APPENDIX I

REGULATORY IMPACT REVIEW
AND
INITIAL REGULATORY FLEXIBILITY ANALYSIS
FOR
AMENDMENT NUMBER 1
TO THE
FISHERY MANAGEMENT PLAN FOR
CORALS AND REEF ASSOCIATED PLANTS AND INVERTEBRATES
OF PUERTO RICO AND
THE UNITED STATES VIRGIN ISLANDS

CARIBBEAN FISHERY MANAGEMENT COUNCIL

JANUARY 1999

TABLE OF CONTENTS

1.0 INTRODUCTION

Executive Order (E.O.) 12866 "Regulatory Planning and Review" was signed on September 30, 1993 and established guidelines for promulgating new regulations and reviewing existing regulations. While the E.O. covers a variety of regulatory policy considerations, the costs and benefits of regulatory actions are a prominent concern. Section 1 of the E.O. is repeated in its entirety:

Section 1. *Statement of Regulatory Philosophy and Principles.*

(a) The Regulatory Philosophy. Federal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary by compelling public need, such as material failures of private markets to protect or improve the health and safety of the public, the environment, or the well-being of the American people. In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts, and equity), unless a statute requires another regulatory approach.

(b) The Principles of Regulation. To ensure that the agencies' regulatory programs are consistent with the philosophy set forth above, agencies should adhere to the following principles, to the extent permitted by law and where applicable:

(1) Each agency shall identify the problem that it intends to address (including, where applicable, the failures of private markets or public institutions that warrant new agency action) as well as to assess the significance of the problem.

(2) Each agency shall examine whether existing regulations (or other law) have created, or contributed to the problem that a new regulation is intended to correct and whether regulations (or other law) should be modified to achieve the intended goal of regulation more effectively.

(3) Each agency shall identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior , such as user fees or marketable permits, or providing information upon which choices can be made by the public.

(4) In setting regulatory priorities, each agency shall consider, to the extent reasonable, the degree and nature of the risks posed by various substances or activities within its jurisdiction.

(5) When an agency determines that a regulation is the best available method of achieving the regulatory objective, it shall design its regulations in the most cost-effective manner to achieve the regulatory objective. In doing so, each agency shall consider incentives for innovation, consistency, predictability , the costs of enforcement and compliance (to the government, regulated entities, and the public), flexibility, distributive impacts, and equity.

(6) Each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify the costs.

(7) Each agency shall base its decisions on the best reasonably obtainable scientific, technical, economic, and other information concerning the need for and consequences of the intended regulation.

(8) Each agency shall identify and assess alternative forms of regulation and shall, to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt.

(9) Wherever feasible, agencies shall seek views of appropriate State, local, and tribal officials before imposing regulatory requirements that might significantly or uniquely affect those government entities. Each agency shall assess the effects of Federal regulations on State, local, and tribal governments, including specifically the availability of resources to carry out those mandates, and seek to minimize those burdens that uniquely or significantly affect such governmental entities, consistent with achieving regulatory objectives. In addition, as appropriate, agencies shall seek to harmonize Federal regulatory actions with related State, local and tribal regulatory and other governmental functions.

(10) Each agency shall avoid regulations that are inconsistent, incompatible, or duplicative with its other regulations or those of other Federal agencies.

(11) Each agency shall tailor its regulations to impose the least burden on society, including individuals, businesses of differing sizes, and other entities (including small communities and governmental entities), consistent with obtaining the regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations.

(12) Each agency shall draft its regulations to be simple and easy to understand, with the goal of minimizing the potential for uncertainty and litigation arising from such uncertainty.

In compliance with E.O. 12866, the Department of Commerce (DOC) and the National Oceanic and Atmospheric Administration (NOAA) require the preparation of a Regulatory Impact Review (RIR) for all regulatory actions which either implement a new Fishery Management Plan (FMP) or significantly

amend an existing plan, or may be significant in that they reflect important DOC/NOAA policy concerns and are of public interest.

The RIR is part of the process of preparing and reviewing fishery management plans and provides a comprehensive review of the changes in net economic benefits to society associated with proposed regulatory actions. The analysis also provides a review of the problems and policy objectives prompting the regulatory proposals and an evaluation of the major alternatives that could be used to solve problems. The purpose of the analysis is to ensure that the regulatory agency systematically and comprehensively considers all available alternatives so that the public welfare can be enhanced in the most efficient and cost effective way.

The Regulatory Flexibility Act (P.L. 96-353) has the purpose of relieving small businesses, small organizations, and small governmental entities from burdensome regulations and record keeping requirements. The Small Business Administration (SBA) classifies commercial fishing firms as small business entities if they have gross receipts of up to $3 million annually. For processors and wholesalers, a small business is a firm that employs less than 500 and 100 employees respectively.

To meet the basic objective of the Regulatory Flexibility Act (RFA), federal agencies are required to determine if proposed regulations will have a significant economic impact on a substantial number of small business entities. The process of making such determinations requires the preparation of an Initial Regulatory Flexibility Analysis (IRFA) and the RIR serves as the source of most of the information for the IRFA. However, certain information required for IRFA determinations is not necessarily available in the RIR. For example, if the RIR does not contain an estimate of the number of small businesses affected, a description of the small businesses affected or a discussion of the nature and size of impacts, then the IRFA would be expanded to include such information.

Pursuant to E.O. 12866 a regulation is considered a "significant regulatory action" if it is likely to result in an annual effect of the economy of $100 million or more or has other economic effects. The total retail value of seafood landings in St. Thomas and St. John U.S. Virgin Islands is in the $3.0 million to $5.0 million range and the proposed measure will negatively impact only a small portion of that total (see Section 6.0.2.2 for estimated losses). The proposed management measure will have minimal impacts on the charter boat and recreational sectors due to the small amount of activities by these segments of the industry within the proposed marine reserve. Hence, combined costs associated with the proposed management measure will be significantly less than the $100 million threshold which would constitute a "significant regulatory finding".

2.0 PROBLEM STATEMENT

The *Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands* (FMP), which became effective in December, 1995, included a reserved management measure establishing a Marine Conservation District (MCD). It is the proposed establishment of an MCD which constitutes the amendment to the FMP. Currently the FMP prohibits the harvest or possession of stony corals, sea fans, and gorgonians, and any species in the fishery management unit if attached or existing upon live-rock, among other management measures (see Amendment document).

As noted in the FMP, reef habitats around the U.S. Virgin Islands are considered to be limited areas of special importance and concern.[1] Degradation that occurs through man-made and natural causes, despite laws designed to mitigate some of these trends, further compromises these significant ecosystems. Anthropogenic stresses on coral reefs not only directly compromise their condition, and that of the organisms that depend on them, but also undermine their ability to recover from natural stressors. Loss of coral reef habitats directly affects a wide range of organisms including fisheries of considerable commercial and recreational significance in the region. Given the importance of the reef habitats for fisheries of commercial and recreational importance, their condition is clearly of significance for the management of other consumptive resources in waters under both state and federal authority.

Lack of management of commercial and recreational fisheries can also impact the reef ecosystem by disturbing the natural biological balance of interacting and co-dependent organisms. The effects of over-fishing on reef community structure, and thereby on the condition of the reefs themselves, are little understood. However, community imbalances in reef-associated organisms may result from large-scale reduction in cover or structural heterogeneity of live coral or other substrate, or from over-fishing of certain components of the commercial fishery. For example, Carpenter et al. (1981) showed that biomass of fishes increased with greater structural diversity of the substrate. Work by Hughes et al. (1987) in Jamaica indicated that increasing fishing pressure on coral reef herbivores , such as parrotfish, may account for observed increases in algal biomass which, in turn, reduces living invertebrate cover. Reef herbivores may reduce the abundance of certain competitively superior algae, thus allowing coral and cementing coralline algae to survive (Birkeland, 1977; Ogden and Lobel, 1978). Over-fishing of reef predators in St. Croix U.S.V.I. was suggested to be the cause of unusual abundances of the sea urchin Diadema antillarum in 1973, which, in turn, can reduce coral reef recruitment (Ogden et al., 1973; Sammarco, 1980). The Scientific and Statistical Committee has recommended that commercial stocks of fishes not be allowed to drop below the level where the interaction between reef fishes and substrate are altered in some way (75th CFMC meeting).

---

[1] Much of the discussion in this section is taken from the *Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands* and , with exceptions, is quoted verbatim with minor editorial changes.

In addition to the impact on the reef ecosystem caused by disturbing the natural biological balance of interacting and co-dependent organisms associated with commercial and recreational fishing, there is substantial evidence that these fishing activities, independent of harvesting levels, can also directly impact the overall integrity of the coral reef structure. Davis (1977), for example, estimated that commercial vessel anchors toppled 20% of the staghorn coral west of Loggerhead Key in Florida's Fort Jefferson National Monument in a single year (cited in Laist, et al., 1986). Similarly, as cited in Laist et al., lobster and fish traps placed near reefs can also negatively impact the surrounding habitat by breaking corals (Laist et al. reference Tunnicliffe, 1980, and the Gulf of Mexico and South Atlantic Fishery Management Councils, 1980). Hence, fishing activities can impact coral reef habitat in both indirect (overharvesting of fish stocks) and direct (anchoring and trap settings) manners.[2]

As noted by Russ (1996), "[a] number of complex characteristics of fisheries on coral reefs make administering conventional fisheries management programs difficult.". Among these factors are: (1) the multi-species and multi-gear nature of most coral reef based fisheries, (2) the uneven spatial distribution of effort, and (3) the tendency for many of these fisheries to be dominated by municipal (i.e. artisanal) fishermen who land their catch over a wide range of sites making problematic the collection of even basic data needed for management purposes, such as catch and effort. All of these characteristics likely prevail, to a greater or lesser extent, in the coral reef based fisheries of the U.S. Virgin Islands. With respect to the first characteristic, for example, Meyers (1994) states "[c]ommercial fisheries in the U.S. Virgin Islands are best described as multi-species, multi-gear fisheries. Typical of this description is the complex fishery for reef fish, involving over 180 species and various harvest methods including traps, hook and line, nets, and spear fishing". With respect to the second characteristic noted by Russ, the different bottom types comprising the shelf space off the U.S. Virgin Islands (i.e., a combination of seagrass beds, coral reefs, sandy bottom, etc.), as well as the slope of the shelf, suggests a highly uneven distribution of effort.[3] Finally, as noted by Garrison (1997), the U.S. Virgin Islands fisheries can best be described as artisanal in nature.

One of the most comprehensive studies documenting the current condition of the reef fish assemblage in the U.S. Virgin Islands is that of Garrison (1997). Findings reported in the referenced study, which censussed the contents of fish traps set by fishermen around St. John for the 1992-94 period included: (a) a decline in the average number of fish per trap, (b) a decline in the average length of trapped fish, (c) a 50% decrease in the mean weight of fish per trap, (d) decreases in the catch rates and relative abundance of groupers, snappers, triggerfishes, angelfishes, parrotfishes and grunts and a simultaneous three-fold increase in the catch rate of tangs, and (e) the lowest relative abundance of groupers (four

---

[2] As noted by one reviewer of an earlier draft of this document, injuries that corals sustain from fish traps, anchors, and other human activities may also make the corals mor susceptible to disease and invasion by algae competing and bioeroding invertebrates.

[3] Differences in numbers of reported trips to the different areas designated on the trip tickets by the commercial fishermen lends further support to the premise of an uneven distribution of effort among the commercial fleet.

percent) recorded in any other study of tropical fisheries. These findings, while specific to St. John, can undoubtedly be generalized to provide some indication of changes that have occurred in St. Thomas.[4]

The previous discussion indicates that coral reef habitat, which is of particular ecological significance, can be easily damaged through natural and anthropogenic causes. One of the anthropogenic causes of damage is excessive fishing on the reef assemblage community. This community, which is very difficult to manage using traditional techniques, is showing signs of stress in St. John which, in turn, may lead to a further compromise of the coral reef habitat. Anthropogenic causes related to anchoring and trap settings, while not documented for the St. Thomas and St. John areas *per se,* also undoubtedly prevail.

[4] This comment is based on the consideration that the two Islands are in close proximity to one another and, in fact, many fishermen tend to fish the waters off of both Islands. Assuming relatively similar ecosystem conditions, economic theory would suggest that, in the long run, the average product of effort around the two Islands would tend to be equal. In other words, if catch per unit effort in one area (i.e., island) is significantly greater than in the other area, effort, in the long run, would tend to migrate to that area where the CPUE is higher (assuming costs are not significantly different).

3.0 OBJECTIVES

The FMP contains one general and eight specific objectives to address the problems of coral resources. They are:

Objective 1. To optimize the benefits to the Nation generated from the resources of coral, live-rock, seagrasses and reef-associated plants and invertebrates, while ensuring their conservation and long-term preservation, through implementation of a management plan consistent with other management plans in the federal waters of the U.S. Caribbean.

Objective 2. To minimize adverse human impacts on coral, live-rock, seagrasses and reef-associated plants and invertebrate resources by reducing fishing pressure, wasteful harvest practices, and the anthropogenic stressors directly affecting them, and allowing for the restoration of naturally-balanced reef systems.

Objective 3. To establish resource data collection and permitting systems, and a research and monitoring program to collect fishery information and develop scientific data necessary to best utilize and preserve components of the management unit and to enable establishment of an OY for reef-associated invertebrates.

Objective 4. To provide, where appropriate, for special management of reef and seagrass habitats of particular concern or ecological importance through the establishment of reserves or other protected areas.

Objective 5. To increase public and government awareness of the importance and vulnerability of reef, seagrass and reef-associated resources. Informing and educating the general public of the importance of these resources will reduce adverse human impacts and foster support for management. Education of resource users, such as tourists and fishers, will promote more conscientious resource use.

Objective 6. To provide for and promote a consistent, coordinated and enforced management regime for the conservation and best utilization of reefs, seagrasses and reef-associated resources, in cooperation with state governments and other nations in the region.

Objective 7. To provide a flexible management system which minimizes regulatory delay while retaining substantial Council and public input into management decisions and which can rapidly adapt to changes in resource abundance, new scientific information, and changes in fishing patterns among user groups, or by area.

Objective 8. To reduce user conflicts in the fishery management unit through management and recommendations.

Objective 9. To eliminate or significantly reduce terrigenous sediment anthropogenic input from upland sources into coastal waters, and the discharge of untreated sewage and petroleum products into coastal waters. This objective may be addressed through recommendations to local governments to encourage compliance with, and enforcement of, laws regulating activities that result in products that negatively affect the condition of reef and seagrass habitats and reef-associated organisms.

4.0 NATURE OF THE MANAGEMENT MEASURE

During the development of the draft *Fishery Management Plan for Corals and Reef Associated Plants, and Invertebrates of Puerto Rico and the United States Virgin Islands*, the Council proposed the establishment of a Marine Conservation District (MCD) South of St. John United States Virgin Islands. Based on comments received during the comment period prior to approval of the Plan, the Council decided to defer the establishment of an MCD until more information became available and further consultation with user groups was carried out. Based on the additional information and consultation, the Council decided on a course of action. Originally, the Council proposed the establishment of an MCD in the Federal waters South of St. John (this original preferred Option is designated as Option C in this report; see Section 6.0). After receiving public comment on the preferred Option, the Council voted to expand the array of Options. Specifically, two new Options, either of which would establish an MCD in the Federal waters Southwest of St. Thomas (strictly as no-take areas), were added to the course of action. These two new Options are identified as Option A and Option B in this report (see Section 6.0 for the specific coordinates). The Council further decided, after the third set of public hearings, that the MCD will then be established in the Federal Waters Southwest of St. Thomas, USVI in an area known as the "Hind Bank" (Management Measure 1 in the Amendment document, Option A in this RIR).

5.0 APPROACH TO THE ANALYSIS

5.1 Intent of the Management Measure

The intent of the proposed management measure, as noted in the *Draft Amendment Number 1 to the Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands*, is to conserve and manage representative samples of marine habitats and ecosystems and to maintain marine biodiversity. In addition, the management measure will provide protection, conservation, and management of economically important species. Implementation of the proposed management measure will directly achieve Objective 4 stated above and will indirectly contribute to meeting Objectives 1 and 2. In addition, the proposed management measure may assist in achievement of Objective 8 in two manners. First, it may result in increased stock of reef assemblage species outside the proposed MCD which may reduce potential consumptive user conflicts (i.e., between different groups of commercial fishermen or between commercial and recreational fishermen). Second, to the extent that future conflict may exist between consumptive and non-consumptive (and even passive) users of the resource, any of the alternative proposed MCDs may lessen this conflict through preserving an area specifically for non-consumptive activities.

5.2 Definition of Net Economic Benefits

Economic benefits include the sum of expected changes in: (1) producer and consumer surplus for landings from the commercial fishery, (2) potential changes in consumer surplus derived from recreational fishing and diving trips, and (3) potential changes in consumer surplus derived from passive (non-use) values related to the environmental services in question (e.g., the coral reef ecosystem). Net economic benefits are calculated by subtracting management costs (plan preparation, enforcement, additional data collection and/or reporting costs).

Since the data on the coral reef ecosystem and related reef assemblage fisheries, and the associated consumptive and passive user groups, are not sufficient to make the calculations implied by the last paragraph, much of the analysis used in this RIR will be qualitative rather than quantitative in nature. In other words, the RIR analysis will attempt to ascertain whether or not the proposed Amendment to the FMP can contribute to economic improvements to the fisheries (and nation) but in many cases no attempt will be made to place estimated dollar values on any gains or losses which are discussed. While the analysis will of necessity be qualitative, existing data will not be ignored because existing reliable information can be used along with theoretical considerations to produce the best estimate as to the possible economic outcome of the proposed measure.

5.3 Short and Long Term Effects and Period of Analysis

The proposed management measure (Option A: a “no-take” MCD in the area known as the ‘Hind Bank’ Southwest of St. Thomas, USVI) entails more restrictive fishing practices. These restrictive

fishing practices, as is usual with management measures designed to rebuild over-fished stocks and/or restore ecosystem integrity, generally entail short term economic losses in producer and/or consumer surplus (i.e. a reduction in economic benefits). These restrictive fishing practices are enacted, however, in expectations that there will accrue some longer term benefits in the form of increased population stocks and/or ecosystem integrity. Some of the increased benefits, particularly those associated with increased stocks, may be reduced over a longer period of time which will be demonstrated in the analysis.

