it must do several things.

First, it must always be made clear if there is a lack of sufficient information on which to base a full evaluation of the environmental consequences of a particular action. Secondly, NEPA requires that if information essential for making a reasoned choice among alternatives is missing, and if the overall costs of obtaining it are not exorbitant, then that information should be obtained and it should be included in the EIS. If, however, the information cannot be obtained either because it is cost-prohibitive, or the means of obtaining it are unknown, the EIS must contain the following elements:

- A statement that such information is incomplete or unavailable;
- A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;

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\(^4\) In the NEPA regulations, “reasonably foreseeable” includes impacts that have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.
• A summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and
• An evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.

Throughout this document, the extent of current information has been described, and where there is information lacking on reasonably foreseeable significant impacts, this has been made clear.

One of the major aims in the analysis of data for the US Caribbean is to find ways to show contrast in the probability of impacts from one location to another (Section 2.1.5.3). Demonstrating contrast enables managers to focus their attention on the areas most at risk and most in need of protection. However, major difficulties were encountered in achieving this aim because the level of information available, particularly on a geographic scale, was generally very low. In many cases, the analyses use information with a high degree of uncertainty. However, in the absence of estimates of that uncertainty, the calculations described in this section treated the available data deterministically. To the extent possible, this analysis has recognized the existence of uncertainty by grouping data and results of calculations into ranked categories. This provides a level of contrast that is workable, without necessarily assuming greater precision in the data than would be prudent.

Considering the NEPA regulations in the context of fisheries management, and the lack of sufficient information that generally exists, one of the most important concepts that has received general and widespread acceptance in the scientific community in recent years is the precautionary approach. The International Code of Conduct for Responsible Fisheries (FAO 1995), to which the US is signatory, states that fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. Critically, the absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment. This has particular relevance in the implementation of the EFH provisions of the M-S Act.

The EFH Final Rule specifies that Councils should review, and if necessary revise, their actions on EFH. During the 5-year period following this EIS, relevant, new information will become available to the Caribbean Council and NOAA Fisheries. Some of the new information may result from deficiencies identified and recommendations made in this EIS. Based on this new information, the Council will start and maintain a list of new actions to consider for describing and identifying EFH, designating HAPC, and addressing adverse fishing impacts on EFH. The Council will delegate to the Council’s HAP and SSC the responsibility for evaluating and consolidating recommendations and bringing to the Council’s attention those actions that have scientific and social justification. The Council will conduct its normal scientific and public review for recommendations to change EFH, HAPC, or regulations to address adverse affects of fishing.
4.2.1 Describing and identifying EFH and HAPCs with limited information

This document has identified significant gaps in the information required to assess the consequences of the alternatives. These gaps occur, for example, in the areas of spatial distribution of habitat (deeper than 25 m), spatial distribution of species and life stages, habitat dependence at various life stages, stock assessment of species managed under the FMPs (no species covered by the FMPs has had any kind of quantitative stock assessment performed recently), and descriptions of the human environment. The NOAA Fisheries EFH guidelines require maps depicting areas of proposed EFH for each alternative, and strongly encourage maps of proposed HAPCs for each alternative. The most significant impediments to describing and identifying EFH and mapping the extent of EFH have been the lack of information on species distributions and the paucity of habitat mapping information deeper than about 25 m.

Little published information demonstrates the utilization of habitats by managed species on an area-specific basis. Information on the distribution of fish habitats and utilization by managed species within the Caribbean is currently insufficient to accurately map the occurrence of those habitats. Collecting more data to map habitats was impractical in the time scale for this DEIS (see below in this section). Mapping incomplete distributions would exclude important habitat. Therefore, the DEIS provides maps of general distributions of habitat and utilization of habitat by species under each FMP, where available, and produces maps illustrating the extent of both known and potential EFH and HAPCs for each alternative.

The NOAA National Ocean Service (NOS) acquired aerial photographs for the nearshore waters of Puerto Rico and the USVI in 1999 (Kendall et al. 2001). These images were used to create maps of the region's coral reefs, seagrass beds, mangrove forests, and other important habitats. However, aerial photographs do not provide information for habitats in water depths too deep for resolution of bottom types.

Several state and Federal agencies have collected and archived physical and biological habitat data, but those data are dispersed and not all are known to all agencies. In some cases, very detailed data exist for small areas, while other data sets contain sparse data over wide areas. Full utilization of the existing data is unlikely without an inter-agency body to assemble the data and coordinate mapping. The Southeast Area Monitoring and Assessment Program (SEAMAP-South Atlantic) established a Bottom Mapping Work Group to develop a regional database that describes the location and characteristics of hard bottom habitat on the continental shelf off the southeastern United States from North Carolina to Florida. Such a working group does not yet exist for the Caribbean.

As funds become available for mapping of habitats, representatives of USGS, NOAA Fisheries, the Council, the governments of Puerto Rico and the USVI, and other participants could resolve the resolution versus funding issue through consultation to match habitat information needs with the ability to provide the data. For example, if highly detailed surveys and intimate understandings of selected areas (representative habitats) exist, we can extrapolate that understanding to areas with lower resolution maps. While surveys might not be able to map every outcrop, detailed survey information of representative shelf edge areas would allow prediction of where particular habitats would occur in unmapped areas (Scanlon et al. 2000).
When more detailed information is needed, a survey of the predicted most-sensitive areas could obtain necessary data at much lower cost than doing a high-resolution survey over a large area.

The use of Side Scan Sonar (SSS) to map bottom topography and habitat has proved to be efficient in identifying a defined set of habitats present in an area, and can provide detailed information on the spatial distribution of highly fragmented “seascapes” (Prada 2002). Prada (2002) generated a detailed benthic map of a section of the insular shelf off La Parguera, Puerto Rico, in a digital format, from SSS imagery acquired during 1998-1999. Through visual interpretation of the bottom SSS mosaics, habitats were classified and delineated utilizing a hierarchical classification scheme, suitable for use with GIS. Habitat information from 5,248 bottom SSS images were processed and merged into 18 habitat mosaics of 3.4 km² (1 nm²) each and one of 0.64 km², at 0.10 m resolution. The habitats were summarized into three major meta-community types: corals and gorgonians on consolidated sediments; submerged aquatic vegetation (SAV) on unconsolidated sediments; and bare/mixed invertebrates on unconsolidated sediments. Ground truthing in selected habitats demonstrated that, in general, visited sites were found within an area of 5 - 25 m in diameter of the GPS reading obtained from the map/imagery.

The SSS provided more detailed habitat mapping than available from NOS mapping (Figure 4.1). The SSS maps had less unidentified habitat, and provided a smaller scale resolution. The intensive effort required to obtain and process the SSS data into maps demonstrates that this technology is more suited for detailed study of small areas. Aerial mapping as performed by NOS provided a much wider scale of habitat mapping suitable for analysis over the entire inner coastal shelf of Puerto Rico and the USVI.

If collecting agencies also provide data to a coordinating body as was done within the South Atlantic Fishery Management Council region, more data will be available for mapping. Then over time, habitat distributions would become more complete.

4.2.2 Addressing adverse fishing impacts with limited information

The lack of specific information on the effects on habitat of fishing gears used in the US Caribbean severely limits the capability to provide a quantitative assessment of the sensitivity of habitats to gears. As result, a consensus approach developed a matrix of impacts for gears and habitats (Hamilton 2000, Barnette 2001, Section 3.5.1). Two key information types limit the spatial analysis of adverse fishing impacts: lack of habitat mapping in waters deeper than about 25 m, and lack of reliable, spatially explicit fishing effort data (Sections 2.1.3.3.3 and 2.1.5.3.1).

4.2.3 On-going work to obtain missing information

4.2.3.1 Council activities

The Council is continuing with developing a permitting strategy for fishing gears (CFMC 1998). This direction that the Council is following will require collection of data necessary to identify
the universe of users and most importantly, what is harvested and how is fishing done in Federal waters. The information required includes, among other items, the number of gears, types of gear, and a description of the way in which these are fished. The Council seeks to obtain information on fishers from Federal waters separate from fishers in State waters prior to establishing a permitting system in Federal waters.

The Council has created sub-committees composed of expert commercial and recreational fishers, scientists, etc. for each of the fisheries under management in the US Caribbean. These sub-committees will provide the Council with recommendations and suggestions regarding management problems. This new information should provide a basis for implementing the permitting process.

There are data from logbooks kept by recreational fishers in the USVI that have not been evaluated and analyzed. These data might prove helpful in evaluating the catch from the two areas (Federal and state) and also in determining effort and bycatch, if accurately recorded.

The Council and the NOAA Fisheries Southeast Region meet annually to produce a US Caribbean Operations Plan. Under the Operations Plan, the Council and NOAA Fisheries agree to a set of priorities and a research program to reach them. The Council submits a list or statement of needs from NOAA Fisheries, including SERO and SEFSC elements, to support the Council actions and activities for the following fiscal year. Topics range from general research needs to specific scientific studies to administrative/support studies. Responses to these topics from the SERO and SEFSC represent the work plan in support of the Council. The Caribbean Operations Plan contains commitments from NOAA Fisheries to provide vital information for a variety of species needed in Caribbean FMPs. Ancillary research from several funding programs (MARFIN, SEAMAP, Cooperative Research Program, etc.) also contribute to the Council research needs.

4.2.3.2 NOAA Fisheries Habitat Research Plan

One of the chief concerns related to living marine resources is how human activities impact fishery productivity. Research is needed to provide knowledge of the ecological processes that affect energy flow leading to fishery productivity and responses of living marine resources to habitat and environmental changes. This understanding of ecological processes must then be linked with information on the health, distribution, and abundance of ecologically important organisms. By understanding the ecological linkages between fisheries, habitat, and production of fishery stocks, managers will be better able to manage activities impacting living marine resources and their Essential Fish Habitat (EFH). No information is available with which to estimate productivity changes from changes in habitat for the US Caribbean. In the absence of such information, this EIS assumed that changes in productivity follow the direction of changes in habitat, but in an unquantified, non-linear manner.

A NOAA Fisheries Habitat Research Plan (HRP) by Thayer et al. (1996) identified the research needed to provide information necessary to protect, conserve and restore aquatic habitats. The HRP systematically guides habitat research in four areas:
• Ecosystem structure and function;
• Effects of alterations;
• Development of restoration methods; and
• Development of indicators of impact and recovery.

Additionally, the plan emphasizes a fifth area -- the need for synthesis and timely information dissemination to managers. The following provides a brief synopsis of each of the five research areas identified in Thayer et al. (1996) along with some specific research topics and projects currently underway in each area.

**Area 1: Ecosystem structure and function** – This key area involves research to understand the structure and function of natural ecosystems, their linkages, both internal and external, and the role they play in supporting and sustaining living marine resources (e.g., their distribution, abundance and health). Research should include studies on the relationships between habitat and yield of living marine resources, including seasonal and annual variability and the influence of chemical and physical changes on these relationships. Resulting information should provide a foundation for predicting organism and habitat response to perturbation, as well as for predicting recovery or restoration success.

Specific research needs include:

Assessment of the quantitative relationship between EFH and Federally managed species and the ecological systems or food webs that support them.

Identification of optimum EFH for managed species, including habitat areas of particular concern.

Mapping of EFH for reef fish in the Caribbean. (Note: Mapping of habitats to approximately 25 m depth has occurred – see Section 2.1.3.3.3)

Identification of EFH for reef fish (Note: This EIS provides alternatives to describe and identify EFH – see Section 2.3)

Identification and understanding of linkages between habitats, fisheries, and protected resources. This would include identification of the role of habitat mosaics or mixtures of habitats necessary to sustain fishery productivity.

Development of simulation models of EFH interactions and the conduct of sensitivity analyses to determine important variables affecting productivity and health.

Importance of seagrasses as EFH in the Caribbean through studies that evaluate growth and production of fishery organisms.

Evaluation of unvegetated flats as EFH within estuaries using both indices of presence and measures of growth and production of fisheries organisms.
Characterization and quantification of EFH for juvenile goliath grouper and Nassau grouper.

Mapping of shelf habitats presumed as important EFH.

**Area 2: Effects of habitat alterations** – This area involves research to quantify the responses of habitats and fishery resources to natural and man-made alterations. Research should include cause-and-effect studies designed to evaluate responses of fishery resources and habitats to physical and chemical modifications of coastal and estuarine systems. Resulting information should provide a basis for determining the degree of impact, the prediction of recovery rates, and the most effective restoration procedures and protective measures.

Specific research needs include:

- Determination of the rates and amounts of EFH losses to natural forces and man-induced perturbations.
- Development of methodologies and processes to determine and track cumulative impacts to EFH.
- Relative significance of various organic and inorganic pollutants on EFH, current pollutant loads, and the assimilative capabilities of EFH.
- Refinement of EFH for commercially and recreationally important fishery species and resulting reduction in development of permit-related impacts.

**Area 3: Habitat restoration methods** – This area involves research designed to improve the current methods to clean up, restore, or create productive habitats, as well as the development and evaluation of new, innovative techniques. Studies should include analyzing the success of sediment sequestration; assessing bioremediation techniques; developing and evaluating new habitat restoration techniques; evaluating the role and size of buffers; and determining the importance of habitat heterogeneity in the restoration process. Resulting information should add to the scientific basis for predicting recovery and stability of restored and created systems. Perhaps most important, the research should generate guidelines for improving best management practices and restoration plans.

Specific research needs include:

- Development of design specifications for restoring functional habitats and enhancing rates of biotic increase and stability of restored habitats.
- Development and refinement of water control structures that maximize the passage of fishery organisms.
- Development of simulation models to predict habitat development trajectories for restored EFH and to test expectations of success.
Development of restoration techniques, siting criteria, and establishment guidelines for EFH in the Caribbean; including seagrass and hard bottoms.

Area 4: Indicators of Impacts and Recovery – This area involves research aimed at the development of indicators to simplify the process of determining whether an ecosystem, habitat, or living marine resource is affected or is recovering. The development of indicators is critical for judging the status of a habitat or living marine resource and the need for corrective action. Studies should include time-dependent population analyses and contaminant-level follow-up evaluations for sediment, biota, and water. This type of research will help managers identify habitat status or “health”; standardize indicators for specific habitats through comparisons across geographic gradients and scales; and develop recommendations on the temporal efficacy of chemical “cleanup” techniques and most appropriate measures to assess success. Such guideposts will be used to develop and improve best management practice approaches.

Specific research needs include:

Identification of chemical and physical factors that limit the production of managed species.

Construction of a nekton density database for estuarine habitats in the Caribbean and development of a user-friendly GIS system to display and analyze density data. The SEFSC is constructing a nekton database for estuarine habitats in the GOM and is working to develop a user-friendly GIS system to display and analyze density data. This project is in progress, and may be applicable for the US Caribbean.

Use of multiple stable isotopes and other tracers to identify functional linkages of fishery organisms to habitats as one measure of identifying EFH.

Use of growth and RNA:DNA ratios as indicators of habitat function and EFH for fishery species.

Preparation and publication of a synthesis report on seagrass habitat restoration technologies and recovery of associated fishery organisms.

Development of plan to reduce diseases/pathologies among fishery organisms in the Caribbean.

Development of quantitative methods for assessing essential reef fish habitat.

Area 5: Synthesis and Information Transfer – This area involves the transfer of technology and information through the use of all available sources and the application of user-friendly information bases. The use of geographic information systems (GIS) is encouraged, as GIS provides the opportunity to amass large quantities of complex, geographically referenced data that provide the potential for making relational observations. Information synthesis and transfer must be provided in a useable format. Specific research needs include:
Literature review and synthesis of all available information for managed fisheries species in the US Caribbean.

Improvement in the ability to use remote sensing platforms to identify habitats and habitat quality.

Improvement in the use of GIS technology to integrate remote sensing information, fisheries and protected resource data, and simulation models.

A synthesis of fisheries habitat value of intertidal and shallow subtidal flats.

Development of a GIS framework for spawning aggregation sites and environmental data and habitat maps of priority fishery reserve zones along the Puerto Rico-Virgin Islands shelf.

Auster and Langton (1999) reviewed nearly 80 years of research related to effects of fishing on the North American Continental shelf, but were unable to draw any conclusions regarding the overall impacts of fishing. They advise that primary information is lacking to strategically manage fishing impacts on EFH without invoking precautionary measures (specific measures not identified in report). A number of areas were highlighted where primary data are lacking, which would allow better monitoring and improved experimentation, leading to predictive capabilities. These are (taken verbatim from Auster and Langton, 1999):

1. The spatial extent of fishing-induced disturbance. Although many observer programs collect data at the scale of single tows or sets, fisheries reporting systems often lack this level of spatial resolution. The available data make it difficult to make observations along a gradient of fishing effort to assess the effects of fishing effort on habitat, community, and ecosystem-level processes.

2. The effects of specific gear types, along a gradient of effort, on specific habitat types. These data are the first-order needs to allow an assessment of how much effort produces a measurable level of change in structural habitat components and the associated communities. Second-order data should assess the effects of fishing disturbance in a gradient of type-1 and type-2 disturbance treatments.

3. The role of seafloor habitats in the population dynamics of fishes. Although good time series data often exist for late-juvenile and adult populations and larval abundance, there is a general lack of empirical information (except in coral reef, kelp bed, and for seagrass fishes) on linkages between habitat and survival that would allow modeling and experimentation to predict outcomes of various levels of disturbance.

These data and research results should allow managers to better strategically regulate where, when, and how much fishing will be sustainable in regards to EFH. Conservation engineering should play a large role in developing fishing gears that are economical to operate and minimize impacts to environmental support functions.
In addition to the above research area needs, specific information needs on a species-by-species basis are reflected in the summary habitat tables presented in Appendix 1. Thus, any and all blanks contained in the tables represent research that is needed to better understand, define and describe EFH for managed species in the US Caribbean.

4.2.3.3 Ongoing habitat-related projects

NOAA Fisheries has initiated or supported the following habitat or habitat related projects through its Operational Plan with the Council:

- Currently in the 3rd year supporting work by Puerto Rico to assess biomass of red hind, tiger grouper and mutton snapper (using hydroacoustic methodology) and determine their habitat needs. The study has focused on the north and south coasts of Puerto Rico, and plans are to include the Virgin Islands in 2004.
- Currently conducting studies of spawning aggregations in the USVI and collecting baseline information on commercially important reef fishes, principally, yellowfin grouper.
- Currently conducting comprehensive studies on essential fish habitat (EFH) characteristics for reef fishes in the USVI --- studies include coral reefs, hard bottom/reef rubble, seagrass, mangrove, and sand habitats. Work is projected to continue in 2004.
- Assessing the recovery and status of reef fishes at restored coral reef grounding sites in the Caribbean (e.g., Mona Island, Puerto Rico).
- Ongoing studies of the extent and impact of trap fishing on hard and soft corals and associated habitats.
- In the second year of developing a windows-based, user-friendly data entry program for collecting and storing data on reef fishes and habitat in the Caribbean. The prototype program is currently undergoing testing, and will be available to researchers throughout the Caribbean. Data collected will be uploaded via the internet, and will be stored at SEFSC, but will be made available to others for analysis.
- SEFSC has provided, through the services of a contractor, support for an experimental public-private aquaculture programs off Puerto Rico. These include submerged cages for mutton snapper and cobia, as well as for spiny lobster culture.
- A project is slated for funding in 2004 to continue trophic modeling work in Caribbean coral reef ecosystems to predict the timeframe and species-specific benefits of MPAs. An initial comprehensive baseline assessment has been completed and is anticipated to continue in the immediate vicinity of Navassa Island. A NOAA Technical Report has been published.
- Projected study in 2004 will examine habitat quality measures by looking at characteristics affecting feeding and diel migration patterns of juvenile grunts in locations near St. Croix, USVI and La Parguera, PR.
- Studies of genetic variability of mutton snapper are being conducted to understand Caribbean-wide distributional patterns of this species.
4.2.3.4 Habitat mapping

The Council has supported efforts by NOS and a large number of partners to continue mapping the shallow water benthic habitats of Puerto Rico and the US Virgin Islands. The work that the PR DNER and the USVI DPNR through their CZMPs includes monitoring of the near shore habitats and fish populations associated with these habitats. NOS has been also lending support to the Department of Interior, USFWS, in their efforts to map and describe the National Parks and the Monuments in the USVI.

The USVI began a benthic habitat-mapping project in 1999. Initial efforts were supported by NMFS and SEAMAP. Funding was then obtained under the US Fish and Wildlife Service USVI F-7 habitat project. The US EPA and its research vessel, the M/V Anderson, have provided assistance for the project. The area targeted for this work is 64 square miles south of St. John. This is the SEAMAP area in St. Thomas/St. John.

A total of 16 square miles has been surveyed using side scan sonar. The University of Puerto Rico completed construction of 2 square miles of mosaics. In addition, a mosaic has been completed of the 8 square miles surveyed by the US EPA vessel. Divers have collected habitat data in a small portion of this area to ground truth the side scan results.

Puerto Rico has been attempting to begin mapping work on the SEAMAP area off the west coast of Puerto Rico with side scan sonar. The effort has been transferred from SEAMAP to CZMP and the areas of priority include, the shelf (20 miles x 17 miles) off the west coast, Mona Island, Desecheo Islands, And the southern shelf of Puerto Rico.

The Hind Bank MCD will have a first benthic map produced (by the end of 2003) from multibeam and side scan sonar images. Large-scale characterization of the area will be available. The preliminary data show large areas of coral formations including patch reefs, plate coral and areas of sand and rubble among expanses of coral and hard bottom. All 16 square miles have been surveyed. The same operation will be conducted in the Lang Bank and Mutton Snapper areas off St. Croix that are seasonally closed sites to protect fish spawning aggregations. This work has also identified fish aggregations within the protected site.

The SeaBed autonomous underwater vehicle, equipped with side scan sonar, bathymetric sonar and a high-resolution digital still camera, will be used to obtain photographs of critical areas within the 16 square mile no-take zone off the south west of St. Thomas. These transect will be based on the multibeam work that has recently been done in the MCD and will help in ground truthing the bathymetric mosaic and in documenting the types and conditions of the substrates found in the area (health status of coral reefs) as well as providing information on the fish and macro-invertebrates found in the area.

Most of the deep coral habitats of the US Caribbean are within the EEZ. The CFMC will be making an inventory of the information available and an atlas (GIS format) of the deep-water reefs in the US Caribbean. High biological diversity exists in the upper slope of the shelf edge, an area that has not been mapped or characterized yet. Mapping and characterization of the fish populations within these areas are necessary.
The USGS and NOAA have several ongoing efforts to collect and compile geological data that could support Council activities to map substrates of interest. The USGS has bottom-mapping projects underway in US coastal waters (Kathryn Scanlon, USGS, personal communication), although no mapping projects are scheduled for the US Caribbean for the foreseeable future. The surveys typically use two techniques: sidescan sonar and multibeam bathymetry systems. Multibeam systems provide bathymetry and bottom hardness – sediment type. Sidescan sonar provides high-resolution details of seafloor features (qualitative information (e.g., bottom roughness, hardness, and relief) in the resulting backscatter and shadows that is missing from multibeam data) at scales of centimeters to kilometers (depending on frequency). Sidescan sonar does not provide bathymetry. Neither sidescan nor multibeam produces "habitat maps." They produce sidescan sonar imagery or bathymetry, respectively. Creating a habitat map requires supporting data (such as samples of substrate and biota, bottom photographs or video, and/or observations from submersibles) and the data must be interpreted and integrated.

The USGS collected seismic-reflection profiles and collected bottom samples with a bottom grab in the 1970s to early 1990s to construct geological maps of the Puerto Rico shelf (Section 2.1.3.3.3). The seismic profiles do not have the resolution of the current sidescan sonar or multibeam systems, but do provide information on the distribution of major bottom types. The USGS maps extend to the shelf break, which would provide information on areas deeper than mapped by NOS (see above in this section). This information could be used for planning and prioritizing future sidescan or multibeam surveys. The USGS bottom grab samples provide an opportunity to compare sidescan or multibeam images with known bottom types to groundtruth the surveys. Although the seismic-reflection surveys did not characterize seagrass, marine algae, or other biological habitats, they did describe the underlying sediments for these habitats. Converting the maps to GIS-compatible formats (see Section 2.1.3.3.3) would assist future reviews and analysis of EFH.

To cover an area of approximately 100 sq miles in 50-150 meters water depth using a 100 kHz sidescan system would require about 10 days at sea on a 120' ship (Kathryn Scanlon, USGS, personal communication). A shallower area would take longer. Salary, travel, and overtime costs would be approximately $65,000. Ten days of ship time would cost approximately $70,000. "Ground truth" research to collect sediment samples or video data to help interpret the sidescan data would require additional costs. Therefore, no additional mapping was attempted for this EIS.

4.2.3.5 Research on the effects of fishing gear on EFH

NOAA Fisheries has conducted research on EFH and gear impacts since 1998. In December 1999 and November 2000, NOAA Fisheries hosted workshops on the effects of gear on essential fish habitat (EFH) to develop a five-year research program on a multi-agency/institution approach. Agencies including the Naval Research Laboratory, the multi-agency Gulf Littoral Initiative program, US Geological Survey (USGS), and Minerals Management Service (MMS) have collaborated with NOAA Fisheries by providing research or equipment in support of the EFH and gear impacts program. NOAA Fisheries and various partners have begun a multi-year,
multi-area effort to investigate the direct impact of pots and traps on Caribbean habitats, especially coral. The results of these investigations will provide the CFMC with the necessary information to determine the need to further regulate traps. Other gear-habitat interactions, especially gill/trammel nets, require similar research. The costs and time required for this type of research preclude new information for this EIS. In the absence of Caribbean-specific information, this EIS used a precautionary sensitivity index for gear-habitat interactions based on previous expert consultations (Hamilton 2000; Barnette 2001).

4.2.3.6 Fish-habitat modeling

4.2.3.6.1 Habitat suitability models

Mathematical models that describe relationships between habitat and fish production are not generally available because of imprecise definitions of habitat and uncertainty in the relationship between habitat and fish abundance and/or production (Rubec et al. in press). Fish abundance varies over areas and habitats as a result of complex interactions of environmental and biological factors. Habitat-use patterns are measurable, however, considerable variation occurs in habitat types and in physical or structural gradients that affect the functional role or importance to a particular species (Clark et al. 1999).

The NOS developed a prototype Habitat Suitability Model applied to 14 species in the US Caribbean for the 1998 Generic EFH Amendment. The model linked life history of the 14 species and habitat distributions. The results are presented in Appendix 2, and are considered to represent a conservative estimate of species distribution across habitats. The use of qualitative information, lack of confirmation of habitat utilization, and applying the model only to St. Thomas limit the applicability of the model.

Two modeling projects, one in Florida and the other in Texas, designed to quantify the relationship between estuarine species and habitat are under way for the GOM. While these modeling efforts do not apply directly to the US Caribbean, the techniques may be applicable. Both use seasonal fishery-independent monitoring of abundance of different life stages in combination with environmental data summarized in seasonal (i.e., salinity, temperature) or overall (i.e., vegetated/non-vegetated, depth) patterns. Both studies use predictive models and Geographical Information Systems (GIS) to test fish-habitat relationships.

The Florida project used spatial habitat suitability index (HSI) models to predict relative species abundance distributions by life stage and season in Tampa Bay and Charlotte Harbor, estuaries on the central west coast of Florida (Rubec et al. 1998; Rubec et al. in press). HSI modeling first derives a function that relates a suitability index \( S_i \) to a habitat variable \( X_i \), for each \( i \)-th environmental factor. They obtained seasonal CPUE from fishery-independent sampling, used seasonal temperature and salinity plus depth as environmental factors, and designated habitat as vegetated or non-vegetated. Suitability functions are expressed as relative density (i.e., CPUE) for each species related to a specific environment. Second, the geometric mean of the \( S_i \) values for each cell of mapped variables calculates the HSI value for a cell. Rubec et al. (1998, in press)
used ArcView Spatial Analysis to create predicted HSI maps. They built models for Charlotte Harbor and Tampa Bay, and crossed referenced the models by applying $S_i$ values from Tampa Bay to the conditions in Charlotte Harbor and vice versa. Cross-referenced models performed well for some species or life stages, but poorly for others. The Texas project used standard multiple regression to predict relative species abundance distributions by life stage and season in Galveston Bay (Clark et al. 1999). They obtained seasonal CPUE from fishery-independent sampling, used seasonal salinity plus depth as environmental factors, and designated habitat as seagrasses, marsh edge, and non-vegetated. Clark et al. (1999) applied the predictive models to the overall area using ArcView to assess habitat suitability. Cross-referencing the model to Matagorda, San Antonio, and Aransas Bays showed variable, but promising, results.

4.2.3.6.2 Cross-shelf habitat utilization

As is the case with HSM models, described in the previous section, relationships between habitat and fish production are not generally available because of imprecise definitions of habitat and uncertainty in the relationship between habitat and fish abundance and/or production (Rubec et al. in press). Fish abundance varies over areas and habitats as a result of complex interactions of environmental and biological factors. Several studies that examined the nature of changes in habitats and fish assemblages across the shelf, from shoreline habitats out to the shelf break, provide an example of work necessary to help relate production and habitat. These studies have focused in the vicinity of La Parguera on the southwestern coast of Puerto Rico. Similar studies in more regions of the US Caribbean are needed to provide a baseline for extending the observations of the following studies beyond the small area of investigation.

Kimmel (1985) visually surveyed fishes in a number of biotopes on the shelf including mangroves, seagrasses, algal plains, sand-mud bottoms, patch reefs, and different zones on coral reefs. He reported that reef and non-reef habitats supported different fish communities, and that there were also differences between the fish assemblages of inshore coral reefs and offshore coral reefs. He found that some fish species were seen at most of the reefs sampled (50 species), others were seen at only some of the reefs sampled (87 species), while other fishes were associated with unconsolidated sediments (39 species).

Christensen et al. (2002) also visually censused fishes from habitats along the cross-shelf gradient including coral reefs, mangroves, and seagrasses. They collected this data with the goal of using the information on the distribution of habitats and fishes to determine the most appropriate areas to propose marine reserves. In addition, they examined grunts and snappers to see if different life stages (i.e. juveniles, subadults, adults) utilized different habitats.

Habitat type seemed to be more important in structuring fish assemblages, than was the shelf zone the habitat was found in. Species richness was highest on coral reef habitats, followed by mangroves, and then seagrasses. Species densities were higher in mangroves due to large numbers of juvenile grunts (haemulids), than in seagrasses or on reefs. No consistent density gradients were seen across the shelf from inner lagoon to the bank shelf zone. No strong seasonal differences were seen among habitats. Grunts (Haemulidae), snapper (Lutjanidae), mojarra
(Gerreidae), silversides (Atherinidae), and barracuda (Sphyraenidae) were found to be mangrove-associated. Clinids (Clinidae), gobies (Gobiidae), jacks (Carangidae), puffers (Tetraodontidae), lizardfish (Synodontidae), wrasse (Labridae), jawfish (Opistognathidae), leatherjackets (Balistidae), tilefish (Malacanthidae), and scorpionfish (Scorpaenidae) were SAV-associated. Damsel-fish (Pomacentridae), butterflyfish (Chaetodontidae), surgeonfish (Acanthuridae), squirrelfish (Holocentridae), seabass (Serranidae), drum (Sciaenidae), cardinalfish (Apogonidae), trumpetfish (Aulostomidae), mackerel (Scombridae), morays (Muridae), basslet (Grammatidae), porcupinefish (Tetradontidae), sea chubs (Kyphosidae), angelfish (Pomacanthidae), blennies (Blennidae), spadefish (Ephippidae), and boxfish (Ostraciidae) were coral reef-associated. Goatfish (Mullidae), parrotfish (Scaridae), and porgy (Sparidae) were associated with both SAV and reefs.

The examination of shifts in habitat use with ontogeny for grunts showed that juveniles were found principally in SAV, subadults in mangroves, and adults in reef areas. A similar pattern was also seen for snapper, including yellowtail snapper. Smaller porgy and goatfish resided mostly in SAV, while larger individuals occurred on reefs. Among parrotfish (scarids), the bucktooth parrotfish (Sparisoma radians) and the greenblotch parrotfish (S. atomarium) spent their whole life cycle in SAV, while the remaining scarids were principally reef-dwellers. Because different life stages of reef fish utilize different habitats, these researchers recommended preserving a mosaic of habitats to assure the maintenance of viable populations. If a particular habitat becomes scarce, a bottleneck could be created, causing declines in fish production. Christensen et al. (2002) also stressed the need for collecting baseline data before closing an area to fishing, to allow later assessment of community changes.

Murphy (2001) also visually censused fishes in seagrass, mangrove, and reef habitats across the shelf, and examined them according to their location on the shelf (water depth and distance to shore) and their geomorphology (level of wave and current energy). In addition, fish communities from the identical habitat types having similar geomorphologies were compared to see if these areas consistently harbored the same kind of fish communities. This was done to determine whether detailed fish assemblage information could be extrapolated to other areas known to have the same habitats.

Murphy (2001) reported that overall, early juveniles were the most abundant life stage, making up 90% of all fish surveyed. Adult reef fish were found most commonly on reefs, and these habitats supported the highest species diversities. As with the Christensen et al. (2002) study, early juvenile and juveniles of many species were found in seagrasses and mangroves. All life stages were found on reefs, but deeper reef zones were inhabited mostly by adults with juveniles being relatively rare. In general, similar habitats/geomorphologies supported similar fish assemblages, but communities in seagrass beds tended to vary more than did those in mangroves and on reefs. Inshore seagrass beds near mangroves had high fish densities, while deeper seagrass beds leeward of reefs had relatively low densities.

Striped parrotfish and redtail/yellowtail parrotfish were seen in most habitats. Striped parrotfish, bluestriped grunt, and bucktooth parrotfish were found to be characteristic inshore seagrass and mangrove species. French grunt, beaugregory, schoolmaster, bluestriped grunt, striped parrotfish, bucktooth parrotfish, and doctorfish were characteristic species of mangroves in all shelf zones.
Dusky damselfish, blue tang, yellowtail damselfish, sergeant major, longspine squirrelfish, and stoplight parrotfish were characteristic reef species.

4.2.3.7 Socio-economic

NOAA Fisheries has contracted for a series of socio-economic studies in Puerto Rico and the USVI. The results of the ongoing research will not be available in time for use in this EIS. In the absence of more complete, this EIS used general economic principles to extrapolate from the current economic situation to conditions under various alternatives.

