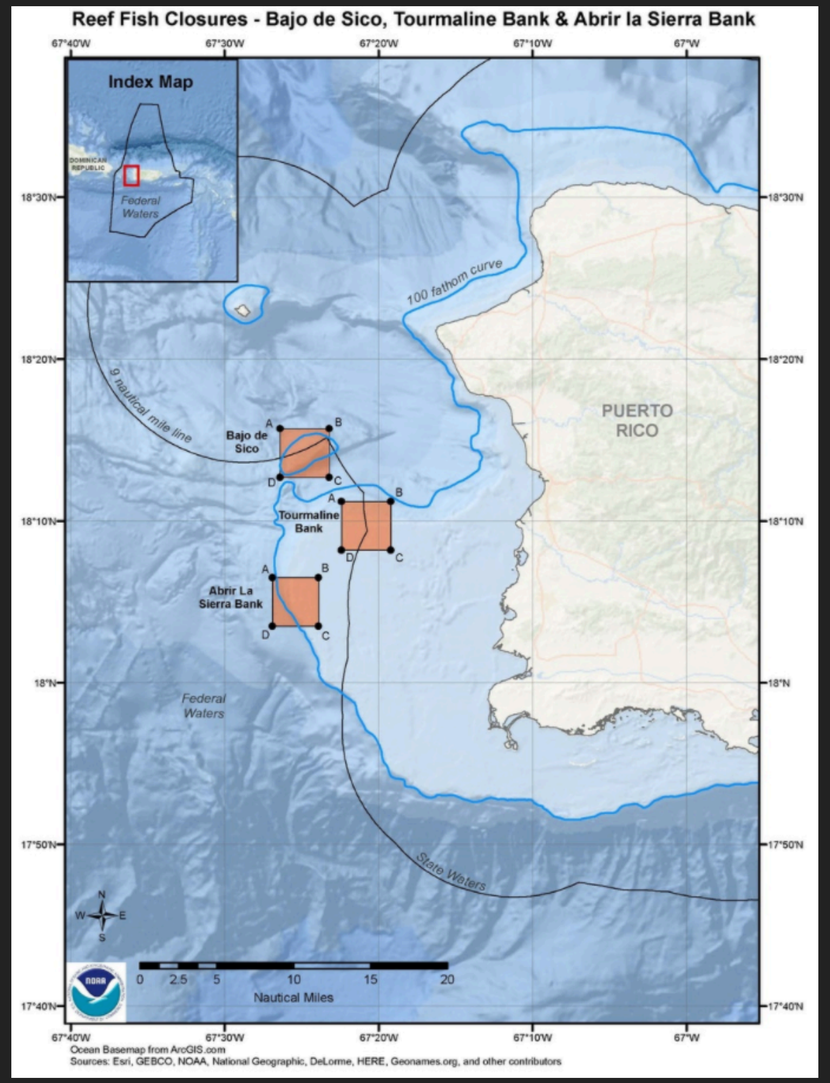
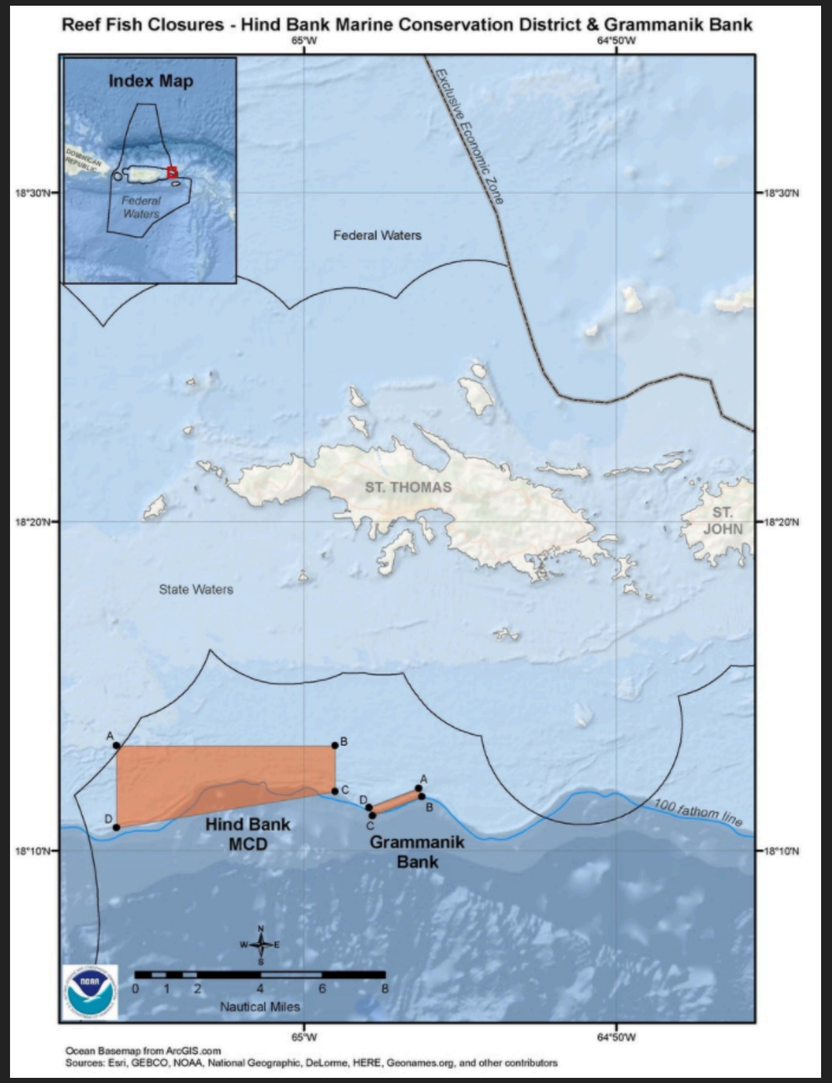
DIANA M. BELTRÁN

US CARIBBEAN MARINE MANAGED AREAS LITERATURE REVIEW

CONTENT

- Summary of the literature review of the seven US Marine Managed Areas (MMAs)
  - Generalities, studies carried out, gaps, and recommendations in each MMA
- General view of the US Caribbean MMAs/MPAs, including those in territorial waters
  - The goal of conserving 30% of oceans by 2030 (UN and the WH)
    - What is the current status of the US Caribbean MPAs under IUCN categories?
    - How much of the US Caribbean waters is currently MPA/MMA?
    - How can we improve?
- General recommendations (MPAs/MMAs as networks)


Reef Fish Closures - Bajo de Sico, Tourmaline Bank & Abrir la Sierra Bank
Index Map
Federal Waters
100 fathom curve
9 nautical mile line
Bajo de Sico
Tourmaline Bank
Abrir La Sierra Bank
PUERTO RICO
Federal Waters
State Waters
Nautical Miles
Ocean Basemap from ArcGIS.com
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors


Reef Fish Closures - Hind Bank Marine Conservation District & Grammanik Bank
Index Map
Federal Waters
Exclusive Economic Zone
ST. THOMAS
ST. JOHN
State Waters
Hind Bank MCD
Grammanik Bank
100 fathom line
Nautical Miles
Ocean Basemap from ArcGIS.com
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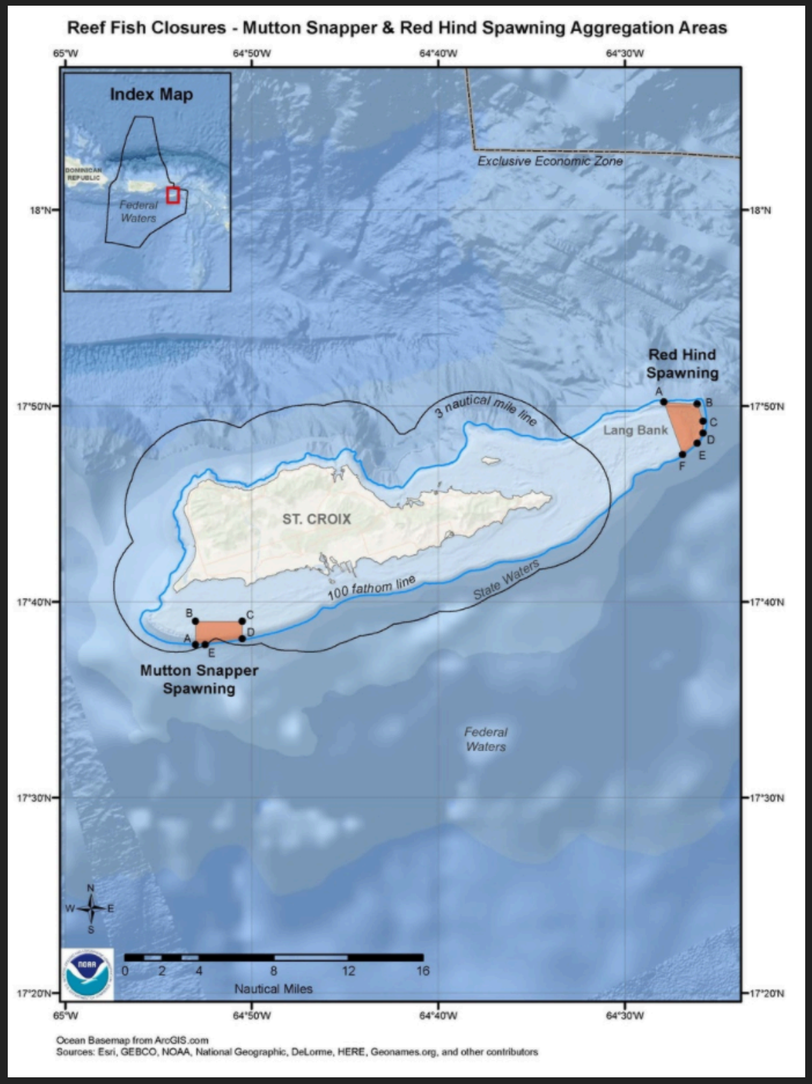
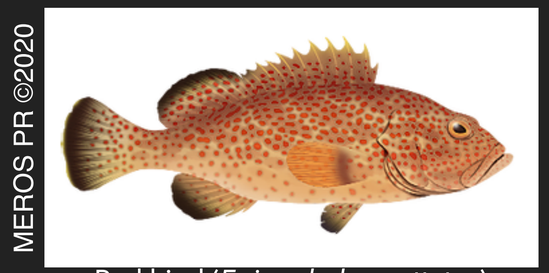