The period of analysis is often critical and, in some cases, can change the direction of the outcome. In the short run, for example, a reduction in available fishing area associated with establishment of an MCD is likely to reduce the overall percentage of stock available for harvest. In heavily fished fisheries, as is characteristic of the fisheries in St. Thomas and St. John, such a stock reduction can be expected to result in a reduction in harvest. This reduction will result in short-run decrease in consumer surplus associated with the local consumption of harvest (assuming price is responsive to quantity harvested) and producer surplus (assuming there exists some positive level of profits before establishment of the MCD).[5]

One of the main features of MCD's is their ability to protect older and larger fish. Protection of these larger fish can in theory, and supported by limited empirical evidence, result in "spillover" and egg dispersal effects that will, in the longer run, increase the population stock available for harvest. As the stock outside the established MCD expands, harvests among existing fishermen will expand commensurately resulting in increased profits to the existing fleet (assuming that the price flexibility for the harvested product is less than one in absolute terms). The increased harvest will, in turn, result in a reduction in the price of the landed product (assuming price responds to changes in harvests) resulting in an enhancement in consumer surplus.

Theoretically, however, increased fleet profits will attract additional entrants into the fleet as well as potentially an increase in effort among the existing fleet, assuming additional management measures aimed at controlling the overall level of effort, such as implementation of ITQ's, are not also enacted. The increased effort, in the long run, will result in a dissipation of profits (producer surplus). Interestingly, however, consumer surplus may not be reduced in the long run as is the case in most management measures that do not directly limit the overall level of effort. This reflects the fact that establishment of a marine reserve can result in indefinite increases in total catch, despite increasing effort.

---

[5] Theoretically, profits will not exist in an open-access fishery if two conditions are met. The first condition is that the fleet is homogeneous in nature. The second condition is that the fishery is in equilibrium. In actuality, neither of these conditions is generally valid at any point in time. Available evidence suggests a highly heterogeneous fleet in St. Thomas and St. John with boat lengths varying from less than 20 feet to in excess of 40 feet, suggesting inframarginal rents may be the norm.

As suggested by the above discussion, producer and consumer surplus associated with the production and consumption of the landed product can vary in relation to the time-frame of analysis. There may also exist non-consumptive (e.g., diving) and passive (utility associated with knowledge that an undisturbed coral reef ecosystem exists) benefits associated with establishment of marine reserves. These benefits should be monotonically increasing over time (though probably at a diminishing rate) up to the point that integrity of the coral reef ecosystem is fully restored.

6.0 ANALYSIS OF PROPOSED MANAGEMENT MEASURE

This proposed rule, if promulgated, will establish a Marine Conservation District (MCD) in the Federal waters Southwest of St. Thomas (Management Measure 1 in the Amendment document, Option A). Other Options considered by the Council during the last set of Public Hearings (June 1998) included Rejected Option B (the same area as A but larger) and Rejected Option C (Federal Waters South of St. John). The various Options associated with the establishment of an MCD are listed below:

OPTION A (Management Measure 1): Establish a no-take Marine Conservation District (MCD) in the EEZ in the area known as the Hind Bank South of St. Thomas, U.S.V.I., within the coordinates specified below.

POINT	LATITUDE	LONGITUDE
A	18E13.2'N	65E06.0'W
B	18E13.2'N	64E59.0'W
C	18E11.8'N	64E59.0'W
D	18E10.7'N	65E06.0'W

OPTION 1A: No action

REJECTED OPTION B: Establish a no-take Marine Conservation District (MCD) in the EEZ, including the area known as the Hind Bank South of St. Thomas, U.S.V.I., but with a modified northern boundary 1 NM north of the present demarcation line. That is, within the coordinates specified below.

POINT	LATITUDE	LONGITUDE
A	18E14.2'N	65E06.0'W
B	18E14.2'N	64E59.0'W
C	18E11.8'N	65E59.0'W
D	18E10.7'N	65E06.0'W

REJECTED OPTION C: Establish a Marine Conservation District (MCD) in the EEZ due South of St. John, U.S.V.I. within the coordinates specified as follows:

The rhumb lines connecting the following coordinates enclose the MCD:

POINT	DESCRIPTION	LATITUDE	LONGITUDE
A	South of Bovocoap Point at Boundary with Territorial Sea	18E 15.3'N	64E 46.9'W
B	South of Ram Head at Boundary with Territorial Sea	18E 15.0' N	64E 42.2'W
C	Southeast corner	18E 12.1'N	64E 42.2'W
D	Southwest corner	18E 11.0'N	64E 46.9'W

Before examining the specific benefits and costs related to the alternative options, a review of some basic economic principles in relation to the establishment of marine reserves is in order. This will help facilitate the discussion of benefits and costs in relation to the different options. The general discussion is presented in the following section.

6.0.1 General Economic Analysis of Marine Reserves

Market-failure arguments, as noted by Tisdell and Broadus (1989), are the basis of government establishment of marine reserves to protect nature (see item 1 under Section (b) in *Statement of Regulatory Philosophy and Principles).* As the authors further assert, two points need to be considered in relation to government provision of such reserves. First, many of the aspects associated with marine reserves tend to be nonrival in consumption, i.e., the marginal costs associated with providing the reserve to an additional individual is equal to, or at least approaches, zero. The second point that needs to be considered, according to the authors, is that of excludability. Specifically, it is difficult if not impossible, given the nature of marine reserves, to deny a wide range of individuals from capitalizing on the benefits derived from establishment of such reserves. Because any one enterprise is unable to extract but a small share of the societal benefits realized from establishment of a marine reserve, private enterprises cannot be expected to establish such reserves. Furthermore, the nonrival nature of marine reserves provides further justification of government intervention.

While the market failure arguments cited above provide a rational for government intervention, such failure, as noted by Panayotou (1993), provides a necessary, but not sufficient condition, for intervention. Sufficient conditions, according to Panayotou, are: (1) government intervention outperforms the market or improves its functions and (2) the benefits accruing from such intervention must exceed all costs including that of implementation and enforcement. If these sufficient conditions are

met, a second issue that should be considered in the establishment of a marine reserve is that of optimum size.[6]

Following Tisdell and Broadhus (1989), net benefits (i.e., gross benefits minus costs) associated with setting aside an area for a marine reserve can be mathematically expressed as follows:

$$NB = B(x) - C(x) \qquad (1)$$

where NB represents net benefits, B(x) represents the gross benefits associated with setting aside an area of size x, and C(x) represents the costs associated with setting aside an area of size x. If gross benefits exceed costs for a given level of x, say x_1, then equation 1 will be positive at that level of x implying that government intervention is warranted, conditioned on the assumption that government intervention outperforms the market or improves on its functions.[7]

The economically optimum reserve size can be determined by differentiating equation 1 with respect to x and setting the resultant equation equal to zero

$$\partial NB/\partial x = \partial B(x)/\partial x - \partial C(x)/\partial x = 0 \qquad (2)$$

This implies that, at the optimum, the marginal benefits associated with the addition of a given amount of area (say hectare), or $\partial B(x)/\partial x$, are equal to the marginal costs (i.e., $\partial C(x)/\partial x$) associated with the addition of that amount of area.

The above cited conditions can be illustrated graphically. Consider Figure 1, for example, where marginal benefits are denoted by the curve MB(x) while marginal costs are denoted by the curve MC(x). In this example the marginal costs exceed marginal benefits at all levels of x implying that government intervention in the creation of a marine reserve cannot be justified on the strict criteria of enhancing society's welfare (i.e., the basis of welfare economics).[8]

---

[6] A third economic issue, not discussed herein, is that of the optimum number of reserves. Discussion of this issue can be found in Tisdell and Broadus (1989).

[7] The assumption that government intervention outperforms a private market created in say the establishment of an ITQ system will be examined at a later point in the analysis.

[8] The condition that marginal costs exceed marginal benefits at all levels of x implies, of course, that costs exceed gross benefits at all levels of x.

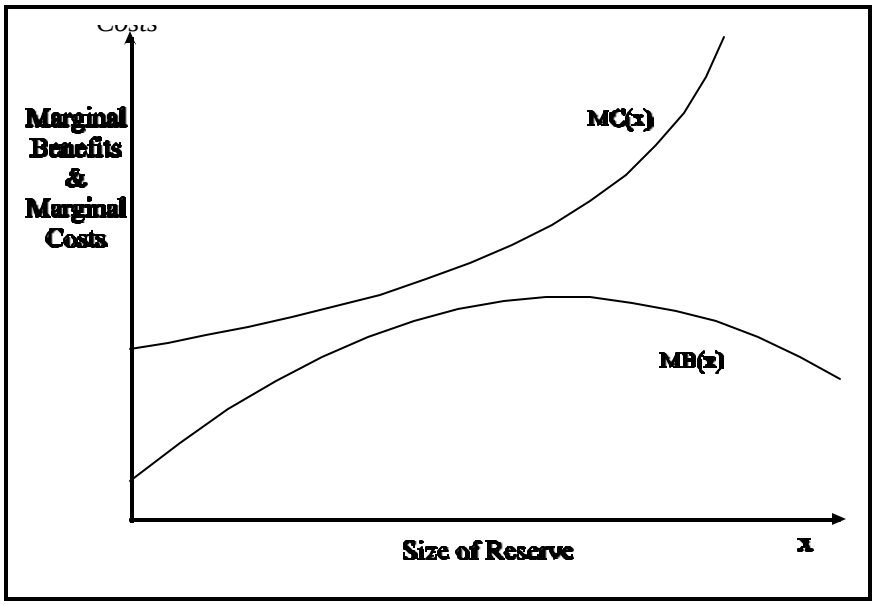

Figure 1: Illustration of the Marginal Cost of Marine Reserve Exceeding Marginal Benefits at All Sizes of Marine Reserve

As a second example, consider Figure 2.

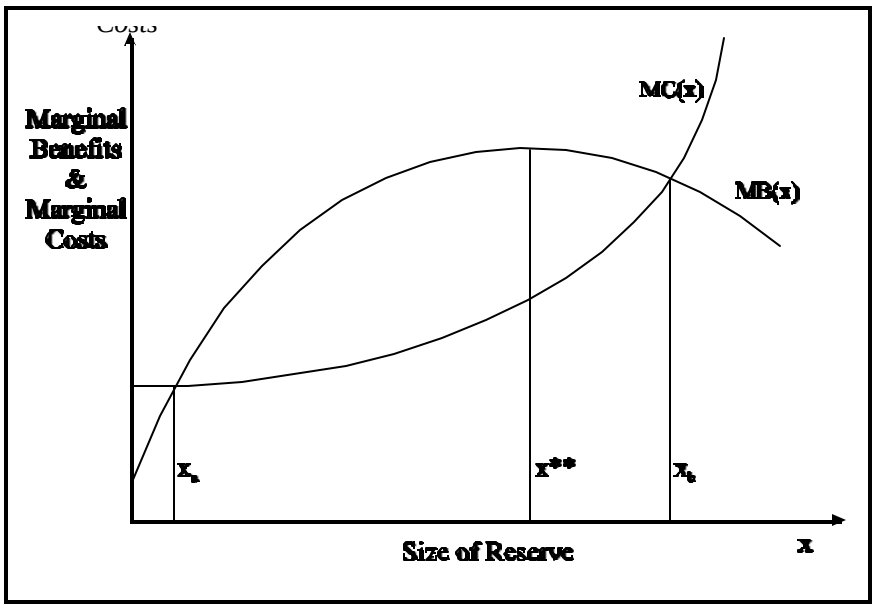

Figure 2: Illustration of Marginal Benefits of Marine Reserve Exceeding Marginal Costs at Some Sizes of Marine Reserves

In this case, marginal benefits exceed marginal costs over a wide range of x, i.e., from x_a to x_b. While government intervention in creation of a marine reserve of any size x within the range of x_a to x_b can be

justified based on welfare economic criteria, the economic optimum reserve size occurs at that point where marginal benefits, denoted by the curve MB, equals marginal costs, denoted by the curve MC; or x_b. It is noteworthy, furthermore, that marginal costs exceed marginal benefits at all reserve sizes to the left of x_a as well as to the right of x_b. One explanation for negative net benefits for a marine reserve size less than x_a in area may be related to relatively high fixed enforcement costs associated with a relatively small marine reserve relative to the benefits accrued therefrom. At the other extreme, i.e., beyond a marine reserve size of x_b, marginal opportunity costs related to displaced fishermen etc. may exceed the marginal benefits derived therefrom. While marginal opportunity costs are likely to be a monotonically increasing function in relation to x, such a relationship does not necessarily hold with respect to benefits. Specifically, beyond the point denoted x**, the change in total benefits associated with an increase in marine reserve size varies from that of increasing at an increasing rate (i.e., the derivative of $MB(x)/Mx > 0$) to that of increasing at a decreasing rate (i.e., the derivative is negative).

While the above discussion helps place the issue of whether to establish a marine reserve, as well as its optimum size, in an economic context, discussion of specific benefits and costs associated with establishment of a marine reserve to this point is lacking. Benefits can be either use or non-use in nature and Tisdell and Broadus (1989) list six economic arguments in favor of public provision of marine reserves. First, there may be an existence value associated with the protection of nature within the confines of the marine reserve. Second, there may be value associated with individuals being able to keep their individual options open (i.e., option value), in this case the option to visit a relatively undisturbed area Southwest of St. Thomas or South of St. John at some future point in time. Third, there exists potential value associated with maintaining a larger and more diversified gene pool (i.e., the value of biodiversity). Fourth, there is a value associated with the avoidance of large potential losses that may occur when common access is the only viable alternative.[9] A fifth potential benefit of public provision of marine reserves, according to Tisdell and Broadus (1989), is reflected in the potential increase in commercial and recreational harvests outside the reserve emanating from conserving species within the reserve, i.e., the "spillover" and egg dispersal effects. Finally, according to Tisdell and Broadus, discounting and risk arguments may favor public provision of marine reserves. Tisdell and Broadus also note, as an aside, that "...an additional compelling reason for establishment of marine reserves is that they provide an alternative and, in some cases, a more efficient approach to extractive activities (p. 38)".

These real or potential benefits must, of course, be weighed against the costs associated with the establishment of a marine reserve (see item 6 of Section (b) in *Statement of Regulatory Philosophy and Principles*). While available literature regarding costs associated with establishment of marine reserves is sparse, several cost factors are immediately apparent. First, displaced fishermen may realize

[9] Given the nature and associated difficulty embodied within the management of coral reef fisheries (e.g., the multi-species and multi-gear nature of these fisheries), relatively large losses may result even outside a common access regime. This aspect of coral reef fisheries will be examined in greater detail elsewhere in the report.

a reduction in profits (i.e., producer surplus), particularly in the short run, as their "preferred" fishing grounds are set aside for marine protection.[10] Second, there may be a reduction in consumer surplus, particularly in the short-run, if establishment of a marine reserve reduces the availability of fresh product to the consumer and price responds to available supply. Third, displacement of effort from the "preferred" fishing site may result in increased stock and crowding externalities in those areas remaining open to fishing practices. Finally, displacement of fishermen to other areas may negatively impact the ecosystem health in those areas remaining open to fishing practices (i.e., those areas outside the proposed MCD).

6.0.2 Benefits, Costs, and Net Benefits Associated With Proposed Marine Reserve

Benefits and costs associated with Management Measure 1 (Option A) of the *Draft Amendment Number 1 to the Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands* are examined below. Due to a lack of data and economic analysis associated with many of the benefits and costs outlined above, the discussion will be largely qualitative in nature. Where sufficient data exist, relevant analyses are presented.

In the following analysis of benefits and costs, it is assumed that compliance is at a level sufficient to maintain, if not increase, the ecosystem integrity associated with the area encompassed by any of the three areas considered by the Council for establishing an MCD.[11] If compliance is zero, costs (particularly those related to enforcement) will be positive but benefits will be zero, implying negative net benefits.[12] Overall, gross benefits, and potentially net benefits[13], will be expected to increase in relation to the level of compliance. Of relevance too is the issue of the level of compliance in the absence of sufficient enforcement. While information is insufficient to provide a quantitative answer to

---

[10] These short-run reductions in profits may reflect either a reduction in revenues associated with fishing in less productive areas, an increase in costs from, say, increased time and distance traveled to the less desirable fishing grounds, or some amalgam thereof. If, however, marine reserves are effective in the long-run enhancement of stocks outside the reserve (either from the "spillover" effect or the egg-dispersal effect), profitability among this group of fishermen may be also be enhanced over some longer period of time (particularly if controls are placed on the overall level of effort). These issues are discussed in greater detail later in the RIR.

[11] This assumption is, of course, predicated on the additional assumption that ecosystem integrity is a function of the level of fishing activities.

[12] This example may be somewhat fallacious in that the level of compliance is generally expected to be positively related to the level of enforcement. This relationship, however, holds only if penalties and probability of apprehension associated with non-compliance are sufficiently high that non-compliance is deterred in part or whole.

[13] Whether net benefits increase in relation to the level of compliance depends upon the cost function. Specifically, if costs accrued are large relative to benefits, then net benefits may be negative.

this question, some inferences can be drawn from the public hearings related to this Amendment. Comments provided at the public hearing suggest that, in general, there is strong opposition to any MCD; implying that "voluntary" compliance (i.e., compliance in the absence of sufficient enforcement) may be relatively minor. If one is to be established, however, there appears to be some agreement that Option A (Management Measure 1) is preferable to Rejected Options B and C; indicating that compliance in the absence of sufficient enforcement, to the extent that it occurs, may be greater if an MCD is established in the Federal waters Southwest of St. Thomas when compared to establishment of an MCD in the Federal waters South of St. John. Taking the analysis one step further, to the extent that Option A is preferred (by the potentially impacted parties) to Rejected Options B and C, compliance with respect to either Option A or Rejected Option B may exceed that of Rejected Option C at any level of enforcement. A final reason to expect that compliance may be higher if Option A or Rejected Option B is selected reflects the fact that there is a three-month closure (December-February) each year in the area where the MCDs associated with these two Options would be established. As such, fishermen are accustomed to a "temporary" closure and, hence, may be more willing to accept a permanent closure.[14]

6.0.2.1 Benefits

Assuming each of the considered MCDs associated with Options A through C listed in Section 6.0 exhibit the necessary conditions (e.g., sufficient size, etc.) required to meet the overall goals related to the establishment of the MCD, the benefits can be discussed in aggregate rather than for each individual Option. Insufficient information (economic as well as ecological) excludes comparing the benefits associated with one of the Options to that of the other Options in any amount of detail. To the extent that establishment of an MCD under Rejected Option B encompasses the MCD associated with that proposed under Option A, however, one would expect the gross benefits related to the MCD in Rejected Option B to be equal to or greater than the benefits derived under Option A. Furthermore, the "equal to" condition would hold only in the extreme case where the size of the proposed MCD (under Option A) is so large that no additional benefits would be derived from increasing its size (i.e., to that associated with Rejected Option B). Such a situation is highly unlikely.[15] Anticipated differences in benefits between Option A and Rejected Option B are discussed in more detail where appropriate.