- Identifying main stakeholders that depend on marine resources, describing their resource use patterns, fishery resource status, and their perceptions and attitudes toward existing conservation and management practices.
- Establishing a baseline of needed socio-economic information to help determine the impact of establishing MPAs and other potential management measures. A contract was awarded during 2003 to prepare survey materials for a study of the socio-economic aspects of various attributes and characteristics of MPAs. The survey will begin in 2004.
- Conducting in-depth socio-economic studies of commercial marine and trap fisheries. The Council has secured funding for the baseline census of commercial fishers in the USVI. The interview portion of the economic survey of trap fishermen has been completed and is currently under review. A report will be completed in 2004.
- Projected work in 2004 will identify and profile fishers, their communities, and coral reef dependencies off eastern Puerto Rico.
- Two contracts were recently awarded to conduct community and ethnographic studies in the USVI and the western half of Puerto Rico. These studies will begin in 2004, with results expected in 2005.
- Funding awarded in FY2003 through the Southeast Cooperative Research Program to conduct Workshops to Determine Fishers’ Attitudes toward Potential Effort Reduction Programs in the US Caribbean.

4.2.3.8 Fish-habitat utilization

Data collected in 1995 by SEAMAP-Caribbean has been included in a GIS format and used to assess the queen conch habitat areas in Puerto Rico and the USVI. This effort includes the description of historical queen conch habitats and the distribution in relation to habitats as described in the NOS Benthic Maps. This project will result in a baseline maps for the queen conch fisheries onto which newer data can be added. Other data that might be added in the future include all the SEAMAP-Caribbean queen conch transects, as well as the spiny lobster collector data. The new maps will show estimated distribution of queen conch juveniles and adult by habitat; historical harvest areas and habitat associations, and potential queen conch habitat for adults and juveniles (Barreto et al. 2003).

The Recovery Plan for queen conch (CFMC March 2002) recommended that marine reserves to protect juvenile queen conch be established to help in the restoration of the fishery and conch
populations. An evaluation of the Luis Peña Channel Natural Reserve, established by the Puerto Rico Department of Natural and Environmental Resources (Administrative Order No. 99-15 of September 30, 1999) as a tool to restore shallow water populations of queen conch was conducted in 2002. All fishing is prohibited within the Reserve. The seagrass bed communities within the Reserve were quantitatively assessed and further monitoring of the juvenile queen conch populations could provide information on the viability of the Reserve as a recovery area for the conch (Hernandez et al. 2002).

4.2.3.9 Protected Resources

Under the NOAA Fisheries-Council Caribbean Operations Plan, the SEFSC is working on the following projects:

- Currently, conducting studies on the very important reef-building Elkhorn and Staghorn corals that are being considered for listing under the U.S. Endangered Species Act, because of Caribbean-wide population declines. These corals provide needed habitat for reef fishes.
- Recently concluded endangered whale survey of the eastern Caribbean from St. Croix to Venezuela and a cetacean survey around Puerto Rico and the Virgin Islands.
- Conducting research on leather back sea turtle sanctuaries in St. Croix, determination of the turtle population status and studies on juvenile Green Sea Turtle foraging.
- NMFS is about to finalize agreements with Puerto Rico as allowed under the ESA act for furthering the recovery and protection of endangered and threatened species – An agreement also is in the works for the U.S. Virgin Islands.

4.2.3.10 Fishery Assessments and Data Collection

Under the NOAA Fisheries-Council Caribbean Operations Plan, the SEFSC is working on the following projects:

- Continue funding SEAMAP activities in the Caribbean, including reef fish, queen conch and spiny lobster surveys.
- Ongoing State/Federal Cooperative Statistics Program with Puerto Rico and the Virgin Islands has featured increasing funding, including funds to support a position in the USVI to enhance collection and analysis of fishery statistics.
- SEFSC is working with investigators at the University of Miami, Rosenstiel School of Marine and Atmospheric Studies toward an analysis of the data available to conduct a population assessment of spiny lobster. Initial report is in the final stages of completion.
- A report entitled “Standardized catch rates and preliminary assessment scenarios for queen conch (Strombus gigas) in the U.S. Caribbean” was completed in November, 2002.
- Queen conch catch and effort data were used to develop relative indices of abundance, and standardized catch rates were estimated. The work was accepted by the University of Miami as part of a finished Ph.D. dissertation in 2003.
- Conducted SEDAR Data Workshop addressing Caribbean yellowtail snapper (early 2003).
• Conducted SEDAR Data Workshop addressing selected Caribbean deep water fish species (November, 2003).
• A project entitled "A Bycatch Study of the Puerto Rico's Marine Commercial Fisheries" has been recommended for funding by MARFIN.

NOAA and the National Park Service are collaborating on a long-term study of the effects of MPA status on fish populations in the Virgin Islands Coral Reef National Monument. Sites have been selected within and adjacent to the monument in comparable habitat to determine if long-term closure to harvest results in an increase in fish species numbers and sizes. This study was initiated in Summer 2003.

4.3 Consequences of alternatives to describe and identify EFH

Identification of EFH in US waters has no direct environmental or physical impact, but is likely to result in controversy within the human environment. Those who want EFH described over large areas may object if it is described for small areas, and vice versa. Indirect impacts will occur due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. The EFH concepts and alternatives have a regional context. The intensity varies among the alternatives under each concept. These alternatives have impacts that may be both beneficial and adverse, would likely generate controversy, have uncertain effects, are related to other actions with cumulatively significant impacts, and may threaten a violation of the M-S Act (Alternatives of Concept 1).

Although EFH alternatives are developed separately for each FMP, each FMP contains the same set of alternatives based on the Concepts presented in Section 2.1.3.4.1. The lack of direct impacts leads to similar consequences of alternatives within a concept across FMPs. This section will initially address consequences of each EFH concept that apply to all FMPs, and will consider indirect consequences specific to FMPs as appropriate.

Under section 305(b)(2) of the Act, each Federal agency must consult with NOAA Fisheries regarding any action authorized, funded, or undertaken by the agency that may adversely affect EFH. The EFH regulations require that Federal agencies prepare EFH Assessments as part of the consultation process (50 CFR 600.920(e)). Under section 305(b)(4)(A) of the M-S Act, NOAA Fisheries must provide EFH Conservation Recommendations to Federal and state agencies regarding any action that would adversely affect EFH. Under section 305(b)(3) of the Act, Councils may comment on and make recommendations to Federal and state agencies regarding any action that may affect the habitat, including EFH, of a fishery resource under Council authority.

Using basic habitat association data results in describing and identifying large areas of the US Caribbean as EFH for one species/life stage or another. When such distributions for all the life stages of all the managed species are overlaid one top of another, the composite EFH comprises a very large proportion of the estuarine and marine environments. The important issue to focus
on, however, is that EFH is correctly identified for each species and life stage individually, so that the necessary steps can be made that will avoid adverse effects to habitat that might otherwise impact one or more of those species and life stages. The overlay of all the EFH for individual species and life stages is important from the perspective describing and identifying EFH for fisheries. Describing and identifying EFH for an FMU will lead to consultations for actions within the EFH, but EFH specific to species/life stages will form the basis of conservation recommendations from NOAA Fisheries.

If the designation of EFH were viewed as essentially a consultative process, then an inclusive definition of EFH would increase the scope of the consultation and, therefore, make it more precautionary. This will give NOAA Fisheries and the Council the greatest possible opportunity to comment on and influence the effects of non-fishing activities on EFH. The extent to which this will result in additional restrictions on fishing activity throughout EFH will depend on the way in which alternatives for minimizing fishing impacts on EFH are applied (for example, some alternatives apply gear restrictions, and others impose permanent or seasonal gear prohibition). NOAA Fisheries has the authority to restrict fishing practices that have adverse impacts on habitat throughout the EEZ. However, a limited definition of EFH, especially if EFH occurred only in state waters, would restrict the area on which NOAA Fisheries could apply management measures to adverse fishing impacts.

EFH conservation recommendations from NOAA Fisheries or a Council to Federal or state agencies are non-binding. Nevertheless, EFH consultations and Conservation Recommendations may result in Federal or state agencies deciding to modify or restrict various activities to avoid or minimize adverse effects to EFH. Such actions could result in project modifications that lead to higher costs for the applicants for Federal or state permits, licenses, or funding. It would be speculative to predict the specific socioeconomic effects of future measures that may be imposed by agencies that authorize, fund, or undertake actions that may adversely affect EFH. Moreover, such agencies typically evaluate socioeconomic effects and other public interest factors under NEPA and other applicable laws before taking final action on any given activity. NOAA Fisheries conducts approximately 6,000 EFH consultations and related EFH reviews nationwide every year, and is unaware of substantial project delays or significant increases in costs resulting from EFH consultations. In general, the larger the area encompassed by EFH designations, the greater the potential for environmental consequences (both positive and negative) from EFH consultations. Ultimately, habitat conservation resulting from EFH consultations is expected to support healthier fish stocks and more productive fisheries over the long term, with associated environmental and socioeconomic benefits. EFH consultations may also lead to indirect benefits for other species that use the same habitats as Federally managed species of fish and shellfish.

Federal agencies will incur costs as a result of conducting EFH consultations, since time and resources will be required to develop EFH Assessments, exchange correspondence, and engage in other coordination activities required for effective interagency consultation. In some cases Federal agencies might also request information from applicants for permits, licenses, or funding to assist the agency in completing EFH consultation. However, the EFH regulations encourage agencies to combine EFH consultations with existing environmental review procedures to promote efficiency and avoid duplication of effort. State agencies and other non-federal entities are not required to consult with NOAA Fisheries regarding the effects of their actions on EFH.
4.3.1 Consequences for the physical environment

Designation of EFH has no direct impact on the physical environment, but may have indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the M-S Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the M-S Act.

From a geological point of view, EFH alternatives will have no direct impacts on the physical environment. None of the alternatives considered will change the general bathymetry, geological configuration, or water quality of the Caribbean. However, fishing gear could have impacts on the biogenic structure and biota living on the bottom, as described in Section 3.5.1 (Fishing Threats). Direct and indirect impacts from fishing gears on vulnerable habitats will be considered in Section 4.5.

Non-fishing activities can adversely affect some geological features through digging, scraping, drilling, modifying deposition, or dumping. These actions could homogenize the seabed surface, cause sedimentation to cover surface features, cause subsidence through removal of oil or gas, or form barriers to river-transported sediments. Consultation by responsible Federal agencies with NOAA Fisheries (and the Council) will have indirect impacts to the degree that consultations mitigate the effects of proposed non-fishing activities.

Non-fishing activities, such as coastal development, dredging, sand and mineral mining, oil and gas exploration, pipelines, and contaminants can affect water quality, dissolved oxygen (DO), or turbidity. In many cases, the indirect impacts of non-fishing activities on EFH occur in areas removed from the area where the activity takes place. For example, rivers may transport high levels of suspended sediments that travel long distances in the marine environment. A wide definition of EFH may, therefore, have benefits in terms of ensuring the consultative process associated with non-fishing activities includes as many potentially damaging activities as possible.

There is no difference among EFH Alternatives or FMPs for direct impacts on the Physical Environment. However, the extent and results of consultations that result from the alternatives may vary.

4.3.2 Consequences for the biological environment

Designation of EFH in US waters has no direct impact on the biological environment, but is likely to result in indirect impacts due to two other provisions of the M-S Act. First, every FMP must minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act.

Adverse impacts have occurred on habitats used by many fishes. Many large and small, possibly insignificant, actions have accumulated to the current significant habitat losses. Describing and
identifying EFH will not by itself restore degraded habitat, but resulting consultations may help to arrest the current degradation and prevent future adverse impacts due to non-fishing activities. This may allow the habitat to begin a recovery from past impacts, if it has not been replaced or destroyed. Measures that improve habitat conditions will have regional and local benefits to the biological environment. Local habitat improvements resulting from consultations or recommendations will offer an opportunity for increased productivity that will likely have spill-over effects to surrounding areas as fish move on and off with daily and seasonal movements. However, over harvest of fishery resources would offset productivity gains. Uncertainty of the role that habitat plays in fish production may have significance by limiting the conclusions one may draw on the effects of designating EFH. However, a precautionary approach would err on the side of conservation.

The Council and NOAA Fisheries can currently regulate fishing activities that have potential to adversely impact EFH, but designation of EFH will help to focus additional consultation in this area. The Council and NOAA Fisheries can also provide input into decisions regarding non-fishing activities, through consultation with other Federal agencies that have responsibility for non-fishing activities. Councils are required to comment on Federal or State activities that are likely to substantially affect habitat of anadromous fishery resources (§ 305(b)(3)(B)), and may comment on Federal or State activities that may affect fish habitat. The effectiveness of consultations on mitigating potential adverse impacts will likely depend on the level at which a managed fish species depends on the habitats at risk, and on the ability to justify that dependence. The available information with which to document fish dependence on habitat is incomplete.

4.3.2.1 EFH Concept 1. (No Action-Roll Back) Do not develop Essential Fish Habitat criteria or identifications.

- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Spiny Lobster FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Queen Conch FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Reef Fish FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Coral FMP

These alternatives violate legal requirements under the M-S Act, but are included as a requirement of NEPA and to serve as a baseline for other alternatives. Under No Action, description and identification of EFH for the Spiny Lobster, Queen Conch, Reef Fish, or Coral FMPs would not occur, a significant concern. Existing designation of EFH would roll back to the situation before the 1998 Generic EFH Amendment. Consultation between NOAA Fisheries and other responsible Federal agencies would occur as before the requirement for EFH, but without the new M-S Act requirements on Federal action agencies. No EFH provisions mandated in the M-S Act would occur. Habitat protection could still be achieved through existing management procedures (the FMPs), but the “significant opportunity to make a difference in improving the success of sustainable fisheries and healthy ecosystems” envisioned by NMFS (NMFS 1998) would not be realized. Loss or degradation of habitat would be more likely than under the other
EFH alternatives that result in some areas being identified. Current habitat protection measures by the Council that address fishing impacts are considered in Section 2.1.5.2.

4.3.2.2 EFH Concept 2. (*Status Quo*) Describe and identify Essential Fish Habitat for managed fish species as provided in the Generic EFH amendment for selected fish species, by identifying and describing Essential Fish Habitat based on the common distributions of the various life stages as are currently known for selected species under management.

- Alternative 2. EFH for the Spiny Lobster fishery consists of areas where various species and life stages of spiny lobster commonly occur
- Alternative 2. EFH for the Queen Conch fishery consists of areas where various species and life stages of queen conch commonly occur
- Alternative 2. EFH for the Reef Fish fishery consists of areas where various species and life stages of reef fish commonly occur
- Alternative 2. EFH for the Coral fishery consists of areas where various species and life stages of coral commonly occur

Of the several hundred species in the four US Caribbean FMPs (Tables 2.1-2.4), only spiny lobster, queen conch, 15 reef fish, and all coral have EFH designated under the 1998 Generic Amendment. While the EFH for an FMP will likely apply to the other species in the FMP, the Generic Amendment does not justify extending EFH of indicator species to all other species. However, these distinctions will have no direct impacts. Indirect impacts will occur from results of consultations and from possible fishery management actions, related to the accumulation of impacts from prior actions. The large areas of EFH designated by the alternatives under Concept 2 provide an opportunity for consultation and NOAA Fisheries recommendations for nearly all Federal Agency projects in the US Caribbean. Some may believe that the description of EFH in such broad terms precludes focusing attention on the most important habitat components of the species/life stage range, which could diminish the impact of EFH designation. It is uncertain if the broad designation of EFH will have significantly more or less beneficial impacts compared to smaller designations of EFH. The large area identified as EFH also allows addressing adverse fishing and non-fishing impacts on EFH on a regional scale. Consultation for non-fishing impacts would be limited to the EFH identified for the indicator species, and would not explicitly consider EFH for the other species.

While the indirect impacts of EFH are expected to benefit managed species, the indirect impacts may also benefit protected species. To the degree that consultations or minimization of adverse fishing impacts reduce damage to or enhances habitat used by protected species, these species will encounter improved habitat. The direct impacts of addressing adverse fishing impacts are considered in Section 4.5.
4.3.2.3 EFH Concept 3. Describe and identify essential fish habitat for managed fish species as all waters of the Caribbean that include submerged aquatic vegetation (SAV), mangroves, algae, plains, reefs, reef-SAV interface, hard/live bottoms, sand, and mud.

This concept was considered but rejected, so no alternatives were developed. This Concept does not consider spawning, breeding, feeding, or growth to maturity. See Section 2.6

4.3.2.4 EFH Concept 4: Describe and identify essential fish habitat based on the known distributions of all the various life stages of all species under management.

This concept was considered but rejected, so no alternatives were developed. Concept 6 provides for all the benefits of Concept 4, plus additional benefits. See Section 2.6

4.3.2.5 EFH Concept 5: Describe and identify essential fish habitat based on habitat related densities of all life stages of all species under management.

No density information is available for species in any of the four FMPs, so no alternatives were developed. While density information would allow developing alternatives using a higher level of information (Section 2.1.3.2), a range of alternatives exists under other concepts. See Section 2.6

4.3.2.6 EFH Concept 6 (Preferred Alternatives). Describe and identify EFH according to functional relationships between life history stages of Federally-managed species and Caribbean marine and estuarine habitats.

- Alternative 6. EFH for the spiny lobster fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by phyllosome larvae – (Figure 2.2) and seagrass, benthic algae, mangrove, coral, and live/hard bottom substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.38), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the queen conch fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.40), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the Reef Fish Fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and all substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.41), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the Coral Fishery in the US Caribbean consists of all waters from mean low water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and coral and hard bottom substrates from mean low water to 100
The Alternatives arising under Concept 6 link life history functions for each species and life stage of each FMP to specific habitats, and infers use by the life stages of the entire area of the habitat, wherever it occurs throughout the species’ assumed range. Appendix 1 lists available information for the habitats that each life stage of the species in the FMPs are known to use. As with other Alternatives, Alternative 6 will have no direct biological impacts. The direct impacts of addressing adverse fishing impacts on EFH are considered in Section 4.5.

The alternatives under Concept 6 lead to the same composite EFH being identified for each FMP that would be identified under the alternatives arising from Concept 2 (Figure 2.38). However, the Concept 6 alternatives describe and identify EFH for more species and life stages than the Concept 2 alternatives (especially for the Reef Fish FMP), and relate the functional relationship of species/life stages to the habitats. The similarity of EFH from alternatives under Concepts 2 and 6 result from the lack of information about the relative importance of different parts of the EEZ, especially for larval stages of managed species. If the pelagic stages – primarily larval – that drift throughout the EEZ were not considered for describing and identifying EFH, then EFH would be a much smaller area limited to the insular shelf (Figures 2.39, 2.40, 2.41, and 2.42). Eliminating the larval stages would violate the M-S Act requirement for considering the life stages of managed species, and therefore would not be a viable alternative. However, identification of the non-larval components of EFH will allow more effective management and consultation on the habitats that have the greatest sensitivity to fishing and non-fishing activities. It is unclear if the broad designation of EFH will have significantly more or less beneficial impacts compared to smaller designations of EFH. The large area identified as EFH also allows addressing adverse fishing and non-fishing impacts on EFH on a regional scale.

Indirect impacts will occur from results of consultations and from possible fishery management actions, related to the accumulation of impacts from prior actions. The large areas designated as EFH under the Concept 6 alternatives provides an opportunity for consultation and NOAA Fisheries recommendations for nearly all Federal-Agency projects in the US Caribbean. Some may believe that identifying a large area as EFH reduces the focus on the most important habitat components of the species/life stage range and that this might diminish the impact of EFH designation. This effect is considered to be less of a problem under the Concept 6 alternatives because information required for evaluation of the likely severity of impacts from proposed projects could be readily obtained from the habitat use database (Appendix 1, Tables 2.5 to 2.8). Consultations for non-fishing impacts will be most comprehensive with this alternative because EFH is related to species/life stage/ecological function for all species with information available. This Alternative would likely result in more and better justification by NOAA Fisheries of recommendations to protect habitat.

While the indirect impacts of EFH are expected to benefit managed species, the indirect impacts may also benefit protected species. To the degree that consultations or minimization of adverse fishing impacts reduces damage to or enhances habitat used by protected species, these species will benefit from improved habitat.
4.3.2.7 Concept 7. Describe and identify Essential Fish Habitat as all marine waters and substrates indicated on maps produced by spatially explicit, qualitative or quantitative information that link fish distributions and habitat.

This concept was considered but rejected, so no alternatives were developed. No information was available for the US Caribbean region. While spatially explicit information would allow developing alternatives using geo-referenced data (Section 2.1.3.3), a range of alternatives exists under other concepts. See Section 2.6.

4.3.2.8 EFH Concept 8. Describe and identify Essential Fish Habitat as all marine waters and substrates indicated on maps produced by HSM

- Alternative 8. EFH for spiny lobster consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.44)
- Alternative 8. EFH for the queen conch consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.45)
- Alternative 8. EFH for the reef fish consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.46)

The alternatives arising under Concept 8 would apply only to the species/life stages and areas for which HSM has been conducted by NOS (Section 2.1.3.3.2): spiny lobster, queen conch, and 12 reef fish in waters around St. John. NOS did not develop HSM maps for coral, as coral is its own habitat. As with the alternatives under Concept 1, the Concept 8 alternatives will have no direct biological impacts. While the indirect impacts of EFH are expected to benefit managed species, the indirect impacts may also benefit protected species. To the degree that consultations reduce damage to or enhance habitat used by protected species, these species will benefit from improved habitat. No indirect impacts will occur as a result of addressing adverse fishing impacts because EFH does not extend into the EEZ. Consultations for non-fishing impacts would encompass a smaller area of EFH than for the alternatives under Concepts 2 or 6, as EFH extends discontinuously around St. John at depths less than 25 m (about 12 fathoms). Alternative 6 uses inferences of habitat use by managed species to perform a crude form of HSM (Section 2.1.3.3.2), by assuming that a species/life stage will use all habitats in the region with which it has an association in the Habitat Use Database. Alternative 8 uses more formal associations, but in a restricted area. The use of qualitative information, lack of confirmation of habitat utilization, and applying the model only to St. Thomas limit the applicability of the model.

EFH consultations with NOAA Fisheries will apply to a small area relative to the area identified as EFH by the alternatives under Concepts 2 and 6, and will not likely lead to protection of all important habitat. This Concept does not link life stage or ecological function to EFH. Selection of these alternatives would not require the Council and NOAA Fisheries to develop measures to minimize, mitigate, or prevent adverse fishing impacts on EFH, because EFH would not extend into the EEZ. It is unclear if the narrow designation of EFH will have significantly more or less beneficial impacts compared to broader designations of EFH. The narrow area identified as EFH does not allow addressing adverse fishing and non-fishing impacts on EFH on a regional scale.
4.3.3 Consequences for the human environment

Designation of EFH in US waters is likely to result in significant controversy within the human environment. Those who want EFH described over large areas may object if it is described for small areas, and vice versa. Landowners, developers, and others with an interest in modifying EFH will likely have concerns that extensive identifications of EFH will limit options for use of the habitats. Similarly, fishers using gears with potential adverse impacts may have concerns that extensive identification of EFH may lead to restrictions on those gears. Environmental organizations, some fishers, and others preferring to limit development, fishing impacts, or other activities may prefer to have more broadly-based EFH to trigger the widest possible consultations or to increase scrutiny of fishing gears. At a Caribbean Coral Reef Fisheries Workshop convened by NOAA Fisheries in 2002 (NMFS 2002a), for example, fishers expressed concern that they were blamed for damage to reefs, and perceived that coastal developers with much greater impacts on habitat did not receive scrutiny for their actions detrimental to the reefs. This likely level of controversy points out that describing and identifying EFH may have positive benefits for the environment and the fish species that use it, but negative impacts on non-fishing activities that adversely impact EFH. In the short term, designating EFH may lead to fishery management measures with short-term negative impacts on fishers (Section 4.5).

Indirect impacts will occur due to two other provisions of the M-S Act. First, every FMP must prevent, mitigate, or minimize to the extent practicable adverse effects of fishing on EFH, pursuant to section 303(a)(7) of the Act. Second, Federal agency actions that may adversely affect EFH trigger consultation and/or recommendations under sections 305(b)(2)-(4) of the Act. Assessing indirect impacts from addressing adverse fishing impacts is discussed in Section 3.3 (Human Environment) and 4.5 (Consequences of fishing alternatives).

EFH recommendations from NOAA Fisheries or the Council to Federal or state agencies are non-binding. Nevertheless, EFH consultations with Federal agencies and Conservation Recommendations may result in Federal or state agencies deciding to restrict or modify various activities to avoid or minimize adverse effects to EFH. Such actions could result in project modifications that lead to higher costs for the applicants for Federal or state permits, licenses, or funding. The specific effects on the human environment are very uncertain, but do not pose unique risks. It would be speculative to predict the specific socioeconomic effects of future measures that may be imposed by agencies that authorize, fund, or undertake actions that may adversely affect EFH. Moreover, such agencies typically evaluate socioeconomic effects and other public interest factors under NEPA and other applicable laws before taking final action on any given activity. Describing and identifying EFH will not affect public health or safety.

NOAA Fisheries conducts approximately 6,000 EFH consultations and related EFH reviews nationwide every year, and is unaware of substantial project delays or significant increases in costs resulting from EFH consultations. In general, the larger the area encompassed by EFH designations, the greater the potential for environmental consequences (both positive and negative) from EFH consultations. Ultimately, habitat conservation resulting from EFH consultations is expected to support healthier fish stocks and more productive fisheries over the long term, with associated environmental and socioeconomic benefits. However, fishers in open access fisheries tend to dissipate economic benefits (Freeman 1993). Potential increases in
productivity from improved habitat condition will be offset through increased effort and harvest. In theory, the net economic condition of fishers would not change.

4.3.3.1 Concept 1. (No Action-Roll Back) Do not develop Essential Fish Habitat criteria or identifications

- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Spiny Lobster FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Queen Conch FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Reef Fish FMP
- Alternative 1. Do not describe and identify EFH in the US Caribbean for the Coral FMP

These alternatives violate legal requirements under the M-S Act. The alternatives arising from Concept 1 would remove descriptions and identifications of EFH from the US Caribbean FMPs. This would likely receive support from individuals and organizations that wish to simplify regulations and to reduce restrictions on modification of habitat. Conversely, those interests that supported development of the EFH provisions in the M-S Act would oppose this action. While Federal agencies proposing actions would still consult with NOAA Fisheries, they would do so without the additional mandate provided by the M-S Act. Therefore, project proponents would have reduced burden for habitat protection, and fishers would be affected by any existing degradation of the resource productivity that results from degraded fish habitat.

4.3.3.2 Concept 2. (Status Quo) Describe and identify Essential Fish Habitat for selected managed fish species as provided in the Generic EFH amendment, by identifying and describing Essential Fish Habitat based on the common distributions of the various life stages as are currently known for these species.

- Alternative 2. EFH for the Spiny Lobster fishery consists of areas where various species and life stages of spiny lobster commonly occur
- Alternative 2. EFH for the Queen Conch fishery consists of areas where various species and life stages of queen conch commonly occur
- Alternative 2. EFH for the Reef Fish fishery consists of areas where various species and life stages of reef fish commonly occur
- Alternative 2. EFH for the Coral fishery consists of areas where various species and life stages of coral commonly occur

The Alternatives under Concept 2 provide for a wide designation of EFH, and incorporates virtually all waters of the US Caribbean. These alternatives would likely generate nearly an opposite response from the Concept 1 alternatives, receiving support from those interests seeking the widest possible mandate for consultations, and opposition from those objecting to restrictions on modification of habitat. The Generic Amendment based designation of EFH on 17 indicator species. While the Generic Amendment provided habitat use information for other species and life stages, it did not use this information to designate EFH for those other species. The Generic Amendment did not map EFH, so proponents of projects had little guidance at specific locations.
However, the maps (Figures 2.5 to 2.21) and Appendix 1 now show habitat requirements for the indicator species and the location of known and potential habitat used by those species. The lack of EFH designation for non-indicator species and the lack of maps will likely reduce support, relative to alternatives with a more complete set of species and EFH maps. This will have an indirect impact on consultations by providing less information with which to justify NOAA fisheries recommendations (Sections 3.3 and 4.5).

The large areas of EFH designated by the alternatives under Concept 2 provides an opportunity for consultation and NOAA Fisheries recommendations for nearly all Federal-agency projects in the US Caribbean, so proponents will have more in-depth consultations than under the no-action alternatives. Some may believe that the identification of large areas as EFH precludes focusing on the most important habitat components of the species/life stage range, which could diminish the impact of EFH designation. Consultations that reduce the degradation of habitat and slow the resulting decline in fish resources will benefit fishers with more harvestable resources than under Alternative 1. The expansive EFH throughout the EEZ provides indirect impacts as the maximum extent on which NOAA Fisheries could implement management measures to address adverse fishing impacts on EFH. Measures to address fishing impacts may cause short-term financial costs to fishers, but should provide longer-term benefits through increased productivity.

4.3.3.3 Concept 3. Describe and identify essential fish habitat for managed fish species as all waters of the Caribbean that include submerged aquatic vegetation (SAV), mangroves, algae, plains, reefs, reef-SAV interface, hard/live bottoms, sand, and mud.

This Concept was considered and rejected, so no alternatives were developed. See Section 2.6.

4.3.3.4 Concept 4: Describe and identify essential fish habitat based on the known distributions of all the various life stages of all species under management.

This concept was considered and rejected, so no alternatives were developed. See Section 2.6.

4.3.3.5 Concept 5: Describe and identify essential fish habitat based on habitat related densities of all life stages of all species under management.

Density information is not available for determining EFH, so no alternatives were developed. See Section 2.6.

4.3.3.6 Concept 6. (Preferred Alternatives) Describe and identify essential fish habitat according to functional relationships between life history stages of federally managed species and Caribbean marine and estuarine habitats.

• Alternative 6. EFH for the spiny lobster fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by phyllosome larvae – (Figure 2.2) and seagrass, benthic algae, mangrove, coral, and live/hard bottom
substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.38), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the queen conch fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.40), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the Reef Fish Fishery in the US Caribbean consists of all waters from mean high water to the outer boundary of the EEZ – habitats used by eggs and larvae – (Figure 2.2) and all substrates from mean high water to 100 fathoms depth – used by other life stages – (Figure 2.41), shown in the aggregate as Figure 2.39

- Alternative 6. EFH for the Coral Fishery in the US Caribbean consists of all waters from mean low water to the outer boundary of the EEZ – habitats used by larvae – (Figure 2.2) and coral and hard bottom substrates from mean low water to 100 fathoms depth – used by other life stages – (Figure 2.42), shown in the aggregate as Figure 2.39

The consequences to the Human Environment are likely to be very similar to those of the alternatives in Concept 2, because the composite extent of EFH is similar in both cases. However, the justification for EFH is greater in Concept 6 because it involves more species and life stages, and provides maps of EFH, maps of habitat distribution, and tables of habitat use for all species and life stages with available information. Identification of the non-larval components of EFH (Figures 2.39-2.42) will allow more effective management and consultation on the habitats that have the greatest sensitivity to fishing and non-fishing activities. This will have an indirect impact on consultations by providing more information with which to justify NOAA fisheries recommendations.

The large areas of EFH designated by the alternatives under Concept 6 provides an opportunity for consultation and NOAA Fisheries recommendations for nearly all Federal-agency projects in the US Caribbean. Some may believe that identifying a large area as EFH reduces the focus on the most important habitat components of the species/life stage range and that this might diminish the impact of EFH designation. This effect is considered to be less of a problem under the Concept 6 alternatives, because information required for evaluation of the likely severity of impacts from proposed projects could be readily obtained from the habitat use database (Appendix 1, Tables 2.5 to 2.8). Alternative 6 would not likely increase the number of consultations with responsible Federal agencies compared to Alternative 2, but will make the consultations more effective. Consultations for non-fishing impacts will be most comprehensive with this alternative because EFH is related to species/life stage/ecological function for all species with information available. Indirect impacts on adverse fishing measures will be similar to those of Alternative 2.

4.3.3.7 Concept 7. Describe and identify Essential Fish Habitat as all marine waters and substrates indicated on maps produced by high quality, spatially explicit, qualitative or quantitative information that link fish distributions and habitat.

This Concept was considered and rejected, so no alternatives were developed.
4.3.3.8 Concept 8. Describe and identify Essential Fish Habitat as all marine waters and substrates indicated on maps produced by Habitat Suitability Models

- Alternative 8. EFH for spiny lobster consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.44)
- Alternative 8. EFH for the queen conch consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.45)
- Alternative 8. EFH for the reef fish consists of a discontinuous band of waters and substrates around St. John from mean high water to a depth of 25 m (Figure 2.46)

Of all the EFH alternatives, those developed under Concept 8 identify the smallest amount of EFH. This Concept limits EFH to a discontinuous zone around the islands in depths less than 25 m (12 fathoms), based on information for several selected species. EFH would occur only in state waters. As a result, individuals and organizations with interests in comprehensive identification of EFH will likely find the alternatives under this Concept inadequate, while those wishing to restrict EFH will likely prefer it to the alternatives under concepts 2 or 6. The alternatives under this Concept may result in a level of controversy intermediate between those under Concept 1 and Concepts 2 and 6. As an indirect impact, consultations with NOAA Fisheries on EFH will occur less often than at present, because of the smaller amount of EFH designated. No indirect impacts will occur from addressing adverse impact of fishing on EFH, because no EFH is identified in the EEZ under this alternative.

4.3.4 Consequences for the administrative environment

Under section 305(b)(2) of the M-S Act, each Federal agency must consult with NOAA Fisheries regarding any action authorized, funded, or undertaken by the agency that may adversely affect EFH. The EFH regulations require that Federal agencies prepare EFH Assessments as part of the consultation process (50 CFR 600.920(e)). Under section 305(b)(4)(A) of the Act, NOAA Fisheries must provide EFH Conservation Recommendations to Federal and state agencies regarding any action that would adversely affect EFH. Under section 305(b)(3) of the Act, Councils may comment on and make recommendations to Federal and state agencies regarding any action that may affect the habitat, including EFH, of a fishery resource under Council authority.

Federal agencies will incur costs as a result of conducting EFH consultations, since time and resources will be required to develop EFH Assessments, exchange correspondence, and engage in other coordination activities required for effective interagency consultation. In some cases, Federal agencies might also request information from applicants for permits, licenses, or funding to assist the agency in completing EFH consultation. However, the EFH regulations encourage agencies to combine EFH consultations with existing environmental review procedures to promote efficiency and avoid duplication of effort. Agreements to streamline the EFH consultation process have been developed for key Federal agencies having responsibility in the US Caribbean. State agencies and other non-federal entities are not required to consult with NOAA Fisheries regarding the effects of their actions on EFH.
For all FMPs and under all EFH Alternatives, NOAA Fisheries staff will continue to review and respond to project applications or proposals for work in waters of the US Caribbean. For other than the No Action Alternative for EFH, NOAA Fisheries would provide through this EIS as well as the FMPs habitat utilization information and maps of habitats for applicants to use in developing applications, and for reviewing potential impacts, in case of consultations resulting from potential adverse impacts to EFH.

