

**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)



The map displays the western Caribbean Sea, with Puerto Rico to the east. Key features include the 100 fathom curve, the 9 nautical mile line, and the boundaries of Federal Waters and State Waters. Three study areas are highlighted: Bajo de Sico, Tourmaline Bank, and Abir La Sierra Bank. Each study area is marked with points A, B, C, and D. An index map in the top left corner shows the location of the study area within the Caribbean Sea. A scale bar in the bottom left corner indicates distances in nautical miles (0 to 20). A compass rose is also present in the bottom left corner.

The map displays the study area in the Caribbean Sea, specifically around the U.S. Virgin Islands. The main map shows the U.S. Virgin Islands (St. Thomas, St. John) and the Dominican Republic. The study area is highlighted in orange, showing the Hind Bank MCD and Grammanik Bank. The map includes latitude and longitude coordinates (18°10'N to 18°30'N, 64°50'W to 65°W) and a scale bar (0 to 8 Nautical Miles). An index map in the top left corner shows the location of the study area within the Caribbean. The map also shows the Exclusive Economic Zone and State Waters.

The map displays the island of St. Croix, US Virgin Islands, with its surrounding waters. Key features include:

- Index Map:** Located in the top left, showing the location of St. Croix within the Caribbean Sea and the Federal Waters of the US Virgin Islands.
- Geographic Labels:**
  - ST. CROIX:** The main island, shown in light green.
  - Lang Bank:** A shallow area to the east of the island.
  - 3 nautical mile line:** A black line defining the territorial sea.
  - 100 fathom line:** A blue line indicating a specific depth contour.
  - State Waters:** The area between the 3 nautical mile line and the 100 fathom line.
  - Federal Waters:** The area beyond the 100 fathom line.
  - Exclusive Economic Zone:** Indicated by a dashed line further out.
- Spawning Areas:**
  - Mutton Snapper Spawning:** Located on the west coast of St. Croix, marked with points A, B, C, D, and E.
  - Red Hind Spawning:** Located in the Lang Bank area, marked with points A, B, C, D, E, and F.
- Map Elements:**
  - Scale Bar:** Shows distances from 0 to 16 Nautical Miles.
  - Compass Rose:** Indicates North (N), South (S), East (E), and West (W).
  - NOAA Logo:** The National Oceanic and Atmospheric Administration logo.
  - Coordinates:** The map is bounded by latitudes 17°20'N to 18°N and longitudes 64°30'W to 65°W.

Map data sources: 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*)

## ▶ Gaps and Recommendations:

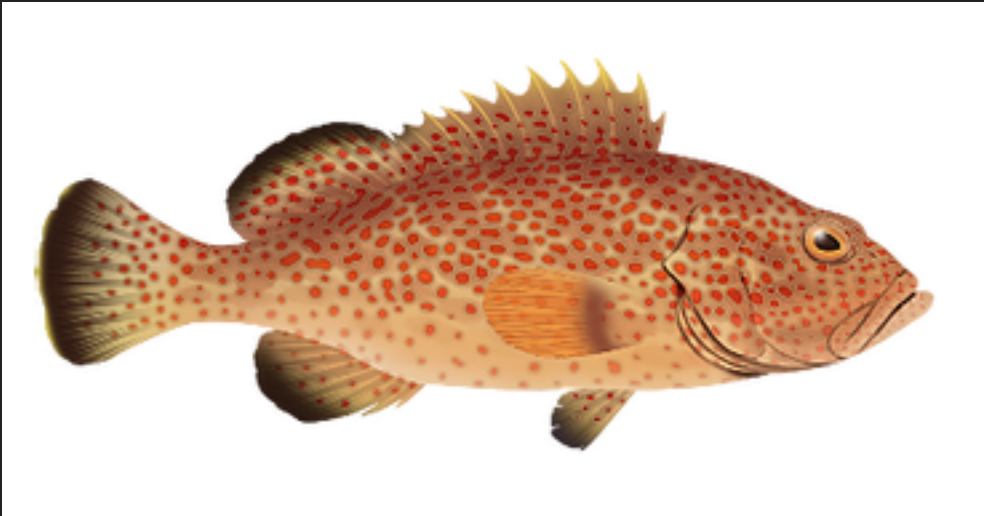
- ▶ The last and only benthic and reef fish surveys were done in 2013 (Garcia-Sais et al., 2013). Need new surveys to know the current state and to know if the closure is helping the recovery of red hind populations
- ▶ Lack of fishery-independent surveys and/or CPUE studies (with data discriminated 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 (Rowell et al 2011; 2012; Ibrahim et al 2018a, 2018b, 2018c; Appeldoorn et al 2018; Zayas et al 2020)

Type of scientific studies carried out at the MMAs	Marine Managed ALS	
	No.	Last*
<u>Coral reef species</u>		
a. Benthic composition	1	2013
b. Coral species health	1	2013
c. Coral species biology/ecology		
<u>Reef fish species</u>		
a. Visual censuses	2	2013
b. Fishery Independent Survey	1	2012
c. Assessing SPA site/Species (acoustic/telemetry)	7	2020
d. CPUE - Independent fishery survey		
*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP		

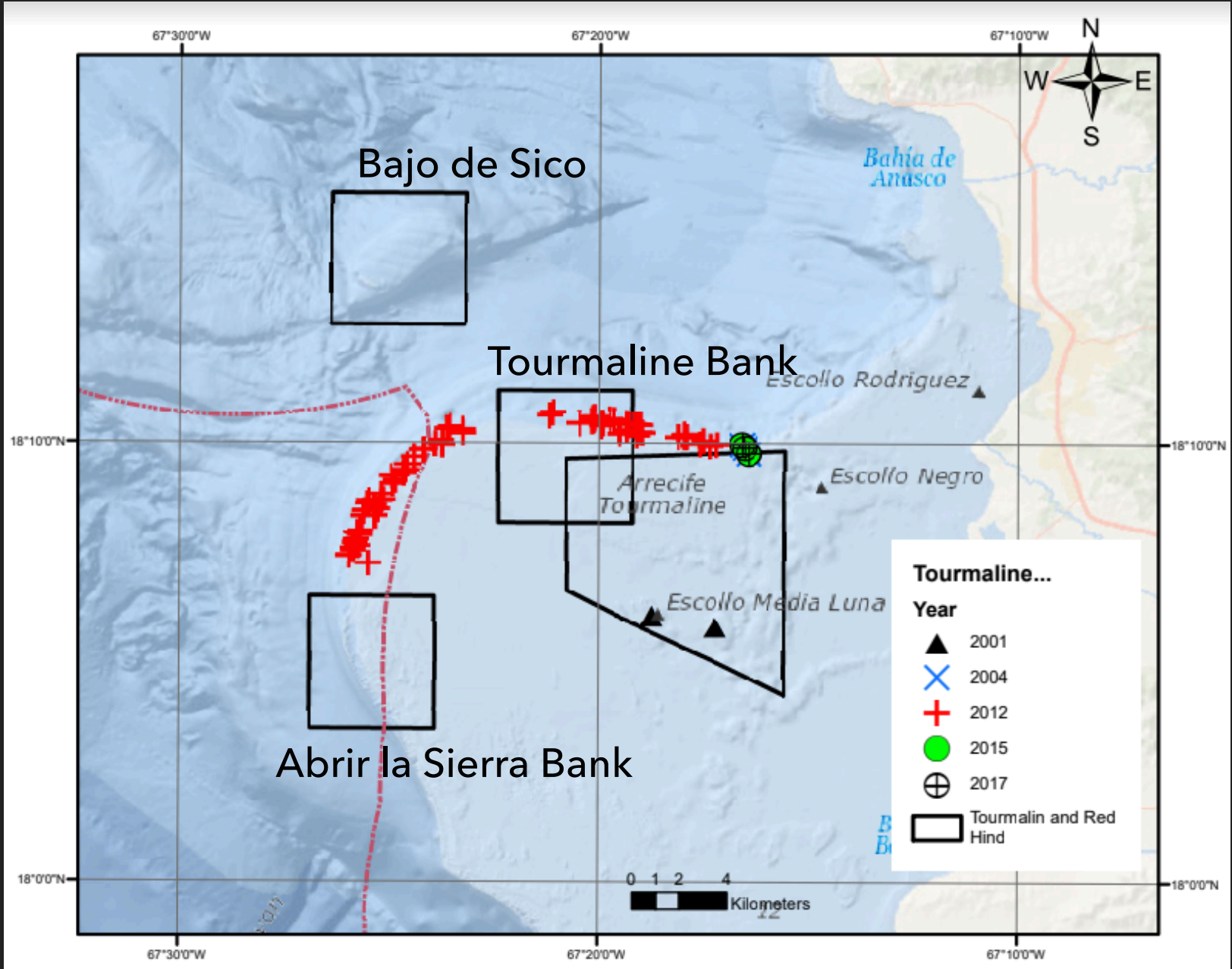
# TOURMALIN BANK

- ▶ 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*)

MEROS PR ©2020



Red hind (*Epinephelus guttatus*)



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

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

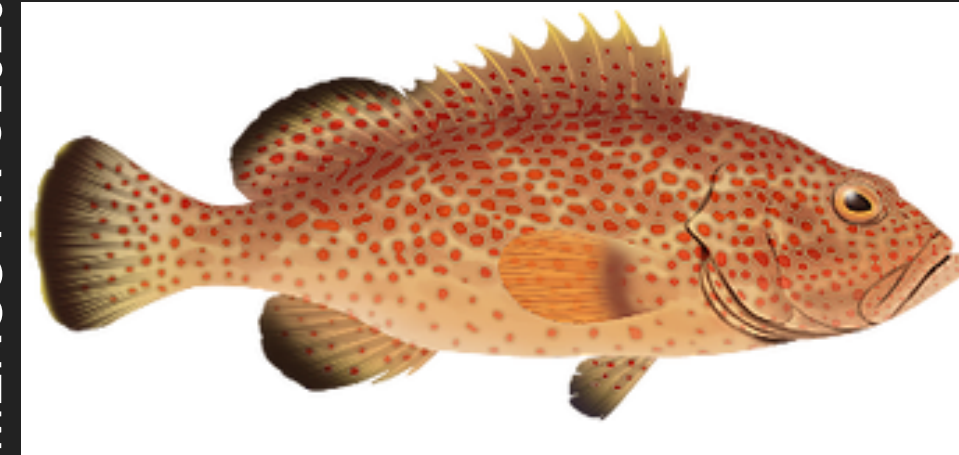
- ▶ **Gaps and Recommendations:**
- ▶ Are there other commercially important reef fish species that use TB as a SPA? García-Sais et al 2013: Mutton, Blackfin, dog and cubera snappers, lionfish, hogfish, and queen triggerfish: abundant mesophotic habitats.
- ▶ Carry out fishery-independent surveys and/or 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 be 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*) and lionfish (*Pterois spp.*)
- ▶ **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 (Schärer-Umpierre et al 2014; Touhy et al 2015; Rowell et al 2018; Ibrahim et al 2018 a, 2018 b; Schärer-Umpierre et al 2019)

