Marine Protected Areas of the US Virgin Islands

Ecological Performance Report

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Marine Protected Areas of the U.S. Virgin Islands Ecological Performance Report

Center for Coastal Monitoring and Assessment
NOAA National Centers for Coastal Ocean Science
Silver Spring, MD 20910

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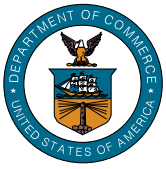

About this Document

This document presents a comprehensive overview of results from more than a decade of work by the NOAA National Centers for Coastal Ocean Science (NCCOS) Biogeography Branch and the Department of the Interior National Park Service (NPS) to assess status and trends within and around federally managed marine protected areas (MPAs) of the U.S. Virgin Islands (USVI).

The report provides: (1) an overview of the history of MPAs, types of MPAs and associated regulations, and a list of all MPAs in the USVI; (2) an ecological performance report for three intensively surveyed MPA units managed by NPS, including 20 biological metrics for fish and benthic habitat; (3) sightings of large-bodied fishes with moderate to high vulnerability to fishing; and (4) synthesis, summary and recommendations for management.

This report is the first time that an assessment of ecological performance has been conducted for MPAs in the USVI. A decade of underwater surveys was analyzed to detect trends on coral reefs inside MPAs and for a similar range of habitats outside of MPAs. The information, data synthesis, interpretation and recommendations are intended to help focus management actions and goal setting, inform outreach products and adjust expectations regarding ecological performance for MPAs in the region. The data presented here provide important baselines required for tracking MPA performance through future monitoring efforts.

For more information about this report and others like it, please visit the NCCOS web site, http://coastalscience.noaa.gov/, or direct comments to:

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Overview and Key Findings

Coral reef ecosystems of the U.S. Virgin Islands (USVI) have deteriorated because a wide range of interacting stressors have reduced coral cover and the abundance of other reef associated animals, including fishes. A wide variety of fishes that are important to maintain healthy and productive coral reef ecosystems also provides valuable goods and services for USVI communities and visitors. Over the past few decades, the number and biomass (weight) of fish on Caribbean coral reefs, particularly large fish such as grouper, snapper and big parrotfish, have declined considerably and are now rarely seen. A functionally intact fish community on healthy reefs should include abundant herbivores and carnivores, especially large-bodied species. In the USVI, declines in fish abundance, particularly of large-bodied economically important species, have resulted in functionally impaired fish communities. To better protect coral reefs and associated fish, marine protected areas (MPAs) have been established in the USVI and across the Caribbean. In fact, some of the world's first MPAs for protecting coral reef ecosystems were designated in the USVI. In accordance with Executive Order 13158, we define a marine protected area as any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.

There are now more than thirty MPAs in the USVI. These include MPA units operated by the Government of the Virgin Islands, federally managed MPAs, as well as two co-managed MPAs. Although all MPAs share the goal of protecting resources, MPAs have a wide range of objectives that focus on managing human uses, including tourism and providing educational resources. Some MPAs have enforcement and boundaries that are physically marked; others do not. Some MPAs include terrestrial land and others are solely marine jurisdictions. A wide range of fishing regulations exist across MPAs of the USVI, with most management units offering opportunities for commercial and recreational fishing. Several no-take MPAs also exist, each with varying levels of enforcement and compliance. Not all MPAs are managed through formal management plans, although efforts are underway to develop new management plans and revise existing ones.

Expectations for MPA performance vary widely among managers, marine stewardship agencies, scientists, fishing communities and other marine users. In general, the expectation for a well-protected MPA is that, over time, protection will result in a healthier reef, and where fishing is prohibited, fished populations will be replenished. Of the many MPAs in the USVI, only four MPAs have received long-term monitoring to evaluate ecological performance and inform management actions, including Buck Island Reef National Monument, Virgin Islands National Park, Virgin Islands Coral Reef National Monument, and Hind Bank Marine Conservation District.

The second section of the report focuses on how we assess ecological performance before providing in-depth information on three MPAs that are managed by the U.S. National Park Service (NPS) and were monitored through a 10-year collaboration with NOAA's National Centers for Coastal Ocean Science.

This report provides the first evaluation of the ecological performance of the three most intensively studied MPAs in the USVI. All data used were collected using consistent survey techniques conducted over a decade. The three assessed MPAs are Buck Island Reef National Monument, northeast, St. Croix; Virgin Islands Coral Reef National Monument, St John (no-take MPAs); and Virgin Islands National Park, St. John (non-commercial fishing allowed). The report provides information on the history of MPAs in the USVI and a chronology of the main catastrophic events that have impacted the structure and function of coral reef ecosystems. The various types of MPAs are described together with maps showing their geographical location.

Here information is provided on enforcement and the type and number of violations of park regulations to describe stress from human uses, including illegal fishing. Ecological performance, however, is measured through the presence of statistically detectable increasing or decreasing trends in selected metrics, both inside MPAs and from similar coral reefs outside of MPAs. Selected metrics were fish species richness; biomass of all fish and key functional and taxonomic groups (herbivores and carnivores, groupers, snappers, parrotfish and surgeonfish); and other important fishery species and measures of benthic composition (percent cover of hard coral, macroalgae, crustose coralline algae, and density of soft corals). The inside versus outside comparison of performance is supported by graphs of temporal trends, statistical confirmation of significant trends and comparison of the first half of the time series with the second half to determine if metric values are increasing or decreasing.

This report, funded by NOAA's Coral Reef Conservation Program, addresses two of the objectives of the USVI Coral Reef Management Priorities: 4 12 - Support the effective implementation of MPAs; and 4 13 - Assess the effectiveness of MPAs in meeting their stated management goals. The report also complements several recent initiatives to support effective management of MPAs in the USVI. In 2011, an MPA Management Assessment Checklist was conducted by NOAA staff to assess the current status of MPA implementation and management, as well as to determine management strengths and needs. In March 2012, local managers of protected areas formed the Virgin Islands Marine Protected Area Network to increase effectiveness of ocean resource protection through improved interagency coordination, communication and collaboration among the Virgin Islands Department of Planning and Natural Resources (VI-DPNR), NPS, NOAA and other supporting partners. This report is intended to provide these managers with the best-available data on status and trends for key biota of coral reef ecosystems within their jurisdiction. The information, data synthesis, interpretation and recommendations can help focus management actions and goal setting, inform outreach products and adjust expectations regarding ecological performance for other MPAs in the region. The data presented here also provide important baselines required for tracking MPA performance through future monitoring efforts. Although rare, such evaluations are increasingly important because of increased applications of MPAs as place-based management tools in coral reef conservation.

Key Findings

Are MPAs Working in the U.S. Virgin Islands?

This synthesis of the ecological performance analyses from three MPAs that were intensively surveyed for 8 to 10 years provides a unique assessment of regional MPA performance. Comparisons of the proportion of observed increasing or decreasing trends in metrics indicate that reefs outside MPAs experienced greater decreases in coral reef ecosystem status than coral reefs inside MPAs. For instance, 27% of 17 key metrics inside MPAs revealed negative trends compared with 32% of metrics for coral reefs outside MPAs. However, regardless of differences in MPA size, age, regulations and enforcement, none of the three MPAs assessed in this report exhibited increases in total fish biomass or in live hard coral cover.

MPA Performance for Coral Reef Fishes

- Regardless of differences in fishing regulations, none of the assessed Federal MPAs in the USVI exhibited an increase in fish biomass, fish species richness, nor the abundance of herbivorous fishes on coral reefs inside their boundaries between 2002 and 2011. Adult parrotfish decreased in the Virgin Islands National Park and adult surgeonfish decreased inside Buck Island Reef National Monument.
- Adult groupers decreased in abundance inside the two no-take National Monuments (Buck Island Reef National Monument and Virgin Islands Coral Reef National Monument).
- The largest-bodied grouper (Epinephelinae), snapper (Lutjanidae) and large parrotfishes with high vulnerability to fishing were very rare in USVI's MPAs.

MPA Performance for Corals and Algae

- No positive MPA effects were detected for coral and algae metrics. Patterns of change were similar inside and outside MPAs suggesting that the same broad scale drivers (e.g., thermal stress, disease, runoff) are operating to influence benthic communities across the region.
- The amount of live coral cover has decreased in all three MPAs and across the region, regardless of differences in regulations and human uses.
- Long-term monitoring of benthic communities at permanent sites by the NPS' Inventory and Monitoring Program also revealed major changes in key biotic indicators of coral reef health, specifically the decline in coral cover following the 2005 global mass bleaching event and disease outbreak, and subsequent increase in macroalgae. This event is widely acknowledged as the single most important cause of coral mortality in the USVI during the study period.

Recommendations

- The no-take MPAs studied here were established in 2003 and monitored until 2010/2011 (8/9 years post establishment). Research suggests that older (>10 years) MPAs usually perform better than younger MPAs, therefore, continued or increased regulations on fishing is eventually expected to yield a positive effect if suitable habitat quality is available to support replenishment.
- MPAs are connected to other places through movements of animals, therefore, what happens outside an MPA can impact what is happening inside an MPA. This is particularly relevant to the need to provide greater protection for nursery habitat and spawning sites for highly mobile fish vulnerable to fishing. For example, fishing at fish spawning aggregations outside MPAs and factors that impact the quality of nursery habitat inside and outside MPAs should be evaluated.
- A greater understanding of fish movement and connectivity between critical habitat in the life cycle of key fish species will be essential to determine the dependency of MPAs on surrounding features of the seascape that can be used to better target and prioritize management strategies. Research on connectivity between the existing MPAs is needed to determine interdependency across the network, which could influence the way MPAs are managed.
- Evaluation of the ecological implications of MPA size and shape may help to inform future options for MPA design to optimize ecological performance.
- Although the presence of NPS Rangers increased the public's awareness and compliance with park regulations, NPS enforcement records also demonstrate that illegal fishing inside no-take MPAs occurred throughout the survey period. Outreach campaigns to improve voluntary compliance in the fishing community, and evaluation of existing enforcement effort, techniques, and tactics could help address illegal fishing inside MPAs. On St. Croix, Buck Island Reef National Monument and East End Marine Park could create joint outreach, management and monitoring initiatives that would share resources and reach a broader section of the community.
- Information on patterns of fishing effort, behavioral response to MPAs, and the effectiveness of existing regulations is insufficient to evaluate the impact of the full range of fishing activities on MPA performance. Social science research is needed to describe patterns of human use in and around MPAs.
- Evaluation of regulations to assess interpretability, compliance, and consistency and potential for synergy among MPA units.
- Activity in the watersheds that drain into MPAs can negatively impact coral reef health and the quality of fish habitat. Strategies that promote awareness of best practices for urban development, including road building, are particularly important on high relief tropical islands.
- Many of the biological metrics showed no significant trend for coral reefs inside MPAs, whereas outside areas declined, suggesting a possible positive MPA effect in maintaining populations. Targeted monitoring of fish populations at several permanent sites to complement the island-wide surveys by NOAA's National Coral Reef Monitoring Program will be required to determine if the potential MPA effects suggested in this report progress to detectable increases for fish abundance and biomass in the future.

- Habitat structure and benthic composition of coral reefs has changed in the past few decades and little is known about the impact of this change on the reefs carrying capacity for fishes. It is possible that MPA performance is being hampered by declining habitat quality, and research to address this is necessary to help align expectations for the potential function that MPAs provide in future replenishment of local fish populations.
- Although macroalgae was decreasing across the study area, it still dominated the benthic community, outcompeting corals. Management could evaluate novel interventions, such as sea urchin transplantation to priority areas. This experimental approach could be conducted in collaboration with academic researchers.

Regional Profile

Virgin Islands Archipelago,
Leeward Islands of the Lesser Antilles

National status

Organized Unincorporated U.S. Territory

Main islands and population size in 2010 :

St. Croix (218 km^2 with 50,601 residents)
St. Thomas (83 km^2 with 51,634 residents)
St. John (52 km^2 with 4,170 residents)

Visitors:
2.55 million visitors in 2010

Fishing

Licensed commercial fishermen (2008)

St. Thomas/St. John: 160
St. Croix: 223

Unknown number of recreational fishers

Unknown number of unlicensed fishers

MPA Governance

Territorial Government MPAs

1 Marine Park (149 km^2)
18 Areas of Particular Concern (503 km^2)

Federal Government MPAs

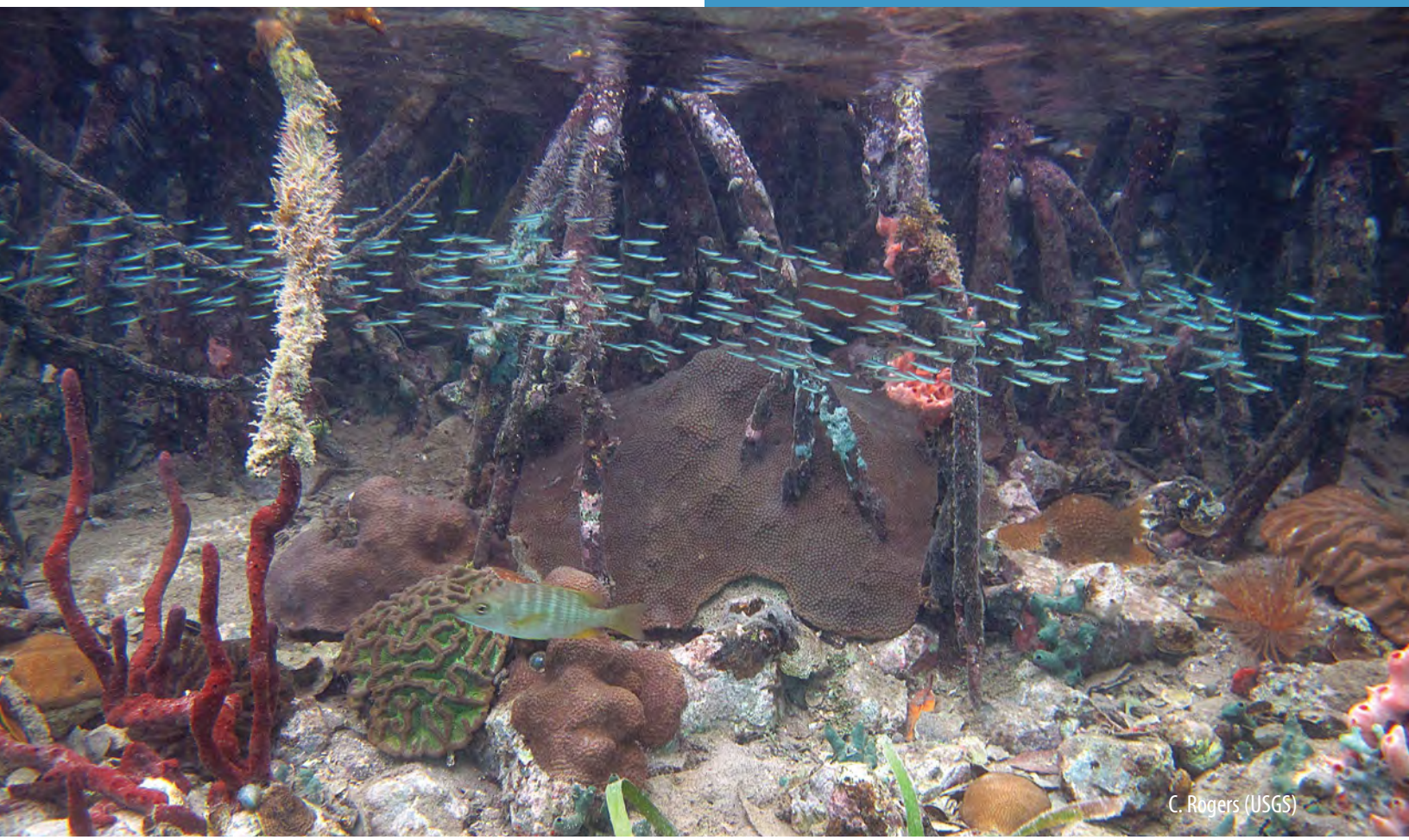
National Park Service
2 National Monuments (128 km^2)
1 National Park (24 km^2)

NOAA Caribbean Fishery Management Council
3 Offshore Fishery Closures (58 km^2)

Co-managed MPAs

Federal and Territorial

1 Historic Park and Ecological Preserve (25 km^2)
1 Fishery Closure (9km^2)


C. Rogers (USGS)

MPAs of the U.S. Virgin Islands

Seascapes of the Virgin Islands

A complex mosaic of interconnected patches of coral reef, seagrasses, mangroves and sandy sediments exist across the insular shelf of the U.S. Virgin Islands (USVI). These seascapes support diverse and highly productive communities of marine organisms with over 40 species of coral, including several listed under the Endangered Species Act, more than 400 species of fish, four species of sea turtle and at least eleven species of whale and dolphin. Coral reefs and associated habitats of the USVI provide important economic, cultural, social, and environmental values and benefits to people. In 2011, the economic value of coral reefs in the USVI was estimated at almost USD $200 million annually[1].

1 van Beukering, P.J.H., L. Brander, B. van Zanten, E. Verbrugge and K. Lems (2011) The Economic Value of the Coral Reef Ecosystems of the United States Virgin Islands. Report number R-11/06. Institute for Environmental Studies (IVM), Amsterdam.


US Army Corp of Engineers

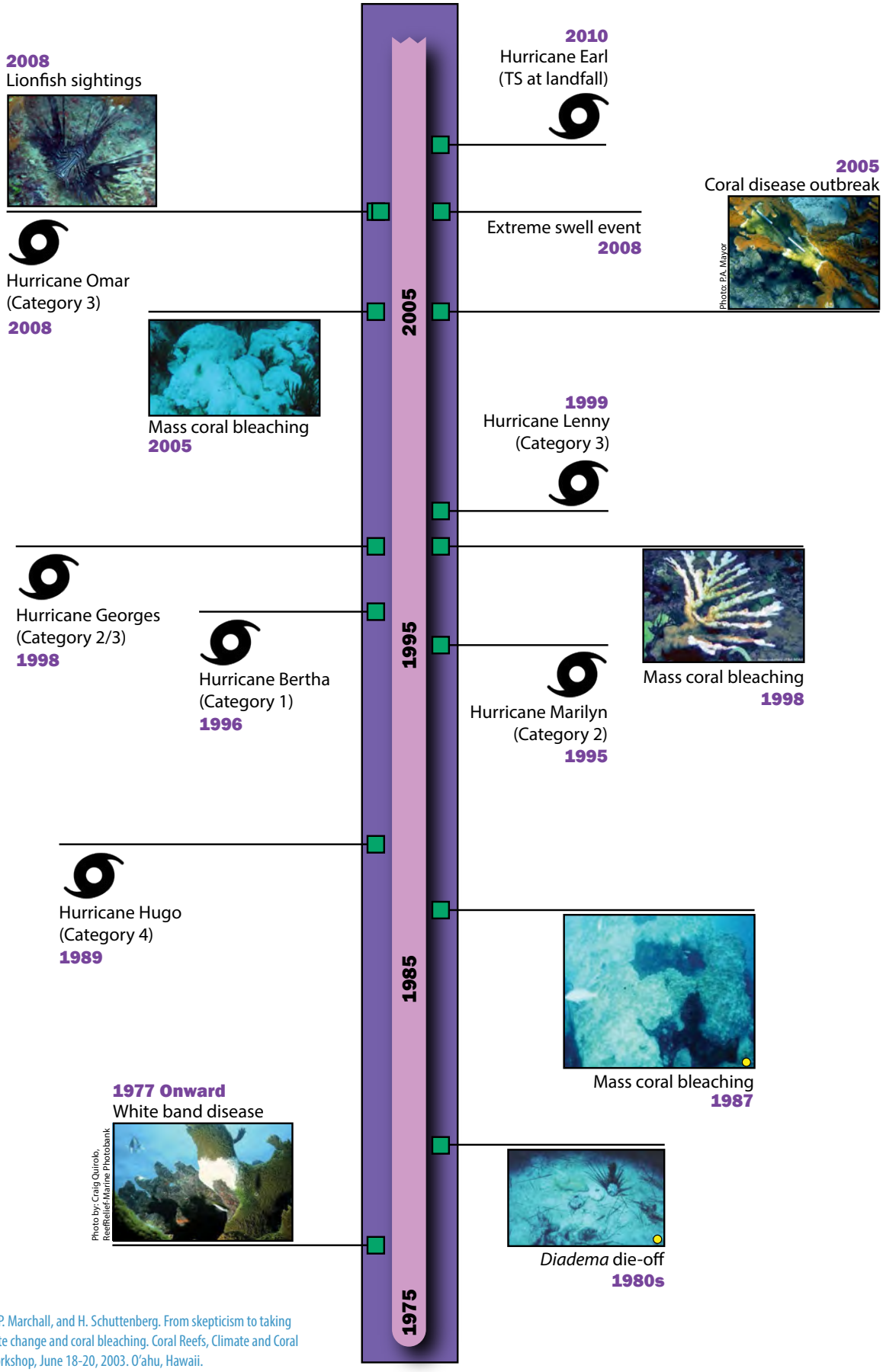
Ecosystem Threats & Stressors

Coral reef ecosystems of the USVI are deteriorating due to a wide range of interacting stressors that have reduced habitat quality for corals and other reef associated animals. In 2008, the national report on coral reef ecosystems indicated that the status of coral reef ecosystems in the USVI was poor, due primarily to elevated sea water temperature that had caused coral bleaching and an increase in coral diseases; physical damage from hurricanes and tropical storms; coastal development that has increased sedimentation and pollution in coastal waters; and fishing that has reduced the abundance of many reef fish, including plant eaters such as parrotfishes and surgeonfishes[2]. Despite establishment of marine protected areas (MPAs) and other conservation actions, the amount of mangrove forest and living coral have declined in the past 30 years, and populations of large-bodied fishes, including the largest grouper, snapper and parrotfish species, are increasingly rare. Since 2008, a new threat has emerged with the invasive lionfish that has spread rapidly across the region and an invasive Indo-Pacific seagrass, *Halophila stipulacea*, that is rapidly displacing native Atlantic species across the Eastern Caribbean[3].

2 Waddell, J.E. and A.M. Clarke (eds.). 2008. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73. Silver Spring, MD. 569 pp.

3 Willette, D.A., J. Chalifour, A.O.D. Debrot, M.S. Engel, J. Miller, H.A. Oxenford, F.T. Short, S.C.C. Steiner, and F. Védie. 2014. Continued expansion of the trans-Atlantic invasive marine angiosperm, *Halophila stipulacea*, in the Eastern Caribbean. Aquatic Botany 112: 98-102.

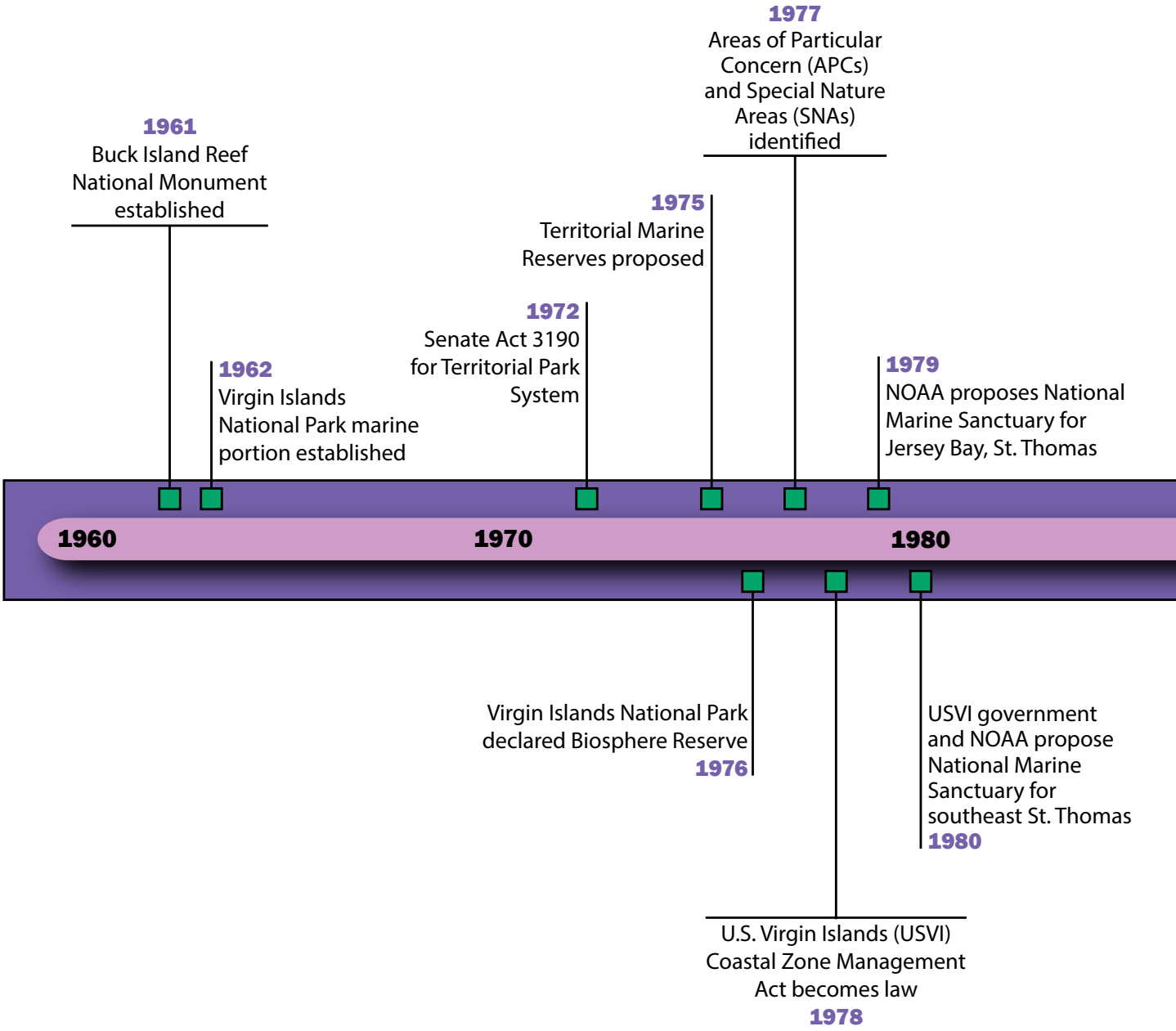
Timeline of destructive events

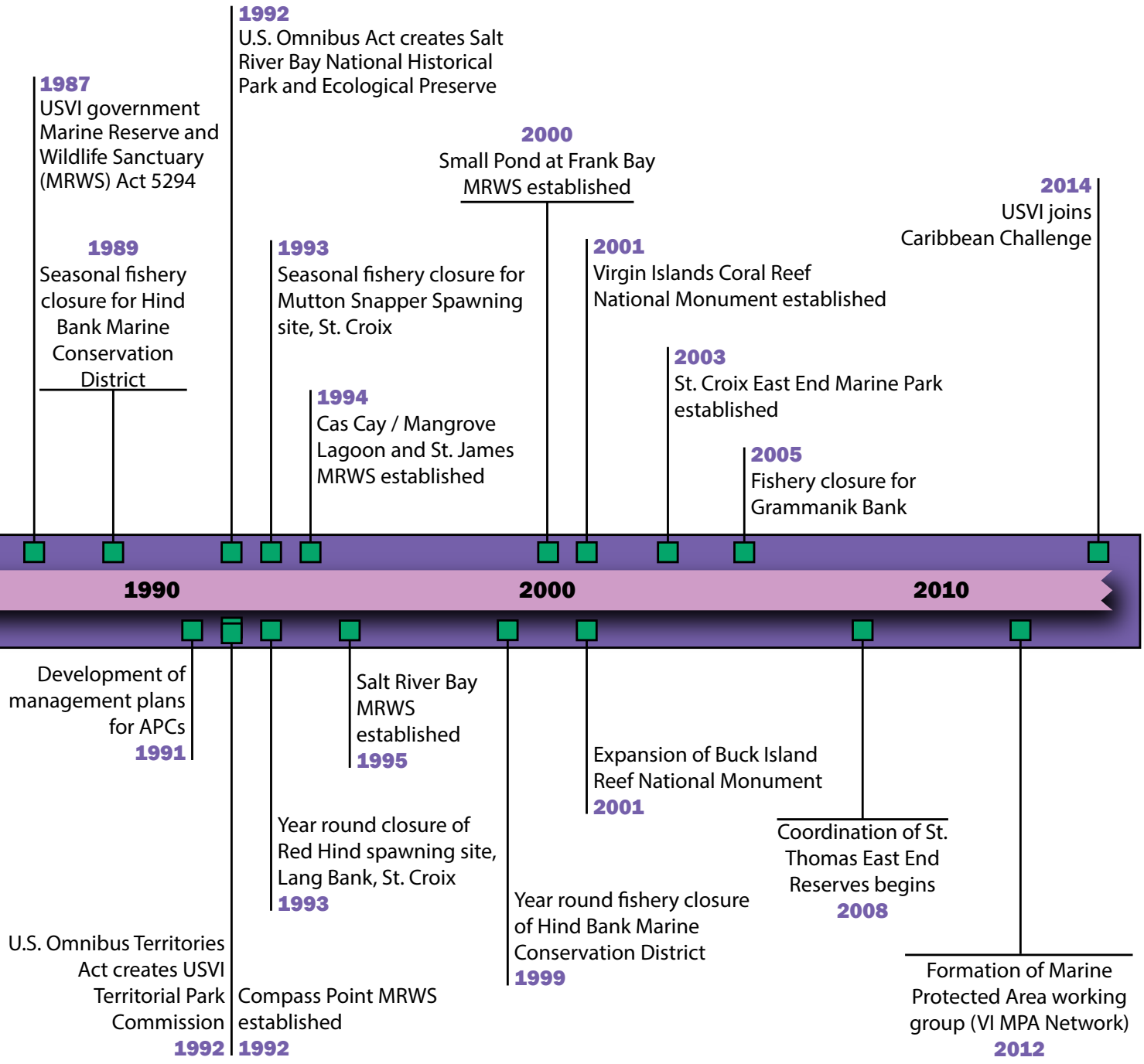


Causey, B.D., P. Marchall, and H. Schuttenberg. From skepticism to taking action: Climate change and coral bleaching. Coral Reefs, Climate and Coral Bleaching Workshop, June 18-20, 2003. O'ahu, Hawaii.

History of MPAs in the U.S. Virgin Islands

Following the establishment of the land portion of the Virgin Islands National Park in 1956, the Virgin Islands government and St. Thomas and St. Croix Chambers of Commerce, jointly with the U.S. Department of the Interior, conducted a survey of recreational needs, sites, and services in the USVI. This study identified areas of high ecological significance to support the development of a Territorial Park System. In the early 1960s, Buck Island Reef National Monument and Virgin Islands National Park were designated, becoming some of the world's first coral reef MPAs.




1987
USVI government Marine Reserve and Wildlife Sanctuary (MRWS) Act 5294
1989
Seasonal fishery closure for Hind Bank Marine Conservation District
1992
U.S. Omnibus Act creates Salt River Bay National Historical Park and Ecological Preserve
1993
Seasonal fishery closure for Mutton Snapper Spawning site, St. Croix
1994
Cas Cay / Mangrove Lagoon and St. James MRWS established
2000
Small Pond at Frank Bay MRWS established
2001
Virgin Islands Coral Reef National Monument established
2003
St. Croix East End Marine Park established
2005
Fishery closure for Grammanik Bank
2014
USVI joins Caribbean Challenge
1990
2000
2010
Development of management plans for APCs
1991
U.S. Omnibus Territories Act creates USVI Territorial Park Commission
1992
Compass Point MRWS established
1992
Year round closure of Red Hind spawning site, Lang Bank, St. Croix
1993
Salt River Bay MRWS established
1995
Year round fishery closure of Hind Bank Marine Conservation District
1999
Expansion of Buck Island Reef National Monument
2001
Coordination of St. Thomas East End Reserves begins
2008
Formation of Marine Protected Area working group (VI MPA Network)
2012

Types and Locations of MPAs

National Parks

The U.S. Federal Government manages MPAs in the USVI primarily through the National Park Service (NPS) of the U.S. Department of Interior and the Caribbean Fisheries Management Council, funded by the U.S. Department of Commerce' National Oceanic and Atmospheric Administration (NOAA). In 1962, U.S. Congress extended the Virgin Islands National Park on St. John to include 5,650 acres of submerged lands "to preserve for the benefit of the public significant coral gardens, marine life, and seascapes." In 1976, the Virgin Islands National Park was designated by UNESCO as an international Biosphere Reserve. In 1978, the legislation establishing the Virgin Islands National Park was amended to add Hassel Island in Charlotte Amalie Harbor on St. Thomas. In 1992, Salt River Bay National Historical Park and Ecological Preserve was established with agreement in Congress that it be co-managed by NPS and the Government of the USVI to preserve "prehistoric and colonial-era archaeological sites, as well as extensive mangroves, coral reefs and a submarine canyon."

C. Rogers (USGS)

National Monuments

National Monuments are established through Presidential Proclamation via the Antiquities Act of 1906 for the "protection of objects of historic and scientific interest... confined to the smallest area compatible with the proper care and management of the objects to be protected." The first Monument was declared off the northeastern shore of St. Croix in 1961 as Buck Island Reef National Monument to protect "one of the finest marine gardens in the Caribbean Sea." In 2001, Buck Island Reef National Monument was expanded by President W.J. Clinton's Presidential Proclamation (7392) to increase protection for interconnected habitats, threatened species and culturally significant objects of interest. Also in 2001, Proclamation 7399 declared a new Monument, Virgin Islands Coral Reef National Monument, off the north and south shores of St. John, to further the existing protection by including all elements essential to the "long-term sustenance of a Caribbean tropical marine ecosystem."

Federal Fishery Closures (Seasonal & Year Round)

In response to historical overfishing at important multi-species fish spawning aggregations, several fishery closures were established by the Caribbean Fishery Management Council with participation from the local fishing community. Offshore closures in Federal waters include the Hind Bank Marine Conservation District (year round closure) and Grammanik Bank (seasonal closure & gear restrictions) on the shelf edge south of St. Thomas, and the Red Hind closure at Lang Bank (seasonal closure & gear restrictions) on the eastern tip of the St. Croix insular shelf. The Mutton Snapper closure (seasonal & gear restrictions) located on the southwestern corner of St. Croix spans both Territorial and Federal waters and is co-managed by Caribbean Fishery Management Council and the Virgin Island Department of Planning and Natural Resources (VI-DPNR), with support from U.S. Coast Guard.

Fishing of several vulnerable species is prohibited in the U.S. Caribbean Exclusive Economic Zone Federal and Territorial waters, including: midnight parrotfish (*Scarus coelestinus*), blue parrotfish (*Scarus coeruleus*), rainbow parrotfish (*Scarus guacamaia*), Nassau grouper (*Epinephelus striatus*) and goliath grouper (*Epinephelus itajara*). Seasonal species closures exist for specific large-bodied grouper and snapper species. Trammel nets are prohibited throughout the USVI and surface gill nets are restricted to baitfish only. Catch limits and size restrictions on specific species also exist (http://www.caribbeanfmc.com/).

How much of the coastal sea is protected by MPAs?

12% of USVI waters (Federal and Territorial) designated as MPAs (including APCs), **7%** without APCs
35% USVI coastal sea (up to 3 nm offshore) designated as MPAs (including APCs), **18%** without APCs
3% Federal waters (3-9 nm offshore) designated as MPAs

Areas of Particular Concern & Territorial Marine Parks

Areas of Particular Concern were declared by the USVI Coastal Zone Management Act of 1978 due to their special significance. After consideration of the criteria suggested for "Area of Particular Concern" designation by the 15 CFR Part 923 regulations, VI-DPNR incorporated those areas that were relevant to the Virgin Islands based on seven categories: Significant Natural Areas; Culturally Important Areas; Recreation Areas; Developed Areas; Hazard Areas; Mineral Resources and Prime Industrial and Commercial Areas. Eighteen sites were selected as Areas of Particular Concern, with boundaries including land areas and most extending out to the Territorial three nautical mile limit. Management and designation of Areas of Particular Concern is guided by The Coastal Land and Water Use Plan. Draft management plans were developed for some Areas of Particular Concern in 1993, but these have not been formally implemented. Several of the Areas of Particular Concern with highest conservation priority guided the formation of the territorial MPAs of St. Thomas East End Reserves and St. Croix's East End Marine Park[4]. Many marine areas in the USVI now have multiple designations, particularly where Areas of Particular Concern overlap with other MPA designations[5]. For example, the Salt River Bay area is designated as the Salt River Bay Area of Particular Concern and Area of Preservation and Restoration; Salt River Bay Marine Reserve and Wildlife Sanctuary; and Salt River National Historical Park and Ecological Preserve.

Marine Sanctuaries & Wildlife Reserves

Between 1992 and 2000, five Marine Reserve and Wildlife Sanctuaries were established as permanent year-round no-take MPAs supported by both the Wildlife and Marine Sanctuaries Act of 1980 (Act No. 5229), and the Virgin Islands Code Title 12, Chapter 1, Sections 94, 96, and 97 authorized in 1994. These MPAs were designated specifically to offer high protection for critical habitat for species of fishery value and for recreational and educational purposes. Three of the MPAs (Cas Cay and Mangrove Lagoon, St. James, and Compass Point Pond) are located on the East End of St. Thomas and are now integrated into the St. Thomas East End Reserves. Small Pond at Frank Bay is located on St. John and Salt River is located on the northern shore of St. Croix. Although broadly categorized as no-take areas, fishing from the shoreline is allowed under permit at St. James and portions of Cas Cay and Mangrove Lagoon. The reserves are managed by VI-DPNR's Division of Fish and Wildlife and regulations enforced by VI-DPNR's Division of Environmental Enforcement.