NOAA Fisheries and the Council staffs could become more involved in consultations with other Federal agencies with responsibility for non-fishing activities with potential to adversely affect EFH. The Southeast Region of NOAA Fisheries has received and commented on 2,674 permit proposals for the US Caribbean from 1981 to June 2002 (Southeast Regional Office, personal communication). Of these, the Southeast Region considered that 158 projects had potentially significant impacts, and determined that proposed projects would cause modification of 1,563 acres. Of these acres, NOAA Fisheries accepted 349 acres without change, recommended against the alteration of 1,214 acres, and recommended 399 acres of mitigation.

Whether additional consultations will occur as a result of designating EFH cannot be determined. In addition to federal resources used in the consultation process, the Council and NOAA Fisheries will generically amend all FMPs together or the four FMPs separately, if the Council chooses alternatives under Concepts 1, 6, or 8. Choosing alternatives under Concept 2 will not require EFH amendments.

Administrative costs to the Council and NOAA Fisheries are reduced by about one-quarter if a Generic Amendment is used to update EFH information, rather than amending each FMP individually. Examples of recent administrative costs for documents prepared by NOAA Fisheries and various US Fishery Management Councils are: South Atlantic Council’s Sargassum FMP at $45K in Council costs and $15K in NOAA Fisheries costs, Gulf of Mexico Council’s Sustainable Fisheries Act Generic Amendment at $35K in Council costs and $22K in NOAA Fisheries costs, and the Dolphin/Wahoo FMP shared by 4 Councils at $248K in Council costs and $50K in NMFS costs. The Council and NOAA Fisheries would normally need approximately 1.5-2 years to implement a generic amendment, and longer to amend each of the FMPs. However, this document contains the analysis needed for preparing a generic amendment, which will reduce the time required to implement an Amendment. A court-ordered schedule requires amending the FMPs, if required, by October 24, 2005.
4.4 Consequences of alternatives for identifying HAPCs

Similarly to the identification of EFH, the designation of HAPCs in US waters has no direct biological impact. Designation of HAPC may result in controversy similar to that described for EFH. It may result in indirect impacts beyond those associated with EFH identification, because resource managers and regulators may prioritize conservation of habitat inside HAPCs as compared to the rest of EFH. NOAA Fisheries and the Council use HAPCs to focus conservation and management efforts on particularly valuable and/or vulnerable subsets of EFH. Although HAPC designation does not automatically convey any higher regulatory standards for addressing adverse effects of fishing or conducting EFH consultations, NOAA Fisheries and the Council may apply more scrutiny to fishing and non-fishing activities occurring in HAPCs as compared to EFH. NOAA Fisheries and the Council may be more risk averse when developing management measures for HAPCs, and when recommending measures to Federal and state agencies. The HAPC alternatives have a regional context. The intensity varies among the alternatives. These alternatives have impacts that may be both beneficial and adverse, would likely generate controversy, have uncertain effects, and are related to other actions with cumulatively significant impacts.

The potential direct environmental and socioeconomic impacts from management measures to protect HAPCs would be similar to those described for EFH. As with EFH, conservation of HAPCs is expected to support healthier fish stocks and more productive fisheries over the long term, with associated environmental and socioeconomic benefits. However, fishers in open access fisheries tend to dissipate economic benefits (Freeman 1993). Potential increases in productivity from improved habitat condition will be offset through increased effort and harvest. In theory, the net economic condition of fishers would not change. However, the indirect impacts will vary among alternatives.

Separate HAPC alternatives were developed for Reef Fish and Coral FMPs. However, the justifications and rationales for identifying HAPCs cut across FMPs and each of the HAPC alternatives have consequences for more than one FMP. The specific sites listed in Alternatives 4, 7, and 8 came from suggestions from the Council’s SSC/HAP. These sites were assigned to FMPs based on predominant species/habitat associations from Appendix 1. None of these sites had primary associations for species in the Queen Conch or Spiny Lobster FMPs. However, the species in these FMPs use habitat and will benefit from HAPC sites. The lack of direct biological impacts of HAPC alternatives leads to similar consequences across FMPs.

4.4.1 Consequences for the Physical Environment

Because HAPCs are a subset of EFH, the impacts discussed for EFH in the previous section would apply to any HAPC areas identified by the Council. By establishing HAPCs, however, the Council provides to the public and to potential developers notice that proposed habitat modification in these areas will undergo enhanced scrutiny because of the ecological importance and/or environmental sensitivity of the areas.
4.4.2 Consequences for the Biological Environment

Designation of HAPCs has no direct environmental impact, but may result in indirect impacts beyond those associated with EFH since resource managers and regulators may prioritize conservation of HAPCs as compared to conservation of all EFH. NOAA Fisheries and the Councils use HAPCs to focus conservation and management efforts on particularly valuable and/or vulnerable subsets of EFH. Although HAPC designation does not convey any higher regulatory standards for minimizing adverse effects of fishing or conducting EFH consultations, NOAA Fisheries and the Councils may apply more scrutiny to fishing and non-fishing activities that affect HAPCs as compared to EFH. NOAA Fisheries and Councils may be more risk averse when developing management measures to minimize adverse effects of fishing on HAPCs, and when recommending measures to Federal and state agencies to minimize adverse effects of non-fishing activities on HAPCs. The potential environmental impacts from management measures to protect HAPCs are comparable to those described above for EFH. As with EFH, conservation of HAPCs is expected to support healthier fish stocks and more productive fisheries over the long term, with associated environmental and socioeconomic benefits.

4.4.2.1 Alternative 1. (No Action/Roll Back) Do not identify any habitat areas of particular concern (HAPCs) under the EFH Amendment.

Alternative 1 would eliminate the HAPC designations from the Generic Amendment for all FMPs, and roll back to the situation before the 1998 Generic EFH Amendment. This action would not violate any laws, but is counter to the strong recommendations of NOAA Fisheries. The impacts would likely be more adverse than beneficial compared to status quo or other alternatives. Fishing and non-fishing actions would have more chance of causing major and minor impacts that could accumulate to significant habitat loss. Consultation between NOAA Fisheries and other responsible Federal agencies would occur as before the requirement for EFH, but would not focus extra conservation attention on any areas. No protections mandated in the M-S Act would occur. Therefore, loss or degradation would likely occur at a faster rate than under the other alternatives. Management of fishing impacts would not use HAPCs in the analysis to determine practicability.

4.4.2.2 Alternative 2. (Status Quo) Describe and identify HAPCs as those areas listed in the 1998 Generic EFH Amendment; no further HAPCs are identified.

This Alternative would maintain the HAPC designations from the Generic Amendment as estuaries, nearshore coral reefs and hard bottom (Figures 2.5-2.15), and Hind Bank MCD (Figure 2.23), if either EFH Alternative 2 or 6 were selected. Both of these EFH alternatives identify widespread EFH. EFH Alternative 1 would not designate EFH, so if the Council and NOAA
Fisheries selected EFH Alternative 1 they could not designate HAPCs, which must be a subset of EFH. EFH Alternative 8 designates EFH as a discontinuous band from the shoreline to approximately 25 m (12 fathoms) for selected species. Therefore, EFH Alternative 8 is incompatible with the HAPCs in this Alternative because EFH could not extend further offshore than the extent of the EFH designated in Alternative 8. The estuaries and nearshore reefs have demonstrated value (HAPC criterion for ecological importance) to US Caribbean fish resources (Appendix 1), and have been and continue to be degraded by non-fishing activities (HAPC criteria for sensitivity and stress). While this Alternative meets the HAPC criteria, it does not meet the NOAA Fisheries Guideline that HAPC should be discrete areas.

4.4.2.3 Alternative 3. Describe and identify habitat areas of particular concern as all habitat areas obligatory to a species life history.

This Alternative was considered and rejected because no information is available to map nursery areas. See Section 2.6. Qualitative information on obligatory use will be incorporated in Alternatives 7 and 8.

4.4.2.4 Alternative 4. Designate HAPCs in the Reef Fish FMP as the following areas based on the occurrence of confirmed spawning locations.

Puerto Rico
- Tourmaline Bank/Buoy 8 (Figure 2.26) (50 CFR 622.33(a))
- Abrir La Sierra Bank/Buoy 6 (Figure 2.26) (50 CFR 622.33(a))
- Bajo de Sico (Figure 2.26) (50 CFR 622.33(a))
- Vieques – El Seco (Figure 2.27) (State waters)

St. Croix
- Mutton snapper spawning aggregation area (Figure 2.26) (50 CFR 622.33(a))
- East of St. Croix (Lang Bank) (Figure 2.26) (50 CFR 622.33(a))

St. Thomas
- Hind Bank MCD (Figure 2.26) (50 CFR 622.33(b))
- Gramanic Bank (Figure 2.26)

This Alternative for HAPCs is consistent with EFH Alternatives 2 or 6. Both of these EFH Alternatives have large areas identified as EFH that would incorporate the areas identified and mapped as spawning areas. EFH Alternative 1 would not designate EFH, so the if the Council and NOAA Fisheries selected EFH Alternative 1 they could not designate HAPCs, which must be a subset of EFH. EFH Alternative 8 designates EFH as a discontinuous band from the shoreline to approximately 25 m (12 fathoms) for selected species. HAPCs in this Alternative could not extend further offshore than the extent of the EFH designated in Alternative 8. This Alternative differs from Alternative 2 by specifying specific areas, in this case mapped spawning sites. All the mapped spawning sites at this time are for reef fish or for coral. While reef fish migrate to spawning aggregations, coral spawn on coral reefs. While spawning species from other FMPs have been observed, no maps of spawning aggregations are available. The candidate sites of this alternative meet the HAPC considerations for ecological importance and sensitivity and sensitivity to human-induced degradation.
Hind Bank, East of St. Croix (Lang Bank), Tourmaline Bank/Buoy 6, Abrir La Sierra Bank/Buoy 8, Baja de Sico

Amendment 1 to the Reef Fish FMP (Hind Bank), Amendment 2 to the Reef Fish FMP (Lang Bank and the original Tourmaline Bank), and a 1996 Regulatory Amendment to the Reef Fish FMP (revised Tourmaline Bank, Abrir La Sierra Bank, Baja de Sico) established seasonal closed areas at these sites. The closures of these sites were designed to reduce harvest of red hind, which the Council believed experienced population reductions below desirable levels. Red hind spawn on coral and hard bottom habitats (Appendix 1). Coral and hard bottom are among the ecologically most important habitats for reef fish. Many reef fish spawn annually at the same site. While the substrate type of these spawning sites may occur elsewhere, something unique and at present unidentified draws the fish to the sites. Currents, depth, topography, and other factors may influence the choice of sites. However, the substrate likely has a significant contributory influence on the site selection. Without good quality habitat at the spawning sites, the conditions that draw fish to the sites may no longer exist, and the fish could move to other sites with lower potential for survival and recruitment of progeny. Additional conservation focus on these areas may safeguard them from future activities.

Mutton snapper spawning aggregation area (Figure 2.26)

Amendment 2 to the Reef Fish FMP established seasonal closed areas at this site. The closure of this site was designed to reduce harvest of mutton snapper. Mutton snapper spawn on coral and hard bottom habitats along the shelf edge (Appendix 1). Coral and hard bottom are among the ecologically most important habitats for reef fish. Many reef fish spawn annually at the same site. While the substrate type of these spawning sites may occur elsewhere, something unique and at present unidentified draws the fish to the sites. Currents, depth, topography, and other factors may influence the choice of sites. However, the substrate likely has a significant contributory influence on the site selection. Without good quality habitat at the spawning sites, the conditions that draw fish to the sites may no longer exist, and the fish could move to other sites with lower potential for survival and recruitment of progeny. Additional conservation focus on these areas may safeguard them from future activities.

Gramanic Bank (Figure 2.26)

A yellowfin grouper spawning site is documented south of St. Thomas adjacent to the MCD. The biological consequences for this site would be similar to those described above for red hind, which have similar spawning requirements.

Vieques – El Seco (Figure 2.27)

A tiger grouper spawning site is documented east of Vieques. The biological consequences for this site would be similar to those described above for red hind, which have similar spawning requirements.
4.4.2.5 Alternative 5. Describe and identify habitat areas of particular concern as those habitat areas used by early life stage development of each species in the management units.

This Alternative was considered and rejected because no information is available to map nursery areas. See Section 2.6. Qualitative nursery ground information will be incorporated in Alternatives 7 and 8.

4.4.2.6 Alternative 6: Describe and identify habitat areas of particular concern as those habitat areas used by managed species as migratory routes.

This Alternative was considered and rejected because no information is available to map migratory routes. See Section 2.6. Qualitative migratory route information will be incorporated in Alternatives 7 and 8.

4.4.2.7 Alternative 7. Designate HAPC For the Reef Fish FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Reef Fish species.

Puerto Rico
- Hacienda la Esperanza, Maniti (Figure 2.31).
- Bajuras and Tiberones, Isabela (Figure 2.31)
- Cabezas de San Juan, Fajardo (Figure 2.31).
- JOBANNERR, Jobos Bay (Figure 2.31).
- Bioluminescent Bays, Vieques (Figure 2.31).
- Boquerón State Forest (Figure 2.32).
- Pantano Cibuco, Vega Baja (Figure 2.31).
- Piñones State Forest (Figure 2.31).
- Río Espiritu Santo, Río Grande (Figure 2.31).
- Seagrass beds of Culebra Island (9 sites designated as Resource Category 1 and two additional sites) (Figure 2.31).
- Northwest Vieques seagrass west of Mosquito Pier, Vieques (Figure 2.33).

St. Thomas
- Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries (Figure 2.34).
- Saba Island/Perseverance Bay, including Flat Cay and Black Point Reef (Figure 2.34).

St. Croix
- Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary (Figure 2.36).
- Altona Lagoon (Figure 2.36)
- Great Pond (Figure 2.36)
- South Shore Industrial Area (Figure 2.36)
- Sandy Point National Wildlife Refuge (Figure 2.36)

This Alternative for HAPCs is consistent with EFH Alternatives 2 or 6. Both these alternatives have widespread EFH that would incorporate the proposed areas (Figures 2.31-2.34, 2.36). EFH
Alternative 1 would not designate EFH, so the if the Council and NOAA Fisheries selected EFH Alternative 1 they could not designate HAPCs, which must be a subset of EFH. EFH Alternative 8 designates EFH as a discontinuous band from the shoreline to approximately 25 m (12 fathoms) for selected species. HAPCs in this Alternative could not extend further offshore than the extent of the EFH designated in EFH Alternative 8. This Alternative differs from Alternative 2 and 4 by specifying areas identified as having special importance, often for nursery areas. Many of these are state or Federal reserves. Mangroves are a key element in these sites. Mangroves have high importance to reef fish species, so these sites are considered for HAPC in the Reef Fish FMP.

NOAA Fisheries and the Council cannot take direct action to manage fisheries in these reserves in state waters. Commercial and or recreational fishing for species in the Council’s FMUs occurs in Jobos Bay, and for non-FMU species in Cabezas de San Juan, Bioluminescent Bay, Boqueron, and Piñones. None of these sites are no-take managed areas.

4.4.2.8 Alternative 8. Designate HAPC for the Coral FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Coral species

Puerto Rico
- Luis Peña Channel, Culebra (Figure 2.31).
- Mona/Monito (Figure 2.31).
- La Parguera, Lajas (Figure 2.32).
- Caja de Muertos, Ponce (Figure 2.32).
- Tourmaline Reef (Figure 2.32).
- Guánica State Forest (Figure 2.32).
- Punta Petrona, Santa Isabel (Figure 2.31).
- Ceiba State Forest (Figure 2.31).
- La Cordillera, Fajardo (Figure 2.31).
- Guayama Reefs (Figure 2.31).
- Steps and Tres Palmas, Rincon (Figure 2.31).
- Los Corchos Reef, Culebra (Figure 2.31)
- Desecheo Reefs, Desecheo (Figure 2.31)
- St. Croix
  - St. Croix Coral Reef Area of Particular Concern (APC), including the East End Marine Park (Figure 2.36).
  - Buck Island Reef National Monument (Figure 2.36)
  - South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36)
  - Frederiksted Reef System (Figure 2.36)
  - Cane Bay (Figure 2.36)
  - Green Cay Wildlife Refuge (Figure 2.36)

This Alternative for HAPCs is consistent with EFH Alternatives 2 or 6. Both these alternatives have widespread EFH that would incorporate the areas identified and mapped as special sites (Figures 2.31-2.34, 2.36). EFH Alternative 1 would not designate EFH, so the if the Council and NOAA Fisheries selected EFH Alternative 1 they could not designate HAPCs, which must be a subset of EFH. EFH Alternative 8 designates EFH as a discontinuous band from the shoreline to
approximately 25 m (12 fathoms) for selected species. HAPCs in this Alternative could not extend further offshore than the extent of the EFH designated in Alternative 8. This Alternative differs from Alternative 2 and 4 by specifying areas identified as having special importance, often for nursery areas. Many of these are state or Federal reserves. The sites have been identified primarily to species in the Coral FMP.

Corals are a key element in these sites. While corals have high importance to reef fish and lobster, these sites are considered for HAPC in the Coral FMP.

Of the sites in Alternative 8, La Parguera, Tourmaline, and Caja de Muertos extend partially into the EEZ. NOAA Fisheries and the Council cannot take direct action to manage fisheries in the portions of these reserves in state waters or in the other reserves. Commercial and or recreational fishing for species in the Council’s FMUs occurs in Mona/Monito, la Parguera, Caja de Muertos, Tourmaline, Guanica, Punta Petrona, Ceiba, La Cordillera, Guayana Reef, and in parts of the St. Croix Marine Park, and for non-FMU species in Rio Espiritu Santos. No-take management occurs in Luis Peña, Cas Cay/Great Lagoon, Saba Island/Perseverance Bay, and parts of the St. Croix Marine Park.

4.4.3 Consequences for the Human Environment

Designation of HAPCs may result in controversies similar to those discussed above for EFH. Those who want increased numbers or sizes of HAPC may object if it is described for small areas, and vice versa. Landowners, developers, and others with an interest in modifying EFH will likely have concerns that extensive identifications of HAPC will limit options for use of the habitats more so than just for EFH. Similarly, fishers using gears with potential adverse impacts may have concerns that extensive identification of HAPC may lead to restrictions on those gears. This likely level of controversy points out that designating HAPC will have positive benefits for the environment and the fish species that use it, but negative impacts on non-fishing activities that adversely impact HAPC. In the short term, designating HAPC may lead to fishery management measures with short-term negative impacts on fishers (Section 4.5). While NOAA Fisheries will directly participate in consultations for HAPC in State or federal waters, the States have jurisdiction over fishing activities in State waters.

Designation of HAPC may result in indirect impacts beyond those associated with EFH if resource managers and regulators give higher priority to conservation of HAPCs as compared to conservation of all EFH. NOAA Fisheries and the Councils use HAPCs to focus conservation and management efforts on particularly valuable and/or vulnerable subsets of EFH. Although HAPC designation does not convey any higher regulatory standards for minimizing adverse effects of fishing or conducting EFH consultations, NOAA Fisheries and the Councils may apply more scrutiny to fishing and non-fishing activities that affect HAPCs as compared to EFH. NOAA Fisheries and Councils may be more risk averse when developing management measures to minimize adverse effects of fishing on HAPCs, and when recommending measures to Federal and state agencies to minimize adverse effects of non-fishing activities on HAPCs. The potential environmental and socioeconomic impacts from management measures to protect HAPCs would be comparable to those described in Section 4.3.2 for EFH. As with EFH, conservation of HAPCs is expected to support healthier fish stocks and more productive fisheries over the long
term, with associated environmental and socioeconomic benefits. However, fishers in open access fisheries tend to dissipate economic benefits (Freeman 1993). Potential increases in productivity from improved habitat condition will be offset through increased effort and harvest. In theory, the net economic condition of fishers would not change.

4.4.3.1 Alternative 1. (No Action/Roll Back) Do not identify any habitat areas of particular concern (HAPCs)) under the EFH Amendment.

This Alternative will likely have consequences for the Human Environment similar to those of the EFH Alternatives arising from EFH Concept 1.

4.4.3.2 Alternative 2. (Status Quo) Describe and identify HAPCs as those areas listed in the 1998 Generic EFH Amendment; no further HAPCs are identified.

The HAPCs identified in the Generic Amendment all fall in state waters. Individuals and organizations wishing to minimize restrictions on modification of habitats may oppose this alternative because it identifies regions (estuaries, nearshore coral and hard bottom), rather than specific areas as recommended by the EFH Final Rule. Controversy resulting from any management actions will depend on regulations from the governments of Puerto Rico and the USVI. The Council and NOAA Fisheries have no direct management authority in state waters.

4.4.3.3 Alternative 3. Describe and identify habitat areas of particular concern as all habitat areas obligatory to a species life history.

This Alternative was considered and rejected. See Section 2.6. Qualitative information on obligatory use will be incorporated in Alternatives 7 and 8.

4.4.3.4 Alternative 4. Designate HAPCs in the Reef Fish FMP as the following areas based on the occurrence of confirmed spawning locations .

**Puerto Rico**
- Tourmaline Bank/Buoy 8 (Figure 2.26) (50 CFR 622.33(a))
- Abrir La Sierra Bank/Buoy 6 (Figure 2.26) (50 CFR 622.33(a))
- Bajo de Sico (Figure 2.26) (50 CFR 622.33(a))
- Vieques – El Seco (Figure 2.27) (State waters)

**St. Croix**
- Mutton snapper spawning aggregation area (Figure 2.26) (50 CFR 622.33(a))
- East of St. Croix (Lang Bank) (Figure 2.26) (50 CFR 622.33(a))
- St. Thomas
  - Hind Bank MCD (Figure 2.26) (50 CFR 622.33(b))
  - Gramanic Bank (Figure 2.26)
Spawning areas are not completely mapped for any species, but maps of spawning aggregations are available for some species of reef fish and for coral. In addition to the MCD and five seasonal spawning closures, SEAMAP surveys have identified spawning aggregations along the southwest coast of Puerto Rico, and hydroacoustic surveys have identified spawning aggregations along the southern coast of Puerto Rico. While these spawning sites can be considered as discrete sites, they extend for considerable distance. Controversy will likely increase as the extent of the area selected for an HAPC increases. No aggregations of conch or lobster have been mapped, so this Alternative would apply to the Reef Fish FMP.

**Hind Bank**
- East of St. Croix (Lang Bank)
- Tourmaline Bank/Buoy 8
- Abrir La Sierra Bank/Buoy 6
- Baja de Sico
- Mutton snapper spawning aggregation area

These sites established by the Council and NOAA Fisheries have existed since 1996 or before. Fishers helped develop these sites by providing information and support conservation of the key species involved. Fisher’s involvement with these sites and the support of at least a portion of the commercial and recreational fishers in the area will tend to minimize controversy from fishers. Because these sites are located in the EEZ, three to nine miles offshore, human-induced adverse non-fishing impacts from development projects are less likely than for sites closer to shore. The several-year existence of these sites has given people an opportunity to get used to them, which will reduce opposition. Any non-fishing opposition to these sites would most likely come from those with interests in offshore projects, such as cables or pipelines.

**Gramanic Bank**
- Vieques – El Seco

These two sites include small, specific spawning aggregation sites for yellowfin grouper and tiger grouper. The St. Thomas sites occur in the EEZ, and the Vieques site occurs in state waters. More controversy from fishers is likely from these sites than from the five existing sites. While federal fishing regulations could apply only in the EEZ, the extra conservation focus would also apply in state waters. As these sites experience fishing, fishers concerned about future fishing restrictions may oppose designating these sites as HAPC. The small size and distance offshore of these sites makes it easier for offshore projects such as cables or pipelines to re-orient around the sites to avoid damage.

4.4.3.5 **Alternative 5.** Describe and identify habitat areas of particular concern as those habitat areas used by early life stage development of each species in the management units.

This Alternative was considered and rejected because no information is available to map nursery areas. See Section 2.6. Qualitative nursery ground information will be incorporated in Alternatives 7 and 8.
4.4.3.6 Alternative 6: Describe and identify habitat areas of particular concern as those habitat areas used by managed species as migratory routes.

This Alternative was considered and rejected because no information is available to map migratory routes. See Section 2.6. Qualitative migratory route information will be incorporated in Alternatives 7 and 8.

4.4.3.7 Alternative 7. Designate HAPC For the Reef Fish FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Reef Fish species.

**Puerto Rico**
- Hacienda la Esperanza, Maniti (Figure 2.31).
- Bajuras and Tiberones, Isabela (Figure 2.31)
- Cabezas de San Juan, Fajardo (Figure 2.31).
- JOBANNERR, Jobos Bay (Figure 2.31).
- Bioluminescent Bays, Vieques (Figure 2.31).
- Boquerón State Forest (Figure 2.32).
- Pantano Cibuco, Vega Baja (Figure 2.31).
- Piñones State Forest (Figure 2.31).
- Río Espiritu Santo, Río Grande (Figure 2.31).
- Seagrass beds of Culebra Island (9 sites designated as Resource Category 1 and two additional sites) (Figure 2.31).
- Northwest Vieques seagrass west of Mosquito Pier, Vieques (Figure 2.33).

**St. Thomas**
- Southeastern St. Thomas, including Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries (Figure 2.34).
- Saba Island/Perseverance Bay, including Flat Cay and Black Point Reef (Figure 2.34).

**St. Croix**
- Salt River Bay National Historical Park and Ecological Preserve and Marine Reserve and Wildlife Sanctuary (Figure 2.36).
- Altona Lagoon (Figure 2.36)
- Great Pond (Figure 2.36)
- South Shore Industrial Area (Figure 2.36)
- Sandy Point National Wildlife Refuge (Figure 2.36)

The sites selected in Alternative 7 are located mostly in state waters and consist mostly of reserves currently under regulations that offer some protection. This Alternative is likely to generate minimal direct controversy because of the existing reserve status of most of the sites. Future management activities for state waters cannot be predicted but could lead to controversy if fishing restrictions increase.
4.4.3.8 Alternative 8. Designate HAPC for the Coral FMP as those EFH habitat areas or sites identified as having particular ecological importance to Caribbean Coral species

Puerto Rico
Luis Peña Channel, Culebra (Figure 2.31).
Mona/Monito (Figure 2.31).
La Parguera, Lajas (Figure 2.32).
Caja de Muertos, Ponce (Figure 2.32).
Tourmaline Reef (Figure 2.32).
Guánica State Forest (Figure 2.32).
Punta Petrona, Santa Isabel (Figure 2.31).
Ceiba State Forest (Figure 2.31).
La Cordillera, Fajardo (Figure 2.31).
Guayama Reefs (Figure 2.31).
Steps and Tres Palmas, Rincon (Figure 2.31).
Los Corchos Reef, Culebra (Figure 2.31)
Desecheo Reefs, Desecheo (Figure 2.31)
St. Croix
St. Croix Coral Reef Area of Particular Concern (APC), including the East End Marine Park (Figure 2.36).
Buck Island Reef National Monument (Figure 2.36)
South Shore Industrial Area Patch Reef and Deep Reef System (Figure 2.36)
Frederiksted Reef System (Figure 2.36)
Cane Bay (Figure 2.36)
Green Cay Wildlife Refuge (Figure 2.36)

The sites selected in Alternative 8 are located mostly in state waters and consist mostly of reserves currently under regulations that offer some protection. This Alternative is likely to generate minimal direct controversy because of the existing reserve status of most of the sites. Future management activities for state waters cannot be predicted but could lead to controversy if fishing restrictions increase.

4.4.4 Consequences for the Administrative Environment

Designation of HAPCs does not cause additional requirements above those of EFH. While NOAA Fisheries, the Council, other Federal agencies, and applicants for proposed projects may focus additional scrutiny on HAPCs, the administrative environment for all species and life stages in all FMPs will be essentially the same as for EFH.

For administrative costs to prepare a new Generic EFH Amendment or amend the four FMPs, see consequences of EFH alternatives, Administrative Environment (Section 4.3.4).
4.5 Consequences of alternatives for preventing, mitigating, or minimizing the adverse effects of fishing on EFH

Under section 303(a)(7) of the M-S Act and the associated provisions of the EFH regulations (50 CFR 600.815(a)(2)), each FMP must contain an evaluation of the potential adverse effects of fishing on EFH in US waters. The authority of Council and NOAA Fisheries fishing regulations is limited to the EEZ, unless the Secretary of Commerce preempts state management. NOAA Fisheries has no authority to manage fisheries of other nations. NOAA Fisheries must act to prevent, mitigate, or minimize any adverse effects from fishing in the EEZ, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature. In determining whether it is practicable to minimize an adverse effect from fishing, Councils and NOAA Fisheries should consider the nature and extent of the adverse effect on EFH and the long and short-term costs and benefits of potential management measures to EFH, associated fisheries, and the nation. For this document, all gear/habitat interactions that rate a zero in Table 3.15a are considered to fall below the minimal and temporary (negligible impact) standard (see Sections 2.1.5.3 and 3.5.1). Higher scores may also fall below the minimal and temporary standard, but that cannot be determined with available information. All gears that scored above 0 in Table 3.15a may have an adverse impact, and those used for FMP fisheries in the EEZ have alternatives developed.

The alternatives to address adverse fishing impacts have a regional context. The intensity varies among the alternatives under each concept. These alternatives have impacts that may be both beneficial and adverse, would likely generate controversy, have uncertain effects, are related to other actions with cumulatively significant impacts, and may violate the M-S Act if the selected action does not prevent, mitigate, or minimize adverse fishing impacts to the degree practicable. Of the additional Specific Guidance on Significance of Fishery Management Actions (NOAA 216-6 §6.02), items g (substantial impact on biodiversity), h (social or economic impacts interrelated with natural or physical environmental effects), and i (likely to be highly controversial) are reasonably expected to occur for some alternatives.

Actions taken by a Council and NOAA Fisheries to prevent, mitigate, or minimize adverse effects of fishing on EFH may include fishing equipment restrictions, time/area closures, harvest limits, or other measures. Any such measures would be designed to reduce ongoing impacts to fish habitats and/or promote recovery of disturbed habitats. Such measures may result in socioeconomic impacts for the affected sectors of the fishing industry, but would be designed to promote sustainable fisheries and long-term socioeconomic benefits. Section 4.6 of this EIS discusses the environmental consequences of the alternative measures to minimize effects of fishing on EFH that are described in Section 2.5. In general, the larger the area encompassed by EFH designations, the greater the potential for environmental consequences (both positive and negative) from fishery management measures designed to minimize adverse effects to EFH.

The alternatives to address adverse fishing impacts on EFH consist of specific management actions that progressively increase the amount of restriction. Each alternative adds to or supercedes provisions of the previous alternative. The groupings of the management measures were designed to provide a wide range of alternatives, but not to consider every possible combination. If the Caribbean Council and NOAA Fisheries decide to amend the FMPs as a
result of the analysis in this EIS, they could consider additional or modified alternatives in the amendment. Additional alternatives may be appropriate if new information becomes available, for example, during preparation of the amendment to consider control rules required under the Sustainable Fisheries Act (SFA Amendment). The wide range of alternatives in the EIS resulted in a broad analysis; however, additional alternatives may require additional NEPA analysis.

Alternative 1, status quo, maintains existing management measures for fishing gear. Alternative 2 specifies gear modifications to reduce fishing gear impacts. Alternative 2.5 adds a gear prohibition on sensitive habitat to the measures of Alternative 2. Alternative 3 adds additional gear modifications to the measures of Alternative 2.5. Alternative 4 adds permanent closure of mapped coral habitat to the management measures of Alternative 3. Alternative 5 prohibits fishing gears with adverse fishing impacts from the EEZ. These alternatives are mutually exclusive.

For this document, the Relative Risk of damage to the function of a habitat by a fishing gear is determined by evaluating the fishing impacts index from the gear with the Ecological Importance of habitats on which gears operate (Section 2.1.5.3). Relative risk is scored on a quartile basis: minor = 0-8, low = 9-17, moderate = 18-26, and high = 27-36. Table 4.1 presents a fishing threat analysis by gear and FMP for Caribbean fish habitats. This Table combines the threat from gears to habitats with the ecological importance of the habitat for species in the FMP to provide a relative risk. The fishing impacts index is scored on a quartile basis: minor = 0-1, low = 2-3, moderate = 4-6, and high = 7-9. However, the ecological importance of a habitat varies among FMPs depending on the species and life stages that use the habitat, so the relative risk to a habitat from a gear will also vary with FMP. If a habitat has a low ecological importance for species in an FMP that allows use of a gear, the Relative Risk would be lower for that FMP than for a different FMP for which the habitat rates a higher Ecological Importance, even though the gear is not allowed or used in that FMP. To use the precautionary approach, the highest value for Ecological Importance for a habitat is chosen from among the FMPs to combine with the gear used in each FMP (Table 4.2). This recognizes the possibility that a gear may cause a higher relative risk on a habitat used by species in another FMP. Section 4.5.1 (Evaluation of gears on habitats) adds the Relative Risk to information on fishing gear presented in Section 3.5.1 to increase comprehensiveness of the evaluation.

Subsequent amendments to the FMP or to its implementing regulations must ensure that the FMP continues to minimize to the extent practicable adverse effects on EFH caused by fishing. In addition to direct fishing management in the EEZ, the Councils and NOAA Fisheries can recommend that states take regulatory action in state waters.

4.5.1 Summary evaluation of fishing gear threats to EFH

Lack of adequate information on the effects of fishing gear and on the recovery of damaged habitat (Barnette 2001, Section 3.5.1.3) makes assessment of environmental consequences of EFH alternatives, and particularly those relating to specific fishing gears, very difficult. Some information exists with which to develop reasonable expectations of impacts, and therefore of the effects of gear modifications or restrictions, but much of this information is not specific to the
US Caribbean habitats or fishery practices. The necessary information does not exist to associate fish production directly with the use of any particular habitat by managed species, and the specific condition of that habitat. In addition, spatially explicit information on the distribution of fishing effort for each gear type used in the US Caribbean does not exist. If such information did exist, it would allow evaluation of habitat areas where sensitivity is high and fishing effort is intense, to help determine need for protection. New studies to determine the effects of fishing gears on habitats in the US Caribbean, and to spatially delineate fishing effort, would be costly and time-consuming. Such work is incomplete for gears and habitats in most regions of the world because of budget and time constraints. Such studies could be included in future EFH assessments if they become available.