Reef Fish Closures - Mutton Snapper & Red Hind Spawning Aggregation Areas
Index Map
Federal Waters
Exclusive Economic Zone
Red Hind Spawning
3 nautical mile line
Lang Bank
ST. CROIX
100 fathom line
State Waters
Mutton Snapper Spawning
Federal Waters
Nautical Miles
Ocean Basemap from ArcGIS.com
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

MARINE MANAGED AREAS IN THE US CARIBBEAN

- Abrir La Sierra: Seasonal closure (December 1 to February 28/29)
- Tourmaline Bank: Seasonal closure (December 1 to February 28/29)
- Bajo del Sico: Seasonal closure (October 1 and March 31)
- Grammanik Bank: Seasonal closure (February 1 and April 30)
- Red Hind Marine Conservation District: Year round closure
- Red hind Closure at Land Bank: Seasonal closure (December 1 to February 28)
- Mutton Snapper Spawning Aggregation: Seasonal closure (April 1 to June 30)

ABRIR LA SIERRA

- Seasonal Fishing Closure Area; 1996; December 1 to February 28
- Red hind (*Epinephelus guttatus*)



Red hind (*Epinephelus guttatus*)

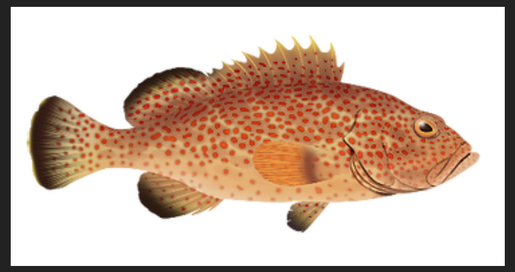
Type of scientific studies carried out at the MMAs	Marine Managed ALS	
	No.	Last*
Coral reef species		
a. Benthic composition	1	2013
b. Coral species heatlh	1	2013
c. Coral species biology/ecology		
Reef fish species		
a. Visual censuses	2	2013
b. Fishery Independent Survey	1	2012
c. Assessing SPA site/Species (accustic/telemetry)	7	2020
d. CPUE - Independent fishery survey		

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

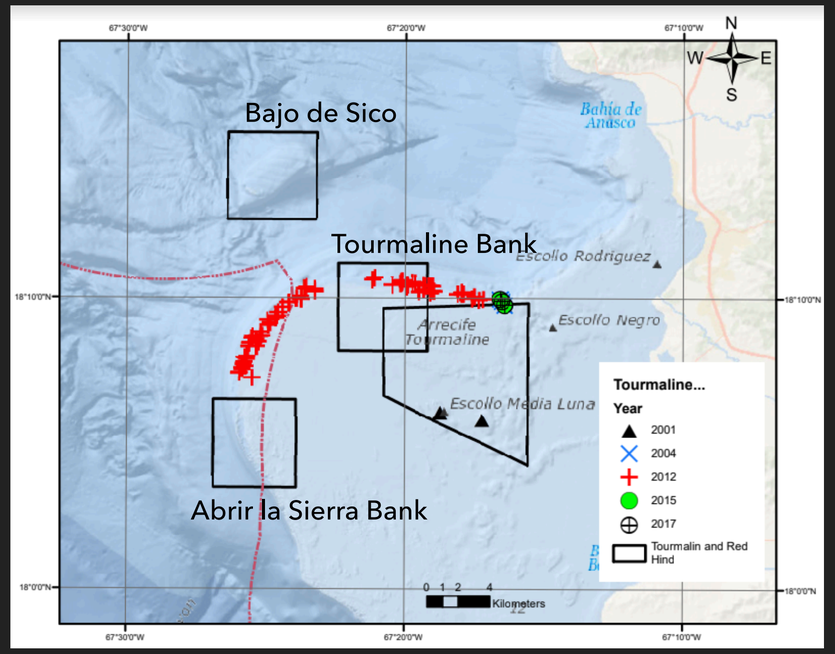
- Gaps and Recommendations:
- The last and only benthic and reef fish surveys were done in 2013 (Garcia-Sais et al., 2013). Need new surveys to know the current state and to know if the closure is helping the recovery of red hind populations
- Lack of fishery-independent surveys and/or CPUE studies (with data discriminated by sampling point, not by landing point)
- Promote studies to quantify the density of other commercially important reef fish species using ALS as a spawning aggregation site
- Encourage/support more acoustic studies to understand fish home ranges and connectivity with nearby MMAs. This will allow us to know if the size of the area is adequate for managing red hind populations

TOURMALIN BANK

- Seasonal Fishing Closure Area; 1993; December 1 to February 28/29
- TB partially coincides with the Puerto Rican marine reserve of Tourmaline
- EEZ (40%) and PR (60%)
- Red hind (*Epinephelus guttatus*)



Red hind (*Epinephelus guttatus*)



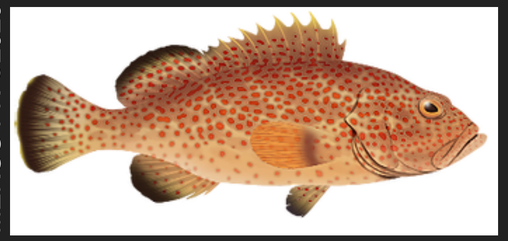
Type of scientific studies carried out at the MMAs	Marine Managed TB	
	No.	Last*
Coral reef species		
a. Benthic composition	12	2019a
b. Coral species heatlh	12	2019a
c. Coral species biology/ecology	2	2019
Reef fish species		
a. Visual censuses	12	2019a
b. Fishery Independent Survey	1	2013
c. Assessing SPA site/Species (accustic/telemetry)		
d. CPUE - Independent fishery survey		

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

- Gaps and Recommendations:
- Are there other commercially important reef fish species that use TB as a SPA?
- Carry out fishery-independent surveys and/or CPUE studies with data discriminated by sampling point, not for landing points
- To carry out passive acoustic telemetry and an acoustic receiver array along TB to track the movements of snapper and groupers that may are using this MMA as a SPA

BAJO DE SICO

- Seasonal closure; 1996; October 1 to March 31
- Red hind (*Epinephelus guttatus*)
- Acoustic studies: Black grouper (*Mycteroperca bonaci*) and Nassau grouper (*Ephinephelus striatus*)
- Gaps and Recommendations:
- Last and only benthic and reef fish surveys were done in 2007 (Garcia-Sais et al., 2007). Need new surveys to know the current state of benthic habitats and to know if the closure is helping the recovery of fish populations
- Lack of fishery independent-surveys and/or CPUE studies (with data discriminated by sampling point, not by landing point) to evaluate the current state of populations of groupers and snappers
- Continue passive acoustic telemetry and an acoustic receiver array studies to track the movements of snapper and groupers within BS



Red hind (*Epinephelus guttatus*)


Nassau grouper (*Ephinephelus striatus*)

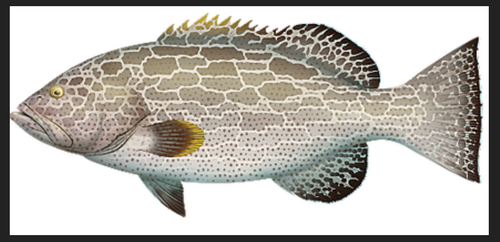

Black grouper (*Mycteroperca bonaci*)

Type of scientific studies carried out at the MMAs	Marine Managed Areas BS	
	No.	Last*
Coral reef species		
a. Benthic composition	1	2007
b. Coral species heatlh	1	2007
c. Coral species biology/ecology		
Reef fish species		
a. Visual censuses	1	2007
b. Fishery Independent Survey	1	2012
c. Assessing SA site/Species	8	2019
d. CPUE		
*Last year where the studies were conducted;	a PR-CRMP;	b USVI TCRMP

GRAMMANIK BANK

- Seasonal closure; 2005; February 1 to April 30
- Species recorded during spawning aggregation at GB: yellowfin grouper, Nassau grouper (*Epinephelus striatus*), dog snapper (*Lutjanus jocu*) and cubera snapper (*Lutjanus cyanopterus*), Bermuda chub (*Kyphosus sectatrix)*

MEROS PR ©2020



Yellowfin grouper (*Mycteroperca venenosa*)