---

[14] Related to this issue, analysis by Beets and Friedlander (1997) suggests that the three-month closure of the Hind Bank has been successful at protecting red hind grouper during the spawning aggregation season. Commercial fishermen, to the extent that they have noted the impact of protection via increased catches throughout the year, may see the benefits of additional protection throughout the remainder of the year and, as such, may be more inclined to comply with the creation of an MCD Southwest of St. Thomas.

[15] As noted in the Draft Amendment Number 1 (May 1998), Dr. Joshua Nowlis suggested that an MCD off the Southwest coast of St. Thomas may be superior to an MCD off the South Coast of St John (Rejected Option C) **if** a portion of the Territorial waters off St. Thomas is also closed. Without the additional closure the performance of Options A and B might not be superior to Option C.

1. *Existence and option values associated with the protection of nature within the confines of the marine park.* [16] Krutilla (1967) is generally credited with introducing the concept of existence value in the economic literature. In his seminal article, the author claimed that individuals did not have to actively use a resource to derive benefits (i.e., value) therefrom. Reasons for this claim are twofold. First, individuals may wish to preserve options for future use. Second, individuals may have an interest and, hence, value associated with bequeathing resources to his or her heirs.

As originally outlined in the literature , irreplaceability of natural resources was the primary justification for the presence of existence value (see Krutilla and Fisher, 1975).[17] As such, the existence value of a marine reserve, the purpose of which is to protect the overall ecosystem integrity within the confines of the park, appears to be a valid argument to include in calculation of benefits associated with the proposed marine reserve.

As reported by Spurgeon (1992), no studies have to date been conducted to determine the existence value of coral reefs (and related ecosystem). There are, however, two easily identifiable factors, as noted by the author, which will dictate the magnitude of existence value. First, existence value will be positively related to "...the quality, condition, and uniqueness of the reef on a national and global scale (p.534)". Second, "[t]he size of population, level of income, standard of education and the environmental perception of people in the country owning the reef will greatly influence the [existence] value (p.534)". The coral reef which is the subject of the current analysis associated with Rejected Option C is, by all accounts, of high quality and in good condition. However, no information regarding unique characteristics associated with the coral reef structure associated with Rejected Option C is available.

Based on discussion by Beets and Friedlander (1997), the site associated with Option A (and by extension Rejected Option B) also appears to be of relatively high quality and, potentially, more unique than the site associated with Rejected Option C. In summarizing the information presented by Beets and Friedlander, Draft Amendment 1 states the following concerning the Hind Bank: "[t]he dominant coral in at this site (i.e., spawning aggregation area observed by Beets and Friedlander) was *Montastrea annularis*. These flattened colonies of *Montastrea annularis* measured 0.5-1 m in diameter by 05.-1 m in height. Erosion of the side of the corals shielded mushroom-type structures. These structures of high relief, compared to the mostly low relief but densely covered shelf edge ridge of souther (*sic*) St. Thomas, offers shelter. These structures are atypical in the Virgin Island shelf." The Draft Amendment further states that "[c]orals, in general, are of slow growth. *Montastrea* in particular has been reported as having annual growth rates of 0.4 - 1.2 cm/yr in the USVI. This means that the dimensions of *M. annularis* ...are more than 100 years old; perhaps somewhat older since erosion of

---

[16] The discussion with respect to existence and option values draws heavily upon the work by Freeman (1993).

[17] It should be mentioned that this assumption has more recently been challenged (see Freeman, p.156).

the sides of the coral were described as giving it mushroom appearance." The Hind Bank (i.e., the site associated with Option A) is also known as an aggregation site for many species other than the red hind grouper. Specifically, Amendment 1 states that other species aggregating at the red hind bank include yellowfin grouper which aggregates in March, the yellowfin snapper, parrotfish, the creole wrasse, and creole fish. In addition, according to the Draft Amendment, Nassau grouper once had spawning aggregations at the bank but few fish are observed anymore.

Given the relatively large quantities of coral reefs in the Caribbean Region, and more generally, throughout the rest of the world, the issue of uniqueness of the coral reefs associated with the three proposed MCD sites is subject to a considerable amount of speculation. The atypical nature of the structures associated with Option A (and by extension Rejected Option B) and the aggregation of species in relation to these atypical structures suggest, however, that existence value may exceed that which would be associated with more typical coral reef structures in the U.S. Virgin Islands and throughout the rest of the Caribbean Region. Paucity of information regarding any unique characteristics associated the coral reef structure associated with the proposed MCD in Rejected Option C limits comments regarding potential existence value with the exception that it would be positive.

The concept of option value, which is closely related to that of existence value, was first introduced by Weisbrod (1964). As argued by the author, an individual uncertain as to whether or not he will visit some unique site at some future point in time would be willing to pay a sum in excess of his consumer surplus to assure that the site would be available in the future should he wish to visit it.[18] The sum over and above the consumer surplus was termed 'option value' by Weisbrod. The full measure of the value of the environmental service then becomes the summation of the expected consumer surplus plus the option value.[19]

Spurgeon (1992) asserts that because coral reefs and their surrounding environs are "unique and irreplaceable natural environments with dwindling supplies and growing demands (p.534)", the option value associated with their protection should be relatively high. While Spurgeon's overall assessment

---

[18] As noted, there is some similarity regarding the concept of existence value and the concept of option value, especially concerning future use of some environmental service. However, the concept of option value expresses a preference for the conservation of the environment or its components for one's own possible use at some future date in the face of uncertain future supply of that service. The concept of existence value, on the other hand, expresses a preference for the conservation of the resource or its components for use by one's heirs. As such, the concept of option value is tied directly to uncertainty whereas the concept of existence value is free of uncertainty considerations.

[19] The concept of option value has been rigorously debated in the literature and there are questions regarding its appropriate expected sign (i.e., positive or negative) if, in fact, it could be estimated (see Freeman, 1993, for discussion). It is noteworthy, however, that the Environmental Protection Agency listed option value as a legitimate value to be included in intrinsic benefits when conducting benefit-cost analysis of proposed regulations mandated under the terms of Executive Order 12291.

regarding option value associated with coral reefs and their surrounding environs is theoretically sound, its relevance with respect to the current analysis (i.e., Options A through C) is, at best, speculative. Like that discussed with respect to existence value, the option value associated with any of the three proposed MCDs is a function of uniqueness. Uniqueness, in turn, is related to the quantity and quality of coral reefs in adjacent and nearby areas and, to a lesser extent, the quantity and quality of coral reefs in more distant locations. With respect to adjacent and surrounding waters, the amount of coral reef within any of the three proposed MCDs constitutes but a small fraction of the total supply; though in theory the MCD will enhance its quality vis-a-vis those areas not being protected. With respect of coral reefs in more distant locations, Sobel (1993) suggests that in excess of 100 protected areas currently exist throughout the Caribbean Region, though the percentage of these areas which were protected to preserve coral reefs (in total or in part) is not given. While specific information regarding the percentage does not exist, the conclusion one draws from the more general information is that the more distant substitutes throughout the Caribbean Region are likely to be large and increasing.

While the option value associated with the proposed marine reserve is undoubtedly positive, the number of nearby and more distant substitutes suggests that its magnitude may be relatively low when compared to the option value associated with more unique environmental entities. Furthermore, given the fact that insufficient information exists which would permit meaningful comparison between Option A (or Rejected Option B) and Rejected Option C, one cannot determine whether the option value associated with an MCD created Southwest of St. Thomas would exceed that associated with an MCD created South of St. John.

2. *The value of biological diversity associated with the protection of nature within the confines of the proposed MCD*. Sobel (1993) groups threats to marine biological diversity into two classes. The first class includes those activities that involve overexploitation of marine resources, including directed or intentional harvesting and the incidental taking of marine life. The second class of threats to marine biological diversity include "...those that destroy or degrade marine habitats (p.21)", such as pollution and coastal development.

The functional importance of coral reefs has been adequately covered elsewhere (see, for example, Smith, 1978) and, as such, will not be covered here with the exception of stating that coral reefs have the highest diversity of any marine ecosystem. Overall, according to Talbot (1995), they can sustain fish yields of 15 tonnes per square km. Alcala (1988) suggests that yields from healthy coral reefs in the Philippines may approach 37 metric tons per square km.

Before considering the economic benefits of biological diversity (or biodiversity), it is useful to briefly discuss what is meant by the term. Simply stated, biological diversity is a general term referring to the extent of variety in nature and is usually considered at three different levels. These levels include (Anonymous, 1993): (1) genetic diversity, i.e., the variety of information contained in all of the individual plants, animals, and microorganisms, (2) species diversity, or the variety of living species, and (3)

ecosystem diversity, or the variety of habitats, biotic communities, and ecological processes, as well as the tremendous diversity present within ecosystems in terms of habitat differences and the variety of ecological processes.[20]

Genetic diversity refers to variation of genes within species. As noted by Polunin (1983) as well as others,[21] genetic diversity can be diminished in heavily fished stocks which, among other things, can result in fish stocks becoming more stressed from environmental perturbations. This increased stress can lead to recruitment failure, etc.

Species diversity is generally classified into three groups of measurement: species richness, species abundance, and taxonomic diversity. Species diversity, no matter how it is measured, tends to be unevenly distributed around the world. Specifically, species richness is concentrated in the equatorial regions and decreases in relation to distance from the equator. In the marine ecosystem, biological diversity appears to be highest on the continental shelves. In general, coral reefs have the highest level of diversity per unit area of any marine ecosystem (Talbot, 1995) and, as stated by the author "... are the marine equivalent of the great rainforests of the tropics ." Like the marine ecosystem in general, the biological diversity of coral reefs is highest in the equatorial regions and diminishes in relation to distances therefrom.

Because the "boundaries" of communities (i.e., associations of species) and ecosystems tend to be very fluid, defining ecosystem diversity tends to be much more complicated than that of genetic or species diversity and the measurement of ecosystem diversity is still in its early stages. As noted in Anonymous (1993)"[e]cosystem diversity encompasses the broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type (p.5)." Some of the potential problems with community imbalances in reef fish organisms have already been alluded to (see Section 2.0).

In a recently completed study of the St. John trap fishery, Garrison (1997) reports some trends suggesting relatively large changes in species composition and, indirectly, evidence of decreasing biodiversity. In relation to species composition, the author found that six species accounted for more than 50% of the total catch during a recent three-year (1992-94) period with blue tang, gray angelfish, and porgies representing the most frequently caught species. The six species, the author suggests, represents a far fewer number than reported in other similar studies. Furthermore, the number of blue tang caught in traps increased from 6.0% in 1992 to almost 31% in 1994. As stated by the author, "[t]he dominance of tangs in this study may be an example of Jennings' and Polunin's (1996) prediction that a small, fast-growing species from a lower tropic level would eventually dominate catch as a result

---

[20] Discussion of these different class relies heavily, and is often taken verbatim, from Anonymous (1993).

[21] See citations within Polunin (1983).

of intense fishing pressure. Change in catch composition would result from fishers simply targeting the remaining available species or keeping species previously considered 'trash' fish or 'bycatch' (p.8)". Similar trends are likely to be occurring in St. Thomas given the proximity of the two Islands.

The obstacles associated with measuring the value of biodiversity in a traditional neoclassical economic framework have been eloquently outlined by several economists, including Randall (1988) and Gowdy (1997). While the measurement of the value of biodiversity is inherently complicated, few economists would argue that there is value to having it. Furthermore, the value of biodiversity in relation to any ecosystem is likely related to: (1) the uniqueness of that ecosystem, (2) the complexity of that ecosystem, (3) current and future (possibly unknown) services and functions provided by that ecosystem, and (4) irreversibility of ecological damages. Most, if not all of these features, as noted in earlier discussion, are characteristics of coral reefs in general. The value of preserving biodiversity by maintaining coral reefs in an undisturbed environment is, therefore, likely to be large.

In lieu of being able to accurately value the benefits associated with any given ecosystem, many economists have proposed employing the safe minimum standards approach[22], as originally proposed by Bishop (1978). Following the discussion by Toman (1994), consider Figure 3 on the following page.

A situation of both modest long-run costs related to environmental damage and a high degree of reversibility is depicted in the lower-right portion of the Box in Figure 3. In this area, tradeoffs can be evaluated using a traditional cost-benefit approach in that there is little danger of high long-term costs to society and damages can be easily rectified given the high degree of reversibility. While costs become relatively high in the upper right-hand corner of the box, they are still relatively reversible. Hence, the current generation can compensate the future for environmental damage through an intergenerational transfer. Because costs are relatively low in the lower left-hand corner of the box, they can be absorbed without significant detrimental effects on future generations, even though irreversibility is relatively high. Overall, the safe minimum standard principle becomes particularly relevant in the upper-left hand corner of the box. In this region, impacts become irreversible due to the high long-run costs and limited substitution options. In addition, since the impacts in question in the upper right-hand corner of the box will often involve large-scale ecosystems and ecological functions, uncertainty is likely to be substantial.

[22] As noted by Toman (1994), the logic of using a safe minimum standard approach in the decision-making process is based on the premise that the cost-benefit approach traditionally used in evaluating tradeoffs may be inadequate if the long-term costs of ecosystem loss are uncertain but potentially substantial. Proponents of the safe minimum standard approach to evaluating tradeoffs argue that, unless society judges that the costs of preservation are unreasonably high, it is best to err on the side of preservation.

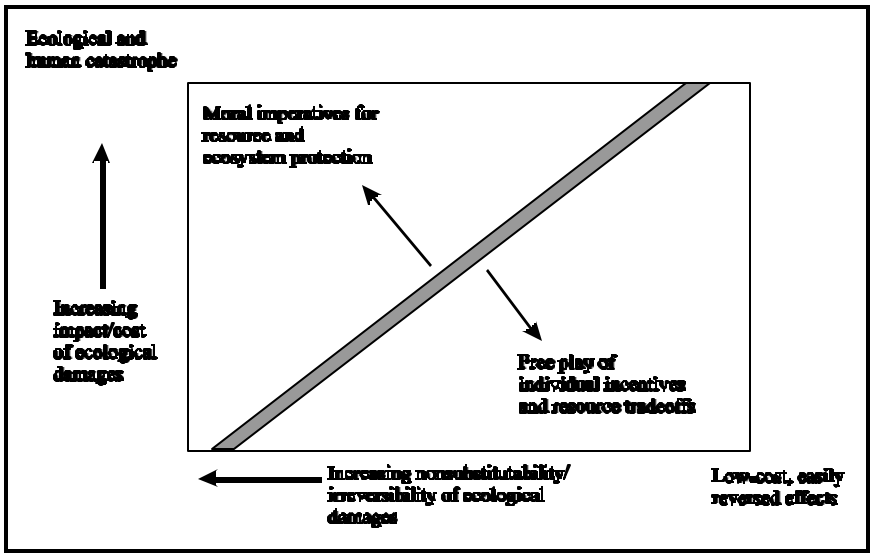

Figure 3: Illustration of the Safe Minimum Standard for Balancing Natural Resource Trade-offs and Imperatives for Prevention (Toman 1994:407)

As one moves toward the upper left hand corner of the figure, as argued by Toman, individualistic valuation criteria (such as the concept of benefit-cost analysis) should give way to social rules regarding the preservation of natural capital. In other words, unless society deems the costs of conservation (preservation) to be excessive, arguments favoring preservation should prevail.

With respect to coral reef ecosystems, the probability of irreversibility associated with ecosystem damage is high given the long regeneration period of coral reefs. Given the many functions related to the coral reef ecosystem, too, societal costs (current and future generations) may be large. These two factors suggest preservation, through establishment of a MCD, may be warranted.

As of yet, there has been no discussion with respect to size of the three proposed MCDs and its relation to the preservation of biodiversity. In general, one would expect, beyond some critical minimum size, a positive relationship between maintaining and/or enhancing biodiversity and the size of the MCD.[23] Whether this relationship increases at an increasing or decreasing rate in relationship to the amount of closed area (i.e., whether the second derivative a change in biodiversity to a change in closed area is positive or negative) is unknown.

Overall, the proposed MCD in Federal waters Southwest of St. Thomas associated with Option A encompasses approximately 16 square miles. This area has been closed for three months during the year (December through February) since 1990 to protect spawning aggregations of red hind groupers.

[23] Another way of saying this is that extremely small marine reserves probably serve no function in maintaining biodiversity.

Rejected Option B encompasses the area associated with Option A plus one additional mile to the north, or approximately 23 square miles in total. The proposed MCD associated with Rejected Option C is in the Federal waters south of St. John and encompasses approximately 20 square miles. Ranging from about 16 square miles (Option A) to 23 square miles (Option B), all three of these Options cover but a small fraction of the total shelf area of St. Thomas and St. John (approx. 1,100 square miles).[24] Without further information regarding range of movement of different species in the respective MCDs associated with the alternative Options etc., it is impossible to state whether any of the proposed MCDs are sufficiently large to maintain or enhance biodiversity and associated benefits derived therefrom. Furthermore, it is impossible to compare between the three alternative Options with the exception that benefits related to the protection of biodiversity under Rejected Option B likely exceed those that would be generated under Option A, assuming the size of either of the proposed MCDs is sufficient to protect the biodiversity.[25]

3. *Value associated with avoidance of large potential losses that may occur when common access is the only viable alternative.* There is ample evidence to suggest that MCD's are successful at increasing the biomass and the average size of fish inside the boundaries of the MCD (see Rowley, 1992, for a general review of the evidence and Polunin and Roberts, 1993, and Roberts, 1994 for two examples specific to the Caribbean Region). This is particularly true when considering species, such as many of the reef fish in the Caribbean Region, that exhibit relatively limited movements and have long life spans for which current size distribution is significantly below that historically reported (Rowley, 1994).[26]

---

[24] Such comparisons, it is noted, are likely to be somewhat misleading. Specifically, much of the shelf area surrounding the respective Islands is not conducive to fishing activities. As such, the fraction of the "effective" fishing area withdrawn as a result of adoption of any of the alternative options will be much larger than one would arrive at by dividing the area related to the different options by the total shelf area. This assertion is supported in written comments received during the public hearing process (see letter to Mr. Miguel Rolon from Ms. Monica Lester and Mr. David Berry).