At present, predicting the consequences of actions that affect fish habitat in terms of fish production is highly problematic. Some general conclusions can be drawn with existing knowledge. For example, we know that production will fall if fish cannot spawn, if larvae and juveniles cannot survive on the nursery grounds, or if fish cannot find adequate forage or refuge from predators. It may be possible to conclude for various species that some habitats have more importance than others. However, all of these processes occur on a sliding scale and can seldom, if ever, be considered on a presence/absence type basis. We have drawn qualitative conclusions on general impacts of EFH degradation and/or losses, and the consequences of the various proposed alternatives in terms of mitigating those impacts.

The following gears are those used in the four FMP fisheries of the US Caribbean determined to have impacts that are more than minimal and not temporary.

4.5.1.1 Bottom longline

Bottom longline gear does not make a major contribution to the harvest of reef fish in the US Caribbean (Matos-Caraballo 2001), accounting for about 60,000 pounds in 2000. Bottom longline harvest occurs in state waters and in the EEZ. Data are insufficient to estimate the proportion of catch taken from state waters or the EEZ. However, about 15% of the shelf area less than 100 fathoms depth occurs in the EEZ (Figure 2.22), and 85% in state waters. Of the shelf area, about 2.6% occurs off Puerto Rico and 12.3% off the USVI. Tobias (2001) states that most USVI fishers fish in waters less than 72 m (about 40 fathoms). Therefore, commercial longline fishing in the US Caribbean occurs primarily in state waters, and probably greater than 85% of the harvest occurs in state waters. Longlines are not used to harvest species in the other FMPs.

Longlines rank in the minor category of relative fishing impacts index on coral and live/hard bottom habitats, and in the minor category for relative risk. For live/hard bottom, the relative fishing impacts index scores 2, and the Ecological Importance scores 4, giving a relative risk of 8 (Tables 4.1, 4.2). For coral habitat, the relative fishing impacts index scores 1 and the Ecological Importance of coral habitat scores 4, giving a relative risk of 4. The total threat to fish habitat and production in the US Caribbean from longlines on coral and live/hard bottom habitats is therefore minor.
Several of the possible actions for minimizing the effects of bottom longline gear on EFH (Section 2.1.5.4.3.3) were considered ineffective. The M-S Act restricts access limitation to programs designed to achieve optimum yield. While loss of habitat could prevent achieving optimum yield, developing a limited access system for the US Caribbean would better proceed as a separate effort. A limitation on the length of longline gear may cause an increase in the amount of gear set and more habitat damage, if the fishers make more sets to maintain harvest. More longline sets mean more anchors, more running line, but not necessarily fewer hooks or less ground line. More sets to achieve the same amount of fishing pressure will increase costs to the fishers.

4.5.1.2 Pots/traps

Trap/pot gear makes a major contribution to the harvest of reef fish and lobsters (Matos-Caraballo 2001), accounting for over 500,000 pounds in 2000. Pots/traps harvest occurs in state waters and in the EEZ. Data are insufficient to estimate the proportion of catch taken from state waters or the EEZ. However, about 15% of the shelf area less than 100 fathoms depth occurs in the EEZ (Figure 2.22), and 85% in state waters. Tobias (2001) states that most USVI fishers fish in waters less than 72 m (about 40 fathoms). Most trap/pot fishers in Puerto Rico fish in nearshore zone (Scharer et al. 2002) at average depths of 40-62 m (less than 30 fathoms). Therefore, commercial pots/traps fishing in the US Caribbean occurs primarily in state waters, and probably greater than 85% of the harvest occurs in state waters. Recreational fishing activity occurs primarily in state waters, with only a limited amount in the EEZ (Table 3.13). Pots/traps are not a major gear for recreational fishing.

Pots/traps rank in the moderate category of Probability of Adverse Impacts on coral, seagrass, and benthic algae habitats, and in the moderate category for relative risk for coral and seagrass. The Ecological Importance of coral, benthic algae, and seagrass habitat scores 4 and the relative fishing impacts index scores 6, giving a relative risk of 24 (Tables 4.1, 4.2). The total threat to fish production from pots/traps on coral, benthic algae, and seagrass habitats is therefore moderate. Pots rank as the highest Relative Probability for adverse fishing impacts of any legal gear in the EEZ. In spite of this ranking, quantitative studies on the impacts of pots on coral show relatively small amounts of damage. Studies indicate that traps/pots land on coral reef habitat ranging from around 17-44% of the time (Garrison 1997, Quandt 1999, Appeldoorn et al. 2000), and that pots often damage an area of the reef smaller than the actual area impacted (Quandt 1999, Ena et al. 1996). Appeldoorn et al. (2000) documented that single-buoyed fish traps off La Parguera, Puerto Rico, have an impact footprint of approximately 1m² on hard bottom or reef. Quandt (1999) estimated that a single trap/pot caused 1.55 inch² (10 cm²) of damage to coral per pot per set, or 1,119 feet² (104 m²) of coral damaged annually in the USVI from traps/pots. The risk from pots/traps on benthic algae and seagrass comes primarily from shading over periods exceeding six weeks. Reports that US Caribbean fishers move pots/traps more often than every six weeks minimizes the shading impacts from pots/traps, and makes the effective threat lower than calculated.

Several of the possible actions for minimizing the effects of pots/traps on EFH (Section 2.1.5.4.3.1) were considered ineffective. The M-S Act restricts access limitation to programs
designed to achieve optimum yield. While loss of habitat could prevent achieving optimum yield, developing a limited access system for the US Caribbean would better proceed as a separate effort. The small size of fishing vessels in the US Caribbean precludes transport of all pots/traps to land-based storage following each trip.

4.5.1.3 Vertical line gear

Vertical line gear makes a major contribution to the harvest of reef fish (Matos-Caraballo 2001), accounting for nearly 1 million pounds in 2000. Vertical line gear includes those actions such as hook and line, handline, bandit gear and rod and reel. They are widely used by commercial and recreational fishermen over a variety of estuarine, nearshore, and marine habitats. Hook and line may be employed over reef habitat or trolled in pursuit of pelagic species in both state and Federal waters. Vertical gear harvest occurs in state waters and in the EEZ. Data are insufficient to estimate the proportion of catch taken from state waters or the EEZ. However, about 15% of the shelf area less than 100 fathoms depth occurs in the EEZ (Figure 2.22), and 85% in state waters. Tobias (2001) states that most USVI fishers fish in waters less than 72 m (about 40 fathoms). Therefore, commercial vertical gear fishing in the US Caribbean occurs primarily in state waters, and probably greater than 85% of the harvest occurs in state waters. Vertical lines are not used to harvest species in the other FMPs. Recreational fishing activity occurs primarily in state waters, with only a limited amount in the EEZ (Table 3.13). Hook and line is the primary gear for recreational fishers.

Vertical gear ranks in the low category of Probability of Adverse Impacts on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category for Relative Risk for coral. The Ecological Importance of hard bottom habitat scores 4 and the relative fishing impacts index scores 3, giving a relative risk of 12 (Tables 4.1, 4.2). The Ecological Importance of coral habitat scores 4 and the relative fishing impacts index scores 2, giving a relative risk of 8 (Tables 4.1, 4.2). The total threat to fish production from vertical gear on coral habitats is therefore minimal. Vertical gear fishing often occurs close to, but usually not on coral, because fish caught on or near coral will dive into a hole or crevasse and break off the line. The proportion of vertical gear occurring over coral or in the EEZ is not known.

Several of the possible actions for minimizing the effects of vertical gear on EFH (Section 2.1.5.4.3.4) were considered ineffective. The M-S Act restricts access limitation to programs designed to achieve optimum yield. While loss of habitat could prevent achieving optimum yield, developing a limited access system for the US Caribbean would better proceed as a separate effort. Circle hooks would not likely cause substantial reductions in the amount of snagging on bottom compared to J-hooks. Prohibiting anchoring while fishing would cause fishers to drift across a reef, increasing the chance of hooks (circle or J) or weights hanging up on vertical relief.
4.5.1.4 Gill/trammel nets

Gill and trammel nets make a major contribution to the harvest of reef fish and lobsters (Matos-Caraballo 2001), accounting for over 500,000 pounds in 2000. Gill/trammel net harvest occurs in state waters and in the EEZ. Data are insufficient to estimate the proportion of catch taken from state waters or the EEZ. However, about 15% of the shelf area less than 100 fathoms depth occurs in the EEZ (Figure 2.22), and 85% in state waters. Tobias (2001) states that most USVI fishers fish in waters less than 72 m (about 40 fathoms). Therefore, commercial fishing in the US Caribbean occurs primarily in state waters, and probably greater than 85% of the harvest occurs in state waters. Recreational fishing activity occurs primarily in state waters, with only a limited amount in the EEZ (Table 3.13). Gill and trammel nets are not often used in the recreational fishery.

Gill/trammel nets rank in the low category of Probability of Adverse Impacts on coral habitats, and in the minor category of Probability for seagrass, hard bottom, and benthic algae. The Ecological Importance of coral habitat scores 4 and the relative fishing impacts index scores 4, giving a Relative Risk of 16 (Tables 4.1, 4.2). The Relative Risk to seagrass reaches a 12 because of the high Effort (3) and high Ecological Importance (4). The Relative Risk on benthic algae and hard bottom rank as 8. The total threat to fish production from gill/trammel nets on coral habitats is therefore low to minor. However, the local impact of gill/trammel nets may have increased in areas of the USVI where SCUBA divers set nets around coral habitats. The actual incidence of damage to coral in the USVI from gill/trammel nets set by SCUBA is uncertain, but possibly higher fishing effort than indicated may lead to a higher score for relative risk than shown in Tables 4.1 and 4.2.

Several of the possible actions for minimizing the effects of gill and trammel nets on EFH (Section 2.1.5.4.3.2) were considered ineffective. The M-S Act restricts access limitation to programs designed to achieve optimum yield. While loss of habitat could prevent achieving optimum yield, developing a limited access system for the US Caribbean would better proceed as a separate effort. Limited information and conflicting views on the benefits or damage that results from setting gill/trammel nets with SCUBA precludes an alternative that requires or prohibits use of SCUBA while setting the nets.

4.5.1.5 Spears

SCUBA and skin diving make a major contribution to the harvest of reef fish (Matos-Caraballo 2001), accounting for over 200,000 pounds in 2000. The proportion of harvest by spear is not given but is assumed to be nearly 100%. Data are insufficient to estimate the proportion of catch taken from state waters or the EEZ. However, about 15% of the shelf area less than 100 fathoms depth occurs in the EEZ (Figure 2.22), and 85% in state waters. Tobias (2001) states that most USVI fishers fish in waters less than 72 m (about 40 fathoms). Few divers other than experts dive to depths greater than 30 m (less than 15 fathoms). Therefore, commercial spear fishing in the US Caribbean occurs primarily in state waters, and probably greater than 85% of the harvest occurs in state waters. Spears are not used to harvest species in the other FMPs. Recreational
fishing activity occurs primarily in state waters, with only a limited amount in the EEZ (Table 3.13). Diving, presumably with spears, is an important recreational fishery.

The Ecological Importance of coral habitat scores 4 and the relative fishing impacts index scores 2, giving a relative risk of 8 (Table 4.1). The total threat to fish production from spears on coral habitats is therefore minor.

Several of the possible actions for minimizing the effects of spear fishing on EFH (Section 2.1.5.4.3.5) were considered ineffective. The M-S Act restricts access limitation to programs designed to achieve optimum yield. While loss of habitat could prevent achieving optimum yield, developing a limited access system for the US Caribbean would better proceed as a separate effort.

4.5.2 Alternative 1. (No Action, status quo). Rely on current regulations to minimize, mitigate, or prevent adverse fishing impacts in State and Federal waters of the US Caribbean for all US Caribbean FMPs.

Alternative 1 will continue any current direct impacts on the physical, biological, human, or administrative environments. All current commercial and recreational fishing practices would continue unless and until changes in fishing regulations occur. The No Action alternative would maintain the present level of fishery interactions with protected species. Available information on the biology and status of protected species and the extent of their interaction with commercial and recreational fisheries in the U.S. Caribbean is summarized in section 3.2.1.4. This Alternative would require a determination that existing management measures (Section 2.1.5.2) adequately minimize, mitigate, or prevent potential adverse fishing impacts, to the degree practicable, for all gears in all FMPs. In this case, cumulative adverse impacts from fishing may have occurred in the past but adverse impacts no longer occur in a significant manner. This alternative is likely to cause a significant level of controversy. Those who believe that habitat (especially corals) receive too little protection will oppose it, while fishers believing that too much management already occurs will support it.

The Council and NOAA Fisheries have taken a variety of measures in past management plan amendments that protect fish habitat. In some cases, habitat protection occurred as direct action for habitat, while in other cases the habitat protection occurred as a benefit of management measures directed for other purposes. Indirect impacts will occur to the degree that adverse impacts from fishing occur, but are not recognized. In all cases, the uncertain link between habitat and fish production leads to uncertain results from fishery management measures: management actions may be too severe or too limited to meet the M-S Act requirements to address adverse fishing impacts.

Direct protection has resulted from prohibitions on the use of explosives and chemicals, prohibitions on anchoring in sensitive areas, designations of some areas as marine protected areas (MPAs), and restrictions on use of some fishing gear (Section 2.1.5.2). The Council has currently protected certain habitat areas important to life stages (e.g. a no take area for a spawning aggregation site for red hind and a proposed no take area for yellowfin grouper). Thus,
the Council and NOAA Fisheries could continue current activities to protect fish habitat and could continue to address impacts of fishing on fish habitat without designation of EFH.

The Council and NOAA Fisheries can take no direct action to prevent, minimize, or mitigate non-fishing impacts in all waters, or fishing impacts in state waters. Most EFH and most fishing occur in state waters. Of the substrates on the shelf – the most vulnerable and most used by managed species – in less than 100 fathoms depth, calculations using GIS show that approximately 15% occurs in the EEZ and 85% occurs in state waters (Figure 2.22). Most degradation of fish habitat and, by inference, reduction of fish production occurs from non-fishing impacts (Section 3.5.2, 4.6). Further reduction of fish production occurs from heavy fishing that removes more fish than the resource can sustain (Sections 3.2.11 and 4.6).

The roughly 1,200 to 1,700 commercial fishers from Puerto Rico and 400 commercial fishers from the USVI (Section 3.3) would continue their current fishing practices in the EEZ. Proportionately more commercial fishing likely occurs in the EEZ around the USVI than in the EEZ around Puerto Rico because the 9-nm territorial sea of Puerto Rico encompasses nearly all the insular shelf. Utilization of gear types would increase and decrease depending on the benefits as perceived by the fishers. Likewise, the roughly 200,000 recreational fishers (Section 3.3) would continue current fishing practices. According to the MRFSS data, most recreational fishing in the EEZ around Puerto Rico occurred for dolphin and tuna, while most bottom fishing occurred in state waters. A higher proportion of bottom fishing likely occurs in the EEZ around the USVI than around Puerto Rico, because of the higher proportion of shelf in the EEZ adjacent to the USVI.

If a future determination were made that fishing practices had an adverse impact on EFH and that practicable means existed to minimize, mitigate, or prevent the impact, action could be taken for those fishing practices.

4.5.2.1 Practicability

*Changes in EFH.* Under the no-action alternative, the on-going trajectory of changes to EFH as a result of fishing will continue into the future (Table 2.17). The gears used in the US Caribbean range in impacts from negligible to minor to moderate impacts. The gear-habitat interactions with the highest fishing sensitivity index (Table 3.15) – pots/traps and gill/trammel nets on coral – do not occur as often as for other habitats. As a result of these interactions, adverse impacts have accumulated at a low rate.

*Population effects on FMU species from changes in EFH.* Populations of fish in the FMUs of the four FMPs may have experienced minor abundance declines from habitat damage caused by fishing gear. However, population has declined as a result of high catch in the fishery. Management restrictions in Federal and state waters to reduce catch would have substantial benefits to productivity of the stocks.

*Ecosystem changes from changes in EFH.* The relatively small adverse impacts to habitat caused by fishing gear have affected mostly coral ecosystems. This may have resulted in lower diversity.
of coral because of small, continuous damage that favors fast growing that recovers rapidly over slower growing coral, possibly resulting in decadal scale changes (Section 4.6).

**Effects on enforcement, management, and administration.** As enforcement resources are currently strained to enforce current regulations, an increase in enforcement from current level would be needed for compliance of the existing measures. Compliance with existing regulations is largely voluntary, and requires support of fishers. The no action alternative does not require amendments to the FMPs.

**Net economic change to fishers.** Fishing is primarily artisanal in the US Caribbean, and imports supply most of the fish sold in the US Caribbean. Fishing provides small, but important, revenue to the fishers; for example the recent ex-vessel value of the Puerto Rico harvest amounted to about $10 million for about 2,000 fishers, or $5,000 on average. Current fish stock sizes lower than desirable leave little prospect for improvement.

**Practicability conclusion.** The Council concluded that adverse fishing impacts occur in the US Caribbean, and that practicable measures exist with which to address them. Therefore, this alternative would not meet the requirements of the M-S Act.

4.5.3 Alternative 2. Establish modifications to anchoring and pots/traps for recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots
- Require at least one buoy at each end of traplines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ
- Require a “trip line anchor retrieval system” (Figure 2.43) retrieval system on anchor lines for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ

This Alternative will have no direct impact on physical environment in terms of altering the geology, bathymetry, or the fundamental structure of the physical environment. The Alternative will have direct impacts on the biological, human, and administrative environments.

4.5.3.1 Biological environment

About 50% of Puerto Rican pot/trap fishers presently use traplines, and 32% of these trapline fishers do not use buoys on their pots/traps (Section 3.3.1). Of trapline fishers not using buoys about 34% grapple to retrieve their pots/traps, suggesting that approximately 5% of Puerto Rican pot/trap fishers use grapples on bottom habitats. No information is available on use of traplines by USVI fishers. While fishers claim pots are not usually fished on coral, studies by Garrison (1997) and Appeldoorn *et al.* (2000) found that about 17-40% of pots/traps surveyed in the US Caribbean were located on reefs. If a mid point value of 30% is used for traps/pots on reefs, and 5% of these are retrieved by grappling, then about 1-2% of all trap/pot retrievals would occur on
coral. However, it would seem difficult to grapple on coral, because the grapple hook would tend to hang up on the physically complex coral habitat.

Trap/pot fishers state that low-relief hard bottom is the preferred habitat for trap/pot deployment (preferred by 34% of fishers – Section 3.3.1). Grappling in hard bottom habitat could occur without loss of the grapple, but damage to gorgonians and sponges might occur. Grappling on seagrass or benthic algae could uproot seagrass and break off algae. The use of floating line for traplines might mitigate impacts because grappling could occur off the bottom and still allow trap retrieval. It is not feasible to ban grappling because it may be necessary for recovery of traps that have accidentally lost their buoys. However, a buoy requirement for traps will minimize the need for grappling. This provision of Alternative 2 will provide reduction to damage from grappling on coral and hard bottom compared to Alternative 1, but the amount of reduction cannot be calculated.

Fishers do not typically use anchors on coral habitat, but they are sometimes deployed there by accident or miscalculation. A trip line anchor retrieval system (Figure 2.43) would minimize dragging and bumping across coral in these instances. In addition, the vertical lifting of anchors will minimize dragging on hard bottom, benthic algae, and seagrass during the retrieval process. Presently, there are no quantitative measures of damage from anchors in the US Caribbean. This provision of Alternative 2 will provide reduction to damage from anchor dragging on coral, hard bottom, seagrass, and benthic algae compared to Alternative 1, but the amount of reduction cannot be calculated.

The measures listed under this Alternative would not cause a reduction in harvest, unless they caused an increase in costs (see Section 3.3) and forced some fishers to drop out of fisheries.

Pots/traps have a relative fishing impacts index score of moderate (6) on coral, seagrass, and benthic algae and a moderate Relative Risk, but observations suggest lower impacts (Section 4.5.1.2). Vertical gear ranks in the low category of Probability of Adverse Impacts on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category for Relative Risk for coral.

The measures in this alternative will have small benefits for fish production compared with the potential benefits from addressing human-induced habitat degradation and addressing what appears as excessive harvest (Section 3.5.2, 4.6). Under this EFH EIS, the Council and NOAA Fisheries cannot address non-fishing impacts, fishing in state waters, or excessive fishing that does not cause adverse impacts to EFH. Only 15% of the most vulnerable EFH occurs in the EEZ (Figure 2.22). In all cases, the uncertain link between habitat and fish production leads to uncertain results from fishery management measures: management actions may be too severe or too limited to meet the M-S Act requirements to address adverse fishing impacts.

Buoy lines on traps/pots are known to adversely affect marine mammals and sea turtles through entanglement and can lead to serious injuries and/or death by drowning. Requiring at least one buoy that floats on the surface on all individual traps/pots and at least one buoy at each end of traplines linking traps/pots would increase the amount of vertical line gear in the water and
therefore, increase the potential for marine mammal and sea turtle takes in Caribbean trap/pot fisheries.

4.5.3.2 Human environment

The ex-vessel value of commercial fisheries in Puerto Rico is about $10 million per year, and about 2,000 fishers participate (Section 3.3.1). Therefore, Puerto Rico fishers average about $5,000 annually. The actual distribution of income across the fishers is not known, but a minor proportion of the fishers generally accounts for a majority of the harvest. A limited amount of economic data is available for the pot fishery of Puerto Rico (Juan Agar, SEFSC, Miami, FL, personal information). Agar estimated that an average pot fisher grosses no more than $200 per day and fishes 3 days per week, for a weekly income of no more than $600. Estimated daily expenses amounted to $50 for crew and $40 for operating, for a total weekly cost of $270 and a weekly net income of no more than $330. Estimates of annual income require information on the number of days or number of weeks fished per year, which is currently unavailable. No comparable information is available for the USVI.

Fishers often do not use buoys on traps/pots to avoid trap robbery. Therefore, a requirement for buoys on traps/pots may indirectly cause more trap hauls due to retrieval by the rightful owners and by robbers. Most US Caribbean fishers have at least some pots/traps, as these fishers typically fish multiple gears. Trap/pot buoys cost about $2-4 apiece (atagulf.com). Approximately 15,000 pots/traps were censused in Puerto Rico, but the proportion used in the EEZ is unknown. Individual fisher trap ownership ranges from 10 to 300 traps, with an average of 67 traps per fisher. Most of the traps/pots are currently fished with buoys, and fishers may also have spare buoys. The total cost of purchasing buoys is unknown, but would add an incremental cost to fishers compared with Alternative 1. For example, if 5,000 pots need buoys in the EEZ, then this measure would add $10,000 to $20,000 to the cost of fishing.

Many fishers anchor while fishing. A trip line anchor retrieval system (Figure 2.43) will minimize anchor damage to complex structure in which the anchor may become stuck, by allowing the anchor to back out of the snag. A trip line consists of a long length of line sufficiently strong to retrieve the anchor tied to the crown (the point where the anchor shank meets the flukes) and attached to a surface buoy with sufficient flotation to remain at the surface during anchoring (Rousmaniere 1999). While some fishers fish to or past the insular shelf, many fish in shallower water. The type of buoy and amount of trip line for an anchor retrieval system depend on depth of anchoring. A small (13 pound flotation) mooring buoy costs approximately $15, and 600 feet of line costs approximately $17 for ¼ inch polypropolene, $39 for ¼ inch nylon, $66 for ½ polypropolene, and $138 for ½ inch nylon (atagulf.com). Recreational vessels registered in the US Caribbean number around 45,000 to 50,000. The proportion of these that fish is not known however, the unit cost of an anchor retrieval system is expected to be the same for both recreational and commercial fishers. Additional vessels transit through the US Caribbean. Anchor systems for these vessels could add several hundred thousand dollars to the total cost, but the actual incremental cost compared to Alternative 1 cannot be calculated.

This alternative is likely to cause a significant level of controversy. Those who believe that habitat (especially corals) receive too little protection will recommend additional actions. Fishers
believing that too much management already occurs will also oppose it. However, fishers are more likely to support this Alternative over more restrictive alternatives.

4.5.3.3 Administrative environment

This gear Alternative is applicable for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ. This gear Alternative is not applicable under EFH Alternative 1 because no EFH would be described and identified, or EFH Alternative 8 because EFH would not be described and identified in the EEZ.

For administrative costs to prepare a Generic EFH Amendment or amend the four FMPs, see Section 4.3.4 (Consequences of EFH alternatives, Administrative Environment).

In terms of enforcement, it may be difficult to enforce regulations requiring buoys on traps/pots traplines because it is not always possible to see pots/traps on the bottom. Enforcement personnel could check the gear on boat decks to see if buoys are available for use. A float on the surface would allow enforcement to check on the legality of pots/traps. Enforcement agents could confirm whether vessels carry the trip line anchor retrieval system, but could determine whether the vessels use them only by observing each anchoring.

These actions comply with NOAA Fisheries guidelines to use modifications of gear types that result in reduced impacts to the habitat without unacceptable reduction in gear efficiency or other factors that may make the modifications impracticable (NMFS 1998). These actions do not eliminate all adverse impacts, but more stringent actions require more costs. This Alternative allows fishing to continue under current regulations, with only minor changes to gear.

4.5.3.4 Practicability analysis

Changes in EFH. Alternative 2 will incrementally reduce adverse impacts to EFH, compared to Alternative 1 (Table 2.17). Anchor retrieval with a trip line may benefit coral and hard bottom habitats by reducing broken coral and other biogenic structure when anchors are retrieved from bottom snags. Buoys used with all traps/pots would require less grappling to retrieve pots tied together with traplines, and benefit coral and hard bottom. In the aggregate, these measures would reduce damage to a small amount of total EFH.

Population effects on FMU species from changes in EFH. The measures of Alternative 2 would likely result in minor, if any, increase in fish abundance. Because the populations have lowered abundance because of heavy catch, they are unlikely to use all available habitats. However, maximum sustainable abundance of the fishery resources would require a broad distribution of healthy habitats. Management restrictions in Federal and state waters to reduce catch would have significant benefits to productivity of the stocks.

Ecosystem changes from changes in EFH. The measures of Alternative 2 may improve carrying capacity for future growth in abundance, but without fish to occupy it until stock sizes increase.
Any improvements in habitat would increase availability for ecological functions. Any habitat loss reduction or habitat improvement may result in small benefit. If small, continuous damage occurs that results in decadal scale changes in coral diversity, the measures in this alternative will cause a small benefit by reducing some impacts on coral and hard bottom habitats to help maintain diversity.

**Effects on enforcement, management, and administration.** The measures proposed in the alternatives to address adverse fishing impacts are feasible, but would require additional enforcement resources to assure compliance. This Alternative would require amendments to the four FMPs a cost to NOAA Fisheries and the Council. Previous FMP amendments in the Southeast Region have cost NOAA Fisheries and the Councils approximately $60,000 to $100,000 and 1½ to 2 years. Information in this EIS should substantially reduce those costs.

**Net economic change to fishers.** The artisanal fishers of the US Caribbean under open access will likely see little or no economic improvement from this alternative: stock size is unlikely to increase without reductions in harvest, and open access would likely cause long-term dissipation of benefits if stocks increased. Fishers would face moderate additional short-term costs for anchor trip lines ($17 to $140 for 600 feet of anchor line and $15 for a float) and pot/trap buoys ($2-4 per buoy).

**Practicability conclusion.** The Council concluded that costs to commercial and recreational fishers for buoys on pots and traps and for an anchor retrieval system are not overly burdensome, given the benefits to EFH from these measures. Reducing habitat damage from anchors that may get hung up on irregular bottom and minimizing the need to grapple for pots/traps will reduce future damage to EFH, within the normal cost of doing business. Therefore, the Council concluded that the management measures of Alternative 2 are practicable.

4.5.4 Alternative 2.5 Establish modifications to anchoring and pots/traps and close areas to pots/traps for recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots under the Spiny Lobster and Reef Fish FMPs under the Spiny Lobster and Reef Fish FMPs
- Require at least one buoy that floats on the surface at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ under all FMPs
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented spawning areas (Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
This Alternative will have no direct impact on physical environment in terms of altering the geology, bathymetry, or the fundamental structure of the physical environment. The Alternative will have direct impacts on the biological, human, and administrative environments.

4.5.4.1 Biological environment

This Alternative has all of consequences of Alternative 2, plus the following.

Permanent closures to pots/traps of the currently seasonally closed areas (50 CFR 622.33(a)) and Gramanic Bank would shift trap/pot fishing effort to areas outside of the closed areas, which would more widely distribute fishing effort and any adverse fishing impacts. The specific ecological function of the habitats to which a fisher would move cannot be determined. This alternative would tradeoff no trap/pot fishing effort in the managed sites for increased effort in remaining areas. The existing seasonal closures are designed to protect red hind and mutton snapper during the spawning season. Making the seasonal closure to permanent for pots/traps and extending the closed areas for pots/traps to include all coral recognizes the important ecological function of these areas, and eliminates any adverse impacts from fishing with traps/pots from the areas. The total harvest of reef fish and spiny lobster may decrease if trap/pot fishers cannot fish in the closed areas. However, these fishers could maintain harvest by increasing effort in open areas.

US Caribbean fishers state that they do not use pots/traps on coral because of damage to traps, but surveys (Sections 3.3 and 3.5.1.2.3) find traps/pots on coral. If the surveys represent the actual situation, permanent closures will remove any adverse impacts on coral and on any other sensitive habitat in the closed areas. If fishers’ statements represent the situation, this prohibition will have little effect on coral habitat. Pots/traps have a relative fishing impacts index score of moderate on coral, seagrass, and benthic algae and a moderate Relative Risk, but observations suggest lower impacts (Section 4.5.1).

The measures in this alternative will have small benefits for fish production compared with the potential benefits from addressing human-induced habitat degradation and addressing what appears as excessive harvest (Sections 3.2.11, 3.5.2, 4.6). Under this EFH EIS, the Council and NOAA Fisheries would not address non-fishing impacts, fishing in state waters, or excessive fishing that does not cause adverse impacts to EFH. Only 15% of the most vulnerable EFH occurs in the EEZ (Figure 2.22).

Traps/pots are known to adversely affect marine mammals and sea turtles by entangling can lead to serious injuries and/or death by drowning. As stated above, the specific habitats to which fishers would move are unknown, therefore impacts on marine mammals and sea turtles cannot be determined. Eliminating trap/pot fishing effort under this alternative in managed sites however, would likely only result in reduced interactions if total trap/pot effort was reduced.
4.5.4.2 Human environment

The additional impacts affect trap/pot fishers, who make up a high proportion of fishers in the US Caribbean. It is not known how much pot/trap fishing presently occurs on the seasonally-closed sites, as such data have not been collected. Puerto Rican fishers use multiple areas, and about half (43%) fish the shelf edge among the suite of areas. In Puerto Rico, 1/3 of fish landings come from the west coast (Matos-Caraballo 2001), where the seasonally closed areas occur in Puerto Rico. Many fishers in the region likely fish the seasonally closed areas at least part of the time. Over 50% of the USVI commercial fishing vessels are kept in St. Thomas-St. John (Section 3.3.1), and most have access to one or more of the USVI seasonally closed areas. The number of pot/trap fishers or amount of harvest from inferred or documented coral habitats in St. Thomas and St. Croix are not known, but likely many fishers in the region fish the areas, at least part of the time. No information is available to indicate the amount of pot/trap gear used on these sites. However, fishers claim not to use pots/traps on coral; if so the use of traps/pots in these areas is likely low.

The amount of coral/hard bottom inferred from spawning areas (Figure 2.26) in the EEZ in Puerto Rico is small relative to the composite EFH under EFH Alternatives 2 and 6 (Figure 2.38). Closing the areas seasonally would require pot/trap fishers to move to other areas or not fish; fishers can minimize impacts of closures by moving to state waters adjacent to the closed areas or to other open areas in the EEZ. However, fishers use the proposed closed areas for a reason, usually higher catch rates or reduced costs. Other areas could have lower catch rates or require fishers to expend more time or money for travel or other logistics, causing participants to fish more for less income. It cannot be determined if trap/pot fishers shifting effort to open areas will make up for lost harvest from the closed areas. As all fish caught by US Caribbean fishers are consumed locally, a catch reduction would probably cause an increase in fish imports. Fishers who fish the seasonally closed areas and who fish on documented coral would likely object to permanent closures.

4.5.4.3 Administrative environment

This Alternative has all of consequences of Alternative 2, plus the following.

This gear Alternative is applicable for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ. This gear Alternative is not applicable under EFH Alternative 1 because no EFH would be described and identified, or EFH Alternative 8 because EFH would not be described and identified in the EEZ.

For administrative costs to prepare a Generic EFH Amendment or amend the four FMPs, see Section 4.3.4 (Consequences of EFH alternatives, Administrative Environment).

This Alternative sets precedent for extending prohibitions of pot/trap fishing as new areas of coral or hard bottom are inferred from newly located spawning areas. The increased enforcement requirements for prohibitions of traps/pot on locations of inferred or documented habitats would further strain enforcement capabilities in the US Caribbean. Allowing other fishing gears in the
inferred habitat sites may provide the opportunity for illegal fishing. Fishers could set illegal gear, and also fish with legal gears, such as hook and line, until they were ready to retrieve the illegal gear and leave the prohibited area. Illegal pots/traps would likely be fished without buoys to avoid detection, and may require grappling to retrieve. Allowing other fishing gears on locations of inferred or documented habitat decreases enforcement effectiveness.

4.5.4.4 Practicability analysis

*Changes in EFH.* Alternative 2.5 will incrementally reduce adverse impacts to EFH, compared to Alternative 2 (Table 2.17). This alternative adds closures to pots/traps of habitat inferred as coral or hard bottom from spawning aggregations. These are the areas seasonally closed plus Gramanic Bank. In the aggregate, these measures would reduce damage to a small amount of total EFH, but the areas involved have high ecological importance to reef fish as spawning sites.

*Population effects on FMU species from changes in EFH.* The measures of Alternative 2.5 would likely result in minor, if any, increase in fish abundance. Because the populations have lowered abundance because of heavy catch, they are unlikely to use all available habitats. However, maximum sustainable abundance of the fishery resources would require a broad distribution of healthy habitats. Management restrictions in Federal and state waters to reduce catch would have significant benefits to productivity of the stocks. However, maintenance of the habitat at these sites may help prevent future abundance declines.

*Ecosystem changes from changes in EFH.* The measures of Alternative 2.5 may improve carrying capacity for future growth in abundance, but without fish to occupy it until stock sizes increase. Any improvements in habitat would increase availability for ecological functions. Any habitat loss reduction or habitat improvement may result in small benefit. If small, continuous damage occurs that results in decadal scale changes in coral diversity, the measures in this alternative will cause a small benefit by reducing some impacts on coral and hard bottom habitats to help maintain diversity.