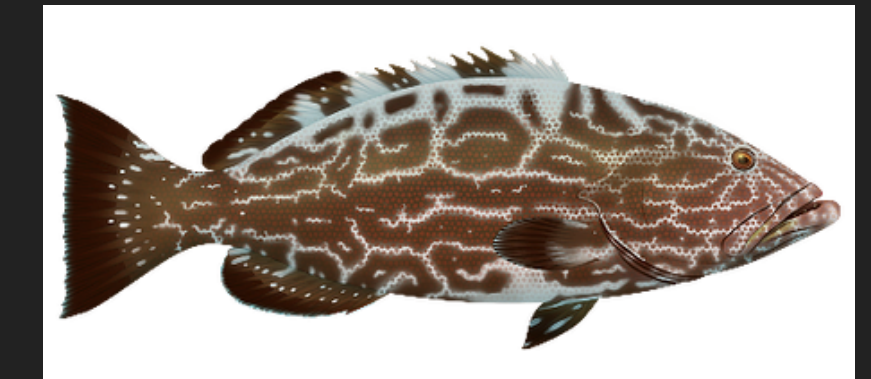
MEROS PR ©2020



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*
<u>Coral reef species</u>		
a. Benthic composition	1	2007
b. Coral species health	1	2007
c. Coral species biology/ecology		
<u>Reef fish species</u>		
a. Visual censuses	1	2007
b. Fishery Independent Survey	1	2012
c. Assessing SA site/Species	8	2019
d. CPUE		

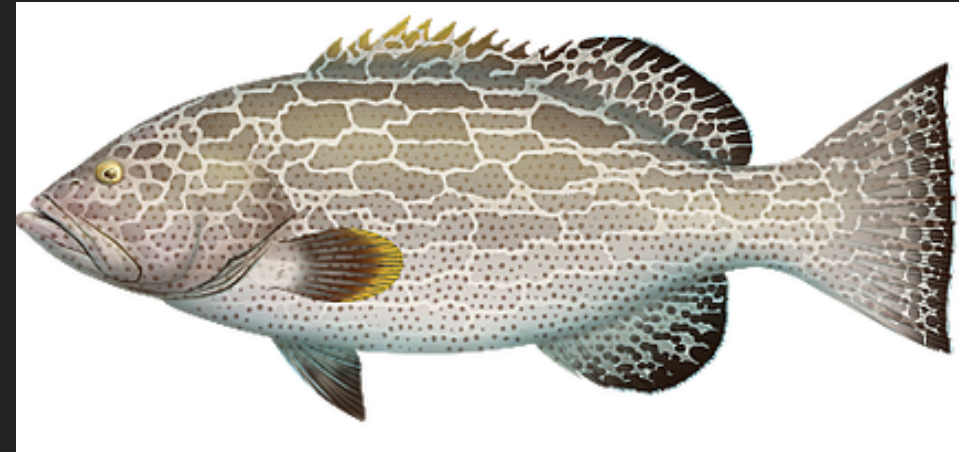
\*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP



# 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

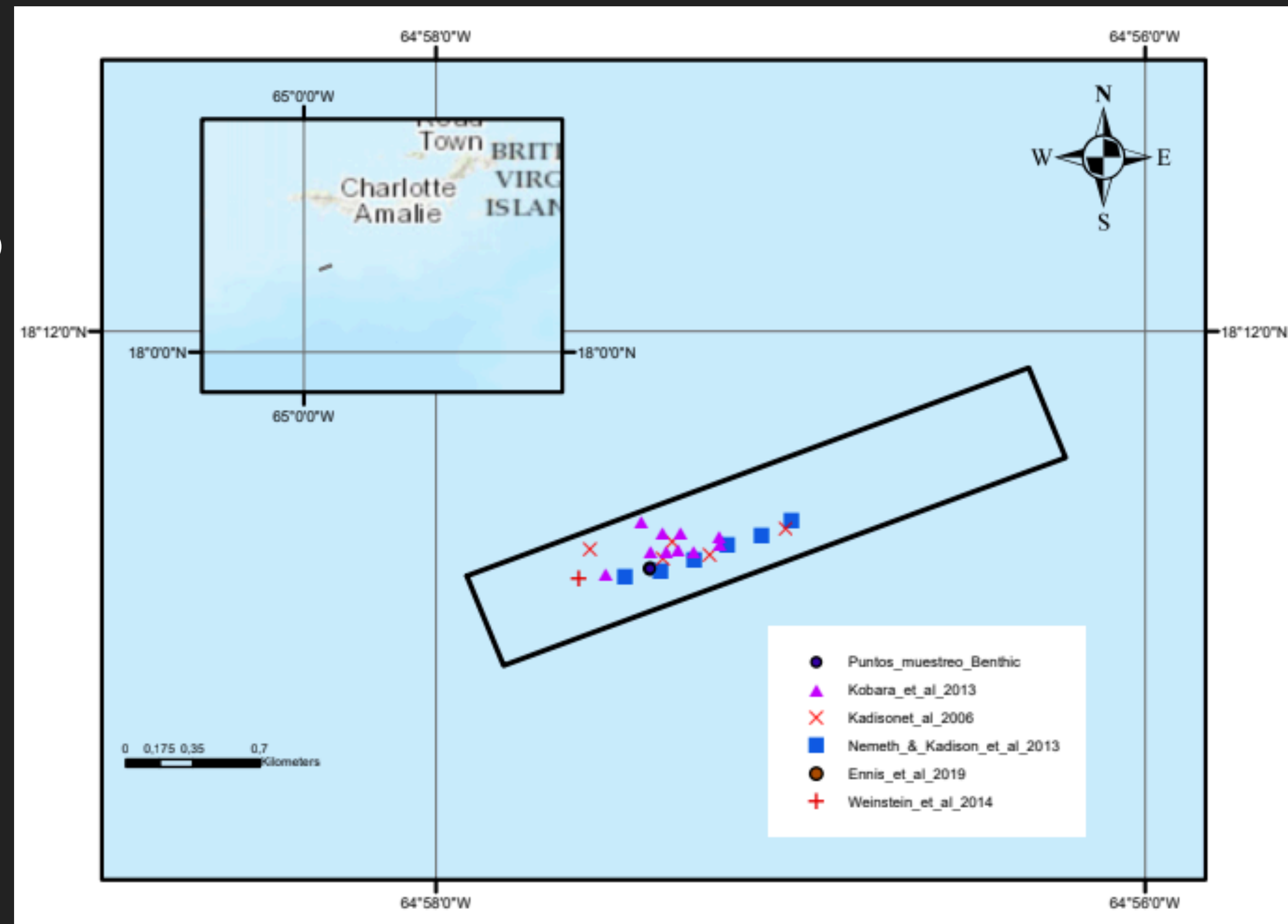
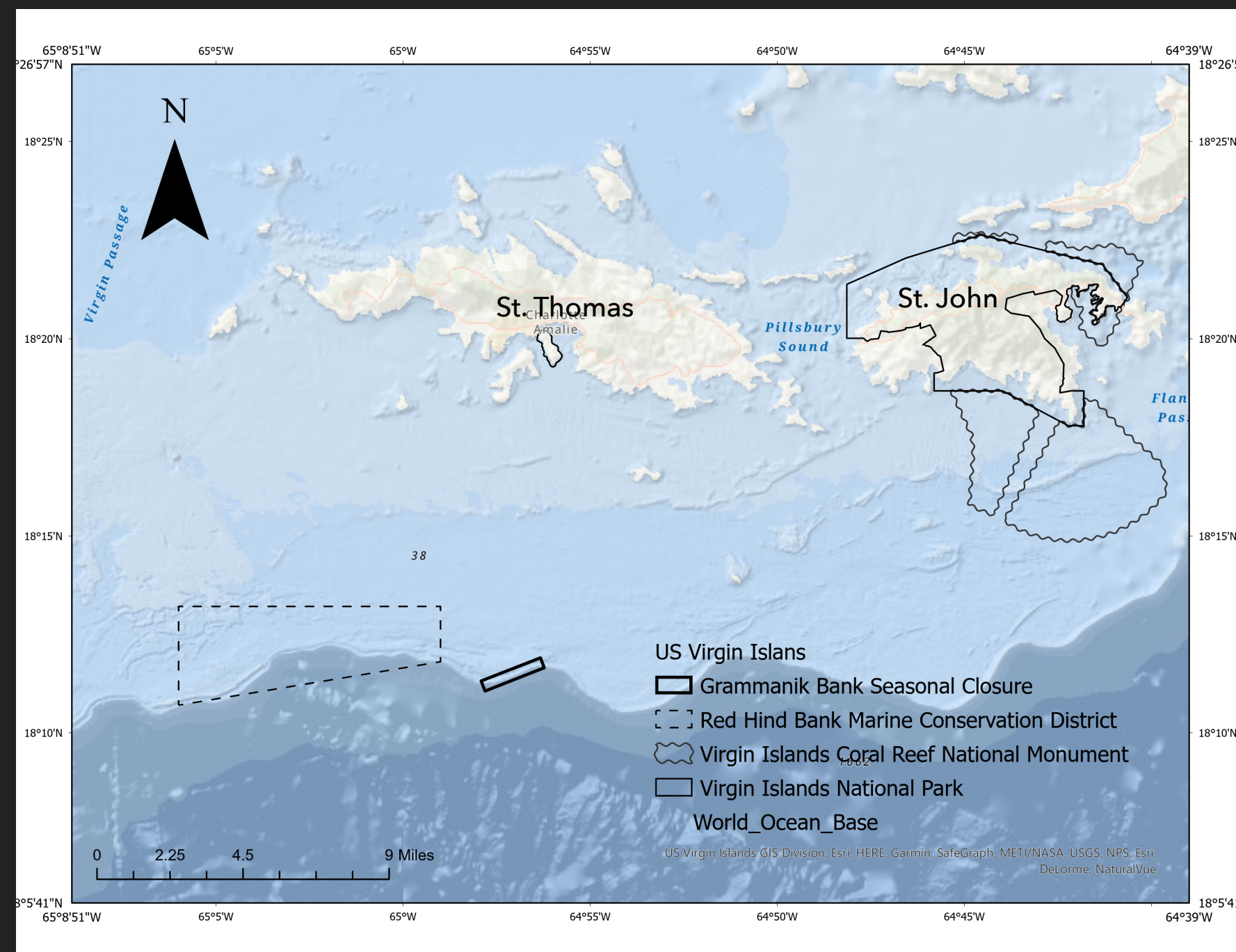


Yellowfin grouper (*Mycteroperca venenosa*)

MEROS PR ©2020



Nassaugrouper (*Epinephelus striatus*)