[25] One factor potentially favoring Option A or Option B over Option C with respect to biodiversity is that the Hind Bank is known to be a spawning aggregation area for many species including the red hind grouper, the yellowtail snapper, the parrotfish, the creole wrasse, and the creole fish. In addition, the Nassau grouper once had spawning aggregations at the site. These spawning aggregations appear to be related to the presence of the dominant coral at the site, *Montastrea annularis.* The atypical relief provided by this coral and the related aggregations may translate into a greater degree of biodiversity.

[26] See Garrison (1997) for a discussion of the historical change in size of reef fish species harvested in St. John.

Benefits (value) associated with avoidance of large potential losses (even in the absence of common access) can take many forms. In the extreme, MCD's can help ensure species' survival.[27] Less draconian in nature, MCD's can help provide a hedge against recruitment failure, assuming "spillover" and egg dispersal effects are positive.[28] As such, MCD's can, in essence, provide " insurance" against the potential, and perhaps, negative impacts related to overfishing. While not being able to quantify it, this "insurance" is a benefit and, hence, is valued by society.[29] Evaluating the issue in a somewhat different manner, consider Figure 3. As the probability of recruitment failure increases, one might expect both an increased probability of irreversible ecological damages associated with a large redistribution of species mix comprising the ecosystem and an increasing and potentially permanent impact/cost related to the disturbed ecosystem. This suggests a movement towards the northwest quadrant of the graph and, as such, increased moral imperative for ecosystem protection; this protection being, in essence, an insurance policy.

Finally, there is a growing consensus that the multi-species, multi-gear nature associated with the harvesting of reef-fish assemblages, such as those prevailing in St. Thomas and St. John, makes traditional management methods somewhat ineffective (see, for example, Roberts, 1997) in sustaining viable populations of targeted, as well as incidentally harvested, species. Management measures that limit the overall level of effort (say boats) may also be ineffective due to expansion of effort within the existing fleet (e.g., increased trips and/or pots).[30] An Individual Transferrable Quota program, while largely untested in fisheries as complex and diverse as that of the reef-fish assemblage fishery in St. Thomas and St. John, is likely to be extremely cumbersome (and expensive) and it is uncertain how well it would perform. As such, MCD's may be a cost effective alternative to more cumbersome and expensive programs (see item 5 in the *Regulatory Philosophy* section). In addition, they can provide additional protection associated with the avoidance of large potential losses when used in conjunction with more traditional management approaches.

---

[27] In this situation, the concepts of existence value and option value become relevant in terms of the benefits associated with the avoidance of large potential losses.

[28] The "spillover" and egg dispersal effects will be discussed in greater detail below.

[29] Examined somewhat differently, assume that the fish stocks are owned by a single individual/corporation. These fish stocks would be considered as capital which could be used in the production process, i.e., the harvesting of fish. As with other forms of capital, the individual may take out an insurance policy as protection in case of natural or human-induced disaster. The decision as to whether such a policy would be taken would depend on: (a) the cost of obtaining such a policy, (b) the "perceived" risk of disaster, and (c) the payoff if a disaster occurs.

[30] This suggests that any effort limitation program will likely necessitate limits being placed on the overall number of entities permitted in the fishery (e.g., vessels) as well as limits being placed on the amount of effort that can be exerted by each of the entities (e.g., traps per vessel).

4. Value associated with (potential) increase in commercial and recreational harvests outside the reserve emanating from conserving species within the reserve. One of the core concepts of marine reserves is that over time (after initial establishment of a marine reserve) stock sizes outside the reserve will be enhanced through the effects associated with "spillover", the effects associated with the export of larvae outside the reserve, or some amalgam thereof. The "spillover" effect emanates from larger fish emigrating outside the border of the reserve over time as carrying capacity within the reserve is attained. The export of larvae, similarly, may enhance recruitment into neighboring fish stocks.

While intuitively appealing, empirical evidence supporting the "spillover" and export of larvae effects is limited. This is particularly true with respect to the export of larvae. As noted by Rowley (1992), however, much of the reason for limited empirical evidence reflects the fact that scientific proof would require rather complicated experimental designs involving multiple sites as well as the need for sampling both before and after closure of the reserve.

To examine potential benefits associated with increased commercial and recreational harvests outside the reserve emanating from conserving species within the reserve, it is first useful to examine current fishing practices. Based on the 1995-96 trip ticket data for St. Thomas and St. John (see Table 1), approximately 14% of the total number of trips taken in the area around these two islands and about 31% of the associated harvest occurred in the Federal waters Southwest of St. Thomas (i.e., the area encompassing the proposed Option A and Rejected Option B). For the Federal waters South of St. John (i.e., the area encompassing the proposed Rejected Option C), the proportion of trips equaled approximately seven percent while the proportion of total catch approximated 14%. These figures establish an upper bound on the percentage of trips taken in and the catch taken from the three alternative MCDs associated with Options A through C.[31]

With respect to potfish, an estimated 19% of the total 2,039 trips reported by the population of fishermen occurred in Federal waters Southwest of St. Thomas (i.e., the area associated with proposed Options A and B) while about 40% of the total potfish harvest, equal to 92 thousand pounds was harvested from this area (Table 1) The Federal waters South of St. John (i.e., the area encompassing proposed Option C) accounted for approximately eight percent of the total number of potfish trips (158 of the 2,039 total) and 11% of the associated harvest.

---

[31] The figures discussed herein reflect upper-bound estimates for two reasons. First, the areas covered by the designations (1) Federal waters Southwest of St. Thomas and (2) Federal waters South of St. John completely encompasses the proposed MCDs (Federal waters Southwest of St. Thomas with respect to Options A and B and Federal waters South of St. John with respect to Option C) but also encompasses additional areas not included in the proposed MCDs (unfortunately, the data did not permit finer delineation). The second reason the figures represent upper bounds is that many fishermen reported fishing in both Territorial and Federal waters on a given trip. In these instances, all catch was attributed to Federal waters for purposes of analysis.

Similarly, about four percent of the total number of hookfish trips (51 of 1,222) reported by the population of fishermen occurred in Federal waters Southwest of St. Thomas (i.e., the area encompassing Options A and B). These 51 trips represented about eight percent of the total hookfish catch in both the Territorial and Federal waters for St. Thomas and St. John. The Federal waters South of St. John accounted for 6.5% of the total number of hookfish trips (i.e., 79 of the 1,222 total) and seven percent of the total hookfish catch (Table 1).

Finally, almost 30% of the total lobster trips reported by all fishermen in St. Thomas and St. John in 1995-96 occurred in Federal waters Southwest of St. Thomas (i.e., 309 out of 1,033 total) and these 309 trips accounted for more than one-half of the total reported take of lobster for the period. By comparison, only 65 lobster trips were reported in the Federal waters South of St. John in 1995-96 (i.e., six percent of the 1,033 total) but these 65 trips accounted for almost 20% of the total take of lobster.

For benefits to accrue in the short run in association with the expected "spillover" and larval dispersal effects (related to the establishment of a marine reserve), effort needs to be displaced in order for growth of the MCD stock to occur. As is evident from the information in Table 1, a moderate amount of displacement is expected in association with the establishment of any of the three proposed alternative MCDs. A moderate reduction in effort suggests, however, that short-run benefits related to the establishment of the proposed MCD are also likely to be only moderate in nature.

The analyses regarding potential displacement with respect to the alternative proposed MCDs, of course, include regions much larger than any of the MCDs that would be chosen under any of the alternative Options. Specifically, the Federal waters Southwest of St. Thomas includes a considerable amount of area outside the proposed MCDs associated with Options A and B. Similarly, the Federal waters South of St. John comprise a significantly larger area than is encompassed by the MCD associated with Option C. This suggests that the upper-bound estimates regarding displacement, as discussed above, may be substantially higher than that which would actually occur.

This issue can be examined in greater detail with respect to Option A and, to a lesser extent, Option B. Specifically, Option A coincides with the area known as the Hind Bank which is closed for three months during the year (December through February) to protect the red hind grouper during the period in which they aggregate to spawn. Option B includes this area plus one mile to the north. While the trip ticket data are of insufficient resolution to determine the actual number of fishermen/trips displaced from the Hind Bank during this three month period, there exists sufficient data to provide a cursory examination pertaining to the issue as to whether this closure displaces effort from the Federal waters Southwest of St. Thomas or merely in the specific area of the three month closure (i.e., the Hind Bank).

As indicated in Table 1, a total of 585 trips were reported in the Federal waters Southwest of St. Thomas in 1995-96 and 384 of these trips reported the harvest of potfish. These trips delineated on a

monthly basis are provided in Table 2.[32] The total number of trips made in the Federal waters Southwest of St. Thomas in 1995-96, as indicated, ranged from 37 (October) to 72 (August). Similarly, the number of potfish trips ranged from 29 (July) to 46 (August). If closure of the red hind bank (Option A) results in significant displacement of effort in the Federal waters Southwest of St. Thomas, one would expect to find a sharp decline in the number of trips made in these waters during the December-February period. This, however, is not the case (see Table 2), suggesting one of two possible scenarios. First, there may exist little effort on the Hind Bank throughout the year in which case there would be little displacement from this area associated with a permanent closure associated with Option A. An alternative explanation is that a significant amount of effort is displaced from the red hind bank during the closed months (i.e., December-February) but the displaced effort simply relocates to other areas within the Federal waters Southwest of St. Thomas. Given the similarities between Options A and B, the same general findings presented herein with respect to Option A likely are valid for Option B. Insufficient data excludes refinement of analysis with respect to Option C.[33]

Evaluating only the immediate displacement and associated benefits may be somewhat "short-sighted" in nature. Specifically, there is ample evidence to suggest that effort into the areas of any of the proposed MCDs associated with the three alternative Options is likely to expand in the absence of a permanent closure. Garrison (1997), for example, makes reference to "... the use of larger, more seaworthy vessels powered by diesel or gasoline engines which have enabled commercial fishers from St. Thomas and Puerto Rico (90 km to the west) to exploit St. John's offshore waters - as far south as the shelf edge... (p.3)." Similarly, evidence of technological change in the St. Thomas fleet which would allow expansion of effort into the area of the proposed MCD associated with Option C is noted by Impact Assessment Inc. (1997) and, *de facto,* into the areas associated with Options A and B. Finally, declining catch per unit effort in the near-shore waters, as noted by Garrison, will most certainly encourage fishermen to increasingly expand the range of fishing activities to deeper waters, such as those in the area of the three alternate MCD proposals. These considerations lead to the conclusion that the greatest benefits associated with increased stock outside the reserve, emanating from protection of species inside any of the three proposed MCDs, may occur at some future point in time rather than in the near term.

---

[32] A monthly breakdown of hookfish trips and lobster trips is not provided due to concerns regarding confidentiality.

[33] To the extent that a permanent closure of the area associated with Option A would result in little displacement of effort, benefits accrued to its closure over time may be small. Nellis, in written comments regarding the establishment of an MCD (see letter to Mr. Miguel Rolon dated 21 June), appears to suggest that only a small fraction of the area associated with Option A supports significant coral communities. If this is the case, effort in the area associated with the proposed MCD may have historically been relatively minor, increasing only during red hind grouper spawning aggregations. This supposition, however, belies evidence regarding aggregation of several other species at the Hind Bank.

Of course, the discussion of benefits in this subsection is based on the premise that stocks outside the reserve will be enhanced as a result of protection of species within the confines of the reserve.

Table 1: Relationship of Effort and Catch in (1) Federal Waters Southwest of St. Thomas, and (2) Federal Waters South of St. John to Total Effort and Catch in St. Thomas and St. John Waters (Territorial and Federal Waters), 1995-1996[a].

	Trips & Catch Inside Federal Waters S.W. of St. Thomas		Trips In All Areas		Percentage of Trips Inside St. Thomas S.W. Federal Waters	
	# of Trips	Total Catch[b]	# of Trips	Total Catch[b]	Trips (%)	Catch (%)[b]
Total	585	121,095	4,035	389,559	14.4%	31.1%
Potfish	384	92,160	2,039	228,084	18.8%	40.4%
Hookfish	51	6,579	1,222	81,045	4.2%	8.1%
Lobster	309	22,557	1,033	40,059	29.9%	56.3%

	Trips & Catch Inside Federal Waters South of St. John		Trips In All Areas		Percentage of Trips Inside St. John South Federal Waters	
	# of Trips	Total Catch[b]	# of Trips	Total Catch[b]	Trips (%)	Catch (%)[b]
Total	283	41,601	4,035	389,559	7.0%	10.7%
Potfish	158	27,334	2,039	228,084	7.8%	12.0%
Hookfish	79	5,925	1,222	81,045	6.5%	7.3%
Lobster	65	7,670	1,033	40,059	6.3%	19.1%

Notes:

a. Trips and catch are based only on information reported in the trip tickets, i.e., not projected to the total.
b. Total catch exceeds summation of individual components (i.e., potfish, hookfish, and lobster) because other fishing activities such as netfishing and conch are included in totals.

This premise raises three natural questions. First, what evidence exists that the stocks outside of the reserve will be enhanced over time? Second, what are the specific benefits that can be expected in association with stock enhancement? Finally, what is the time frame in relation to the benefits. Each of these questions are addressed in turn below.

As discussed in the *Draft Amendment 1 to the Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands*, the selection of Rejected Option C was based on several factors including: (1) the critical size of the MCD is sufficient and the habitats present are adequate to potentially

Table 2: Monthly Fishing Activities in Federal Waters Southwest of St. Thomas, 1995-96

	Total		Potfish	
Month	# of trips	$/trip	# of trips	$/trip
July	48	844	29	948
August	72	798	46	813
September	46	1,000	30	934
October	37	828	27	778
November	46	758	30	838
December	48	744	31	809
January	47	896	34	845
February	41	926	31	772
March	42	1,003	23	902
April	53	834	33	763
May	52	842	32	905
June	53	811	38	813

protect reef fish, (2) the area South of St. John is still protected from urban pollution[34], coastal run-off, and development through the protection of afforded to the area of the National Park Service, and (3) the areas are linked from coastal nursery areas, shallow water and deep water reefs, sea grass beds, and algal plains to deep water (i.e., good representation of habitat). These considerations, while no guarantee, should be beneficial to stock enhancement both inside and outside the proposed MCD. In

[34] A reviewer of an earlier draft of this report suggests that the proposed MCDs associated with Option A and Option B are also not likely to be directly affected by land-based activities due to their offshore distance.

addition, information presented by Kojis (1997) suggests that larval dispersal outside the proposed MCD, to the extent it is significant, will likely be in the direction of St. Thomas.[35]

[35] Less information is available regarding the MCDs associated with proposed Options A and B. Nowlis (Northeast Fisheries Science Center, NMFS-NOAA), however, in a recent presentation to the Caribbean Fishery Management Council suggests that an MCD off the Southwest Coast of St. Thomas may be superior to one off the South Coast of St. John if a portion of the Territorial waters off St. Thomas is also closed. Without the additional closure of the Territorial waters, however, the performance of Option A (or Option B) relative to Option C is unknown.

Table 3.a: Trip and catch Information Based on 25 Identified Fishermen Who Reported Trips in St. Thomas SW Federal Waters, 1995-1996

	Trips [b]	Avg. Catch/Trip		Boat Length	Pots [d]
		lbs.	Value ($) [a]		
Trips Taken Inside St. Thomas SW Federal Waters					
Total	585	207	847	29.2	---
Potfish	384	240	840	30.7	71
Hookfish	51	129	517	20.6	---
Lobster	309	73	475	30.8	79 [d]
All Other Trips					
Total	928 (561)	152 (167)	668 (716)	27.3 (27.2)	--- (---)
Potfish	443 (254)	172 (186)	602 (651)	28.7 (28.7)	55 (57)
Hookfish	219 (184)	129 (140)	516 (561)	23.9 (24.1)	--- (---)
Lobster	451 (223)	82 (92)	532 (597)	29.2 (29.2)	56 [d] (48) [d]
Total Trips Taken					
Total	1513	174	737	28.0	---
Potfish	827	204	712	29.5	63
Hookfish	270	129	516	23.3	---
Lobster	760	78	509	29.8	67 [d]

Notes:

a. Estimated revenues per trip reflect the retail value harvests based on prices reported by Meyers for 1993-94. To the extent that larger vessels may not process and market their catch to the final consumer, the estimated revenues may be over-estimated.

b. Summation of trips by gear type will exceed total because some fishermen report harvesting more than one species on a given trip.

c. Numbers in parentheses reflect number of trips and related statistics pertaining to those trips in Federal Waters other that those in St. Thomas SW.

d. Average number of lobster pots is based only on that portion of identified fishermen reporting the use of lobster pots.