*Effects on enforcement, management, and administration.* The measures proposed in the alternatives to address adverse fishing impacts are feasible, but would require additional enforcement resources to assure compliance. This Alternative would require amendments to the four FMPs at costs similar to those of Alternative 2.

*Net economic change to fishers.* The artisanal fishers of the US Caribbean under open access will likely see little or no economic improvement from this alternative: stock size is unlikely to increase without reductions in harvest, and open access would likely cause long-term dissipation of benefits if stocks increased. The amount of fishing that occurs at the proposed closed sites is unknown, but pot/trap fishers would face displacement from currently available fishing grounds and additional costs of moving to other sites, changing fishing gears, or reducing the amount of fishing.

*Practicability conclusion.* The Council concluded that costs to commercial and recreational fishers for buoys on pots and traps, for an anchor retrieval system, and prohibition of traps/pots
on spawning sites are not overly burdensome, given the benefits to EFH from these measures. In addition to the measures of Alternative 2, the prohibition of traps/pots on coral-hard bottom will reduce future damage to EFH, within the normal cost of doing business. Therefore, the Council concluded that the management measures of Alternative 2.5 are practicable.

4.5.5 Alternative 3. Establish modifications to anchoring techniques; establish modifications to construction specifications for pots/traps; and close areas to certain recreational and commercial fishing gears (i.e., pots/traps, gill/trammel nets, and bottom longlines) to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

- Require at least one buoy that floats on the surface on all individual traps/pots
- Require at least one buoy at each end of trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs
- Require an anchor retrieval system (trip line) consisting of a line from the crown of the anchor to a surface buoy (Figure 2.43) for commercial and recreational fishing vessels that fish for or possess Caribbean reef species in or from the EEZ
- Prohibit the use of pots/traps on coral or hard bottom habitat as inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank for these gears – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of gill/trammel nets coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit the use of bottom longlines on coral/hard bottom areas inferred from documented reef fish spawning areas (Results in year-round closure of the existing seasonally closed areas plus Gramanic Bank – Figure 2.26) in the EEZ under the Reef Fish FMPs

This Alternative will have no direct impact on physical environment in terms of altering the geology, bathymetry, or the fundamental structure of the physical environment. The Alternative will have direct impacts on the biological, human, and administrative environments.

4.5.5.1 Biological environment

This Alternative has all of consequences of Alternative 2.5, plus the following.

Divers in St. Croix deploy gill or trammel nets on the seafloor around coral formations in a targeted fishery for parrotfish. Divers may attach the nets to bottom structure – which could often be coral or other biogenic structure – to hold the nets fixed to the bottom, and then drive fish to the net by beating on the bottom or other methods of making noise. This technique is similar to the muro-ami fishing practice formerly used and now banned in Asian countries. Muro-ami used free divers to set nets in and around coral and to drive fish into the nets by beating on the bottom (Burke et al., 2002). Divers broke and fragmented coral by standing on it to set nets, and by
beating on it during the fish drives. While this technique is not common elsewhere in the US Caribbean EEZ, declining fish populations currently or in the future could lead fishers to target parrotfish in other areas. About 20 fishers, each with two helpers, currently use SCUBA to set gill/trammel nets in waters around St. Croix (W. Tobias, DPNR, personal communication).

While some controversy exists whether SCUBA divers lead to more or less damage to coral (Section 4.5), the SSC and HAP concluded that damage from setting the nets with SCUBA is a cause for concern. Use of SCUBA provides USVI fishers with a mechanism to carefully retrieve gill and trammel nets without damaging coral (Robert McAuliffe, Fishermen’s United Services Cooperative of St. Croix, personal communication), but observations of careless net retrieval has documented damage to coral from gill/trammel nets (William Tobias, USVI DPNR, personal communication). Widespread use of gill or trammel nets would increase damage to coral and hard bottom structures above that occurring from other sources. This management measure would directly address a conservation issue in the EEZ around St. Croix and prevent spread of the fishing activity in a precautionary manner.

Permanent closures of the currently seasonally-closed areas (50 CFR 622.33(a)) and Gramanic Bank to gill/trammel nets and longlines would shift fishing effort from these to areas outside of the closed areas, which would more widely distribute fishing effort and adverse fishing impacts. The specific habitats to which fishers would move and the ecological function of those habitats cannot be determined. This alternative would tradeoff no fishing effort by the gears with the highest risk of adverse fishing impacts in the managed sites for increased fishing effort in the remaining areas. This Alternative would protect both the generally important functions, and also the specific spawning function. The existing seasonal closures are designed to protect red hind and mutton snapper during the spawning season. Making the seasonal closure to permanent for gill/trammel nets and longlines recognizes the important ecological function of these areas, and eliminates the adverse impacts from fishing with gill/trammel nets and longlines from the areas. The total harvest of reef fish and spiny lobster may decrease if gill/trammel nets and longlines fishers cannot fish in the closed areas. However, these fishers could maintain harvest by increasing effort in open areas, which would increase costs, with participants fishing more for less income.

The amount of bottom longline fishing on coral is not known. However, US Caribbean fishers do not use bottom longlines extensively. Longlines can shear fragile vertical structure during retrieval, and prohibition of longlines on inferred coral will remove that potential threat.

Pots/traps have a relative fishing impacts index score of moderate on coral, seagrass, and benthic algae and a moderate Relative Risk, but observations suggest lower impacts (Section 4.5.1). However, the fishing impacts and relative risk for pots/traps do not include the effects of traplines. Vertical gear ranks in the low category of Probability of Adverse Impacts on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category for Relative Risk for coral. Longlines rank in the minor category of Probability of Adverse Impacts on coral and live/hard bottom habitats, and in the minor category for Relative Risk.

The measures in this alternative will have small benefits for fish production compared with the potential benefits from addressing human-induced habitat degradation and addressing what
appears as excessive harvest (Sections 3.2.11, 3.5.2, 4.6). Some increase in biodiversity of coral may occur as a result of reducing continuous, but low level, perturbations on coral (Section 4.6). Under this EFH EIS, the Council and NOAA Fisheries cannot address non-fishing impacts, fishing in state waters, or excessive fishing that does not cause adverse impacts to EFH. Only 15% of the most vulnerable EFH occurs in the EEZ (Figure 2.22).

Actions that reduce effort, such as time area closures and partial or complete gear prohibitions, may reduce the potential for interactions.

4.5.5.2 Human environment

This Alternative has all of the consequences of Alternative 2.5, plus the following.

The additional impacts affect trap/pot and gill/trammel net fishers, who make up a high proportion of fishers in the US Caribbean, and longline fishers, who account for a small proportion of catch. It is not known how much trapline fishing with pots/traps, gill/trammel net fishing, or longline fishing presently occurs on the seasonally-closed or documented coral sites as such data have not been collected. Puerto Rican fishers use multiple areas, and about half (43%) fish the shelf edge among the suite of areas. In Puerto Rico, 1/3 of fish landings come from the west coast (Matos-Caraballo 2001), where the seasonally closed areas occur in Puerto Rico. Over 50% of the USVI commercial fishing vessels are kept in St. Thomas-St. John, with the remainder in St. Croix (Section 3.3.1), and most have access to one or more of the USVI seasonally closed areas. The number of gill/trammel net or longline fishers or amount of harvest from inferred or documented coral habitats in St. Thomas and St. Croix are not known, but likely many fishers in the region fish the areas, at least part of the time. The amount of coral/hard bottom inferred from spawning areas (Figure 2.26) and the amount of mapped coral (Figure 2.47) in the EEZ in Puerto Rico is small relative to the composite EFH under EFH Alternatives 2 and 6 (Figure 2.38). Closure of the areas would force these fishers to move to other areas.

Closing the inferred and documented areas permanently would require gill/trammel net and longline fishers to move to other areas or not fish; fishers could minimize impacts of closures by moving to state waters adjacent to the closed areas or to other open areas in the EEZ. However, fishers use the proposed closed areas for a reason, usually higher catch rates or reduced costs. Other areas could have lower catch rates or require fishers to expend more time or money for travel or other logistics, causing participants to fish more for less income. It cannot be determined if gill/trammel net or longline fishers shifting effort to open areas will make up for lost harvest from the closed areas. As most fish caught by US Caribbean fishers are consumed locally, a catch reduction would probably cause an increase in fish imports.

Fishers using traps/pots displaced from shipping lanes by a trapline prohibition use the shipping lanes for a reason, usually higher catch rates or reduced costs. As with the closed areas discussed above, participants may fish more for less income, or overall harvest could decrease.

This alternative is likely to cause a significant level of controversy. Those who believe that this alternative will not afford sufficient protection to habitat (especially corals) will oppose it and
seek more restrictive actions; fishers believing that too much management already occurs will also oppose it. The closed area restrictions on the most-used gears will apply to a large number of fishers, most of whom will not want to lose productive fishing grounds. However, fishers who support spawning aggregation closures will support those measures. Most fishers in the US Caribbean use pots/traps at least part time, and about half of them use trap lines. Most will not likely wish to give up the use of trap lines.

4.5.5.3 Administrative environment

This Alternative has all of consequences of Alternative 2.5, plus the following.

This gear Alternative is applicable for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ. This gear Alternative is not applicable under EFH Alternative 1 because no EFH would be described and identified, or EFH Alternative 8 because EFH would not be described and identified in the EEZ.

For administrative costs to prepare a Generic EFH Amendment or amend the four FMPs, see Section 4.3.4 (Consequences of EFH alternatives, Administrative Environment).

This Alternative sets precedent for extending prohibitions on fishing as new areas of coral or hard bottom are inferred from newly located spawning areas. The increased enforcement requirement prohibition of gill nets/trammel nets and longlines on inferred or documented coral habitats would further strain enforcement capabilities in the US Caribbean. Allowing other fishing gears in the closed areas may provide the opportunity for illegal fishing. Fishers could set illegal gear, and also fish with legal gears, such as hook and line, until they were ready to retrieve the illegal gear and leave the closed area. Illegal gear would likely be fished without buoys to avoid detection, and may require grappling to retrieve it. Allowing other fishing gears in closed areas decreases enforcement effectiveness.

4.5.5.4 Practicability analysis

*Changes in EFH.* Alternative 3 will incrementally reduce adverse impacts to EFH, compared to Alternative 2.5 (Table 2.17). This alternative adds permanent closures to gill/trammel nets and longlines of habitat inferred as coral or hard bottom from spawning aggregations. These are the areas seasonally closed plus Gramanic Bank. In the aggregate, these measures would further reduce damage to a small amount of total EFH, but the areas involved have high ecological importance to reef fish as spawning sites.

*Population effects on FMU species from changes in EFH.* The measures of Alternative 3 would likely result in minor, if any, increase in fish abundance. Because the populations have lowered abundance because of heavy catch, they are unlikely to use all available habitats. However, maximum sustainable abundance of the fishery resources would require a broad distribution of healthy habitats. Management restrictions in Federal and state waters to reduce catch would have
significant benefits to productivity of the stocks. However, maintenance of the habitat at these sites may help prevent future abundance declines.

_Ecosystem changes from changes in EFH._ The measures of Alternative 3 may improve carrying capacity for future growth in abundance, but without fish to occupy it until stock sizes increase. Any improvements in habitat would increase availability for ecological functions. Any habitat loss reduction or habitat improvement may result in small benefit. If small, continuous damage occurs that results in decadal scale changes in coral diversity, the measures in this alternative will cause a small benefit by reducing some impacts on coral and hard bottom habitats to help maintain diversity.

_Effects on enforcement, management, and administration._ The measures proposed in the alternatives to address adverse fishing impacts are feasible, but would require additional enforcement resources to assure compliance. This Alternative would require amendments to the four FMPs a cost to NOAA Fisheries and the Council at costs similar to those of Alternative 2.

_Net economic change to fishers._ The artisanal fishers of the US Caribbean under open access will likely see little or no economic improvement from this alternative: stock size is unlikely to increase without reductions in harvest, and open access would likely cause long-term dissipation of benefits if stocks increased. While the amount of fishing that occurs on these sites is unknown, gill/trammel net and longline fishers would face displacement from currently available fishing grounds and additional costs of moving to other sites, changing fishing gears, or reducing the amount of fishing.

_Practicability conclusion._ The Council concluded that costs to commercial and recreational fishers for buoys on pots and traps, for an anchor retrieval system, and prohibition of traps/pots, gill/trammel nets, and bottom longlines on spawning sites are not overly burdensome, given the benefits to EFH from these measures. In addition to the measures of Alternative 2.5, the prohibition of gill/trammel nets and bottom longlines on coral-hard bottom inferred from reef fish spawning activity will reduce future damage to EFH, within the normal cost of doing business. Therefore, the Council concluded that the management measures of Alternative 3 are practicable.

4.5.6 Alternative 4. Establish modifications to anchoring and pots/traps, and close additional areas to pots/traps, gill/trammel nets, bottom longlines, and fishing with SCUBA, for recreational and commercial fishing gears to prevent, mitigate, or minimize adverse fishing impacts in the EEZ:

In addition to the measures listed under Alternative 3:

- Prohibit all pots/traps for use in fishing or on board vessels fishing on mapped coral areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit gill and trammel nets for use in fishing or on board vessels fishing on mapped coral areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit SCUBA for use in fishing or on board vessels fishing on mapped coral areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs,
- Prohibit bottom longlines for use in fishing or on board vessels fishing on mapped coral areas (Figure 2.47) in the EEZ under the Spiny Lobster and Reef Fish FMPs
- Prohibit trap lines linking traps/pots for all fishing vessels that fish for or possess Caribbean spiny lobster or Caribbean reef fish species in or from the EEZ under the Spiny Lobster and Reef Fish FMPs

This Alternative will have no direct impact on physical environment in terms of altering the geology, bathymetry, or the fundamental structure of the physical environment. The Alternative will have direct impacts on the biological, human, and administrative environments.

4.5.6.1 Biological environment

This Alternative has all of consequences of Alternative 3, plus the following.

US Caribbean fishers claim not to fish traps/pots on coral, and the ability to pull tralplines without damaging habitat. There are some studies of traps/pots dropped on coral, but none regarding traps with tralplines. Any shearing action by tralplines on fragile vertical relief during retrieval of pots/traps could damage coral and gorgonians. Fishers often use floating line to connect pots. Floating tralplines might reduce adverse effects by floating above biogenic structures. Floating tralplines allow for trap retrieval with less grappling on the bottom and reduce the shearing of benthic structures by tralplines. Less than 4% of trap/pot fishers would likely grapple on coral bottom (Section 3.3.1), as surveys found traps on coral less than 40% of the observation, about a third of fishers use tralplines, and about a third of tralpline fishers grapple the line during retrieval \((0.40 \times 0.33 \times 0.33 = 0.04)\). Because grapples tend to hang up on the irregular coral bottom, fishers would likely use a retrieval method other than grappling on coral. Prohibiting tralplines would reduce adverse impacts from the small proportion of fishers that grapple on coral, but prevent fishers from using tralplines on habitats that do not experience adverse impacts. Fishers state that they don’t use pots/traps on coral because of damage to traps, but surveys (Sections 3.5.1.2.3 and 3.3) find traps/pots on coral. If the surveys represent the actual situation, prohibition of tralplines will reduce adverse impacts on coral. If fishers’ statements represent the situation, this prohibition will have little effect on coral habitat.

Prohibiting use of the pots/traps, gill/trammel nets, bottom longlines, and SCUBA with spears in mapped coral areas in the EEZ would remove about 5.5% of US Caribbean mapped coral habitat from access by fishers (Figure 2.16). EEZ areas closed to these gears would include the outer edge of the coral bank in western Puerto Rico and coral reef habitat in eastern St. Croix. This would prohibit the use of gears determined to have adverse impacts from mapped coral year around, but would exclude any coral areas not mapped at this point. Elimination of these gears would reduce harvest of herbivorous fish, such as parrotfish and surgeonfish, which do not often bite baited hooks. Reduction of herbivore harvest would maintain grazing on algae, which would reduce the growth of algae on coral reefs.
While coral has many ecological functions for fish species of the US Caribbean, the specific functions supported by the mapped coral areas are not known. This Alternative does not provide the specific ecological function for the protected habitat as given by Alternative 3. US Caribbean fishers report that they do not use traps/pots on coral. While fishers claim pots are not usually fished on coral, studies by Garrison (1997) and Appeldoorn et al. (2000) found that about 17-40% of pots/traps surveyed in the US Caribbean were located on reefs.

The use of spears is common over coral habitat. Most coral habitats mapped in the EEZ are of sufficient depth that most spear fishers will use SCUBA. The SCUBA prohibition will substantially reduce the amount of spear fishing on these coral areas, which will reduce the amount of touching or re-suspended sediment that can damage coral.

This Alternative is similar to Alternative 3, but adds all mapped coral habitat for protection. The area of mapped coral in the EEZ likely represents only a small amount of the total coral in EEZ, with the remainder as yet unmapped. Prohibitions on the use of pots/traps, gillnets, trammel nets, and longlines on mapped coral/hard bottom habitat would eliminate those gears with the most potential for habitat damage. As an indirect consequence of this Alternative, overall catch in the fisheries would likely decrease, which would directly benefit overfished stocks using those areas. It is not possible to estimate the amount of catch reduction that would occur under this Alternative. However, it is possible that fishers could increase fishing effort in other areas to maintain catch quantities at present levels.

Pots/traps have a relative fishing impacts index score of moderate (6) on coral, seagrass, and benthic algae and a moderate Relative Risk, but observations suggest lower impacts (Section 4.5.1). Vertical gear ranks in the low category of Probability of Adverse Impacts on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category for Relative Risk for coral. Longlines rank in the minor category of Probability of Adverse Impacts on coral and live/hard bottom habitats, and in the minor category for Relative Risk.

No Council fisheries are listed in Categories I or II for marine mammals. Gears used in the US Caribbean have had observed interactions with marine mammals or turtles (e.g., NMFS 2001j). Buoys on pots/traps would increase vertical line gear in the water and therefore could increase the potential for marine mammals interactions. The NOAA Fisheries Southeast Region is considering re-evaluating gill/trammel nets as a Category 2 gear because observed interactions in other areas suggest potential in the US Caribbean. The agency has not made a decision whether to pursue re-evaluation or to initiate a Section 7 consultation. Actions that reduce effort, such as time area closures and partial or complete gear prohibitions, may reduce the potential for interactions.

4.5.6.2 Human environment

This Alternative has all of consequences of Alternative 3, plus the following.

A prohibition of traplines would prevent fishers from using this gear on habitats not or minimally adversely affected, and would cause approximately the approximately 96% of fishers who do not
grapple on coral (Section 4.5.5.1) from the opportunity to use this gear. It is unclear how much economic benefit accrues from use of traplines with traps/pots, as many fishers do not use them. Many fishers who fish with traps/pots in or near shipping lanes use traplines without buoys to prevent large ships from entangling buoy lines and the resulting loss of pots. Prohibition of traplines may force these fishers to move to other areas and would decrease fishing efficiency.

There is presently no quantitative information on the importance of the EEZ mapped coral areas to fishers in the US Caribbean. The mapped coral in the EEZ amounts to about 5.5% of the total mapped coral. About 15% of the habitat shallower than 100 fathoms – the non-pelagic EFH under EFH Alternatives 2 and 6 – occurs in the EEZ, and of the total, about 12.3% occurs adjacent to the USVI and 2.6% adjacent to Puerto Rico. As a substantial portion of mapped St. Croix coral and a substantial portion of potential coral extend into EEZ adjacent to the USVI, this Alternative would likely have a substantial impact on USVI fishers. Even so, the majority of fishing would occur in state waters, because most of the habitat occurs in state waters. In addition, this alternative is more likely to affect USVI gill net and trammel net fishers who use SCUBA to set nets in coral areas than Puerto Rico gill net and trammel net fishers who do not usually set nets near coral. Prohibiting fishing on mapped coral implies that future mapping would lead to closures, and to decreased catch and increased costs to fishers.

As with Alternative 3, it is not known how much fishing presently occurs on the mapped coral sites as such data have not been collected. Puerto Rican fishers use multiple areas, and about half (43%) fish the shelf edge among the suite of areas. The number of fishers or amount of harvest from the coral habitat in the southwest Puerto Rico area is not known, but the largest numbers of fishers in Puerto Rico are found in this region. Many fishers in the region likely fish the inferred habitat areas at least part of the time. No information is available to indicate the gear used on these sites. About 40% of the USVI commercial fishing vessels have homeports in St. Croix, but other fishers could reach St. Croix fishing grounds.

Fishers state that they don’t use pots/traps on coral because of damage to traps, but surveys (see above) find traps/pots on coral. If the surveys represent the actual situation, these closures will reduce use of pot gear on the sites. If fishers’ statements represent the situation, these closures will have little effect on coral habitat.

While gill nets and trammel nets are not typically used on coral habitats in Puerto Rico, they are used in the vicinity of coral reefs in the USVI in conjunction with SCUBA divers who set the nets and herd fish into them. Use of SCUBA provides USVI fishers with a mechanism to carefully retrieve gill and trammel nets without damaging coral (Robert McAuliffe, Fishermen’s United Services Cooperative of St. Croix, personal communication), but observations of careless net retrieval has documented damage to coral from gill/trammel nets (William Tobias, USVI DPNR, personal communication). Prohibition of these nets from coral areas will remove a threat primarily in state waters of USVI and prevent Puerto Rico fishers from using the gear in inferred coral areas.

The amount of longline fishing on coral is not known. However, US Caribbean fishers do not use longlines extensively. Longlines can shear fragile vertical structure during retrieval, and prohibition of longlines on inferred coral will remove that potential threat.
Similar to Alternative 3, closing coral areas would require fishers to move to other areas or not fish. Fishers might be forced to use an opportunistic fishing strategy rather than targeting on these known spawning aggregations. Other areas could have lower catch rates or require fishers to expend more time or money for travel or other logistics. This Alternative would cause a decrease in harvest greater than in Alternative 3 because of the additional closed area, but the amount of decrease cannot be predicted. Harvest of herbivores is important to fishers in the US Caribbean. Closure of the mapped coral areas to pots/traps, gill/trammel nets, and use of spear fishing with SCUBA would especially reduce the harvest of herbivores in the EEZ, a catch that could not be made up with other legal gears, as these species do not often bite baited hooks. Fishers may increase effort in open areas to make up for closed areas, which would increase costs, with participants fishing more for less income.

As all fish caught by US Caribbean fishers are consumed locally, a catch reduction would probably cause an increase in fish imports.

The additional impacts of Alternative 4 primarily affect trap/pot and gill/trammel net fishers, who make up a high proportion of fishers in the US Caribbean. It also affects longline fishers and spear fishers using SCUBA, who account for a small proportion of catch.

This alternative is likely to cause a significant level of controversy. Those who believe that habitat (especially corals) requires additional protection will support it, but may also seek more restrictive actions; fishers believing that too much management already occurs will also oppose it. The closed area restrictions on the most-used gears will apply to a large number of fishers, most of whom will not want to lose even more productive fishing grounds than under Alternative 3. Fishers who support spawning aggregation closures may not support closures on coral because spawning does not occur over all coral.

4.5.6.3 Administrative environment

This Alternative has all of consequences of Alternative 3, plus the following.

This gear Alternative is applicable for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ. This gear Alternative is not applicable under EFH Alternative 1 because no EFH would be described and identified, or EFH Alternative 8 because EFH would not be described and identified in the EEZ.

As with Alternative 3, this Alternative also sets precedent for extending prohibitions on fishing as new areas of mapped coral are added.

It may be hard to enforce these prohibitions on western Puerto Rico mapped coral located at the outer edge of reefs continuous in state waters. Divers could swim between unprotected coral habitat in state waters and protected coral in the EEZ. In general, increased enforcement requirements for prohibitions of trawlines for traps/pot and for gear prohibitions on mapped EEZ coral for traps/pots, gill nets, trammel nets, spears, and longlines would further strain enforcement capabilities in the US Caribbean. Allowing other fishing gears on mapped coral
habitat sites may provide the opportunity for illegal fishing. Fishers could set illegal gear, and fish with legal gears, such as hook and line, until they were ready to retrieve the illegal gear and leave the prohibited area. Illegal gear would likely be fished without buoys to avoid detection, but then require grappling to retrieve it. Prohibiting all fishing gears on mapped coral habitat in the EEZ could increase enforcement effectiveness.

For administrative costs to generically amend the four FMPs together or to separately amend each FMP, see consequences of EFH alternatives, Administrative Environment (Section 4.3.4).

4.5.6.4 Practicability analysis

Changes in EFH. Alternative 4 will incrementally reduce adverse impacts to EFH, compared to Alternative 3 (Table 2.17). This alternative adds permanent closures to pots/traps, gill/trammel nets, longlines and fishing with SCUBA of mapped coral habitats. While only a small amount of coral is mapped in the EEZ (5.5% of the total mapped coral), this alternative would significantly increase the amount of areas closed to many fishing gears compared to Alternative 3. In the aggregate, these measures would further eliminate damage to a moderate amount of total EFH, but the areas involved have high ecological importance many species in the FMUs for a variety of ecological functions.

Population effects on FMU species from changes in EFH. The measures of Alternative 4 would likely result in minor, if any, increase in fish abundance. Because the populations have lowered abundance because of heavy catch, they are unlikely to use all available habitats. However, maximum sustainable abundance of the fishery resources would require a broad distribution of healthy habitats. Management restrictions in Federal and state waters to reduce catch would have much larger benefits to productivity of the stocks. However, maintenance of the habitat at these sites may help prevent future abundance declines. Sustainability of fishery resources requires healthy habitats.

Ecosystem changes from changes in EFH. The measures of Alternative 4 may improve carrying capacity for future growth in abundance, but without fish to occupy it until stock sizes increase. Any improvements in habitat would increase availability for ecological functions. Elimination of adverse fishing impacts on coral sites will further maintain diversity of coral over decadal scales by removing the small, continuous damage.

Effects on enforcement, management, and administration. The measures proposed in the alternatives to address adverse fishing impacts are feasible, but would require additional enforcement resources to assure compliance. This Alternative would require amendments to the four FMPs a cost to NOAA Fisheries and the Council at costs similar to those of Alternative 2.

Net economic change to fishers. The artisanal fishers of the US Caribbean under open access will likely see little or no economic improvement from this alternative: stock size is unlikely to increase without reductions in harvest, and open access would likely cause long-term dissipation of benefits if stocks increased. While the amount of fishing that occurs on these sites is unknown, fishers using pots/traps, gill/trammel nets, longlines and SCUBA would face displacement from
currently available fishing grounds and additional costs of moving to other sites, changing fishing gears, or reducing the amount of fishing. Fishers would lose access to herbivorous species in the EEZ, which do not often bite baited hooks. Some pot/trap fishers would face additional burdens of fishing individual gear rather than strings of gear connected with traplines.

**Practicability conclusions.** The Council concluded that adding a prohibition of trap lines and prohibiting gears on mapped coral areas to the management measures of Alternative 3 are overly burdensome, given the benefits to EFH from these measures. The small likelihood of damage from traplines described above would result in minor benefits, but at high costs to fishers. Commercial and recreational fishers depend on the areas mapped as coral, and closing the areas would deprive fishers of a fishing opportunity. The proposed closure would cause a harvest reduction in the EEZ of herbivorous species caught mainly on coral. Many areas of the USVI, where most of the mapped coral occurs, are already closed (e.g., the national monuments and the St. Croix East End Park), at high cost to fishers. A large portion of SCUBA fishing occurs on the mapped coral of St. Croix’ Lang Bank, which would close under this Alternative. St. Thomas and St. John fishers extensively use the mapped coral sites near St. Thomas. The expanded closed areas would put an undesirable additional burden on enforcement capabilities already strained with existing measures and the measures proposed under Alternative 3. The Council chose to focus management attention on sites of known ecological function (spawning sites of Alternative 3), while the specific ecological function of the mapped coral areas has not been determined. Therefore, the Council concluded that the management measures of Alternative 4 are not practicable.

4.5.7 Alternative 5. Establish total prohibitions on selected fishing gears to minimize, mitigate, or prevent adverse fishing impacts in the EEZ by the following actions:

Prohibit the use of the use of the following gears for fishing throughout the EEZ

- Pots/traps,
- Gill and trammel nets,
- Vertical line gear,
- Spears,
- Bottom longlines

This Alternative will have no direct impact on physical environment in terms of altering the geology, bathymetry, or the fundamental structure of the physical environment. The Alternative will have direct impacts on the biological, human, and administrative environments.

4.5.7.1 Biological environment

This Alternative eliminates from the EEZ those gears that cause adverse impacts to EFH and provides the most complete protection, and is the most restrictive of the alternatives. As far as is known now, corals and hard bottoms are the habitats occurring in the EEZ, which would gain the most from a prohibition of the above gears. Pots/traps can damage corals through direct contact,
especially the branching-type corals, and corals were labeled as being moderately sensitive to damage by pots/traps. Gill/trammel nets can also damage corals through incidental entanglement resulting in coral breakage, particularly for branching and foliaceous corals, and corals were listed as moderately sensitive to damage by gill/trammel nets also. Corals were considered to have a low sensitivity to damage from the remaining gears. Hard bottom habitats were listed as having a low to moderate sensitivity to damage from the above gears. While some benefits would accrue to coral and hard bottom habitats in the EEZ from a prohibition of fishing gears with adverse impacts on habitats, much larger areas of these habitats are found in state waters. If fishers attempt to make up for lost harvest by fishing in state waters, previous adverse fishing impacts from the EZ will move into state waters. Fishing effort, and therefore adverse impacts, will decline if fishers leave the fishery in state waters due to increased competition in a smaller area, and possible reductions in catch rates resulting from heavier fishing pressure in state waters.

This Alternative would nearly eliminate reef fish and lobster catch from the EEZ and provide an opportunity for rebuilding in species with lower than desirable abundance. This effect could be particularly beneficial to protected reef fish species, such as Nassau grouper or goliath grouper. The EEZ prohibition would, however, be likely to cause more intense fishing in state waters. It is not possible to predict how much lost EEZ fishing would shift to state waters, and how much additional harvest would shift to state waters. A shift to state waters would be more likely in the USVI than in Puerto Rico, because more of the USVI insular shelf extends into the EEZ where fishing the above gears would be prohibited.

Pots/traps have a relative fishing impacts index score of moderate on coral, seagrass, and benthic algae and a moderate Relative Risk, but observations suggest lower impacts (Section 4.5.1). Vertical gear ranks in the low category of Probability of Adverse Impacts on coral and hard bottom habitats, in the low category for hard bottom, and in the minor category for Relative Risk for coral. Longlines rank in the minor category of Probability of Adverse Impacts on coral and live/hard bottom habitats, and in the minor category for Relative Risk. Spears rank in the low category of Probability of Adverse Impacts on coral and live/hard bottom habitats, and in the minor category for Relative Risk.

No Council fisheries are listed in Categories I or II for marine mammals. Gears used in the US Caribbean have had observed interactions with marine mammals or turtles (e.g., NMFS 2001j). Buoys on pots/traps would increase vertical line gear in the water and therefore could increase the potential for marine mammals interactions. The NOAA Fisheries Southeast Region is considering re-evaluating gill/trammel nets as a Category 2 gear because observed interactions in other areas suggest potential in the US Caribbean. The agency has not made a decision whether to pursue re-evaluation or to initiate a Section 7 consultation. Actions that reduce effort, such as time area closures and partial or complete gear prohibitions, may reduce the potential for interactions.
4.5.7.2  Human environment

This Alternative would eliminate most fishing in EEZ, allowing only hand harvest (mainly of conch and lobster). Fishers would be excluded from habitats in the EEZ that have low or no sensitivity to fishing gear. The effect would be greater for USVI fishers than Puerto Rico fishers because proportionately more of the USVI shelf occurs in the EEZ. USVI fishers might feel that they were being made to bear a disproportionate share of the burden in the case, creating further controversy. USVI net fishers might be particularly affected because they tend to set nets near the shelf edge to catch parrotfish. Closure of EEZ EFH to fishing in Puerto Rico would primarily affect fishers on the southwest coast. In St. Thomas/St. John, closures would affect sizeable portions of insular shelf fishing areas off the south and north coasts. In St. Croix, fishers working off the east coast would be affected.

Due to the multi-species, multi-gear nature of the fisheries in the US Caribbean, it is not possible to examine fishing activities according to gear type. It is also not possible to determine how many fishers use the EEZ or what how much total fishing effort occurs there compared to state waters. It seems an EEZ closure might reduce landings of deepwater fishes, like silk and queen snapper (which comprise 9% of landings in Puerto Rico), more than the shallow reef species.

Approximately 15% of all US Caribbean EFH less than 100 fathoms occurs in the EEZ. This breaks down to about 2.6% from Puerto Rico and about 12.3% from the USVI. If fishing were distributed evenly across the shelf, the elimination of fishing in the EEZ off Puerto Rico might result in a loss of 2.6% of landings (2.2 million pounds) and value ($4.4 million), or 57,200 pounds of landed fishery species valued at about $114,400, based on average commercial landings data of FMU species (Table 3.12) and average values (Matos-Caraballo 2001). Fishing off USVI might decline 12.3 % from 1.4 million pounds (Table 3.12), or 172,200 pounds. At the same value as for Puerto Rico, this results in a $344,400 loss. Fishers shifting from the EEZ to state waters would offset at least part of these losses. Since all domestic catch is consumed locally, catch reductions would probably cause an increase in fish imports to meet local demand.

Fishers forced out of the fishery by closures might have difficulty finding alternative employment, as economic prospects in the US Caribbean are not good at present. Many part-time fishers work other jobs but fish to supplement their incomes, so closures may create hardships for these fishers as well.

A closure of the EEZ to traps/pots, gill/trammel nets, longlines, vertical line gear, and spears provides protection to sensitive habitats at the expense of eliminating a substantial portion of the US Caribbean to fishers. The lost harvest and its value are disproportionately severe relative to the benefits derived.

This alternative is likely to cause a significant level of controversy. The severity of the alternative is likely to receive support only from those who believe that habitat (especially corals) requires near-total protection. Fishers are unlikely to give any support to this alternative as nearly all would lose some fishing grounds.
4.5.7.3 Administrative environment

This gear Alternative is applicable for EFH Alternatives 2 and 6, which describe and identify EFH in the EEZ. This gear Alternative is not applicable under EFH Alternative 1 because no EFH would be described and identified, or EFH Alternative 8 because EFH would not be described and identified in the EEZ.

For administrative costs to prepare a Generic EFH Amendment or amend the four FMPs, see consequences of EFH alternatives, Administrative Environment (Section 4.3.4).