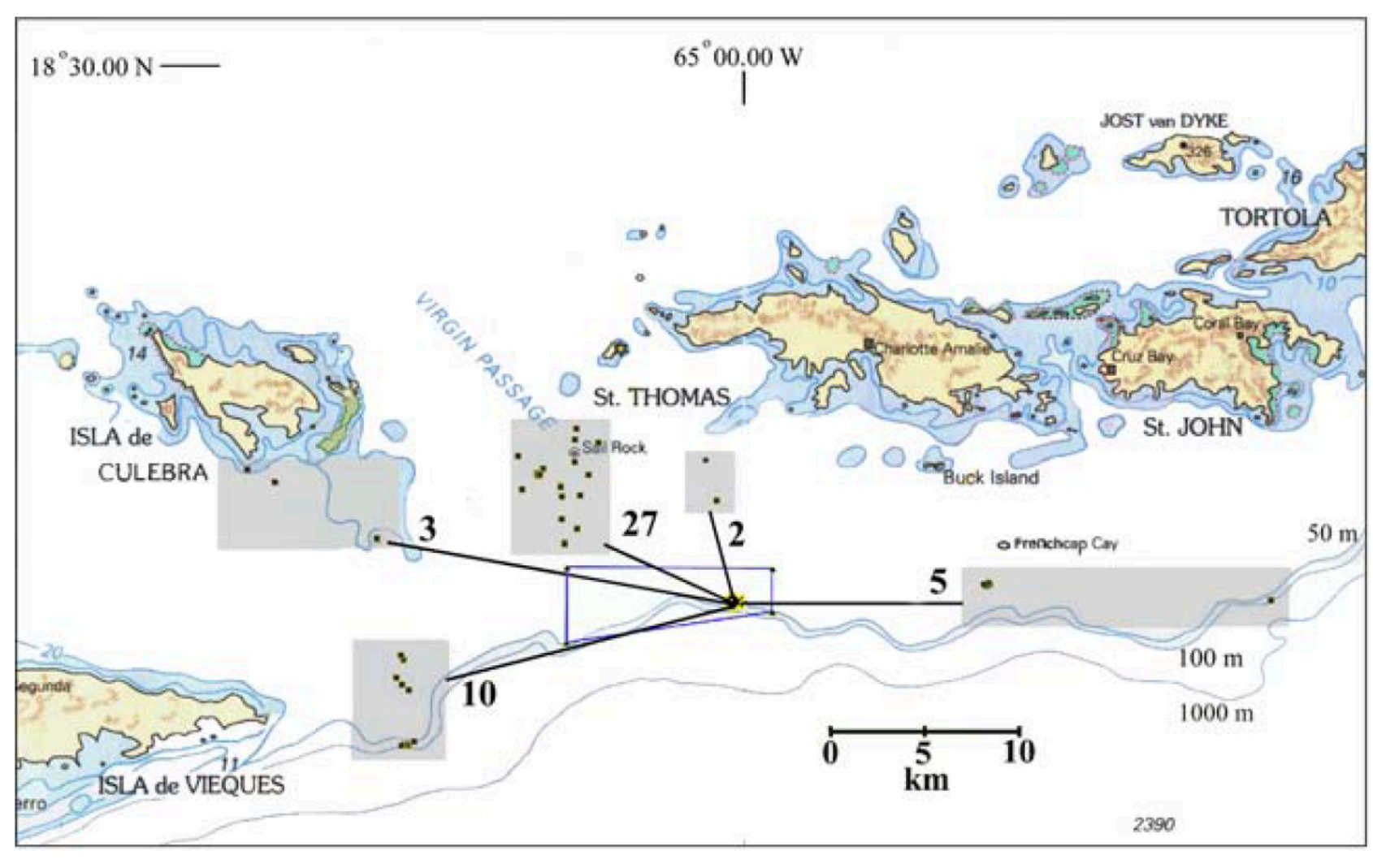


# GRAMMANIK BANK

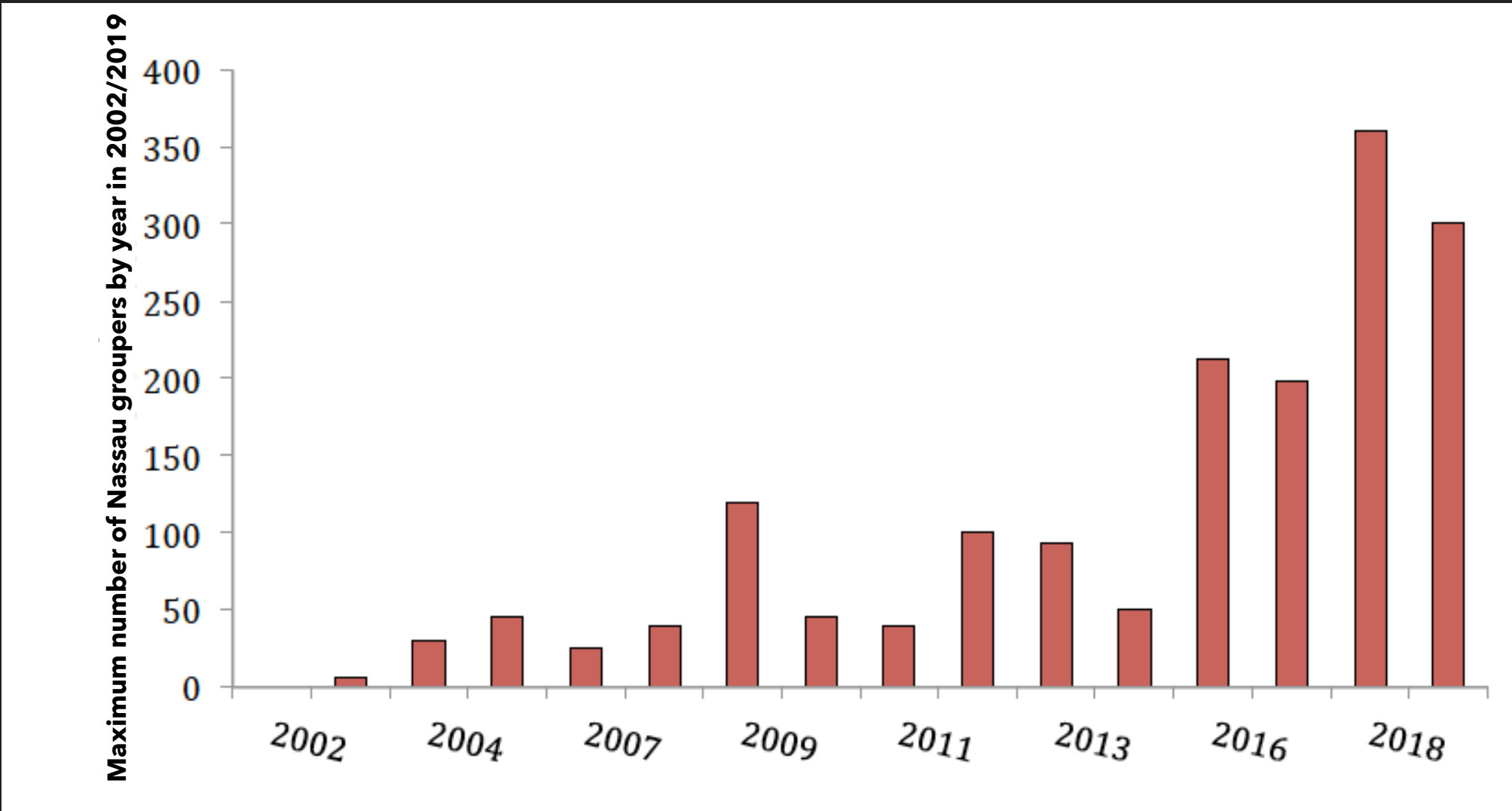
- ▶ **Gaps and Recommendations:**
- ▶ Best studied MMA in the US Caribbean
  - ▶ Passive acoustic and acoustic tagging studies have determined temporal reproductive activity, and site use
    - ▶ Nassau grouper (Kadison et al 2010; Scharer et al 2012b; Rowell et al 2015, 2018; Bernard et al 2016) and yellowfin grouper (Kadison et al 2011; Rowell et al 2015; Nemeth et al 2020)
  - ▶ 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*
<u>Coral reef species</u>		
a. Benthic composition	19	2020b
b. Coral species health	19	2020b
c. Coral species	8	2016
<u>Reef fish species</u>		
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)



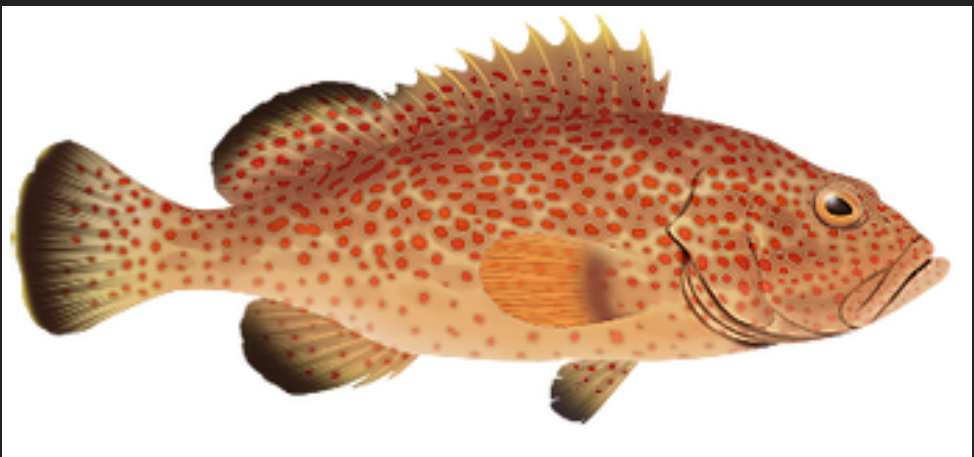
Nassau grouper across all northern USVI sites conducted annually from 2003-2017 (from Smith et al. 2018)



# RED HIND MARINE CONSERVATION DISTRICT

- ▶ Year-round no-take zone; 1999
  - ▶ Red hind (*Epinephelus guttatus*) Nemeth et al 2007; Nemeth et al 2008; Cherubin et al 2011; Schärer-Umpierre et al 2012
  - ▶ Tiger grouper (*Mycteroperca tigris*)
  - ▶ Nassau grouper (*Epinephelus striatus*) and yellowfin grouper (*Mycteroperca venenosa*) Rowell et al 2015
- ▶ This MMA is allowing red hind populations to increase (2005)
- ▶ New method classification of the call Types Ibrahim et al. (2019); Passive acoustic monitoring at MCD; Cherubin et al. (2020)

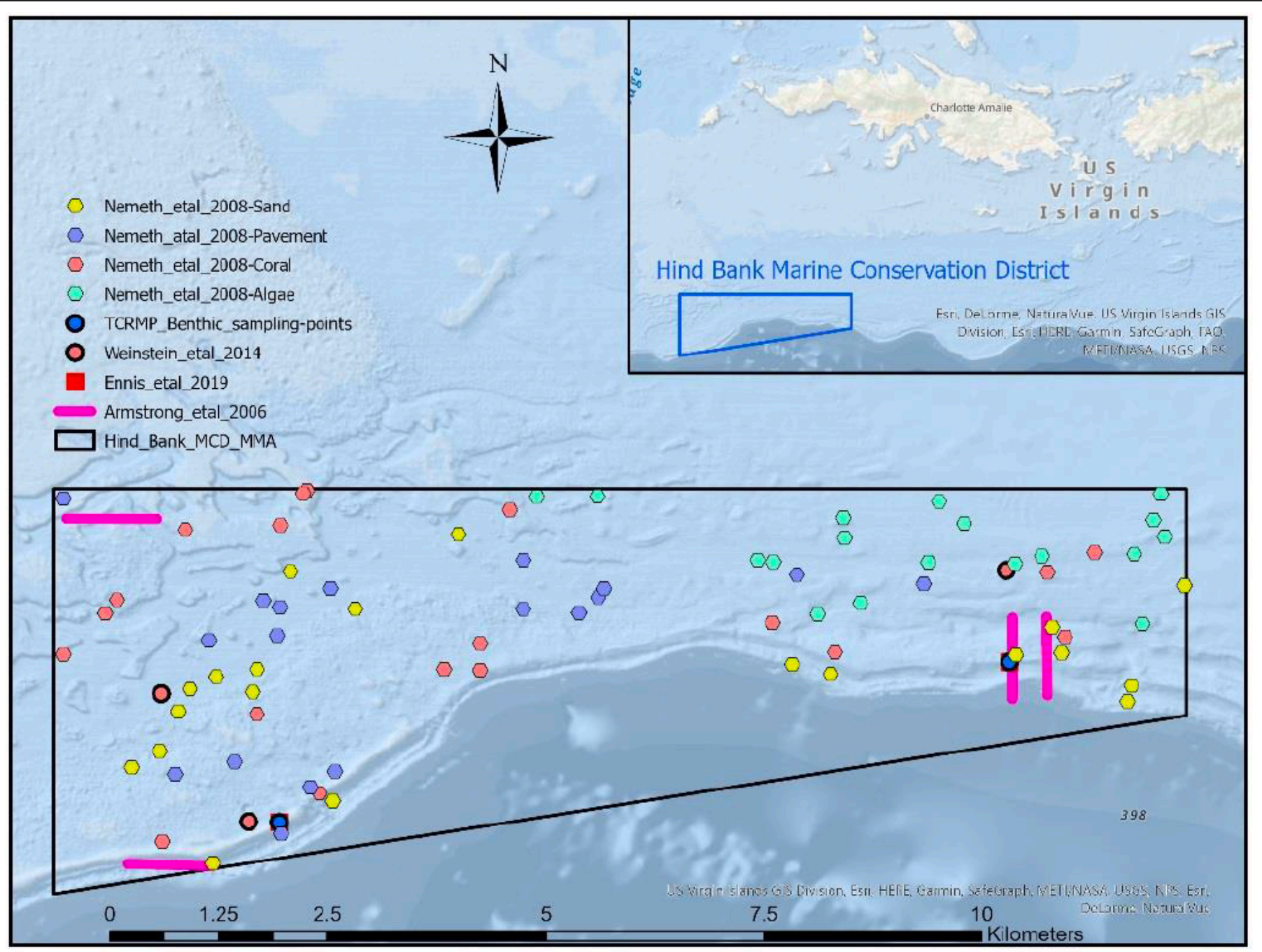
MEROS PR ©2020



Red hind (*Epinephelus guttatus*)