What are the expected benefits of the establishment of any of the three proposed MCDs in relation to increased stocks outside the reserve?[36] First, commercial harvest is expected to be enhanced resulting in a short-term increase in profits (producer surplus). Second, the increased harvest will result in a decline in price of the landed product, *ceteris paribus,* increasing the total level of consumer surplus derived from consumption of the landed product (based on the assumption that price responds to changes in landings). Third, increased fish stocks outside the reserve will result in higher levels of catch per trip in the recreational sector, resulting in increased consumer surplus in this sector of the fishing industry. Fourth, consumer surplus associated with non-consumptive activities, such as recreational diving, should be enhanced. The increase in benefits related to these activities may be significant. Finally, increased stocks outside the proposed MCD suggest that deterioration of the coral-reef habitat outside the MCD may be mitigated to the extent that the severity of community imbalance outside the marine reserve, in existence prior to the establishment of the MCD, is lessened.[37]

The short-term increase in profits in the commercial sector will, over time, induce new entrants into the fishery and is likely to encourage existing firms (fishermen) to expand individual levels of effort. This expansion of effort will, through time, lead to an erosion of profits (i.e., producer surplus) in relation to a decline in the catch per unit effort. Because the stock size outside the reserve can be maintained at higher levels than pre-MCD conditions, higher levels of consumer surplus, related to sustained higher commercial harvests in aggregate may be maintained over a long-run period of time. With respect to recreational fishing activities, a short-run increase in catch per trip, as noted in the previous paragraph, will encourage additional recreational fishing trips, assuming the demand for trips responds positively to increases in catch per trip. The additional number of trips will, in turn, tend to result in a reduction in catch per trip over time with a commensurate reduction in the per trip consumer surplus. Total consumer surplus related to recreational fishing activities may, however, remain at an enhanced level in the long run due to the overall increase in the number of trips. The long-run demand for non-consumptive activities should be enhanced in the long run in relation to sustained enhancement of stocks outside the reserve. This should, in the absence of any significant congestion externalities, result in a long run increase in consumer surplus to this segment of the population that receives utility from the

---

[36] The discussion of benefits is based, of course, on the premise that stock outside the proposed MCD will be enhanced by a "significant" amount over time in relation to "spillover" and larval displacement effects. If the enhancement is not "significant" benefits will be reduced accordingly and in the limit (i.e., no "spillover" or displacement effects) will tend towards zero.

[37] Whether the deterioration of the coral-reef habitat outside the MCD is mitigated in the long run may, to some extent, be related to the long-run change in effort outside the MCD in association to increased stocks outside the MCD. Specifically, as discussed in greater detail later in this RIR, an increase in effort outside the reserve in response to increased fish stocks may result in increased degradation of the coral-reef habitat via possible effects associated with the increased setting and hauling of traps over and around the coral reefs.

non-consumptive use of the resource.[38]. Finally, the long-run enhancement of fish stocks outside the MCD, associated with its establishment, indicates that partial or total restoration of community balance, and enhancement of the coral reefs therefrom, may be permanent in nature.[39]

6.0.2.2 Costs

As was the case with benefits, information which would allow comparison of costs associated with establishment of an MCD under each of the three alternative Options is, for the most part, lacking. Assuming costs are positive under each of the three alternative Options, however, one would expect them to be higher under Option B than under Option A. This reflects the fact that the proposed MCD associated with Option A is totally contained within the MCD which would be established under Option B.

1. *Opportunity costs associated with displacement of fishermen from their preferred fishing grounds.* To examine opportunity costs associated with displacement of fishermen from their preferred fishing grounds in association with establishment of a marine reserve , it is useful to begin discussion by stating the objective function of commercial fishermen. In lieu of any empirical information to the contrary, fishermen are assumed to maximize profits on a per trip basis subject to possible capital and/or time constraints. Stated formally, this can be represented as:

$$\max Đ_t = TR_t - TC_t \quad s.t. \ (\ capital,\ time\ ) \qquad (1)$$

where $\max Đ_t$ is equal to maximum per trip profits, TR_t is equal to per trip revenues, and TC_t is equal to per trip total variable costs. Expressed somewhat differently, the assumed function can be given as follows:

$$\max Đ = P_Q Q + p_x X \qquad (2)$$

---

[38] Congestion externalities with respect to non-consumptive activities (such as diving) may exist if, for example, utility associated with, say, solitude is diminished due to an excessive number of divers in the immediate vicinity.

[39] The permanent nature suggested herein reflects the fact that establishment of an MCD, to the extent it is effective in restoring community balance, enhances the coral reef inside the MCD which, *de facto*, results in an increased carrying capacity. This is akin to an increase in the parameter *k* in the standard Schaefer model. Within the confines of this scenerio, the "traditional" sustainable yield curve of the fishery will be enhanced at all levels of effort. This increase, however, must be weighed against the potential for increased degradation outside the MCD and the reduction in carrying capacity associated therefrom.

Where P_Q is the price received by the fisherman for the harvested product, Q is the quantity harvested on a per trip basis, p_x represents a vector of input prices used in the production process, and X represents a vector of inputs employed in the production process expressed on a per trip basis.(for purposes of convenience, the subscript t is omitted but all discussion refers to a per trip basis).

To evaluate the potential dislocation costs of establishing an MCD associated with any of the three alternative Options outlined in Section 6.0 on the short-run objective function of the individual fisherman, it is useful to rewrite equation (2) as follows

$$\max \pi = P_Q Q - (p_{x1} X_1 + p_{x2} X_2) \qquad (3)$$

where X_1 represents a vector of inputs which will not be impacted by establishment of a marine reserve, e.g., costs associated directly with hauling pots in the potfish fishery, while X_2 represents a vector of inputs that will likely be impacted (e.g., change in fuel costs per trip and the opportunity costs of time associated with running to less preferable fishing locations). The terms p_{x1} and p_{x2} represent respective vectors of input prices (i.e., costs).

Holding quantity of output Q constant, the change in profits due to a change in preferred fishing location (PL) can be expressed as [40]

$$\frac{\partial \pi}{\partial PL} = \overline{Q} = P_{x2} \frac{\partial X_2}{\partial PL} \qquad (4)$$

Where $P_{x2} \frac{\partial X_2}{\partial PL} > 0$ represents the change in costs to the fisherman on a per trip basis due to a change in input usage. [41] Alternatively, the fisherman may choose to hold costs related to traveling

[40] The variable PL is treated as continuous for purposes of the theoretical model. While this is certainly not the case in reality, the same conclusions would certainly be reached if a discrete model was employed for analysis.

[41] For purposes of the theoretical model, it is assumed that fishermen will have to travel more, rather than less, to harvest the same amount of product under implementation of the Adopted Measure. Intuitively, this assumption appears valid. Specifically, if a fisherman could, under present conditions, catch the same amount of product at a location closer to point of embarkment as that in the proposed MCD, traveling to the MCD site would, in fact, represent a reduction in potential profits, *ceteris paribus* due to increased traveling costs and the associated costs of one's time. In addition, it should be noted that the assumption is implicitly being made that other areas, more distant than the proposed MCD, which will yield higher catches per trip are available to the fishermen. The validity of this assumption is unknown.

constant but allow output to vary in response to a change in location fished (PL). This can be expressed as:

$$\frac{\partial \Pi}{\partial PL} * \overline{X_2} = P_Q \cdot \frac{\partial Q}{\partial PL} - \left(\frac{\partial Q}{\partial PL} \cdot \frac{\partial X_1}{\partial Q} \right) \cdot P_{x1} \qquad (5)$$

where $P_Q \cdot \frac{\partial Q}{\partial PL}$ represents a lower level of revenues on a per trip basis, and the second term $\left(\frac{\partial Q}{\partial PL} \cdot \frac{\partial X_1}{\partial Q} \right) \cdot P_{x1}$ represents a reduction in harvesting cost associated with a reduction in harvest. Given the maintained hypothesis of profit maximization, the reduction in revenues (i.e., the first term on the right-hand side of equation 5) will necessarily exceed the reduction in harvest costs (i.e., the second term).

While both of these decisions represent a reduction in profits (Π) on a per trip basis, neither fulfills conditions of the stated objective function, i.e., maximization of profits. To do so, quantity (Q) and inputs (X_1 and X_2) must be allowed to vary simultaneously, or

$$\frac{\partial \Pi}{\partial PL} = P_Q \cdot \frac{\partial Q}{\partial PL} - \left(\frac{\partial Q}{\partial PL} \cdot \frac{\partial X_1}{\partial Q} \right) \cdot P_{x1} - P_{x2} \cdot \frac{\partial X_2}{\partial PL} \qquad (6)$$

In the profit maximizing case, the fisherman will likely incur both a change in costs (i.e., $\partial X_2/\partial PL$) from traveling a different distance , some change in catch (i.e., $\partial Q/\partial PL$), and some change in costs related to a change in catch (i.e., $(\partial Q/\partial PL * \partial X1/\partial Q)*P_{x1}$). If they travel a shorter distance, the change in costs will be less than zero. The change in catch will also, presumably, be less than zero (otherwise, it would not have been economically rationale for them to travel a greater distance). Furthermore, it can be stated with certainty that the reduction in catch, which can be transformed to revenues by multiplying by a constant output price, will exceed the reduction in costs, *ceteris paribus*. This indicates that profits will be reduced.

Though the information necessary to estimate equation 6 is lacking, sufficient information does exist to help ascertain whether displacement costs will occur and , to a lesser extent, the degree of displacement.. In total, 25 individuals were identified in the Virgin Island trip ticket data base as having fished in the Federal waters Southwest of St. Thomas in 1995-96[42] (data pertaining to commercial

[42] This figure is likely to be somewhat lower than the actual number of fishermen due to the fact that a certain percentage of licensed fishermen due not submit the required trip ticket information. Assuming the group not submitting the trip ticket information is not significantly different from the group submitting the required information, the analysis and results discussed herein should not be seriously

fishing activities in the Virgin Islands is collected on a July through June basis). The fishermen reported a total of 1,513 trips, which translates to an average of approximately 60 trips per fisherman (see Table 3.a). Of the total 1,513 trips reported by the 25 identified individuals, 585, or almost 40%, were made in the Federal waters Southwest of St. Thomas; the area encompassing the proposed Options A and B outlined in Section 6.0. Overall, 19 of the identified 25 fishermen in this category (76%) made 50% or less of their total trips in the Federal waters Southwest of St. Thomas while more than 40% of the group of fishermen in this category made less than one-quarter of their total trips in the Federal waters Southwest of St. Thomas.

Rejected Option C encompasses the Federal waters South of St. John. The Virgin Island trip ticket data base for 1995-96 identifies 21 individuals fishing in this area. The total number of trips reported by these identified fishermen equaled 1,061, or approximately 50 per fisherman (see Table 3.b on following page). Of the total 1,061 trips reported by the 21 identified individuals, 283, or 27%, were made in the Federal waters South of St. John (the area encompassing Rejected Option C). Overall, two-thirds of the 21 identified fishermen in this category made 50% or less of their total trips in the Federal waters South of St. John (i.e., the area encompassing Rejected Option C) while 40% of the fishermen made less than one-quarter of their total trips in the Federal waters South of St. John.

The 25 identified individuals who reported fishing activities in the Federal waters Southwest of St. Thomas in 1995-96 (i.e., the area associated with Options A and B), made a total of 827 trips where potfish was harvested, 46% (i.e., 384) of which were made in the area of the proposed MCDs associated with Options A and B (i.e., the Federal waters Southwest of St. Thomas). This group of fishermen also made 270 trips where hookfish was harvested, 51 of which (i.e., 19%) were made in the area of the proposed MCDs associated with Options A and B. Finally, about 40% of the 760 trips where lobster was harvested by the 25 identified fishermen who reported fishing activities in the Federal waters Southwest of St. Thomas in 1995-96 were taken in the area of the proposed Options A and B.[43]

The 21 identified individuals who reported fishing activities in the Federal waters South of St. John in 1995-96 (i.e., the area associated with Rejected Option C) made a total of 433 trips where potfish was

---

flawed. The same general comment holds with respect to the analysis and discussion presented with respect to option C.

[43] Two points need to be made regarding the current and ensuing discussion based on trip ticket data. First, for purposes of analysis, catch information reported by fishermen who reported fishing in both Territorial and Federal waters on a given trip was all allocated to Federal waters. Hence, the catch from Federal waters will be somewhat overstated. Second, the proposed MCDs associated with the three different Options outlined in Section 6.0 of this report all cover a somewhat smaller area than the Federal water designation used in the respective analyses. This factor will also tend to inflated the estimated proportion of the total catch from the areas contained in the proposed MCDs associated with the three alternative Options.

harvested, 36% (i.e., 158) of which were made in the area of the proposed MCD associated with Rejected Option C. Of the 283 trips where hookfish was harvested by the 21 fishermen who reported fishing activities in the Federal waters South of St. John, 28% were made in the area of the proposed MCD associated with Rejected Option C. Finally, about 15% of the 422 trips where lobster was harvested by the 21 fishermen who fished in the Federal waters South of St. John in 1995-96 occurred in the area of the proposed MCD associated with Rejected Option C.

Catch among the 25 identified fishermen who reported activities in the Federal waters Southwest of St. Thomas in 1995-96 (i.e., the area of the proposed MCDs associated with Options A and B outlined in Section 6.0) equaled 174 pounds per trip, with associated per trip revenues of $737.[44]

[44] Revenues were calculated by multiplying quantity landed by the respective retail price as reported in the 1992-93 published landings statistics for the United States Virgin Islands. To the extent that some fishermen do not market their harvest directly to the final consumer (see Impact Assessment, Inc.), estimated revenues per trip will be somewhat inflated.

Table 3.b: Trip and Catch Information Based on 21 Identified Fishermen Who Reported Trips in St. John Federal Waters, 1995-1996

	Trips [b]	Avg. Catch/Trip		Boat Length	Pots [d]
		lbs.	Value ($)[a]		
Trips Taken Inside St. John Federal Waters					
Total	283	147	609	28.0	---
Potfish	158	173	607	26.7	52
Hookfish	79	75	300	29.3	---
Lobster	65	118	770	31.1	104 [d]
Trips Taken Outside St. John Federal Waters					
Total	778 (366)[c]	171 (210)	734 (900)	29.6 (31.2)	--- (---)
Potfish	275 (160)	258 (319)	904 (1,119)	30.7 (32.1)	64 (72)
Hookfish	204 (85)	94 (53)	377 (213)	28.7 (31.7)	--- (---)
Lobster	357 (169)	92 (112)	598 (732)	31.6 (30.7)	90 [d] (89)[d]
Total Trips Taken					
Total	1061	165	701	29.1	---
Potfish	433	227	796	29.2	60
Hookfish	283	89	356	28.9	---
Lobster	422	96	624	31.5	92 [d]

Notes from Table 3.b:

a. Estimated revenues per trip reflects the retail value harvest based on prices reported by Meyers for 1993-94. To the extent that larger vessels may not process and market their catch to the final consumer, the estimated revenues may be over-estimated.

b. Summation of trips by gear type will exceed total because some fishermen report harvesting more than one species on a given trip.

c. Numbers in parentheses reflect number of trips and related statistics pertaining to trips taken in federal waters outside the federal waters south of St. John.

d. Average number of lobster pots is based only on that portion of identified fishermen reporting the use of lobster pots.

For the 585 trips made within the Federal waters Southwest of St. Thomas by this group of fishermen, revenues per trip equaled $847, on average, or almost $180 per trip more than the $668 estimated for the 928 trips reported outside the Federal waters Southwest of St. Thomas by the 25 identified

fishermen.[45] Potfish revenues among the 25 fishermen who reported activities in the Federal waters Southwest of St. Thomas averaged $712 per trip, on average. This figure is based on per trip revenues of about $600 for the 443 trips outside the area of the proposed MCDs associated with Options A and B and per trip revenues of $840 for the 384 trips taken within the Federal waters of Southwest St. Thomas (i.e., the area of the proposed MCDs associated with Options 1 and 2).[46] Estimated hookfish revenues per trip for the 51 trips within the area of the proposed MCDs associated with Options A and B (i.e., Federal waters Southwest of St. Thomas), however, were not found to be different than the average hookfish revenues per trip outside the Federal waters Southwest of St. Thomas (approximately $515 per trip). Finally, per trip revenues received from lobster-based activities by the 25 identified individuals who fished in St. Thomas Southwest Federal waters averaged $509 for the 760 lobster trips taken in total. For the 309 reported lobster trips occurring in the Federal waters Southwest of St. Thomas, average revenues per trip equaled $475. This figure is almost $60 less per trip than the $532 reported for the 451 lobster trips outside the Federal waters Southwest of St. Thomas.

Catch among the 21 identified fishermen who reported activities in the federal waters South of St. John in 1995-96 (i.e., the area of the proposed MCD associated with Rejected Option C outlined in Section 6.0) averaged 165 pounds per trip, with associated per trip revenues of about $700.[47] For the 283 trips made within Federal waters south of St. John by these 21 fishermen, revenues per trip equaled $609, on average, or about $125 less than the $734 estimated for the 778 trips reported outside the Federal waters South of St. John. Potfish revenues per trip among the 21 identified fishermen equaled $795 per trip, on average. This figure is based on per trip revenues of about $900 for the 275 trips taken outside the Federal waters South of St. John and per trip revenues of slightly more than $600 for the 158 trips taken within the Federal waters South of St. John (i.e., the area of the proposed MCD associated with Rejected Option C).[48] Similarly, estimated revenues per trip associated with hookfish activities averaged about $70 less inside the Federal waters South of St. John (i.e., the area of the propose MCD associated with Rejected Option C) than outside the area (i.e., $300per trip compared with $370 per trip). Finally, per trip revenues received from lobster-based activities by the 21 fishermen who reported fishing activities in Federal waters South of St. John in 1995-96 averaged

---

[45] Among Federal trips reported by the 25 identified individuals, exclusive of those in Federal waters Southwest of St. Thomas, revenues per trip equaled $716, on average, based on a total of 561 trips.

[46] Two- hundred-and-fifty-four of the 443 trips taken outside the Federal waters Southwest of St. Thomas by the 25 identified fishermen occurred in Federal waters, or approximately 57% of the total. Average revenues among the 254 trips equaled $651, on average.

[47] Among Federal trips reported by the 21 identified individuals, exclusive of those in Federal waters South of St. John, revenues per trip equaled $900, on average, based on a total of 366 trips.

[48] One-hundred-and-sixty of the 275 potfish trips taken outside the Federal waters South of St. John by the 21 identified individuals occurred in Federal waters, or about 60% of the total. Average revenues among the 160 trips occurring in the Federal waters equaled $1,119, on average.

$770 within the Federal waters South of St. John compared to about $600 outside the Federal waters South of St. John.