4.5.7.4 Practicability analysis

Changes in EFH. Alternative 5 will nearly eliminate adverse fishing impacts to EFH (Table 2.17), an area of about 15% of the US Caribbean insular shelf. This alternative closes the EEZ to pots/traps, gill/trammel nets, longlines, and spears. A significant, but unknown, proportion of the EEZ contains sand/shell, soft bottom, and rubble habitats that have a low or negligible fishing sensitivity to fishing gears used in the US Caribbean, and would not benefit from these prohibitions.

Population effects on FMU species from changes in EFH. The gear prohibitions of Alternative 5 would likely result in an increase in fish abundance because of the size of the closed area. Management restrictions in state waters may also be required to reach full benefits to productivity of the stocks.

Ecosystem changes from changes in EFH. The prohibitions of Alternative 5 may improve carrying capacity for future growth in abundance, and provide additional fish with which to occupy it. Elimination of adverse fishing impacts on all coral sites in the EEZ may increase diversity of coral over decadal scales by removing the small, continuous damage. Improvements in habitat quality could benefit marine mammals, turtles, or seabirds that use the EEZ.

Effects on enforcement, management, and administration. The measures proposed in the alternatives to address adverse fishing impacts are feasible, but would require additional enforcement resources to assure compliance. This Alternative would require amendments to the four FMPs at cost to NOAA Fisheries and the Council similar to those of Alternative 2.

Net economic change to fishers. The artisanal fishers of the US Caribbean under open access will likely see a net loss from this alternative. While the amount of fishing that occurs in the EEZ is unknown, fishers using pots/traps, gill/trammel nets, longlines, vertical gear and spears face displacement from the EEZ and additional costs of moving to other sites, changing fishing gears, or reducing the amount of fishing. If fishing were distributed evenly across the shelf and not made up by moving to open areas, fishers could lose $144,000 from Puerto Rico and $470,000 from the USVI. Increased fishing in state waters would offset these projected losses.

Practicability conclusions. The management measures of Alternative 5 are more severe and burdensome than the measures of Alternative 4, which the Council determined to be not
practicable. Therefore, the Council also determined that the measures of Alternative 5, which would have the greatest adverse economic impact on small fishers, are also not practicable.

4.6 Cumulative effects

The Council on Environmental Quality’s (CEQ) regulations (40 CFR § 1500 - 1508) implementing the procedural provisions of NEPA, as amended (42 U.S.C. § 4321 et seq.), define cumulative effects as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR § 1508.7).

In developing the environmental consequences section of an EIS, the CEQ regulations recommend incorporating the following principles of cumulative effects analysis:

- address additive, countervailing, and synergistic effects.
- look beyond the life of the action.
- address the sustainability of resources, ecosystems, and human communities.

As discussed previously, there is little quantitative data available for the US Caribbean to enable a rigorous analysis of cumulative effects. Nevertheless, to the extent possible, this section has been developed following these principles.

4.6.1 Assessment of cumulative effects

Approaches to assessment of cumulative impacts on EFH will vary depending on several factors (NMFS 1998), including:

- The types of habitats under consideration
- Characteristics of the ecosystem
- The nature and extent of identified threats
- The availability and quality of data
- Available resources and expertise

The first three items are addressed in Section 3 (Affected Environment). The US Caribbean region is primarily a coral-based ecosystem, and consists of the coral, live/hard bottom, sand/shell, benthic algae, mangrove, and pelagic habitats that are typical of those systems. Several estuaries associated with watersheds in the region provide estuarine ecosystems associated with but not part of the coral ecosystems. Both ecosystems occur from the shoreline to several miles offshore, on an insular shelf less than 100 fm deep. The relatively nearshore location of the ecosystems makes them especially vulnerable to anthropogenic impacts, and at highest risk in regions closest to centers of human populations or areas of growth in human activities. The last two items in the above list are addressed in Section 2.1 (Methodology). The US Caribbean region is data and information limited. Little information exists to describe the
distribution of habitats in waters deeper than 25 m or to describe the distribution of fish beyond several small areas. Functional relationships of species, life stages, and habitats are described only qualitatively. Socioeconomic information exists in small amounts related to catch and value, but not much for fishers. The region has a small pool of expertise, which is involved in many aspects of habitat review and fishery management. While regional experts possess information for many subjects relevant to EFH, little is published and most information exists as anecdotal.

Cumulative effects include multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts), and an assessment of the ecological risks resulting from the impact of those threats on the managed species' habitat. The effects of describing and identifying EFH and designating HAPC are primarily secondary, resulting from consultation and management of fishing gears. While the cumulative analysis addresses these effects, the cumulative effects section focuses on addressing adverse fishing impacts to EFH, on effects of catch on fish productivity, and effects on anthropogenic non-fishing effects (Table 2.16). For the purposes of this analysis, cumulative effects are impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions.

The analysis of cumulative impacts is based on CEQ (1997) recommendations, which list 11 analytical methods. The text below provides a summary of how these methods were used and the results obtained. Subsequent parts of Section 4.6 provide additional detail for the results of these analyses.

CEQ Method 1. Questionnaires, interviews, and panels. Preparation of the EIS extensively used panels to obtain information. The Council’s HAP and SSC met on two occasions to discuss EFH issues during preparation of this EIS. The HAP and SSC responded to several requests for information. Both panels rated habitat loss from non-fishing activities and loss of productivity of fish resources from heavy fishing as more serious problems than habitat impacts from fishing gears. The preferred fishing impact alternative will reduce the adverse impacts to specific areas of coral habitat, but will not reduce catch to a substantial degree or reduce non-fishing impacts.

CEQ Method 2. Checklists. The lists of fishing and non-fishing threats to habitat provided in Section 3.5 describe the likely effects from specific activities. The effects in these lists were used in developing analyses of cumulative effects using CEQ Methods 3 and 4.

CEQ Method 3. Matrices. Several matrices provided in the EIS (Tables 2.13, 2.14, and 2.15) provide direct comparisons of impacts of the alternatives for EFH and HAPC and of alternatives to address adverse fishing impacts. The matrix of fishing impacts on habitats provides a semi-quantitative risk to habitat from fishing (Tables 4.1, 4.2). The practicability matrix (Table 2.17) brings together biological, socio-economic, and administrative issues to compare the cumulative impacts of the alternatives.

CEQ Method 4. Network and system diagrams. Figure 4.2 qualitatively demonstrates the cumulative impacts of fishing and anthropogenic non-fishing activities on the habitats that make up EFH in the US Caribbean. This portrayal of cumulative impact uses information from Methods 2 and 3. The two types of activities often impact different habitats, and may affect the
same habitat types in different locations, but have the highest overlap on coral, hard bottom, and benthic algae habitats.

The network of activities demonstrates the relative risk to the habitats from fishing gears (Section 2.1.6.2.1), showing the highest risk from pots/traps and gill/trammel nets. The relative risk combines gear-habitat sensitivity, fishing effort, and ecological importance. Coral, hard bottom, and seagrasses are at the highest risk. This analysis does not reflect the possibility that setting gill/trammel nets around coral with SCUBA may expand in use from St. Croix to other regions of the US Caribbean, which would greatly increase the overall risk. It also does not reflect that risk of damage to seagrasses from pots/traps occurs from shading over a 6-week or longer period, which does not often happen in the US Caribbean.

The non-fishing activities are distributed more widely over habitats than are fishing gears. However, lack of information prevented quantifying non-fishing impacts on habitats: neither sensitivity nor stress was available (Sections 2.1.4.2.2 and 2.1.4.2.3). As a result, one should not interpret Figure 4.2 as showing low risk from the non-fishing impacts.

CEQ Method 5. Modeling. CEQ (1997) states that while modeling provides a powerful technique for quantifying the cause and effect relationships leading to cumulative effects, it often requires large amounts of data, and can be intractable with many interactions. There are clearly a large number of interactions in the effects of fishing and non-fishing activities on habitat. To evaluate these in a quantified model would require substantially more data than are available in the US Caribbean (data limitations are discussed in Section 2.1.5.3.3). A limited amount of analysis was undertaken to evaluate the relative risk to EFH posed by fishing gears (Section 2.1.5.3); however this cannot be considered to constitute modeling of the type envisioned in CEQ (1997).

CEQ Method 6. Trends analysis. Data are insufficient to quantitatively track changes in the effects of fishing and non-fishing activities over time. Using the available expert panels under CEQ method 1 (the HAP and SSC), however, advice was obtained on likely trends in impacts, which are discussed throughout Sections 3 and 4 of the DEIS. The trend in number of fishers in Puerto Rico has not changed substantially since 1974, while landings have declined (Section 3.3) (Similar data are not available for USVI). The level of fishing impacts is generally low, but it may accumulate over time (Section 4.5) (see also CEQ Method 9). An un-quantified but large amount of Puerto Rico and USVI marine and estuarine habitats have been lost to or degraded by non-fishing activities (Section 3.5.2). Adverse effects caused by anthropogenic non-fishing activities will continue into the future, but perhaps at a declining rate from the present because existing EFH consultations have led to some modifications of projects (Lisamarie Carrubba, NOAA Fisheries, Puerto Rico, personal communication). Natural impacts are considered to continue as in the past. However, human activities may change the intensity, for example, global warming may cause warmer water temperatures, more intense hurricanes, and decreased rainfall. Coral bleaching may be increased by warmer water temperatures and by dust carried by winds from expanding African deserts. If these human-induced changes fall outside of the normal conditions for species in the US Caribbean ecosystem, they will likely cumulatively degrade the ecosystem.
CEQ Method 7. Overlay mapping and GIS. This EIS utilized GIS mapping extensively for available data on habitat and bathymetry and delineation of existing management areas. However, lack of spatial data precluded the development of mapping overlays of several useful categories, including catch, fishing effort, fishing impacts, non-fishing impacts, or risks to vulnerable fishing communities.

CEQ Method 8. Carrying capacity analysis. Insufficient information exists to perform stock assessments for the FMU species, so calculation of carrying capacity cannot be made. In a qualitative sense, as habitat improves, carrying capacity will increase. In an environment where heavy fishing reduces abundance of stocks of the FMU species, as in the US Caribbean, fish may not be able to fill the available habitats (Section 4.5). All other things being equal, reducing catch would allow abundance to increase, resulting in greater occupancy of habitats by managed species. Habitat could therefore become limiting to sustainability in the future, at which stage carrying capacity could become a more important concern.

CEQ Method 9. Ecosystem analysis. Components of the US Caribbean ecosystem range in status from pristine to destroyed (Section 3.2). Elimination of habitat removes the ecological function of that habitat, and is likely to reduce biodiversity. Even small impacts may cause decreasing diversity if they continue over the longer term by favoring fast growing species with more rapid recovery from impacts: slow growing species may decline while rapid growing species increase (Section 4.5). Such changes could occur over a scale of decades.

CEQ Method 10. Economic impact analysis. Data limitations in the US Caribbean prevented the preparation of a rigorous analysis of economic consequences of alternatives. Qualitative evaluation suggests that the primary effect of fishing impacts alternatives on fishers will be an adverse economic impact as management measures add costs for purchasing gear and displacement from current fishing locations. Fishers are unlikely to benefit financially from improved productivity in the longer term (for example, resulting from improved habitat condition), as economic rent is likely to be dissipated in an open access fishery (Section 3.3).

CEQ Method 11. Social impact analysis. Virtually no data exist for US Caribbean fishers with which to conduct a social impact analysis, and it is outside the scope of the EIS to collect the necessary data. The fishing communities are small, usually consisting of fewer than 100 fishers in Puerto Rico (Section 3.3.2). However, many of the towns with fishing communities are small, so any adverse changes in the economic condition of fishers will likely have a significant effect on the communities.

4.6.2  Physical environment

The majority of impacts to the physical environment in the US Caribbean are a result of past geological scale actions (e.g. geologic formations, earthquakes, volcanic activity and sea floor movements) and storm events. Alternatives implementing the EFH provisions of the M-S Act will have minimal direct consequences for the physical environment. No actions will occur to allow or prohibit changes in the physical environment. Indirectly, as a result of consultations, dredging, filling, shoreline armoring, or other activities may occur at a lower rate than without
EFH requirements. Fishing activities will not affect the physical environment, although they may affect the biota associated with the physical environment. The suite of preferred alternatives provides a broader scope of indirect protection for EFH than any other combination of alternatives.

4.6.3 Biological environment

4.6.3.1 Changes in the quality of EFH

Habitats used by species managed by the Council and NOAA Fisheries consist of two major components: habitat on the shelf (from the shoreline to approximately the 100 fm contour) where most ecological functions of managed species occur, and habitat in open waters (beyond the 100 fm contour to the outer boundary of the EEZ) used by eggs and larvae of managed species. EFH alternatives 2 and 6 describe and identify EFH in both the shelf and offshore areas, and EFH Alternative 8 describes EFH only for a small zone in state waters around St. John from the shoreline to approximately 25 m depth. The US Caribbean fisheries occur with a variety of gear on or over a variety of habitats. However, the Council and NOAA Fisheries can address adverse impacts of fishing on EFH only if they select EFH Alternative 2 or 6. EFH Alternative 1 does not designate EFH, and EFH Alternative 8 describes and identifies EFH only for a small band in state waters around St. John.

The M-S Act states that loss of habitat is one of the greatest threats to the viability of commercial and recreational fisheries in the US. Adverse impacts on fish habitat and fish production in the US Caribbean result from non-fishing impacts (natural and anthropogenic), from direct removals of fish by harvest (commercial and recreational), and from impacts of fishing gears on the habitats. NMFS (2002) and Turgeon (2002) emphasized the anthropogenic impacts on coral reefs and associated ecosystems, the cornerstone of Caribbean habitats, and implicated fishing in contributing to the degradation of coral habitats and associated ecosystems. NMFS (2002) identified the coral reefs and associated ecosystems of Puerto Rico and the USVI as degraded to some degree. For both areas, the main impacts are attributed to diseases, hurricanes, fishery resource removals from heavy fishing, algal and sponge overgrowth, and non-fishing anthropogenic impacts. Similarly, Rogers and Beets (2001) attributed degradation of the US Caribbean ecosystem and observed declines in associated fish and invertebrate abundance to increased incidence of major storms, coral diseases, and intensive fishing, and noted that decreases in abundance of herbivorous fish and invertebrates mean that these species are less able to control growth of algae on coral reefs.

The most significant negative impact of fishing gears on seagrass habitat is from shading caused by pots/traps. Studies in the Florida Keys indicate that pots that rest on seagrass for less than six weeks do not cause shade-related damage, and that recovery occurs within months to a year (Uhrin et al., unpublished). Fishers in the US Caribbean typically do not leave pots on seagrass for more than six weeks, so further action to prevent adverse impacts would be required only if fishers begin to leave pots on vegetation for longer periods. In this case, no negative impacts will occur for pot/trap fishers who fish on seagrass.
Some controversy exists on the impacts of gill/trammel nets on coral and gorgonian habitats. While use of SCUBA to set gill/trammel nets around coral habitats has the potential to also carefully retrieve the nets (Robert McAuliffe, Fishermen’s United Services Cooperative of St. Croix, personal communication), some observations indicate that careless setting and retrieval has and continues to cause damage to coral (William Tobias, USVI DPNR, personal communication). Use of SCUBA with gill/trammel nets in parts of Puerto Rico. The lack of consensus concerning direct adverse impacts of using SCUBA with nets in USVI indicates that more information is required to support developing gill/trammel net component in the preferred alternative. Indirect impacts of the St. Croix gill/trammel net result from capture of herbivores on and around the coral reefs. Removal of a large proportion of parrotfish by capture in gill/trammel nets has allowed algae cover to increase on the reefs (William Tobias, DPNR, USVI, personal communication). The algal cover smothers the coral. In the absence of selection of an alternative that prohibits or restricts through area management, gill/trammel nets would continue in the US Caribbean. Some observers consider gill/trammel nets as the most damaging gear in the US Caribbean (HAP/SSC meeting, April 2003). However, the impacts are localized rather than pervasive, and disagreement exists on the damage from the nets. Gill/trammel nets occur mostly in state waters, beyond the immediate authority of NOAA Fisheries. Continued use of the gill/trammel nets will allow the continued harvest of reef fish and spiny lobster. Many of these species have experienced heavy harvesting pressure from nets and other gears that may have reduced abundance below desirable levels, and declines of herbivores will allow continued algal growth on coral.

Under the preferred Alternative 3, prohibition would occur for pots/traps, gill/trammel nets, bottom longlines, and SCUBA in selected closed areas consisting of coral habitats used for reef fish spawning aggregations.

Specific information on localized non-fishing effects on the Islands’ coastal areas are observable, but not well documented. The amount and rate of human-induced wetland losses have not been well quantified for the US Caribbean, but development has been extensive and most of the land areas and nearshore areas have been modified as a consequence of urban, industrial, and commercial development (CFMC 1998). These effects are expected to continue into the future. Non-fishing effects on EFH have been discussed in general terms in Section 3.5.2 and many of the specific coastal modifications can produce a variety of individual and synergistic effects.

The Islands’ economies rely heavily on the tourist trade and this has resulted in extensive nearshore development for hotels, motels, facilities for cruise ships, and the infrastructure needed to support the development. The coastal zone of Puerto Rico is more heavily developed than that of the USVI. However, the development in both areas has progressed to the point where remaining coastal systems, including proposed EFH, are already stressed and their ability to produce fishery resources is compromised. Coastal systems that have been directly modified, (e.g., dredged and filled) no longer serve as fishery habitat, or their quality has been degraded. Remaining coastal systems continue to be stressed indirectly by water quality degradation, sedimentation, thermal additions, and consequences of human activities such as vessel groundings in coral and SAV areas, oil spills, anchor damage to corals and SAV, etc. For example, human impacts on reef habitat result from activities such as pollution, dredging and
salvage, boat anchor damage, fishing and diving related perturbations, and petroleum hydrocarbons (Jaap 1984).

Direct habitat removal or modification related to coastal development in the Islands over the last 20 years include barriers and impoundments; beach nourishment projects; bridges, roads, and causeways; docks, piers, and other structures; housing developments; commercial and industrial developments; etc.; maintenance dredging; navigation projects, ports, marinas, etc.; irrigation, flood control, and drainage works related to agriculture and urban development; oil, gas, and chemical pipelines; bulkheads, small fills, groins, etc.; transmission lines; power generating facilities; mining activities; and oil and gas development (Unpublished NOAA Fisheries data). An additional problem of note is the proliferation of unauthorized fixed and floating structures that provide for human habitation. An example is the many unauthorized houseboats that formerly anchored at La Parguera, Puerto Rico. Most of these houseboats had no contained sewage or trash collection facilities and seriously attenuated light needed by SAV in the area.

Inshore, water quality degradation also is a threat to fishery habitat. This results from the discharge or spillage of petrochemicals, sewage, heavy metals, and other chemicals in industrial and chemical wastes and from non-point-source discharges such as from septic tanks and parking lots. Urban and agricultural runoff can be laden with sediments and toxic substances such as petrochemicals, pesticides, heavy metals, and herbicides. Thermal effluent from power generating facilities cooling can raise the temperature of nearshore waters making them less suitable or uninhabitable by aquatic species, especially during summer. The discharge of sewage also can create problems for the organisms that reside in the waters where the discharge occurs.

Offshore species may be adversely affected due to the discharge of petroleum products and the Islands have been subject to repeated oil spills over the years. Research reviews have described the deleterious effects of petroleum fractions on fish (Malins et al. 1982; Malins et al. 1988; Schmitt and Dethloff 2000). Studies have documented injuries to wild fish by petroleum pollutants (Baumann et al. 1982; Black 1983; Oris et al. 1998).

The effects of human activities on reefs broadly depend on two factors: the distance of the reefs from shore (inshore or offshore), and the general health of the reefs (CFMC 1998). Many reefs in Puerto Rico have suffered considerable damage from human activities. Extensive coral reef degradation has been observed at the following sites: 1) all reefs from San Juan to Las Cabezas de San Juan, 2) inshore Fajardo reefs, 3) Humacao reefs, 4) annular reef off Puerto Yabucoa, 5) inshore Ponce reefs, 6) all reefs off Bahia Guayanilla and Bahia de Tallaboa, 7) all reefs off, and fringing, Guánica, 8) all west coast inshore reefs from Boqueron to Rincon, 9) reefs off Arecibo, and 10) reefs off Dorado.

In the USVI damage is being done to reefs at both inshore and offshore areas: on the shelf edge, Long Reef, Teague Bay reef, of St. Croix, Brewers Bay, north coast, Mandahl Bay, Magens Bay, Sapphire Bay (Red Bay) St. Thomas, and Bays in St. John’s National Park (US Department of the Interior), Cruz Bay, Trunk Bay and Trunk Cay, Johnson’s Reef, Windswept Beach, St. John.

Damage to reefs around the islands, and, by extension, organisms closely associated with reef habitats, is being caused by one or several of the following factors: sedimentation and siltation;
eutrophication; pollution (toxic and thermal); physical damage and overfishing. The Council’s Coral Reef Conservation Working Group has listed 24 human activities detrimental to coral reefs. Overall, and on a worldwide scale, the most serious damage is caused by collecting shells, corals and fish; sedimentation from freshwater runoffs; and dredging activities. These sources of damage are also among those to which reefs of Puerto Rico the USVI are most commonly subjected, although not necessarily in the same order of severity.

Coastal development will undoubtedly continue, with development projects (e.g. condominiums, houses, and resorts), displacing traditional coastal settlements such as fishing villages and rural communities (Pizzini 2001). In general, conflicts among coastal zone stakeholders have increased since the mid-90s. The development of resorts and residential subdivisions threaten wetlands on the east and west coasts of Puerto Rico. Fishers believe that coastal development has hurt local fisheries (habitat loss, sewage disposal, etc.). The present construction boom is expected to last until 2006 (Pizzini 2001). Selling of government-owned coastal lands into private ownership has also led to increased stresses on coastal habitats.

Water quality will continue to be of concern, especially in Puerto Rico where urbanization has spread to mountainous areas, causing increased erosion and higher sedimentation rates in coastal areas. The rise of industrial development has led to the increased production of toxic wastes, and the construction of electric plants and water supply systems to support industrial development has also created environmental problems (Pizzini 2001).

For coastal zone habitats that are protected, the level of funding is insufficient for adequate management and enforcement, although recently some NGOs have taken co-management roles in resource stewardship (Pizzini 2001). In general, the concept of sustainability should be brought into local government policy making.

Diseases affecting coral reef ecosystems are a natural occurrence that human-induced environmental degradation may enhance. A number of diseases have increased worldwide since the early 1980s (Turgeon et al. 2002), including in the US Caribbean, and appear more prevalent near population centers. If human activities enhance the virulence of the disease or reduce ability of organisms to ward off the disease, the intensity of these diseases is likely to continue in the future following the response of coral reef ecosystems to human activities. Natural events such as El Niño cause warmer sea temperatures that also enhance some diseases.

Hurricanes often cause major damage to coral reef ecosystems. Reefs have adapted to recover from tropical storms. Under normal conditions, hurricanes do not pose a major threat to coral reefs, and may help keep diversity high (Rogers 1993). If global warming increases the sea surface temperature in the tropics, hurricanes in the US Caribbean will likely increase. Natural climatological events such as El Niño-La Niña enhance or degrade conditions for hurricanes. However, if an increasing trend of hurricanes occurs, reefs may not have time to recover between storms. A single storm could cause damage that far exceeds the current gear impacts on fish habitat in coral reef ecosystems. Minor gear impacts will fall within the ability of reefs to recover. However, if hurricanes increase in frequency and or intensity, adverse gear impacts could further diminish the recovery of coral reef ecosystems between storms. As adverse impacts increase, the ability of reefs to recover would diminish further.
4.6.3.2 Population effects on FMU species

With respect to maintaining or rebuilding fish populations, addressing adverse fishing impacts on habitat must be viewed in the context of both the effects of fishing (i.e. direct mortality) and non-fishing impacts. Habitats considered as EFH under Alternative 2 and the preferred Alternative 6 are subject to a variety of adverse impacts (Figure 4.2). In the US Caribbean, EFH and resource productivity appear adversely affected by heavy fishing pressure and by non-fishing impacts more than by adverse fishing gear impacts on habitat. Groundings, prop scarring, and anchor damage, mostly from non-fishing vessels, likely cause similar or more damage than fishing gear (Sections 3.5.2.1.1 and 3.5.2.1.7). In the absence of reductions in fishery removals and anthropogenic non-fishing impacts, adopting fishing impacts alternatives would place the burden of habitat recovery on the fishers. The potential benefits to habitat and to fish production from restricting fishing on EFH are small compared to the potential benefits of controlling fishery removals and reducing non-fishing impacts. Therefore, the results of consultations that avoid further habitat damage from non-fishing impacts and actions by the Council and States to reduce harvest of heavily exploited species will provide the greatest benefits to species managed under the US Caribbean FMPs.

If the abundance of a resource has declined because of heavy fishing that has otherwise left habitat largely unaffected, it will use a smaller proportion of available habitat than if abundance were higher. In this case, restoring the population to the biomass at MSY is the most important step in restoring fish production. Availability of habitat is unlikely to be the limiting factor in this process. Additional or higher quality habitat will probably not directly benefit the resource until the resource rebuilds to a point at which habitat availability becomes limiting. This is not to suggest that continued habitat loss is acceptable for overfished resources. Any action that might hamper the recovery process should be avoided, particularly when impacts on habitat may adversely affect several species at once. However, in terms of priority actions, increased protection of habitat is less likely to lead to increased stock abundance in the short term than, for example reducing fishing mortality.

By contrast, if the resource has declined due to reductions in quantity or quality of habitat, then recovery of the habitat is the first priority. If the abundance is being maintained at or above the maximum sustainable level consistent with the current amount and quality of habitat, reduction in harvest will not directly benefit the resource (because harvest is not the limiting factor). The most effective habitat restoration program would result from addressing the activities with the greatest habitat impact. However, the Council and NOAA Fisheries do not have control over most activities that directly affect habitat (i.e. non-fishing impacts), but do have control over fish harvest in the EEZ. If the Council wishes to directly address habitat loss and recovery, it would have to focus management attention on impacts of fishing gear. In some cases, adverse non-fishing impacts on EFH may exceed the adverse impacts of fishing on EFH.

Analysis underway by the NOAA Fisheries Southeast Region to assist the Council in complying with the requirements of the SFA indicates that several species are believed to be at relatively low levels of abundance, based on the best available information, as a result of heavy fishing.
pressures. NOAA (2002) also points to fishing pressures as component of degradation of Caribbean coral reefs.

Fishing pressure in the EEZ will likely decrease as a result of future decisions by the Council to respond to SFA requirements. However, heavy fishing pressure will likely continue in state waters unless the governments of the USVI and Puerto Rico change management measures to restrict harvest, or unless the Secretary of Commerce preempts management in state waters.

Limited stock assessment information suggests overfishing for several species. Queen conch, Nassau grouper, and goliath grouper have overfished designations. The 1992 Reef Fish SAFE report (Appeldoorn et al. 1992) suggested that several species were overexploited, in spite of inadequate information. Limited information prevents full assessment of rebuilding for goliath and Nassau grouper, but rebuilding is not indicated (Sadovy and Eklund 1999). Although spiny lobster were not listed as overfished in the 1991 Spiny Lobster SAFE report (Bohnsack et al. 1991), Mateo and Tobias (2001) suggested an overfishing status for spiny lobster in St. Croix and suggested review of status in other Caribbean areas. Various management measures have been introduced to promote the rebuilding of these and other stocks deemed to be in danger of becoming or being overfished.

The draft SFA document under preparation by NOAA Fisheries and the Council has examined available information, and described several species or species groups as heavily fished. This draft has not yet determined if these groups meet the M-S Act definitions of overfished or undergoing overfishing, but several species are believed to be at relatively low levels of abundance based on the best available information. Overfished condition or overfishing is likely to occur for some species if the SFA analysis continues as a present, and if the Council accepts the analysis.

The Council has taken a series of steps to rebuild overfished stocks and/or to prevent future overfishing and stocks becoming overfished or depleted. The Council has developed or is developing management parameters and control rules as required under the National Standard Guidelines, and is in the process of establishing rebuilding schedules for overfished species as required by the M-S Act. To achieve rebuilding, the Council has set and NOAA Fisheries has implemented catch prohibition for Nassau and goliath grouper, bag or trip limits, minimum size limits, and time-area management.

The FMPs for Spiny Lobster, Reef Fish, and Coral prohibit use of explosive, poisons, or drugs for the harvest of resources. The FMPs have limited harvest of many species to a small number of gears: hand harvest with no hookah for conch resources, slurp gun and dip nets for aquarium species, and hand harvest, slurp gun and dip nets for coral reef resources. Traps and pots used for reef fish and spiny lobster must have biodegradable escape panels. Fishers may not use spears, hooks, or other similar gears for spiny lobster.

These restrictions provide benefits to the resources, especially those that are overharvested, by reducing the harvest efficiency and the total harvest. These measures also reduce potential habitat damage. Hand harvest, slurp guns, and dip nets reduce waste and discard because fish can be selected individually or in small numbers and handled to minimize damage. These gears also
replace other gears that may damage habitat if used. Prohibition on use of dynamite or poisons also reduces waste because stunned or killed fish do not end up in inaccessible areas, and prevent direct damage to habitats. Prohibition on spears and hooks for lobster prevent damage or mortality for undersized lobster. However, as hookah was not typically used previously, the prohibition probably had minimal effect on harvest of queen conch.

The Reef Fish FMP requires a minimum size limit of 12 inches for yellowtail snapper. The Queen Conch FMP requires a 9-inch total length or 3/8-inch lip thickness measured at the thickest point of the lip as a minimum size for queen conch. The Draft SFA Generic Amendment has as a preferred alternative the prohibition of catch of queen conch. The Spiny Lobster FMP requires a minimum size limit for spiny lobster of 3.5-inch carapace length. The 1991 SAFE (Bohnsack et al. 1991) noted that increased compliance with the spiny lobster minimum size would ultimately increase yield.

The Council has set bag limits only for queen conch: 3 per recreational fisherman or 12 per vessel, and licensed commercial fishers may land 150 queen conch per day.

The Council has set seasonal closures for four red hind spawning areas and closed Hind Bank to all fishing as Marine Conservation District (Figure 2.23).

4.6.3.3 Ecosystem changes

A relatively small but long-term adverse effect on coral from pots/traps or gill/trammel nets, and perhaps other gears, may cause long-term impacts that result from changing the productivity of coral structures. The Intermediate Disturbance Hypothesis (Connel 1978) refers to the varying levels of disturbance that coral reefs may experience and its effect on species diversity. Connel showed that varying the frequency and intensity of a disturbance may have a profound effect on coral diversity. Small, continuous damage would favor fast growing species, which would out compete species with slower growth, resulting in decadal scale changes: fast growing species would recover, while slower growing species would continue to degrade. Setting pots/traps or gill/trammel nets on coral can be regarded high frequency/low intensity impacts. Continuous fish trap damage on branching corals, sponges, gorgonians and other delicate benthic reef organisms may reduce diversity on coral reefs depending upon the frequency of impact in an area.

Branching corals (*Acropora* spp.) have declined over the past decades due to non-fishing impacts, and are easily damaged by impacts with fishing gears. Boulder-type corals have become relatively more abundant, and are more resistant to damage from fishing gears (Richard Nemeth, University of the Virgin Islands, personal communication). The studies during the 1990s on trap/pot damage occurred more on boulder-type coral than on branching coral (Richard Nemeth, University of the Virgin Islands, personal communication), and likely underestimated the damage that pots/traps could cause on the more sensitive branching coral. Future recovery of branching coral may be diminished if traps/pots or other gears occur on the site of branched coral growth.
4.6.3.4 Effects on protected species

Buoys on pots/traps would increase vertical line gear in the water and therefore could increase the potential for marine mammals interactions. Gill/trammel nets have potential for interactions with marine mammals or protected species. Currently, all US Caribbean gears are in Category III (low or no interactions), but gill nets interact with marine mammals in other regions. However, the NOAA Fisheries Southeast Regional Office has concerns that marine mammals interact with gill/trammel nets in the US Caribbean (Kathy Wang, SERO, personal communication). Such interactions are poorly documented, but analogy with other regions where marine mammal-gill net interactions are known to occur has led the Southeast Region to consider elevating gill and trammel nets to Category II. Unless elevation of gill/trammel nets to Category II occurs, no change in the status of the gear with marine mammals is expected. Similarly, gill and trammel nets can capture sea turtles. Gill and trammel net mortalities of sea turtles have occurred elsewhere in the US, and dead sea turtles consistent with gill or trammel net mortality have been reported in the USVI (William Tobias, USVI DPNR, personal communication). No monitoring or research has been conducted to document the level of marine mammal or sea turtle interactions in the US Caribbean. Actions that reduce effort, such as time area closures and partial or complete gear prohibitions, may reduce the potential for interactions.

4.6.4 Administrative environment

4.6.4.1 Effects on management and administration requirements

None of the Alternatives proposed for meeting the EFH requirements will have direct consequences unless and until a generic amendment is created to amend all four FMPs, or one or more of the four FMPs is amended individually. Review by NOAA Fisheries of proposals that potentially affect fish habitat will continue, whether designation of EFH occurs. Descriptions and identification of EFH and HAPCs will give NOAA Fisheries more precise information with which to conduct consultations when necessary. Most areas recommended as HAPCs occur in state waters, so the Council and NOAA Fisheries can primarily recommend changes to the governments of the USVI and Puerto Rico.

If a decision is made to prepare a Generic EFH Amendment or amend the FMPs, the Council and NOAA Fisheries will begin a process of further analysis and public hearings leading to implementation of the chosen measures. A Generic EFH Amendment will require less funding and other resources than amending each FMP individually. Amendments since 1998 to existing FMPs or developing new FMPs have cost $35,000 to $60,000 each for regional council participation and $15,000 to $25,000 for NOAA Fisheries participation. The preferred alternatives will require approximately the same resources as other alternatives through the amendment process.

As stated previously, the Council and NOAA Fisheries have jurisdiction only in the EEZ, unless the Secretary of Commerce pre-empts state authority. Therefore, the minimization, mitigation, or prevention of adverse fishing impacts on EFH in state waters will require review, analysis, and determination of a need for action by the governments of Puerto Rico and the USVI. The USVI
and Puerto Rico have representatives as voting members of the Council. This relationship offers an opportunity for the USVI and Puerto Rico officials to understand the issues and to carry Council action as a recommendation to the local governments. However, the governments of Puerto Rico and the USVI have in the past chosen to retain fishery regulations different from those selected by the Council. At this time, the degree to which the governments of Puerto Rico and the USVI will choose to coordinate fishing regulations with the Council to address adverse fishing impacts cannot be foreseen. Due to the importance of EFH in state waters in the US Caribbean, if the management actions envisioned in the preferred alternative for addressing fishing impacts is not reflected in similar action in state waters, its effectiveness will be substantially diminished.