Tiger grouper (*Mycteroperca tigris*)



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

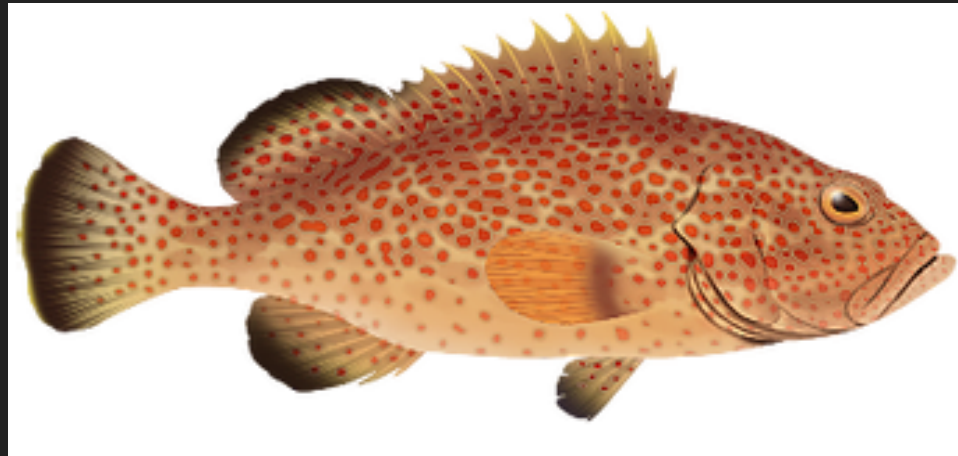
\*Last year where the studies were conducted; a PR-CRMP; b USVI TCRMP



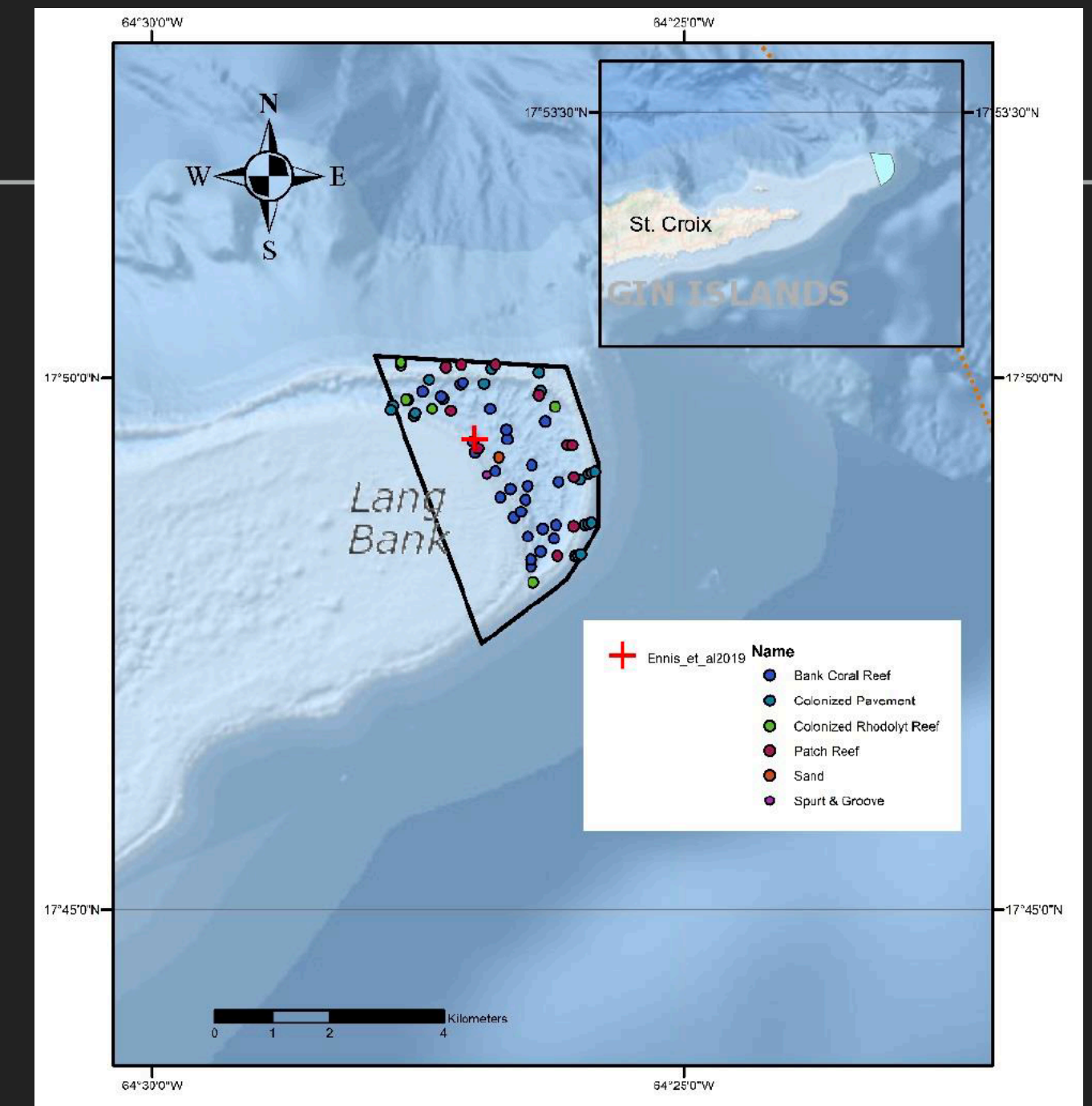
# LANG BANK

- ▶ Seasonal closure; 1993; December 1 to February 28/29
- ▶ Red hind (*Epinephelus guttatus*) Nemeth et al 2007; 2008
- ▶ Independent fishery survey of 22 commercially important fish and two shellfish (queen conch and spiny lobster) García-Sais et al 2014
- ▶ Spatial and temporal movement patterns of Queen triggerfish (*Balistes vetula*) Bryan et al 2019
- ▶ Passive acoustic telemetry to infer *Caranx latus* movement patterns within Buck Island Reef National Monument (BIRNM) Novak et al. (2020)
- ▶ **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

MEROS PR ©2020



Red hind (*Epinephelus guttatus*)



Type of scientific studies carried out at the MMAs	Marine Managed Areas LB	
	No.	Last*
<u>Coral reef species</u>		
a. Benthic composition	16	2020b
b. Coral species health	13	2020b
c. Coral species		
<u>Reef fish species</u>		
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		

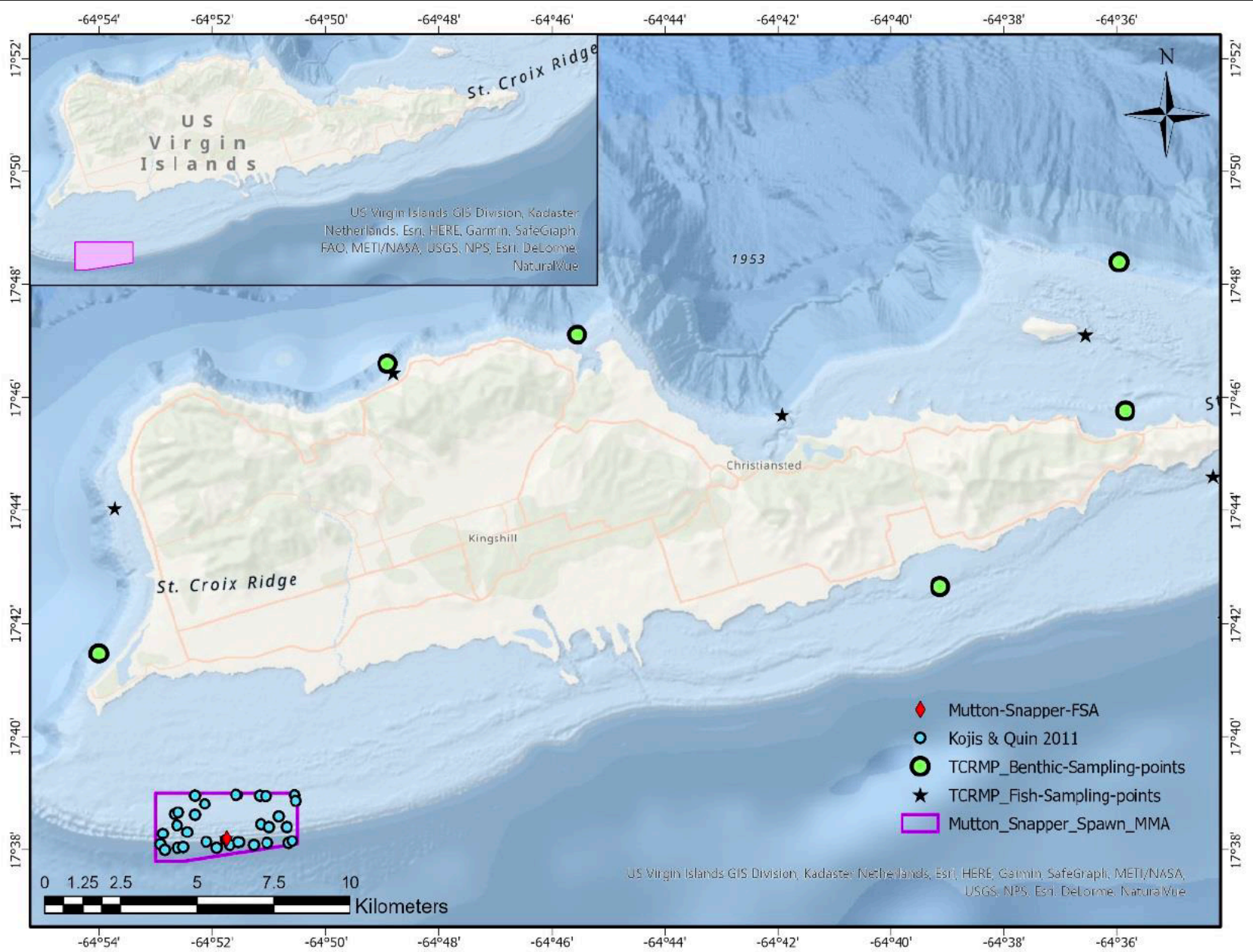


# MUTTON SNAPPER SPAWNING AREA

- ▶ 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*
<u>Coral reef species</u>		
a. Benthic composition	17	2020b
b. Coral species health	17	2020b
c. Coral species biology/ecology	1	2013
<u>Reef fish species</u>		
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*
<u>Coral reef species</u>														
a. Benthic composition	1	2013	12	2019a	1	2007	19	2020b	19	2020b	16	2020b	17	2020b
b. Coral species health	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
<u>Reef fish species</u>														
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	