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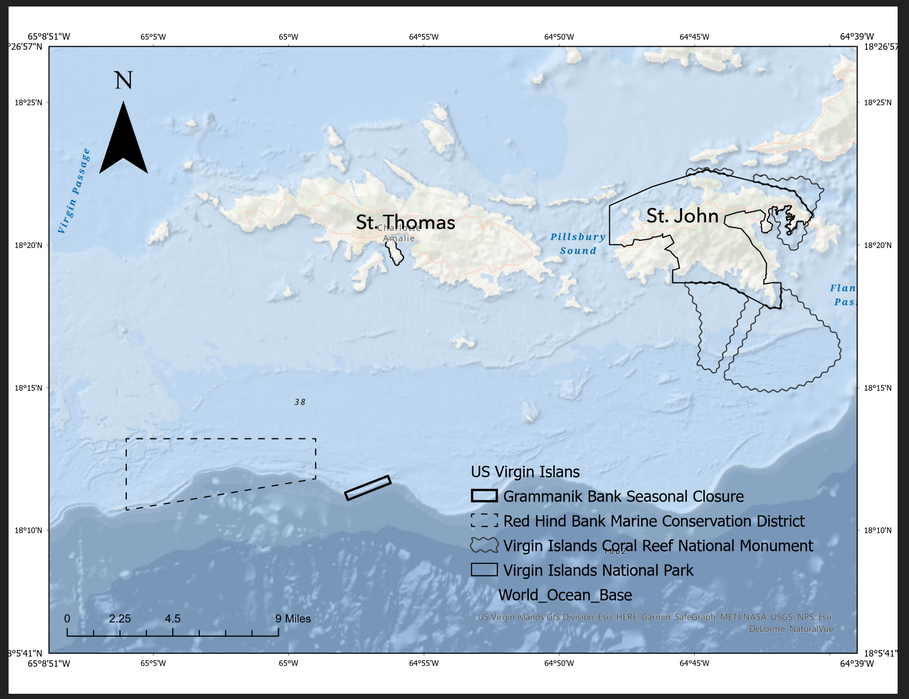
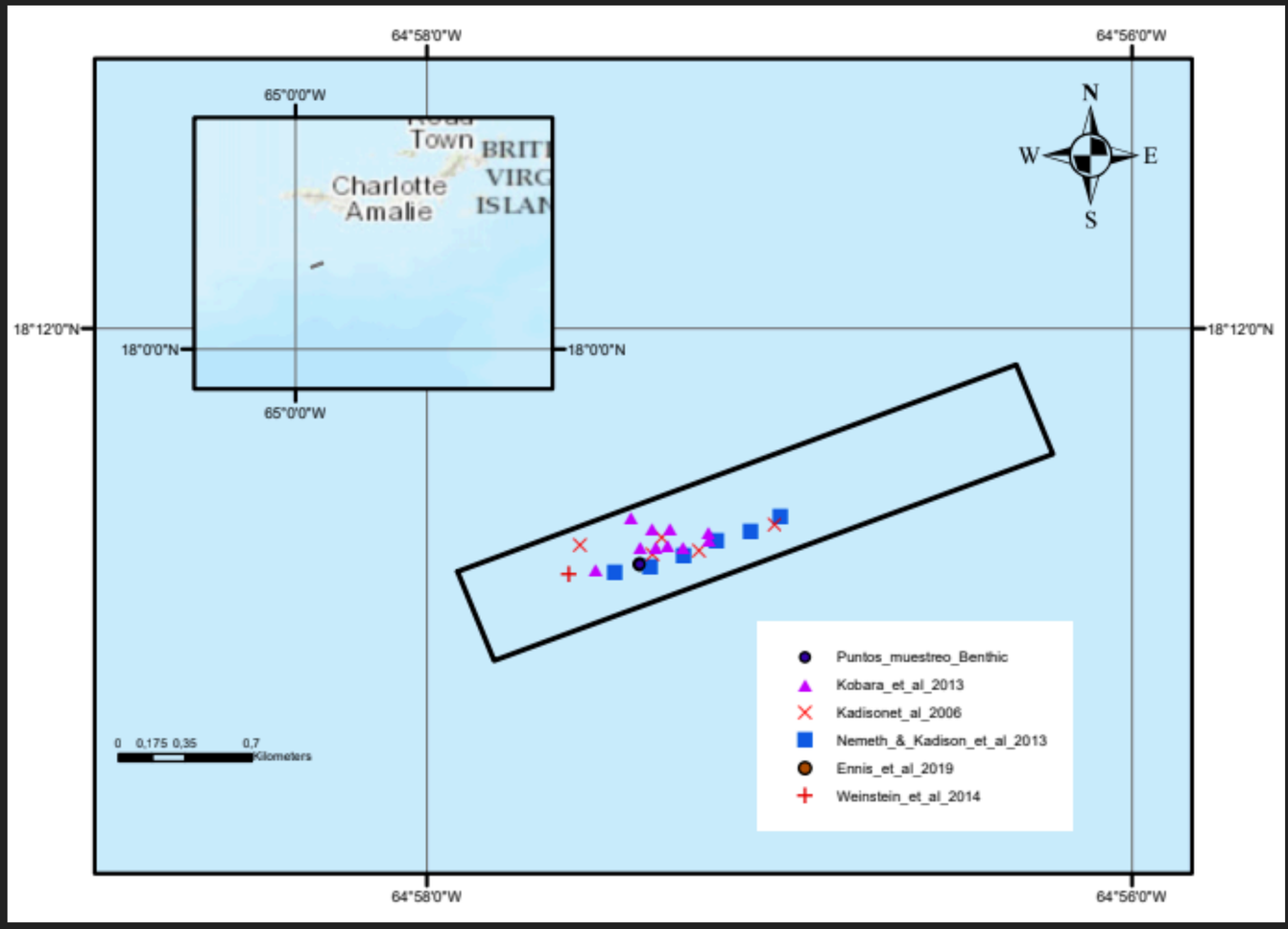
Nassaugrouper (*Ephinephelus striatus*)



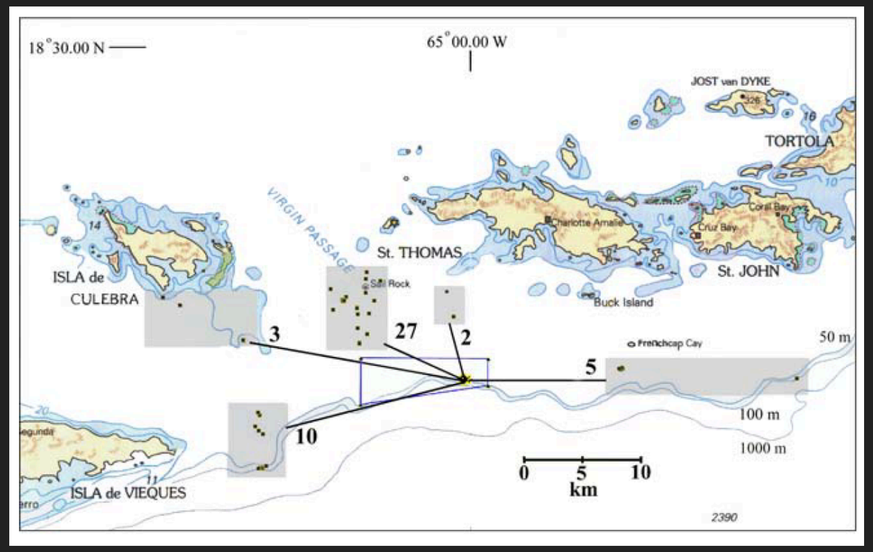


GRAMMANIK BANK

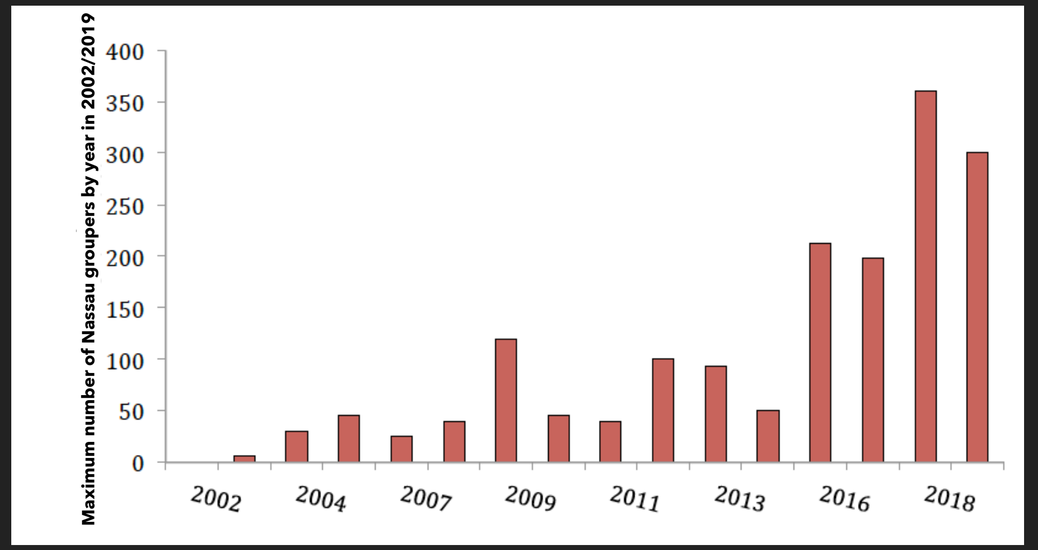
- Gaps and Recommendations:
- Best studied MMA in the US Caribbean
  - Passive acoustic and acoustic tagging studies have determined temporal reproductive activity, and site use
    - Nassau grouper and yellowfin grouper
  - During the closed season, these species enter and leave GB to MCD (2.5 km) and cross an unprotected coral corridor (potentially being fished). Consider including this corridor as part of the seasonal closure
- Males arrive earlier and stay longer than the closing season, suggesting a closure extension from three to six months

Type of scientific studies carried out at the MMAs	Marine Managed GB	
	No.	Last*
Coral reef species		
a. Benthic composition	19	2020b
b. Coral species heatlh	19	2020b
c. Coral species	8	2016
Reef fish species		
a. Visual censuses	19	2020b
b. Fishery Independent Survey		
c. Assessing SA site/Species	13	2020
d. CPUE		
e. Populations genetics (Nassau grouper)	2	2016

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP



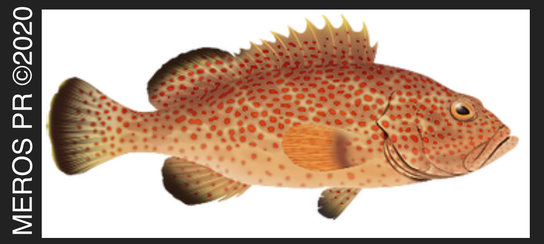
Recapture locations (dots within shaded areas) of *E. guttatus* tagged at spawning aggregation sites in St Thomas and recaptured by fishermen. Spawning aggregations are located with the two protected areas shown as polygons, and numbers along radiating lines indicate total recaptured fish within each shaded area (from Nemeth et al. 2007)