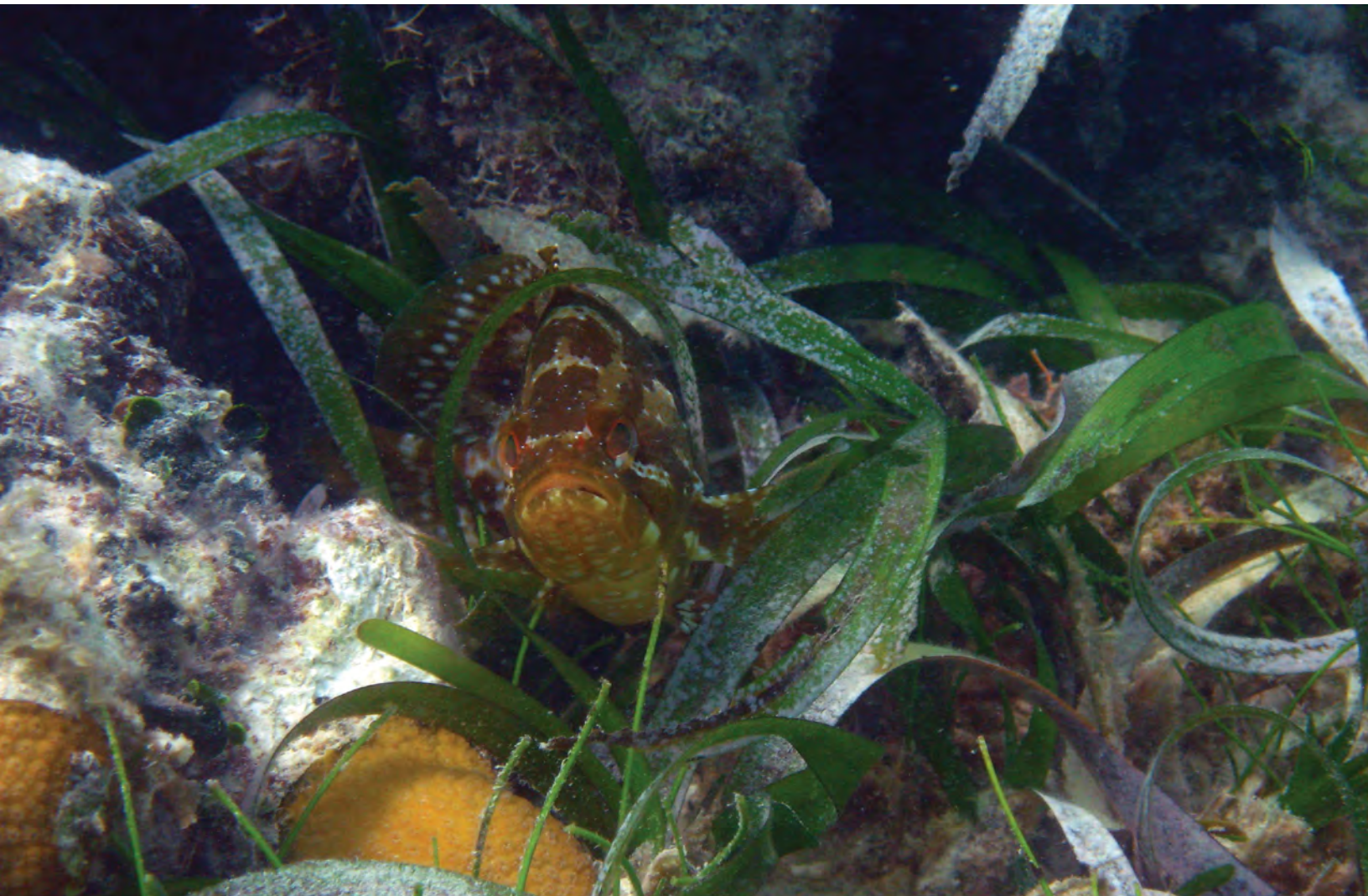
4 U.S. Virgin Islands Marine Resources and Fisheries Strategic and Comprehensive Conservation Plan. 2005. VI Department of Planning and Natural Resources. St Thomas, U.S. Virgin Islands.

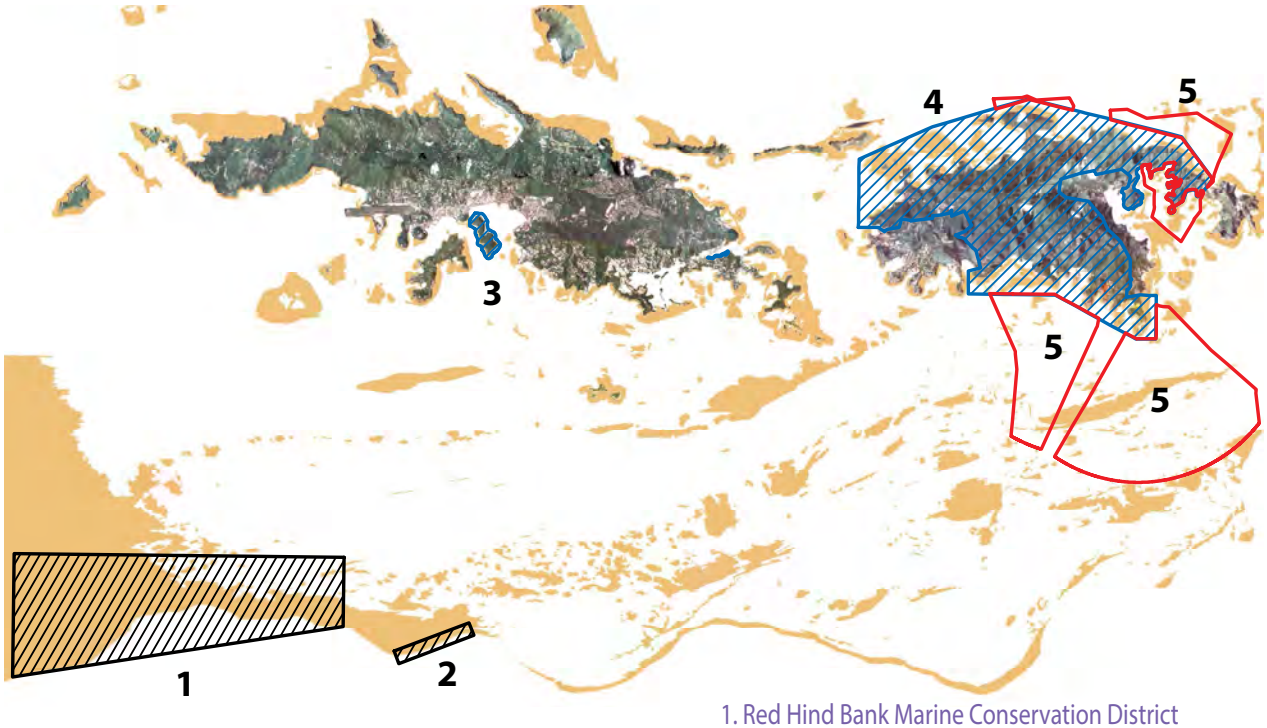
5 Gardner, L. 2002. Management framework for a network of marine protected areas (MPAs) for the U.S. Virgin Islands. University of the Virgin Islands and VI Department of Planning and Natural Resources.

National MPA networks

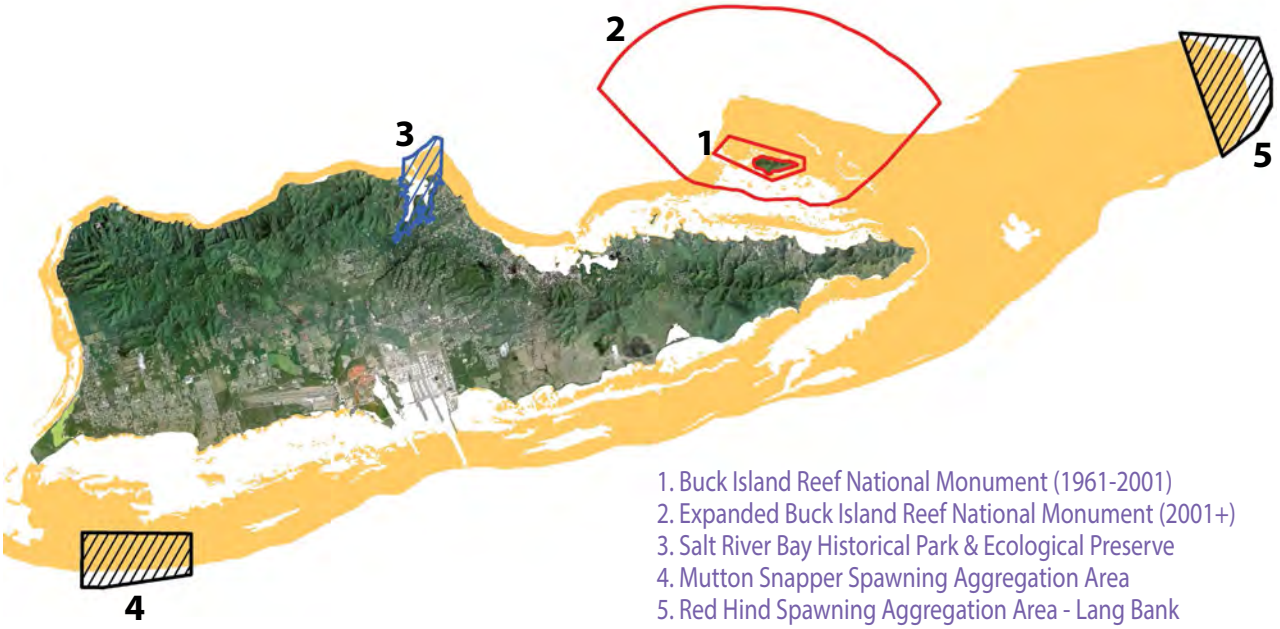
By 2012, the St. Croix East End Marine Park and the St. Thomas East End Reserves had joined the four MPAs (Virgin Islands National Park, Virgin Islands Coral Reef National Monument, Buck Island National Monument, and Salt River Bay National Historical Park and Ecological Preserve) managed by the Department of Interior (National Monuments and National Parks) as members of the U.S. National System of MPAs formed in response to Executive Order 13158-Marine Protected Areas (2000). The National System of MPAs develops a scientifically based, comprehensive national system of MPAs representing diverse U.S. marine ecosystems, and the Nation's natural and cultural resources[6]. In 2012, the Virgin Islands MPA community established the Virgin Islands MPA Network to improve coordination, cooperation, communication, and collaboration among USVI MPAs within the National MPA Network.

6 NOAA MPA Center. 2008. Framework for the national system of marine protected areas of the United States of America. http://marineprotectedareas.noaa.gov/nationalsystem/framework/



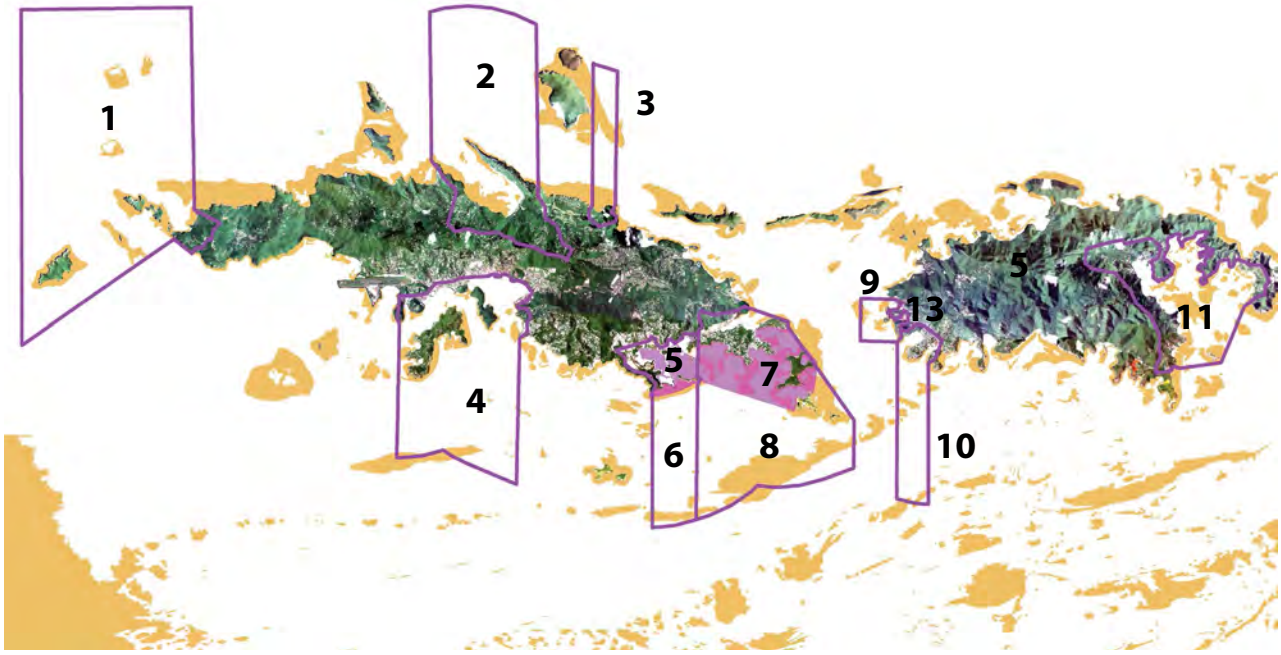


1. Red Hind Bank Marine Conservation District
2. Grammanik Bank Seasonal Closure
3. Hassel Island Historic District
4. Virgin Islands National Park
5. Virgin Islands Coral Reef National Monument



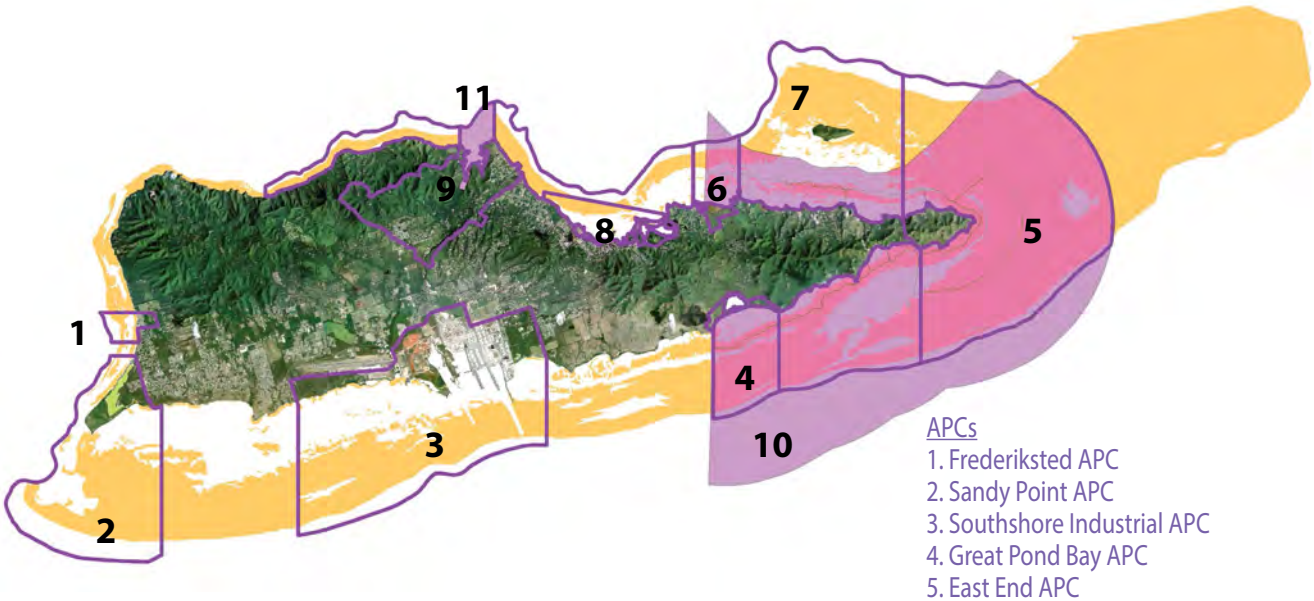
1. Buck Island Reef National Monument (1961-2001)
2. Expanded Buck Island Reef National Monument (2001+)
3. Salt River Bay Historical Park & Ecological Preserve
4. Mutton Snapper Spawning Aggregation Area
5. Red Hind Spawning Aggregation Area - Lang Bank

Maps of National Monuments and National Parks (blue and red) and Fishery Closures (black) of St. Thomas and St. John (top) and St. Croix (bottom). Brown shading represents shallow (<35 m) hard bottom substrate.



Territorial MPAs
5. Cas Cay/Mangrove Lagoon MSWR
7. St. James and Compass Point Pond MSWR
12. St. Thomas East End Reserve (5 and 7 combined)
13. Small Pond at Frank Bay MSWR

APCs
1. Botany Bay APC
2. Magens Bay APC
3. Mandahl Bay APC
4. St. Thomas Harbor APC
6. Mangrove Lagoon/Benner Bay APC
8. Vessup Bay/East End APC
9. Enighed Pond/Cruz Bay APC
10. Chocolate Hole/Great Cruz Bay APC
11. Coral Bay APC



Territorial MPAs
10. East End Marine Park
11. Salt River MSWR

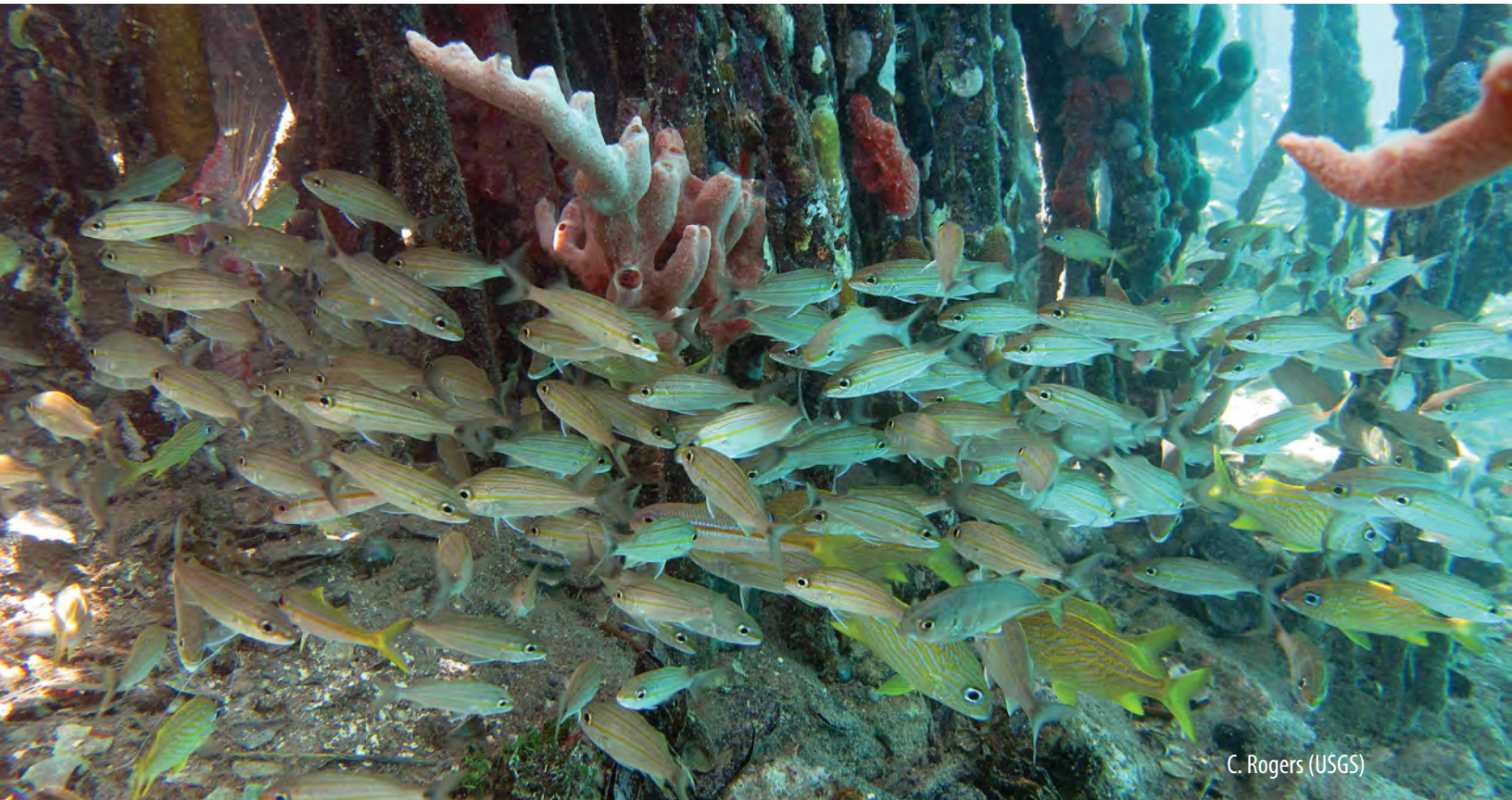
APCs
1. Frederiksted APC
2. Sandy Point APC
3. Southshore Industrial APC
4. Great Pond Bay APC
5. East End APC
6. Southgate Pond/Chenay Bay APC
7. St. Croix Coral Reef System APC
8. Christiansted APC
9. Salt River/Sugar Bay APC

Maps of Areas of Particular Concern (APC; purple outline) and Territorial MPAs (solid purple) of St. Thomas and St. John (top) and St. Croix (bottom). Brown shading represents shallow (<35 m) hard bottom substrate. MSWR= Marine Sanctuary and Wildlife Reserve.

MPAs with Fishing Regulations

There are a wide range of fishing regulations across MPAs of the USVI, with most management units offering opportunities for commercial and recreational fishing. On St. Croix, fishing is allowed in the offshore areas of East End Marine Park, but for inshore no-take and recreation zones, fishing is allowed only from the shoreline. In contrast, Buck Island Reef National Monument is a fully no-take MPA. In Virgin Islands National Park commercial fishing is prohibited and non-commercial fishing is allowed only outside of all designated swim areas (and Trunk/Jumbie Bays). Fishing outside Virgin Islands National Park in Territorial waters is regulated by Territorial government laws. In contrast, the Virgin Islands Coral Reef National Monument is no-take except for catch of blue runner and baitfish. Around St. Thomas, fishing is allowed in Territorial waters except for St. James and Cas Cay/Mangrove Lagoon Marine Reserve and Wildlife Sanctuaries which are year round no-take MPAs, with limited shoreline fishing and baitfishing permissible under permit. NOAA fishery closures at spawning aggregations are either closed to fishing seasonally or all year round: Red Hind Bank Marine Conservation District is closed to fishing all year; Grammanik Bank, Red Hind and Mutton Snapper Spawning Aggregation Areas are seasonal closures, with a year-round ban on fishing with pots, traps, bottom longlines, gillnets or trammel nets. In both Federal and Territorial waters, Nassau grouper and goliath grouper are protected species and must be released if caught.

Specific guidance on fishing regulations, including catch limits, is provided to fishers by the U.S. Caribbean Fisheries Management Council and VI-DPNR's Division of Fish and Wildlife: http://www.caribbeanfmc.com/pdfs/FishersBooklet%202012-JULY%20Final.pdf



C. Rogers (USGS)

List of MPAs of the U.S. Virgin Islands.

Marine Protected Area	Island	Governing Institution	Establish Date	Level of Protection†	Management Plan
National Monuments and National Parks					
Virgin Islands National Park	St. John	NPS	1962	Zoned; Multiple-use w/ No-take	In revision
Virgin Islands Coral Reef NM	St. John	NPS	2001	Zoned; Multiple-use w/ No-take	No
Buck Island Reef NM	St. Croix	NPS	1961	No-take; Restricted Anchoring	Yes (2012)
Salt River National Historic Park and Ecological Preserve	St. Croix	NPS/VI-DPNR	1992	Fishing regulations in review	In revision
Territorial Marine Parks					
St. Croix East End Marine Park	St. Croix	VI-DPNR	2006	Zoned; Multiple-use w/ No-take	Yes
Marine Sanctuary and Wildlife Reserve					
St. Thomas East End Reserves	St. Thomas	VI-DPNR	2011	Zoned; Multiple-use w/ No-take	Yes
Cas Cay/Mangrove Lagoon MSWR	St. Thomas	VI-DPNR	1994	Zoned; Multiple-use w/ No-take	No
Compass Point Pond MSWR	St. Thomas	VI-DPNR	1992	Zoned; Multiple-use w/ No-take	No
St. James MSWR	St. Thomas	VI-DPNR	1994	Zoned; Multiple-use w/ No-take	No
Small Pond at Frank Bay MSWR	St. John	VI-DPNR	2000	No-take	No
Salt River MSWR	St. Croix	VI-DPNR	1995	No-take	No
Fishery Closure Areas and Marine Conservation Districts					
Red Hind Bank MCD	St. Thomas	NOAA-CFMC, VI-DPNR	1989	Year-round; No-take	Yes
Grammanik Bank	St. Thomas	NOAA-CFMC, VI-DPNR	2005	Seasonal Closure; No-take	Yes
Mutton Snapper	St. Croix	NOAA-CFMC, VI-DPNR	1993	Seasonal Closure; No-take	Yes
Lang Bank	St. Croix	NOAA-CFMC, VI-DPNR	1993	Seasonal Closure; No-take	Yes
Areas of Particular Concern					
Botany Bay APC	St. Thomas	VI-DPNR	1993	Multiple-Use	No
Magens Bay Watershed APC	St. Thomas	VI-DPNR	1993	Multiple-Use	No
St. Thomas Harbor and Waterfront APC	St. Thomas	VI-DPNR	1993	Multiple-Use	No
Mandahl Bay APC	St. Thomas	VI-DPNR	1993	Multiple-Use	Yes - Draft
Mangrove Lagoon/Benner Bay APC	St. Thomas	VI-DPNR	1993	Multiple-Use	No
Vessup Bay/East End APC	St. Thomas	VI-DPNR	1993	Multiple-Use	No
Enighed Pond/Cruz Bay APC	St. John	VI-DPNR	1993	Multiple-Use	No
Chocolate Hole/Great Cruz Bay APC	St. John	VI-DPNR	1993	Multiple-Use	No
Coral Bay APC	St. John	VI-DPNR	1993	Multiple-Use	Yes - Draft
Sandy Point APC	St. Croix	VI-DPNR	1993	Multiple-Use	Yes - Draft
Frederiksted Waterfront APC	St. Croix	VI-DPNR	1993	Multiple-Use	No
Southshore Industrial Area APC	St. Croix	VI-DPNR	1993	Multiple-Use	Yes - Draft
St. Croix Coral Reef System APC	St. Croix	VI-DPNR	1993	Multiple-Use	Yes - Draft
Salt River Bay APC	St. Croix	VI-DPNR	1993	Multiple-Use	No
Christiansted Waterfront APC	St. Croix	VI-DPNR	1993	Multiple-Use	Yes - Draft
Southgate Pond/Chenay Bay APC	St. Croix	VI-DPNR	1993	Multiple-Use	No
Great Pond Bay APC	St. Croix	VI-DPNR	1993	Multiple-Use	No
East End APC	St. Croix	VI-DPNR	1993	Multiple-Use	No

Federal Agencies: NPS – National Park Service, NOAA – National Oceanic and Atmospheric Administration, CFMC – Caribbean Fisheries Management Council
Territorial Agencies: VI-DPNR – U.S. Virgin Islands Department of Planning and Natural Resources
† Adapted from Wusinich-Mendez and Curtis (2007)

Ecological Performance for Three Federal MPAs

Evaluating MPA Performance

Fish Populations

Status and Trends

Coral reef ecosystems of the USVI include a wide variety of fishes that are important to maintain a healthy and productive ecosystem that provides valuable goods and services for island communities and visitors. Over the past few decades, the number and biomass (weight) of fish on Caribbean coral reefs, particularly large fish such as grouper, snapper and big parrotfish, have declined considerably[7]. To better protect coral reefs and associated fishes, MPAs have been established in the Caribbean. A functionally intact fish community on healthy reefs is expected to include abundant herbivores and carnivores, including large-

7 Stallings, C.D. 2009. Fishery-independent data reveal negative effect of human population density on Caribbean predatory fish communities. PLoS ONE 4(5): e5333

bodied species. In the USVI, declines in fish abundance, particularly of large-bodied economically important species has resulted in a functionally impaired fish community. The expectation for a well-protected MPA is that, over time, protection will result in a healthier reef, and where fishing is prohibited, fished populations will be replenished. Economic benefits for fisheries are thought to occur from the spillover of fish from the MPA into neighboring waters outside the MPA. Although this study does not examine spillover, a related study that tracked fish movements in and out of MPAs in the USVI provides direct evidence of spillover through fish movement out from MPAs into neighboring unprotected areas where they can be fished[8]. The performance of an MPA is measured and assessed to help resource managers evaluate their actions, set realistic expectations for performance and guide strategic decisions for future actions. We use a decade of fish survey data from the joint NOAA and NPS coral reef ecosystem monitoring project to examine trends in key fishery species, and groups of species (e.g., grouper), and the number of species (i.e., species richness) from coral reefs inside and outside MPAs. With statistical analyses this report determines if a trend exists over the monitoring period and whether a trend is increasing or decreasing inside the MPA compared with data from a structurally similar range of seascapes outside the MPA. These results represent status and trends for shallow water (<35 m) fish communities associated with coral reef and colonized hardbottom habitat types sampled during daylight hours. More details on the sampling design and analyses used can be found in the Appendix.

Coral & Algae

Status and Trends

Over the past few decades, the composition of seafloor (benthic) communities and the structural complexity of Caribbean coral reefs have changed dramatically together with a decline in the occurrence and spatial coverage of living coral in many areas[9,10]. In the USVI, the major drivers of change have been thermal stress events and disease outbreaks, storms, poor water quality and the decline of key grazers of algae, such as parrotfishes and black spiny sea urchins[8,9]. A major thermal stress event in 2005 resulted in mass coral bleaching and subsequent disease causing widespread coral mortality across the region[11]. Declines in branching coral species of elkhorn (*Acropora palmata*) and staghorn (*Acropora cervicornis*) have led to these species being proposed as Endangered Species under the Endangered Species Act.

8 Pittman, S.J., M.E. Monaco, A.M. Friedlander, B. Legare, R.S. Nemeth, M.S. Kendall, R.D. Clark, L.M. Wedding and C. Caldow. 2014. Fish with Chips: Tracking reef fish movements to evaluate size and connectivity of Caribbean marine protected Areas. PLoS ONE 9(5): e96028

9 Rogers, C.S., J. Miller, E.M. Muller, P. Edmunds, R.S. Nemeth, J.P. Beets, A.M. Friedlander, T.B. Smith, R. Boulon, C.F. G. Jeffrey, C. Menza, C. Caldow, N. Idrisi, B. Kojis, M.E. Monaco, A.Spitzack, E.H. Gladfelter, J.C. Ogden, Z. Hillis-Starr, I. Lundgren, W.B. Schill, I.B. Kuffner, L.L. Richardson, B.E. Devine, and J.D. Voss 2008. Chapter 8: Ecology of Coral Reefs in the U.S. Virgin Islands. pp 303-374. In: B. Riegl, R.E. Dodge (eds). Coral Reefs of the USA, Vol. 1. Springer. 803 pp.

10 Rogers, C.S. and J. Beets. 2001. Degradation of marine ecosystems and decline of fishery resources in marine protected areas in the U.S. Virgin Islands. Environmental Conservation 28(4): 312-322

11 Miller, J., R. Waara, E. Muller, and C. Rogers. 2006. Coral bleaching and disease combine to cause extensive mortality on reefs in U.S. Virgin Islands. Coral Reefs 25(3): 418-418

MPAs typically include regulations to reduce negative human impacts to the seafloor and associated organisms, such as prohibiting anchoring and fishing and minimizing impacts from land-based sources of pollution. By controlling and minimizing threats to coral reef communities, MPAs are considered to help restore or maintain conditions that will ensure the growth and survival of vulnerable living corals. A global analysis on the ability of MPAs to prevent coral loss found that coral cover within MPAs remained constant, while coral cover on unprotected reefs declined with greatest effects in the oldest (15-30 years) MPAs[12]. Maintaining and restoring functionally diverse faunal communities, including herbivores, is thought to control algal growth on reefs and support coral and coralline algal settlement and growth. Expectations are that enhanced protection will slow or halt the degradation of coral reef ecosystems and promote recovery and resilience.

Methodologies

Survey Methods

NOAA Methods

Data on coral were collected as part of NOAA's Caribbean Coral Reef Ecosystem Monitoring Project, a collaborative effort between NOAA's National Centers for Coastal Ocean Science (NCCOS), NOAA's Coral Reef Conservation Program, NPS and VI-DPNR. Biological surveys were conducted once a year to characterize, monitor, and assess the marine resources within three MPAs and the adjacent areas outside of the MPAs[13]. Survey sites were selected randomly from hardbottom and softbottom habitats, both within and outside the MPA. For the temporal trend analyses in this document, data were restricted to surveys collected in the MPA during the summer survey missions and on the most commonly occurring hardbottom types (pavement, aggregate reef, spur and groove, and patch reefs). This provided a focus on coral reefs and minimized variability from seasonal differences in fish abundance. The years of data used differed slightly among the three MPAs due to variations in the data collection. For both the fish and benthic analyses, data was included for years 2003-2010 for Buck Island Reef National Monument and 2002-2011 for Virgin Islands National Park. For Virgin Islands Coral Reef National Monument, data was included for years 2002-2011 for the fish analysis, but only 2003-2010 for the analysis of benthic metrics due to changes in the benthic data collection methods. A summary table and maps of the survey locations and counts are provided in the Appendix. For the assessment of occurrence of large bodied fishes all samples were used, regardless of habitat type.

12 Selig, E.R. and J.F. Bruno. 2010. A global analysis of the effectiveness of marine protected areas in preventing coral loss. PLoS ONE 5(2): e9278

13 Friedlander, A.M., C.F.G. Jeffrey, S.D. Hile, S.J. Pittman, M.E. Monaco and C. Caldow (eds.). 2013. Coral reef ecosystems of St. John, U.S. Virgin Islands: Spatial and temporal patterns in fish and benthic communities (2001-2009). NOAA Technical Memorandum 152. Silver Spring, MD. 150 pp.

All NOAA data used in this report is open access via the NOAA Coral Reef Monitoring Program Database (http://www8.nos.noaa.gov/bpdmWeb/queryMain.aspx).

Surveys of benthic habitats and fish communities were conducted within a 25x4 m transect (100 m^2), along a random compass heading at spatially random locations. Two divers performed the survey at each site. One diver was responsible for visually counting and estimating the size of fish, which were identified to species. Fish surveys were conducted along the transect using a fixed survey duration (15 minutes) regardless of habitat type or complexity. The number of individuals per species was recorded in 5 cm size class increments up to 35 cm based on fork length (distance from tip of mouth to point at which the caudal fin forks). Individuals greater than 35 cm were recorded as an estimate of the actual fork length to the nearest centimeter. The second diver collected data on the benthic cover. In Buck Island Reef National Monument and Virgin Islands National Park, the percent cover of multiple biotic cover groups was measured within five 1-m^2 quadrats placed randomly along the 25x4 m transect. Hard corals were identified to species, while algae, gorgonians, and sponges were identified to morphological group. In addition, the abundance of gorgonian and sponge individuals within each quadrat was recorded. A Rapid Habitat Assessment method was used in Virgin Islands Coral Reef National Monument due to limited bottom times at the depths typically encountered on the Mid-Shelf Reef and deeper parts of Coral Bay. For this method, the diver estimated the percent cover of broad biotic cover groups (e.g., hard corals, algae, soft corals, sponges) within a 15-m diameter sampling area. No species specific data was collected. These standardized protocols have been used to monitor marine fish communities on all three islands of the USVI and in Puerto Rico[14,15,16].

14 Monaco, M.E., A.M. Friedlander, C. Caldow, J.D. Christensen, J. Beets, J. Miller, C. Rogers, and R. Boulon. 2007. Characterizing reef fish populations and habitats within and outside the U.S. Virgin Islands Coral Reef National Monument: a lesson in MPA design. Fisheries Management and Ecology 14(1): 33-40

15 Pittman, S.J., S.D. Hile, C.F.G. Jeffrey, C. Caldow, M.S. Kendall, M.E. Monaco, and Z. Hillis-Starr. 2008. Fish assemblages and benthic habitats of Buck Island Reef National Monument (St. Croix, U.S. Virgin Islands) and the surrounding seascape: A characterization of spatial and temporal patterns. NOAA Technical Memorandum 71. Silver Spring, MD. 80 pp.

16 Pittman, S.J., S.D. Hile, C.F.G. Jeffrey, C. Caldow, R. Clark, K. Woody, M.E. Monaco, and R. Appeldoorn. 2010. Coral reef ecosystems of Reserva Natural de La Parguera (Puerto Rico): Spatial and temporal patterns in fish and benthic communities (2001-2007). NOAA Technical Memorandum 78. Silver Spring, MD. 177 pp.

NPS Methods

Benthic cover was monitored using the random sample selection and video monitoring protocols developed by the U.S. Geological Survey (USGS) and NPS[17,18]. Study sites varied in size between approximately 7,000 to 40,000 m^2 criteria of high coral cover, diversity and complexity, in combination with areas of particular interest to park managers or to maintain continuity with historical monitoring. At each study site, 20 ten-meter, permanent transects were randomly chosen by mapping the site boundaries, determining the total sample (transect) population, then randomly choosing from that population. Each transect was filmed along a fiberglass measuring tape with a digital video camera pointed down, 40 cm above the substrate. Adjacent, non-overlapping images (n=25-35) were captured from the video of each transect; 10 points were randomly applied to each captured image. The benthic feature under each random point was identified to greatest taxonomic resolution (species or functional group), entered into a Microsoft Access database, and summarized for varying analyses.