The previous discussion regarding trips and catch per trip (and related per trip revenues) among the 25 identified fishermen who reported fishing activities in the Federal waters Southwest of St. Thomas (i.e., the area of the proposed MCDs associated with Options A and B in Section 6.0) and the 21 identified fishermen who reported fishing activities in the Federal waters South of St. John (i.e., the area of the proposed MCD associated with Rejected Option C) leads to several findings. First, a relatively large percentage of the 25 identified individuals who reported fishing activities in Federal waters Southwest of St. Thomas in 1995-96 utilized these waters for a relatively small proportion of their total overall fishing activities, when evaluated on the basis of trips. This same conclusion holds but to an even greater extent among the 21 identified individuals who reported fishing activities in the Federal waters South of St. John in 1995-96. A second finding is that catch per trip (and related revenues) within the Federal waters Southwest of St Thomas (i.e., the area of the proposed MCDs associated with Options A and B) tended to be substantially higher than outside these waters among the 25 individuals who utilized the Federal waters Southwest of St. Thomas in 1995-96.[49] Conversely, catch per trip (and related revenues) within the Federal waters South of St. John (i.e., the area of the proposed MCD associated with Rejected Option C) tended to be lower than outside these waters among the 21 individuals who utilized the Federal waters South of St. John in 1995-96.

Much of the differences in reported catch per trip, as discussed above, is the result of differing levels of effort used in the respective areas. For example, potfish revenues in the Federal waters Southwest of St. Thomas averaged $840 per trip by the 25 fishermen reporting harvests from this area while this same group of fishermen reported potfish revenues averaging only $602 in other areas fished. However, average number of pots hauled per trip in the Federal waters by this group of fishermen equaled 71 compared to only 55 outside the Federal waters Southwest of St. Thomas. These figures suggest revenues per trap haul of $11.80 within the Federal waters Southwest of St. Thomas compared to $10.95 elsewhere. Similarly, potfish revenues per trip in the Federal waters South of St. John equaled $607, on average, among the 21 identified fishermen who reported fishing activities in the Federal waters South of St. John in 1995-96. Potfish revenues outside these Federal waters by the same group of fishermen averaged $904 per trip. The number of pots hauled per trip in the Federal waters averaged only 52, however, compared to 64 outside the Federal waters South of St. John. On a per haul basis, these figures translate into revenues of $11.70 within the Federal waters South of St. John compared to $14.12 outside the Federal waters being considered.

---

[49] The significantly higher overall catches and revenues from the Federal waters Southwest of St. Thomas primarily reflects, as indicated from the information contained in Table 3, higher potfish catches. Specifically, average potfish catch in the Federal waters Southwest of St. Thomas equaled 240 pounds per trip within the Federal waters (i.e., the area of the proposed MCDs associated with Options A and B) compared to only about 170 pounds per trip outside the St. Thomas Southwest Federal waters.

Overall, the discussion and supporting information leads to two general conclusions. The first one is that the vast majority of the fishermen who target species in the areas of the three proposed Options tend to be relatively mobile. This suggests that they can compensate, to a large extent, for an area closure by moving gear to different areas. The discussion and supporting information also suggests that catch (and associated revenues) per trip, after accounting for differences in the level of gear employed tends not to differ significantly, in many cases, between the areas of the proposed MCDs and other areas not being considered for closure. Both of these conclusions suggest that displacement costs are probably relatively small. As further evidence that displacement cost are probably low, no evidence of displacement was apparent when examining the red hind grouper closure during the months of December through March (see Table 2).

The charter boat fleet in the St. John area, as noted by Impact Assessment Inc. (1997), generally operates vessels in the 25 foot to 48 foot range. In total, four vessels fall in the 25 foot to 31 foot range while another seven vessels fall in the 40-foot to 48-foot range. Fishing in the MCD which would be established under Rejected Option C by this fleet is relatively common, particularly in the winter months when weather conditions prevent extensive charter activities on the north side (Impact Assessment Inc., 1997). This fleet will likely experience some minor short-run displacement costs associated with the establishment of the proposed MCD. No information is available to ascertain potential displacement costs of the charter boat fleet in the St. Thomas area that would be forthcoming with adoption of Option A or Option B.

Finally, analysis by Impact Assessment Inc.(1997) also indicates that the MCD associated with Rejected Option C is frequented by the recreational sector. As such, this group may also experience some displacement costs associated with the establishment of an MCD. Potential displacement costs to the recreational sector associated with adoption of Option A or Option B is unknown due to lack of relevant information pertaining to the recreational sector in St. Thomas.

In general, one can state that the displacement costs associated with establishment of an MCD under Rejected Option B will exceed those associated with establishment of an MCD under Option A because the MCD specified under Rejected Option B contains all the area within the MCD specified under Option A plus additional area (approx. seven square miles more). There is insufficient information, however, to compare potential displacement costs which would be incurred under Rejected Option C with those of either Option A or Rejected Option B.

2. Costs related to stock and crowding externalities related to displacement of fishermen associated with establishment of an MCD. As noted, up to seven percent of the total fishing effort occurs in the area of the MCD to be established under Rejected Option C and upwards of 10% of the total reported harvest is taken from the region.[50] Displacement of this effort to areas outside the

[50] As previously noted, these figures should be considered upper-bound estimates because the area delineated as Federal waters South of St. John includes the entire area of the proposed MCD and a

proposed MCD will likely result in a short-run increase in both stock and crowding externalities given the apparent heavily fished nature of many of the species in the region and the limited amount of shelf area available to fishing activities.[51]

The stock externality is expected to result in a reduction in catch per fisherman, the extent of which depends on: (1) the amount of displaced effort which is transferred to areas outside the proposed MCD and (2) the biological status of the targeted stocks. Profits per trip (i.e., per trip producer surplus) will fall by a significantly higher amount than the decline in catch (or revenue) due to the overall relationship between revenues and costs. Given the heavily fished nature of many of the species (indicating that total catch will respond only minimally to further increases in effort), reduction in short-run profits (i.e., producer surplus) may be sizeable.

The crowding externality associated with the limited shelf area is expected to result in a higher level of costs per unit of effort independent of catch or other factors. While the short-run costs (i.e., reduction in producer surplus) associated with this externality is thought to be positive, it may be relatively minor.

If stocks outside the proposed MCD expand over time as the result of spillover and larval dispersal effects, the initial impacts on fleet profitability will be positive. This, however, may encourage additional capital in the fishery which could exacerbate crowding externalities.

In general, one would expect the crowding externality costs associated with establishment of the MCD under Rejected Option B to exceed those associated with Option A.

3. Costs related to a short-run (and possibly long-run) reduction in consumer surplus associated with establishment of an MCD. As noted above, establishment of an MCD associated with any of the three Options is expected to result in a reduction in the overall level of harvest in the short run. Assuming price of the landed product is negatively related to quantity harvested, the short-run reduction in harvest will result in a commensurate reduction in consumer surplus.[52] Furthermore, if long-run

---

sizeable amount of additional area.

[51] It is possible that the reduction in profits in the short run may lead to a large amount of exit from the fishery mitigating the initial impacts related to both the stock and crowding externalities.

[52] The validity of the assumption that price responds to changes in local landings may be somewhat tenuous and depends strongly on the availability of substitute products, primarily imported product. Specifically, if price is invariant to quantity produced (implying a horizontal demand curve) then changes in local production will have no impact on consumer surplus. If for example, there exists perfect substitutability of imported product for domestic landings, demand for imports can be specified as follows (see Goldstein and Kahn 1985)

$D = f(P, Y)$ $\quad f_1 < 0, f_2 > 0$
$S = g(P, F)$ $\quad g_1 > 0, g_2 < 0$
$I = D - S$

increases in harvestable stocks, emanating from "spillover" and egg dispersal impacts associated with establishment of the MCD, do not occur, as predicted, long-run losses in consumer surplus related to long-run reductions in domestic harvests become a distinct possibility.

4. Costs related to deterioration of ecosystem stability outside the MCD. Displacement of fishing effort in association with the establishment of an MCD in association with any of the three Options will result in a short run increase in effort in the remaining shelf area open to harvesting.[53] This will, in the short run, result in increased deterioration of the habitat outside the proposed MCD. Furthermore, if "spillover" and/or egg dispersal effects are positive and significant, additional effort (including recreational fishing activities) will be directed in those areas outside the MCD suitable to fishing activities. This will place further stress on the habitat (particularly coral reef) outside the proposed MCD.[54] Interestingly, while profits in the commercial fishery may be dissipated in the long run in association with increased effort, stocks will not fall to pre MCD levels (assuming they remain successful over time with respect to "spillover" and egg dispersal effects). Hence, overall effort will, in the long run, exceed that which was being sustained, at a lower stock size, before establishment of the proposed MCD, *ceteris paribus*. This increased effort, furthermore, will be distributed over a smaller area, suggesting higher habitat degradation per unit of effort than that which prevailed prior to establishment of the MCD.[55] The increased habitat degradation, while not quantifiable, represents a

---

where D is the total quantity of species' imports (related to those being impacted by the proposed MCD) in the U.S.V.I., S is the supply of the species' produced in St. Thomas and St. John, P is the domestic price of the species' , Y and F are money income and factor costs, and I is equal to imports. In this relatively naive model, the demand for imported product represents and "excess" demand for the locally produced product. Assuming demand and supply conditions in the U.S.V.I. are too small to effect the world price of the product, an increase (decrease) in the domestic supply will reduce (increase) import demand directly with no corresponding price change.

[53] It is possible that stock and crowding externalities are sufficiently large in magnitude that overall level of effort in the fishery is reduced by a significant amount in the short run. If this occurs, habitat degradation associated with increased concentration of effort in a more confined area may be minimized. Empirical evidence on other fisheries suggests a certain amount of 'stickiness' in relation to vessels exiting.

[54] A reviewer of the initial draft of this RIR questioned whether further deterioration of the habitat outside the MCD would occur in association with increased effort. Specifically, he suggested that the habitat outside the MCD is likely already so degraded that additional effort would have only minimal, if any, impacts. This is an empirical issue for which no information exists. To the extent that further degradation will not be forthcoming, however, associated costs related to habitat degradation will be minimal.

[55] The distribution of effort over a smaller area is of particular relevance if "spillover" effects are very large. Specifically, stocks will be highest on the outside fringes of the MCD and will decrease in relation to distance from the MCD. In a situation such as this, effort is expected to be very high on the MCD fringes and decline in relation to the decline in stock as one moves away from the MCD. It follows, if the coral reef within the MCD is of particular importance, the coral reef on the fringes of the MCD will also be relatively important.

loss to society and, hence, a potentially significant cost which needs to be recognized. And interestingly, the more successful the MCD at increasing stock outside the reserve, the greater the potential environmental degradation and costs to society.[56]

6.0.2.3 Summary of Benefits and Costs

Benefits associated with the adoption of any of the three Options establishing an MCD, as analyzed in Section 6.0.2.1, while potentially large, were found to accrue primarily in the future. Costs, with the exception of long run habitat degradation, were found to occur in the short run. These costs, particularly when including those associated with the potential increase in habitat degradation, were also potentially large. If "spillover" and larval dispersal effects are significant, no conclusion can be drawn regarding benefits associated with adoption of any of the three Options relative to costs, because much of the economic outcome would depend on the value of habit outside the MCD that was being damaged. Specifically, the following benefits and costs associated with establishing an MCD were identified in the preparation of the RIR:

Benefits:

1. Existence and option values associated with the protection of nature within the confines of an MCD. This benefit, under establishment of any of the three MCDs associated with the three alternative Options, was estimated to be positive. The structure of the coral reefs in association with Options A and B appear atypical to those generally observed throughout much of the U.S. Virgin Islands and, hence, potentially increasing the existence and option values associated with these sites. Insufficient information regarding the characteristics associated with coral reefs in the area of Option C limits meaningful discussion regarding existence and option values except to say that they are positive.

2. The value of biological diversity associated with the protection of nature within the confines of any of the three proposed MCDs. In particular, the benefits associated with restoring community balance outside the proposed MCDs may be large. While positive, based on the assumption that the sizes of the proposed MCDs are sufficient, no quantitative estimates could be established. To the extent, however, that the area associated with Option A and Option B is known to support spawning aggregations for several species, one might expect that the value of biological diversity associated with either of these two Options may exceed that associated with the creation of an MCD in accordance to Option C. Specifically, the issue of whether biological diversity will be preserved/enhanced if an MCD is created South of St. John is, due to lack of empirical data, more speculative than if an MCD is created Southwest of St. Thomas where known aggregations occur. Finally, to the extent that the MCD created under Option B includes in entirety the MCD created under Option A plus

[56] These environmental degradation costs must, of course, be weighed against potential environmental benefits associated with an increased ecosystem stability.

additional area, one would generally expect the value of biodiversity under Option B to exceed that under Option A.

3. Value associated with avoidance of large potential losses that may occur when common access is the only viable alternative. The problems associated with managing a multi-species and multi-gear fishery such as that present in the United States Virgin Islands was discussed in section 6.0.1. An MCD, to the extent that it protects older fish, can thus be considered as an insurance policy against large potential losses.

4. Value associated with the potential increase in commercial and recreational harvests outside the MCD emanating from conserving species within the MCD. This value, while believed to be positive could not be quantified. In general, to the extent that the "spillover" and egg dispersal effects associated with creation of an MCD are forthcoming, creation of an MCD is akin to increasing carrying capacity. As such, populations outside the MCD may be enhanced even in the long run. As such, consumer surplus associated with the harvested product may increase, even in the long run. Also, long-run consumer surplus derived from non-consumptive activities, such as diving, may be enhanced.

Costs:

1. Opportunity costs associated with displacement of fishermen from preferred fishing grounds. This cost, while positive, is thought to be relatively small under each of the three proposed MCDs due to the large degree of mobility among fishermen. This conclusion is supported by empirical evidence. With respect to Options A and B, for instance, little or no movement outside the St. Thomas Southwest quadrant was evident during the three-month period during which time the Hind Bank is closed to potfish activities suggesting that dislocation costs associated with a permanent closure of the Hind Bank may be relatively minor.

2. Costs related to stock and crowding externalities. Implementation of any of the three proposed MCD sites will result in an increased concentration of effort in the remaining shelf area. As a result, crowding externalities, as a result of an MCD implementation, are anticipated to be positive. Given available evidence, however, they are anticipated to be relatively minor.

3. Costs related to short-run (and possibly long run) reduction in consumer surplus associated with establishment of an MCD. Establishment of an MCD is expected to result in a reduction in the overall level of harvest in the short run. The short-run reduction in harvest will likely result in a commensurate reduction in consumer surplus.

4. Costs related to deterioration of ecosystem stability outside the MCD. Depending on the overall condition of the current fishing grounds, establishment of an MCD may result in the long-run degradation of the habitat outside the MCD. Specifically, if the MCD is successful

at increasing the stock of fish outside the MCD, long-run effort outside the MCD can be expected to expand. To the extent that the fishing area outside the MCD is not already severely degraded, the increase in effort may result in habitat degradation.

Interestingly, the establishment of an MCD associated with any of the three Options considered may be more justified, on the basis of welfare economics, if "spillover"and egg dispersal effects are not significant. In this situation benefits still accrue in terms of maintaining biodiversity, existence and option value, and insurance. Two primary benefits, however, will be foregone. These two benefits reflect increased consumer surplus (passive use values and the possible decline in price associated with a long-run increase in commercial harvest) and the ecosystem stability provided by increased grazing stocks (see Section 2.0 for a discussion of the importance of grazing species in a coral reef community) outside the MCD. While these two benefits will be foregone in the absence of "spillover" and egg dispersal effects, costs may also be reduced by a significant amount. In the absence of "spillover" and egg dispersal effects, specifically, long-run effort is not expected to increase significantly, *ceteris paribus*. Without this long-run increase in effort, increased habitat degradation caused by anchoring, traps, etc. will not subsequently forthcoming.

Based on the previous discussion, some conclusions can be drawn as to conditions under which the expected net benefits associated with the three alternative Options would be less than, greater than, or about equal to the benefits under the status quo. Specifically, if costs related to deterioration of the ecosystem outside the MCD are minor, than net benefits associated with adoption of any of the three proposed Options are expected to be positive. The larger the deterioration, however, the smaller becomes the net benefits and if deterioration is large, net benefits will likely be negative. The extent of the deterioration is, as previously noted, a function of several empirically unknown factors. The first of these factors is the current condition of coral-reef ecosystem outside the proposed MCDs. If the coral reefs outside the proposed MCDs are already heavily degraded, then creation of an MCD will have little to no additional negative impact. The second of these factors is the extent of "spillover" and egg dispersal effects that will be forthcoming in association with creation of an MCD. If this factor is minor (i.e., the "spillover" is small, then the creation of an MCD will have little to no additional negative impact on ecosystem stability outside the MCD. Finally, the response in effort to changes in stocks outside the proposed MCDs will influence the ecosystem stability outside the MCD. Specifically, if responses in effort in relation to increases in stock size are minor, then there will be little additional degradation of the ecosystem outside the MCD.

Option 1A, as outlined in Section 6.0, calls for maintaining the status quo (i.e., no establishment of an MCD). The costs of maintaining the status quo would be the loss in benefits, as outlined above, which would be derived from the establishment of an MCD. The benefits of maintaining the status quo would be the absence of costs, as outlined above, which would be forthcoming if a MCD is created.

Possible alternatives to activities within the MCD established within the framework of Option C as originally set forth by the Council: Note; these alternatives are with respect only to Option C because the MCDs that would be established under Options A and B are designated as no take. Also, the following discussion applies only to the consideration of activities that were considered under Option C (South of St. John).

Alternative 1: No Take within the MCD established through the management measure above.

This alternative is similar to Rejected Option C but more stringent. Specifically, removal of organisms for restoration, educational, or scientific purposes would also be prohibited or would be allowed under permit on a case by case basis. The value of these organisms for educational and/or scientific purposes is unknown. If an MCD is established, therefore, it is not known whether Option C is superior to Alternative 1 based on relative benefits and costs. Given the fact, however, that much of the information that would be required for educational and scientific purposes could be collected using non-extractive methods (e.g., videotaping etc.), the benefits associated with allowing any take for these purposes appear to be relatively minimal.

Alternative 2: Allow hand lines or floating within the MCD established through the management measure above.