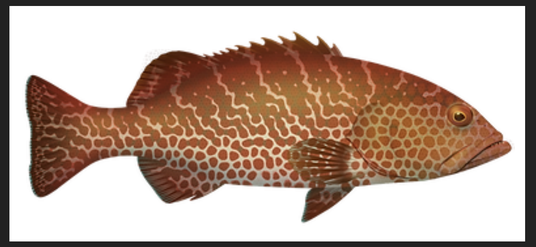
Nassau grouper across all northern USVI sites conducted annually from 2003-2017 (from Smith et al. 2018)

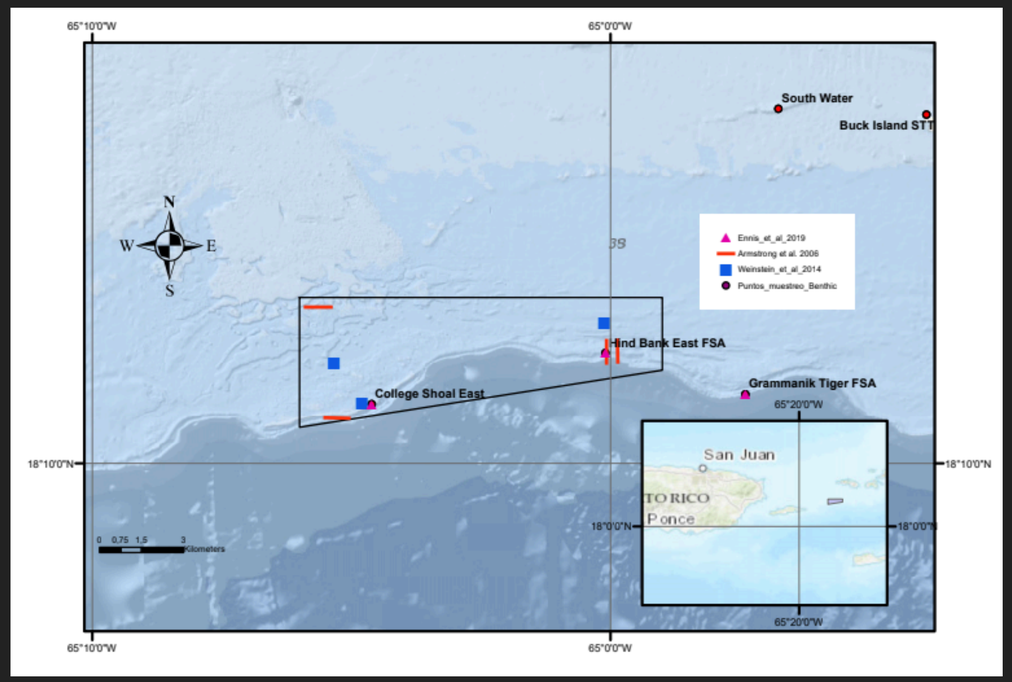
RED HIND MARINE CONSERVATION DISTRICT

- Year-round no-take zone; 1999
  - Red hind (*Epinephelus guttatus*)
  - Tiger grouper (*Mycteroperca tigris*)
- This MMA is allowing red hind populations to increase (2005)
- New study to estimate current population density at MCD



Red hind (*Epinephelus guttatus*)


Tiger grouper (*Mycteroperca tigris*)

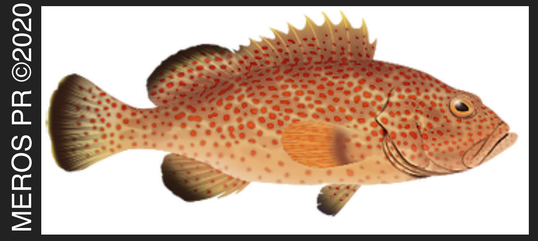


Type of scientific studies carried out at the MMAs	Managed Marine Areas MCD	
	No.	Last*
Coral reef species		
a. Benthic composition	19	2020b
b. Coral species heatlh	19	2020b
c. Coral species biology/ecology	3	2019
Reef fish species		
a. Visual censuses	19	2020b
b. Fishery Independent Survey		
c. Assessing SA site/Species (accustic/telemetry)	9	2020
d. CPUE - Independent fishery survey	1	2005

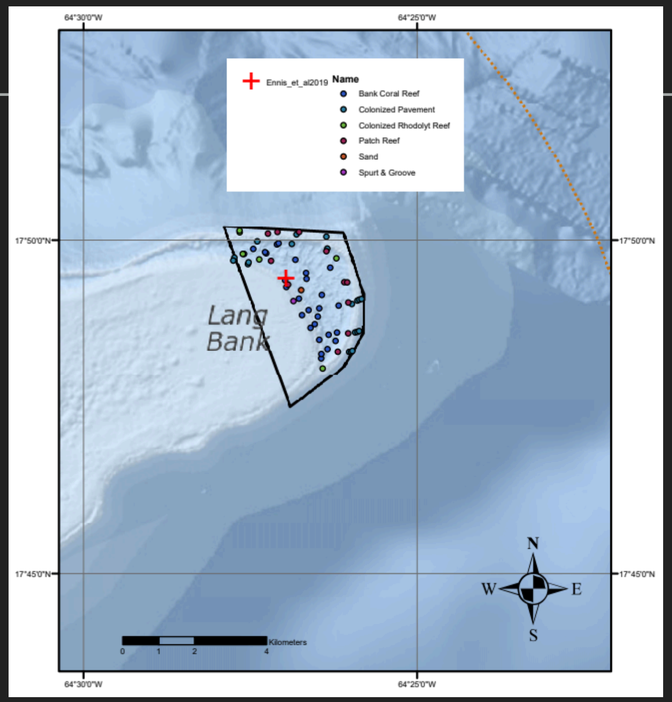
*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

LANG BANK

- Seasonal closure; 1993; December 1 to February 28/29
- Red hind (*Epinephelus guttatus*)



Red hind (*Epinephelus guttatus*)



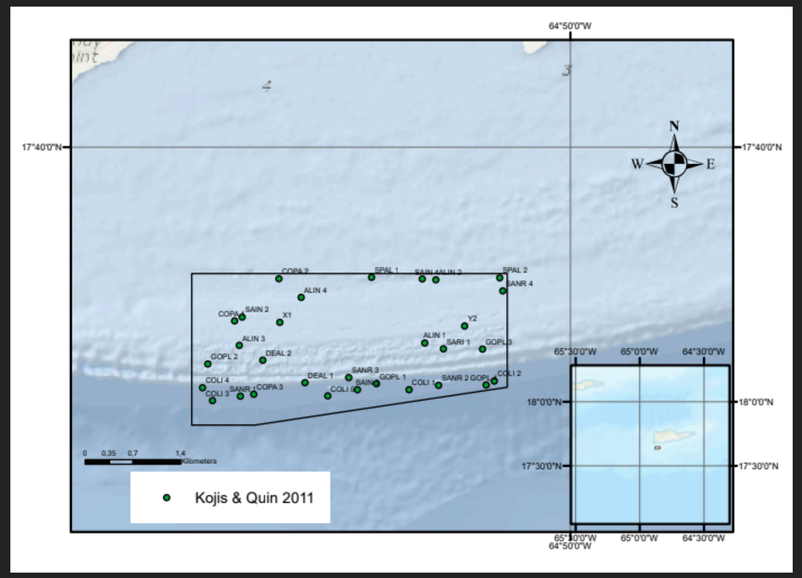
- Gaps and Recommendations:
- Lower predatory fish density in St Croix than in the Northern Virgin Islands (Kadison et al. 2017; "fish-encounters" in fish surveys)
- Lack of current/new fishery-independent surveys and/or CPUE studies (with data discriminated by sampling point, not by landing point) to quantify the red hind current population size

Type of scientific studies carried out at the MMAs	Marine Managed Areas LB	
	No.	Last*
Coral reef species		
a. Benthic composition	16	2020b
b. Coral species heatlh	13	2020b
c. Coral species		
Reef fish species		
a. Visual censuses	14	2020b
b. Fishery Independent Survey	2	2014
c. Assessing SA site/Species	1	2019
d. CPUE		

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

MUTTON SNAPPER SPAWNING AREA

- Seasonal closure; 1993; December 1 to February 28/29
- Mutton snapper (*Lutjanus analis*)



- Gaps and Recommendations:
- The visual census did not find spawning aggregations, but an independent fishery study suggest a robust mutton snapper spawning aggregation (exact location unknown) (Kojis and Quinn, 2011)
- TCRMP, UVI's scientists had visited MSSA several times and found few specimens of the mutton snapper
- Alternative methods are needed. To find the primary spawning site, we can conduct acoustic telemetry with acoustic receiver arrays along MSSA
- Lower predatory fish density in St Croix than in the Northern Virgin Islands (Kadison et al. 2017; "fish-encounters" in fish surveys)
- Lack of current/new fishery-independent surveys and/or CPUE studies (with data discriminated by sampling point, not by landing point) to quantify the mutton snapper current population size at MSSA

Type of scientific studies carried out at the MMAs	Marine Managed Areas MSSA	
	No.	Last*
Coral reef species		
a. Benthic composition	17	2020b
b. Coral species heatlh	17	2020b
c. Coral species biology/ecology	1	2013
Reef fish species		
a. Visual censuses	14	2020b
b. Fishery Independent Survey	1	2013
c. Assessing SA site/Species		
d. CPUE	1	2011

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

SUMMARY OF SCIENTIFIC STUDIES

Type of scientific studies carried out at the MMAs	Marine Managed Areas													
	ALS		TB		BS		GB		MCD		LB		MSSA	
	No.	Last*	No.	Last*	No.	Last*	No.	Last*	No.	Last*	No.	Last*	No.	Last*
Coral reef species														
a. Benthic composition	1	2013	12	2019a	1	2007	19	2020b	19	2020b	16	2020b	17	2020b
b. Coral species heatlh	1	2013	12	2019a	1	2007	19	2020b	19	2020b	13	2020b	17	2020b
c. Coral species			2	2019			8	2016	3	2019			1	2013
Reef fish species														
a. Visual censuses	2	2013	12	2019a	1	2007	19	2020b	19	2020b	14	2020b	14	2020b
b. Fishery Independent Survey	1	2012	1	2013	1	2012					2	2014	1	2013
c. Assessing SPA site (acoustic/telemetry)	7	2020			8	2019	13	2020	9	2020	1	2019		
d. CPUE - Independent fishery survey									1	2005			1	2011