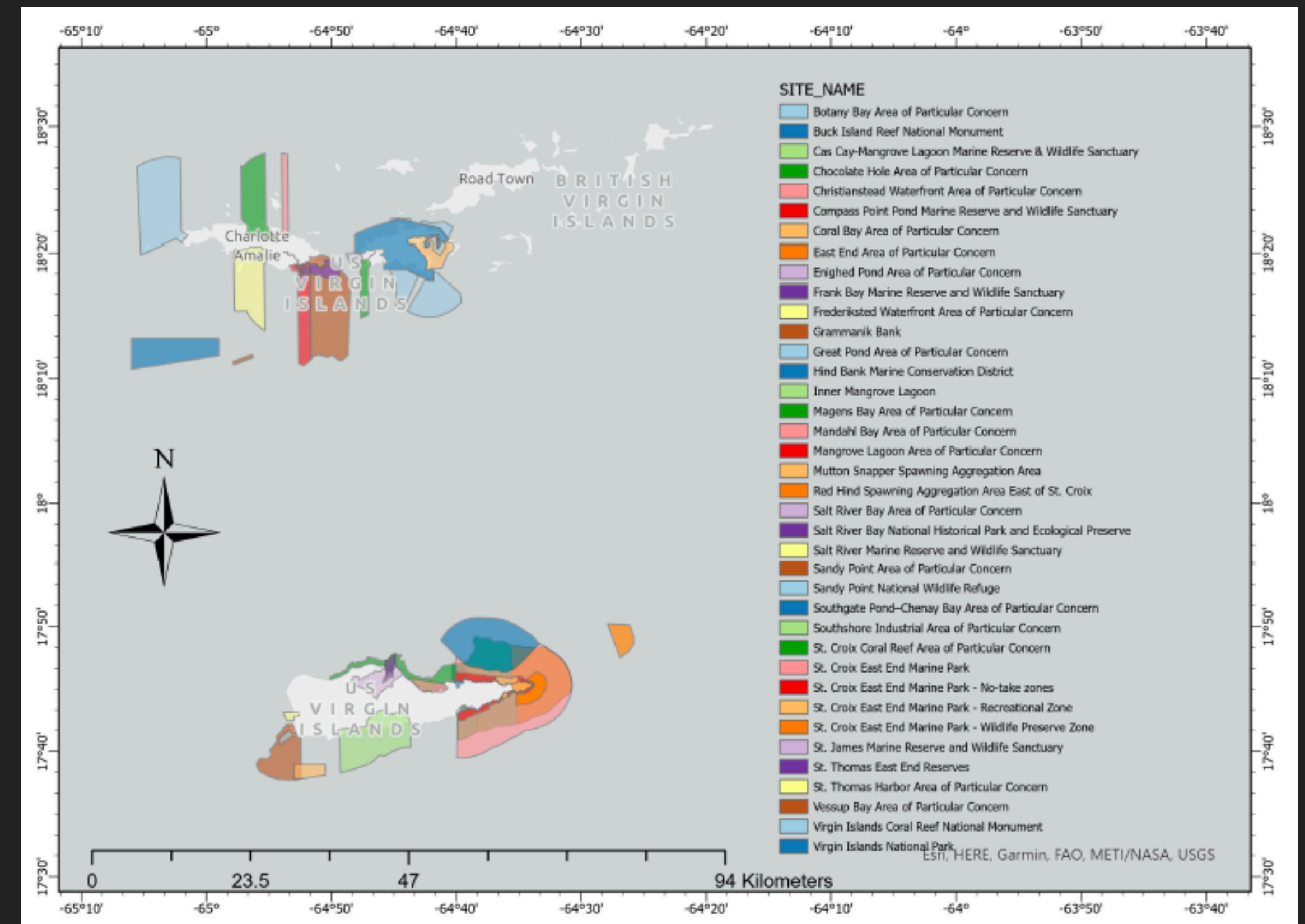
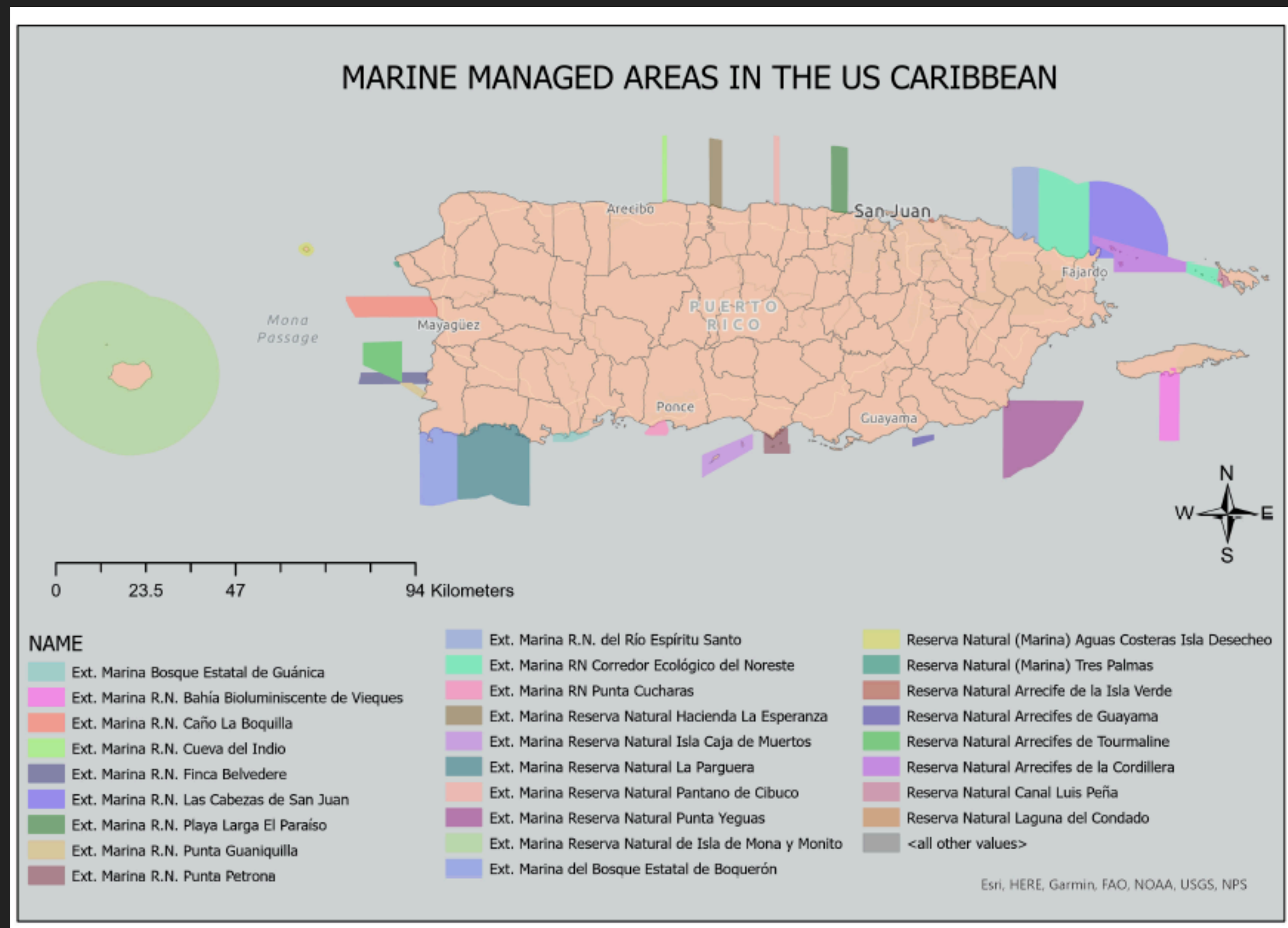
# ALL PROTECTED AREAS IN THE US CARIBBEAN

---



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

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



- ▶ 58 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)