This alternative management measure is a less restrictive measure than Rejected Option C. As indicated by the information contained in Table 1, hookfish activities within the proposed MCD associated with Option C are relatively minor in relation to the total number of hookfish trips reported by St. Thomas and St. John fishermen in 1995-96. Furthermore, the overall level of hookfish harvest within the proposed MCD area is relatively small compared to the total (an estimated 7.3% of the total).

The costs of allowing hand lines or floating within the proposed MCD associated with Option C include at least three separate components. First, there exists an increased probability of coral reef degradation related to anchoring activities associated with floating. Second, enforcement becomes more complicated and, hence, potentially costly. Finally, while little is known of the characteristics of the ecosystem within the proposed MCD, it is likely that taking fish by hand lines or floats will result in an imbalance in the ecosystem and, hence, a deterioration in its overall condition.

The benefits of allowing hand lines or floating within the proposed MCD include potentially higher profitability (producer surplus) and a potentially lower price to the consumer (consumer surplus). Given the small amount of reported hookfish product taken from the area, however, potential benefits appear to be small.

Overall, the RIR concludes that if an MCD is established, Option C is superior to Alternative 2 based on relative benefits and costs.

Alternative 3: Prohibit all gear except trolling within the MCD established through the management measure above.

This alternative management measure is less restrictive than the Option C but more restrictive than Alternative 2. As such, the expected benefits derived from this proposed measure are less than those derived in Alternative 2 but costs are also reduced.

Specifically, the probability of coral reef degradation due to anchoring activities is minimized within the context of Alternative 3. Also, complications with enforcement are minimized since it can (presumably) easily be established whether a vessel is trolling in the MCD. Finally, as noted in the Amendment, trolling activities are unlikely to affect the coral reef ecosystem, particularly if planners are prohibited.

Benefits, as noted, are potentially minor. This claim is especially true if the species harvested by trolling gear tend to migrate through the area of the proposed MCD. It is noted in the Amendment that trolling has been known to harvest yellowtail and other reef fish assemblage species.

Overall, the RIR cannot conclude whether Option C is superior to Alternative 3 on the basis of relative benefits and costs.

Alternative 4: No Action

Overall, the examination of benefits and costs associated with Option C suggested that potential benefits associated with the establishment of an MCD could be significant. It also identified that potential costs could be significant. A determination as to whether benefits exceeded costs could not be made. As such the RIR cannot conclude whether the Option C is superior to Alternative 4 on the basis of relative benefits and costs. It is worthwhile noting, however, that if action is taken, long-term management costs, primarily associated with enforcement will be incurred (see Section 8.0). As such, the MCD net discounted benefits (associated with Option C) over the time period of analysis (assuming they are positive) would have to exceed the discounted costs of management to have a determination of an expected increase in overall net benefits.

7.0 OPTIONS CONSIDERED BUT REJECTED

Rejected Option D: (see draft Amendment 1 pages 37-38)

This option is practically the same as current Option C except that the Southern most boundary, following the 100 fathom contour line, would also be included in the MCD and, hence, would be considered a no take area.

There is, overall, little or no information which allows comparison of the original Option B with the current Option C. To the extent that this option encompasses a larger area than the current Option C,

overall costs will likely be somewhat larger. Given that benefits are also likely to increase in relation to MCD size, this option may yield some additional benefits not provided within the context of the current Option C. Whether the additional costs are justified by the commensurate increase in benefits is unknown.

Rejected Option E, F and G: (see draft Amendment 1 pages 38-41)

Since any fish migrating to the east would enter BVI waters, potential losses would accrue to U.S.V.I. fishermen in the form of profits (producer surplus). Also, there may also be a reduction in consumer surplus vis-a-vis any of the proposed current Options due to lower available supply and associated higher price. Third, recreational fishing activities by U.S.V.I. residents and tourists visiting the islands may be lower than that associated with any of the three proposed current Options indicating a potential loss in consumer surplus due to a reduction in demand for recreational activities.

8.0 MANAGEMENT COSTS

One of the management measures included in the Coral FMP called for the establishment of a Marine Conservation District (MCD) (marine reserve) south off St. John, USVI. The measure became a controversial one specifically, in the USVI. The Council decided to hold a series of meetings with the fishers from the area of the proposed MCD to discuss the pertinent data and issues related to the reserve. On March 15, 1994, a Workshop on Marine Reserves was held in St. Thomas, USVI. Experts from NOAA/NMFS and from different Caribbean countries presented their findings and experiences regarding marine reserves established in the continental US and in the Caribbean. On June 22, 1994, the MCD Sub-Committee met in St. Thomas, USVI. On August 30, 1994, the MCD Work Group met in St. Thomas, USVI. On September 28, 1994, one Council member and three staff members met with fishers in St. John, USVI.

At its 82nd Meeting, the Council discussed the possibility of cooperation with the BVI government to establish an MCD contiguous to the USVI. Government officials from the BVI were invited to these meeting. At the 83rd Meeting, the Council decided that the management measure to establish the MCD proposed in the Coral FMP was to be reserved and that the establishment of the MCD was to be included in the first amendment to the FMP. On November 1995, the Final Rule on the Coral FMP was published.

Public hearings were held between March 12 and March 14, 1996, in the USVI, regarding the establishment of the MCD. The Scientific and Statistical Committee (SSC) and the Advisory Panel (AP) held meetings on March 25, 1996, in St. Thomas, USVI, to discuss and make recommendations to the Council on the establishment of the MCD. At its 88th Regular Meeting in St. Thomas, USVI, the Council, based on recommendations from the SSC and the AP, instructed the staff to prepare draft amendment number one to the Coral FMP establishing an MCD south off St. John.

At its 89th Regular Meeting held on August 1996, the Council decided to conduct a socioeconomic study on the projected MCD. On October 1996, the Council contracted with Impact Assessment, Inc. for the Rapid Socioeconomic Study on the Marine Conservation District off St. John, USVI. The results of the socioeconomic study were presented to the Council at its 91st Regular Meeting held on March 1997, in St. Thomas, USVI. The Council decided to contract with Dr. Walter Keithly for the preparation of the Regulatory impact Review (RIR) on the establishment of the Marine Conservation District. The report on the RIR was presented to the Council by Dr. Walter Keithly at its 92nd Meeting held on August 11-13, 1997, in St., Croix, USVI.

Public hearings were again held between October 21st and October 23rd, 1997, in St. John, St. Thomas, and St. Croix, respectively. Significant changes were made to the proposed MCD options and a final set of Public Hearings were held between June 9 and June 11, 1998, in the USVI. Final action was taken by the Council at its 94th Regular Meeting held during August 12th and 13th, 1998 in St. Thomas, USVI.

Statement of Estimated Cost - As of August 1998

I. Consideration at the Council Meetings

Estimated Cost of Council Members Compensation for One Council Meeting [1)]	$5,994.00
Estimated Cost of Compensation and Travel Expenses [2)]	$3,948.00
Estimated Cost of Compensation and Travel Expenses	$9,942.00

Council meetings are estimated to last 16 hours, of which at least an average of 3 hours have been devoted to the discussion of the establishment of the Marine Conservation District, during the meetings 82nd through 94th. (8 meetings; no discussion on meetings 84th, 85th, 86th, 90th and 93rd .)

Estimated Cost Per Meeting:

3 hours ÷ 16 hours = 18.75%	
$9,942 x 18.75% x 8 meetings	$14,913.00

1) Based on the average daily compensation for the years 1995 to 1998
2) Based on the average per Diem for the years 1995 to 1998

II. Time Devoted by the Staff

It is estimated that the Special Assistant to the Executive Director devoted ten percent (10%) of her time to the development of Amendment number one to the Coral FMP during the period 1995 to 1998.

Salary for 1995	$45,214.00
Salary for 1996	$46,120.00
Salary for 1997	$48,609.00
Salary for January - August, 1998	$33,095.00
Total	$173,095.00
Estimated Cost - $173,095 x 10% =	$17,309.00

It is estimated that the Executive Director devoted ten percent (10%) of his time to the development of the First Amendment to the Coral FMP during the period 1995 to 1997.

Salary for 1995	$72,471.00
Salary for 1996	$73,920.00
Salary for 1997	$77,982.00
Salary for January - August 1998	$54,798.00
Total	$279,171.00
Estimated Cost - $279,171 x 10% =	$27,917.00

III. Public Hearings

The Council held public hearings related to the establishment of the MCD on March 12- 14, 1996; October 21-23, 1997; and June 9-11, 1998 in the USVI.

Estimated Council Members Compensation (1 x 3 days x 3 meetings)	$2,934.00
Estimated Council Member Travel Expenses (1 x 3 days x 3 meetings)	$1,974.00
Estimated Staff Travel Expenses (3 x 3 days x 3 meetings)	$3,948.00
Estimated Cost	$8,856.00

IV, Other Related Meetings

Workshop on Marine Reserves - March 15, 1995

Estimated Council Members Compensation (5 x 1 day)	$1,595.00
Estimated Council Member Travel Expenses (5 x 1 day)	$1,040.00
Estimated Staff Travel Expenses (3 x 1 day)	$625.00
Estimated Cost	$3,260.00

MCD Sub-Committee Meeting - June 22, 1994

Estimated Council Members Compensation (2 x 1 day)	$638.00
Estimated Council Member Travel Expenses (2 x 1 day)	$416.00
Estimated Staff Travel Expenses (2 x 1 day)	$416.00
Estimated Cost	$1,470.00

MCD Work Group Meeting - August 30, 1994

Estimated Council Members Compensation (2 x 1 day)	$638.00
Estimated Council Member Travel Expenses (2 x 1 day)	$416.00
Estimated Staff Travel Expenses (2 x 1 day)	$416.00
Estimated Cost	$1,470.00

Coral FMP Committee - August 31, 1994

Estimated Council Members Compensation (6 x 1 day)	$1,914.00
Estimated Council Member Travel Expenses (6 x 1 day)	$1,248.00
Estimated Staff Travel Expenses (3 x 1 day)	$624.00
Estimated Cost	$3,786.00

V. Contractors

Contract with Impact Assessment for the Rapid Socioeconomic Study on the MCD	$38,770.00
Contract with Dr. Walter Keithly for the Preparation of the RIR	$9,000.00

Estimated Cost	$47,770.00

V1. NMFS Administrative Costs $25,000.00

VI1. Summary of Estimated Costs

Consideration at Council Meetings	$14,913.00
Time devoted by Staff	$45,226.00
Public Hearings	$8,856.00
Other Related Meetings	$9,986.00
Contractors	$47,770.00
NMFS administrative (not included in the Total Council Costs)	$25,000.00
Total Estimated Council Costs	$126,751.00

V111. Enforcement Costs

NMFS Agent response/investigation and oversight 18 days annually	$6,000.00
NMFS reimbursement for USVI patrol expense 4 hours week equipment & personnel	$8,500.00
U.S. Coast Guard surface patrol 110' cutter 2 hours week	$47,500.00
Total Estimated Enforcement Costs	$62,000.00

SUMMARY CO COSTS OF FMP

Caribbean Council (through August, 1998)	$126,751.00
Enforcement (annual)	$62,000.00
NMFS	$25,000.00
TOTAL FIRST YEAR COSTS	$213,751.00

Note: The estimated enforcement costs, as presented, were those provided in relation to the implementation of Option C (i.e., the initial Preferred Option). Enforcement costs associated with either Option A or Option B may be somewhat less than this estimate because the three-month closure of the Hind Bank suggests that enforcement is already present in this area during a portion of the year.

ANNUAL COSTS AFTER FIRST YEAR $62,000.00

9.0 SUMMARY OF NET ECONOMIC BENEFIT OF PREFERRED AND ALTERNATIVE MANAGEMENT MEASURES

The following table constitutes the summary of economic outcomes associated with the three alternative options.

CORALS AND REEF ASSOCIATED PLANTS AND INVERTEBRATES FMP

1(a). Option A (Establish a no-take Marine Conservation District (MCD) in the EEZ in the area known as the Hind Bank South of St. Thomas, U.S.V.I.,

A. Benefits:

(i.) Long-run increase in consumer surplus related to positive existence and option values.

(ii.) Long-run increase in consumer surplus related to non-consumptive activities (e.g., diving) if "spillover" and egg-dispersal effects are positive in relation to establishment of MCD.

(iii.) Potential for long-term increase in consumer surplus derived from charter boat and recreational activities if "spillover" and egg-dispersal effect are positive in relation to establishment of MCD.

(iv.) Potential for long-run increase in consumer surplus derived from the consumption of a lower priced locally harvested product (if "spillover and egg-dispersal effects are positive).

(v.) Some intermediate increase in producer surplus within the commercial fishing fleet (assuming "spillover" and egg-dispersal effects are positive).

(vi.) Potential increase in protection of the coral reef habitat outside of MCD in association with restoring community balance (assuming "spillover" and egg dispersal effects are positive).

Costs:

(i.) Anticipated short-run decline in producer surplus within the local commercial fishing fleet.

(ii.) Anticipated short-run decline in consumer surplus associated with both the charter boat sector and recreational sector.

(iii.) Potential short-run decline in consumer surplus as a result of lower quantity of locally harvested product (assuming price responds to local harvest levels)

(iv.) Potential for long-run increase in habitat degradation outside the MCD associated with increased commercial (trap and anchor damage) and recreational activities (anchor

damage) if long-run stock sizes outside the MCD increase resulting in increased long-run commercial and recreational activities.

Net Benefits:

(i.) Net benefits will be positive if the cost resulting from long-run increases in commercial and recreational fishing activities (i.e., item iv. under summary costs) is not significant.
(ii.) If costs related to habitat degradation are large due to long-run increased commercial and recreational activities (i.e., item iv. under the summary of costs), then it becomes uncertain as to whether net benefits are positive or negative).

1(b). Option B: Establish a no-take Marine Conservation District (MCD) in the EEZ, including the area known as the Hind Bank South of St. Thomas , U.S.V.I., but with a modified northern boundary 1 NM north of the present demarcation line.

Benefits: The expected benefits under Option B will be the same as those noted with respect when evaluated on a qualitative basis.

Costs: The expected costs under Option B will be similar to those noted with respect to Option A when evaluated on a qualitative basis.

Net Benefits: The expected net benefits under Option B will be the same as those noted with respect to Option A when evaluated on a qualitative basis.

1(c). Option C: Establish a Marine Conservation District (MCD) in the EEZ due South of St. John , U.S.V.I.

Benefits: The expected benefits under Option C will be the same as those noted with respect to the two previous Options when evaluated on a qualitative basis.

Costs: The expected costs under Option C will be the same as those noted with respect to the two previous Options when evaluated on a qualitative basis with minor exceptions. Specifically, enforcement costs may be somewhat higher for two reasons. First, there is greater opposition to the MCD created under Option C than under either Option A or Option B and, hence, more enforcement may be required for a given level of compliance. Second, enforcement in the area associated with Options A and B is currently in place for the three month period from December through February.

Net Benefits: The net benefits under Option C will be the same as those noted with respect to the two previous Options when evaluated on a qualitative basis.

Discussion: In general, insufficient information exists by which to compare the benefits and costs across the establishment of an MCD in relation to the three alternative options. A few general comments are, however, warranted. First, the relative benefits between Option C and Option A (or Option B) will depend primarily on the overall level of habitat degradation associated with the proposed MCD to be established under Option A (or Option B). Specifically, The habitat associated Option C is thought to be in relatively good condition. Less is known regarding the habitat condition associated with Option A (or Option B). If this habitat is seriously degraded, than the benefits which would be derived under adoption of Option C would probably be substantially greater than those which would accrue under Option A (or Option B).

If the habitat associated with Option A (or Option B) is seriously degraded, the costs associated with establishment of an MCD are likely to be relatively minor. Specifically, the more degraded the habitat, the less effort there is likely to be in the area. As such, displacement costs are likely to be relatively minor. If this is the case, the costs associated with adoption of Option C would likely to be substantially higher than those associated with adoption of Option A (or Option B).

Finally, there is a perception that fishermen favor Option A (or Option B) over Option C. This suggests a higher level of compliance with respect to adoption of Option A in the absence of sufficient enforcement. Furthermore, since there is currently a three month closure each year associated with the area where the MCD under Option A would be established, fishermen may be more willing to accept this Option (and comply voluntarily).

2. Possible alternatives to activities within the MCD established under Option C.

A. No take within the MCD established through the management measure above (Option C).

Benefits: Benefits are essentially those listed with respect to Option C but may be slightly more since no allowances will be given for take for scientific purposes associated with Option C.

Costs: Costs are essentially those listed with respect to Option C but may be slightly more if there is value in the scientific information that can be obtained from the take of organisms within the MCD

Net Benefits: Could be either more or less than those associated with Option C depending upon value of scientific information obtained from the take of organisms within the MCD relative to the benefits of leaving the organisms *in situ.*

B. Allow hand lines or floating within the MCD established through Option C.

Benefits: Benefits are essentially those listed with respect to Option C with the exception that, given the less restrictive nature of this alternative, short-term losses in producer and consumer surplus will be less than those associated with Option C.

Costs: Costs are likely to be higher than those reported under Option C for three reasons. First, there is an increased probability of coral reef degradation from anchoring which is used in floating activities. Second, enforcement may be more complicated and, hence, expensive. Finally, the take of fish by handlines will perpetuate community imbalance in the coral reef ecosystem. Short-run displacement costs, however, will be lessened.

Net Benefits: If net benefits from the implementation of Option C are positive, they will be somewhat diminished if handlining and floating are permitted.

3. Prohibit all gear except trolling within the MCD established through Option C

Benefits: Roughly equivalent to those specified under Option C with exception that short-run producer and consumer surplus may be slightly higher than that associated with Option C because this alternative entails less restrictive harvesting practices.

Costs: Overall costs are likely to be less than those reported under Option C because displacement costs will be somewhat lessened.

Net benefits: May be either greater or less than those of the Adopted Measure.

4. No Action.

Benefits: Costs specified within the context of Option C will not be incurred.

Costs: Benefits specified within the context of Option C will not be forthcoming.

Net Benefits: Since it is unknown whether or not implementation of Option C will generate positive net benefits, it cannot be determined whether "no action" generates more or less net benefits.