*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP

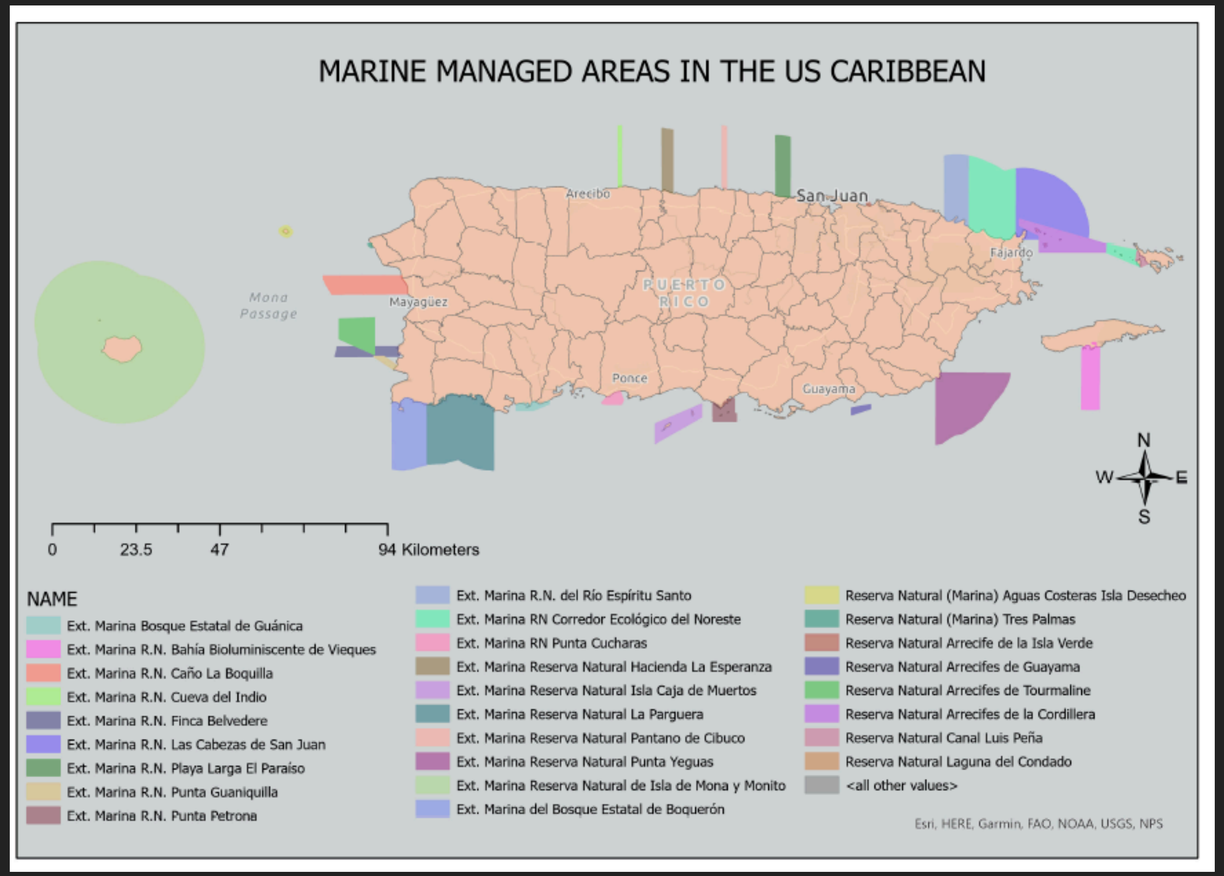
SUMMARY OF SPECIES REPORTED PER MMA

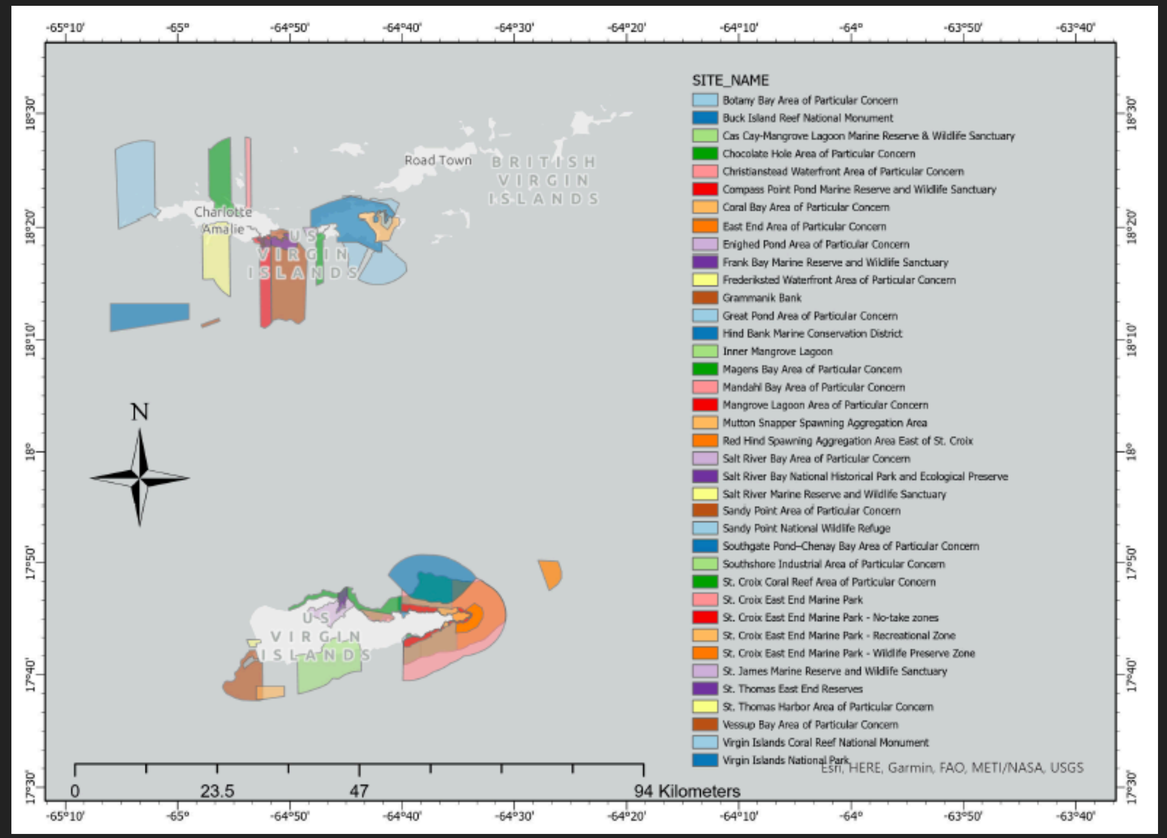
Recorded species that spawn at the MMAs	Marine Managed Areas						
	ALS	TB	BS	GB	MCD	LB	MS
Red hind/Mero cabrilla (Epinephelus guttatus)	X	X	X		X	X	
Nassau grouper/Mero cherna (Epinephelus striatus)				X			
Yellowfin grouper/Guajil (Mycteroperca venenosa)				X			
Tiger grouper/Mero tigre (Mycteroperca tigris)				X	X		
Yellowmouth grouper / Cherna boca amarilla (Mycteroperca interstitialis)				X			
Mutton snapper/Sama (Lutjanus analis)	X						X
Dog snapper/Pargo colorado (Lutjanus jocu)				X			
Cubera snapper/Pargo cubera (Lutjanus cyanopterus)				X			
Queen trigger/Pejepuerco (Balistes vetula)						X	

ALL PROTECTED AREAS IN THE US CARIBBEAN

US CARIBBEAN (ALL AREAS –INCLUDING THOSE IN TERRITORIAL WATERS)

- The World database on Protected Areas (WDPA) developed by IUCN http://prtotectedplanet.net
- The MPA Inventory, developed National by the Oceanic and Atmospheric Adminitrations (NOAA) http://marineprotectedareas.noaa.govaboutmpas/
- A Comprehensive Inventory of Protected Areas and other Land Conservation Mechanisms in Puerto Rico. Department of Agriculture Forest Service, International Institute of Tropical Forestry.