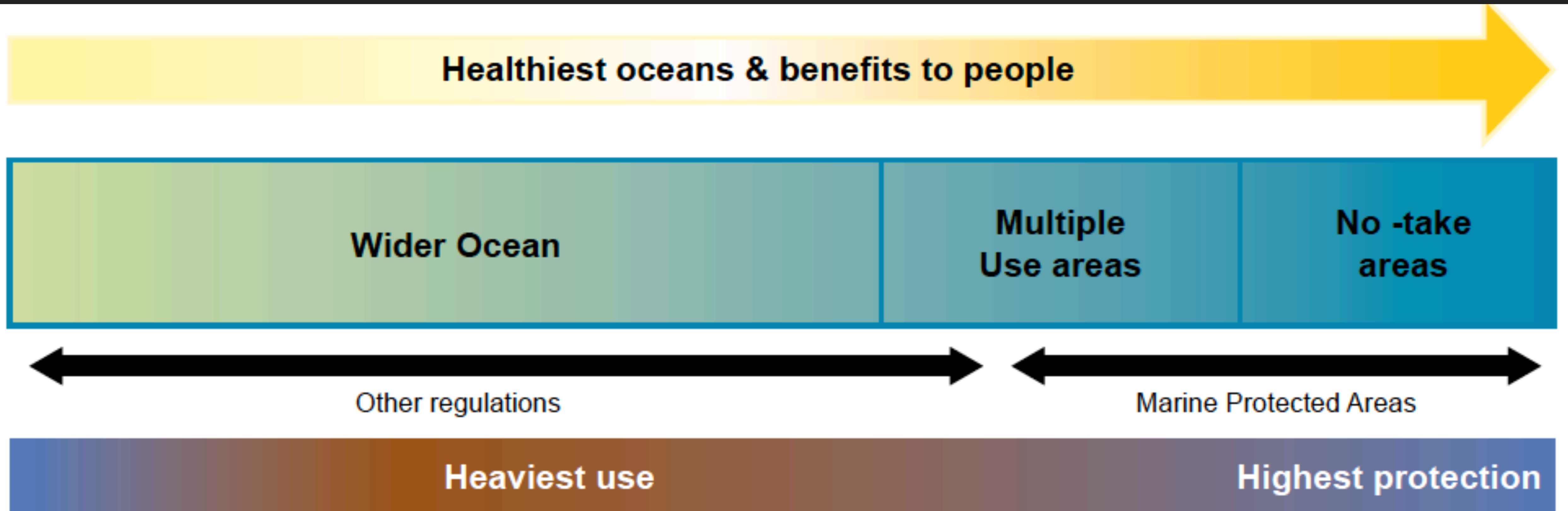
---

- ▶ 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



# 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

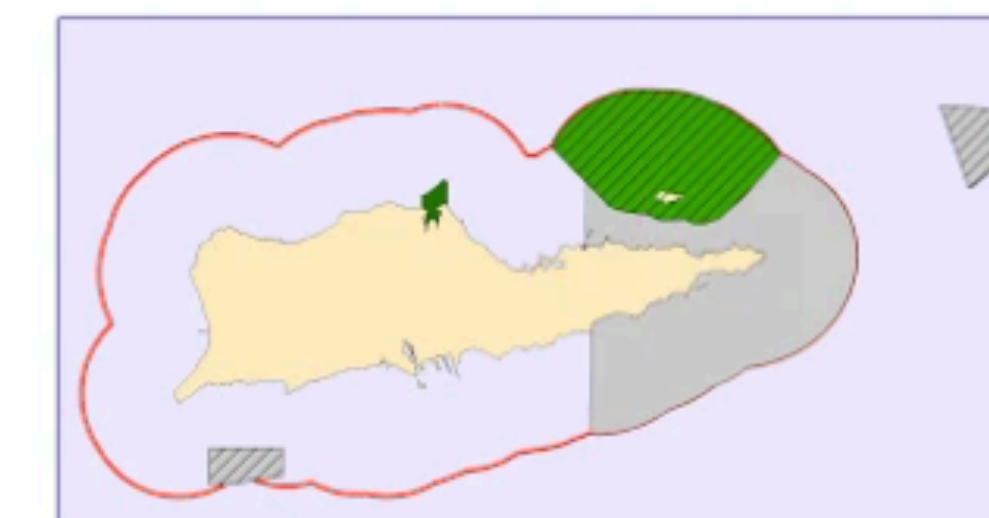
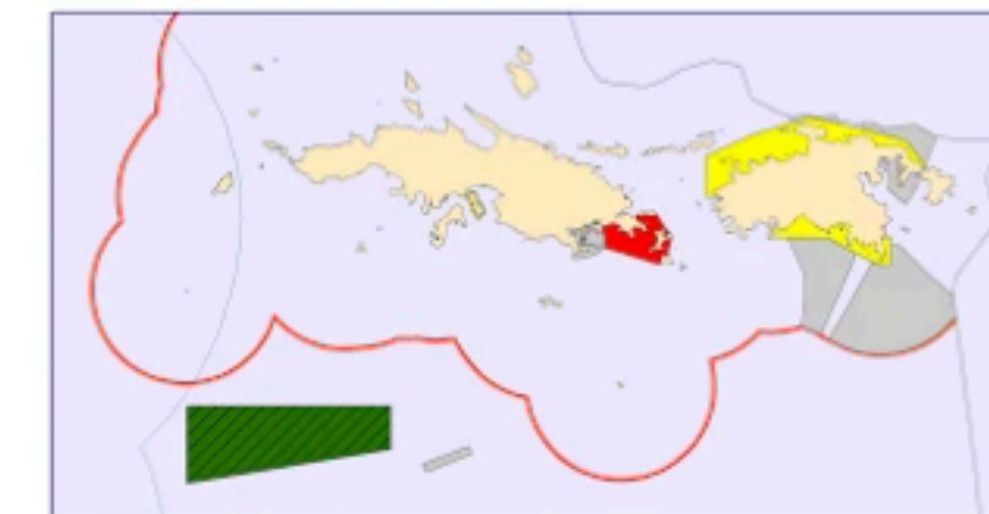
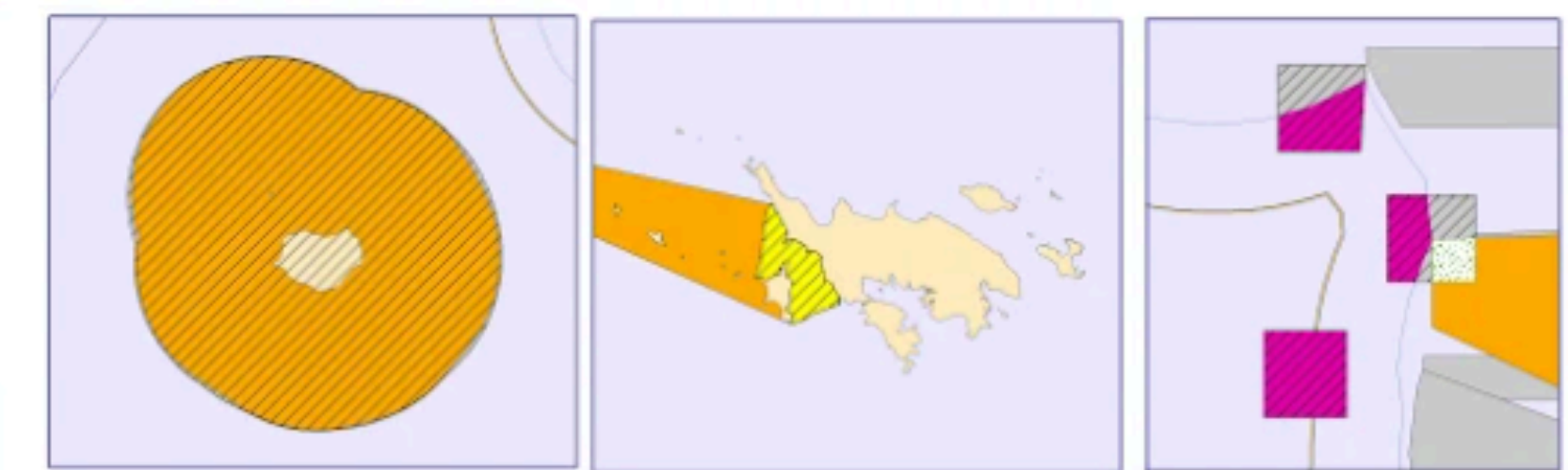
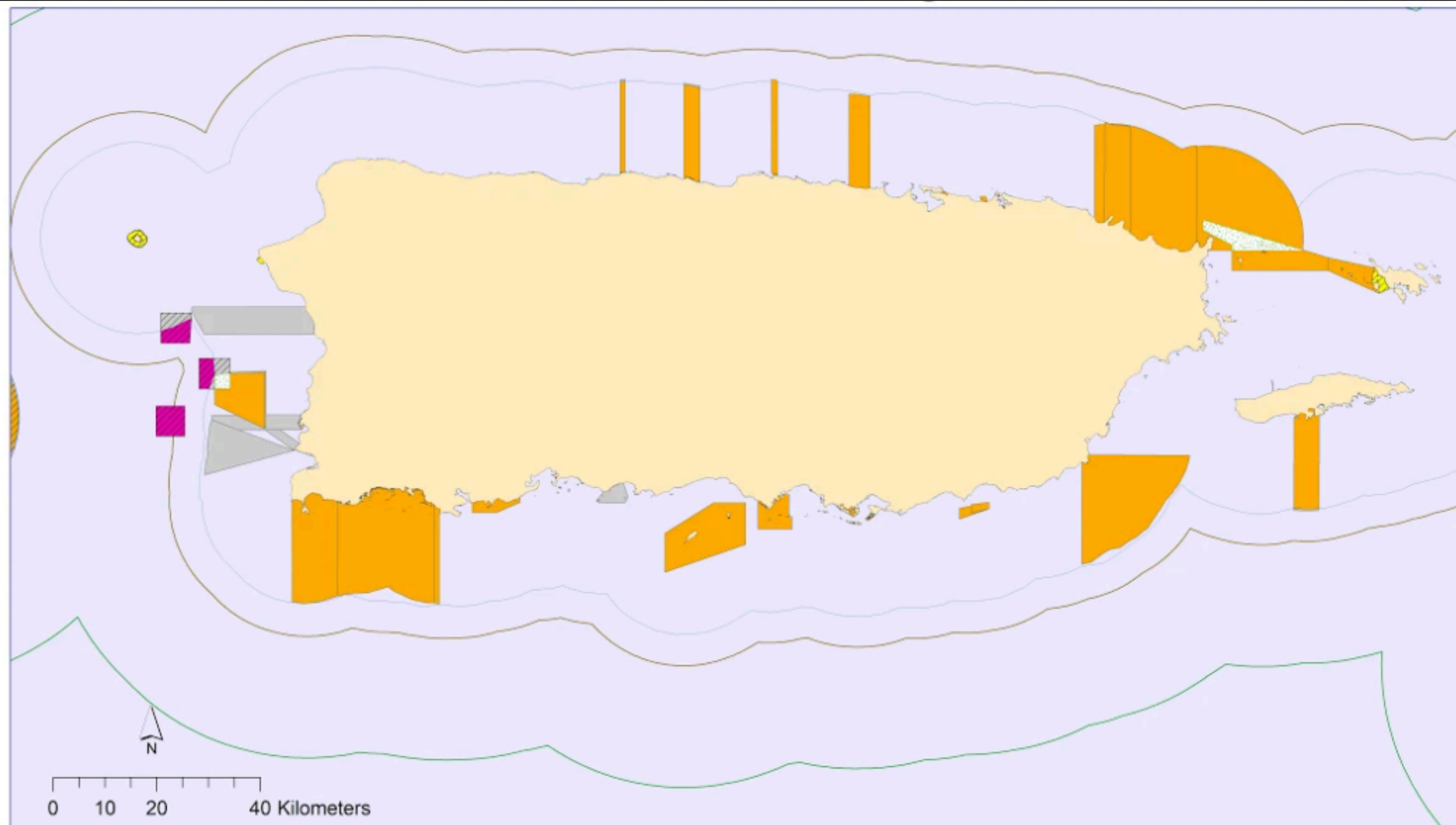
**Key:**

*	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.



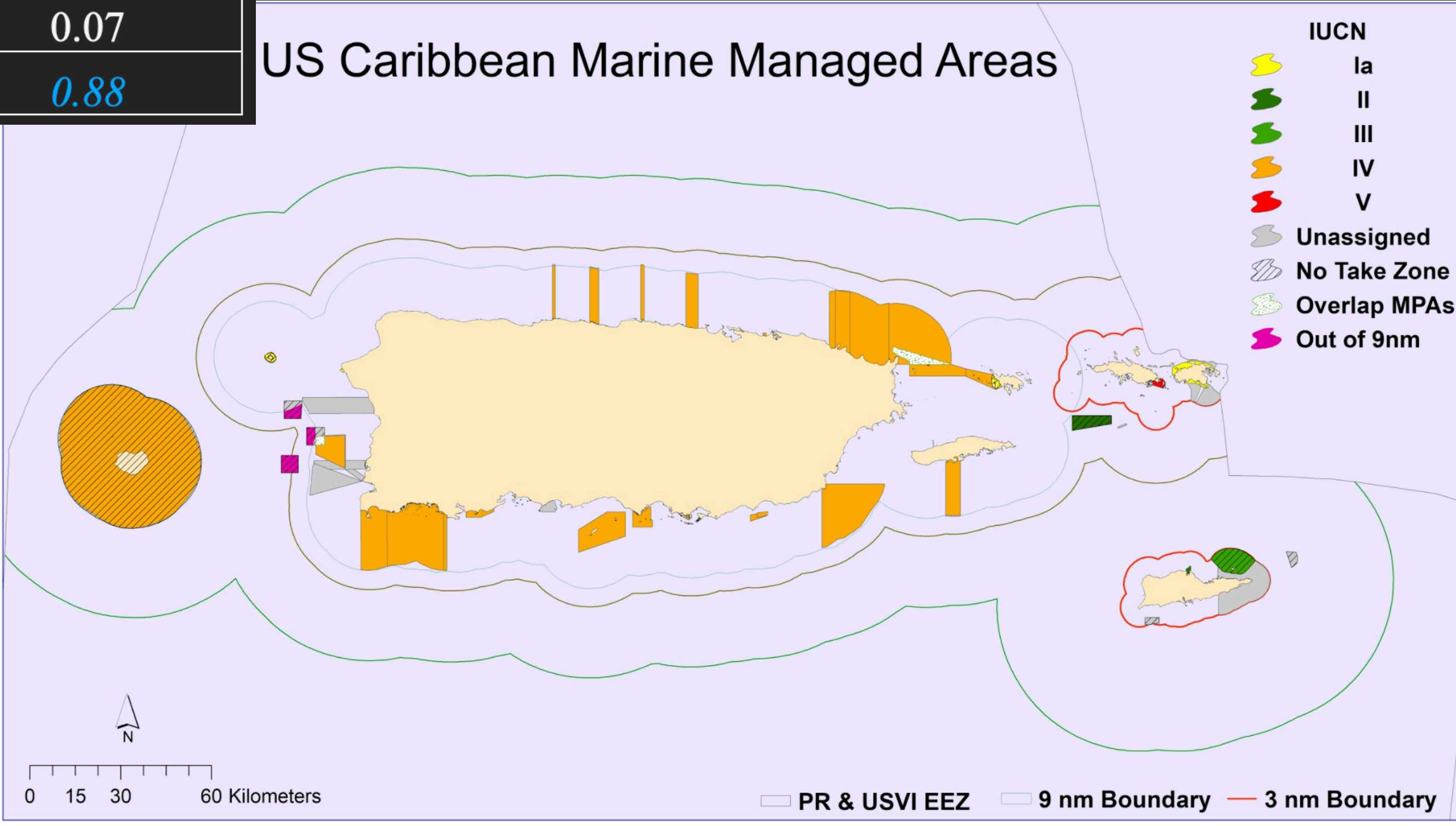
# WHERE ARE WE IN THE US CARIBBEAN?