17 Miller, J. 2002. Using the AquaMap System at a Study Site. U.S. Geological Survey Technical Report. https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=486009&file=Coral_Monitoring_Aquamap_Protocol.pdf

18 Miller, J. and C. Rogers. 2002. Using Videography To Monitor Coral Reefs. U.S. Geological Survey Technical Report. https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=486002&file=Coral_Monitoring_Video_Protocol.pdf

Enforcement Data Analysis Methods

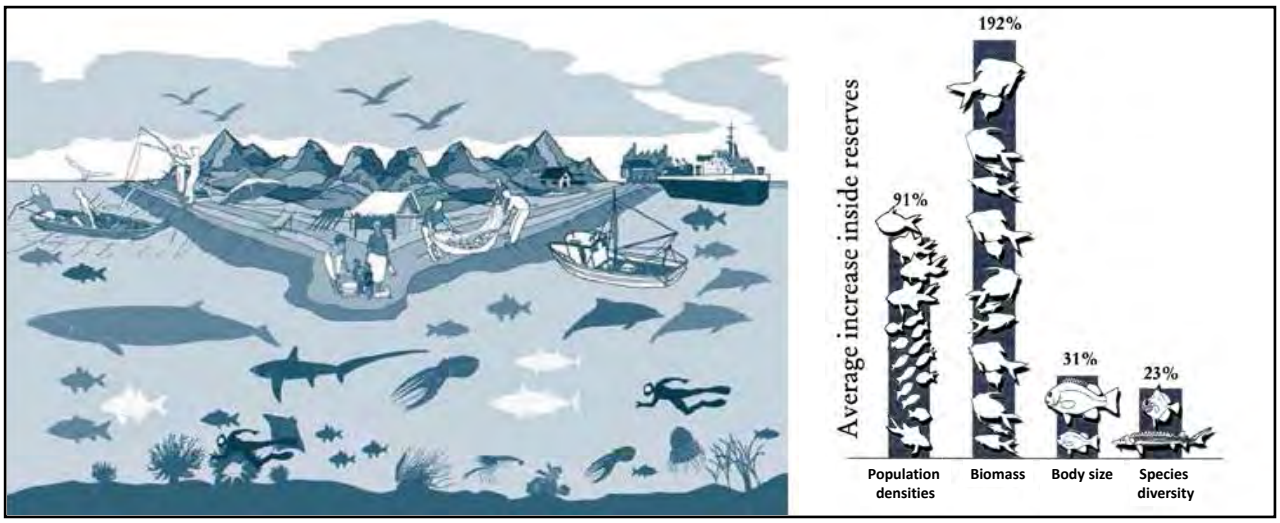
Information about enforcement intensity and level of users' compliance with regulations were compiled or reconstructed through: (1) unstructured informal interviews with the Chief Resource Managers, Superintendents, and Chief Rangers of each park; (2) review of available citation databases maintained by the Parks' Chief Rangers; and (3) annual narrative reports written by the parks' Superintendents. In addition, Compendium Reports were reviewed to identify additional closures, designations, or restrictions imposed by discretionary authority of the Superintendent. Enforcement intensity was broadly defined as the annual number of park rangers stationed at each park, because data on the number of hours and extent of areas patrolled by rangers were not available. Information on issued citations was classified into categories of infractions to create graphic displays of infraction incidence and occurrence for each park. These types of information represents mostly the expert opinions of the parks' managers and do not adequately characterize temporal or spatial patterns in enforcement intensity or user compliance; however, they provide the best available measure of differences in enforcement and compliance among the MPAs. Clearly, the paucity of these data indicates a critical need for understanding. This could be achieved through enforcement and non-compliance studies which would help managers assess whether or not their policies and efforts would result in improved resource conservation and management.

Analytical Methods

Biological Metics

For fishes, metrics of ecological performance focus on species that are targeted by the USVI fishery. Because fishing preferentially targets adult fish this report uses density of adult fish as a performance metric for fishery species since reduced fishing is, at some point, expected to result in an increase of adult fish. In addition, studies of MPA effects around the world frequently use changes in fish biomass to evaluate MPA performance. Metrics on fish biomass for key herbivores and carnivore species and fish families were selected, as well as biomass of all fish combined and the number of fish species as an estimate of fish species diversity. The selected species are relatively abundant and widely distributed across the study areas. Furthermore, the occurrence of sightings for less common, large-bodied, comparatively late maturing fish species with highest vulnerability to fishing (groupers and snappers) were calculated.

Why do big fish matter? Recent research shows that removing the larger, older individuals of a population reduces the rate of stock replenishment. This impact is even greater with the removal of larger, older females, which often produce significantly more offspring, many of which are larger and faster growing with greater fat reserves. MPAs where fishing is excluded provide one option for protecting a wide range of ages and sizes. Big fish, such as grouper, snapper and some parrotfish, also have important functional roles making them appropriate targets for replenishment strategies.



Global evidence of MPA performance in replenishing fish populations. Adapted from Food and Agriculture Organization of the United Nations.[19]

Biological metrics for benthic composition of sedentary organisms focuses on indicators of coral reef health. The amount of live scleractinian (i.e. hard) coral cover is expected to increase inside MPAs if threats and stressors are reduced. Where fishing of herbivorous fish is restricted, macroalgal abundance is expected to be lower or to decrease over time compared with areas where herbivorous fish are being harvested. Reef substratum that is well grazed should allow calcareous coralline algae and juvenile corals to settle and grow. In some areas where conditions are less favorable for hard coral, macroalgae and fast growing soft corals may become dominant resulting in a so-called 'phase shift' in community composition to a less desirable status for coral reef ecosystems.[20]

The combined percentage cover of five coral species listed as "Threatened" under the Endangered Species Act (ESA) in 2014, including *Mycetophyllia ferox*, *Dendrogyra cylindrus*, and *Orbicella* spp. (*O. annularis, O. faveolata, O. franksi*), were analyzed. Acroporid species (*A. palmata* and *A. cervicornis*) were not included because they were too infrequently encountered in the spatially random surveys.

Detecting Trends Inside & Outside MPAs

Statistical trend analysis was applied to biological metrics from hardbottom habitat inside and outside the MPA (2002-2011). In this report, we employ a suite of statistical analyses to examine a decade of benthic survey data collected jointly by NOAA and NPS to determine whether trends in the abundance of key benthic organisms and groups of species associated with coral reefs are responding differently inside MPAs compared with reefs outside the MPAs. These analyses did not assess the ecological effects of MPAs on the

19 Fisheries management. 2011. 4. Marine protected areas and fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 4. Rome, FAO. 198 pp.

20 Mumby, P.J., C.P. Dahlgren, A.R. Harborne,C.V. Kappel, F. Micheli, D.R. Brumbaugh, K.E. Holmes, J.M. Mendes, K. Broad, J.N. Sanchirico, K. Buch, S. Box, R.W. Stoffle, and A.B. Gill. 2006. Fishing, trophic cascades, and the process of grazing on coral reefs. Science 311:98–101.

composition of biological communities, but rather compared temporal trends in individual components that function as potential indicators of MPA performance. Details of the statistical methods are provided in the Appendix. For each biological metric, the mean (plus standard error) value for surveys conducted on coral reefs during approximately the same months in each year is shown on graphs for each metric.

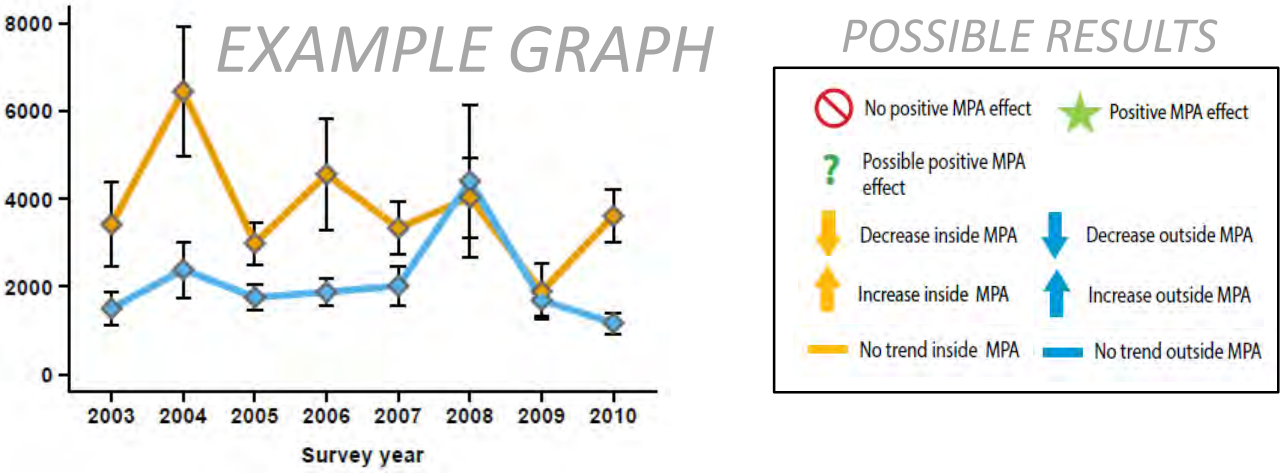
A positive MPA performance effect is indicated by:

- A significant increasing trend in a biological metric (e.g., fish biomass, coral cover) inside the MPA over time when outside areas show no increase. For algae, a decreasing trend inside would indicate a positive MPA effect
- No significant decrease inside the MPA when outside areas show a significant decrease is considered a potential positive effect. For algae, no significant increase inside when algae increased outside would indicate a potential positive MPA effect

No positive MPA effect is indicated by:

- No significant increase or decrease inside or outside
- A significant decrease inside where outside areas show a significant increase (the converse for algae)
- A significant increase outside where inside areas show no increase (the converse for algae)

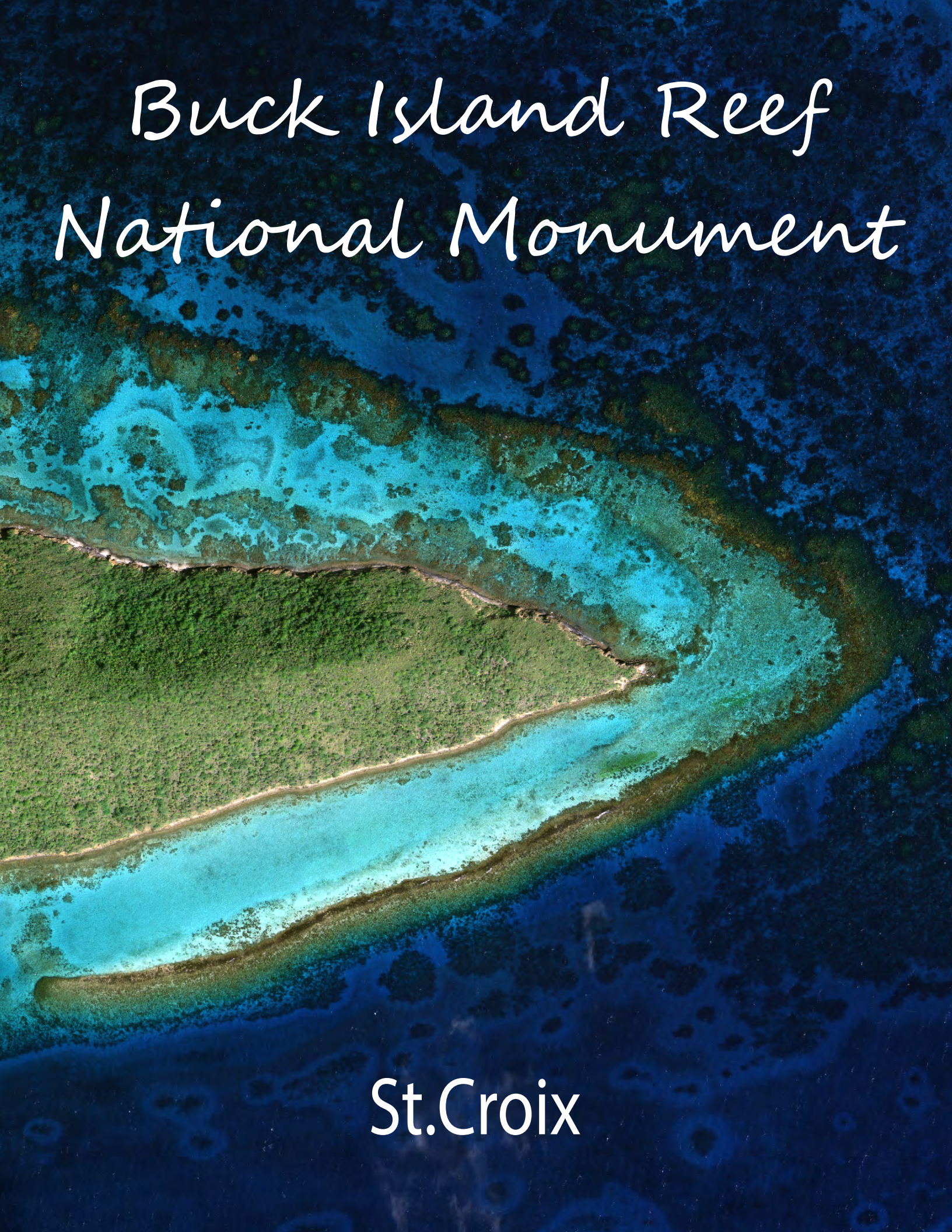
Each graph is accompanied by a series of arrows that indicate a statistically significant increasing or decreasing trend over time or no significant trend detected. The symbols are used in the subsequent results section to communicate the findings. An example follows:



A Closer Look: Three Federal MPAs

US Army Corp of Engineers

Buck Island Reef National Monument



St.Croix

Location:
Northeast coast of St. Croix
U.S. Virgin Islands

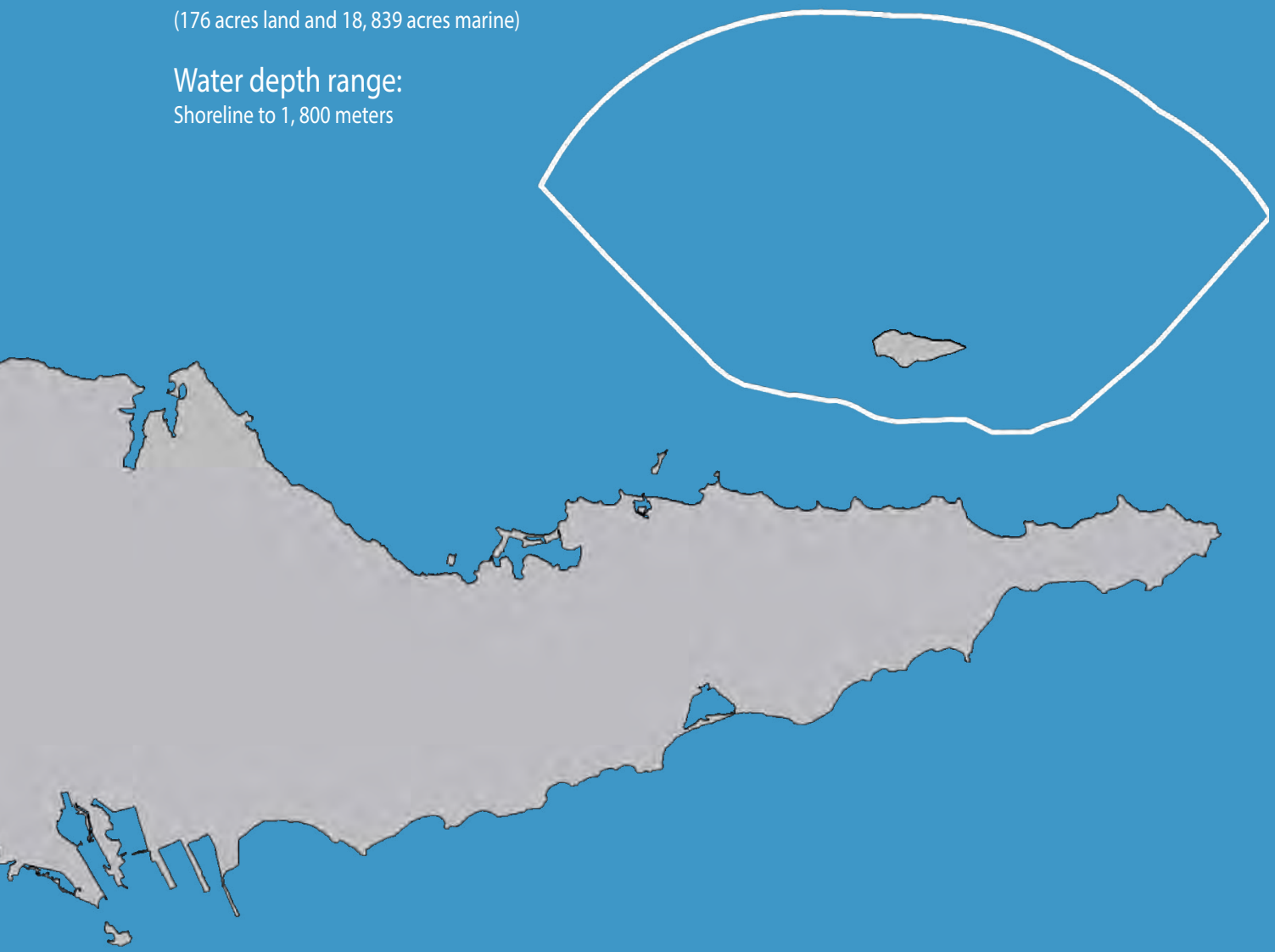
Origin:
Established 1961 by Presidential Proclamation
Expanded 1975 and 2001 by Presidential Proclamation

Governance:
U.S. Federal Government; U.S. Department of the Interior

Enforcement:
National Park Service

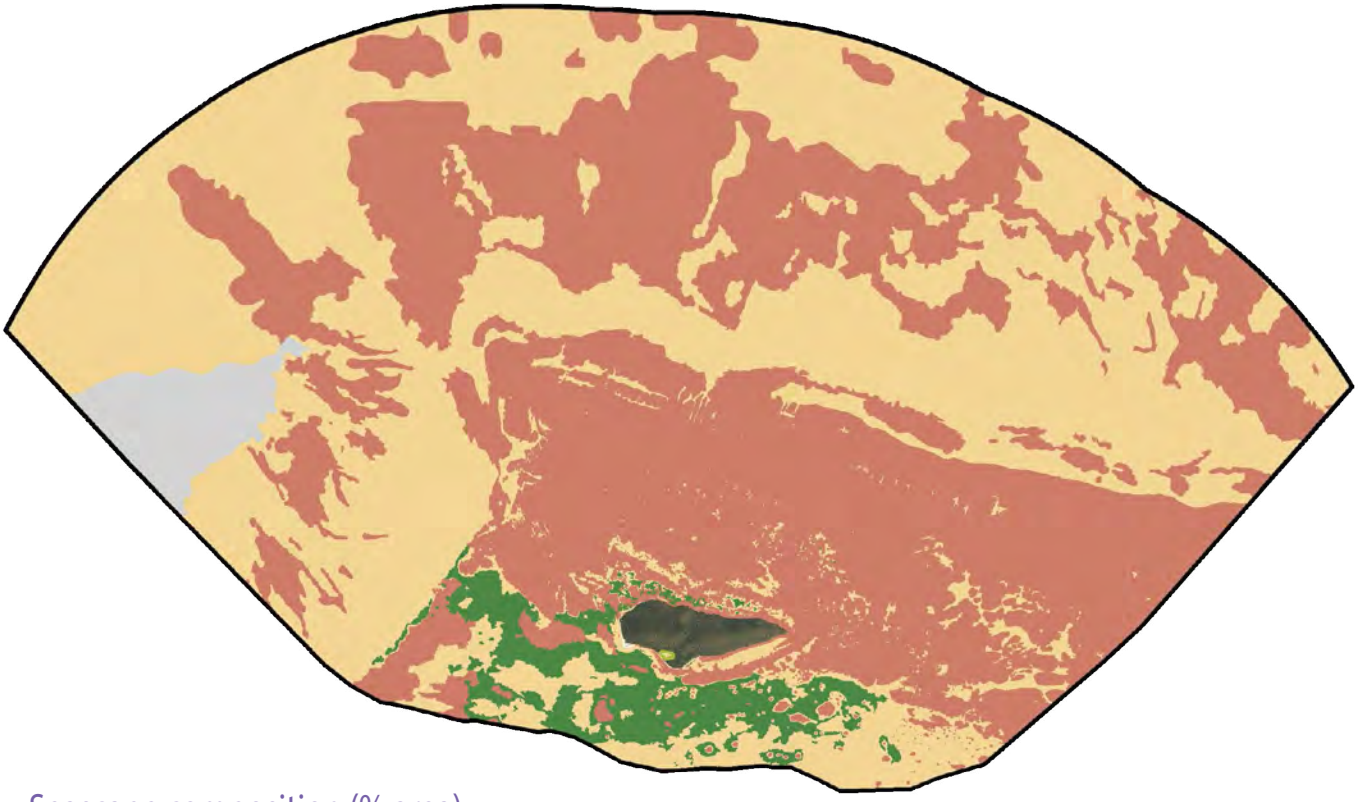
Total area:
19,015 acres
(176 acres land and 18, 839 acres marine)

Water depth range:
Shoreline to 1, 800 meters



About the MPA

Buck Island is located a mile and a half off the north-east shore of St. Croix and is surrounded by a seascape of coral reefs, rocks, sand and seagrasses. In 1961, Buck Island and the surrounding submerged lands were designated a National Monument by President Kennedy (Presidential Proclamation 3443), with the purpose of preserving "one of the finest marine gardens in the Caribbean Sea." The original monument encompassed approximately 850 acres (176 land, 704 water), and was zoned to include the Marine Garden on the south shore of Buck Island as a 'no-take' marine reserve[1]. The boundaries were expanded by 30 acres in 1975 to include additional submerged lands (Presidential Proclamation 4346), and expanded again in 2001 by 19,015 acres (Presidential Proclamation 7392), with new regulations making the entire monument a 'no-take' and 'restricted anchoring' zone. The managing agency, NPS, implemented Interim Regulations (36 CFR Part 7.73) in 2003 and completed the General Management Plan in 2012[2].



Seascape composition (% area):

- Coral Reef and Hardbottom - 47%
- Unconsolidated Sediment - 47%
- Seagrass - 3.5%
- Mangrove - <0.1%
- Unknown - 2.4%
- Monument Boundary

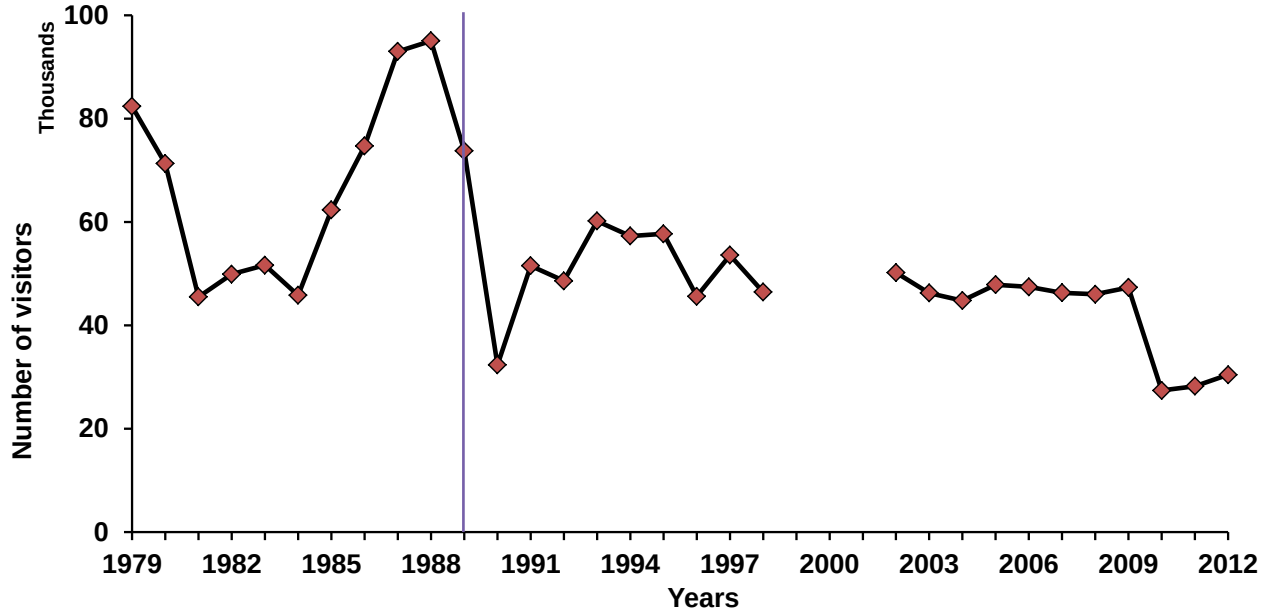
1 Pittman, S.J., S.D. Hile, C.F.G. Jeffrey, C. Caldow , M.S. Kendall, M.E. Monaco, and Z. Hillis-Starr. 2008. Fish assemblages and benthic habitats of Buck Island Reef National Monument (St. Croix, U.S. Virgin Islands and the surrounding seascape: a characterization of spatial and temporal patterns. NOAA Technical Memorandum NOS NCCOS 71. Silver Spring, MD. 96 pp.

2 National Park Service (NPS). 2012. Buck Island Reef National Monument Draft General Management Plan/Environmental Impact Statement. National Park Service, U.S. Department of the Interior. Boulder, CO.

Human Uses

Buck Island Reef National Monument is the most popular tourist destination in St. Croix, receiving between 40 and 50 thousand visitors annually between 1995 and 2008.[2] Generally, the annual number of visitors declined between 1979 and 2012, with a precipitous reduction in 1990 (most likely due to Hurricane Hugo which occurred in 1989). In 2011, visitors (local and non-local) to Buck Island Reef National Monument spent approximately $2,018,000 on the local economy.[3]

Access to the Monument is limited to private vessels and concessionaires, and restricted access to vessels for hire. Anchoring within the monument is prohibited except in designated areas or by permit. Visitors use the park for recreational activities such as: snorkeling, SCUBA diving, hiking, sailing and boating, swimming, sunbathing, and picnicking[2].



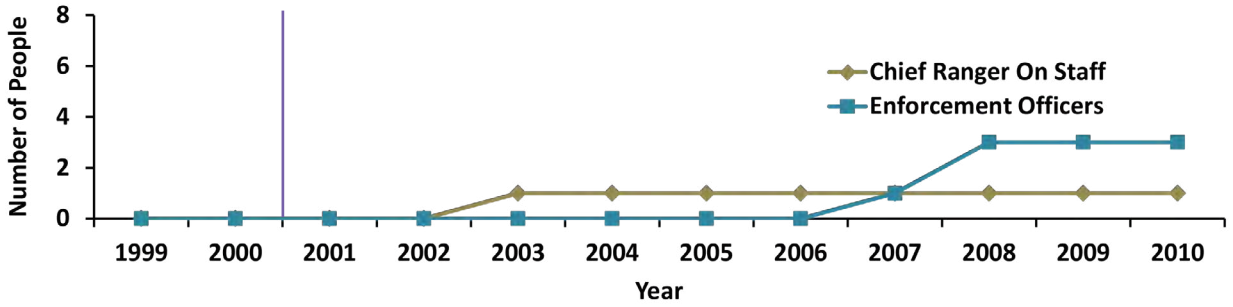
Annual number of visitors to Buck Island Reef National Monument from 1979-2012. Data were not available from 1999-2001. Line indicates advent of Hurricane Hugo. Source: National Park Service

3 Cui, Yue, Mahoney, E. & Herbowicz, T. 2013. Economic benefits to local communities from national park visitation, 2011. Natural Resource Report NPS/NRSS/EQD/NRTR—2013/631. National Park Service, Fort Collins, Colorado.

Regulation & Stewardship

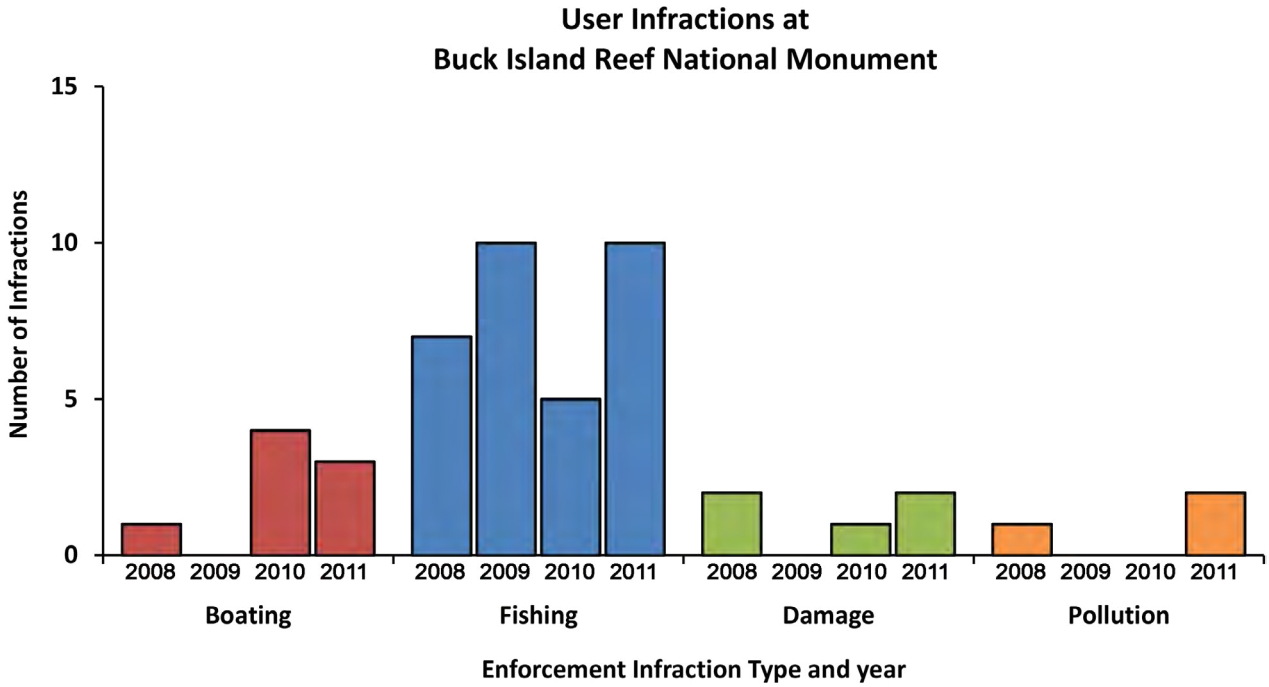
Buck Island Reef National Monument has several special regulations in place to conserve the marine environment and life within its boundaries. NPS Rangers on St.Croix are primarily responsible for enforcing these regulations, but they also do the same at two other national parks: the Christiansted National Historic Site and the Salt River Bay National Historical Park and Ecological Preserve. In general, NPS Rangers work with local managers (for example the superintendent, administrative staff, and natural resource managers); the Virgin Islands Police Department; and U.S. Coast Guard to educate residents and visitors about safety, permitted activities, and other applicable conservation policies; as well as ensure the public follows park rules, local territorial laws, and fisheries regulations. While patrolling, NPS Rangers will often board and inspect boats; hand out brochures and maps; and ensure divers, boaters, and fishers know, understand, and follow local regulations. Such active education can be effective in increasing compliance and reducing repeat violations. Moreover, NPS Rangers often are the first responders to marine emergencies, such as vessel accidents and groundings, and they help maintain the public's welfare by enforcing Title 18 of the U.S. Criminal Code of the United States in addition to enforcing resource conservation laws[4].

Information about the intensity of enforcement activity, such as the number of Rangers on staff prior to 1999, the number of hours patrolled by Rangers within the MPA, and the target species caught by illegal fishers was unavailable for inclusion in this report. Between 1999 and 2002, however, the Superintendent represented the main source of enforcement at the Monument because no Park Rangers were stationed in St. Croix.[4] A Chief Ranger was appointed in 2006 and the first Enforcement Officer was hired in 2007. Since 2008, three fully commissioned Rangers have been employed at the Monument and are trained in law enforcement. The Superintendent's annual narrative reports (2008 through 2010) indicate that the presence of NPS Rangers increased the public's awareness and compliance with park regulations. For example, the Superintendent stated that the "Buck Island Reef National Monument anchoring permit registration and compliance program worked very well, boaters' knowledge and education of park regulations increased, and visitor complaints decreased because of increased marine patrols and visibility of Rangers." Not only did NPS Rangers record numerous user infractions within the MPA between 2009 and 2012, they also issued several violation notices and completed three arrests in 2010.



Number of enforcement officers and Chief Rangers for Buck Island Reef National Monument from 1999 to 2010.[4] Purple line indicates when NOAA MPA monitoring began in 2001.

4 Tutein, J. 2010. Superintendent Annual Narrative Reports, 2008 to 2010. National Park Service. Christiansted, St. Croix.



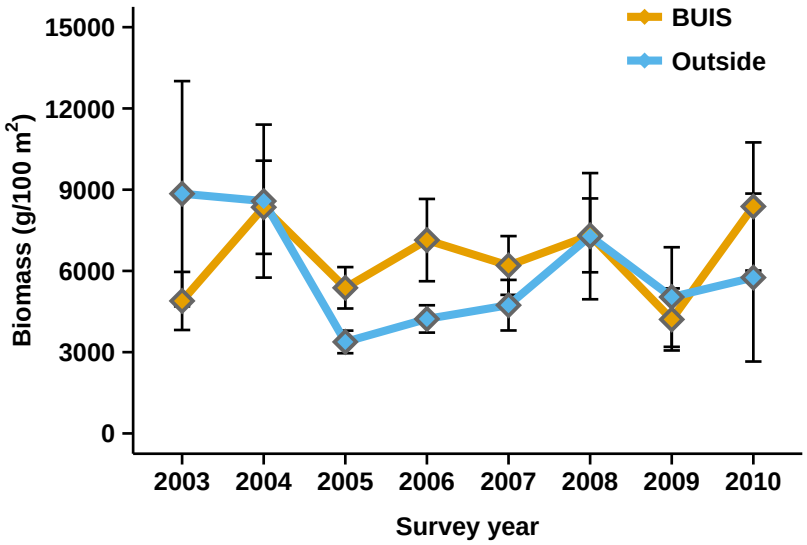
Number of infractions by year in Buck Island Reef National Monument. Damage is defined as disturbance to benthic substrates, such as illegal anchoring and groundings. Boating is defined as illegal mooring, location or abandonment of a vessel or personal watercraft. Data are unavailable before 2008. Source: National Park Service.

MPA Performance Metrics

This section presents the results of trend analysis for biological metrics inside and outside of Buck Island Reef National Monument (2003 to 2010). A written summary and interpretation of the findings is presented at the end of the section.