If the Council and the local governments decide to coordinate fishing regulations, they could work informally together, or could formalize the decision with a Memorandum of Understanding (MOU). While a MOU would not bind the Council and the governments to an outcome, it would convey a sense of importance to the process. The MOU could specify goals and objectives, participants, schedules, and other matters to help reach a consensus on common fishery management. In some cases, different fishing practices in EEZ or the state waters could lead to different management actions in the EEZ or the state waters of the USVI or Puerto Rico, but still consistent with the goals and objectives of the MOU.

NOAA Fisheries convened a Caribbean Coral Reef Fisheries Workshop, in October 2002 (NMFS 2002a). Most of the comments and recommendations were for action in Commonwealth and Territorial waters, and were directed to the agencies with the appropriate jurisdiction, DNER and DPNR. However, participants from fishing constituencies did look to NOAA for help to address the following:

- The coordination of Federal and state maritime and resource regulations to reduce overlaps, conflicts, or gaps.
- The development of government partnerships with fishers in data collection, enforcement, education, and management.
- The creation of opportunities for fishers to exchange experiences, and financial support to make this possible. There was particular interest in opportunities for exchange between communities that had no-take reserves and those where new areas were proposed.

NOAA Fisheries is addressing follow-up on several of these issues with three workshops for Puerto Rico’s fishing communities and other marine resource users, hosted by the NOAA Fisheries Caribbean Field Office. NOAA also expects funding to be available in FY-03 for activities designed by the Commonwealth and Territory through the Coral Reef Conservation Grants Program.

The Caribbean Coral Reef Fisheries Workshop recognized that certain fishing techniques and operations also have impacts on habitats (NMFS 2002a). While these are neither the only nor the biggest impact degrading coral reef habitats, on a local scale they can cause damage and need to be addressed. The workshop informally ranked gill nets as the most damaging gear, followed by pots/traps.
4.6.4.2 Effects on enforcement requirements

From the perspective of the administration and enforcement of fishery management measures, the measures proposed in the alternatives to address adverse fishing impacts are considered to be feasible. Agents can determine if vessels comply with the regulations by visiting the vessel in port, during at-sea patrols, through establishing new techniques such as vessel monitoring systems, or through remote sensing techniques. However, any new management measures will put additional burdens on the administrative and enforcement frameworks, which will require additional resources. If resources are currently fully allocated, or possibly over allocated, an increase in enforcement from current level would be needed to support compliance with new measures. The increase in resources required is generally greater the more restrictive the measures. Accordingly as the actions in the fishing impacts alternatives are progressively more restrictive, so the burden on the administrative environment is also progressively greater.

4.6.5 Human environment

4.6.5.1 Net economic change to fishers

For depleted fish stocks, either due to overfishing or habitat loss, recovery of the stocks is a primary objective and requirement of the M-S Act. However, fishers in general will not fully benefit from rebuilding in the current open access environment of the US Caribbean. Management measures that increase stock productivity, whether from improved habitat (Freeman 1993) or increased growth through restrictions (CFMC 1990), tend not to provide long-term increased benefits to fishers in an open access fishery. As with optimum management, quantities initially increase and prices initially decrease, leading to increased profits for fishers. However, increased benefits attract more fishers or more effort. Over a longer term, benefits disappear as fishers’ costs increase and net revenues may decline to original or lower levels (CFMC 1990).

As discussed in Section 4.5, fishing gear regulations could occur for EFH in the EEZ only if EFH Alternatives 2 or 6 are selected. Most fishing in the US Caribbean occurs in state waters. An exact division of the numbers of fishers, the proportion of total harvest, or the income of fishers derived from the EEZ cannot be made with available information. However, the EEZ accounts for only 15% of the potential EFH on the insular shelf. If the Caribbean Coral Reef Fisheries Workshop correctly assessed adverse impacts of fishing gear as occurring on a local scale (see Biological Environment above), then further research and consultation to identify the localities suffering damage would focus management measures in regions that most need it. The preferred fishing gear Alternative 3 recommends management measures that apply to pots/traps and vertical line gear throughout the EEZ. None of the fishing gear alternatives target specific areas with identified problems with damage to EFH. Therefore, all fishers using these gears would have to comply with the restrictions if selection of an alternative leads to an amendment to FMPs and subsequent regulations.

The preferred Alternative 3 has intermediate social and financial impact on fishers compared to the four non-status quo alternatives. Fishers using pots/traps would need to purchase enough
buoys to assure that all pots/traps set individually have a buoy attached and that all pots/traps on traplines have a buoy at either end. Buoys cost $2 to $4, and the number required depends on the number of pots/traps set individually, the number of pots/traps currently buoyed, and the number of spare buoys possessed by fishers. All fishers using vertical gear would need to purchase or make trip line anchor retrieval system. A trip line system could cost approximately $30 to $140. Alternative 4 would retain these costs and add others, as it adds requirements to the previous alternative. Alternative 5 has the most far-reaching impacts on fishers by prohibiting from the EEZ all gears with adverse impacts to EFH.

The expected continuation of non-fishing impacts will likely further degrade EFH, especially in inshore areas closest to population centers or development (see Sections 3.5.2 and 4.6). Fish abundance dependent on the degraded habitat will likely continue to decline, resulting in decreased catch and income for fishers. Fishing effort from fishers trying to maintain current levels of catch may cause further declines in abundance. Fishers’ opportunity and ability to harvest and sell fish will likely decline in the future.

There may be some economic cost to fishers related to protected species issues. The owner of a vessel or non-vessel gear engaging in a Category I or II fishery must obtain a marine mammal authorization from the National Marine Fisheries Service (NMFS), or its designated agent, to lawfully incidentally take a marine mammal in a commercial fishery. Currently, all fisheries in the US Caribbean fall into Category III. Should NOAA Fisheries re-evaluate gill and trammel nets and designate them as category II, all fishers using the gears would need to register with NOAA Fisheries. Should subsequent monitoring determine a serious problem with marine mammal and gill/trammel net interactions, NOAA Fisheries could implement further restrictions. The preferred alternatives will not directly impact marine mammals or protected species.

4.6.5.2 Effects on development

The Alternatives for EFH and HAPC will result in consultations for Federal agency actions on EFH. EFH Alternatives 2 and 6 (Preferred) establish the broadest EFH, so would require the most consultations. EFH Alternative 1 would not establish EFH, so no consultations would be required under the M-S Act. HAPC Preferred Alternatives 4, 7, and 8 would not require additional consultation requirements, but NOAA Fisheries may give activities proposed for those areas more conservation scrutiny. EFH consultations using the existing Generic EFH Amendment have resulted in increased protection for habitat.

Other than through consultations, NOAA Fisheries or the Council has no direct authority over development, so the alternatives to address adverse fishing impacts would have no direct impacts on development. Pressure to protect EFH from development activity may increase if reviewers conclude that non-fishing impacts on EFH and fish productivity are larger than impacts of fishing gear on EFH.
4.7 Conservation recommendations

4.7.1 Council policy on fisheries management in an ecosystem context

The fisheries of the US Caribbean contribute to the food supply, economy, and health of the Nation, and provide recreational and commercial fishing opportunities. The fisheries are dependent upon the survival of these resources, which can only be assured by the wise management of all aspects of the fishery, including habitat. Accordingly, activities that adversely affect habitat also will require action by the Council and by the State governments. Increased productivity of stocks may not be possible without habitat maintenance and regulatory restrictions. The Council recommends that Commonwealth and Territorial governments review compliance with existing laws and regulations that control pollution, sedimentation, development, and other activities that would have an adverse impact on EFH. All attempts by the regulating agencies that decrease these inputs will have a beneficial impact on the marine environment and EFH.

Recognizing that all species are dependent on the quantity and quality of their essential habitats, it is the policy of the Caribbean Council to protect, restore, and improve habitats upon which commercial and recreational marine fisheries depend, to increase their extent, and to improve their productive capacity for the benefit of the present and future generations. This policy shall be supported by three objectives, which are to:

- Maintain the current quantity and productive capacity of habitats supporting important commercial and recreational fisheries, including their food base (This objective may be accomplished through the recommendation of no net loss and minimization of environmental degradation of existing habitat);
- Restore and rehabilitate the productive capacity of habitats which have already been degraded; and
- Create and develop productive habitats where increased fishery productivity will benefit society.

The Council has formed a Habitat Committee and a Habitat Advisory Panel for the US Caribbean region to bring to the Council’s attention activities that may affect the habitat of the fisheries under their management. The Council, pursuant to the M-S Act, will use existing authorities to support state and Federal environmental agencies in their habitat conservation efforts and will directly engage the regulatory agencies on significant actions that may affect habitat. This may include commenting on specific actions, policies, or regulations that affect the habitat of species being managed.

Public hearings and the building of administrative records also may be conducted to assure an adequate disclosure of facts and public participation in actions that adversely affect habitat. The goal is to insure that habitat losses are kept to the minimum and that efforts for appropriate mitigation strategies and applicable research are supported.
4.7.2 Recommendations concerning fishing impacts in state waters

This EIS has developed a series of alternatives for addressing adverse fishing impacts to EFH in the EEZ, but has not specifically addressed adverse fishing impacts in state waters. Many of the gears with potential adverse impacts to EFH are used only in state waters. Other gears are used in both the EEZ and state waters. No alternatives were developed for fishing gears not currently used, used only in state waters, or rated as minimal and temporary in the EEZ. General measures for preventing, minimizing, or mitigating adverse fishing impacts to EFH by these gears are presented below for future consideration. The Council recommends that the governments of Puerto Rico and the US Virgin Islands review the potential adverse impacts of these gears on EFH in state waters, determine the necessity of additional gear restrictions, and implement regulations as appropriate. The sensitivities of habitats to fishing gears (Table 3.15a) indicate the habitat-gear combinations with the highest potential for adverse impacts. The Council recommends that NOAA Fisheries, Puerto Rico, and the US Virgin Islands prohibit all trawling in the US Caribbean (Section 4.7.2.2).

4.7.2.1 Fishing on spawning areas

The Council selected a preferred alternative to address adverse fishing impacts that included prohibition of gill/trammel nets, pots/traps, and bottom longlines on sites inferred as coral or live/hard bottom from confirmed spawning aggregations. The Council noted that one of the confirmed spawning aggregations, El Seco near Vieques (Figure 2.27), is in state waters of Puerto Rico. The Council and NOAA Fisheries have no direct authority in state waters. However, the Council recognized the advantages of consistent regulations and recommended that government of Puerto Rico consider and develop appropriate fishery management for the site.

4.7.2.2 Trawl

Trawl fishing does not currently occur in the US Caribbean EEZ. However, current Federal regulations allow trawling for non-FMP fisheries, and Puerto Rico and US Virgin Islands regulations allow trawling in state waters. Of the fishing gears authorized in the US Caribbean region, trawling has the highest fishing sensitivity (level 3) for coral habitats and has a moderate fishing sensitivity (level 2) for hard bottom, seagrass, benthic algae, sand/shell, and soft bottom (Section 3.5.1, Table 3.15a). Recent inquiries to Dr. Richard Nemeth (University of the Virgin Islands, personal communication) concerning trawling indicate potential interest for future use of this gear. The complex mosaic of coral on the insular shelf (Figure 2.16) leaves little space available for trawling that would not have direct impacts on coral. Prohibition on coral is precautionary to prevent use of a gear with high risk of adverse fishing impacts on sensitive and important habitat. The Council recommends that NOAA Fisheries prohibit all trawling in the EEZ of the US Caribbean. The Council recommends that the governments of Puerto Rico and the US Virgin Islands prohibit all trawling in state waters. This prohibition includes pelagic and demersal trawls; many pelagic trawls have a near-bottom orientation, and a likelihood of impacting sensitive vertical relief.
4.7.2.3 Poisons and toxins

Current Federal regulations prohibits poisons and toxins for some, but not all, FMPs. Poisons are prohibited in the US Caribbean only for reef fish (50 CFR 622.31(e)(1), and toxins are prohibited only for coral reef resources (50 CFR 622.31(b). Poisons and toxins have the highest fishing sensitivity (level 3) for all habitats (Section 3.5.1, Table 3.15a). The Virgin Islands prohibits the use of poisons and toxins that pollute the water, and the use of explosives for fishing (Title 11, Chapter 27, Virgin Islands Code). A permit must be acquired from the DPNR for activities that include, but are not limited to, collecting of Virgin Islands indigenous or endangered species, whether for commercial, private, educational or scientific use (Indigenous and Endangered Species Act of 1990). Puerto Rico Law 278, Article 13 does not prohibit the use of chemicals for harvesting fish, but prohibits dumping of any chemicals in the water that might hurt fish. The Council recommends that NOAA Fisheries prohibit all use of poisons and toxins in the EEZ of the US Caribbean and that the governments of Puerto Rico and the US Virgin Islands confirm that no loopholes exist that could allow harvesting of resources with poisons or toxins. The regulatory agencies should consider issuing permits for use of poisons and toxins for scientific research.

4.7.2.4 Slurp guns

The following actions could restrict slurp guns in EFH or HAPC to minimize habitat damage during fishing activities.

- Reduce fishing effort by some amount.
- Establish time or area closure that restricts fishing activity by some amount.
- Prohibit slurp guns on coral or hard/live bottom habitat.

Barnette (2001) notes that use of slurp guns may result in coral breakage, but described the damage as generally minor (See Section 3.5.1). Few studies have focused on the potential affects of slurp guns to habitat. Negative impacts include broken coral, touching reefs, and re-suspended sediments. Touching coral removes a protective coating, and makes the coral more susceptible to disease and infection. Sedimentation buildup can smother corals. Touching and re-suspended sedimentation result from actions of divers that may occur in the absence of slurp guns.

Slurp guns are a minor activity in terms of total effort and total harvest compared to vertical gear or longline gear. However, slurp guns are a major gear for harvesting species for the aquarium trade. The amount of damage currently done by slurp guns in the Caribbean is not known. Slurp gun fishers rely on finding concentrations of fish within range. Concentrations of many managed fish species are higher on hard bottom areas with relief than on sand or mud bottoms.

4.7.2.5 Beach seines

The following actions could restrict beach seines in EFH or HAPC to minimize habitat damage during fishing activities.

- Reduce fishing effort by some amount.
• Limit the length of beach seines.
• Prohibit beach seines in areas of concern.

Barnette (2001) indicated that damage to SAV from beach seines would be minimal, but that cumulative effects might be seen in SAV at established haul-out sites. Lead lines might cause some seagrass blade breakage or shear off some benthic algae at their stipes.

4.7.2.6 Hand harvest

The following actions could restrict hand harvest in EFH or HAPC to minimize habitat damage during fishing activities.

• Reduce fishing effort by some amount.
• Establish time or area closure that restricts fishing activity by some amount.
• Prohibit hand harvest of live/hard bottom habitat.

Barnette (2001) notes that hand-harvesting techniques may result in coral breakage, but described the damage as generally minor (See Section 3.5.1). Few studies have focused on the potential affects of hand harvest to habitat. Negative impacts could include broken coral, touching reefs, and re-suspended sediments. Touching coral removes a protective coating, and makes the coral more susceptible to disease and infection. Sedimentation buildup can smother corals. Touching and re-suspending sediments can result from actions of divers that occur in the absence of hand harvest.

Hand harvest of conch, spiny lobster, and ornamentals is a minor activity in terms of total fishing effort and total fish harvest compared to traps, nets, vertical gear or longline gear fishing. The Council prohibited the most damaging hand harvest, the direct harvest of coral and live/hard bottom for commercial or personal use. The existing hand harvest for conchs, lobsters, and ornamentals is generally considered minor based on the analysis by Barnette (2001).

4.7.2.7 Dip nets

The following actions could restrict dip nets in EFH or HAPC to minimize habitat damage during fishing activities.

• Reduce fishing effort by some amount.
• Establish time or area closure that restricts fishing activity by some amount.
• Prohibit dip nets on coral habitat.

Barnette (2001) notes that use of dip nets may result in minor isolated impacts to coral species (See Section 3.5.1). No studies have focused on the potential affects of dip nets to habitat. Negative impacts include broken coral, touching reefs, and re-suspended sediments. Touching coral removes a protective coating, and makes the coral more susceptible to disease and
infection. Sedimentation buildup can smother corals. Divers without dip nets may also touch and break corals and re-suspend sediments.

4.7.2.8 Powerheads

The following actions could restrict powerheads in EFH or HAPC to minimize habitat damage during fishing activities.

- Reduce fishing effort by some amount.
- Establish time or area closure that restricts fishing activity by some amount.
- Prohibit dip nets on coral habitat.

Barnette (2001) noted that use of powerheads occurs mostly for large fish. While Barnette noted studies that indicated spears probably cause negligible damage, errant powerhead use could cause a shotgun shell blast on the substrate, damaging fragile structure such as coral.

4.7.2.9 Cast nets

The following actions could restrict dip nets in EFH or HAPC to minimize habitat damage during fishing activities.

- Reduce fishing effort by some amount.
- Establish time or area closure that restricts fishing activity by some amount.
- Prohibit cast nets on coral habitat.

Barnette (2001) noted observations of dislodged organisms or entangled nets during cast net use, but referenced a study that concluded negligible damage from cast nets.
4.7.3 Non-fishing project-specific recommendations

The following discussion of various types of coastal development activities addresses measures to minimize or avoid development impacts to marine and estuarine habitats. This discussion is based on project review guidance developed by the Habitat Conservation Division of NOAA Fisheries Southeast Region (US Department of Commerce 2000). In 2000, the Habitat Conservation Division of NOAA Fisheries' Southeast Region updated its uniform guidance prepared for use by its field biologists in reviewing permit applications and proposals by Federal construction agencies. The guidelines were developed to ensure uniform and adequate levels of habitat protection; expedited the review of private and governmental water-development projects through useful and timely response; and to provide a reference for how to minimize environmental impacts. Organization of the guidelines is by project type (e.g., marinas, ocean dumping, transportation, mitigation, etc), and within the discussion of each project type are general assessments of potential impacts and measures that could be implemented to avoid or minimize those impacts. Project review guidance has been developed for use by the Council in its evaluation of development activities proposed in the US Caribbean.

4.7.3.1 Docks and piers

Docks and piers, whether built over or floating on the water, are generally acceptable methods of gaining access to deep water. General considerations include:

- Docks and piers should be constructed so that water flow restriction and blockage of sunlight on wetland surfaces is avoided or minimized;

- Docks and piers should be of adequate length to reach navigational depths without increasing dredging needs; and

- Docks and piers should be designed and located to avoid areas that support submerged aquatic vegetation, shellfish beds and harvest areas, and other fragile and productive habitats.

4.7.3.2 Boat ramps

- Sites should be located along shorelines that do not support wetland vegetation and where adjacent waters have adequate navigational depths. Acceptable sites may include existing marinas; bridge approaches and causeways (with highway agency approval) where construction access channels exist; and natural and previously created deep-water habitats;

- Preferably, sites should be restricted to areas that do not require dredging to gain access to navigable waters. When located in the vicinity of seagrass beds, adequate navigation channels must exist and should be clearly marked. Boat ramps should not be located in areas where boats will encroach on sensitive and productive habitats;
• Ramps should not be located in areas where encroachment into wetlands is likely to occur. Sites should contain adequate upland area for parking and for boat launching/removal; and

• Adequate waste collection facilities should be required at public facilities.

4.7.3.3 Marinas

All marinas adversely affect aquatic habitats to some degree. These effects can be minimized through proper location and design. In addition to applicable recommendations for boat ramps, bulkheads, and seawalls, the following apply:

• Marinas should be located in areas where suitable physical conditions exist. For example, potential sites should be located close to navigable waters and in locations where marina-related activities would not affect living marine resource forage, cover, harvest, and/or nursery habitats. Attention also should be given to sediment deposition rates and maintenance dredging requirements;

• Marinas should be located at least 1,000 feet from shellfish harvest areas, unless state regulations or other considerations specify differently;

• Dry-stack storage is generally preferable to wet mooring of boats. Open dockage extending into deep water is generally preferable to basin excavation;

• Mooring basins should be sited in uplands rather than wetlands, and they should be designed so that water quality degradation does not occur. This may require consideration of basin flushing characteristics and incorporation of other design features such as surface and waste water collection and treatment facilities;

• Turning basins and navigation channels should not create sumps and other slack-water areas that could degrade water quality nor should they be located in areas where circulation is poor. Depths generally should not exceed those of adjoining waters and, where practicable, they should provide for light penetration that is capable of sustaining benthic plant life. Dissolved oxygen levels in channels and basins should be adequate for fish and macroinvertebrate survival;

• Consideration should be given to aligning access channels and configuring marinas to take full advantage of circulation from prevailing summer winds;

• Permanent dredged material disposal sites (for use in initial and maintenance dredging) that do not impact wetland areas should be identified and acquired. Suitable disposal alternatives include placing dredged material on uplands, and using dredged material to create/restore wetlands. Projects that lack permanent disposal sites should not be authorized if maintenance dredging is needed and disposal sites/options are not available;
• Catchment basins for collecting and storing surface runoff should be included as components of the site development plan. Marine railways or upland repair facilities should be equipped with hazardous material containment facilities so that biocides such as marine paints, oil and grease, solvents, and related materials are not directly or indirectly discharged into coastal waters and wetlands;

• Consideration should be given to parking and other support facilities when it appears that available uplands are not adequate to support such needs and wetland encroachment is anticipated;

• Marinas with fueling facilities should be designed to include practical measures for reducing oil and gas spillage into the aquatic environment. Spill control plans may be needed when marina facilities are to be located in the vicinity of large, emergent wetland areas, shellfish harvest sites, and other fragile/productive aquatic sites; and

• Facilities for collection of trash and potential marine debris should be required. Where vessels with marine toilets will be moored, pump out facilities and notices regarding prohibition of sewage and other discharges should be provided.

4.7.3.4 Bulkheads and seawalls

Bulkheads are used to protect adjacent shorelines from wave and current action and to enhance water access. Applications for bulkheads usually specify construction in open water followed by placing fill material behind the structure. Bulkheads may adversely impact wetlands through direct filling, through isolation, and through exacerbation of wave scour. Applying the following criteria may reduce adverse impacts:

• Except in cases of recent and rapid erosion, structures should be aligned at or shoreward of the normal high waterline. Structures should be constructed so that reflective wave energy does not scour or otherwise adversely affect adjacent EFH or wetlands. For example, in areas that support fringing wetlands consideration should be given to the use of breakwaters (with regular openings) or placement of riprap at the toe of the bulkhead or along the waterward edge of eroding wetlands;

• Where possible, sloping (3:1) riprap, gabions, or vegetation should be used rather than vertical seawalls; and

• Shoreline protection devices that are located in areas having fringe wetlands should have openings that allow for fish ingress and egress and water circulation. Recommended spacing for structure openings is no less than one linear foot per five linear feet of structure.
4.7.3.5 Cables, pipelines, and transmission lines

Wetland excavation is sometimes required for installing submerged cables, pipelines, and transmission lines. Construction also may require temporary or permanent wetlands filling. The following recommendations apply:

- Wetland crossings should be aligned along the least environmentally damaging route. Submerged aquatic vegetation, shellfish beds, coral reefs, etc., must be avoided;

- Construction of permanent access channels should be avoided since they disrupt natural drainage patterns and destroy wetlands through direct excavation, filling, and bank erosion. The push-ditch method, in which the trench is immediately backfilled, reduces the impact duration;

- Excavated wetlands should be backfilled with either the same material as removed or a comparable material that is capable of supporting suitable replacement wetlands. Original marsh elevations should be restored and, where practicable, excavated vegetation should be stockpiled, kept viable, and returned to the excavated site. After backfilling, erosion protection measures should be implemented where needed to prevent fish habitat degradation and loss;

- Excavated materials should be stored on uplands. If storage in wetlands cannot be avoided, discontinuous stockpiles should be used to allow continuation of sheet flow. Where practicable, stockpiled materials should be stored on construction cloth rather than bare marsh surfaces. Topsoil and organic surface material such as root mats should be stockpiled separately and returned to the surface of the restored site;

- In open-water areas, excavated materials should be deposited in discontinuous piles to preclude significant blockage of water movement. Backfilling is recommended if the excavated material would alter circulation patterns or interfere with fishing;

- Use of existing rights-of-way should be recommended when use of these areas would lessen overall wetland encroachment and disturbance; and

- Directional drilling, a technique that allows horizontal, sub-surface, placement of pipelines should be used in situations where normal trenching and backfill would cause unacceptable levels of habitat loss or alteration.

4.7.3.6 Transportation

State and Federal highway agencies generally have the capability of conducting advanced planning with road, causeway, and bridge construction. To the extent possible, NOAA Fisheries personnel should participate in early planning efforts. Since highway projects are generally considered to be in the public interest and frequently require wetland crossings, identification of mitigation needs, and development of suitable mitigation plans should be undertaken early in the planning process. The following criteria should be considered:
• Transportation corridors/facilities should avoid wetlands. Where wetland crossings cannot be avoided, bridging should be used rather than filling, and the least environmentally damaging route, preferably along existing rights-of-way and road beds, should be followed;

• Disrupting or reducing fish and invertebrate migration routes should be avoided;

• Structures should be designed to prevent shoaling and alteration of natural water circulation. Suitable erosion control and vegetation restoration should be implemented at wetland crossings; and

• Transportation facilities should be designed to accommodate other public utilities, thus avoiding the need for additional wetland alteration. An example would be using bridges to support transmission lines and pipelines.

4.7.3.7 Navigation channels and boat access canals

Construction and maintenance of navigation channels and boat access canals may cause severe environmental harm. In addition to direct habitat losses associated with wetland and deepwater excavation and filling, these activities may significantly modify salinity and water circulation patterns. These changes could greatly modify the distribution and abundance of living marine resources. The following criteria should be followed:

• Where possible, dredging should be minimized through the use of natural and existing channels;

• Alignments should avoid sensitive habitats such as shellfish beds, finfish and invertebrate nurseries, submerged aquatic vegetation, and emergent wetlands;

• Permanent dredged material disposal sites should be located in non-wetland areas. Where long-term maintenance excavation is anticipated, disposal sites should be acquired and maintained for the entire project life;

• Boat access canals should be designed to ensure adequate flushing and should be uniform in depth or made progressively deeper in the direction of receiving waters. Where possible, they should be aligned to take advantage of wind and lunar tides;

• Construction techniques that minimize turbidity and dispersal of dredged materials into sensitive wetland areas (e.g., submerged grasses and shellfish beds) are encouraged. Work should be scheduled to avoid periods of high biological activity such as fish and invertebrate migration and spawning;

• Care should be taken to avoid adverse alteration of tidal circulation patterns, salinity regimes, or other factors that influence local ecological and environmental conditions; and
• Channels and access canals should not be constructed in areas known to have high sediment contaminant levels. If construction must occur in these areas, consideration should be given to the use of silt curtains or other techniques needed to contain suspended contaminants.

4.7.3.8 Disposal of dredged material

Previous and on-going disposal of dredged material is a major contributor to wetland losses in marine and estuarine ecosystems. Recognizing that most navigation channels and access canals require periodic maintenance dredging, it is important that long-range plans be developed and that they provide for mitigation of unavoidable adverse environmental impacts. Implementing the following criteria would minimize adverse impacts associated with most dredged material disposal activities:

• Dredged material should be viewed as a potentially reusable resource and beneficial uses of these materials should be encouraged. Materials that are suitable for beach replenishment, construction, or other useful purposes should be placed in accessible non-wetland disposal areas;

• Disposal sites that are located in unprotected coastal areas and adjacent to wetlands are especially susceptible to wind and water erosion. These forces can carry substantial quantities of dredged material into aquatic habitats. If located near wetlands, disposal site surfaces should be stabilized using vegetation or other means to eliminate possible erosion or encroachment onto adjacent wetlands;

• Dredged material should be placed in contained upland sites or approved open-water locations where adverse impacts to living marine resources are minimal. When placed in open water, dredged material should be used to enhance marine fishery resources. For example, materials could be used to renourish eroding wetlands or to fill previous borrow sites;

• The capacity of existing disposal areas should be used to the fullest extent possible. This may necessitate increasing the elevation of embankments to augment the holding capacity of the site and applying techniques that render dredged material suitable for export or for use in reestablishing wetland vegetation;

• Where possible, outfalls should be positioned so that they discharge into the dredged area or other sites that lack biological/ecological significance. When evaluating potential upland disposal sites, the possibility of saltwater intrusion into ground water and surrounding freshwater habitats should be assessed by the construction/regulatory agencies. Groundwater contamination could necessitate redesign of disposal practices, with subsequent harm to living marine resources; and

• Toxic and highly organic materials should be disposed in impervious containment basins located on upland. Effluent should be monitored to ensure compliance with state and
Federal water quality criteria and measures should be incorporated to ensure that surface runoff and leachate from dredged material disposal sites do not enter aquatic ecosystems.

4.7.3.9 Impoundments and other water-level controls

Wetlands may be impounded each year in the Caribbean for purposes such as aquaculture, agriculture, flood control, and hurricane protection. Projects range in size from minor, such as repair of existing embankments, to large-scale marsh management projects where constructing dikes and water-control structures may affect thousands of wetland acres.

Proposals to impound or control marsh water levels should contain water management plans with sufficient detail to determine the accessibility of impounded areas to marine organisms and the degree to which detrital and nutrient export into adjacent estuarine areas will be affected. Significant adverse impacts can be avoided or minimized with implementation of the following recommendations:

- Proposals to impound or re-impound previously unimpounded wetlands are unacceptable unless designed to accommodate (1) normal access and wetland use by marine fish and invertebrates and (2) continuation of other biological interaction, such as nutrient exchange, and other similarly important physical and chemical interactions; and

- Proposals to repair or replace water control structures will be assessed on a case-by-case basis.

Water-development agencies sometimes propose impounding rivers, and tributaries for such purposes as flood control or creation of industrial, municipal, and agricultural water supplies. Activities of this type are usually unacceptable because associated alteration of the quality, quantity, and timing of freshwater flow into estuaries may cause large-scale adverse modification or elimination of estuarine and marine habitats. Such actions also may block fish and invertebrate migrations.

4.7.3.10 Drainage canals and ditches

Drainage canals may be important components of upland development. Their potential to shunt polluted runoff and fresh water directly into tidal waters requires intermediate connection to retention ponds or wetlands. This allows natural filtration and assimilation of pollutants and dampening of freshwater surges prior to discharge into tidal waters. Recommendations include:

- Drainage canals that de-water or cause other adverse wetland impacts are unacceptable and should not be built;

- Drainage canals and ditches from upland development generally should not extend or discharge directly into wetlands;
• Constructing upland retention ponds and other water management features such as sheet-flow diffusers is encouraged. A retention pond or other pollution elimination/assimilation structure should be required if the effluent contains or may contain materials that are toxic to marsh vegetation or other aquatic life.

• Excavated materials resulting from canal and retention pond construction should be placed on upland or used to restore wetlands;

• Proposed drainage plans should be in accordance with comprehensive flood plain management plan(s) and applicants should be encouraged to consult with the EPA and appropriate state agencies to ensure that Federal and state water quality standards are met;

• Locating mosquito control ditches in wetlands should be discouraged. If built, they should be designed so that they do not drain coastal wetlands. They also should be designed to avoid water stagnation, and they should provide access for aquatic organisms that feed on mosquito larvae; and

• Use of innovative techniques such as rotary ditching, spray dispersal of dredged materials, and open-water marsh management should be encouraged where appropriate.

4.7.3.11 Oil and gas exploration and production

Exploration and production of oil and gas resources in wetlands usually have adverse impacts since excavation and filling are generally required to accommodate access and production needs. In open marine waters, dredging and filling is usually not necessary, but special stipulations are required to minimize adverse impacts to living marine resources. In addition to the above recommendations for navigation channels, access canals, and pipeline installation, the following apply:

In coastal wetlands:

• Activities should avoid wetland use to the extent practicable. Alternatively, the use of uplands, existing drilling sites and roads, canals, and naturally deep waters should be encouraged. When wetland use is unavoidable, work in unvegetated and disturbed wetlands is generally preferable to work in high quality and undisturbed wetlands;

• Temporary roadbeds (preferably plank roads) generally should be used instead of canals for access to well sites;

• Bridges or culverts should be used for water crossings to prevent alteration of natural drainage patterns;

• Culverts or similar structures should be installed and maintained at sufficient intervals (never more than 500-feet apart) to prevent blockage of surface drainage or tidal flow;
• Petroleum products, drilling muds, drill cuttings, produced water, and other toxic substances should not be placed in wetlands;

• If the well is productive, the drill pad and levees should be reduced to the minimum size necessary to conduct production activities; and

• Defunct wells and associated equipment should be removed and the area restored to the extent practicable. Upon abandonment of wells in coastal wetlands, the well site, various pits, levees, roads, and work areas should be restored to pre-project conditions by restoring natural elevations and planting indigenous vegetation whenever practicable. Abandoned well access canals should generally be plugged at their origin (mouths) to minimize bank erosion and saltwater intrusion, and spoil banks should be graded back into borrow areas or breached at regular intervals to establish hydrological connections.

In open estuarine waters:

Activities in estuarine waters should be conducted as follows:

• Existing navigable waters already having sufficient width and depth for access to extraction sites should be used to the extent practicable;

• Petroleum products, drilling muds, drill cuttings, produced water, and other toxic substances should not be placed in wetlands; and

• Defunct equipment and structures should be removed.

On the continental shelf:

Activities should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the sea floor. The following measures may be recommended with exploration and production activities located close to hard banks and banks containing reef building coral:

• Drill cuttings should be shunted through a conduit and discharged near the sea floor, or transported ashore or to less sensitive offshore locations approved by NOAA Fisheries. Usually, shunting is effective only when the discharge point is deeper than the site that is to be protected;

• Drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef;

• All pipelines placed in waters less than 300 feet-deep should be buried to a minimum of three feet beneath the sea floor, where possible. Where this is not possible and in deeper waters where user-conflicts are likely, pipelines should be marked by lighted buoys and/or lighted ranges on platforms to reduce the risk of damage to fishing gear and the pipelines. Pipeline alignments should be located along routes that minimize damage to
marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.

4.7.3.12 Other mineral mining/extraction

- Proposals for mining mineral resources (sand, gravel, shell, phosphate, etc.) from or within 1,500 feet of exposed shell reefs and vegetated wetlands, and within 1,500 feet of shorelines are unacceptable except when the material is to be used for oyster clutch; and
- All other proposals will be considered on a case-by-case basis.