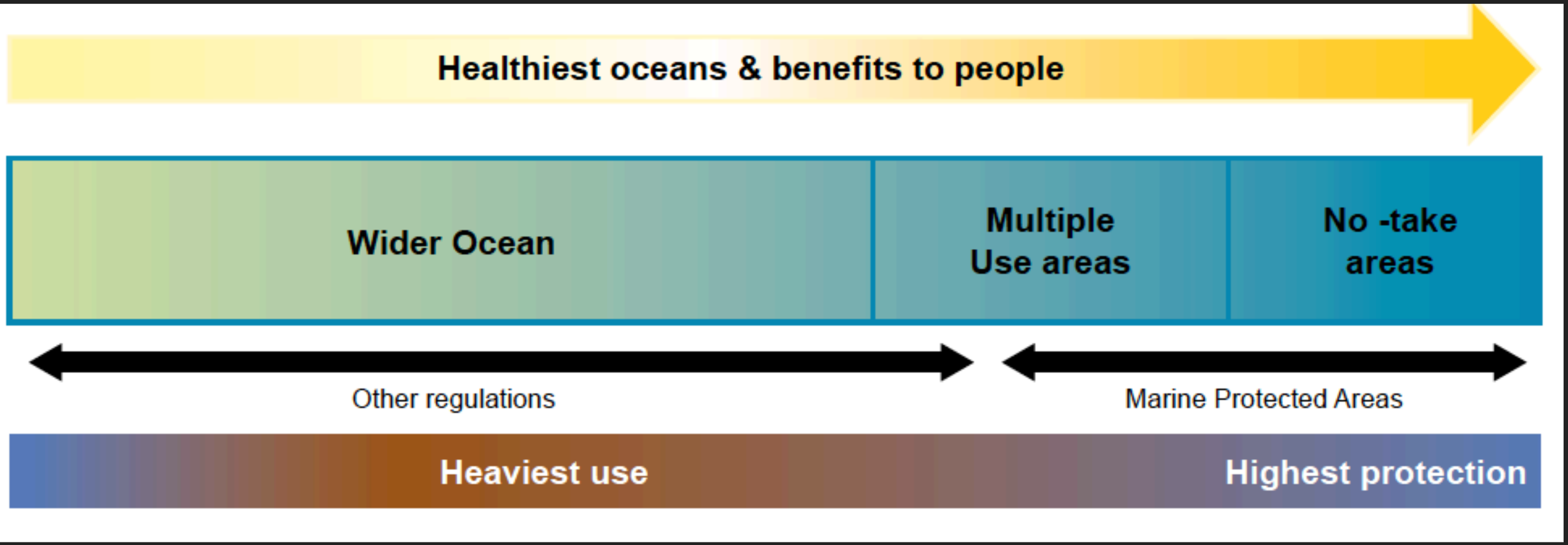
- 51 protected areas (including all types of designations). Need standardization of the categories of the protected areas (IUCN)

IUCN CATEGORIES (INTERNATIONAL UNION FOR CONSERVATION OF NATURE)

- Need to standardize worldwide classification
  - What is a MPA (Marine Protected Area): *"A protected areas is a clearly defined geographical space, recognized, dedicated and management, through legal or other effective means, to achieve the long term conservation of nature with associate ecosystems service and cultural values"* (IUCN, 2008)
  - Under IUCN: *"Temporal or permanent fishing closures that are establish primary to help build up and maintain reserve stocks for fishing in the future, and don't have wider conservation aims or achievements are not considered to be MPAs" (IUNC, 2019)*

IUCN CATEGORIES

- Need to standardize worldwide classification



Day et al, 2019

COMPATIBILITY OF FISHING/COLLECTING ACTIVITIES IN DIFFERENT MANAGEMENT CATEGORIES A PRELIMINARY ASSESSMENT

IUCN category	Long term and sustainable local fishing/ collecting practices	Recreational fishing/ collecting	Traditional fishing/ collecting	Collection for research
Ia	No	No	No	No*
Ib	No	No	Yes**	Yes
II	No	No	Yes**	Yes
III	No	No	Yes**	Yes
IV	Variable#	Variable#	Yes	Yes
V	Yes#	Yes	Yes	Yes
VI	Yes#	Yes	Yes	Yes

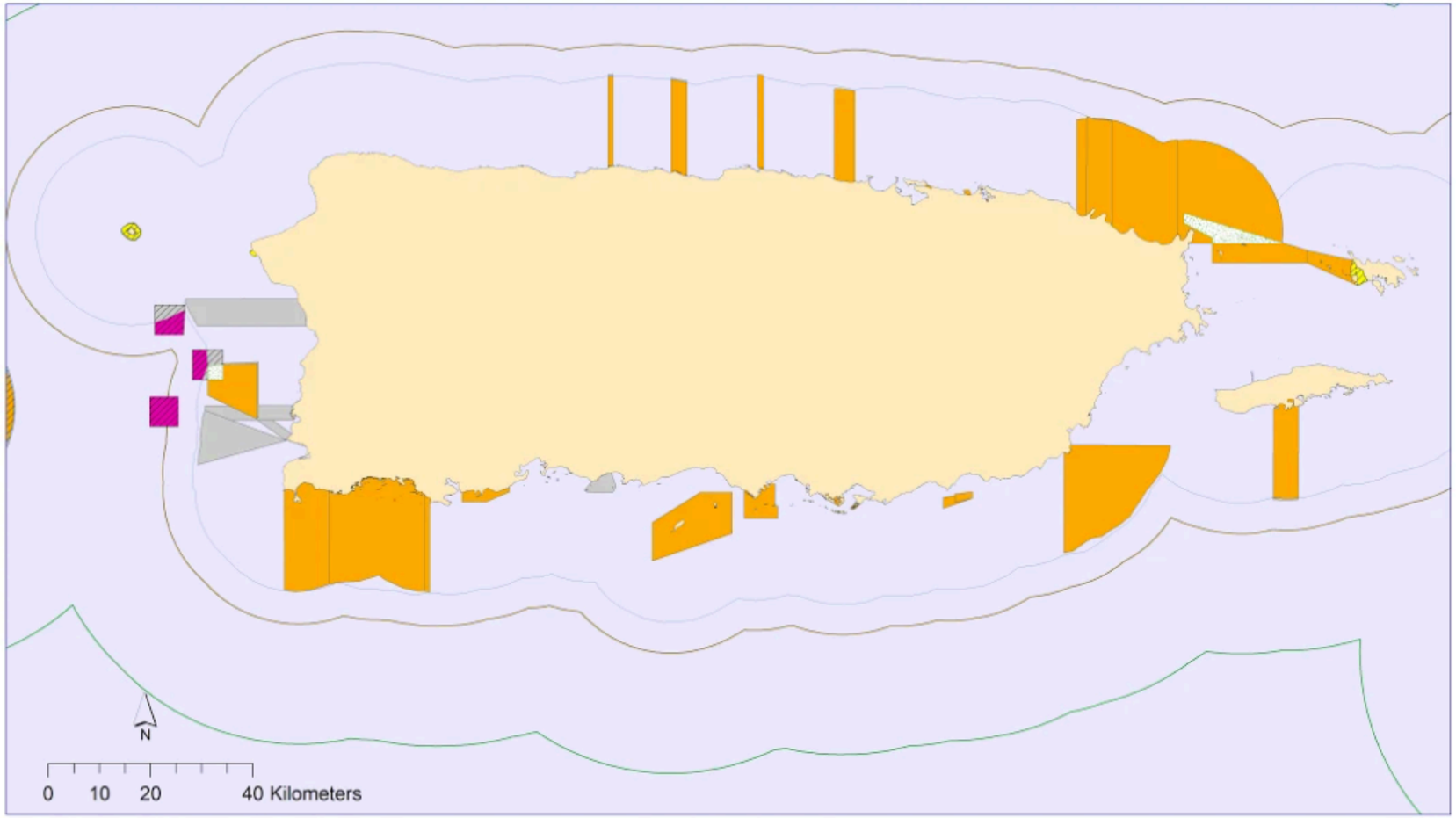
Key:

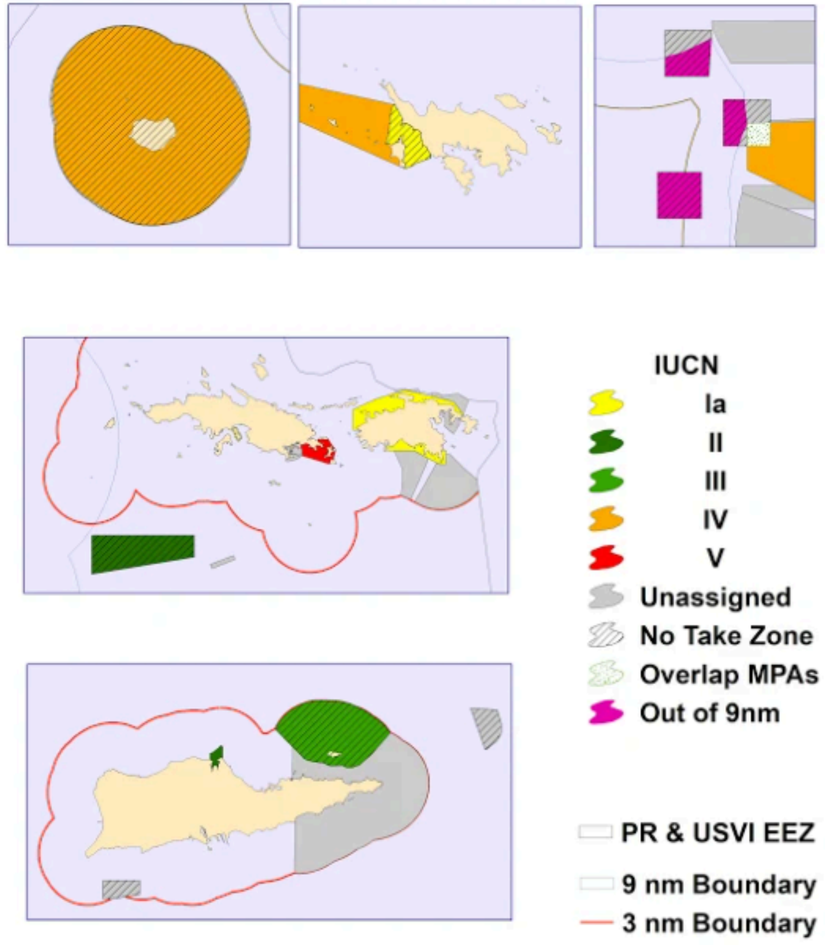
*	any extractive use of Category Ia MPAs should be prohibited with possible exceptions for scientific research which cannot be done anywhere else.
**	in Categories Ib, II and III MPAs traditional fishing/collecting should be limited to an agreed sustainable quota for traditional, ceremonial or subsistence purposes, but not for purposes of commercial sale or trade.
#	whether fishing or collecting is or is not permitted will depend on the specific objectives of the MPA.

Day et al.,2019

WHERE ARE WE IN THE US CARIBBEAN?