Fish Community Metrics

Mean Fish Biomass

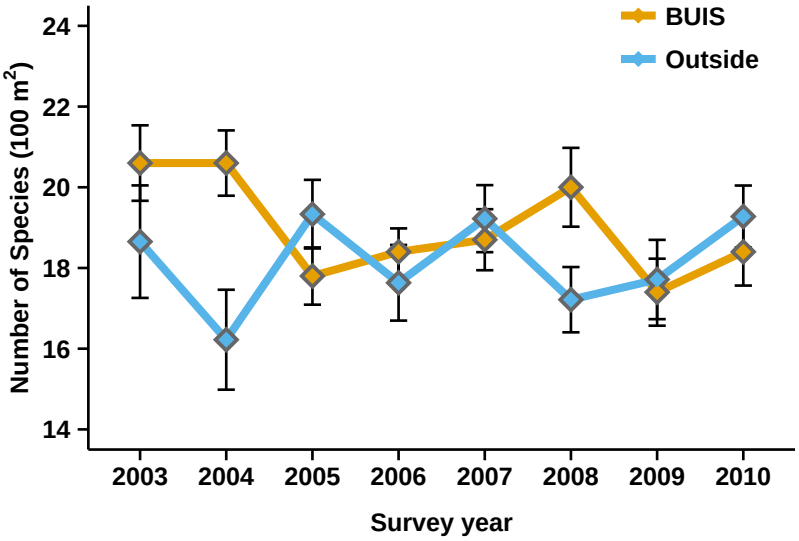


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Species Richness

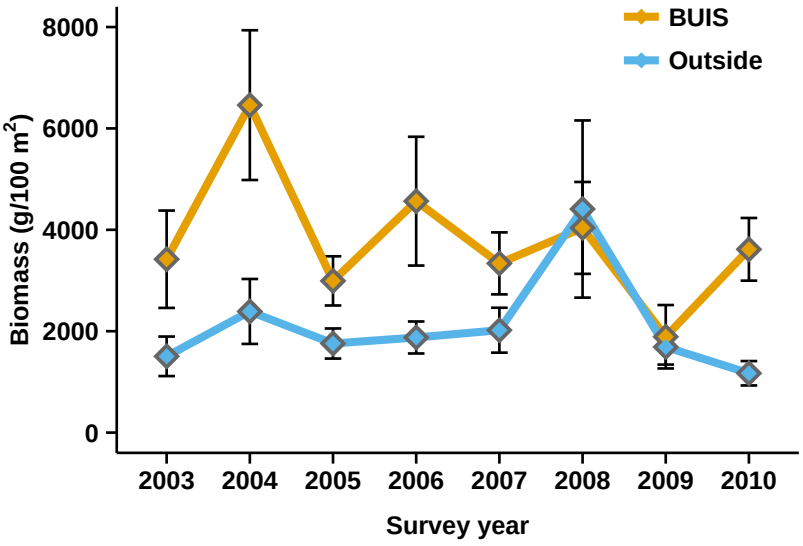


Decrease inside MPA

No trend outside MPA

No positive MPA effect

Mean Herbivore Biomass



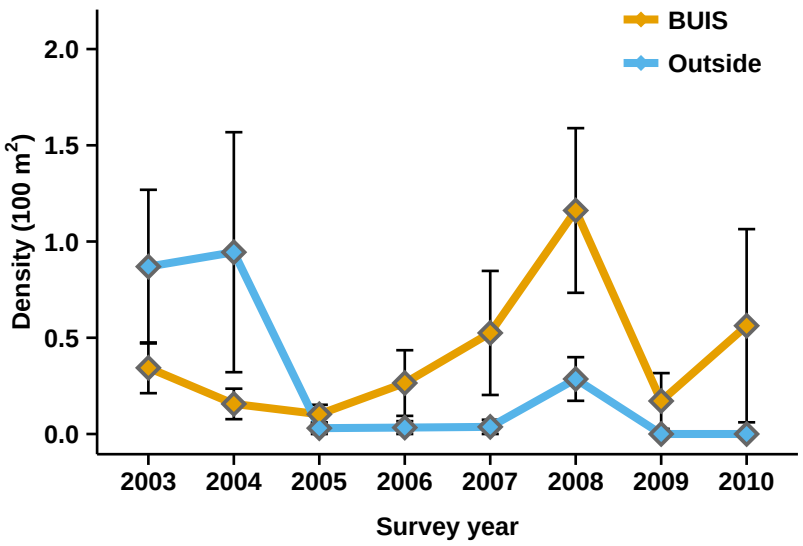
No trend inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Adult Snapper Density

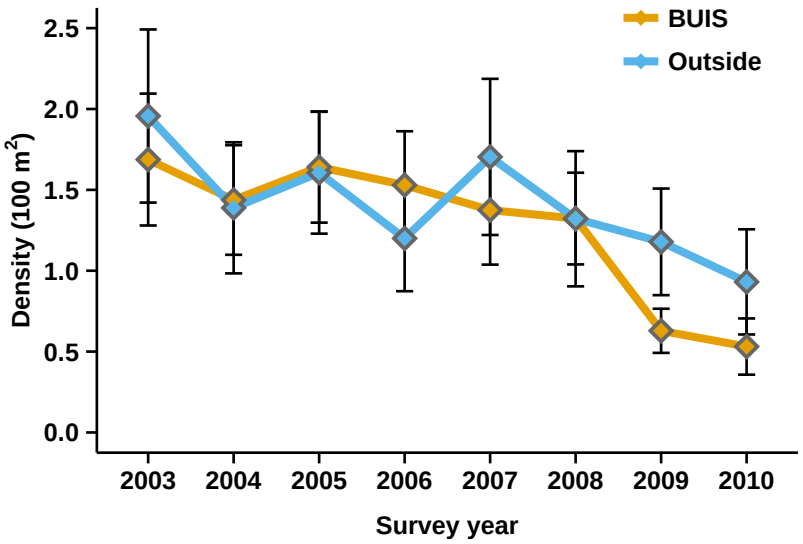


Increase inside MPA

Decrease outside MPA

Positive MPA effect

Mean Adult Grouper Density

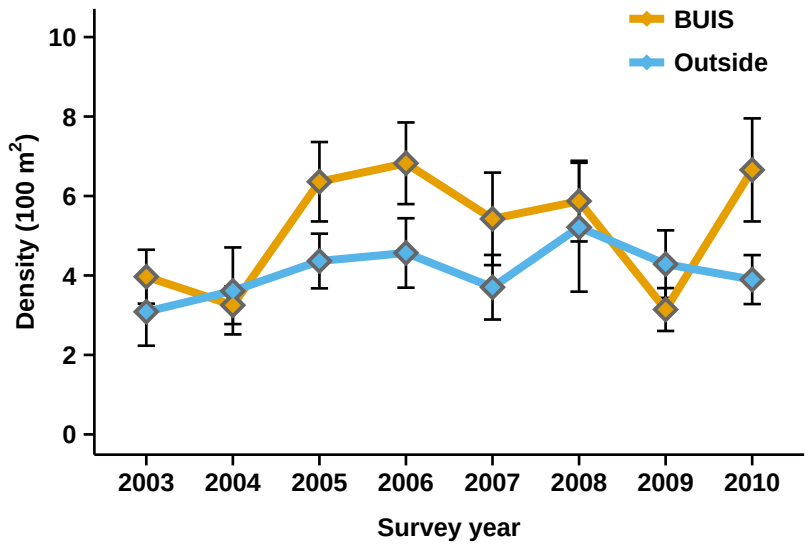


Decrease inside MPA

No trend outside MPA

No positive MPA effect

Mean Adult Parrotfish Density



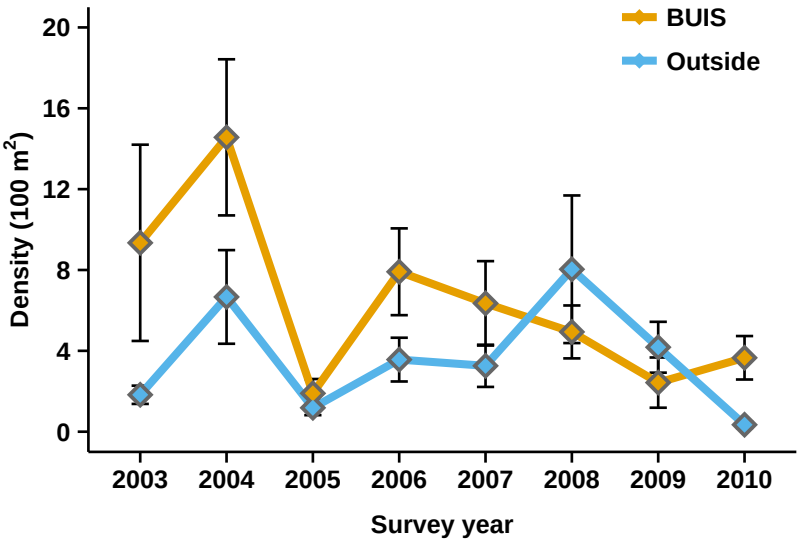
No trend inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Adult Surgeonfish Density

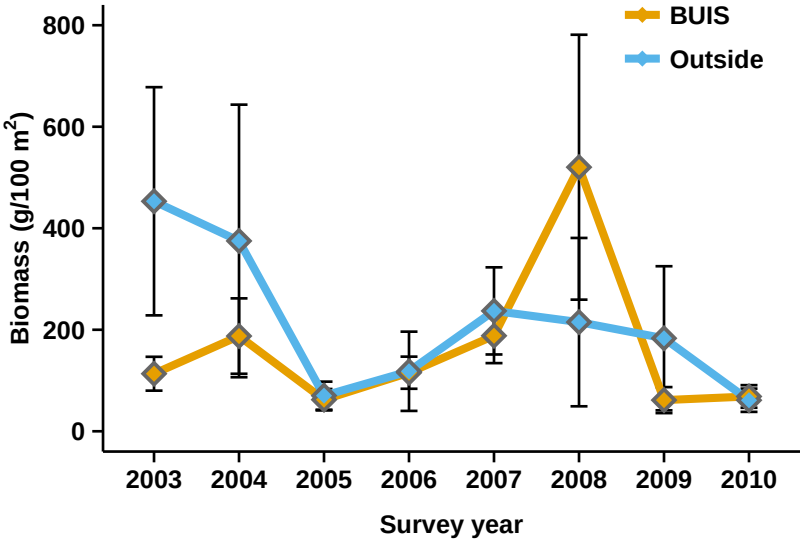


Decrease inside MPA

No trend outside MPA

No positive MPA effect

Mean Grunt (All Species) Biomass

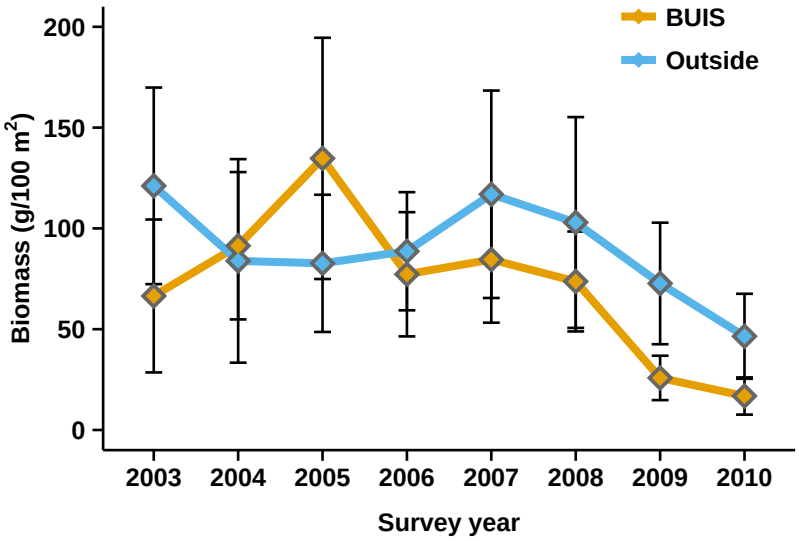


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Red Hind Biomass



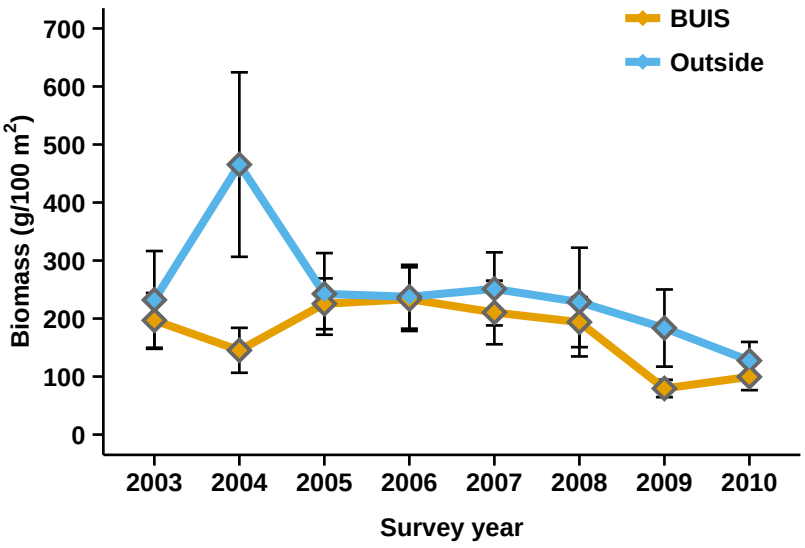
No trend inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Coney Biomass

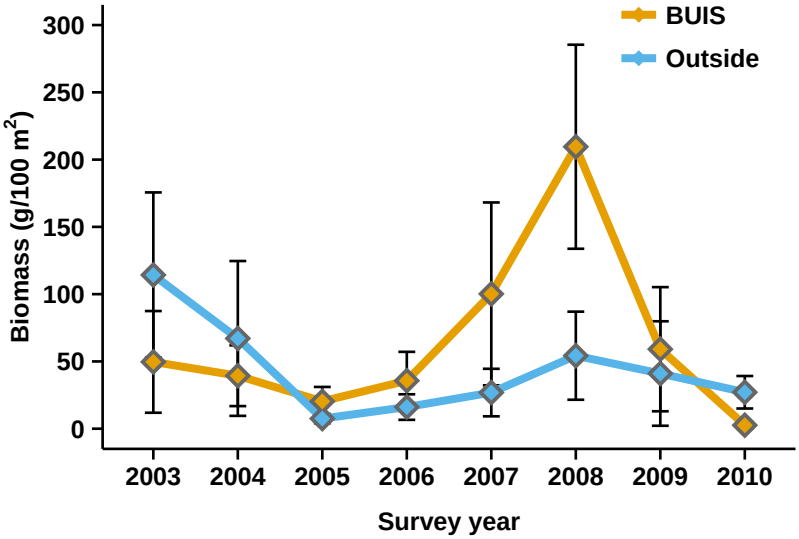


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Mean Yellowtail Snapper Biomass

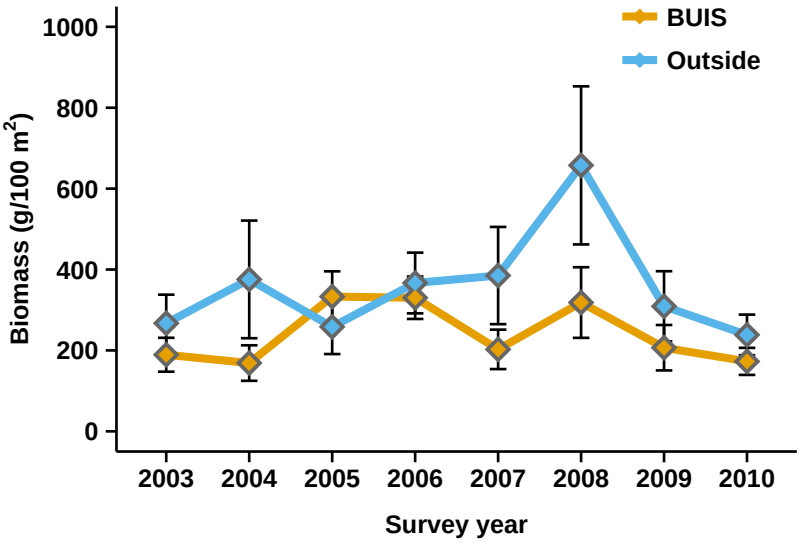


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Redband Parrotfish Biomass



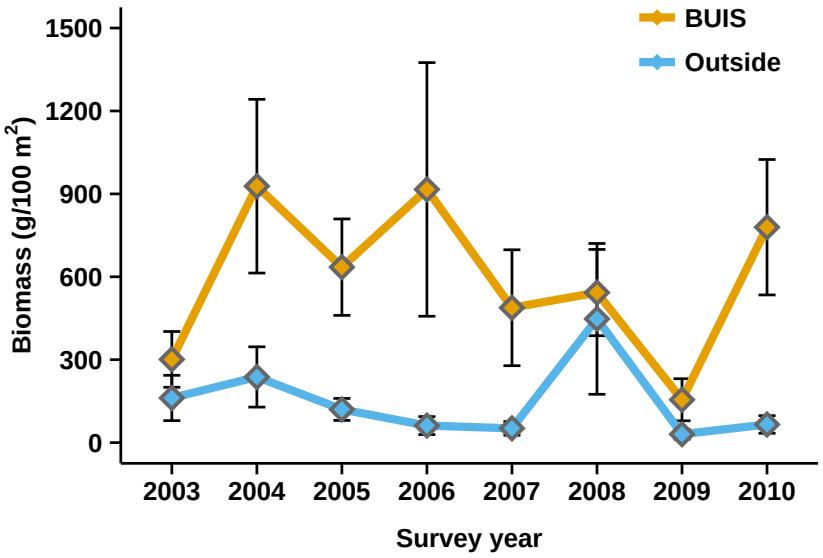
No trend inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Stoplight Parrotfish Biomass

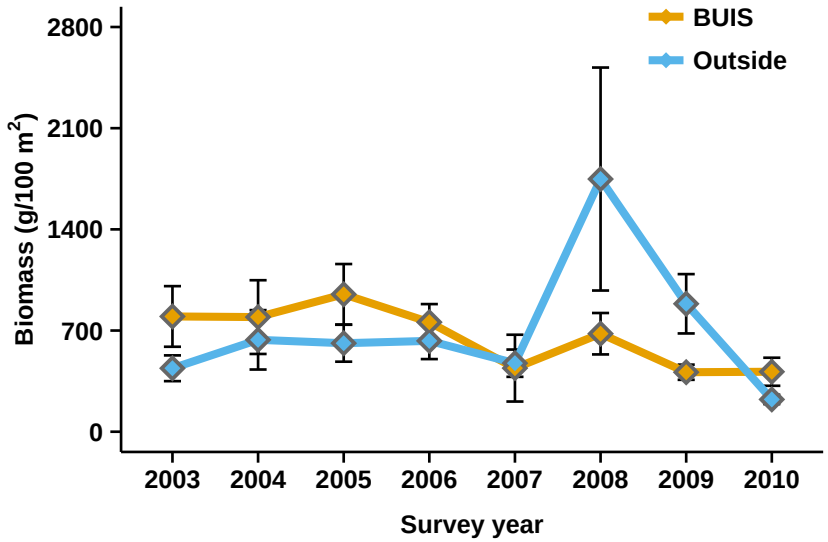


No trend inside MPA

Decrease outside MPA

Possible positive MPA effect

Mean Ocean Surgeonfish Biomass

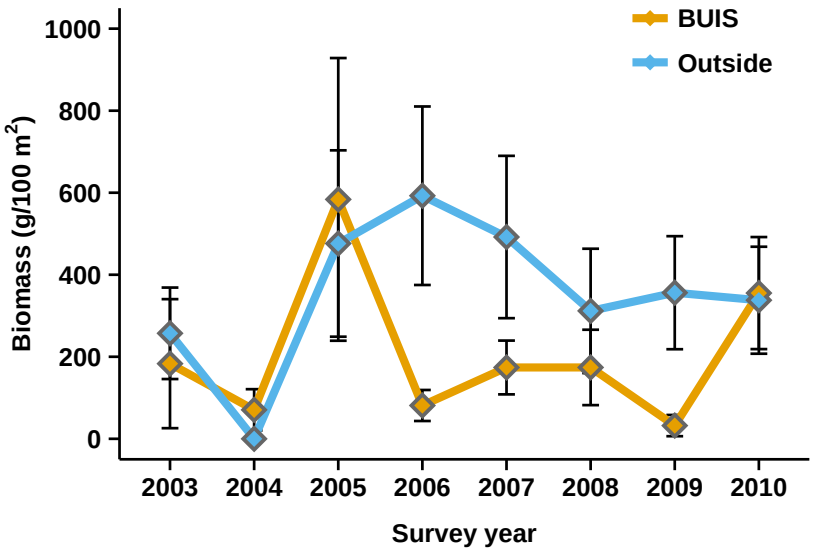


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Queen Triggerfish Biomass



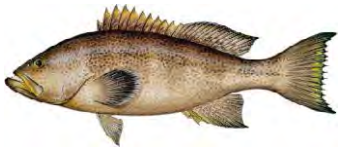
No trend inside MPA

Increase outside MPA

No positive MPA effect

Species with Moderate to High Vulnerability to Fishing

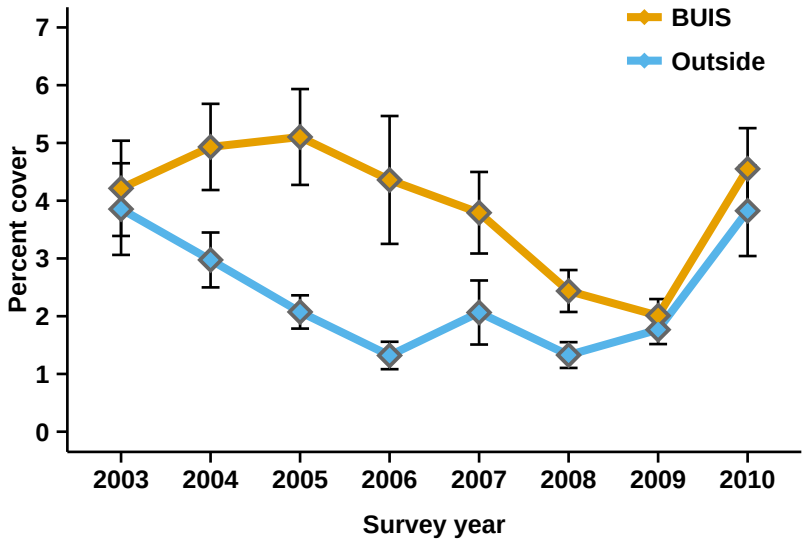
Occurrence of large-bodied species with moderate to high vulnerability to fishing in shallow water (<35 m) habitat types within Buck Island Reef National Monument 2001-2010 (1149 underwater visual surveys)

Tiger grouper *Myctoperca tigris*  1 sighting	Nassau grouper *Epinephelus striatus*  0 sightings	Yellowfin grouper *Mycteroperca venenosa*  0 sightings
Yellowmouth grouper *Myctoperca interstitalis*  0 sightings	Dog snapper *Lutjanus jocu*  2 sightings	Cubera snapper *Lutjanus cyanopterus*  0 sightings
Rainbow parrotfish *Scarus guacamaia*  14 sightings	Blue parrotfish *Scarus coeruleus*  2 sightings	Midnight parrotfish *Scarus coelestinus*  1 sighting

Fish Illustrations by Diana Peebles

Coral & Macroalgae Metrics

Hard Coral Cover

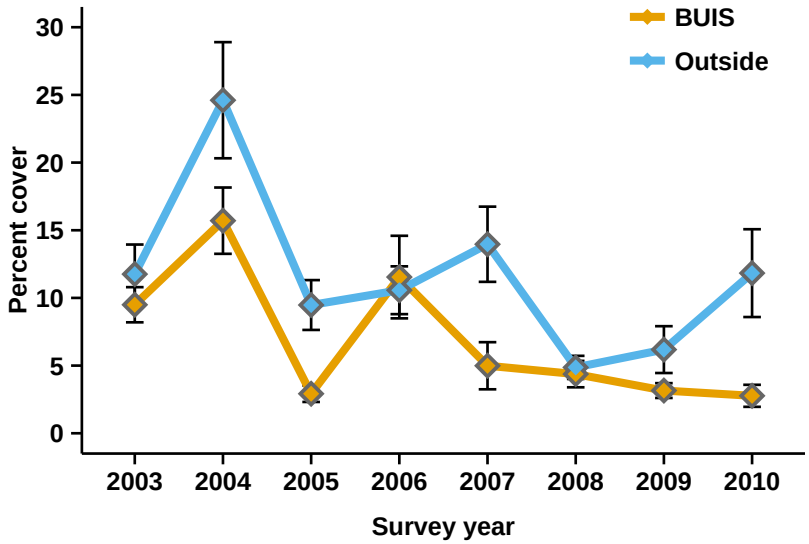


Decrease inside MPA

No trend outside MPA

No positive MPA effect

Macroalgae Cover

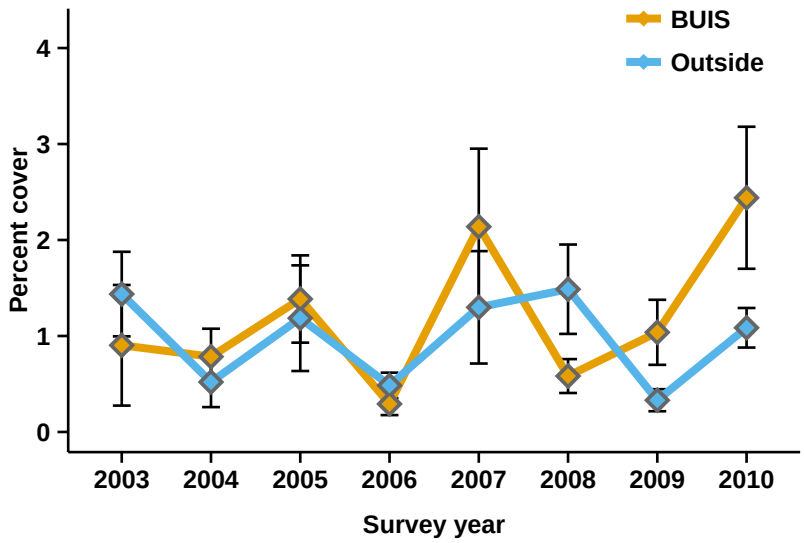


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Crustose Coralline Algae Cover



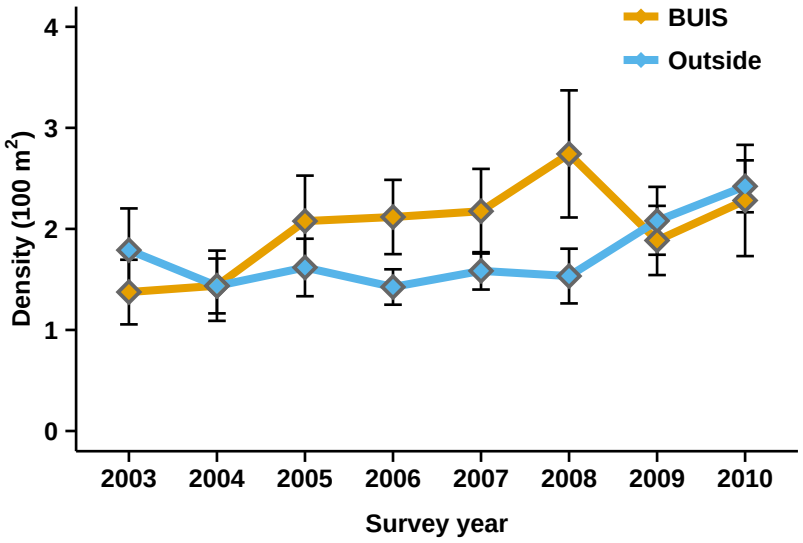
Increase inside MPA

Increase outside MPA

No positive MPA effect

Coral & Macroalgae Metrics

Soft Coral Abundance

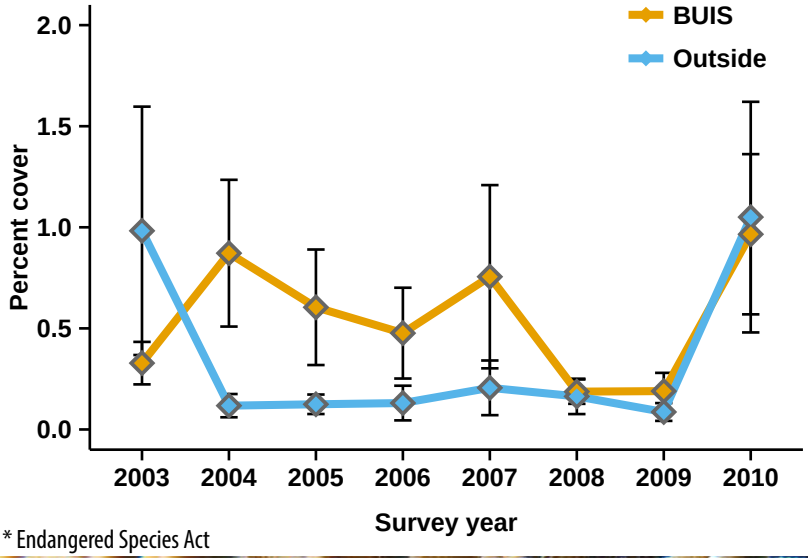


Increase inside MPA

Increase outside MPA

No positive MPA effect

Newly Listed ESA* Coral Species Cover

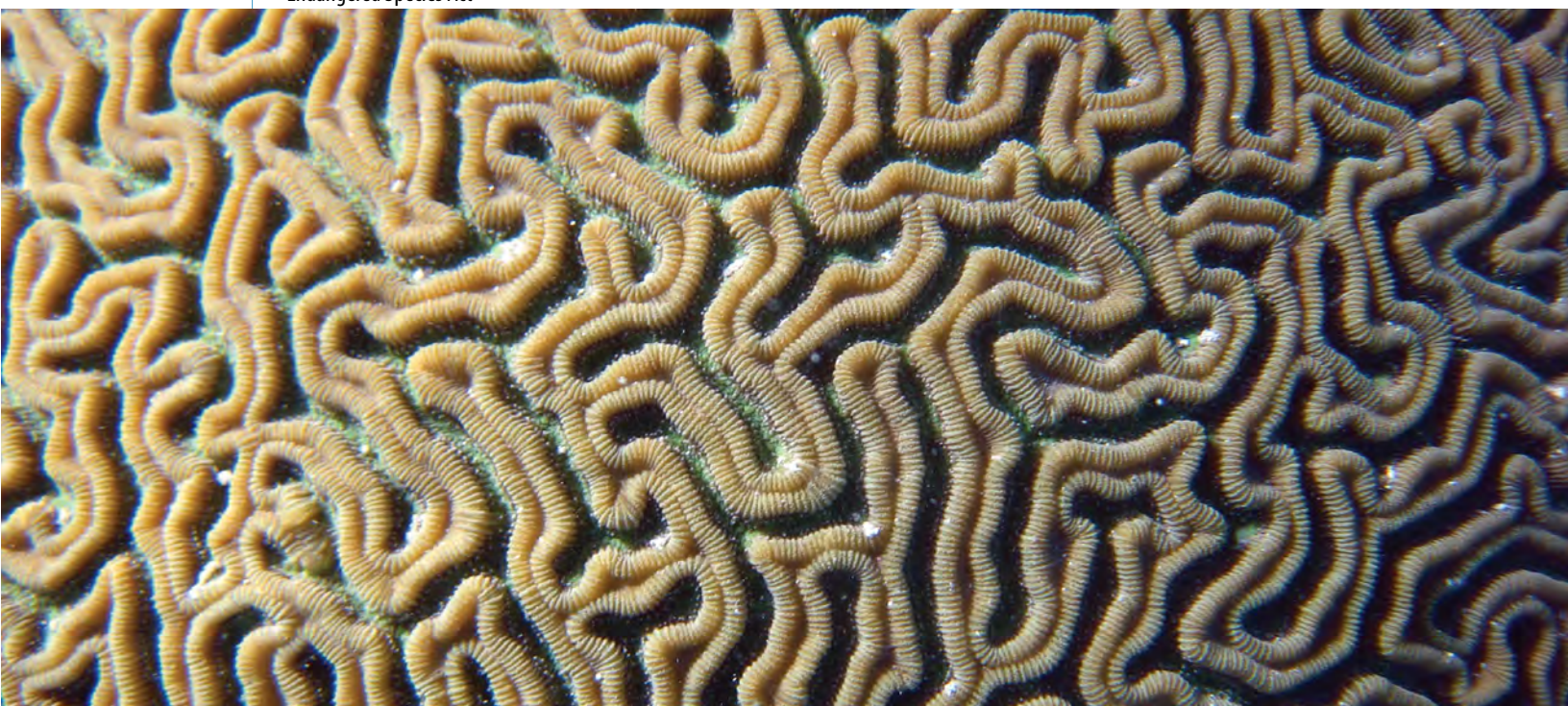


No trend inside MPA

No trend outside MPA

No positive MPA effect

* Endangered Species Act



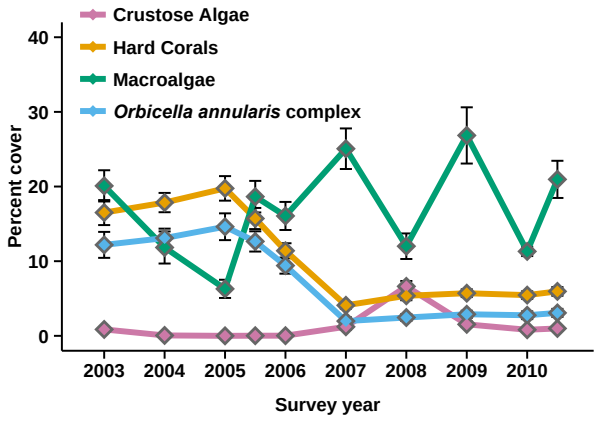
Coral & Macroalgae: NPS Long-Term Monitoring Sites

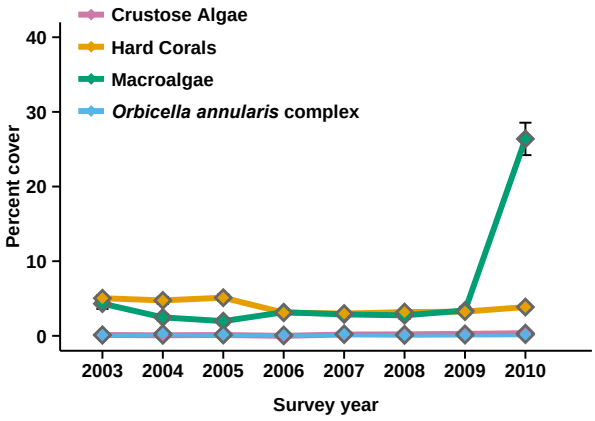
The National Park Service has two long-term monitoring sites within Buck Island Reef National Monument. The following graphs display the trends in percent cover of coral/macroalgae/crustose coralline algae and soft coral at those locations (South Fore Reef and Western Spur and Groove) from 2003-2010.

South Fore Reef

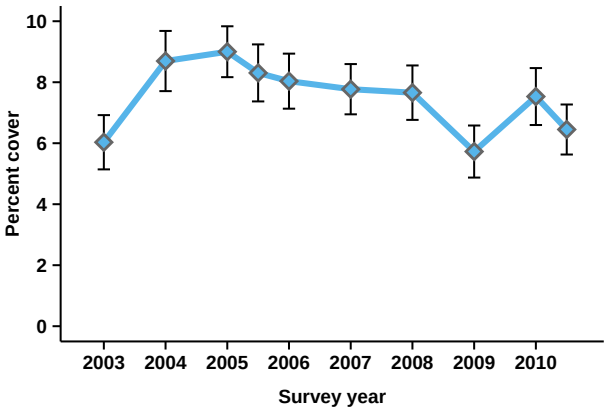
Western Spur & Groove

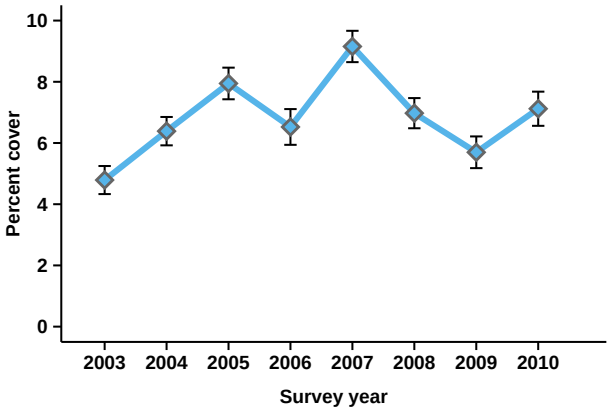
Coral/Macroalgae/Crustose Coralline Algae Cover





Soft Coral Cover





Summary

MPA Effect on Fish

Fish biomass for all species exhibited inter-annual variability with no significant increase or decrease detected inside or outside Buck Island Reef National Monument over the eight year monitoring period (2003-2010). Therefore, an MPA effect was not detected for fish biomass, which suggests that the Monument had not provided the replenishment function for fish biomass that has been widely reported for many other MPAs closed to fishing. Significant decrease inside the Monument was detected for four of 15 fish metrics, including species richness, density of adult surgeonfishes (key herbivores), density of adult groupers, and the biomass of coney (*Cephalopholis fulva*). Biomass of the red hind (*Epinephelus guttatus*) grouper showed a year-on-year decrease from 2007-2010 both inside and outside Buck Island Reef National Monument, but this was not a significant trend when examined across the entire monitoring period.

In contrast, a significant increase in the density of all adult snapper inside Buck Island Reef National Monument was detected for the period 2003-2010, whereas for the same period, similar seascapes outside the Monument experienced a decline in adult snapper density. This result is indicative of a positive MPA

effect for snapper (Lutjanidae). The analyses here are unable to determine the causal mechanisms for the potential MPA effect, which could be attributed to greater protection provided by the no-take MPA, or some unmeasured ecosystem characteristic (e.g., habitat quality or predator-prey dynamics). Weaker evidence for a positive MPA effect occurred with stoplight parrotfish (*Sparisoma viride*) biomass, whereby the MPA was able to maintain populations inside while the population outside significantly decreased. When the first four years of the time series (2003-2006) was compared with the latter four years (2007-2010), adult surgeonfish density, especially ocean surgeonfish, was significantly lower inside the MPA in 2007-2010 than in 2003-2006.

Eight of 15 fish metrics exhibited no detectable trend inside or outside Buck Island Reef National Monument, also providing evidence that for many metrics, the MPA had not been sufficiently re-building previously fished populations to detectable levels. In addition, one metric, queen triggerfish (*Balistes vetula*) biomass, exhibited an increase outside the Monument, but not inside the Monument, although this could be an artifact of preferential selection of deeper water habitat in outside areas.

Status of Big Fish

Only one individual of the large-bodied grouper species (a tiger grouper [*Mycteroperca tigris*]) and two individuals (dog snapper [*Lutjanus jocu*]) of the large-bodied snapper species were sighted from 1,149 underwater surveys (all habitat types), representing 287.25 hours of underwater observation within Buck Island Reef National Monument between 2001-2010. Nassau grouper, a species listed on the Endangered Species Act, was not sighted inside the MPA during the 10 year survey period, and yellowmouth (*Mycteroperca intersitialis*) and yellowfin (*Mycteroperca venenosa*) grouper also were not observed. Comparison with similar surveys conducted in 1979 revealed that tiger, Nassau and yellowfin grouper were present in low abundance around Buck Island.[5] The largest bodied parrotfish (blue and midnight parrotfish) classified as "moderate vulnerability to extinction," (www.fishbase.org) were rarely sighted in the MPA during 10 years of observations. The life-history traits of these large-bodied species results in a low resilience to environmental

5 Gladfelter, E.H. and W.B. Gladfelter. 1980. Environmental studies of Buck Island Reef National Monument III, St. Croix, U.S. Virgin Islands. West Indies Laboratory, Fairleigh Dickinson University. St. Croix, U.S. Virgin Islands. 116 pp.

Key Findings

- Buck Island Reef National Monument, a no-take MPA, is not producing a measurable increase in reef fish biomass within its borders.
- Adult grouper, particularly the largest bodied species, have decreased in abundance inside the MPA.
- Abundance of adult surgeonfish, a key herbivore group, decreased within the MPA.
- Overall, the cover of live coral decreased inside the MPA between 2003 and 2010.
- Future monitoring as part of an adaptive management process will be required to collect evidence to determine if longer term recovery has begun.

impacts, such as loss of reef structure and high vulnerablity to extinction through fishing[6]. Investigations are required to determine if current habitat is still suitable for large-bodied fish, and if the strength of connectivity between the MPA and spawning sites is sufficient for replenishment, or if illegal fishing is impeding recovery.