4.7.3.13 Sewage treatment and disposal

Urbanization and high density development of coastal areas has resulted in a substantial increase in proposals to construct sewage treatment and discharge facilities in coastal wetlands. Since many of these facilities utilize gravity flow systems for movement of wastewater and materials, wetlands and other low-lying areas are often targeted as sites for placement of pipelines and treatment facilities. Since pipelines and treatment facilities are not water dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. The guidance provided in the section on "Cables, Pipelines, and Transmission Lines," also applies to sewage collector and discharge pipelines. The following guidance should be considered with other aspects of sewage treatment and discharge:

- Discharges should be treated to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances;
- Use of land treatment and upland disposal/storage techniques should be implemented where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges should be limited to those instances where other less damaging alternatives are not available and the overall environmental and ecological suitability of such an action has been demonstrated;
- Discharging into open ocean waters is generally preferable to discharging into estuarine waters since discharging into estuarine waters is more likely to result in living marine resources contamination and nutrient overloading. Discharge points in coastal waters should be located well away from shellfish beds, seagrass beds, coral reefs, and other similar fragile and productive habitats. Proposals to locate outfalls in coastal waters must be accompanied by hydrographic studies that demonstrate year round dispersal characteristics and provide proof that effluents will not reach or affect fragile and productive habitats.
4.7.3.14 Steam-electric plants and other facilities requiring water for cooling or heating

Facilities that require substantial intake and discharge of water, especially heated and chemically-treated discharge water, are generally not suited for construction and operation in estuarine and near-shore marine environments. Major adverse impacts may be caused by impingement of organisms on intake screens; entrainment of organisms in heat-exchange systems or discharge plumes; and through the discharge of toxic materials in discharge waters. There is a specific need to develop methodology for toxicity tests using local, marine-tropical organisms. Protected Resources personnel should be notified of such projects early in the planning process since the operation of steam-electric plants often affects endangered species such as West Indian manatee. Projects that must be sited in the coastal zone and utilize estuarine and marine waters are subject to the following recommendations:

- Facilities that rely on surface waters for cooling should not be located in areas such as estuaries, inlets, or small coastal embayments where fishery organisms are concentrated. Discharge points should be located in areas that have low concentrations of living marine resources, or they should incorporate cooling towers that employ sufficient safeguards to ensure against release of blow-down pollutants into the aquatic environment;

- Intakes should be designed to minimize impingement. Velocity caps that produce horizontal intake/discharge currents should be employed and intake velocities across the intake screen should not exceed 0.5 feet per second;

- Discharge temperatures (both heated and cooled effluent) should not exceed the thermal tolerance of the majority of the plant and animal species in the receiving body of water;

- The use of construction materials that may release toxic substances into receiving waters should be minimized. The use of biocides (e.g., chlorine) to prevent fouling should be avoided where possible and least damaging antifouling alternatives should be implemented; and

- Intake screen mesh should be sized to avoid entrainment of most larval and post-larval marine fishery organisms. Acceptable mesh size is generally in the range of 0.5 mm and rarely exceeds 1.0 mm in estuarine waters or waters that support diadromous, anadromous, catadromous, freshwater and marine fish eggs and larvae.

4.7.3.15 Mariculture/aquaculture

The culture of estuarine and marine species in coastal areas can reduce or degrade habitats used by native stocks of commercially and recreationally important fisheries (Dayton et al. 2002). The following criteria should be employed to reduce or eliminate adverse impacts:

- Facilities should be located on uplands. Tidally influenced wetlands should not be enclosed or impounded for mariculture purposes. This includes hatchery and grow-out operations;
• Water intakes should be designed to avoid entrainment and impingement of native fauna;

• Water discharge should be treated to avoid contamination of the receiving water, and should be located only in areas having good mixing characteristics;

• Where cage mariculture operations are undertaken, water depths and circulation patterns should be investigated and should be adequate to preclude the buildup of waste products, excess feed, and chemical agents; and

• Mariculture sites should be stocked with hatchery-reared organisms only. Non-native species should be certified to be disease free, and project design features that minimize escape or accidental release of cultured species should be required. The rearing of ecologically undesirable and exotic species is unacceptable since escape and accidental release of these species is virtually assured.

4.7.4 Mitigation

This discussion is based on project review guidance developed by the Habitat Conservation Division of NOAA Fisheries Southeast Region (US Department of Commerce 2000). As a general rule, compensatory mitigation will be considered only after a project has been demonstrated to be water-dependent, has no feasible alternative, is clearly in the public interest, and all significant impacts are found to be unavoidable. In all cases, mitigation shall comply with the definition of mitigation that is provided at 40 CFR 1508.20 of the Council on Environmental Quality Recommendations. Those recommendations define mitigation as a sequential process whereby impacts are avoided, minimized, rectified, reduced over time, or are offset through compensation.

Despite increasing use of mitigation to offset wetland and other losses, there are situations (e.g., projects affecting large, high-quality seagrass beds) where the affected habitats are of such enormous value that the anticipated adverse impacts cannot be offset. In these situations mitigation should be used only after project relocation or abandonment are fully considered and rejected by the construction/regulatory agency. There is also considerable disagreement over the functional equivalency of created and natural wetlands and it should not be assumed that comparable or even larger sized replacement wetlands are necessarily equivalent with regard to habitat values and functions.

As a general rule, mitigation that restores previously existing habitats is more desirable and likely to succeed than that which seeks to create new habitat. The numerous impacted wetlands that exist in the Caribbean provide substantial opportunity for wetlands restoration. Restoration may be relatively simple, such as restoring tidal flows to an impounded wetland area, or more complex such as restoring dredged cuts and disposal areas. Restoration of destroyed emergent and, to a lesser degree, SAV is a feasible and recognized option when implemented with the services of experienced restoration personnel.
The creation of new wetland habitat involves conversion of uplands or, in some situations, submerged bottom to vegetated wetlands or another desirable habitat. Generation of wetland habitat should not involve converting one valuable wetland type to another. For example, building emergent wetlands in shallow water is unacceptable unless it can be demonstrated that the site is insignificant with regard to habitat or water quality function(s) or it previously supported wetland vegetation and restoration is desirable in terms of the ecology of the overall hydrological unit (e.g., estuary). Regardless of which option is used (restoration or creation), a ratio of at least two acres of mitigation for each acre of habitat destroyed should be recommended.

Four basic considerations involved in the planning for habitat generation are type of habitat to be created, and its location, size, and configuration. Each of these considerations must be applied to the specific ecological setting and in accordance with the following recommendations:

- **Habitat type** - As a general rule the created habitat should be vegetatively, functionally, and ecologically comparable to that which is being replaced. The principal exception would be those cases where a different habitat is shown to be more desirable based on overall ecological considerations.

- **Location** - Except in the case of overriding ecological considerations, the new site should be located as near as possible to the site that would be eliminated. In any event, the new site should be in the same estuarine system as the habitat that is being replaced. The replacement wetland should consider physical implications such as shoaling and existing circulation and drainage patterns.

- **NOAA Fisheries** considers the overall ecological and environmental implications of its recommendations, including upland impacts. Mitigation that may alleviate impacts to aquatic environments, but cause significant adverse impacts to important upland habitats should be carefully evaluated.

- **Size** - The habitat to be restored or created should be at least twice the (area) size of that which would be destroyed. This requirement is designed to offset differences in productivity and habitat functions that may exist between established project site wetlands and newly developed replacement wetlands. This size difference is also designed to address the possibility that the overall, long-term functional and ecological value of replacement habitats may be less than those of the impacted wetlands at the worksite.

- **Configuration** - Ecological setting and physical factors, such as existing drainage and circulation patterns, determine the configuration of replacement habitats. Consideration should be given to maximizing edge habitat and to the needs of desirable biota that may inhabit the site.

Interest in the use of "mitigation banks" or created/restored wetlands that are intended for use in offsetting anticipated future wetland losses is increasing nationwide. Because of the complexity of developing and administering mitigation banks, guidance concerning their creation is beyond
the scope of this document. NOAA Fisheries Caribbean Region Habitat Conservation Division Field Office personnel that are participating in such efforts should consult early with other NOAA Fisheries office personnel that have undertaken or are involved in such efforts since reliance on existing mitigation banking agreements may be beneficial. Habitat Conservation Division Field Office personnel also should notify other participating agencies that signatory authority for mitigation bank agreements rests with the Regional Administrator. In all cases, consideration of mitigation banks should be guided by the principle that no net-loss of wetlands would be incurred.

4.7.5  Recommendations for improving habitat information

The chief concern related to living marine resources is how human activities impact fishery productivity. Research is needed to provide knowledge of the ecological processes that affect energy flow leading to fishery productivity. This understanding of ecological processes must then be linked with information on the health, distribution, and abundance of ecologically important organisms. By understanding the ecological linkages to the production of fishery stocks, managers of fisheries and habitat will be better able to manage living marine resources. In general, researchers monitoring reef fish and researchers monitoring coral on reefs need to better integrate their methods to achieve a more unified approach, especially as regards using the same spatial scale when sampling (Lindeman et al. 2001).

4.7.5.1  Research needs

Research needed to provide the information necessary to protect, conserve and restore aquatic habitats has been identified in a NOAA Fisheries Habitat Research Plan (HRP) by Thayer et al. (1996). The HRP systematically guides habitat research in four areas: (1) ecosystem structure and function; (2) effects of alterations; (3) development of restoration methods; and (4) development of indicators of impact and recovery. Additionally, the plan emphasizes a fifth area -- the need for synthesis and timely information dissemination to managers. Following is a brief synopsis of each of the five research areas identified in Thayer et al. (1996).

Area 1:  Ecosystem structure and function  - This key area involves research to understand the structure and function of natural ecosystems, their linkages to one another, and the role they play in supporting and sustaining living marine resources (e.g., their distribution, abundance, and health). Research should include studies on the relationship between habitat and yield of living marine resources, including seasonal and annual variability and the influence of chemical and physical changes on these relationships. Resulting information should provide a foundation for predicting organism and habitat response to perturbation, as well as for predicting recovery or restoration success.

Area 2:  Effects of habitat alterations  - This area involves research to quantify the responses of habitats and fishery resources to natural and man-made alterations. Research should include cause-and-effect studies designed to evaluate responses of fishery resources and habitats to physical and chemical modifications of coastal and estuarine systems. Resulting information
should provide a basis for determining the degree of impact, the prediction of recovery rates, and the most effective restoration procedures and protective measures.

Area 3: Habitat restoration methods - This area involves research designed to improve the current methods to clean up, restore or create productive habitats, as well as the development and evaluation of new, innovative techniques. Studies should include analyzing the success of sediment sequestration; assessing bioremediation techniques; developing and evaluating new habitat restoration techniques; evaluating the role and size of buffers; and determining the importance of habitat heterogeneity in the restoration process. Resulting information should add to the scientific basis for predicting recovery and stability of restored and created systems. Perhaps most important, the research should generate guidelines for improving management practices and restoration plans.

Area 4: Indicators of impacts and recovery - This area involves research aimed at the development of indicators to simplify the process of determining whether an ecosystem, habitat, or living marine resource is affected or is recovering. The development of indicators is critical for judging the status of a habitat or living marine resource and the need for corrective action. Studies should include time-dependent population analyses and contaminant-level follow-up evaluations for sediment, biota and water. This type of research will help managers identify habitat status or "health"; standardize indicators for specific habitats through comparisons across geographic gradients and scales; and develop recommendations on the temporal efficacy of chemical "cleanup" techniques and most appropriate measures to assess success. Such guideposts will be used to develop and improve management practice approaches.

Area 5: Synthesis and information transfer - This area involves the transfer of technology and information through the use of all available sources and the application of user-friendly information bases. The use of geographic information systems (GIS) is encouraged, as GIS provides the opportunity to amass large quantities of complex data, which provides the potential for making relational observations. Information synthesis and transfer must be provided in a useable format.

4.7.5.2 Council’s information and research needs

The NOAA Fisheries EFH Final Rule lists four levels of information with which to describe and identify EFH (Section 2.1.3). At the present time, information exists only at level 1 (distribution) for Council consideration. The final Rule also requires mapping of EFH. Extensive mapping by NOS has occurred for nearshore areas (Kendall et al. 2001), but limited to depths of visibility of aerial photography. Data for deeper habitats, out to the shelf break and upper slope, are not available for mapping. Other agencies and programs (such as the CZMP in both Puerto Rico and the USVI) have and will be directly collaborating with the Council in support of the EFH initiative. Knowledgeable individuals state that habitat extends deeper than indicated by the NOS maps, and more surveys are needed to complete mapping into deeper water. Therefore, immediate needs for describing and identifying EFH require research for increasing the level of information and for complete mapping of habitat.
Preventing, minimizing, or mitigating adverse fishing impacts requires knowledge of gear-specific effects on habitats, and of relationships between habitat and fish production. At present, Caribbean researchers have conducted few studies that quantify the damage done by gears to habitats, and none that link fish production to habitat. Therefore, immediate needs for addressing gear impacts require research to quantify effects of fishing on habitats, and to quantify relationships of fish production and habitat.

Each FMP includes a section that lists the research needs to monitor the fishery and determine the effectiveness of the management measures implemented by the Council and NOAA Fisheries. Dayton et al. (2002) recommend both fisheries-dependent and -independent monitoring programs, with an emphasis on tagging studies of both target and non-target species. They further suggest including fishers as an integral part of the data collection process, and requiring accurate data recording which includes regulatory discard and non-endangered bycatch information. Better data collection should lead to better stock assessments. The Council’s Operations Plan lists specific research that needs to be conducted in support of the successful management of sustainable fisheries. Specific information and research needs identified for the US Caribbean are listed below for the four FMPs.

4.7.5.2.1 Reef fish FMP

1. Identification, mapping and quantification of shelf and slope habitats.
2. Distribution and abundance of fish eggs, larvae, juveniles, and adults.
3. Identification, description and mapping of natural fish nursery areas.
4. Identification, description, and mapping of spawning areas.
5. Impact of gear on habitat (applies also to Coral FMP).
6. Identification of recreational fishing/boating activities on species abundance (per life history stage), and habitat (anchoring).

- High priority - short and long term

Closed areas have been established for the red hind and the mutton snapper. However, no monitoring is being carried out for the spawning aggregations intended for protected in these areas. A monitoring program should be set up as soon as possible. This could be through the use of divers who could conduct visual censuses of the area three times a week during the months of area closures and once a month during the rest of the year. Individual fish should be tagged at the spawning site and length, weight and sex ratios (either from stripping or through cannulation) determined. (A master fisher, with a special permit could be contracted to assist the scientists in the study.)

Characterization of bottom topography of the known spawning aggregation grounds.

Assessment of the effect of recreational harvest on reef fish at spawning aggregations.

Surveys should be conducted to identify other spawning-aggregation sites of groupers and snappers in the Reef Fish FMP management unit. These surveys should be based in the
topographic description and the characteristics described from the known spawning sites
(e.g., apparent association between the red hind *Epinephelus guttatus* and the reef building
coral *Montastrea annularis*)

Identification of species in seasonally closed areas.

Identification of species in proposed marine conservation districts.

Socioeconomic studies for trap reduction program and/or harmonization of trap mesh size.

Assessment of gear impact on fish habitat (e.g., nets).

- **Medium priority - short and long term**

  Validation of growth curves (age at length) via the use of tetracycline for red hind, coney and
  other groupers, as well as for the mutton snapper and other snappers.

- **Low priority - long term**

  Collect more biological information by species, particularly concerning fecundity, growth,
  and mortality.

  Continue to standardize data collection, entry, and storage as much as possible. Document
  and initiate universal procedures for data collection and entry in the US Caribbean. Expand
  NOAA Fisheries data collection programs and data files to routinely update and include new
  Caribbean data, especially "state-federal" landings for the USVI and Puerto Rico.

4.7.5.2.2 Coral FMP

1. Identification, mapping and quantification of shelf and slope habitats.
2. Impacts of gear, (traps and nets) on habitats (coral reefs, seagrass beds, etc.)
3. Identification of recreational fishing /boating activities on species abundance (per life
   history stage), and habitat (anchoring).

- **High priority**

  Characterization of bottom in areas considered for marine reserves. This includes visual
  census of marine reserve biotopes and monitoring of selected areas before, during and after
  closure, and determination if there is any area that could be re-opened to public access in the
  future. Marine reserve systems should include a wide range of habitats to accommodate all
  ontogenetic stages of fishery species, and also have replicates of each habitat type
  (Appeldoorn and Lindeman 2003).

  Assessment of all anthropogenic activities affecting corals.
Assessment of anchor damage and other recreational activities on reefs.

Baseline study on recreational use of coral reef areas (e.g., areas visited, number of boats, etc.)

- Medium priority
  Growth, recruitment, and replacement rates of coral species in the fishery management unit.

- Low priority
  Assessment of corals and associated species mortality due to harvesting, handling, and shipping.
  Monitoring of scientific work being conducted at reefs.

4.7.5.2.3  Spiny Lobster FMP

1. Identification, mapping and quantification of shelf and slope habitats.
2. Distribution and abundance of lobster larvae, juveniles, and adults.
3. Identification of natural nursery areas.
4. Identification of migration paths to spawning areas. Identification of spawning areas.
5. Impact of gear (traps, nets) on habitats (Coral FMP, Reef fish FMP).
6. Identification of recreational fishing /boating activities on species abundance (per life history stage), and habitat (anchoring).

- High priority - short term

  The diver-based spiny lobster fishery in Puerto Rico should be studied in terms of total effort, areas fished, and size composition of landings, by month, to determine if a closed season is needed for this fishery.

  Also, there is a need to assess the taking of spiny lobster by recreational fishers. Survey should include charter boats, SCUBA diving schools, head boats, beach diving, and others.

- High priority - long term

  Growth and mortality studies are needed for Puerto Rico and the USVI to produce yield-per-recruit models, among other needs.

  Fishery independent sampling of lobster size-frequency distributions is needed to better estimate spawning potential.
Setting collectors for juvenile spiny lobster could enhance recruitment of lobster to nursery areas. These areas should be sampled on a weekly/monthly basis to determine whether this practice should be expanded throughout the local range of the spiny lobster.

- **Medium priority - short term**

  More information is needed on frequency of female spawning by size class.

- **Low priority - short and long term**

  To continue standardizing, as much as possible, data collection, entry, and storage.

4.7.5.2.4 Queen Conch FMP

1. Identification, mapping and quantification of shelf and slope habitats.
2. Distribution and abundance of queen conch eggs and larvae.
3. Identification of juvenile habitats.
4. Identification of recreational fishing/boating activities on species abundance (per life history stage), and habitat (anchoring).

- **High Priority - Short Term**

  The FMP was approved in 1997. Therefore, monitoring of the commercial and recreational catch needs to be done immediately since bag limits have been established. Reduction of these bag limits is contingent upon the status of the fishery. (This is needed on a short-term and long-term basis.)

  A database of commercial fishers involved in the conch fishery is of extreme importance at this time. A total of 319 commercial fishers use SCUBA gear (Matos-Caraballo and Torres Rosado, 1989) yet few report their catch statistics. An estimate of effort by fisher, boat, area, and time is needed to evaluate the queen conch fishery.

  Recreational fishing for queen conch needs to be assessed in the USVI since bag limits have been established in Federal waters for this fishery.

- **High Priority - Long Term**

  Growth and mortality studies are needed for the areas of Puerto Rico and the USVI to produce yield-per-recruit models.

  More information is needed on frequency of female spawning by size class.

  Studies conducive to the re-seeding of areas should be undertaken, such as:
1. Identification and information on natural nursery areas,
2. Release techniques need to be improved to increase survival of juveniles,
3. Studies conducted toward improvement of the quality of hatchery-reared stocks.

- Medium Priority

Collection of landings and fishing data of other conch species, such as *Strombus pugilis*, among others.

4.7.5.3 Monitoring fisheries to support management in an ecosystem context

In a report prepared for the Pew Commission, Dayton *et al.* (2002) state that in addition to increased and better monitoring, fishery managers should adopt a precautionary approach with ecosystem-based planning and marine zoning. Use of a flexible/adaptive management scheme is recommended because the end result of an action cannot be predicted. Data-gathering procedures and management policies may have to be overhauled and isolated from political expediency (Walters and Martell 2002; Pitcher 2001), and the definition of overfishing may have to be expanded to include ecosystem effects (Murawski 2000). Modification of the current trip ticket system may be necessary to get better data, including information about the location of the catch and bycatch composition (Valle-Esquivel 2002). More region-wide fishery-independent monitoring is also needed, but this is unlikely due to lack of funding. Dayton *et al.* (2002) suggest managing marine resources for all citizens, and not just the resource users; and encourage a shift in perception from fishing as a right, to fishing as a privilege.

Development of ecosystem models, and a restructuring of the regulatory milieu to use ecosystem-based, adaptive, proactive management would be preferred to the present single-species, reactive management policies. In implementing marine zoning, reserve areas should be sufficiently large and include ecologically sensitive habitats (Dayton *et al.* 2002). However, in the case of protecting specific habitat features, areas could be smaller. To ensure compliance around closed areas, commercial and for-hire recreational vessels should be required to carry “vessel monitoring systems”, which would also provide accurate information on fishing effort in space and time.

Dayton *et al.* (2002) also stress making regulations enforceable, and requiring permits for all fishers in US waters (both general and species-specific permits). They recommend requiring permit forfeiture for some violations (habitat destruction, repeat violations), and making those fishers who destroy highly productive, structurally complex habitats liable for habitat restoration costs. In addition such fishers should be charged with habitat destruction, instead of the typical poaching charge.
4.8 Short- and long-term productivity, irreversible and irretrievable commitments

4.8.1 Short-term uses versus long-term productivity

Short-term uses are generally those that determine the present quality of life for the public. The quality of life for future generations depends on long-term productivity; i.e., the capability of the environment to provide resources on a sustainable basis. Fisheries have the potential to reduce long-term productivity of fish and non-fish resources if management standards are not met. Monitoring determines whether fishery control measures are effective and correctly applied to achieve management objectives.

None of the alternatives would be expected to cause long-term loss of productivity of fish resources harvested under the Spiny Lobster, Queen Conch, Reef Fish, or Coral FMPs. All non-status quo (or no action) alternatives are designed to improve long-term productivity. Productivity of fish resources in the US Caribbean is largely influenced by fishing in state waters and by non-fishing activities.

4.8.2 Irreversible resource commitments

Irreversible commitments of resources are actions that disturb either a non-renewable resource or a renewable resource to the point that it can be renewed only over a long period of time (decades). Loss of biodiversity may be an irreversible resource commitment. For example, extinction of an endangered species would constitute an irreversible loss.

EFH and HAPC alternatives are intended to promote careful review of proposed projects to assure that the minimum practicable adverse impacts occur on EFH. However, NOAA Fisheries has no direct control over final decisions on such projects. The cumulative effects of these alternatives depend on decisions made by agencies other than NOAA Fisheries, as NOAA Fisheries and the Council have only a consultative role. Decisions made by other agencies that permit destruction of EFH in manner that does not allow recovery, such as bulkheads on former mangrove or marine vegetation habitats, would constitute irreversible commitments. Irreversible commitments should occur less frequently as a result of EFH and HAPC designations. Accidental or inadvertent activities such as ship groundings on coral reefs could also cause irreversible loss.

Alternatives to address adverse fishing impacts are intended to develop measures to reduce impacts to the habitat without unacceptable reduction in gear efficiency or other factors that may make the measures impractical. Absent preemption of management authority in state waters by the Secretary of Commerce, NOAA Fisheries and the Council have only an advisory role for fishery management in state waters. The amount of productive fishing grounds on EFH in the EEZ represents only 15% of the total EFH on the insular shelf of the US Caribbean (Figure 2.22). No irreversible commitments are expected as a result of measures to address adverse fishing impacts. However, the decade-plus recovery time for coral habitats could make unanticipated destruction of coral an irreversible commitment.
4.8.3 Irretrievable resource commitments

An irretrievable commitment is the loss of opportunities for production or use of a renewable resource for a short to medium period of time (years). EFH and HAPC alternatives are intended to promote careful review of proposed projects to assure that the minimum practicable adverse impacts occur on EFH. However, NOAA Fisheries has no direct control over final decisions on such projects. The cumulative effects of these alternatives depend on decisions made by agencies other than NOAA Fisheries, as NOAA Fisheries and the Council have only a consultative role. Decisions made by other agencies that permit temporary destruction of EFH, such as disruptions caused by access to construction sites, would constitute irretrievable commitments. Irretrievable commitments should occur less frequently as a result of EFH and HAPC designations. Accidental or inadvertent activities such as propeller scars on seagrass could also cause irretrievable loss.
5 PUBLIC REVIEW

5.1 List of Agencies Consulted

Caribbean Fishery Management Council
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NOAA Fisheries
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NOAA Fisheries
  Office of Protected Resources
  Office of Habitat Conservation
  Office of Sustainable Fisheries
  Office of Policy & Strategic Planning
  Office of Science and Technology
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  SERO Fisheries Operations Team
  SERO Fisheries Economics Office
  SERO Habitat Conservation Division
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US Dept. of State
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US Dept. of Agriculture
US Dept. of the Interior
   Office of Environmental Affairs
   US Fish and Wildlife Service
   National Park Service
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GLOSSARY

ALGAE - A collective, or general name, applied to a number of primarily aquatic, photosynthetic groups (taxa) of plants and plant-like protists. They range in size from single cells to large, multicellular forms like the giant kelps. They are the food-base for almost all marine animals. Important taxa are the dinoflagellates (division Pyrrophyta), diatoms (div., Chrysophyta), green algae (div. Chlorophyta), brown algae (div. Phaeophyta), and red algae (div. Rhodophyta). Cyanobacteria are often called blue-green algae, although blue-green bacteria is a preferable term.

ANTHROPOGENIC - Refers to the effects of human activities.

BATHYMETRIC - A depth measurement. Also refers to a migration from waters of one depth to another.

BENTHIC - Pertaining to the bottom of an ocean, lake, or river. Also refers to sessile and crawling animals which reside in or on the bottom.

BIOGENIC - Features built by or consisting of living organisms.

BIOMASS - The total mass of living tissues (wet or dried) of an organism or collection or organisms of a species or trophic level, from a defined area or volume.

CALCAREOUS - Composed of calcium or calcium carbonate.

CONTINENTAL SHELF - The submerged continental land mass, not usually deeper than 200 m. The shelf may extend from a few miles off the coastline to several hundred miles.

CONTINENTAL SLOPE - The steeply sloping seabed that connects the continental shelf and continental rise.

CORAL REEF - Coral communities exist under a variety of water depths, bottom types, water quality, wave energy and currents. Well-developed active coral reefs usually occur in tropical and subtropical waters of low turbidity, low terrestrial runoff, and low levels of suspended sediment. Some of the best developed reefs in Puerto Rico are those which receive the lowest levels of terrigenous inputs (Turgeon et al. 2002). The percentage of live coral cover generally increases with distance from shore. Corals may occur scattered in patches attached to hard substrates. Corals in the Caribbean are formed by the major reef-building (hermatypic) coral genera Acropora, Montastrea, Porites, Diploria, Siderastrea and Agaricia (Tetra Tech, 1992).

CRUSTACEA - A large class of over 26,000 species of mostly aquatic arthropods having five pairs of head appendages, including laterally opposed jaw-like mandibles and two pairs of antennae.
DEMERSAL-Refers to swimming animals that live near the bottom of an ocean, river, or lake. Often refers to eggs that are denser than water and sink to the bottom after being laid.

DISTRIBUTION-1) A species distribution is the spatial pattern of its population or populations over its geographic range. See RANGE. (2) A population age distribution is the proportions of individuals in various age classes. (4) Within a population, individuals may be distributed evenly, randomly, or in groups throughout suitable habitat.

ECOSYSTEM ENGINEER-Organisms that build biogenic structure or modify substrates in or on which they live.

EELGRASS-Vascular flowering plants of the genus *Zostera* that are adapted to living under water while rooted in shallow sediments of bays and estuaries.

ESCARPMENT-A steep slope in topography, as in a cliff or along the continental slope.

ESTUARY-A semi-enclosed body of water with an open connection to the sea. Typically there is a mixing of sea and fresh water, and the influx of nutrients form both sources results in high productivity.

FOOD WEB (CHAIN)-The feeding relationships of several to many species within a community in a given area during a particular time period. Two broad types are recognized: (1) grazing webs involving producers (e.g., algae), herbivores (e.g., copepods), and various combinations of carnivores and omnivores; and, (2) detritus webs involving scavengers, detritivores, and decomposers that feed on the dead remains or organisms from the grazing webs, as well as on their own dead. A food chain refers to organisms on different trophic levels, while a food web refers to a network of interconnected food chains. See TROPHIC LEVEL.

FRINGING REEFS-Emergent reefs extending directly from shore and often extensions of headlands or points, or separated from the shore by an open lagoon.

HABITAT-The particular type of place where an organism lives within a more extensive area or range. The habitat is characterized by its biological components and/or physical features (e.g., sandy bottom of the littoral zone, or on kept blades within 10 m of the water surface).

HABITAT SUITABILITY INDEX – (HSI) An index of the suitability of one or more habitat characteristics (e.g. depth, substrate) for a species. HSIs are used in habitat suitability models.

HABITAT SUITABILITY MODEL - Habitat suitability modeling (HSM) is a tool for predicting the quality or suitability of habitat for a given species based on known affinities with habitat characteristics, such as depth and substrate type. This information is combined with maps of those same habitat characteristics to produce maps of expected distributions of species and life stages.

HABITAT USE DATABASE – The relational database of habitat preferences and functional relationships between fish species and their habitat created for the EFH analysis.
HERBIVORE-An animal that feeds on plants (phytoplankton, large algae, or higher plants).

INSULAR-Of or pertaining to an island or its characteristics (i.e., isolated).

INTERTIDAL-The ocean of estuarine shore zone exposed between high and low tides.

ISOBATH-A contour mapping line that indicates a specified constant depth.

ISOTHERM-A contour line connecting points of equal mean temperature for a given sampling period.

LAGOON-A shallow pond or channel linked to the ocean, but often separated by a reef or sandbar.

LARVAE-An early developmental stage of an organism that is morphologically different from the juvenile or adult form.

LITTORAL-The shore area between the mean low and high tide levels. Water zones in this area include the littoral pelagic zone and the littoral benthic zone.

LIVE-ROCK-Live-Rock or Live-bottom is a special term used by aquarists and the marine aquarium industry to describe hard substrate colonized by sessile marine invertebrates and plants (Wheaton 1989).

NERITIC-An oceanic zone extending from the mean low tide level to the edge of the continental shelf.

NICHE-The fundamental niche is the full range of abiotic and biotic factors under which a species can live and reproduce. The realized niche is the set of actual conditions under which a species or a population of a species exists, and is largely determined by interactions with other species.

OCEANIC-Living in or produced by the ocean.

PATCH REEFS-Small irregular shaped reefs that rise from the bottom and are separated from other reef sections. Patch reefs are diverse coral communities typified by the presence of hermatypic (reef-building) and ahermatypic species. Typically, patch reefs form on coralline rock or another suitable substrate such as coral rubble (Marszalek, et al. 1977).

PELAGIC-Pertaining to the water column, or to organisms that live in the water column.

PISCIVOROUS-Refers to a carnivorous animal that eats fish.
PRECAUTIONARY-The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and the need to take action with incomplete knowledge, it requires, inter alia: consideration of the needs of future generations and avoidance of changes that are not potentially reversible; prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly; that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a time scale not exceeding two or three decades; that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource; that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further contained when resource productivity is highly uncertain; all fishing activities must have prior management authorization and be subject to periodic review; an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and appropriate placement of the burden of proof by adhering to the requirements above.

PRODUCTION-Gross primary production is the amount of light energy converted to chemical energy in the form of organic compounds by autotrophs like algae. The amount left after respiration is net primary production and is usually expressed as biomass or calories/unit area/unit time. Net production for herbivores and carnivores is based on the same concept, except that chemical energy from food, not light, is used and partially stored for life processes. Efficiency of energy transfers between trophic levels ranges from 10^-65% (depending on the organism and trophic level). Organisms at high trophic levels have only a fraction of the energy available to them that was stored in plant biomass. After respiration loss, net production goes into growth and reproduction, and some is passed to the next trophic level. See FOOD WEB and TROPHIC LEVEL.

RANGE-(1) The geographic range is the entire area where a species is known to occur or to have occurred (historical range). The range of a species may be continuous, or it may have unoccupied gaps between populations (discontinuous distribution). (2) Some populations, or the entire species, may have different seasonal ranges. These may be overlapping, or they may be widely separated with intervening areas that are at most briefly occupied during passage on relatively narrow migration routes. (3) Home range refers to the local area that an individual or group uses for a long period of life.

REEF FISH-Fish species that live on or near coral reef or hard bottom with biogenic structure.

RISK AVERSE-Philosophy or measures intended to minimize likely adverse impacts or proposed activities.

SETTLEMENT-The act of or state of making a permanent residency. Often refers to the period when fish and invertebrate larvae change from a planktonic to a benthic existence.

SOLITARY CORALS-Individual coral colonies found in bottom communities where corals are a minor component of biotic diversity. Although these solitary corals contribute benthic relief
and habitat to communities throughout the fishery conservation zone, they apparently comprise a minor percentage of the total coral stocks in the management area.

**SPAWN**—The release of eggs and sperm during mating. Also, the bearing of offspring by species with internal fertilization.

**SPECIES**—(1) A fundamental taxonomic group ranking after a genus. (2) A group of organisms recognized as distinct from other groups, whose members can interbreed and produce fertile offspring.

**SUBMERGED REEFS**—Fringing reefs that have not developed to the surface; they may be predominantly composed of active coral growth or covered with abundant communities of colonial gorgonians, sponges and corals.

**TERRITORY**—An area occupied and used by an individual, pair, or larger social group, and form which other individuals or groups of the species are excluded, often with the aid of auditory, olfactory, and visual signals, threat displays, and outright combat.

**TRAP LINE**—A line that connects a series of traps or pots that are set and hauled together.

**TROPHIC LEVEL**—The feeding level in an ecosystem food chain characterized by organisms that occupy a similar functional position. At the first level are autotrophs or producers (e.g., kelps and diatoms); at the second level are herbivores (e.g., copepods and snails); at the third level and above are carnivores (e.g., salmon and seals). Omnivores feed at the second and third levels. Decomposers and detritivores may feed at all trophic levels.

**VELIGER**—A ciliated larval stage common in molluscs. This stage forms after the trochophore larva and has some adult features, such as a shell and foot.

**WATER COLUMN**—The water mass between the surface and the bottom.
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