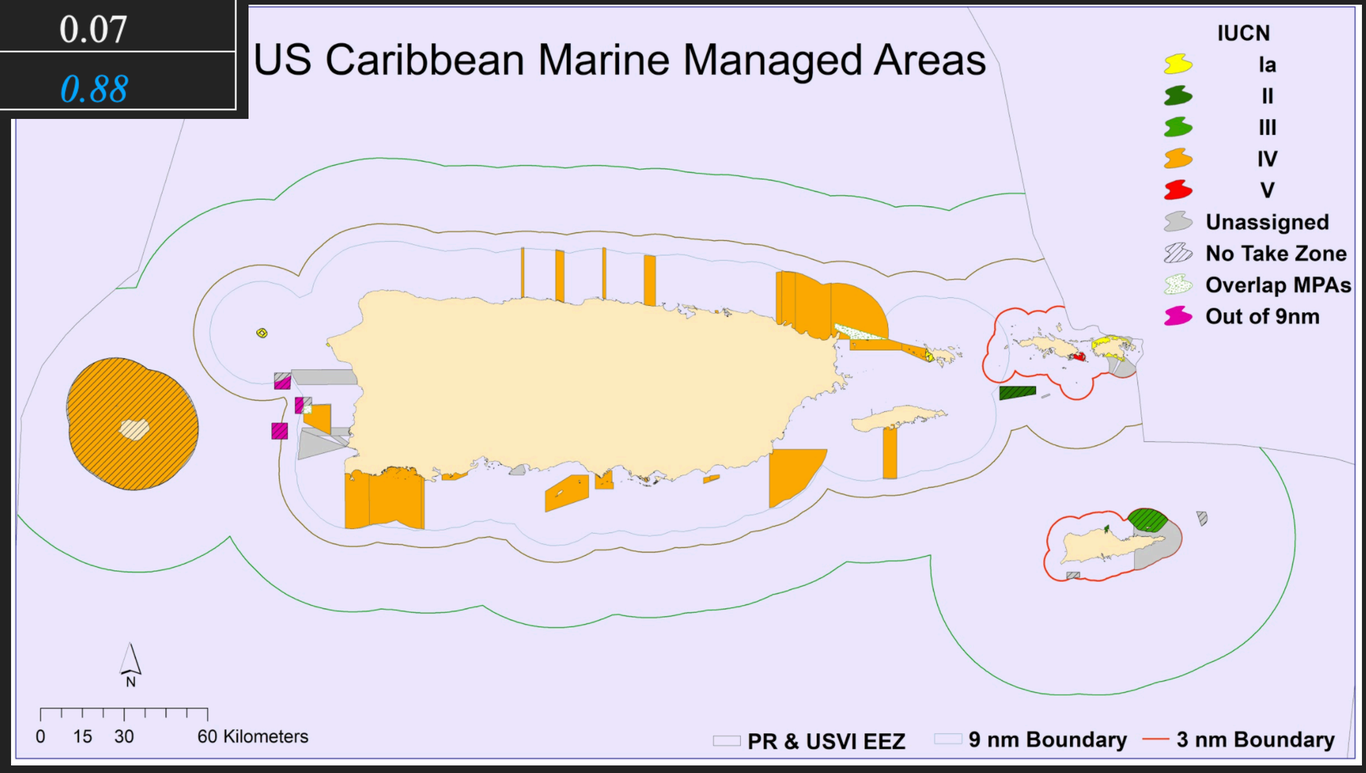
IUCN category	Long term and sustainable local fishing/ collecting practices	Recreational fishing/ collecting	Traditional fishing/ collecting	Collection for research
IV	Variable#	Variable#	Yes	Yes





So how much of the US Caribbean EEZ is protected?

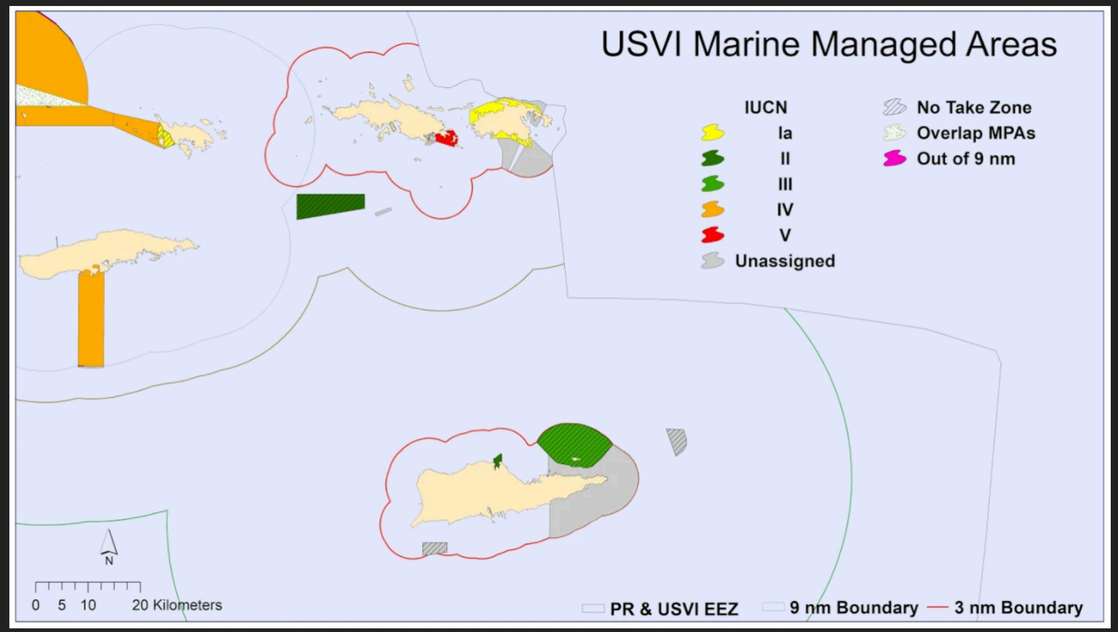
US CARIBBEAN	Area (km^2)	Number of Areas	US Caribbean Basin (%)
Total Area MMAs : 51 Total	*4276.41*	*51*	*2.02*
Ia	123.03	8	0.06
Unassigned	792.58	24	0.38
IV	3110.80	20	1.47
II	63.00	2	0.03
III	51.00	1	0.02
V	149.00	1	0.07
No Take areas (includes seasonal no-take)	*1864.03*	*13*	*0.88*



How much in the USVI?

USVI	Area (km^2)	Number of Areas	Territorial Water (%)	USVI EEZ (%)
Total Area MMAs : 15 Total	*393.03*	*12*	*27.68*	
Ia	77.025	2	5.42	
Unassigned	42	4	2.96	
IV	11	2	0.77	
II	63	2	4.44	
III	51	1	3.59	
V	149	1	10.49	
No Take in territorial waters (in 3 NM)	*159.02*	*5*	*11.20*	
*No Take EEZ (out 3 NM)**	*58*	*3*		*0.15*

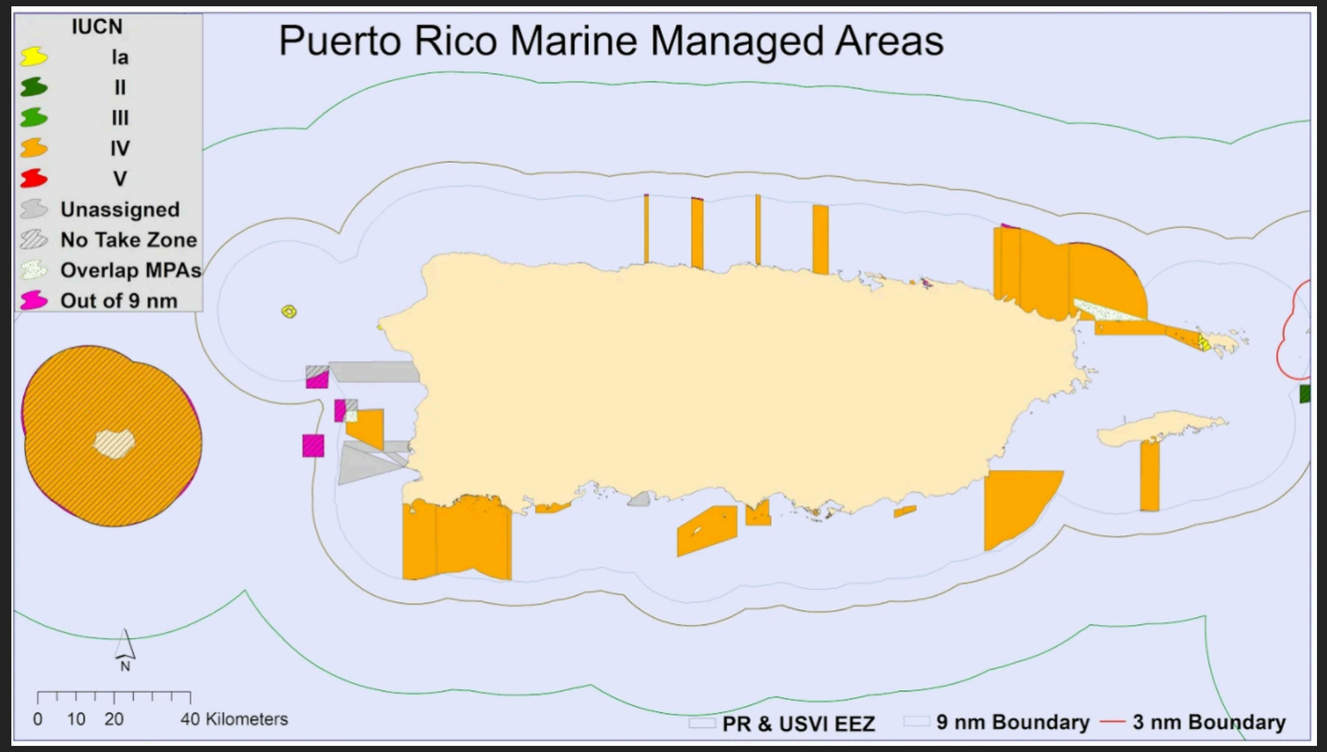
Area PR Territorial Waters	13443
Area USVI Territorial Waters (3nm)	1420
USVI EEZ	38275
PR EEZ	182882
Total Area EEZ	211242



How much in the Puerto Rico?