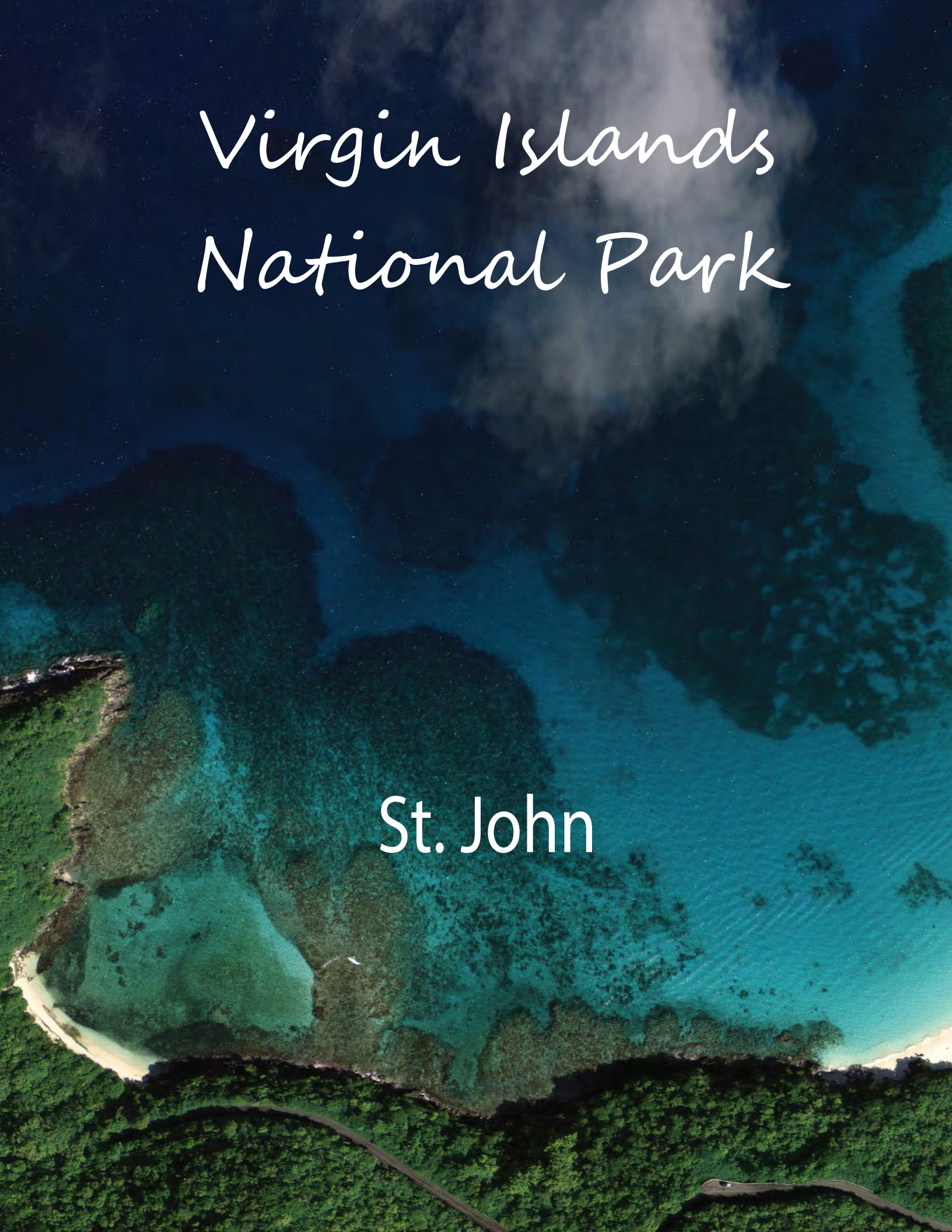
Benthic Composition

All benthic composition metrics, except species proposed for listing under the Endangered Species Act, changed significantly inside Buck Island Reef National Monument during an eight year survey period (2003-2010) based on analysis of data from spatially random surveys. The average amount of live hard coral cover decreased, whereas crustose coralline algae and soft coral abundance increased inside the MPA. Inside the MPA, live hard coral cover decreased year after year after the mass bleaching event in 2005 until 2010. Although live hard coral also decreased outside the MPA, the trend was not statistically significant over the entire survey period due to inter-annual variability. The proposed Endangered Species Act coral species were higher in abundance inside the MPA, but did not increase or decrease significantly inside or outside the MPA. Coralline algae, an important indicator of coral reef health, exhibited high variability, but increased significantly both inside and outside the MPA. Coralline algae is thought to be an indicator of good habitat for juvenile corals. Average macroalgal cover (i.e., fleshy green, red or brown algae) was lower inside the MPA, but over the study period macroalgal cover decreased significantly both inside and outside the MPA. Four of the five benthic composition metrics exhibited similar trends inside and outside the MPA, suggesting that benthic composition is affected by stressors that influence processes across the study region. Overall, an increase in coralline algae and a decrease in macroalgae are considered positive trends required to support future recovery of hard coral populations through the increased availability of suitable surfaces for hard corals to settle, survive and grow. Further evidence for change is provided when the first four years of the time series (2003-2006) was compared with the latter four years (2007-2010). Live hard coral cover and macroalgal cover was significantly lower inside the MPA in 2007-2010 than in 2003-2006. In contrast, coralline algal cover was higher in the 2007-2010 period than 2003-2006.

In addition, long-term monitoring of benthic communities at two permanent sites by the NPS' Inventory and Monitoring Program also revealed major changes in key biotic indicators of coral reef health between 2003 and 2010. Although NPS monitoring was only conducted at two locations and cannot be extrapolated to the MPA as a whole, the data complements the spatially random surveys and more precise changes in benthic cover at the specific sites. At the "South Fore Reef" site within Buck Island Reef National Monument, average percent cover of live hard coral increased from 17.2% (±1.9) in 2002 to 19.6% (±1.6) in February 2005 ($p<0.02$), then declined precipitously to a low of 4.1% in 2007. The decline in average live coral cover was also very pronounced for the threatened *Orbicella annularis* complex, which declined from 13.6% in 2005 to

6 Cheung, W.W.L., T.J. Pitcher, and D. Pauly, 2005. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. Biological Conservation 124: 97-111

1.9% in 2007. The 79.3% decline in average coral cover reflects the overwhelming and destructive effect of the 2005-07 bleaching and disease event that affected the British Virgin Islands, USVI and Puerto Rico. The majority of coral mortality was caused by the disease epidemic (primarily the coral disease "white plague") that followed the severe coral bleaching in 2005. Throughout this study, macroalgal cover has exhibited large inter-annual fluctuations. However, the abundance of cover by other benthic organisms varied less, with crustose coralline algae remaining very low (~1%) for most years, except in 2008 when it averaged over 6%. The cover of soft corals increased from an average of 6% in 2003 to 9% in 2005, and hereafter averaged 7-8% until 2010. Changes observed at the Western Spur and Groove Reef monitoring site were less severe. Average cover of live hard coral, at 5%, was relatively stable between 2003 and 2005, after which it decreased to approximately 3% between 2006 and 2010. *Pseudodiploria strigosa*, the dominant coral found at this site prior to the 2005 bleaching and disease event, comprised approximately 40% of the coral community, but it declined from 2.2% in 2005 to 0.6% in 2006; and it has since remained near this level. Average cover of the *O. annularis* complex remained between 0.1 and 0.4% from 2003-2010, and macroalgal cover remained fairly constant, ranging from 1-5% between 2003 and 2009, but then increased to 25% in 2010. However, this spike for macroalgal cover likely occurred due to the timing of the monitoring (October rather than March-June as in previous years). Crustose coralline algae existed only in low abundance at the Western Spur and Groove site. Permanent monitoring at these two sites, each with different biotic composition, highlights the spatial variability of coral reef change. Permanent monitoring at these two sites, each with different biotic composition, demonstrates how the pervasive nature of the 2005-2007 bleaching and disease event affected reef cover and composition regardless of initial coral cover levels.


Virgin Islands
National Park
St. John

US Army Corp of Engineers

Location:
North and south shore of St. John

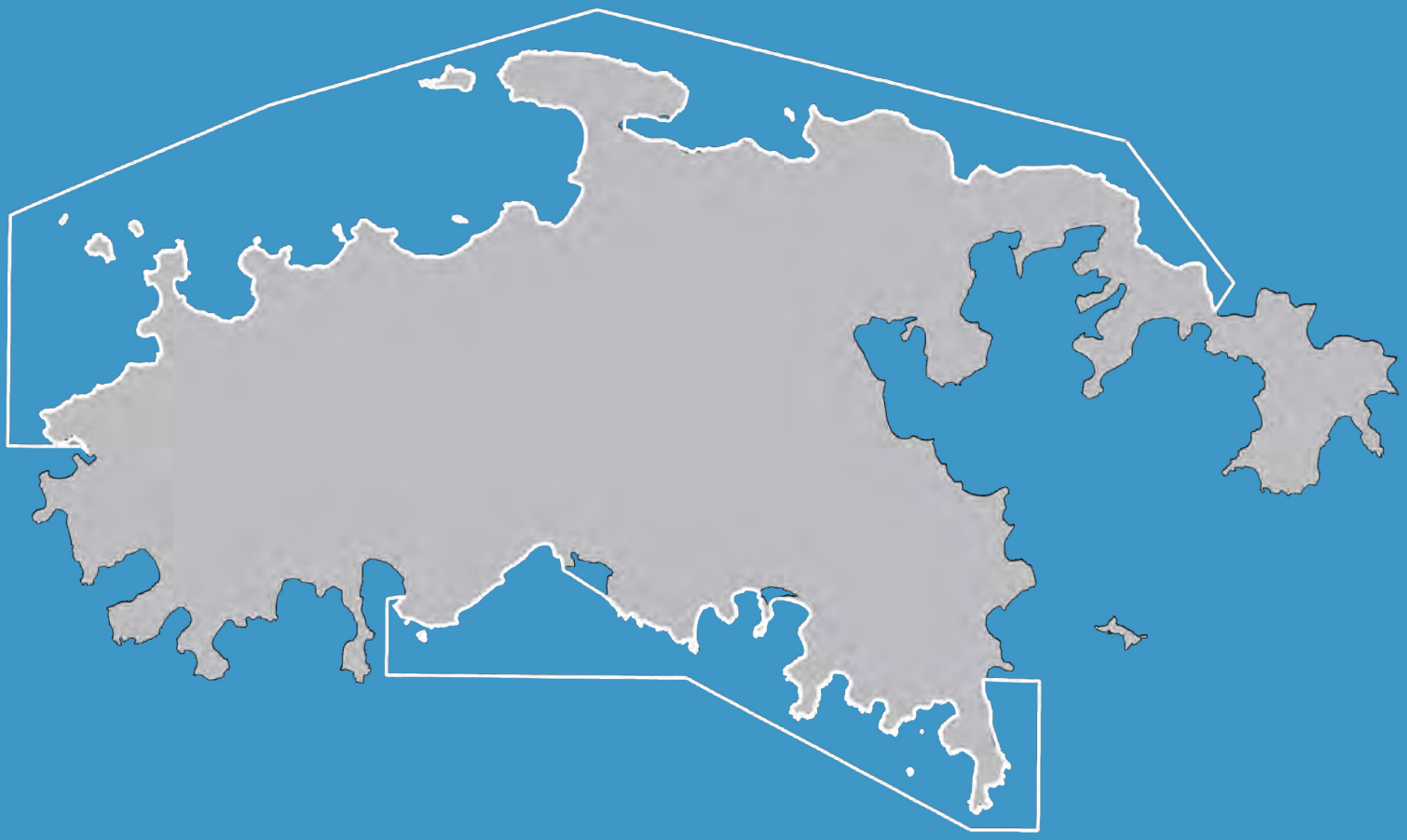
Origin:
Submerged lands established in 1962

Governance:
U.S. Federal Government; U.S. Department of the Interior

Enforcement:
National Park Service

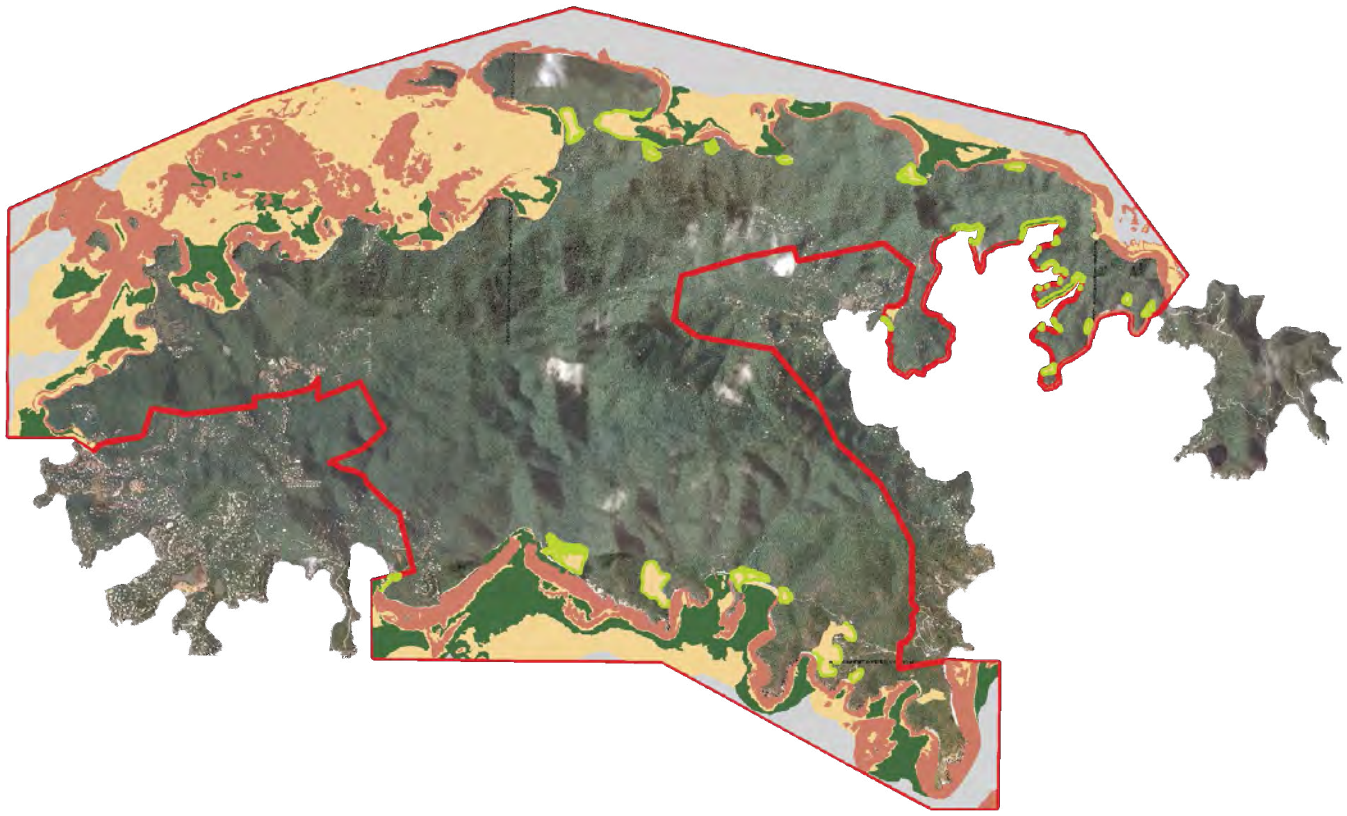
Total area:
5,650 marine acres

Water depth range:
Shoreline to 30 meters



About the MPA

Virgin Islands National Park protects both land and water within its boundaries on St. John, USVI. The park encompasses 7,146 acres, or 54%, of land on the islands, and 5,650 acres in marine waters[1]. The land portion of the park was established in 1956 with the purpose of protecting the islands ecosystems, and expanded in 1962 to include a marine portion on the north and south shore of St. John[2]. The MPA allows non-commercial fishing except for several specific areas which are zoned as no-take areas.



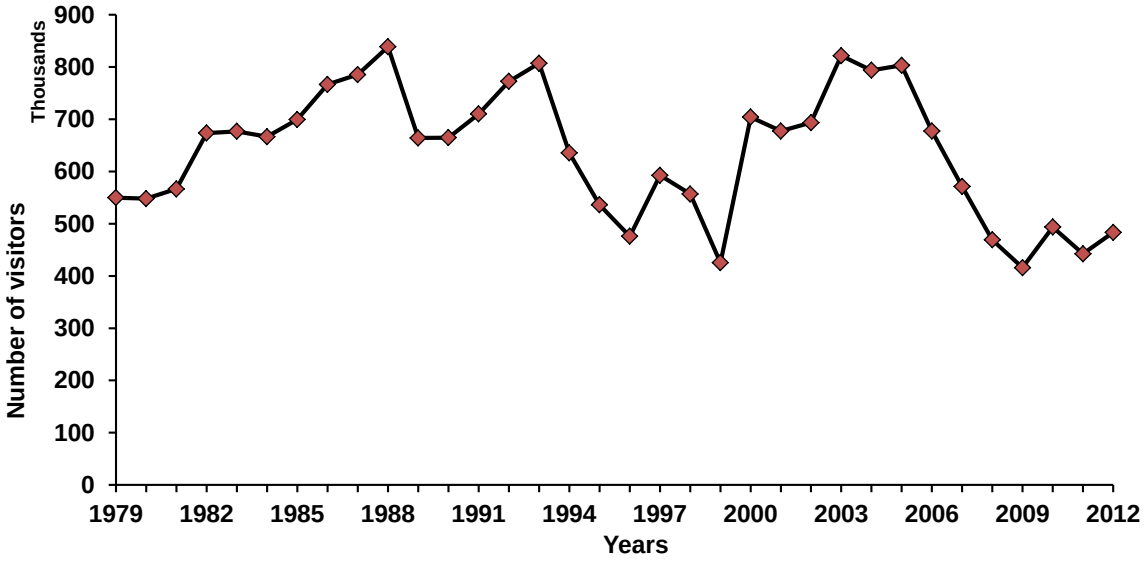
1 National Park Service (NPS). 2012. Buck Island Reef National Monument Draft General Management Plan/Environmental Impact Statement. National Park Service, U.S. Department of the Interior. Boulder, CO.

2 Friedlander, A.M., C.F.G. Jeffrey, S.D. Hile, S.J. Pittman, M.E. Monaco and C. Caldow (eds.). 2013. Coral reef ecosystems of St. John, U.S. Virgin Islands: Spatial and temporal patterns in fish and benthic communities (2001-2009). NOAA Technical Memorandum 152. Silver Spring, MD. 150 pp.

Human Uses

Approximately 500,000 visitors visit the Virgin Islands National Park per year. In 2011, visitors (local and non-local) spent an estimated $58,649,000 on the local economy and supported over 1,000 jobs.[3]

Common visitor activities include camping, hiking and sunbathing within the land portion of the park; while snorkeling and boating are common activities in the marine portion of the park.



Annual number of visitors to the Virgin Islands National Park from 1979-2012. Source: National Park Service

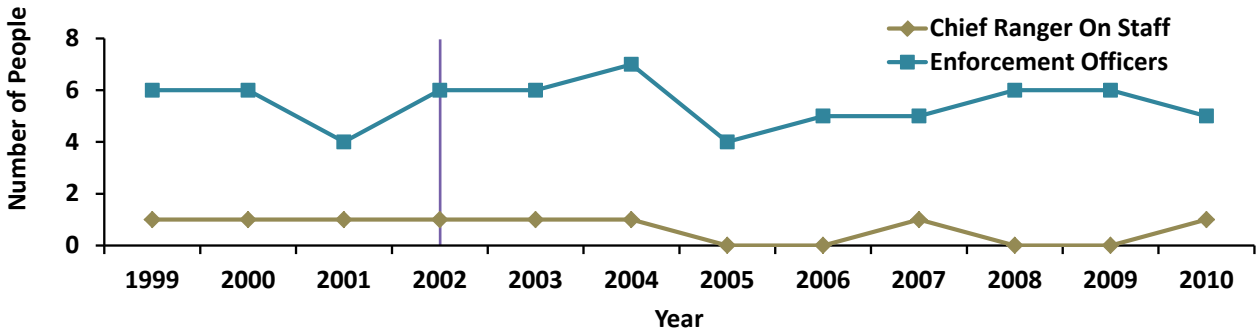
3 Cui, Yue, Mahoney, E. & Herbowicz, T. 2013. Economic benefits to local communities from national park visitation, 2011. Natural Resource Report NPS/NRSS/EQD/NRTR—2013/631. National Park Service, Fort Collins, Colorado.

Regulation & Stewardship

The Virgin Islands National Park has several special regulations in place to conserve the marine environment and life within its boundaries. NPS Rangers are primarily responsible for enforcing regulations at the Virgin Islands National Park and the Virgin Islands Coral Reef National Monument. In general, NPS Rangers work with local managers (for example the Superintendent, administrative staff, and natural resource managers); the Virgin Islands Police Department; and U.S. Coast Guard to educate residents and visitors about safety, permitted activities, and other applicable conservation policies, and to ensure the public follows park rules, local territorial laws, and fisheries regulations. While patrolling, NPS Rangers will often board and inspect boats; hand out brochures and maps; and ensure divers, boaters, and fishers know, understand, and follow local regulations. Such active education can be effective in increasing compliance and reducing repeat violations. Moreover, NPS Rangers often are the first responders to marine emergencies such as vessel accidents and groundings, and they help maintain the public's welfare by enforcing Title 18 of the U.S. Criminal Code of the United States in addition to enforcing resource conservation laws.

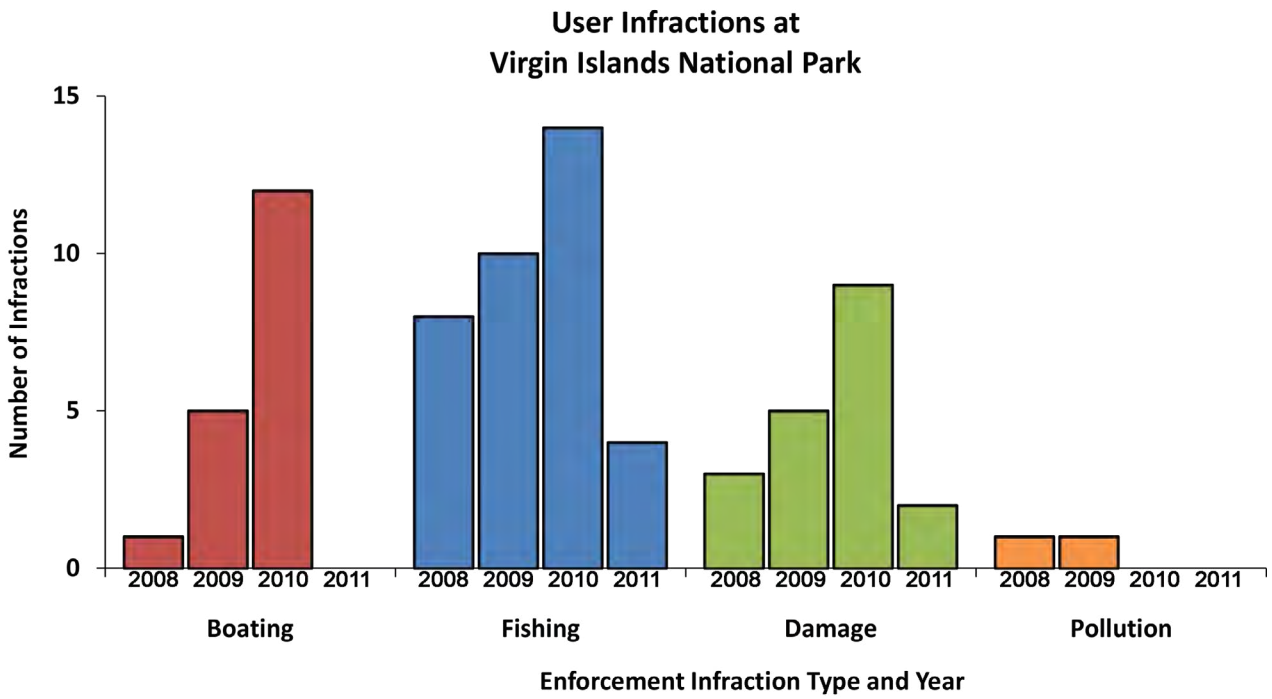
Spearfishing for lionfish is permitted for users certified by the Caribbean Oceanic Restoration & Education Foundation (CORE).

Information about the intensity of enforcement activity such as the number of Rangers on staff prior to 1999, the number of hours patrolled by Rangers within the MPA, and the target species caught by illegal fishers was unavailable for Virgin Islands National Park and Virgin Islands National Monument. Between 1999 and 2010 however, a Chief Ranger along with four to six Enforcement Officers worked to increase the public's awareness and compliance with park regulations.[4] The NPS Rangers also recorded numerous infractions and issued several violation notices to users between 1999 and 2010. For a complete listing of restricted activities, refer to the Superintendent's Compendium - available on the park's website (http://www.nps.gov/viis/parkmgmt/upload/Superintendent-s-Compendium-2013.pdf).



Number of enforcement officers and Chief Rangers by year for the Virgin Islands National Park from 1999 to 2010. Purple line indicates when NOAA MPA monitoring began in 2002.

4 Tutein, J. 2010. Superintendent Annual Narrative Reports, 2008 to 2010. National Park Service. Christiansted, St. Croix.



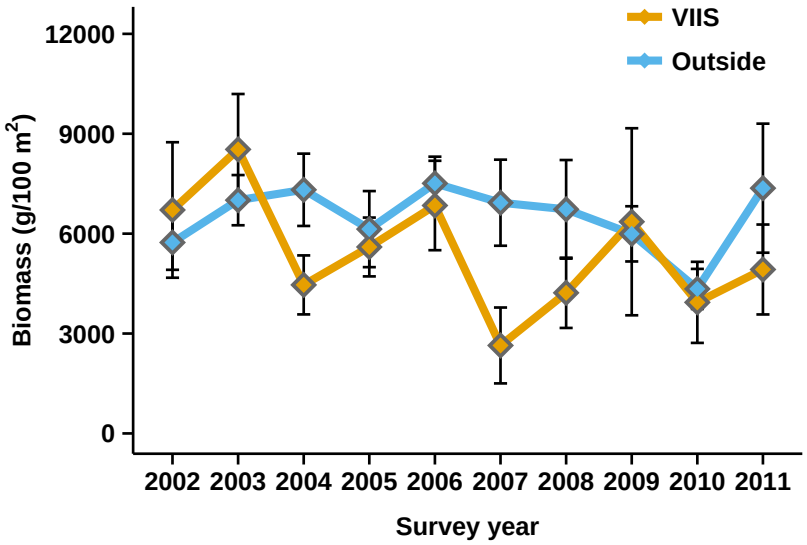
Number of infractions by year within the Virgin Islands National Park. Damage is defined as disturbance to benthic substrates, such as illegal anchoring and groundings. Boating is defined as illegal mooring, location or abandonment of a vessel or personal watercraft. Data are unavailable before 2008. Source: National Park Service

MPA Performance Metrics

This section presents the results of trend analysis for biological metrics inside and outside of Virgin Islands National Park (2002 to 2011). A written summary and interpretation of the findings is presented at the end of the section.

Fish Community Metrics

Mean Fish Biomass

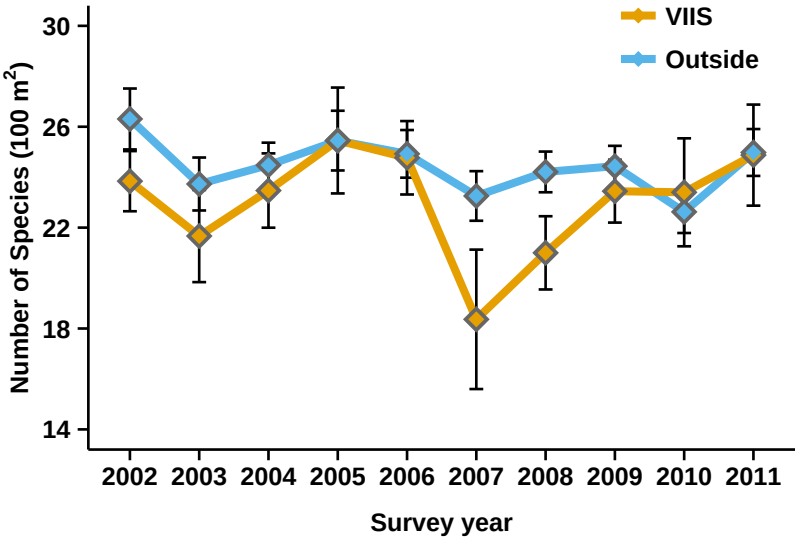


No trend inside MPA

Decrease outside MPA

Possible positive MPA effect

Mean Species Richness

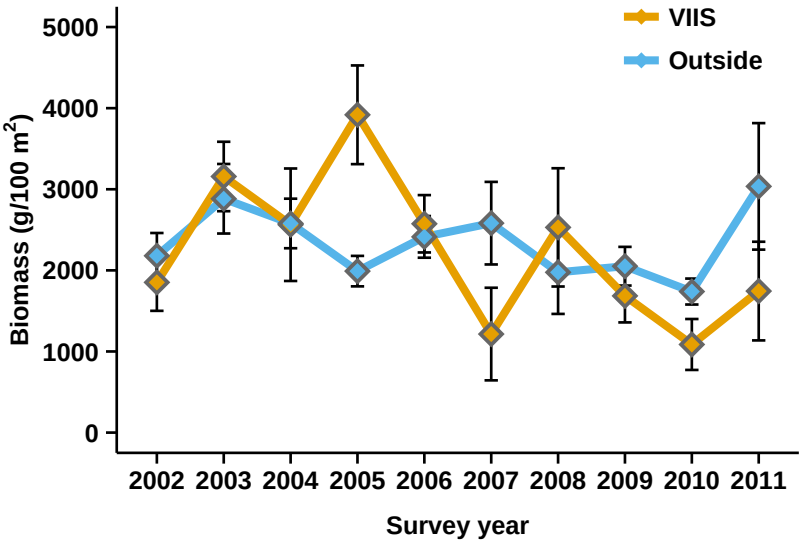


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Herbivore Biomass



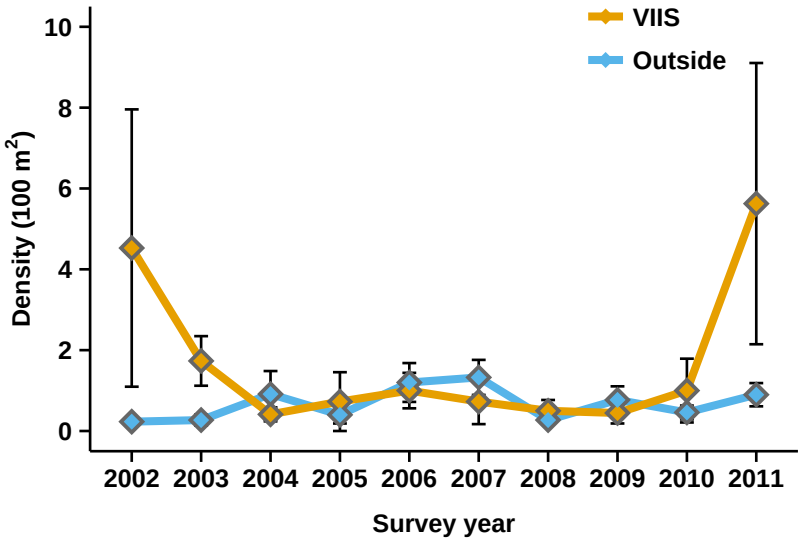
No trend inside MPA

Decrease outside MPA

Possible positive MPA effect

Fish Family & Species Metrics

Mean Adult Snapper Density

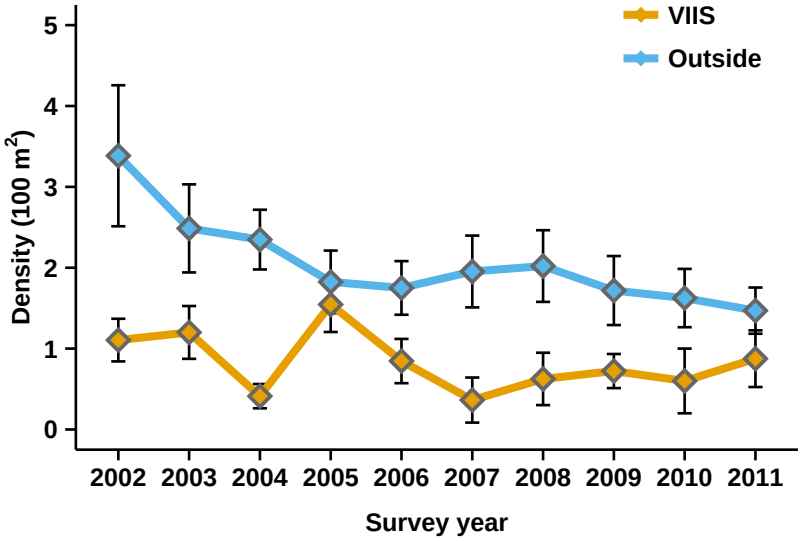


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Adult Grouper Density

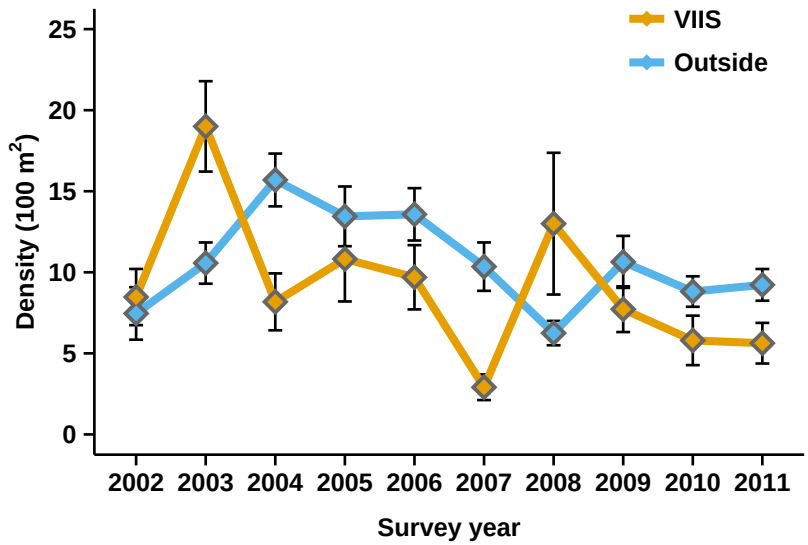


No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Mean Adult Parrotfish Density



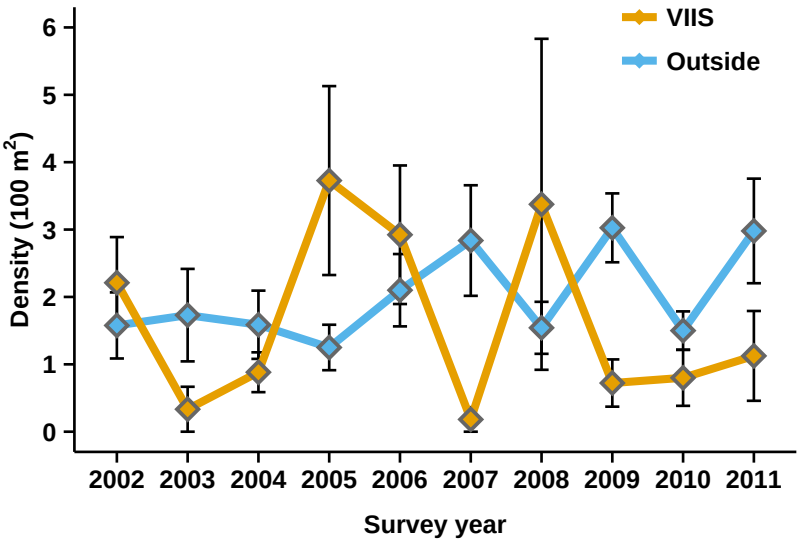
Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Adult Surgeonfish Density

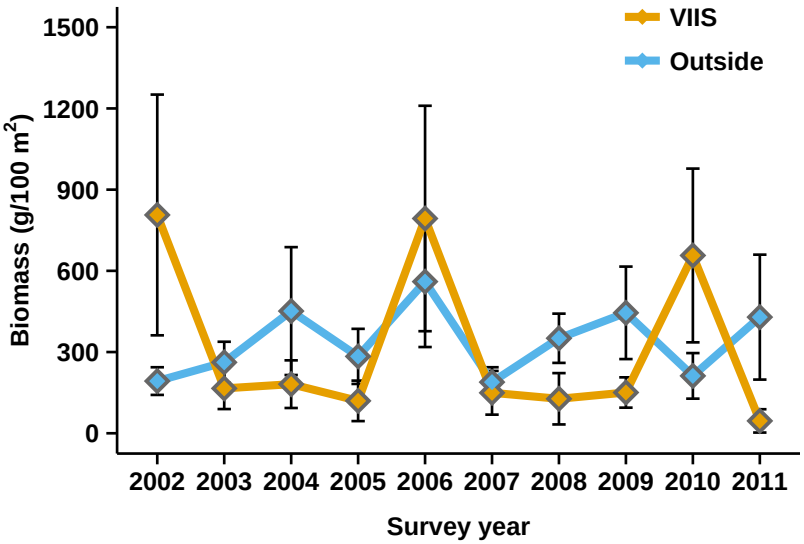


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Grunt (All Species) Biomass

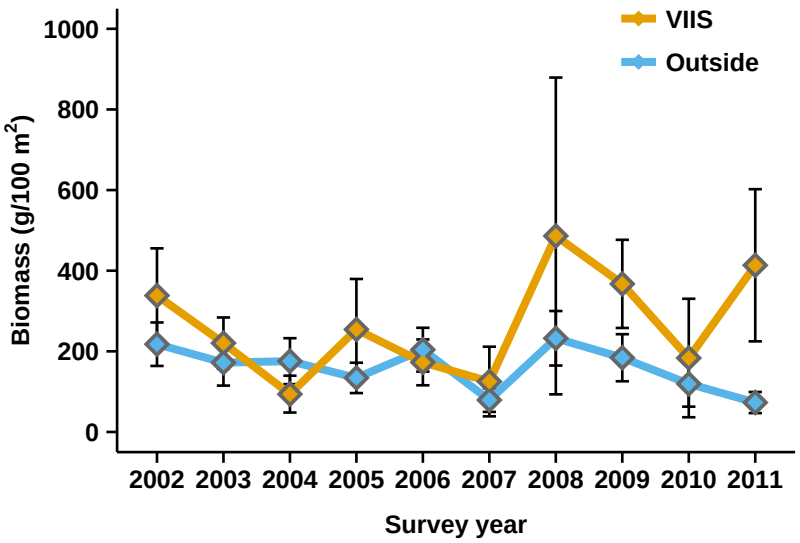


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Red Hind Biomass



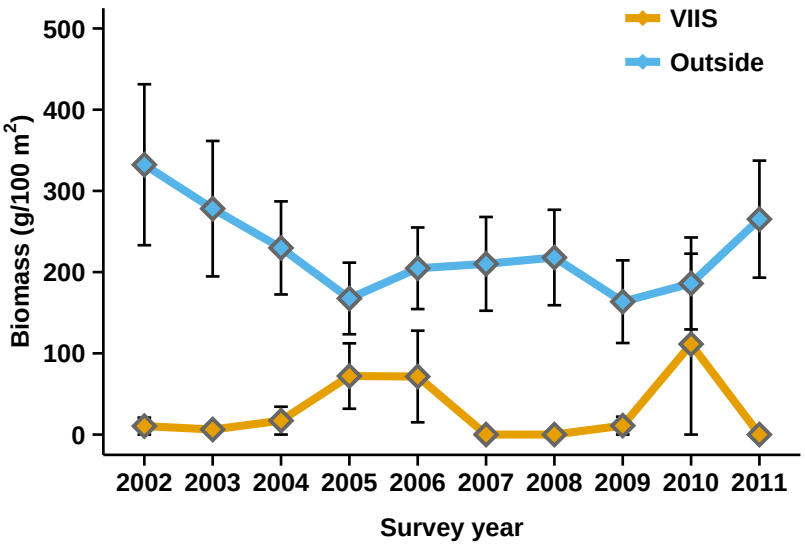
No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Fish Family & Species Metrics