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 <sup>2</sup> )	Number of Areas	US Caribbean Basin (%)
<i>Total Area <u>MMA</u>s : 51 Total</i>	<i>4276.41</i>	<i>51</i>	<i>2.02</i>
<u>Ia</u>	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
<i>No Take areas (includes seasonal no-take)</i>	<i>1864.03</i>	<i>13</i>	<i>0.88</i>

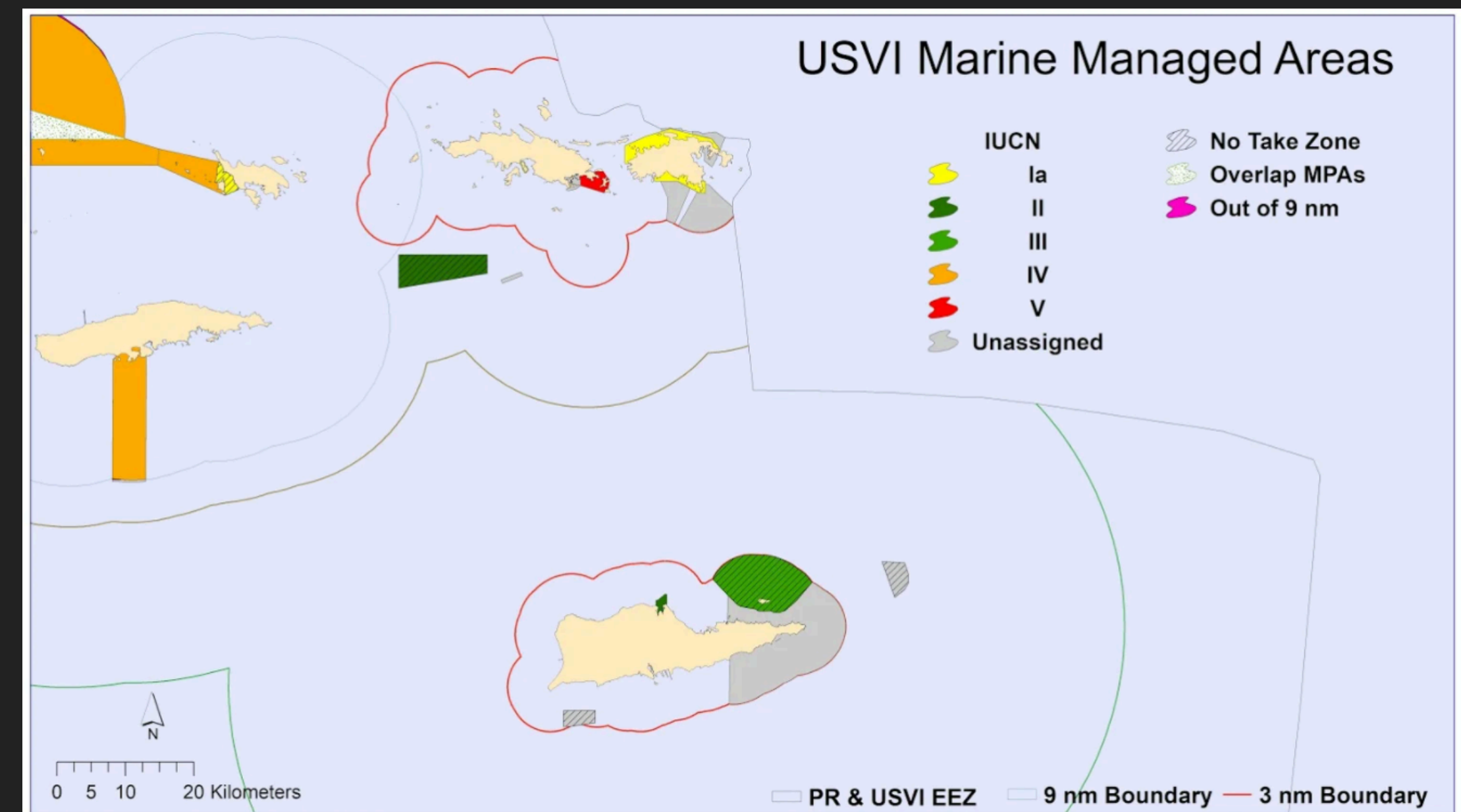




# How much in the USVI?

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

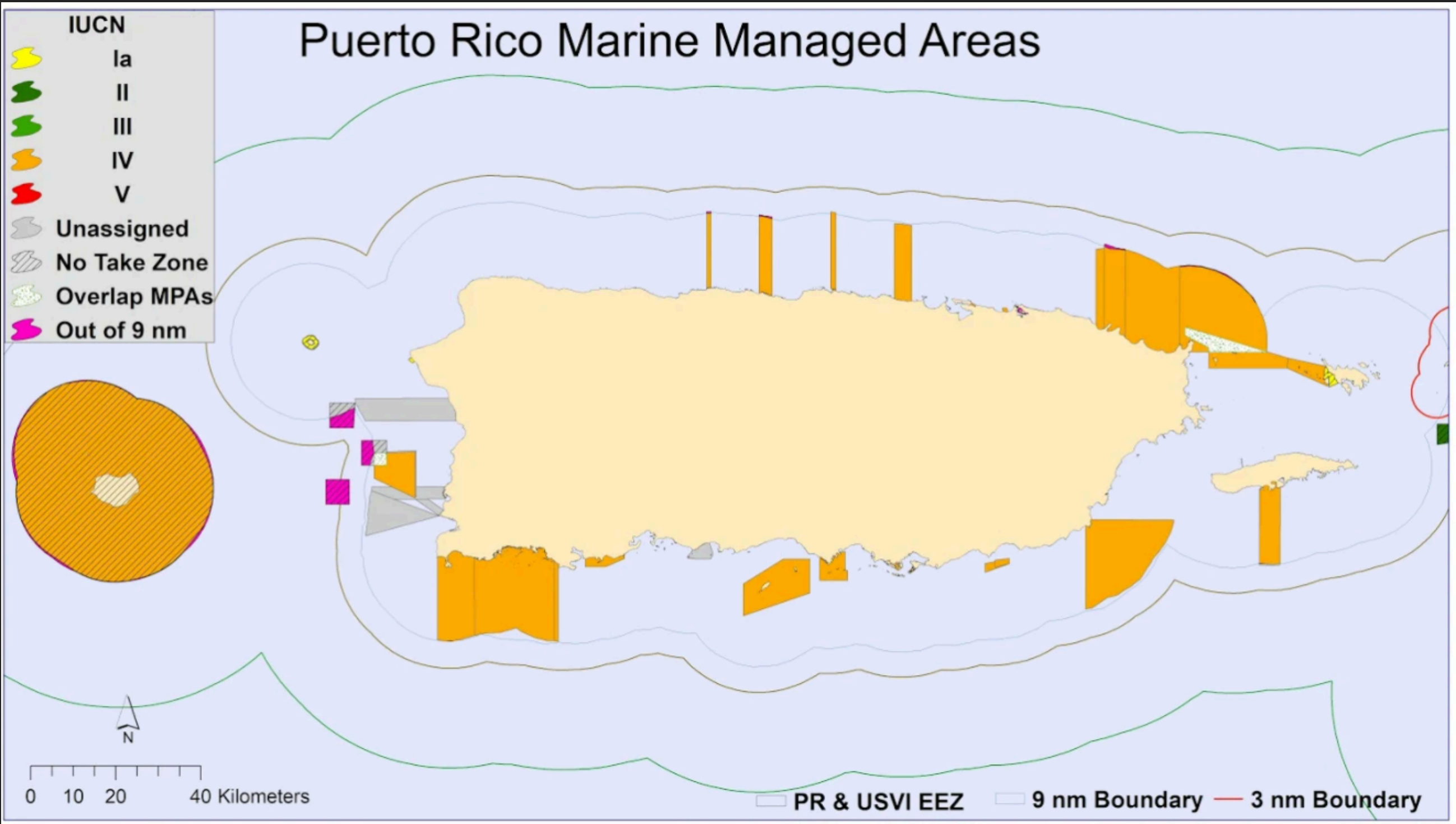
<b>Area PR Territorial Waters</b>	13443
<b>Area USVI Territorial Waters (3nm)</b>	1420
<b>USVI EEZ</b>	38275
<b>PR EEZ</b>	182882
<b>Total Area EEZ</b>	211242



# How much in the Puerto Rico?

PUERTO RICO	Area (km²)	Number of Areas	Territorial Water (%)	PR EEZ (%)
Total Area <u>MMA</u> s : 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 dyeing