PUERTO RICO	Area (km^2)	Number of Areas	Territorial Water (%)	PR EEZ (%)
Total Area MMAs : 37 Total	*3825.21*	*37*	*28.46*	
Ia	46.00	5	0.34	
Unassigned	693.58	15	5.16	
IV	3085.63	17	22.95	
No Take in territorial waters (in 9NM)	*126.86*	*5*	*0.94*	
*No Take EEZ (out 9 NM)**	*60.99*	*3*		*0.03*

Area PR Territorial Waters	13443
Area USVI Territorial Waters (3nm)	1420
USVI EEZ	38275
PR EEZ	182882
Total Area EEZ	211242



- In territorial waters, we are close to the 30 % goal (about 27%). Far in the EEZ (2%)
  - Consider year-round closures on sections of MMAs, so they become MPAs
  - Consider increasing size in areas that studies suggest they should increase (i.e., GB-MCD)
  - Consider increasing the area of no-take in existing MPAs/MMAs. Some are too small for fish home ranges
  - Revise all management plans and develop one in areas that do not have one

OTHER RECOMMENDATIONS

OTHER RECOMMENDATIONS

- Periodic (every five years so) stock assessment analysis of the top commercially important species to understand changes through time and the current status of their populations
- Coral reef habitats are essential fish habitats in the MMAs (i.e., spawning grounds).
    - Monitoring on permanent transects would allow estimating changes through time and the current state of the benthic communities. Currently, only a few of the MMAs (i.e., Grammanik Bank) have this monitoring in place. All others have only been characterized once (i.e., Bajo de Sico) or surveyed in different years at different habitats or depths, making comparisons inadequate across time.
- Acoustic tagging and telemetry could also be implemented more broadly across the MMAs to complement fisheries-based assessments. These telemetry approaches provide:
    - 1) Identifying specific habitats within MMAs that fish use for reproduction or feeding
    - 2) Help to evaluate the effectiveness of management strategies, the optimal MMA size, ecological connectivity (adult movement) among nearby protected areas
    - 3) Provide baseline information about multispecies spawning aggregations
    - 4) Allows determining if spawning aggregation shifts spatially or temporally and the extent of the spawning season within MMAs, allowing managers to adjust conservation measures (i.e., extend closure times).

OTHER RECOMMENDATIONS

- Start considering new technologies for monitoring/surveys
  - For instance, underwater drone-type equipment coupled with high-resolution cameras guided by virtual reality and GIS adjusted maps could provide a new way to give a more comprehensive way to monitor benthic and fish communities
  - Managers can use drones to quantify fishers during banning times and design patrolling activities based on these observations
- Publicly available data facilitates work by managing agencies, decreases chances for duplicating efforts, stimulates research, and allows for analysis of changes through time of the habitats within MMAs. All collected data (i.e., SEMAP) from and all locations should be made publicly available and easy to download

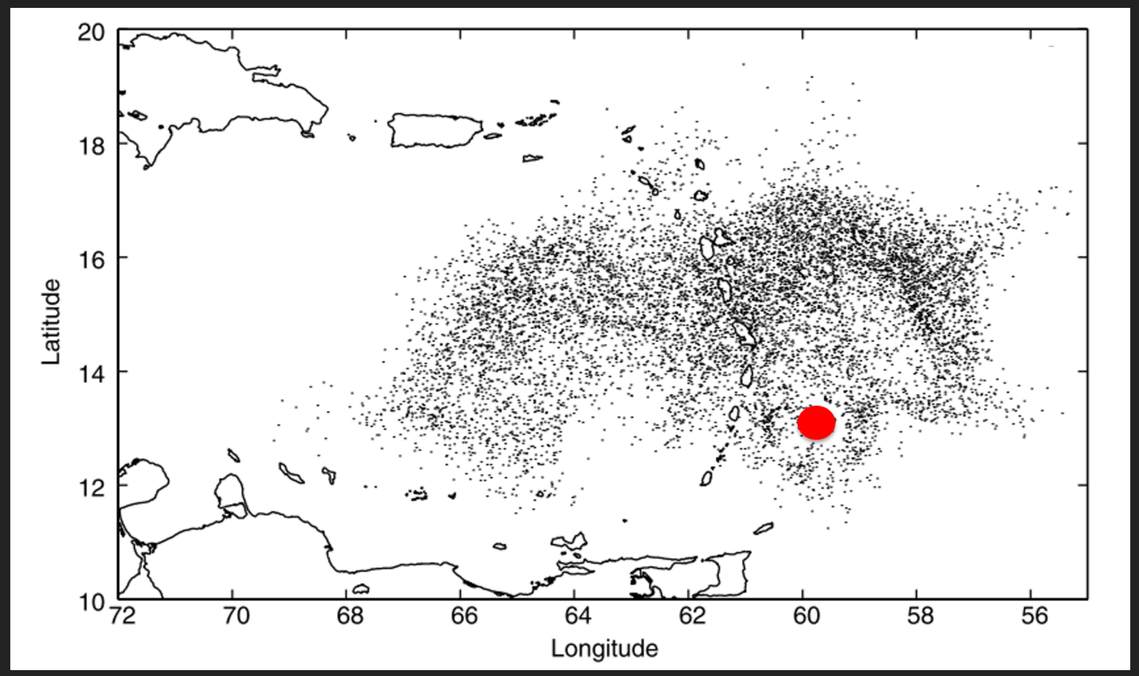
FINAL CONSIDERATION

- Evidence indicates that ecological connectivity enhances the effectiveness, biodiversity, productivity, stability, and resilience of marine protected areas (MPAs) and MMAs. For example, the structure of marine communities and the performance of an MMA/MPA in replenishing fish populations can be influenced by connectivity among coastal marine ecosystems and offshore habitat, with well-documented examples including interconnected nursery habitats, ontogenetic shifts to deeper water, migrations to spawning aggregations, and larval supply. The need for information on ecological connectivity within the US Caribbean is evident and urgent. Targeted transdisciplinary scientific research and decision support tools that explicitly incorporate ecological connectivity into the design and management of MMA and MPA networks are required to support near-term capacity building for managers across the US Caribbean
    - Larval connectivity genetics, parentage analysis, assignment tests, physical models, acoustic tagging, otoliths microchemistry, chemical dying

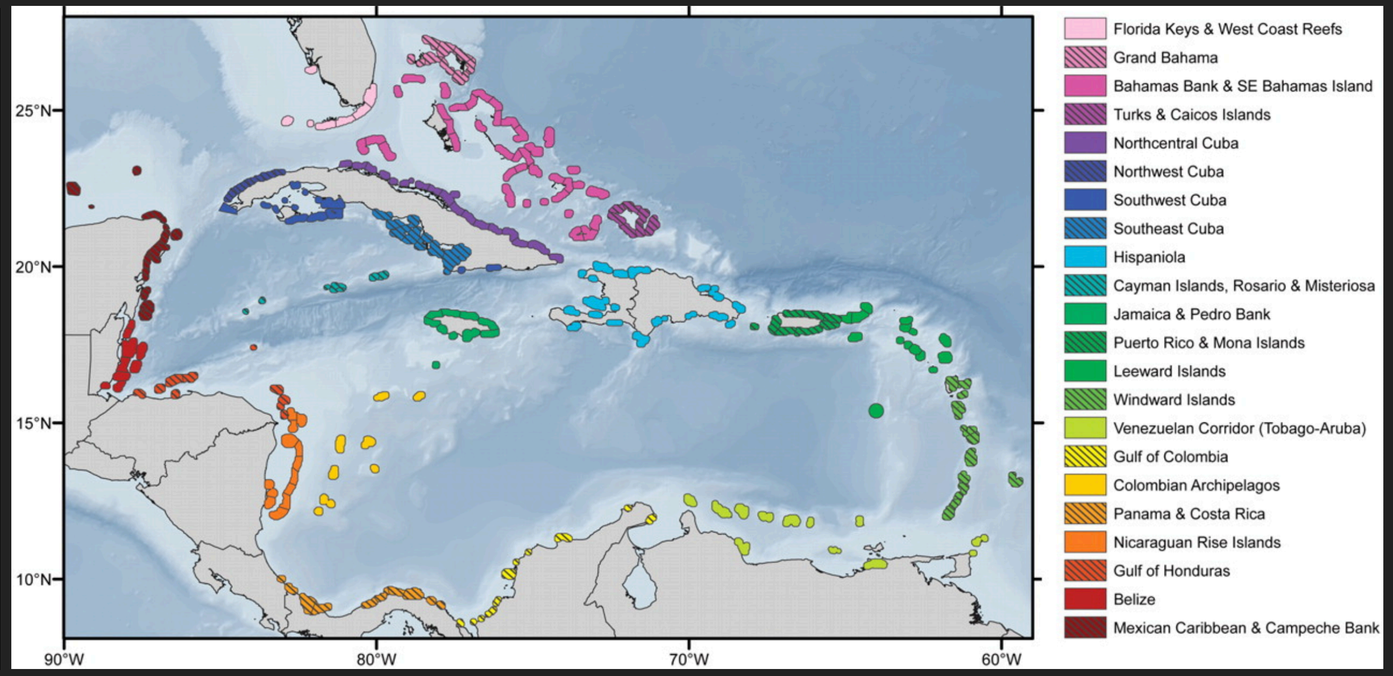
FINAL CONSIDERATION

- There are 51 areas with some level of protection, including areas managed by the CFMC and areas managed by the PR or USVI Departments of Natural Resources. From our review, it is clear that most areas are managed as single units and not as networks of protected areas
    - We recommend a committee/task force that begins the coordination of activities across the various protected areas and design strategies that incorporate the network nature of these managed areas. This committee should also coordinate monitoring programs and scientific efforts to understand the level of connectivity across the different protected areas and the habitats within and among the various protected areas

CONNECTED AMONG THEM!



Cowen et al, 2000



Cowen et al, 2006