Mean Coney Biomass

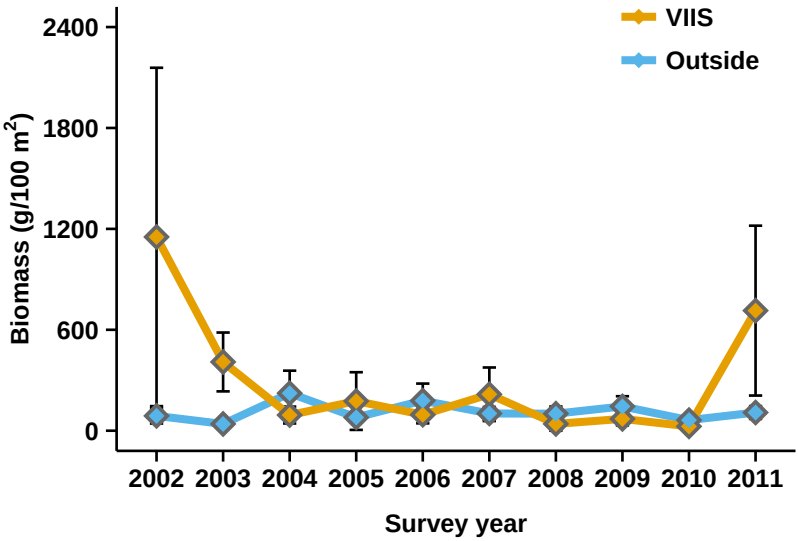


No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Mean Yellowtail Snapper Biomass

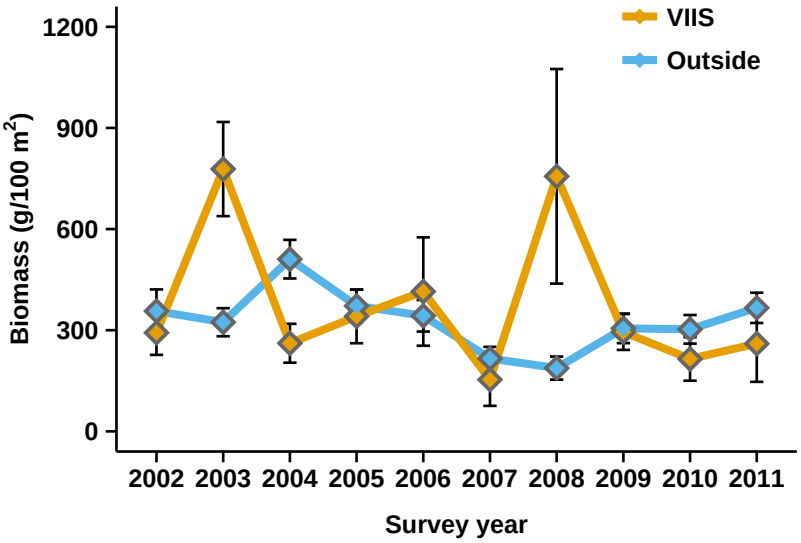


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Redband Parrotfish Biomass



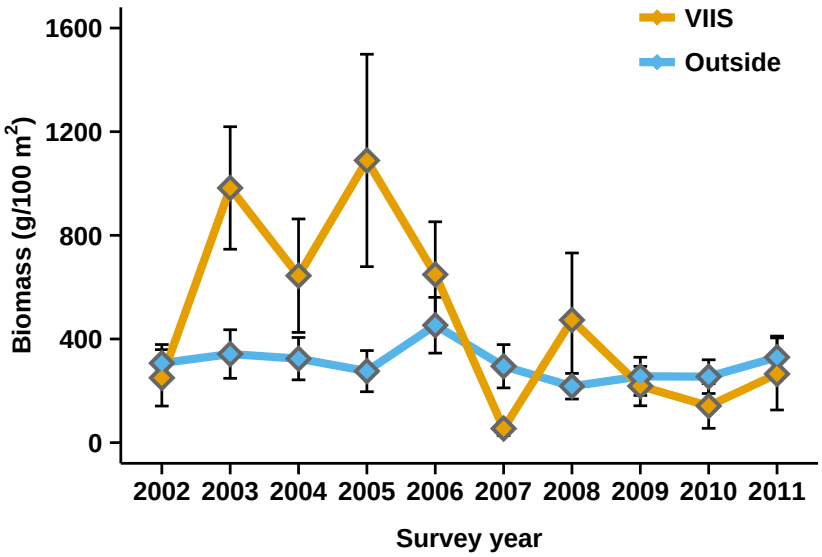
Decrease inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Stoplight Parrotfish Biomass

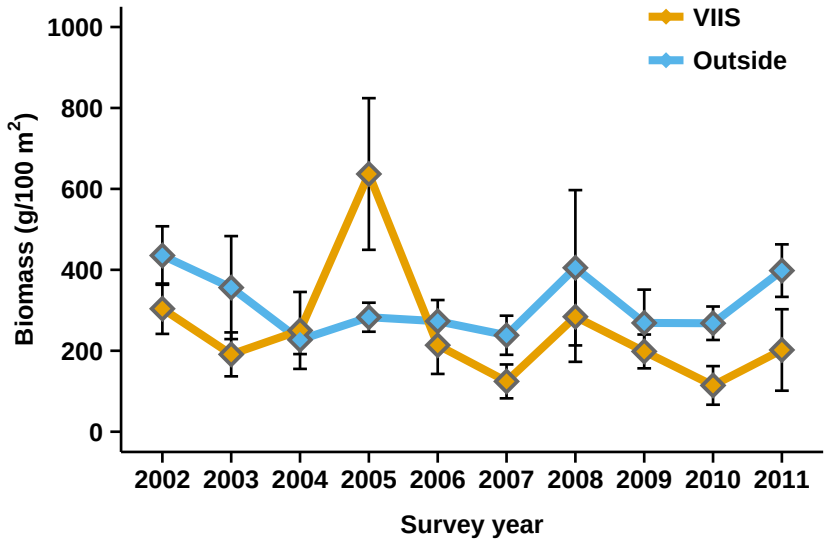


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Ocean Surgeonfish Biomass

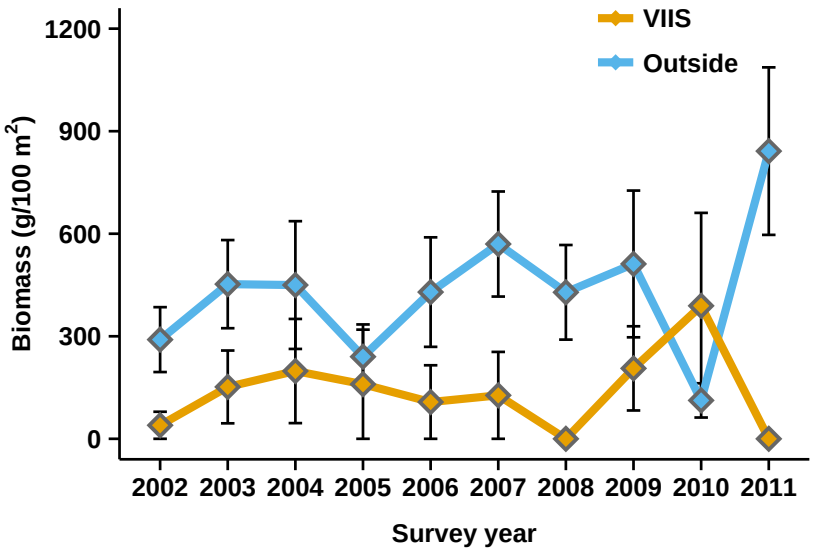


No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Mean Queen Triggerfish Biomass



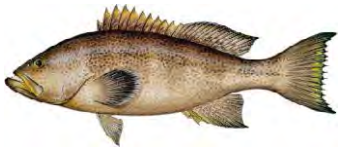
No trend inside MPA

No trend outside MPA

No positive MPA effect

Species with Moderate to High Vulnerability to Fishing

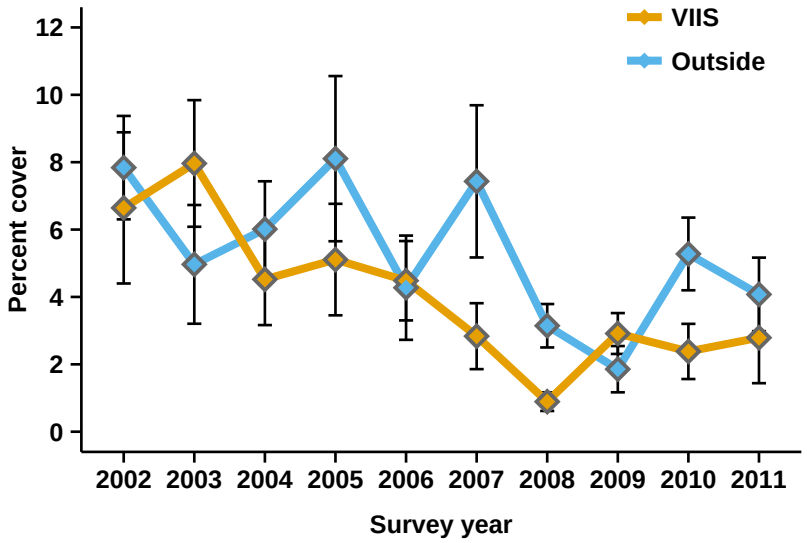
Occurrence of large-bodied species with moderate to high vulnerability to fishing in shallow water (<35 m) habitat types within Virgin Islands National Park 2002-2011 (417 underwater visual surveys)

Tiger grouper *Myctoperca tigris*  0 sighting	Nassau grouper *Epinephelus striatus*  0 sightings	Yellowfin grouper *Mycteroperca venenosa*  0 sightings
Yellowmouth grouper *Myctoperca interstitalis*  0 sightings	Dog snapper *Lutjanus jocu*  4 sightings	Cubera snapper *Lutjanus cyanopterus*  0 sightings
Rainbow parrotfish *Scarus guacamaia*  0 sightings	Blue parrotfish *Scarus coeruleus*  3 sightings	Midnight parrotfish *Scarus coelestinus*  1 sighting

Fish Illustrations by Diana Peebles

Coral & Macroalgae Metrics

Hard Coral Cover

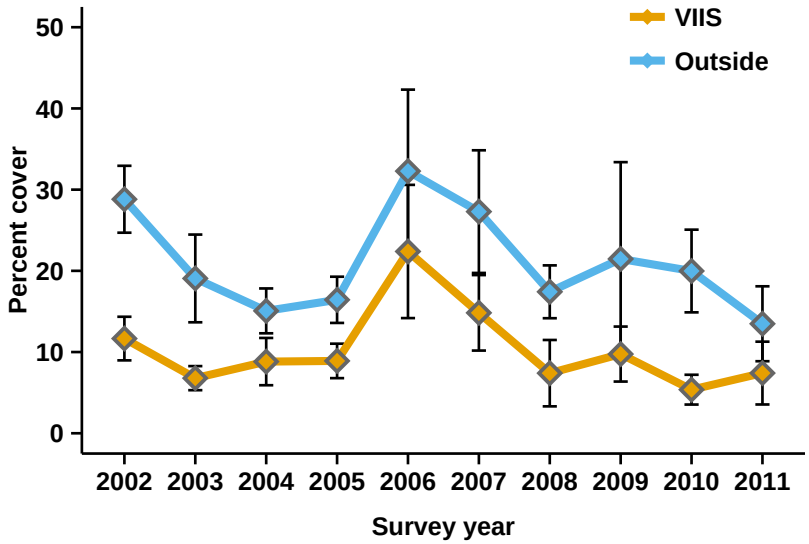


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Macroalgae Cover

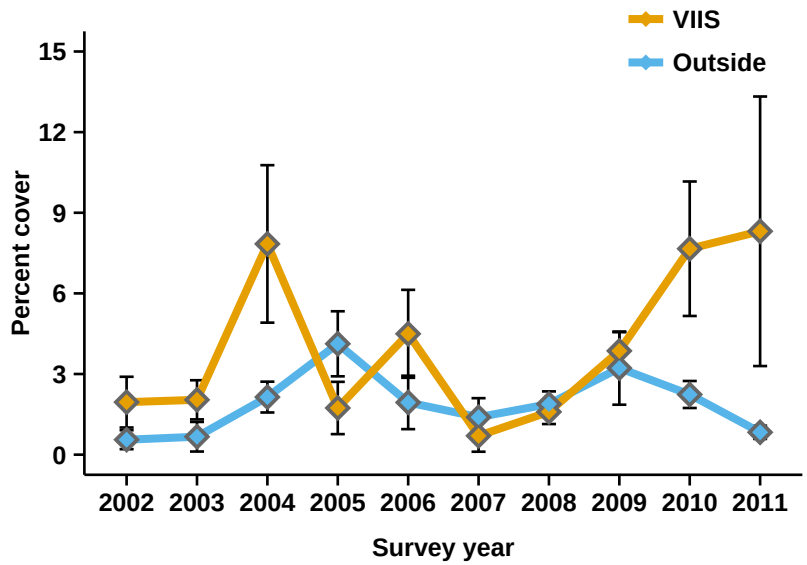


No trend inside MPA

Decrease outside MPA

No positive MPA effect

Crustose Coralline Algae Cover



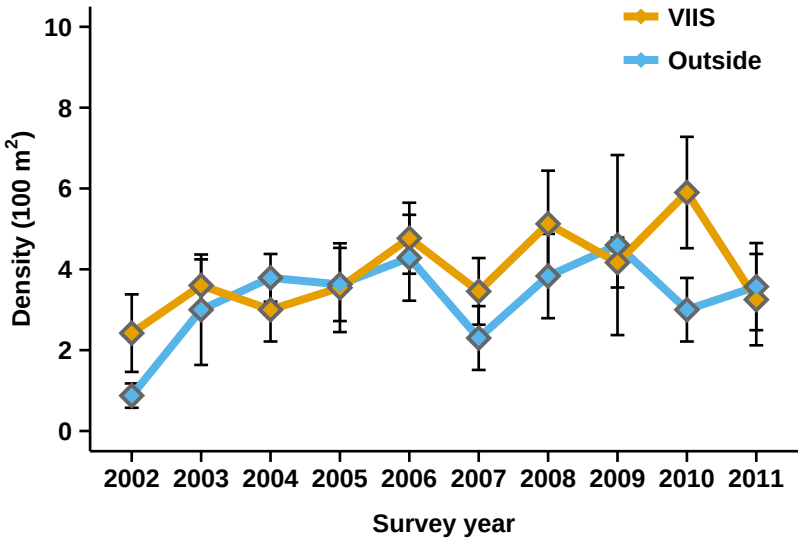
Increase inside MPA

Increase outside MPA

No positive MPA effect

Coral & Macroalgae Metrics

Soft Coral Abundance

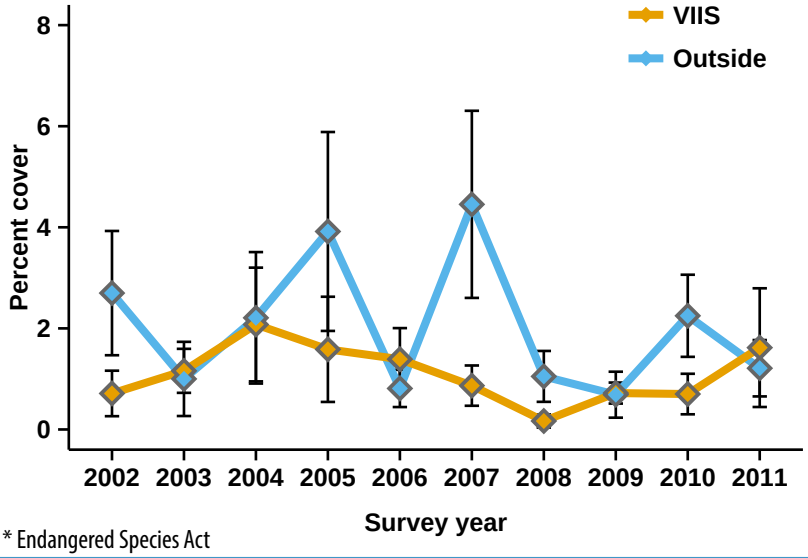


Increase inside MPA

Increase outside MPA

No positive MPA effect

Newly Listed ESA* Coral Species Cover



No trend inside MPA

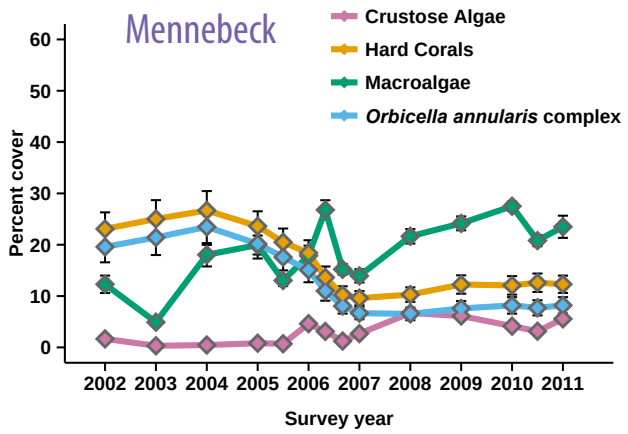
No trend outside MPA

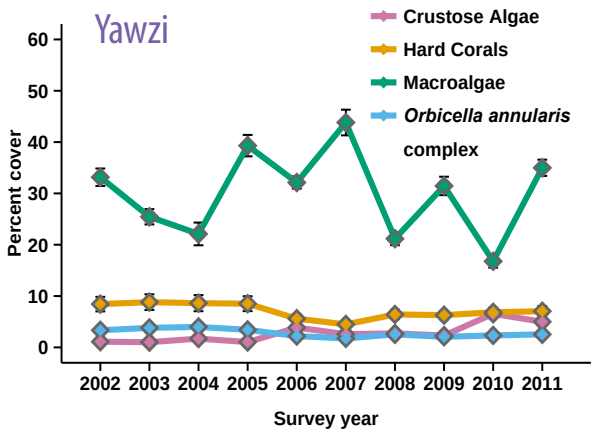
No positive MPA effect

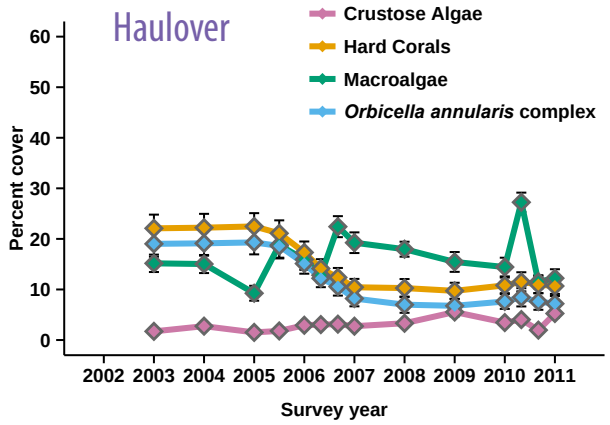
* Endangered Species Act

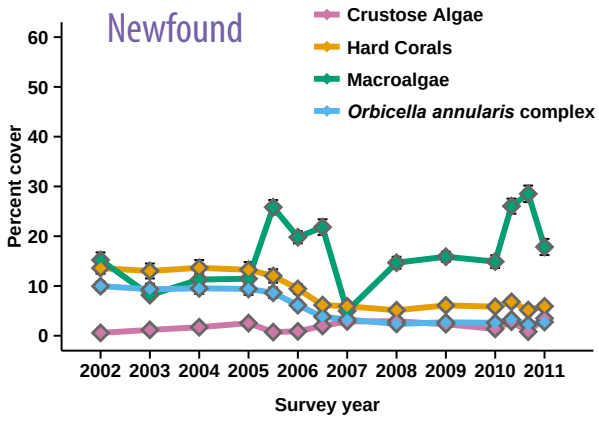
Coral & Macroalgae: NPS Long-Term Monitoring Sites

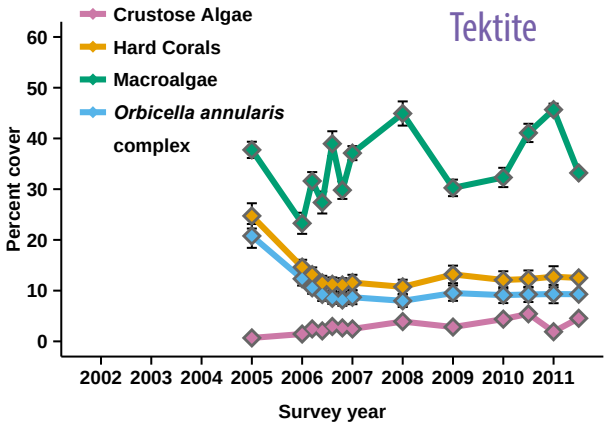
The NPS has five long-term monitoring sites within the Virgin Islands National Park. The following graphs display the trends in percent cover of coral/macroalgae/crustose coralline algae and soft coral at those locations (Mennebeck, Yawzi, Haulover, Newfound, and Tektite) from 2002-2011.







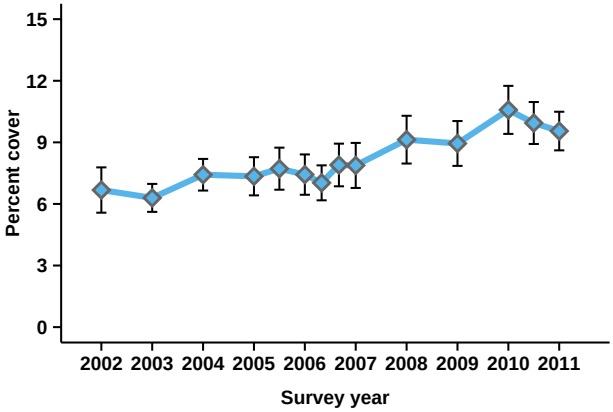




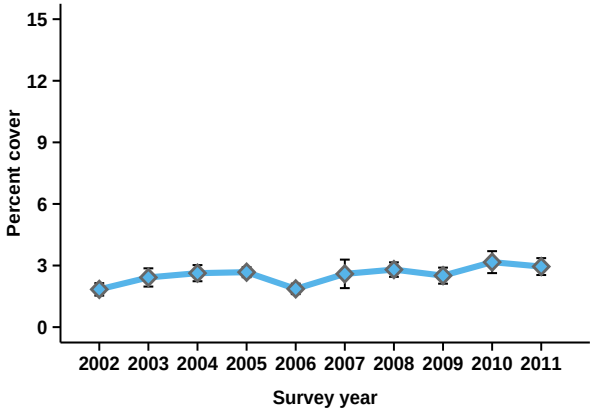
Coral & Macroalgae: NPS Long-Term Monitoring Sites

Soft Coral Cover

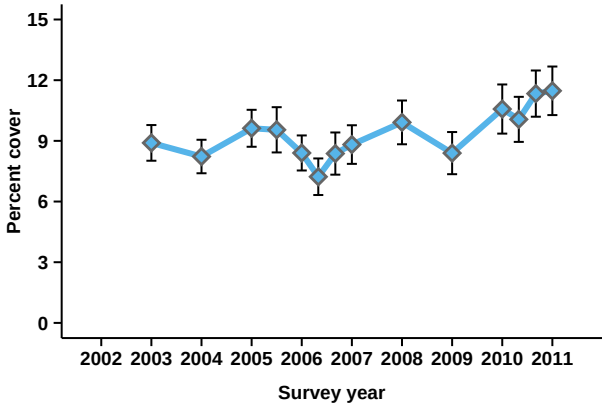
Mennebeck



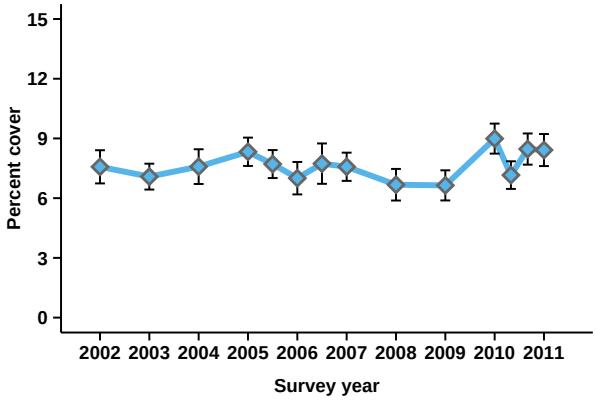
Yawzi



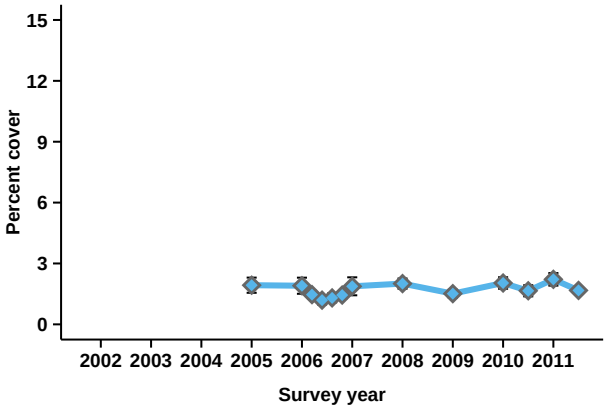
Haulover

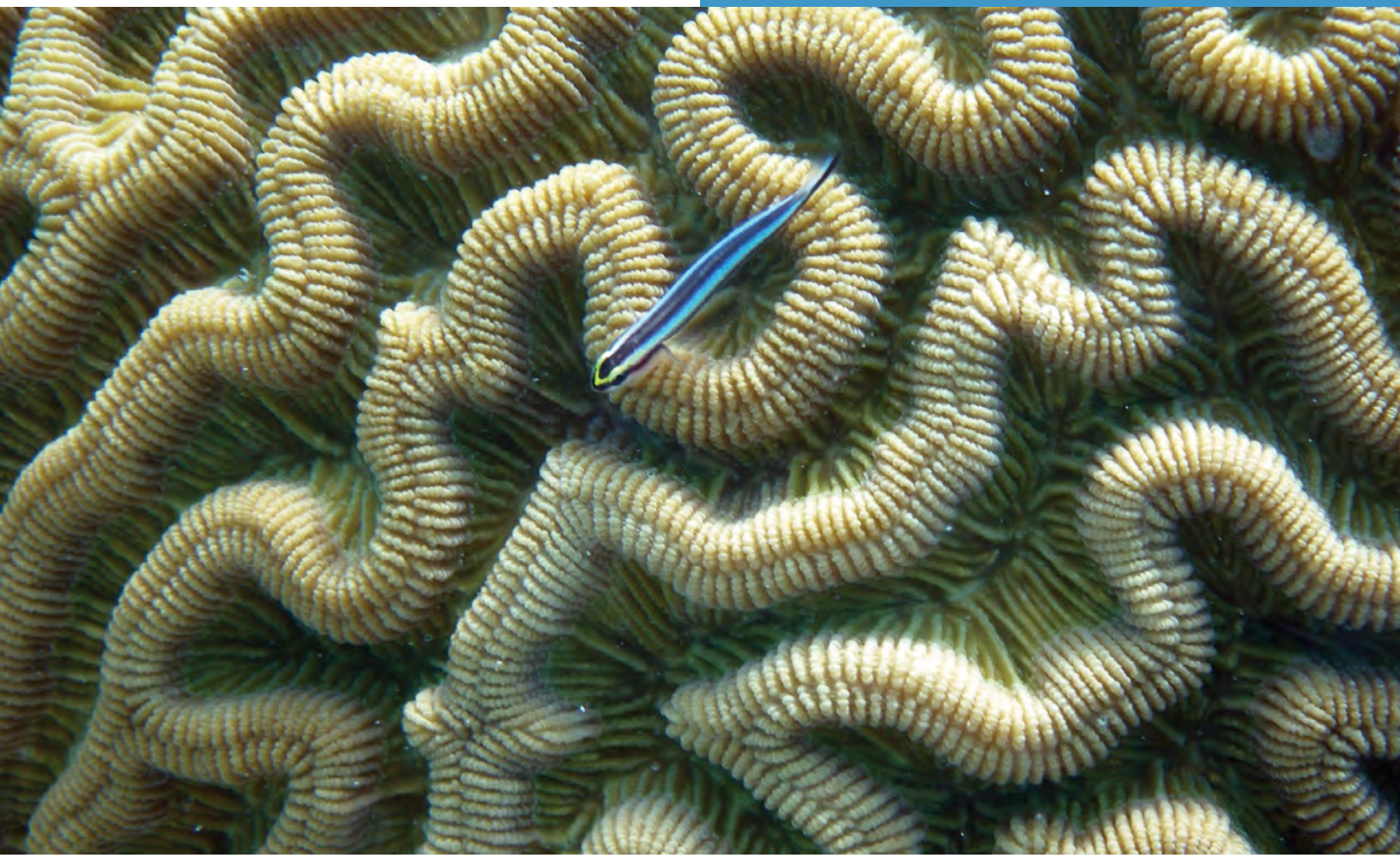


Newfound



Tektite





Summary

MPA Effect on Fish

None of the 15 fish metrics exhibited a significant increase inside the MPA indicating that the MPA had no clear positive effect in rebuilding local fish populations for key species. Fish biomass for all species combined exhibited inter-annual variability, with no significant increase or decrease detected inside Virgin Islands National Park over the ten year monitoring period (2002-2011). However, fish biomass decreased significantly on reefs outside the MPA. Overall, six metrics declined outside the MPA (fish biomass, herbivore biomass, adult grouper and parrotfish density, red hind [*Epinephelus guttatus*], coney [*Cephalpholis fulva*] and ocean surgeonfish [*Acanthurus bahianus*] biomass), while inside no decrease or increase was detected. This could be indicative of a positive effect whereby existing regulations or a reduction in fishing pressure is sufficient to maintain populations, but not strong enough to generate a significant increase in biomass or abundance for any species. Further monitoring is required to determine if the lack of a significant trend inside the MPA represents evidence for a positive MPA effect.

In contrast, adult parrotfish density, including redband parrotfish biomass, decreased significantly inside the Virgin Islands National Park. Furthermore, when the first five years of the time series (2002-2006) was compared with the latter five years (2007-2011), herbivore biomass and stoplight parrotfish biomass was significantly lower inside the MPA in 2007-2011 than in 2002-2006.

Status of Big Fish

No large-bodied grouper species were sighted from 417 underwater surveys, representing 104.25 hours of underwater observation within Virgin Islands National Park between 2002 and 2011. Nassau grouper (*Epinephelus striatus*), a species listed on the Endangered Species Act, was not sighted inside the MPA during the 10 year survey period, and yellowmouth (*Mycteroperca interstitialis*) and yellowfin (*Mycteroperca venenosa*) grouper were also not observed. This recorded absence is a measure of relative rarity and not confirmation that the species does not exist in the MPA. Dog snapper (*Lutjanus jocu*) was the only large bodied snapper species observed (four individuals) in 10 years of observations. The largest bodied parrotfish (blue parrotfish [*Scarus coeruleus*]) classified as having "moderate vulnerability to extinction," were sighted only three times in the MPA. Midnight (*Scarus coelestinus*) and rainbow (*Scarus guacamaia*) parrotfish were not observed within the MPA. The life-history traits of these large-bodied species result in a low resilience to environmental impacts, such as loss of reef structure and high vulnerability to extinction through fishing.

Benthic Composition

Based on spatially random surveys, live hard coral cover decreased both inside and outside the MPA between 2002 and 2011. Coral species proposed for listing under the Endangered Species Act, however, showed no significant trend in live cover. Macroalgal cover inside the MPA was highest after the bleaching and disease event in 2005 and 2006, but no significant temporal trend in time was detected over the 10 year study period. The abundance of soft coral and crustose coralline algae increased inside the MPA. The observed multi-year decrease in live hard coral cover and increase in soft coral cover suggests that chronic stressors are impacting hard corals across the region, and that some of the newly available space is being colonized by soft corals. Crustose coralline algae, which is thought to be indicative of suitable settlement sites for some hard coral species, increased both inside and outside the MPA between 2002 and 2011. Further evidence of the changes observed were provided when the first five years of the time series (2002-2006) was compared

Key Findings

- Virgin Islands National Park, an MPA with non-commerical fishing allowed, is not producing a measurable increase in reef fish biomass within its borders.
- Herbivore biomass was lower in 2007 to 2011 than 2002 to 2006 and adult parrotfish decreased in abundance inside the MPA.
- The amount of live coral decreased inside the MPA.
- Future monitoring as part of an adaptive management process will be required to determine if the MPA is able to maintain species populations when areas outside are decreasing.

with the latter five years (2007-2011). Live hard coral cover was significantly lower inside the MPA in 2007-2011 than in 2002-2006, and coralline algal cover and soft corals were significantly higher in the 2007-2011 period than 2002-2006.

Long-term monitoring at five permanent sites (Mennebeck Reef, Yawzi Reef, Haulover Reef, Newfound Reef, and Tektite Reef) by the NPS further indicates that benthic composition in the Virgin Islands National Park changed between 2002 and 2011. The data compliments the spatially random set by providing more precise changes in cover at individual sites. Monitoring at these sites showed the impact of the 2005 bleaching and disease event, with average coral cover (all sites combined) decreasing from 18.3% in 2005 to 8.2% in 2008[5]. Episodic monitoring conducted during this time period demonstrated the majority of this 55% decline in average coral cover was due to the coral disease (white plague) outbreak that followed the massive bleaching of 2005. While changes in cover of the recently ESA listed *O. annularis* complex could not be detected with the spatially random dataset, the average cover of this species complex declined by 66%; from 14.8% in 2005 to 5.0% in 2008, at the NPS reef monitoring sites. In 2005, this slow growing but important reef-building species comprised 75.4% of the coral community on these reefs. In 2011, their relative abundance declined to 54% of the coral community. Substantial coral bleaching occurred again in Virgin Islands National Park in 2010, but episodic monitoring conducted at the NPS monitoring sites showed no significant outbreaks of coral disease or decreased in average coral cover. Average coral cover at these 5 sites has increased from a low of 8.2% (2008) to 10.2% in 2011. Macroalgae cover fluctuated during the study period from 13.4% (2003) to 28% (2011); however this does not represent a steady increase in macroalgae. Small increases in crustose coralline algae cover occurred at a few monitoring locations between 2002 and 2011. Similarly, soft coral cover increased slightly at Haulover and Mennebeck reefs while remaining fairly constant at the other locations.

5 Miller, J., E. Muller, C. Rogers, R. Waara, A. Atkinson, K.R.T. Whelan, M. Patterson, and B. Witcher. 2009. Coral bleaching and disease combine to cause extensive mortality on reefs in U.S. Virgin Islands. Coral Reefs 5(3): 418-418.