10.0 INITIAL REGULATORY FLEXIBILITY ANALYSIS

The Regulatory Flexibility Act requires a determination as to whether or not a proposed rule has a significant impact on a substantial number of small entities. If the rule does have this impact then an Initial Regulatory Flexibility Analysis (IRFA) has to be completed for public comment. The IRFA becomes final after the public comments have been addressed. If the proposed rule does not meet the criteria for "substantial number" and "significant impact," then a certification to this effect must be prepared.

This proposed rule, if promulgated, will establish a Marine Conservation District (MCD) in the Federal waters Southwest of St. Thomas. The various other Options associated with the establishment of an MCD are listed below:

OPTION A (Management Measure 1): Establish a no-take Marine Conservation District (MCD) in the EEZ in the area known as the Hind Bank South of St. Thomas, U.S.V.I., within the coordinates specified below.

POINT	LATITUDE	LONGITUDE
A	18E13.2'N	65E06.0'W
B	18E13.2'N	64E59.0'W
C	18E11.8'N	64E59.0'W
D	18E10.7'N	65E06.0'W

OPTION B (Rejected): Establish a no-take Marine Conservation District (MCD) in the EEZ, including the area known as the Hind Bank South of St. Thomas, U.S.V.I., but with a modified northern boundary 1 NM north of the present demarcation line. That is, within the coordinates specified below.

POINT	LATITUDE	LONGITUDE
A	18E14.2'N	65E06.0'W
B	18E14.2'N	64E59.0'W
C	18E11.8'N	65E59.0'W
D	18E10.7'N	65E06.0'W

OPTION C (Rejected): Establish a Marine Conservation District (MCD) in the EEZ due South of St. John, U.S.V.I. within the coordinates specified on the following page.

The rhumb lines connecting the following coordinates enclose the MCD:

POINT	DESCRIPTION	LATITUDE	LONGITUDE
A	South of Bovocoap Point at Boundary with Territorial Sea	18E 15.3'N	64E 46.9'W
B	South of Ram Head at Boundary with Territorial Sea	18E 15.0' N	64E 42.2'W
C	Southeast corner	18E 12.1'N	64E 42.2'W
D	Southwest corner	18E 11.0'N	64E 46.9'W

All of the finfish and/or shellfish harvesters affected by the rule will qualify as small business entities because their gross revenues are less than $3 million annually. Hence, it is clear that the criterion of a substantial number of small business entities comprising the finfish and shellfish harvesting industry being affected by the proposed rule will be met. The outcome of "significant impact" is less clear but can be triggered by any of the five conditions or criteria discussed below.

The regulations are likely to result in a change in annual gross revenues by more than 5 percent. The major economic effects associated with any of the three alternative Options will directly impact approximately 20 to 30 entities that will no longer be able to take any fishing trips in their preferred fishing grounds. The proposed regulation will also indirectly impact up to approximately 100 additional entities through increased fishing effort in a more confined area. While it is unclear how much the revenues among these two groups of entities will be reduced, information provided in the RIR indicates that the five percent criteria may not be reached. This conclusion is based on two findings. First, the majority of entities that fished in the preferred grounds also made multiple trips in areas outside the proposed MCD suggesting that movement in effort from one area to another is relatively flexible. Second, with respect to Option C, gross revenues per trip outside the proposed MCD, in general, exceeded those reported inside the proposed MCD. While revenues per trip within the Federal waters Southwest of St. Thomas (i.e., that area which encompasses Options A and B) were higher than outside this area, on average, much of the difference can be explained by more pots being hauled per trip. On a per pot basis, revenues inside and outside the Federal waters Southwest of St. Thomas are relatively close. It is expected that with adoption of either Option A or Option B, impacted fishermen will increase the number of pots outside the closed area.

Annual compliance costs (annualized capital, operating, reporting, etc) increase total costs of production for small entities by more than 5 percent. Analysis presented in the RIR suggests that annual compliance costs will not increase total costs of production for small entities by more than 5 percent. Consider first, selection of Option C; the establishment of an MCD South of St. John. Most of the trips originating to this proposed MCD area originated from St. Thomas. Analysis presented in the RIR indicated that catch per trip, in general, tended to be relatively high in the waters South of St. Thomas. Hence, it is expected that much of the displaced effort (trips) will relocate in the area South of St. Thomas. As such, fuel costs, opportunity costs of time, etc. may actually decline.

Now, consider the selection of Option A or Option B; the establishment of an MCD Southwest of St. Thomas. While limited, empirical evidence tends to suggest that the adoption of either of these two Options will result in only small, if any increases, in total cost of production for small entities. Specifically, the Hind Bank (i.e., the area associated with the MCD which would be established under Option A and containing Option B) is currently closed to potfishing activities during the red hind spawning aggregation season (December-February). Little movement of effort outside the St. Thomas Southwest quadrant is evident during this period suggesting little displacement of effort. As such, it is believed that a permanent closure of this area will not result in significant costs to small entities.

Compliance costs as a percent of sales for small entities are at least 10 percent higher than compliance costs as a percent of sales for large entities. All of the firms expected to be impacted by the rule are small entities and hence there is nor differential impact.

Capital costs of compliance represent a significant portion of capital available to small entities considering internal cash flow and external financing capabilities. Since annual compliance costs are thought to be extremely small (if positive at all), the capital costs of compliance do not represent a significant portion of capital available to small entities.

The requirements of the regulation are likely to result in a number of the small entities affected being forced to cease business operations. This number is not precisely defined by SBA but a "rule of thumb" to trigger this criterion would be two percent of the small entities affected. If any one of the three propose MCDs is implemented, there will likely result in some, but an unknown, reduction in short-run profits among entities in the St. Thomas and St. John fishing fleet. This reduction in profitability may result in certain entities exiting the fishing sector although whether two percent or more exit is not known.

Considering all the criteria discussed above, no definitive conclusion can be drawn as to whether small businesses will be significantly affected by the proposed rule. It appears possible, however, that the proposed rule may have a significant economic impact on a substantial number of small business entities. Further, this action is of high public interest, the federal action would be unique in US

Caribbean waters, and the action proposes a major change in management policy. Hence, an Initial Regulatory Flexibility Analysis (IRFA) was conducted.

The full details of the economic analyses conducted for the proposed rule are contained in the RIR and some of the relevant results are summarized for the purposes of the IRFA.

Description of the reasons why action by the agency is being considered: The Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the United States Virgin Islands (FMP) which became effective in December, 1995 included a reserved management measure establishing a Marine Conservation District (MCD). It is the proposed establishment of and MCD (in the Federal waters Southwest of St. Thomas) which constitutes the proposed Amendment to the FMP and why action is being considered. The intent of the management measure is to conserve and manage representative samples of marine habitats and ecosystems and to maintain marine biodiversity. In addition, the management measure will provide protection, conservation, and management of economically important species.

Statement of the objectives of, and legal basis for, the proposed rule: The objectives of the FMP are to conserve and protect the species in the Fishery Management Unit for the maximum benefit of the Nation, to fairly allocate resources among different user groups, to reduce the potential for user conflict, to identify data gaps which impede management, and to provide relevant recommendations to the states.

The objectives in the FMP are unchanged and addressed in the proposed amendment in the following manner. It is continuously reported that coral reefs (locally, regionally, and worldwide) are in peril. A management option available to the Council is the establishment of MCD's "to conserve and protect the species in the FMU for the maximum benefit of the Nation" (i.e., Objective 1 in the FMP). Objective 2 (to minimize adverse human impacts on coral, live-rock, seagrasses and reef-associated plants and invertebrate resources by reducing fishing pressure, wasteful harvest practices, and the anthropogenic stressors directly affecting them, and allowing for the restoration of naturally-balanced reef systems) and Objective 4 (to provide, where appropriate, for special management of reef and seagrass habitats of particular concern or ecological importance through the establishment of reserves or other protected areas) are met through the management strategies of "no take", allowing non-consumptive use of the resource (e.g., diving), or allowing certain types of activities. The Magnuson-Stevens Fishery Conservation and Management Act provides the legal basis for the rule.

Description and estimate of the number of small entities to which the proposed rule will apply: A total of about 121 licensed commercial fishermen reported harvests in 1995-96 (This number will to some extent underestimate the total number of fishermen because not all fishermen provided the required catch data. Specifically, another 28 licensed fishermen reported that they commercially fished but reported no harvest). These fishermen reported a total catch of approximately 390 thousand pounds

valued at approximately $1.7 million (retail value). This indicates per entity gross sales of approximately $12 thousand. Identified fishermen made approximately 35 trips each (associated with Option C), on average, and approximately 60 trips each when Options A and B are examined. Only a small portion of these trips, however, take place in the areas which would be effected by any of the three proposed MCDs. The small firms generally operated vessels in the 16 to 40 foot range. Crew size is normally two, but some of the smaller vessels may fish with a crew of only one (Impact Assessment Inc., 1997). The proposed rule will apply to all of these entities.

Description of the projected reporting, recordkeeping, and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and type of professional skills necessary for the preparation of the report or records: No additional reporting, recordkeeping, or other compliance requirements by small entities are envisioned.

Identification of all relevant Federal rules which may duplicate, overlap, or conflict with the proposed rule: No duplicative, overlapping, or conflicting Federal rules have been identified.

Description of significant alternatives to the proposed rule and discussion of how the alternatives attempt to minimize economic impacts on small entities: The revised amendment presented four Options. The first two of these Options, designated as Option A and Option B, would create an MCD Southwest of St. Thomas. The third Option, designated Option C, would create an MCD South of St. John. The final Option, designated Option D, was for a status quo. The Council has taken final action and adopted Option A as Management Measure 1 in the Amendment document.

The first two Options, i.e., Options A and B, were defined as no-take MCDs. As such, no extractive activities would be permitted within the confines of the established MCDs associated with these two Options. No alternatives to these Options were presented. Option C, i.e., creation of an MCD South of St. John, was not originally defined as a no-take MCD. Three significant alternatives were proposed in relation to this Option. The first alternative (i.e., Alternative 1) would establish the MCD created under Option C as a no-take MCD. This alternative would prohibit the removal of organisms for restoration, educational, or scientific purposes.. The second alternative in relation to Option C would allow hand lines or floating within the MCD established within the confines of Option C. Similarly, the third alternative in relation to Option C would prohibit all gear except trolling within the MCD established within the confines of Option C.

The first of these alternatives, i.e., the prohibition of the removal of organisms for restoration, educational, or scientific purposes, would have minimal or no differential economic impact on small entities when compared to Option C. Instead, the additional costs (if any) associated with this alternative would be borne primarily by the educational and scientific communities. The second alternative, allowing hand lines or floating within the MCD established within the confines of Option C, would reduce economic impacts on small entities by permitting limited types of fishing activities within

the MCD. Overall, an estimated 7.3% of the total level of hookfish harvest in St. Thomas and St. John occurred within the boundaries of the proposed MCD associated with Option C. Allowing hand lines or floating would provide the opportunity for some unknown portion of this 7.3% to remain active within the MCD thereby reducing, by some unknown extent, economic burdens on the 21 fishermen who would be displaced from their "preferred" fishing ground. Hookfish activities represented an estimated 13.8% of the revenues generated from the area of the proposed MCD associated with Option C. The third alternative in relation to Option C, the prohibition of all gear except trolling within the confines of Option C, like the second alternative would permit limited fishing activities within the MCD and, hence, would reduce the economic impact on small entities resulting from a creation of an MCD.

11.0 REFERENCES

Alcala, A.C. 1988. " Effects of Marine Reserves on Coral Fish Abundances and Yields of Philippine Coral Reefs." Ambio, 17(3):193-199.

Anonymous. 1993. "Biodiversity and its Value (Biodiversity Series No.1)." Paper prepared by the Biodiversity Unit within the Commonwealth Department of the Environment, Sport, and Territories, Commonwealth of Australia: GPO Box 787, Canberra ACT 2601 (http//www/erin.gov.au/life/general_info/op1.html).

Birkeland, C. 1977. "The Importance of Rate of Biomass Accumulation in Early Successional Stages of Benthic Communities to the Survival of Coral Recruits." Proc. Third Int. Coral Reef Symp., Miami.

Bishop, R. 1978. " Endangered Species and Uncertainty: The Economics of the Safe Minimum Standard." American Journal of Agricultural Economics, 60(1):10-18.

Carpenter, K.E., R.I. Miclat, V. D. Albaladejo, and V. J. Corpuz. 1981. "The Influence of Substrate Structure On the Local Abundance and Diversity of Philippine Reef Fishes." Proceedings of the Fourth International Coral Reef Symposium, Manila 2:497-502.

Davis, G. E. 1977. "Anchor Damage to a Coral Reef on the Coast of Florida." Biological Conservation, 11:29-34.

Freeman, M. 1993. The Measurement of Environmental and Resource Values: Theory and Methods. Resources for the Future, Washington, D.C.

Garrison, G. 1997. "St. John, U.S. Virgin Islands Fish Trap Study, 1992-94." Unpublished manuscript, Biological Resources Division, USGS Virgin Islands National Park.

Goldstein, M. and M. S. Kahn. 1985. "Income and Price Effects in Foreign Trade," Ch. 20 In R.W. Jones and P. B. Kenen (eds.), Handbook of International Economics, Vol. II. Elsevier Science Publishers B. V. pp. 1041-1105.

Gowdy, G.M. 1997. "The Value of Biodiversity: Markets, Society, and Ecosystems." Land Economics, 73(1): 25-41.

Gulf of Mexico and South Atlantic Fishery Management Councils. 1983. Fishery Management Plan and Final Environmental Impact Statement for Coral and Coral Reefs. April 1982 version, Tampa, Fl.

Hughes, T.P., D.C. Reed, and M. J. Boyle. 1987. "Herbivory on Coral Reefs: Community Structure Following Mass Mortalities of Sea Urchins." J. Exp. Mar. Biol. Ecol. 113:39-59.

Impact Assessment Inc. (1997). Rapid Socioeconomic Evaluation of the Proposed Marine Conservation District St. John, United States Virgin Islands. (Report prepared for the Caribbean Fishery Management Council).

Jennings, S. and N. V. C Polunin. 1996. "Impacts of Fishing on Tropical Reef Ecosystems." Ambio 25(1):44-49.

Kojis, B. L. 1997. "Baseline Data on Coral Recruitment in the Northern U.S. Virgin Islands." Unpublished manuscript prepared for the Caribbean Fishery Management Council.

Kruitilla, F. 1967. "Conservation Reconsidered." American Economic Review, 57(4):777-786.

Kruitilla, F. and A. C. Fischer. 1975. The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources. The John Hopkins University Press, Baltimore, Md.

Laist, D. W., T. E. Bigford, G. W. Robertson, and D. R. Gordon. 1986. "Management of Corals and Coral Ecosystems in the United States." Coastal Zone Management Journal 13(3/4):203-239.

Meyers, S. 1994. "Annual Summary Report: April 1993 - March 1994." Unpublished report submitted to the National Marine Fisheries Service, Southeast Regional Office, 9450 Koger Blvd., St. Petersburg FL 33702.

Ogden, J. C. and P. S. Lobel. 1978. "The Role of Herbivorous Fishes and Urchins in Coral Reef Communities." Env. Biol. Fish. 3(1):49-63.

Ogden, J. C., R.A. Brown, and S. Salesky. 1973. "Grazing by the Echinoid Diadema antillarum Philippi-formation of Halos Around West Indian Patch Reefs." Science 182:715-717.

Panayotou, T. 1993. "The Economics of Environmental Degradation: Problems, Causes and Responses," In A. Markandya and J. Richardson, eds., Environmental Economics, Earthscan Publications Ltd, London.

Polunin., N. V. C. 1983. "Marine 'Genetic' Resources and the Potential Role of Protected Areas in Conserving This." Environmental Conservation, 10(1):31-41.

Polunin, N. V. C. and C.M. Roberts. 1993. "Greater Biomass and Value of Target Coral-reef Fishes in Two Small Caribbean Marine Reserves." Marine Ecology Progress Series, 100:167-176.

Randall, A. 1988. "What Mainstream Economists Have to Say About the Value of Biodiversity." In E.O. Wilson, ed. Biodiversity, National Academy Press, Washington, D.C.

Roberts, C.M. 1994. "Rapid Build-up of Fish Biomass in a Caribbean Marine Reserve." Conservation Biology, 9(4): 815-824.

Roberts, C.M. 1997. "Ecological Advice for the Global Fisheries Crisis." TREE, 12(1):35-38.

Rowley, R. J. 1992. "Impacts of Marine Reserves on Fisheries: a Report and Review of the Literature." Published by Head Office, Department of Conservation, P O Box 10-420, Wellington, New Zealand.

Rowley, R. J. 1994. "Marine Reserves in Fisheries Management." Aquatic Conservation: Marine and Freshwater Ecosystems, 4:233-254.

Russ, G. R. 1996. "Fisheries Management: What Chance on Coral Reefs?" The ICLARM Quarterly.

Sammarco, P. W. 1980. "Diadema and its Relationship to Coral Spat Mortality: Grazing, Competition, and Biological Disturbance." J. Exp. Mar. Biol. Ecol. 45:245-272.

Smith, S.V. 1978. Coral Reef Area and Contribution of Reefs to Processes and Resources of the World's Oceans. Nature, 273:225

Sobel, Jack. 1993. "Conserving Biological Diversity Through Marine Protected Areas: A Global Challenge." Oceanus 3:19-26.

Spurgeon, J. P. G. 1992. "The Economic Valuation of Coral Reefs," Marine Pollution Bulletin 24(11):529-536.

Talbot, F. 1995. " Coral Reefs and Biodiversity: What Does Management Have To Do With It?" IMS (International Marine Science) Newsletter (http://hookomo.aloha.net/~sos/Talbot.html).

Tisdell, C. and J.M. Broadus. 1989. " Policy Issues Related to the Establishment and Management of Marine Reserves." Coastal Management, 17:37-53.

Toman, M.A. 1994. "Economics and 'Sustainability': Balancing Trade-offs and Imperatives." Land Economics, 70(4):399-413.

Tunnicliffe, V. J., 1980. Biological and Physical Processes Affecting the Survival of a Stony Coral, *Acropora cervicornis.* Ph.D. Thesis, Yale University, New Haven, CT.

Weisbrod, B. A. 1964. "Collective-consumption Services of Individual-consumption Goods." Quarterly Journal of Economics, 78:471-477