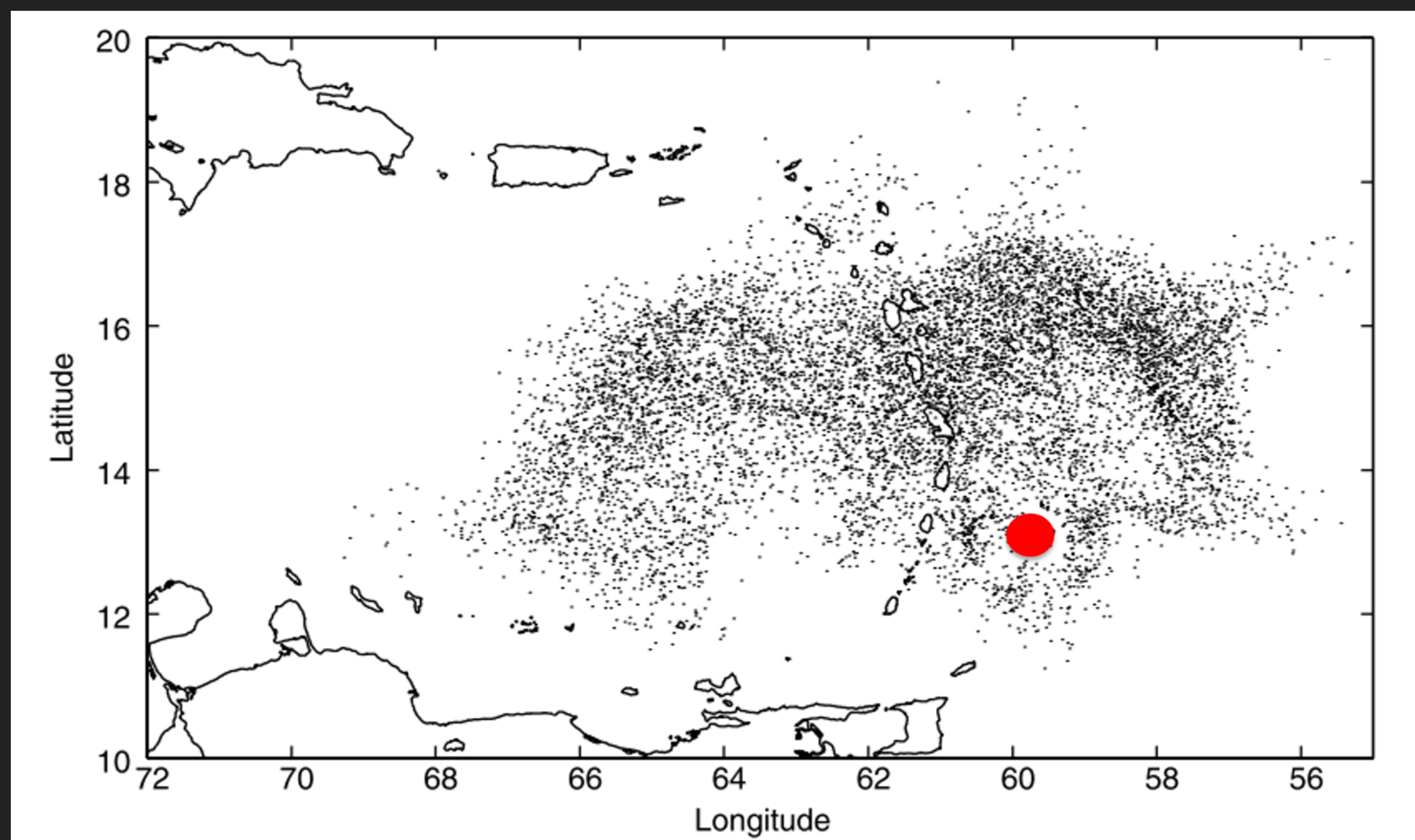
# FINAL CONSIDERATION

---

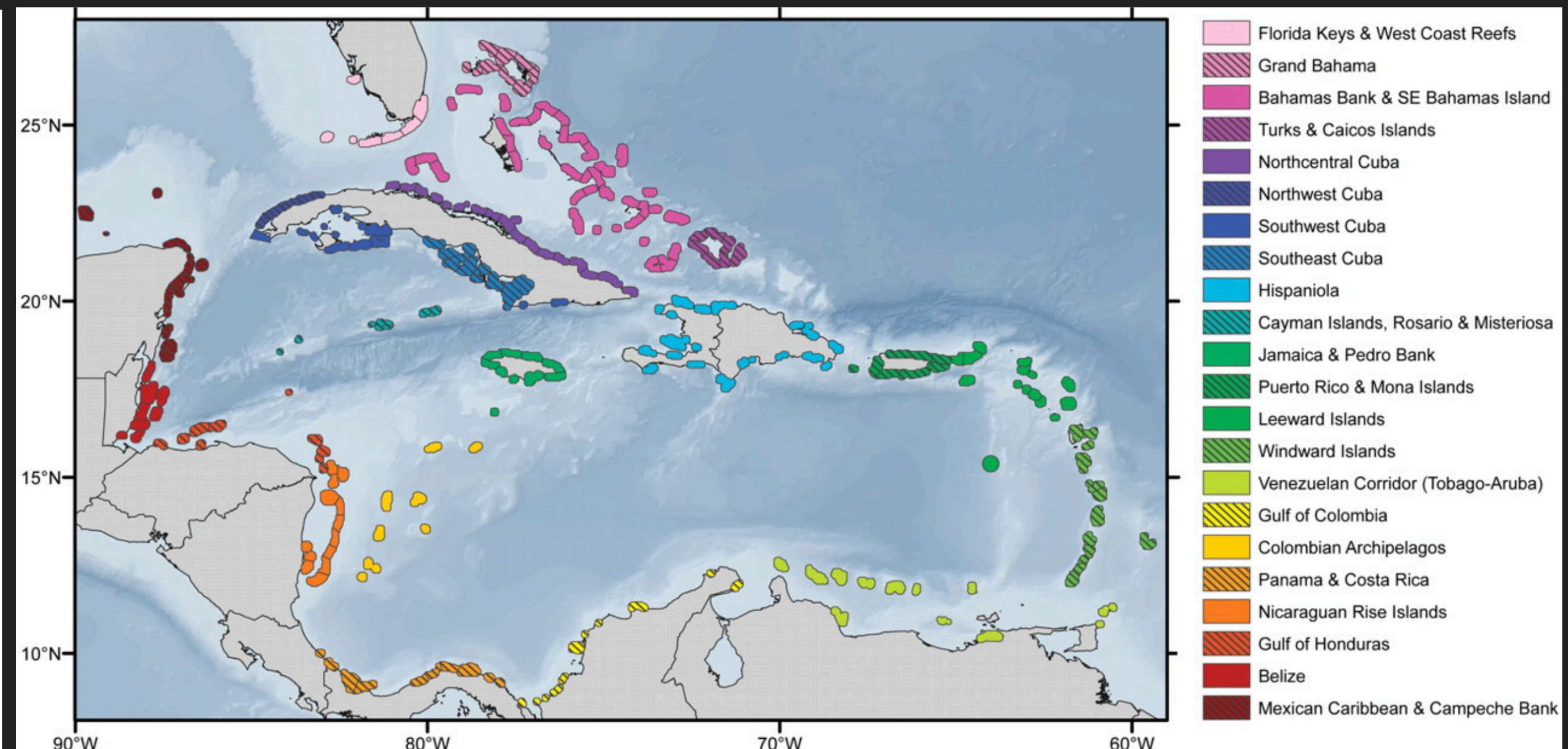
- ▶ There are 51 areas with some level of protection, including areas managed by the CFMC and areas managed by the PR or USVI Departments of Natural Resources. From our review, it is clear that most areas are managed as single units and not as networks of protected areas
  - ▶ We recommend a committee/task 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!

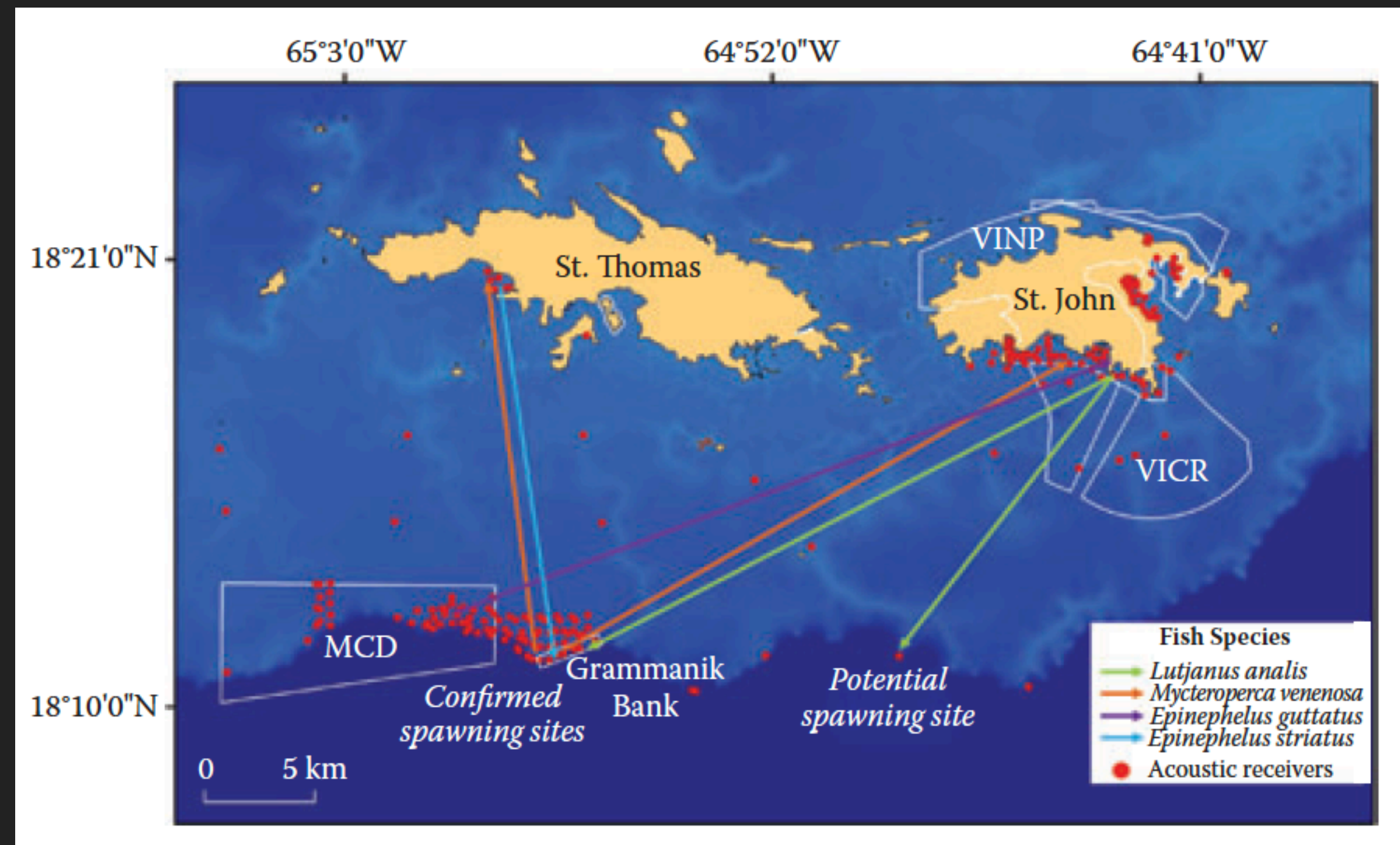


Cowen et al, 2000



Cowen et al, 2006





Acoustic array detections of tagged fishes providing direct evidence of connectivity between nearshore coral reef ecosystems and shelf-edge spawning aggregations for three species of grouper (*Mycteroperca venenosa*, *Epinephelus guttatus* and *E. striatus*) and a mutton snapper (*Lutjanus analis*) (Pittman & Legare 2010, CCMA 2011). Straight lines represent direct links between receiver locations rather than actual movement pathways. Marine Conservation District (MCD) and Grammanik Bank are sites of known spawning aggregations. Virgin Islands Coral Reef National Monument (VICR) and Virgin Islands National Park (VINP) are marine protected areas. (From Kobara et al, 2013)



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*
<u>Coral reef species</u>														
a. Benthic composition	1	2013	12	2019a	1	2007	19	2020b	19	2020b	16	2020b	17	2020b
b. Coral species health	1	2013	12	2019a	1	2007	19	2020b	19	2020b	13	2020b	17	2020b
c. Coral species biology/ekol			2	2019			8	2016	3	2019			1	2013
<u>Reef fish species</u>														
a. Visual censuses	2	2013	12	2019a	1	2007	19	2020b	19	2020b	14	2020b	14	2020b
b. Fishery Independent	1	2012	1	2013	1	2012					2	2014	1	2013
c. Assessing SA site/Species	7	2020			8	2019	13	2020	9	2020	1	2019		
d. CPUE									1	2005			1	2011

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