Virgin Islands Coral Reef National Monument

St. John

US Army Corp of Engineers

Location:
North and south shore of St. John and Coral Bay

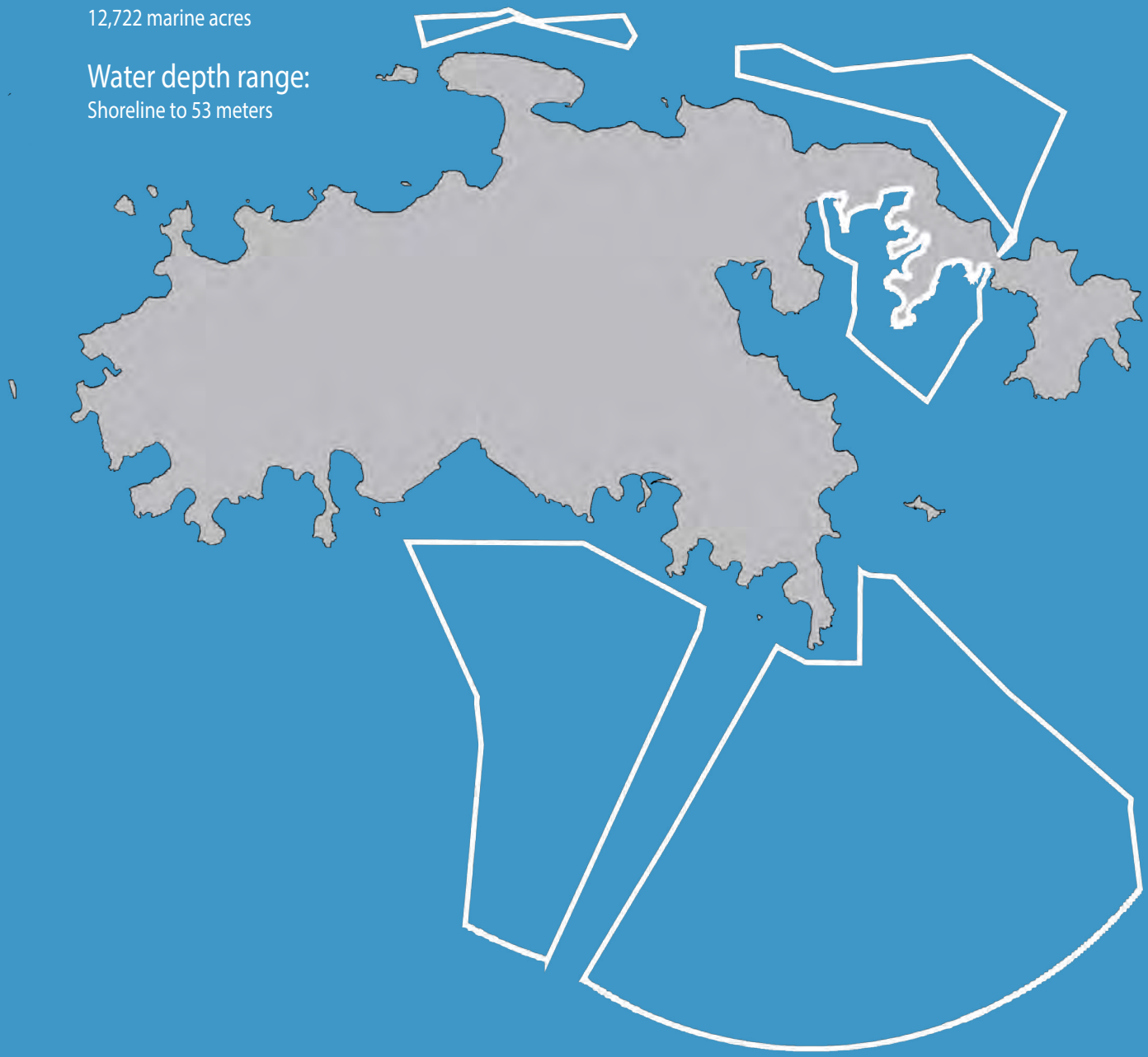
Origin:
Presidential Proclamation in 2001

Governance:
U.S. Federal Government; U.S. Department of the Interior

Enforcement:
National Park Service

Total area:
12,722 marine acres

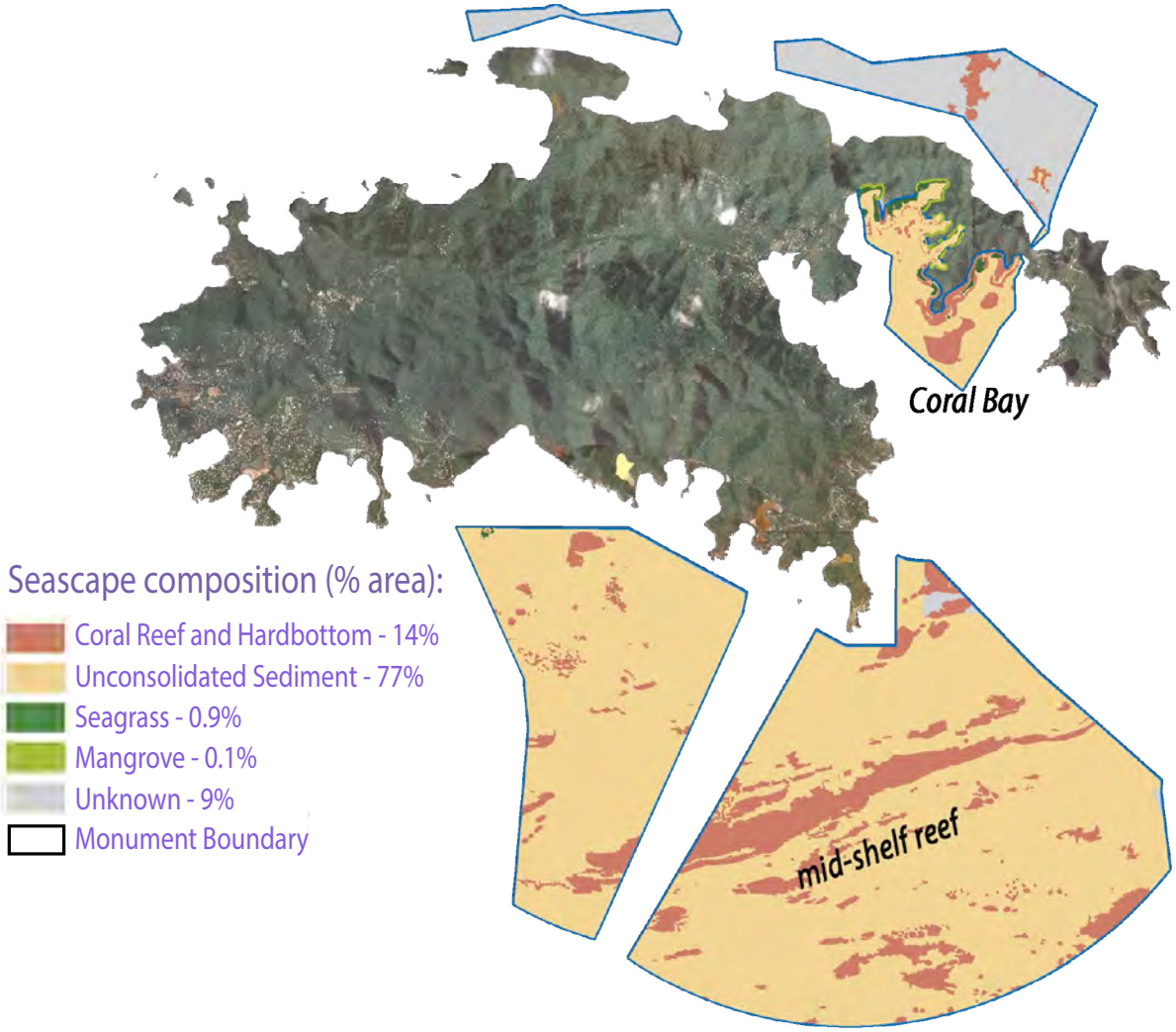
Water depth range:
Shoreline to 53 meters



About the MPA

Virgin Islands Coral Reef National Monument was established in 2001 by Presidential Proclamation (Presidential Proclamation 7399). There are five distinct components of the MPA boundary which share a boundary with the Virgin Islands National Park (Virgin Islands National Park). Two enclosed areas on the south side of St. John, USVI, one area within the northeast part of Coral Bay and two additional areas on the north and northeast side of St. John. All of these areas adjoin the Virgin Islands National Park. The two largest areas of the monument to the south encompass large sections of the mid-shelf reef feature.

The Coral Bay portion of the MPA was included in the monument to protect the mangrove lined bays and diverse coral reefs and seagrass beds that are recognized as important fish habitat. Unique, high diversity coral communities thrive along the rocky mangrove lined shores of Hurricane Hole within the Coral Bay portion of the Monument[1]. The entire MPA is a no-take reserve with a few exceptions, although very little is known about the level of fishing that occurs within the MPA.



1 Rogers, C.S. 2009. High diversity and abundance of scleractinian corals growing on and near mangrove prop roots, St. John, U.S. Virgin Islands. Coral reefs 28(4): 909-909.

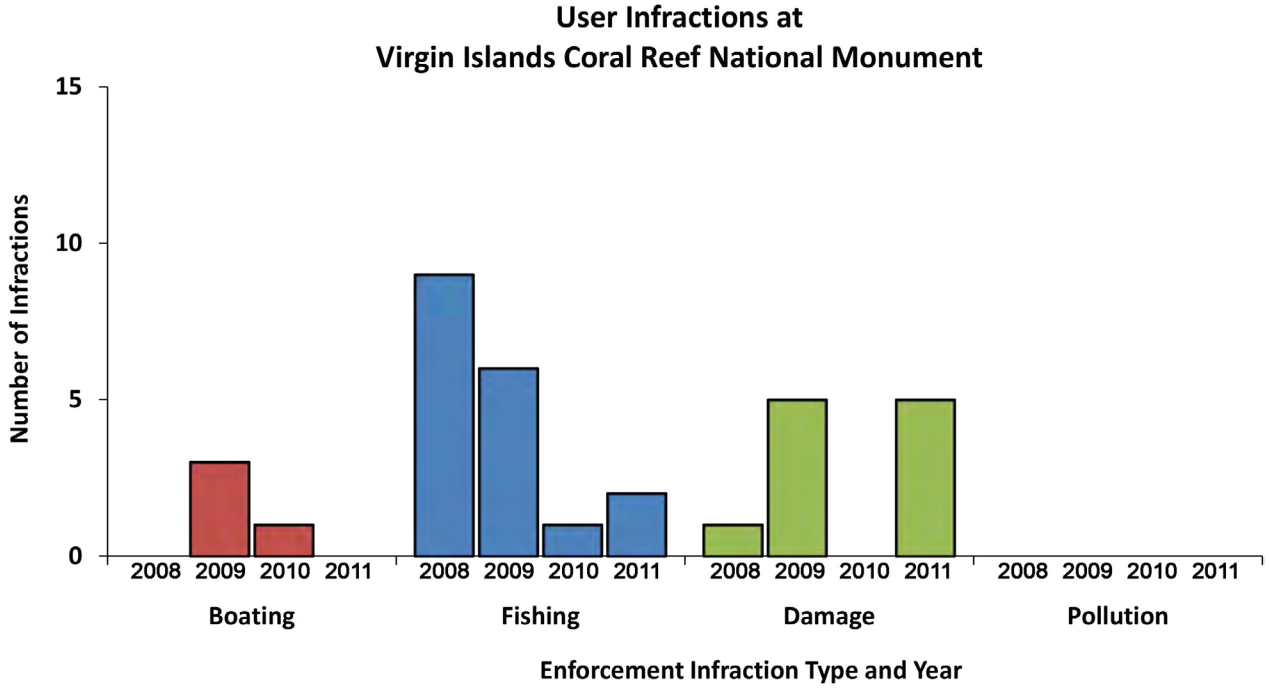
Human Uses

There is no visitor information available at this time.

Regulation & Stewardship

NPS Rangers are primarily responsible for enforcing Virgin Islands Coral Reef National Monument regulations along with those of the Virgin Islands National Park. Information about the intensity of enforcement activity at the Monument is not available separately from that of the Virgin Islands National Park. The provisions within the Virgin Islands National Monument prohibit all extractive uses with the exception of:

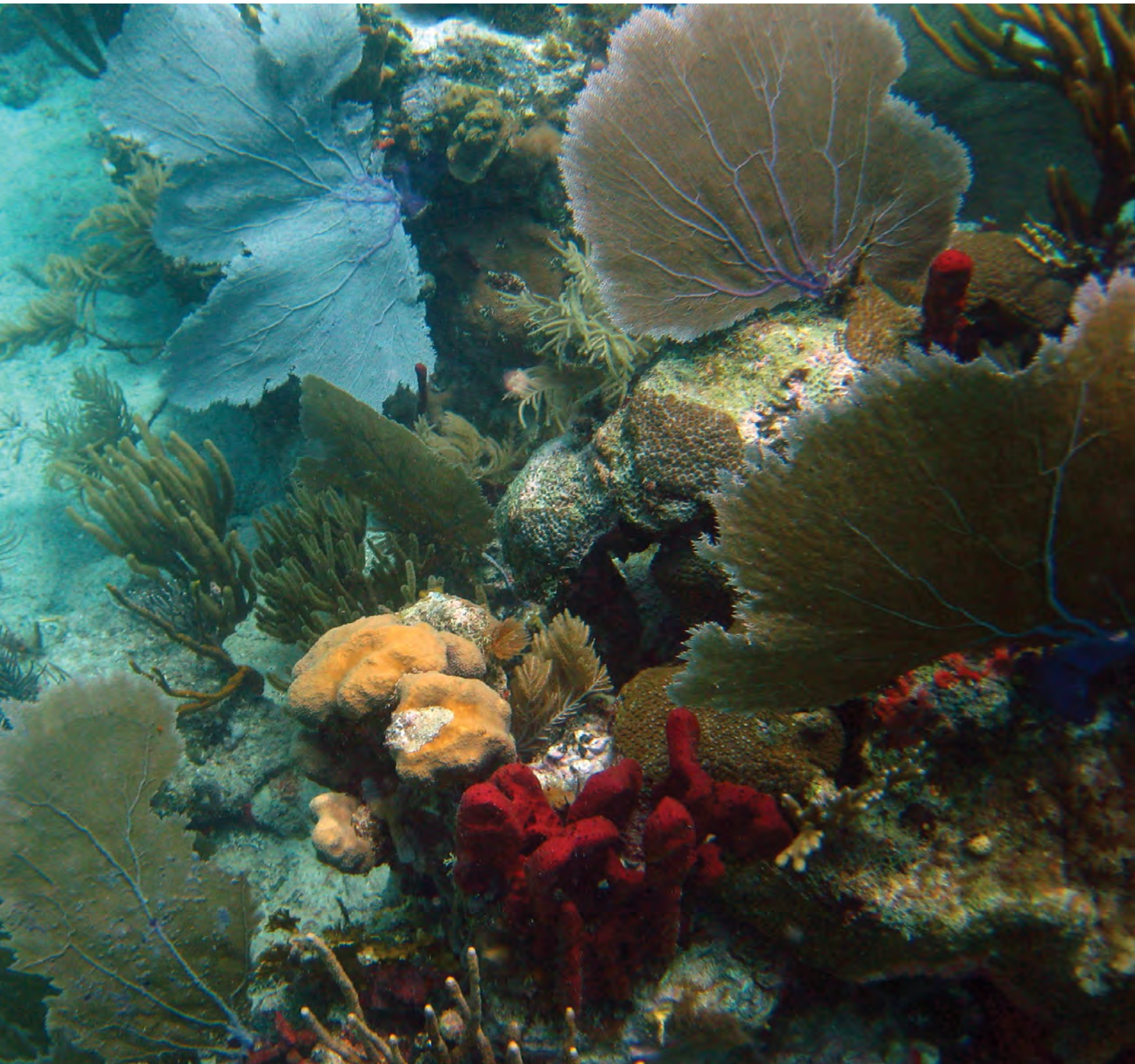
- Fishing for blue runner, *Caranx crysos*, within the boundaries south of St. John
- Bait fishing in a small designated area within the Coral Bay portion of the Monument
- Boat anchoring is also prohibited, except for emergency or authorized administrative purposes.



Number of infractions by year within the Virgin Islands Coral Reef National Monument. Damage is defined as disturbance to benthic substrates, such as illegal anchoring and groundings. Boating is defined as illegal mooring, location or abandonment of a vessel or personal watercraft Source: National Park Service

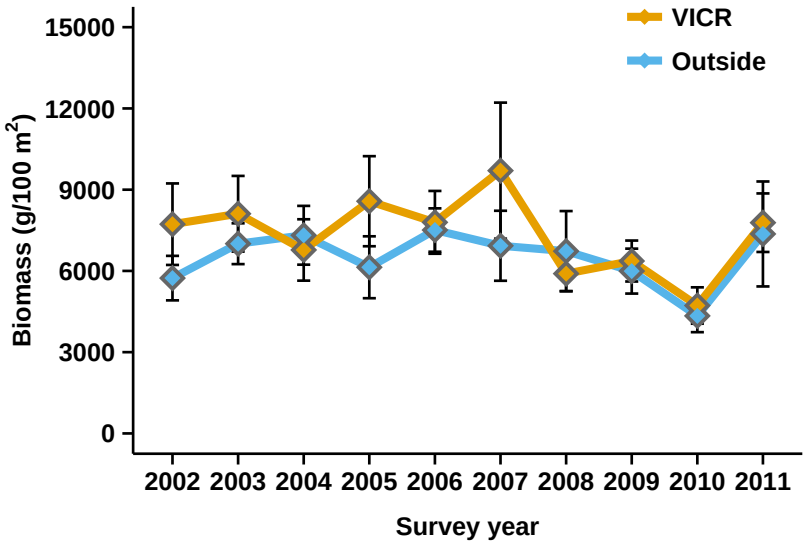
MPA Performance Metrics

This section presents the results of trend analysis for biological metrics inside and outside of Virgin Islands Coral Reef National Monument (2002 to 2011). A written summary and interpretation of the findings is presented at the end of the section.



Fish Community Metrics

Mean Fish Biomass

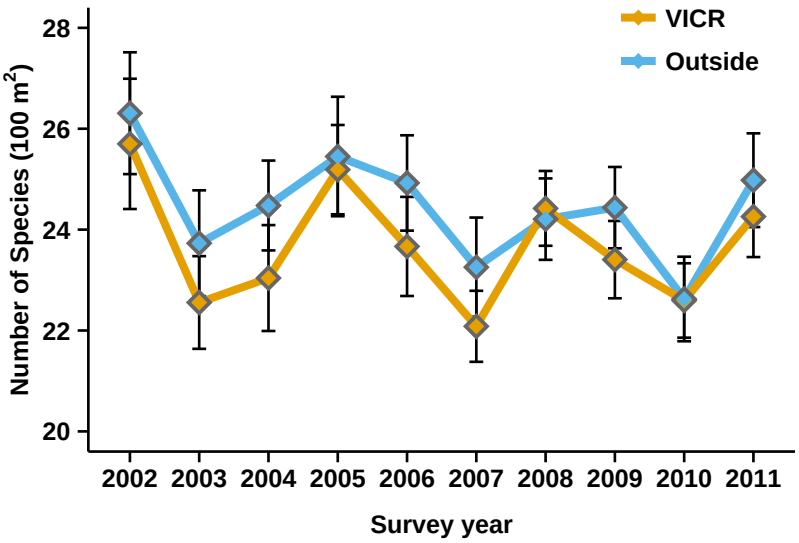


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Mean Species Richness

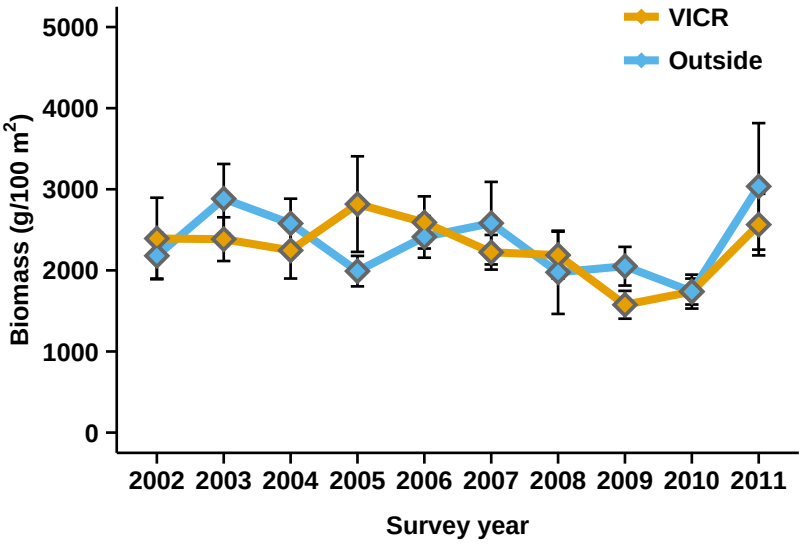


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Herbivore Biomass



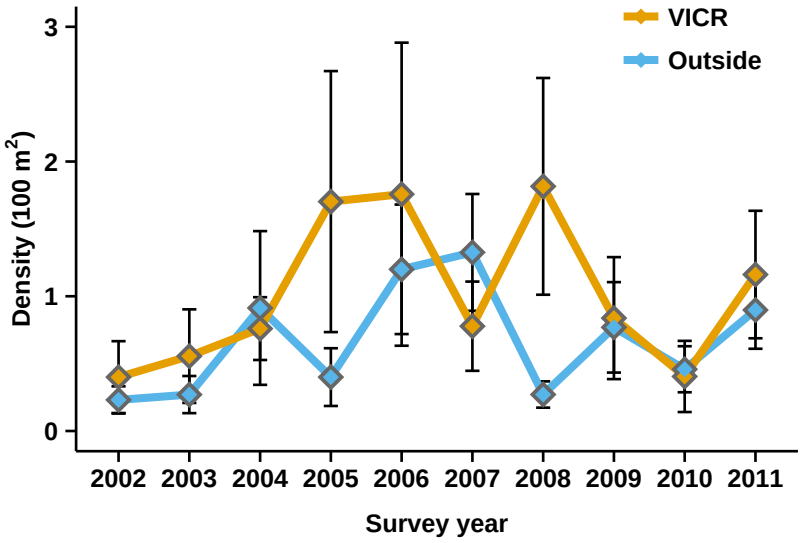
Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Adult Snapper Density

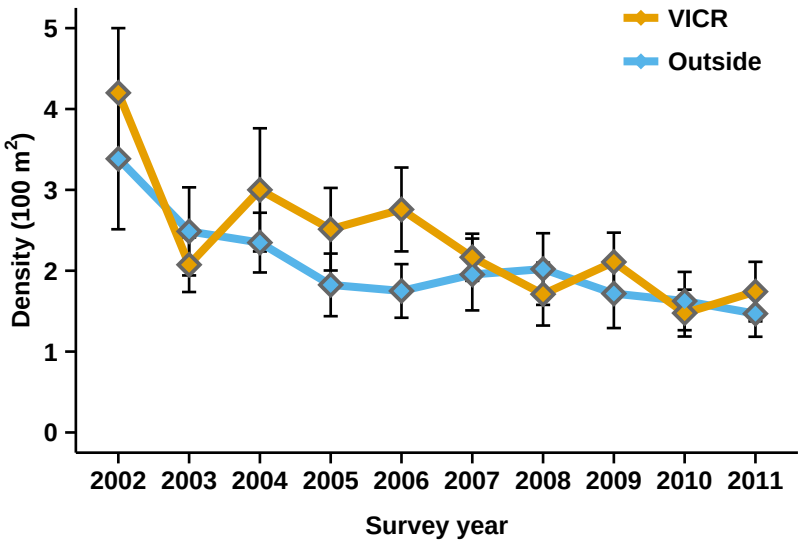


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Adult Grouper Density

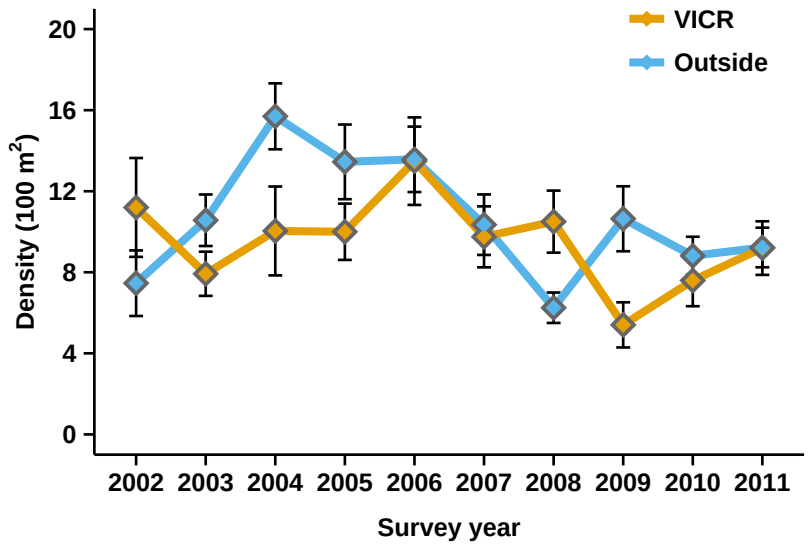


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Mean Adult Parrotfish Density



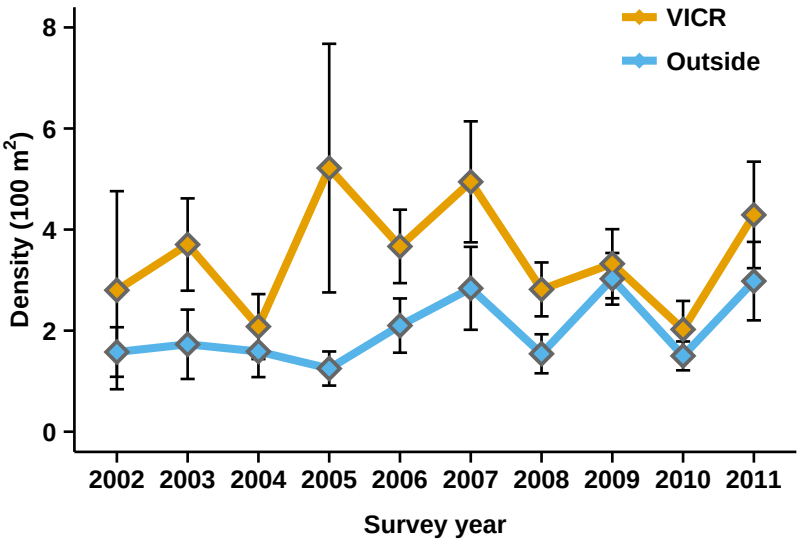
No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Fish Family & Species Metrics

Mean Adult Surgeonfish Density

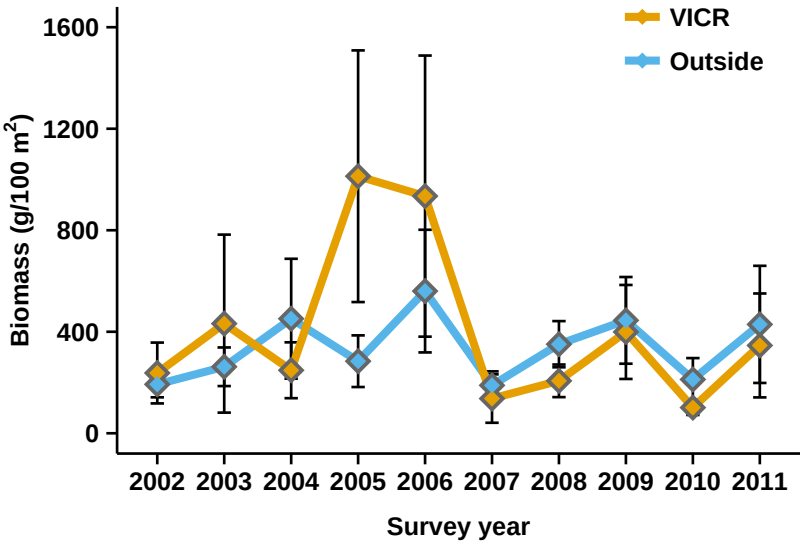


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Grunt (All Species) Biomass

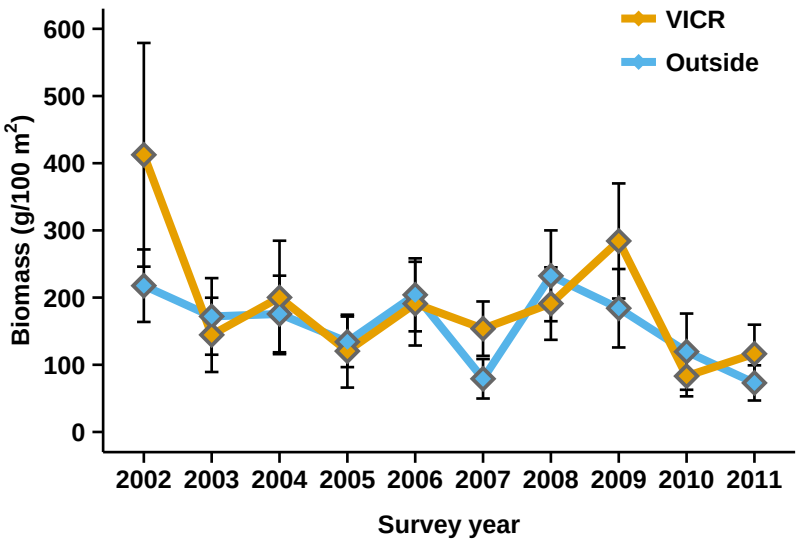


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Red Hind Biomass



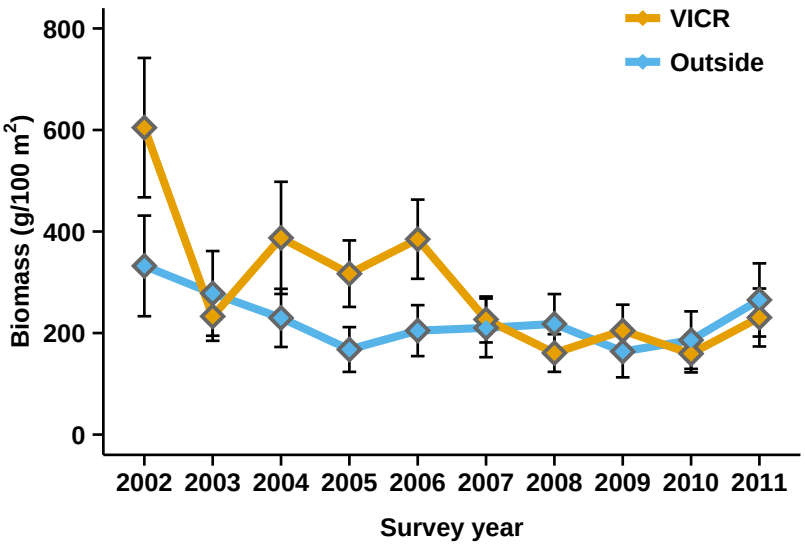
No trend inside MPA

Decrease outside MPA

? Possible positive MPA effect

Fish Family & Species Metrics

Mean Coney Biomass

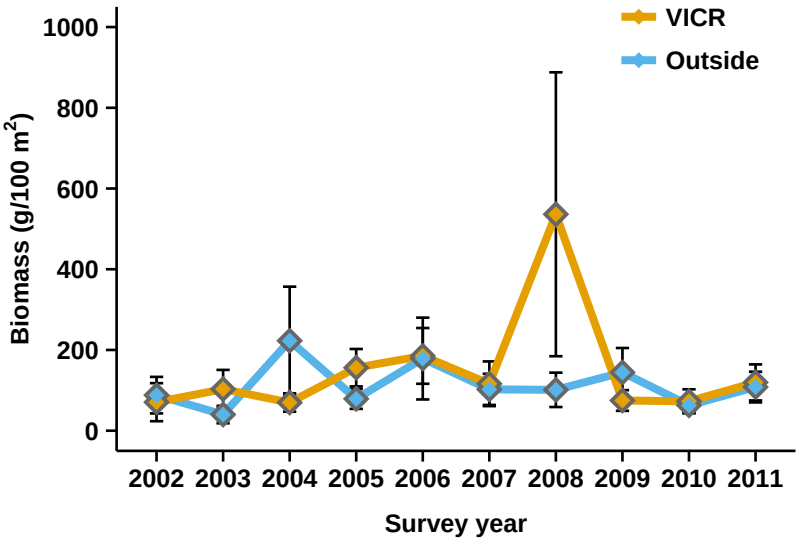


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Mean Yellowtail Snapper Biomass

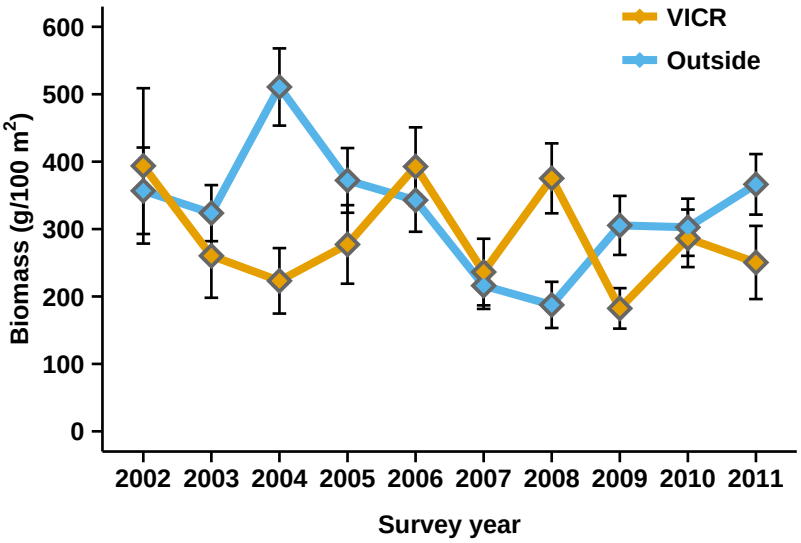


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Redband Parrotfish Biomass



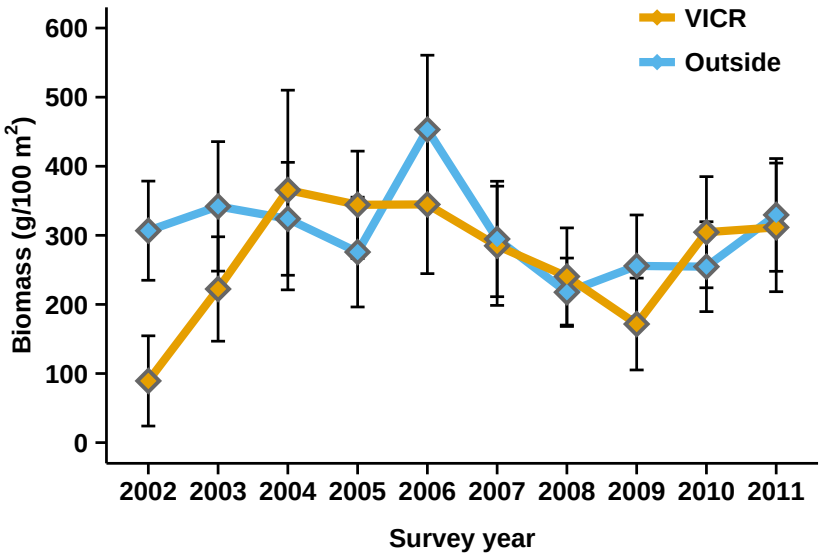
No trend inside MPA

No trend outside MPA

No positive MPA effect

Fish Family & Species Metrics

Mean Stoplight Parrotfish Biomass

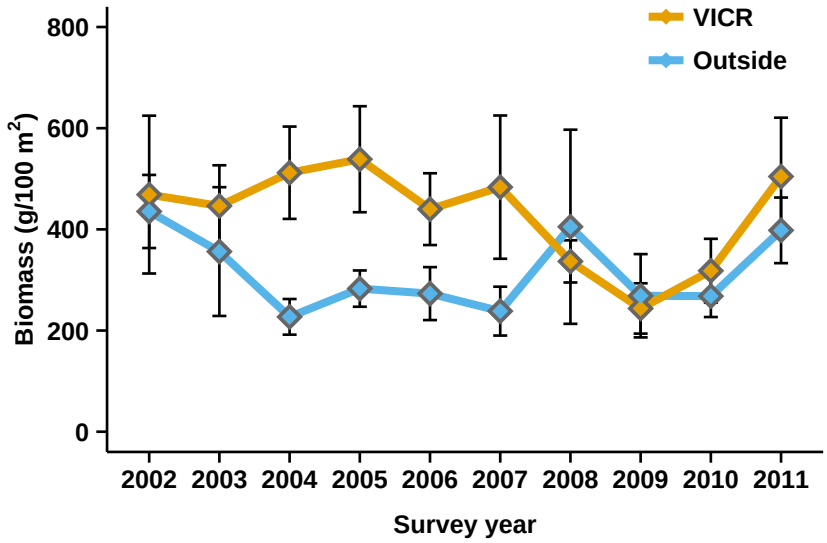


No trend inside MPA

No trend outside MPA

No positive MPA effect

Mean Ocean Surgeonfish Biomass

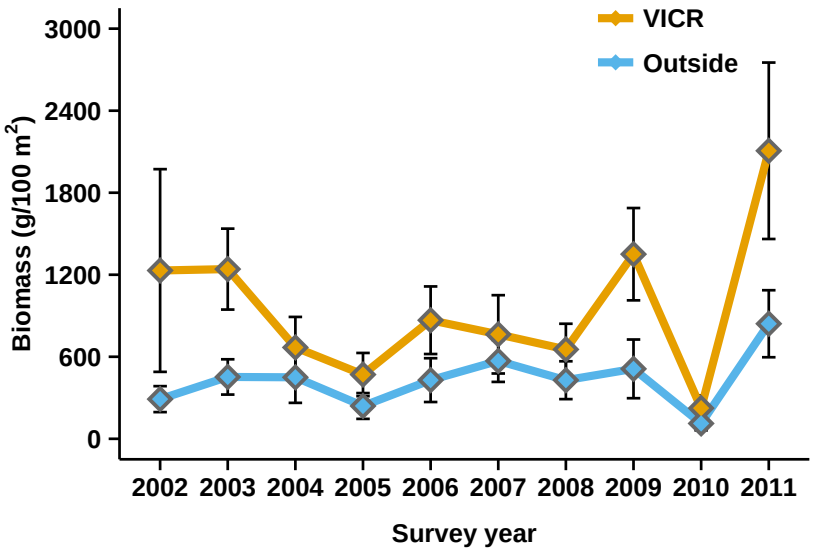


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Mean Queen Triggerfish Biomass



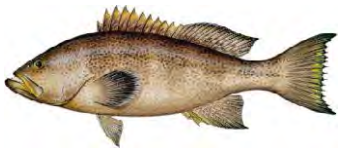
No trend inside MPA

No trend outside MPA

No positive MPA effect

Species with Moderate to High Vulnerability to Fishing

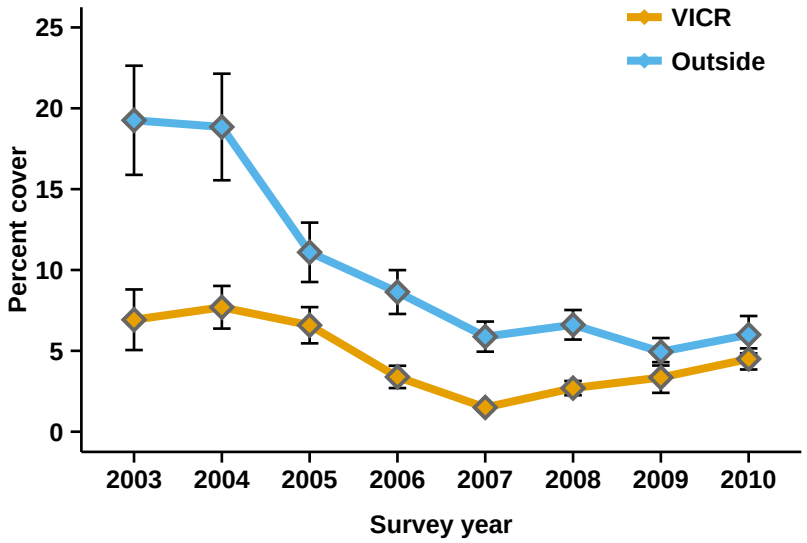
Occurrence of large-bodied species with moderate to high vulnerability to fishing in shallow water (<35 m) habitat types within Virgin Islands Coral Reef National Monument 2002-2011 (471 underwater visual surveys).

Tiger grouper *Myctoperca tigris*  0 sighting	Nassau grouper *Epinephelus striatus*  9 sightings	Yellowfin grouper *Mycteroperca venenosa*  0 sightings
Yellowmouth grouper *Myctoperca interstitalis*  0 sightings	Dog snapper *Lutjanus jocu*  9 sightings	Cubera snapper *Lutjanus cyanopterus*  0 sightings
Rainbow parrotfish *Scarus guacamaia*  0 sightings	Blue parrotfish *Scarus coeruleus*  0 sightings	Midnight parrotfish *Scarus coelestinus*  0 sighting

Fish Illustrations by Diana Peebles

Coral & Macroalgae Metrics

Hard Coral Cover

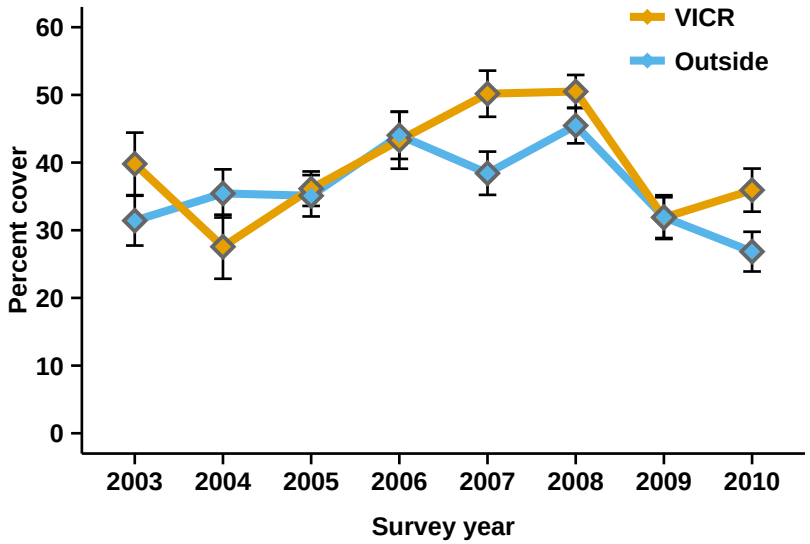


Decrease inside MPA

Decrease outside MPA

No positive MPA effect

Macroalgae Cover



No trend inside MPA

No trend outside MPA

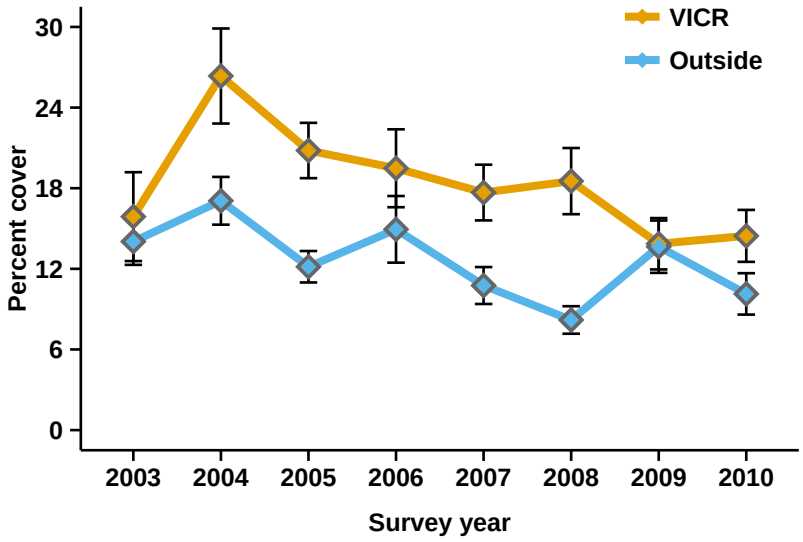
No positive MPA effect

Crustose Coralline Algae Cover

Crustose coralline algae was not recorded in the Virgin Islands Coral Reef National Monument

Coral & Macroalgae Metrics

Soft Coral Cover



Decrease inside MPA

Decrease outside MPA

No positive MPA effect

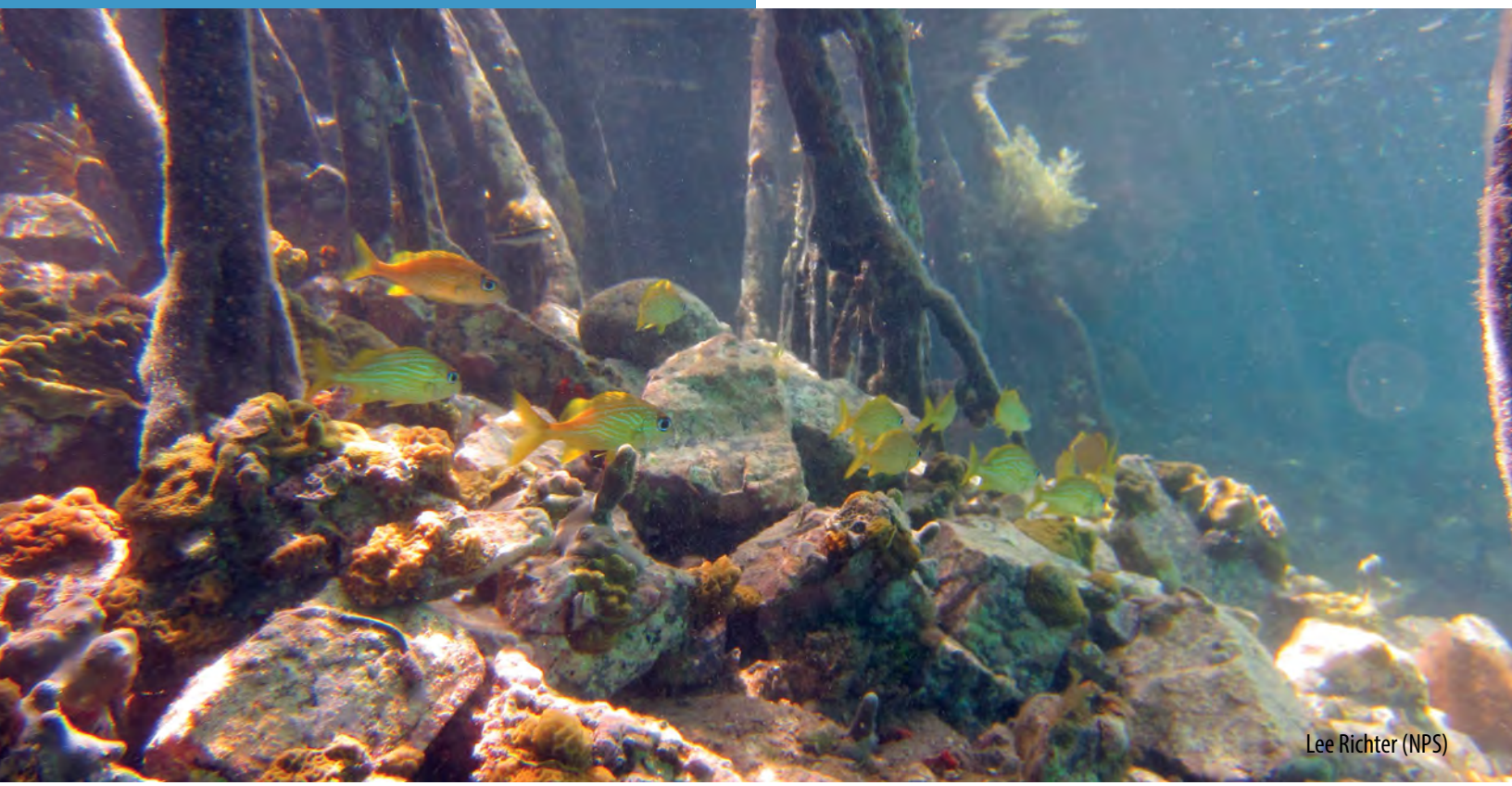
Newly Listed ESA* Coral Species Cover

Coral species were not recorded in the Virgin Islands Coral Reef National Monument

* Endangered Species Act

Coral & Macroalgae: NPS Long-Term Monitoring Sites

The National Park Service does not currently have any permanent monitoring sites within the Virgin Islands Coral Reef National Monument.



Lee Richter (NPS)

Summary

MPA Effect on Fish

None of the 15 fish metrics exhibited a significant increase inside the MPA indicating that the Virgin Islands Coral Reef National Monument had no detectable positive effect in rebuilding local fish populations for key species. Five of 15 fish metrics decreased significantly inside and outside the MPA over the ten year monitoring period (2002-2011) including fish biomass, herbivore biomass, adult grouper density, coney (*Cephalopholis fulva*) and ocean surgeonfish (*Acanthurus bahianus*) biomass. The decrease was also confirmed when the first five years of the time series (2002-2006) was compared with the latter five years (2007-2011) for coney biomass and ocean surgeonfish biomass which was significantly lower inside the MPA in 2007-2011 than in 2002-2006.

Two metrics declined outside the MPA (adult parrotfish density and red hind [*Epinephelus guttatus*] biomass), while inside no decrease or increase was detected. This could be indicative of a positive effect whereby the closure to fishing is sufficient to maintain populations, but not yet able to generate a significant increase in biomass or abundance for any species. Further monitoring is required to determine if the lack of a significant trend inside the MPA represents evidence for a positive MPA effect. Similarly, eight additional metrics exhibited inter-annual variability, but with no directional trend detected either inside or outside the MPA. These metrics also provided no evidence of an MPA effect.

Status of Big Fish

Nine individuals of large-bodied grouper (Nassau grouper [*Epinephelus striatus*]) and nine individuals of large bodied snapper (dog snapper [*Lutjanus jocu*]) were sighted between 2002 and 2011 from 471 underwater surveys representing 117.75 hours of underwater observation within Virgin Islands Coral Reef National Monument. Tiger (*Mycteroperca tigris*), yellowmouth (*Mycteroperca insterstitialis*) and yellowfin (*Mycteroperca venenosa*) grouper were not sighted inside the MPA. Cubera snapper (*Lutjanus cyanopterus*) was also not sighted. This recorded absence is a measure of relative rarity and not confirmation that the species does not exist in the MPA. The largest bodied parrotfish (blue [*Scarus coeruleus*], midnight [*Scarus coelestinus*] and rainbow [*Scarus guacamaia*] parrotfishes) classified as having moderate vulnerability to extinction were not sighted in the MPA during 10 years of observations. The life-history traits of these large-bodied species result in a low resilience to environmental impacts such as loss of reef structure and high vulnerability to extinction through fishing. Even with a cessation of fishing, these high vulnerability species may take longer than a decade to recover. For example, limited data on Nassau grouper suggests that females may not reach reproductive maturity until they are approximately 50 cm fork length and the species has an estimated low population doubling time of 4.5 to 14 years (www.fishbase.org).

Benthic Composition

Overall, live hard coral cover decreased significantly inside and outside of Virgin Islands Coral Reef National Monument from 2003-2010 with lowest coral cover recorded in 2007. Outside the MPA, changes in coral cover were more dramatic, falling from an average of 19% in 2003 to 6% in 2010. In contrast to the Virgin Islands National Park a significant decrease in soft coral cover was detected both inside and outside the MPA. Algal cover (all algal growth types) peaked in 2007 and 2008, but decreased after 2008 although no significant trend was detected either inside or outside the MPA over the study period. These patterns suggest that benthic habitats within the MPA and adjacent areas outside might be affected by similar stressors. Further evidence for change was provided when the first four years of the time series (2003-2006) was compared with the latter four years (2007-2010). Live hard coral cover was significantly lower inside the MPA in 2007-2010 than in 2003-2006 and algal cover was significantly higher in the 2007-2010 period than 2003-2006.

Key Findings

- Virgin Islands Coral Reef National Monument, a no-take MPA, with a few exceptions, is not producing a measurable increase in reef fish biomass within its borders.
- Adult grouper abundance and herbivore biomass decreased inside the MPA.
- The amount of live coral decreased inside the MPA.
- Future monitoring as part of an adaptive management process will be required to determine if the MPA is able to maintain species populations when areas outside are decreasing

Summary and Synthesis

Are MPAs Working in the USVI?

A synthesis of the ecological performance analyses from three intensively surveyed MPAs across a period of 8-10 years provides a unique assessment of regional MPA performance in support of management. In addition, comparing the performance of individual metrics between MPAs with differing regulations for fishing is also informative for management. To address the question: Are MPAs working? This section of the report summarizes the results on status and trends from 20 biological metrics or indicators of MPA ecological performance and presents the synthesis as a list of findings. Information in this report can be used as a baseline for future assessments of ecological status and trends and also to set restoration targets for key species and develop targeted long term strategies to support recovery.

Synthesis

When comparing the proportion of negative and positive trends inside MPAs versus outside MPAs for 17 key metrics, it is apparent that outside MPAs were experiencing greater decrease in coral reef ecosystem health than coral reefs inside MPAs. For instance, 27% of all metrics inside MPAs were negative trends compared with 32% of metrics for coral reefs outside MPAs; 4% were positive trends inside MPAs and 6% were positive outside MPAs. For fish metrics, 22% of fish metrics inside MPAs were negative trends compared with 29% outside MPAs. Positive (i.e. , increasing) trends occurred for only one fish metric inside MPAs (density of adult snapper) and outside (queen triggerfish biomass) MPAs.

MPA Performance for Coral Reef Fishes

Productivity

- None of the assessed Federal MPAs in the USVI exhibited an increase in fish biomass on coral reefs inside their boundaries between 2002 and 2011, regardless of differences in fishing regulations.

Biodiversity

- None of the assessed Federal MPAs in the USVI exhibited an increase in the number of fish species on coral reefs inside their boundaries between 2002 and 2011.

Herbivores

- None of the assessed Federal MPAs in the USVI exhibited an increase in herbivorous fish biomass on coral reefs inside their boundaries between 2002 and 2011.
- None of the assessed Federal MPAs in the USVI exhibited an increase in the abundance of adult parrotfish and surgeonfish on coral reefs inside their boundaries between 2002 and 2011.
- Adult parrotfish decreased in the Virgin Islands National Park and adult surgeonfish decreased inside Buck Island Reef National Monument.

Key Fishery Species

- Adult groupers decreased in abundance inside the two no-take National Monuments (Buck Island Reef National Monument and Virgin Islands Coral Reef National Monument).
- Adult snapper abundance increased inside Buck Island Reef National Monument, but the increase was minor because abundance in the last four years of study (2007-2010) was not significantly higher than the first four years (2003-2006).
- The largest-bodied groupers (Epinephelinae) with high vulnerability to fishing are very rare in USVI's MPAs. A total of 2,037 underwater fish surveys from 2001-2011 sighted only nine federally protected Nassau grouper inside the MPAs. No sightings were recorded for yellowfin, yellowmouth or goliath grouper.
- The largest-bodied snappers (Lutjanidae) with high vulnerability to fishing are very rare in USVI's MPAs. A total of 2,037 underwater fish surveys from 2001-2011.
- The largest-bodied parrotfishes (Scaridae) with high vulnerability to fishing are very rare in USVI's MPAs. Fourteen rainbow parrotfish were sighted, but only five blue parrotfish and two midnight parrotfish were sighted from the surveyed MPAs.
- Five of the seven fish metrics showing a decreasing trend outside the Virgin Islands Coral Reef National Monument were also decreasing inside the Monument, suggesting that similar drivers are operating inside and outside.

MPA Performance for Corals & Algae

- No positive MPA effects were detected for coral and algae metrics. Patterns of change were similar inside and outside MPAs suggesting that the same broad scale drivers (e.g., thermal stress, disease, runoff) are operating to influence benthic communities across the region.
- The amount of live coral cover has decreased in all three MPAs and across the region, regardless of differences in regulations and human uses.
- Long-term monitoring of benthic communities at permanent sites by the NPS' Inventory and Monitoring Program also revealed major changes in key biotic indicators of coral reef health, specifically the decline in coral cover following the 2005 global mass bleaching event and disease outbreak, and subsequent increase in macroalgae. This event is widely acknowledged as the single most important cause of coral mortality in the USVI during the study period.

Synthesis of 17 performance metrics inside and outside the three federal MPAs. Positive change was assumed when metrics were trending in a direction that was considered desirable for restoring coral reef health (i.e., decreasing macroalgae and increasing live coral cover). ns = no trend detected due to high variability, green = positive trend, red = negative trend. BUIS= Buck Island Reef National Monument, VIIS= Virgin Islands National Park, VICR= Virgin Islands Coral Reef National Monument.

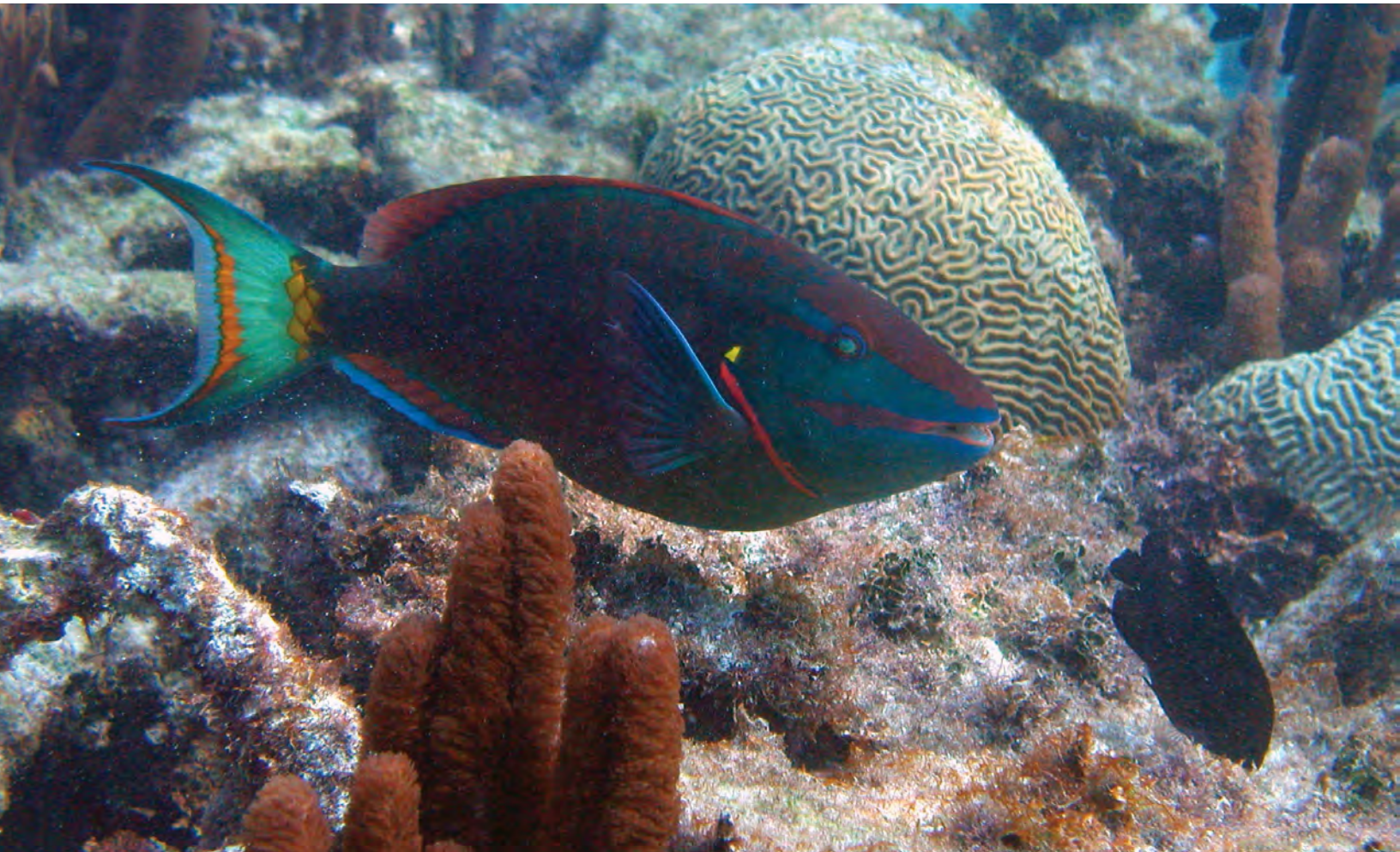
Performance Metric	Sampled area				
	Inside BUIS	Outside BUIS	Inside VIIS	Inside VICR	Outside VIIS & VICR
Fish					
Total fish biomass	ns	ns	ns	down	down
Species richness	down	ns	ns	ns	ns
Total herbivore biomass	ns	ns	ns	down	down
Adult snapper density	up	down	ns	ns	ns
Adult grouper density	down	ns	ns	down	down
Adult parrotfish density	ns	ns	down	ns	down
Adult surgeonfish density	down	ns	ns	ns	ns
Grunt (all species) biomass	ns	ns	ns	ns	ns
Yellowtail snapper biomass	ns	ns	ns	ns	ns
Red hind biomass	ns	ns	ns	ns	down
Coney biomass	down	down	ns	down	down
Redband parrotfish biomass	ns	ns	down	ns	ns
Stoplight parrotfish biomass	ns	down	ns	ns	ns
Ocean surgeonfish biomass	ns	ns	ns	down	down
Queen triggerfish biomass	ns	up	ns	ns	ns
Benthic components					
Coral cover (%)	down	ns	down	down	down
Macroalgal cover	down	down	ns	ns	ns
% assumed negative trend	**29.4**	**17.6**	**17.6**	**35.3**	**47**
% assumed positive trend	**11.8**	**11.8**	**0**	**0**	**0**
% no significant trend	**58.8**	**70.6**	**82.4**	**64.7**	**53**

What Can Be Done to Help Ecological Performance of MPAs?

- The no-take MPAs studied here were established in 2003 and monitored until 2010/2011 (8/9 years post establishment). Research suggests that older (>10 years) MPAs usually perform better than younger MPAs, therefore, continued or increased regulations on fishing is eventually expected to yield a positive MPA effect if suitable habitat quality is available to support replenishment[1].
- MPAs are connected to other places through movements of animals, therefore, what happens outside an MPA can impact what is happening inside an MPA. This is particularly relevant to the need to provide greater protection for nursery habitat and spawning sites for highly mobile fish vulnerable to fishing. For example, fishing at fish spawning aggregations outside MPAs and factors that impact the quality of nursery habitat inside and outside MPAs should be evaluated.
- A greater understanding of fish movement and connectivity between critical habitat in the life cycle of key fish species will be essential to determine the dependency of MPAs on surrounding features of the seascape that can be used to better target and prioritize management strategies. Research on connectivity between the existing MPAs is needed to determine interdependency across the network which could influence the way MPAs are managed.
- Evaluation of the ecological implications of MPA size and shape may help to inform future options for MPA design to optimize ecological performance.
- Although the presence of NPS Rangers increased the public's awareness and compliance with park regulations, NPS enforcement records also demonstrate that illegal fishing inside no-take MPAs occurred throughout the survey period. Outreach campaigns to improve voluntary compliance in the fishing community and evaluation of existing enforcement effort, techniques, and tactics could help address illegal fishing inside MPAs. On St. Croix, Buck Island Reef National Monument and East End Marine Park could create joint outreach, management and monitoring initiatives that would share resources and reach a broader section of the community.
- Information on patterns of fishing effort, behavioral response to MPAs, and the effectiveness of existing regulations is insufficient to evaluate the impact of the full range of fishing activities on MPA performance. Social science research is needed to describe patterns of human use in and around MPAs.
- Evaluation of regulations to assess interpretability, compliance, and consistency and potential for synergy among MPA units.
- Activity in the watersheds that drain into MPAs can negatively impact coral reef health and the quality of fish habitat. Strategies that promote awareness of best practices for urban development, including road building, are particularly important on high relief tropical islands.

1 Edgar, G.J., R.D. Stuart-Smith, T.J. Willis, S. Kininmonth, S.C. Baker, et al. 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature 506(7487):216-220.

- Many of the biological metrics showed no significant trend for coral reefs inside MPAs, whereas outside areas declined, suggesting a possible positive MPA effect in maintaining populations. Targeted monitoring of fish populations at several permanent sites to complement the island-wide surveys by NOAA's National Coral Reef Monitoring Program will be required to determine if the potential MPA effects suggested in this report progress to detectable increases for fish abundance and biomass in the future.
- Habitat structure and benthic composition of coral reefs has changed in the past few decades and little is known about the impact of this change on the reefs carrying capacity for fishes. It is possible that MPA performance is being hampered by declining habitat quality, and research to address this is necessary to help align expectations for the potential function that MPAs provide in future replenishment of local fish populations.
- Although macroalgae was decreasing across the study area, it still dominated the benthic community, outcompeting corals. Management could evaluate novel interventions such as sea urchin transplantation to priority areas. This experimental approach could be conducted in collaboration with academic researchers.



Appendix

Temporal Trend Analysis

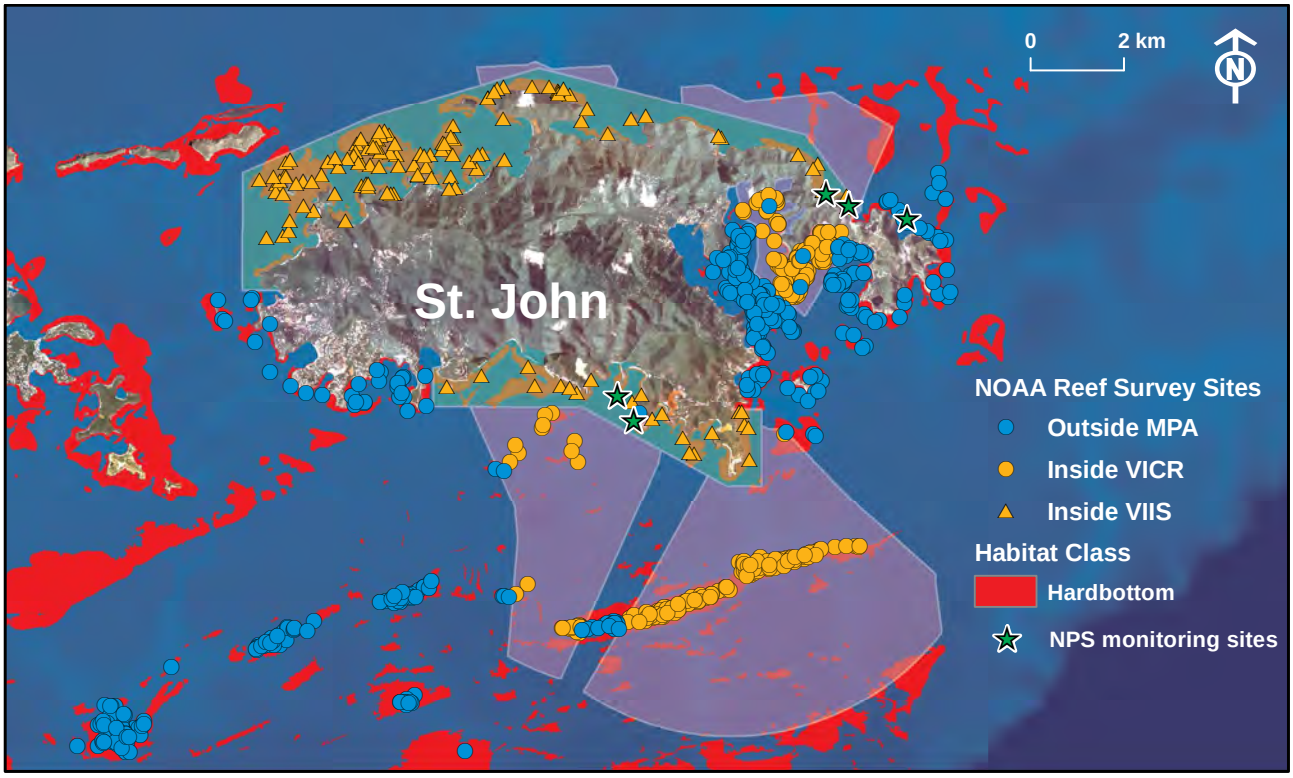
Temporal trends in fish community and select species metrics within and outside the MPA were analyzed across years (2002-2011). A generalized linear model (GLM), with year as a predictor variable, was used for species richness, total biomass and herbivore biomass. Biomass data were log-transformed before they were analyzed. Some density data contained a high number of zero values (i.e. sights where fish species were not observed) therefore a zero-inflated regression was used. The zero-inflated regression model consists of two components – a negative binomial regression model that estimated the number of fish, and a zero-inflated model that predicted the number of excess zeros. The appropriate fit of the regression models were determined with both the negative binomial and poisson distributions[1].

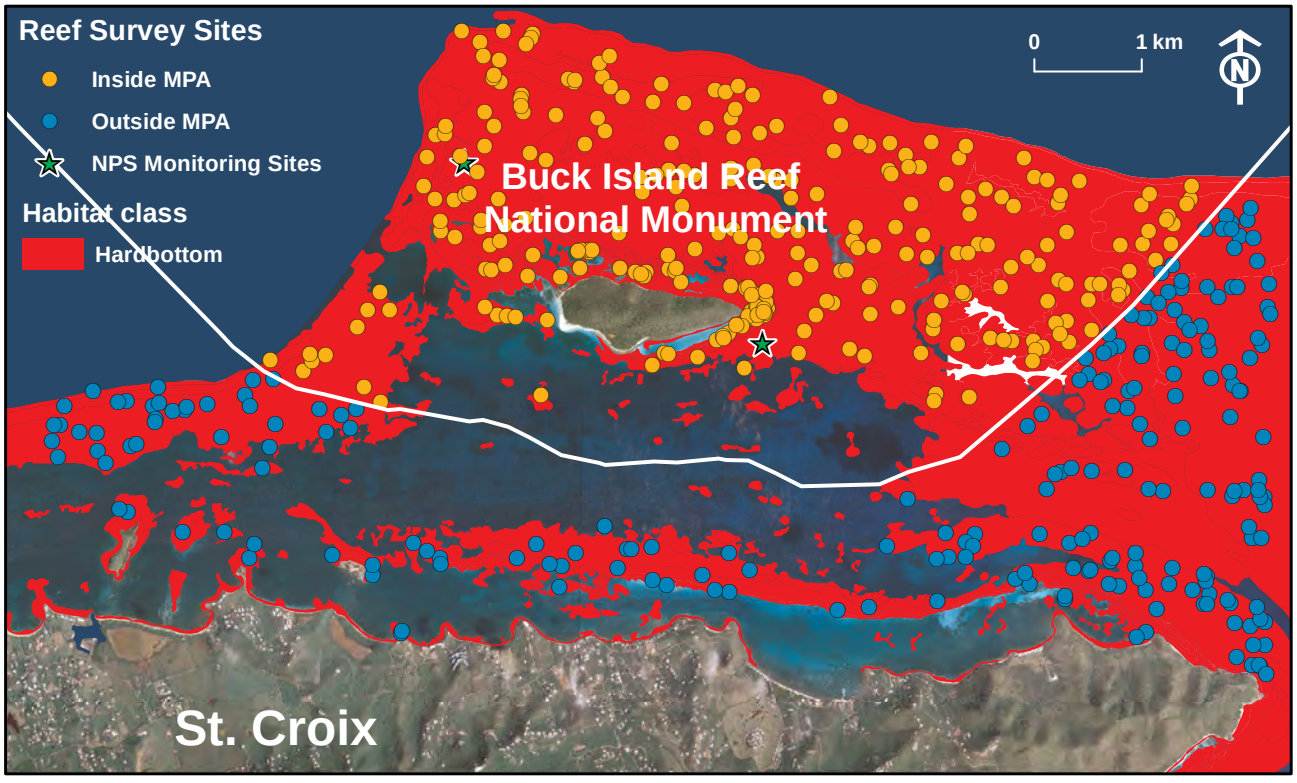
For species biomass variables, a two-stage approach (i.e., hurdle model) was used to separate the probability of presence of a species from its relative biomass. In the first step, presence/absence of the species is modeled with logistic regression to obtain a probability of presence. In the second step, non- zero values are modeled with a GLM and lognormal distribution to estimate the magnitude of biomass, given presence of the species. These two models were combined to estimate biomass for a given year.

Temporal trends in percent cover of corals and algae were analyzed using the nonparametric Jonckheere-Terpstra (JT) test to examine whether significant change in percent cover occurred between 2003 and 2010. The JT test is a rank based procedure in which data are tested for a hypothesized sequential increase or decrease in the percent cover across years.

1 Cunningham, R. and D. Lindenmayer. 2005. Modeling count data of rare species: some statistical issues. Ecology 86(5): 1135-1142.

Maps of Sample Site Locations

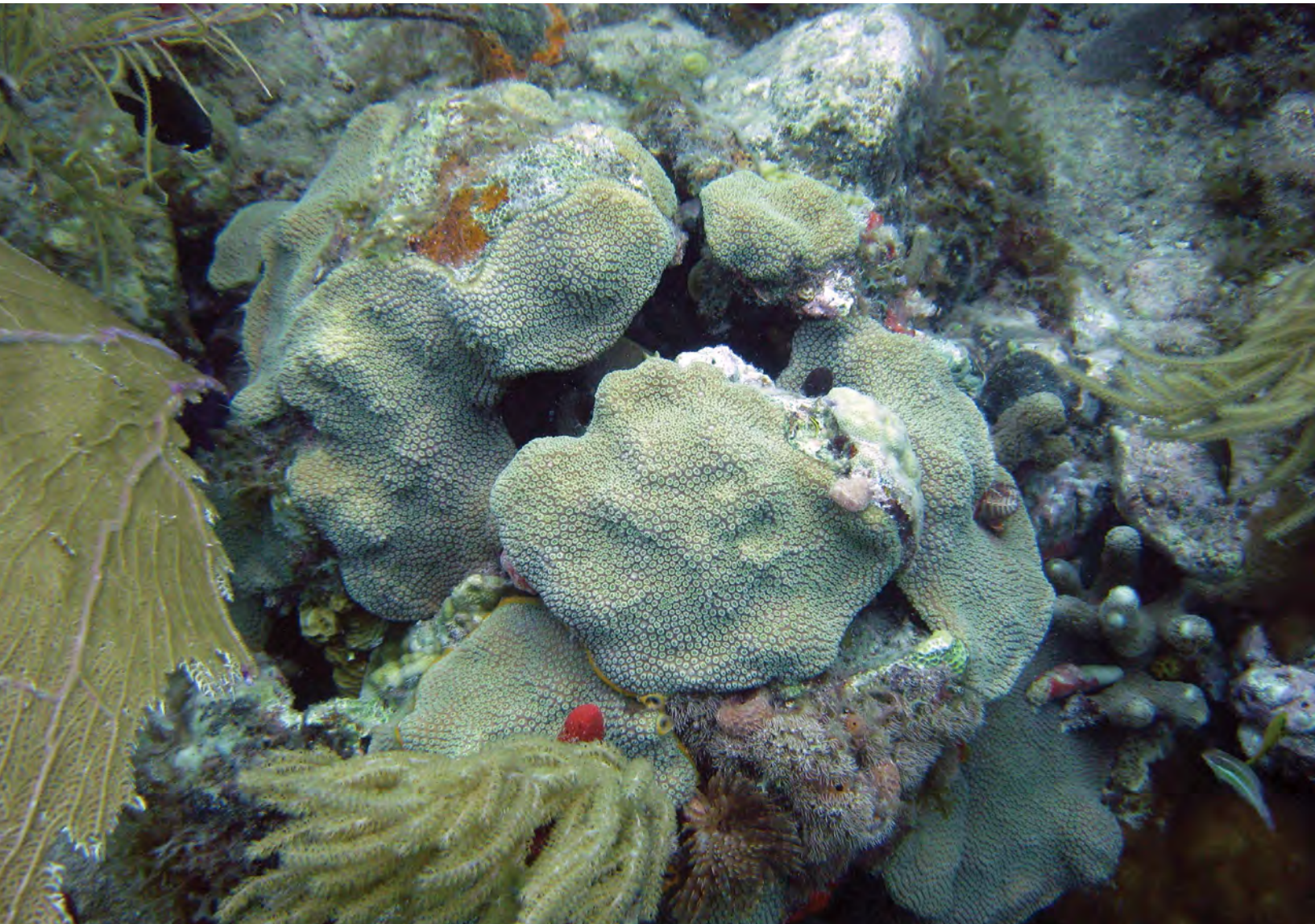




Maps of hardbottom survey sites sampled in St. John (top) and St. Croix (Bottom). VIIS - Virgin Islands National Park, VICR - Virgin Islands Coral Reef National Monument, BUIS - Buck island Reef National Monument.

Number of hardbottom surveys included in the temporal trend analysis. Surveys conducted in the summer/fall months were included for the years specified. VIIS - Virgin Islands National Park, VICR - Virgin Islands Coral Reef National Monument, BUIS - Buck island Reef National Monument.

Marine Protected Area	Location	Metric	Years	Number of Surveys
Buck Island Reef National Monument	Inside	Fish and Benthics	2003-2010	275
	Outside	Fish and Benthics	2003-2010	216
Virgin Islands National Park	Inside	Fish and Benthics	2002-2011	130
	Outside	Benthics	2002-2011	108
Virgin Islands Coral Reef National Monument	Inside	Fish	2002-2011	316
	Inside	Benthics	2003-2010	265
	Outside	Benthics	2003-2010	268
Virgin Islands National Park AND Virgin Islands Coral Reef National Monument	Outside	Fish	2002-2011	416



U.S. Department of Commerce

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