REPORT: CARIBBEAN FISHERY MANAGEMENT COUNCIL

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REVIEW OF RESEARCH IN THE GRAMMANIK BANK AND HIND BANK MCD, ST. THOMAS, USVI

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ISLA MAR RESEARCH EXPEDITIONS

TABLE OF CONTENTS

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Front cover image: Coney by JP Zegarra

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Nassau grouper by JP Zegarra

Two marine protected areas (MPAs) in the U.S. Caribbean economic exclusive zone of St. Thomas, USVI are closed to fishing all year or seasonally. Grammanik Bank hosts a multi-species spawning aggregation site for certain groupers and snappers and is closed to fishing from February 1 to April 30 each year, except fishing for approved highly migratory species. The Hind Bank Marine Conservation District is a well-known spawning aggregation site for red hind (*Epinephelus guttatus*) and is closed all year to fishing and anchoring. This review was designed to present an overview of various types of research that have been conducted directly in – or provide some mention of – the Grammanik Bank and Hind Bank MCD in St Thomas, USVI.

There were a total of 229 items that were discovered in the search that related to Grammanik Bank or Hind Bank MCD in some capacity. A total of 59 peer-reviewed publications have focused on these two MPAs. These items are summarized in a general context to describe the work that has been performed to date.

However, a detailed summary (Directory) of each individual project or item reviewed in the search can be found in the Repository and outlined in the Directory spreadsheet.

The oceanographic components (Biological, Physical, and Geological) were the most abundant sources of research. The benthos of both sites (bathymetry, geological composition, biological habitat characterization) and information on key target species' fish spawning aggregations (FSAs) at the sites have been well documented. Connectivity (such as migration potential) between both MPAs has also been demonstrated for some fish species. Larval connectivity and transport potential have been recently explored and could be expanded upon to model other target fish species. The benefits of both MPAs for protecting FSAs have also been clearly defined and demonstrated. Additional work should be focused on evaluating the Socioeconomic, Management, and Governance aspects that are critical to understanding how MPAs are impacting the communities around them.

INTRODUCTION

Two marine protected areas (MPAs) in the U.S. Caribbean economic exclusive zone (EEZ) of St. Thomas, USVI are closed to fishing all year or seasonally (Figure 1). The EEZ, or Federal waters, begins three nautical miles (nm) from shore and extends up to 200 nm from shore. Both MPAs are included in this literature review.

Grammanik Bank is located south of St. Thomas, USVI (18°11.898′ N, 64°56.328′ W; 18°11.645′ N, 64°56.225′ W; 18°11.058′ N, 64°57.810′ W; 18°11.311′ N, 64°57.913′ W). This MPA hosts a multi-species aggregation site for certain species of groupers and snappers. The MPA is closed to fishing from February 1 to April 30 each year, except fishing for approved highly migratory species (HMS) (50 CFR 622.514(a)(1)(i)). Fishing with pots, traps, bottom longlines, gillnets and/or trammel nets is prohibited year-round at Grammanik Bank (50 CFR 622.514(a)(1)(ii)).

The Hind Bank Marine Conservation District (Hind Bank MCD) is located south of St. Thomas, USVI (18°13.2' N, 65°06.0' W; 18°13.2' N, 64°59.0' W; 18°11.8' N, 64°59.0' W; 18°10.7' N, 65°06.0' W). This MPA is closed all year to fishing and anchoring (50 CFR 622.514(a)(2)), including the prohibition of fishing for HMS and spiny lobster.

These MPAs are managed by the Caribbean Fishery Management Council (CFMC) through regulations proposed and voted on during council sessions and then legally established in the Code of Federal Regulations (CFR).

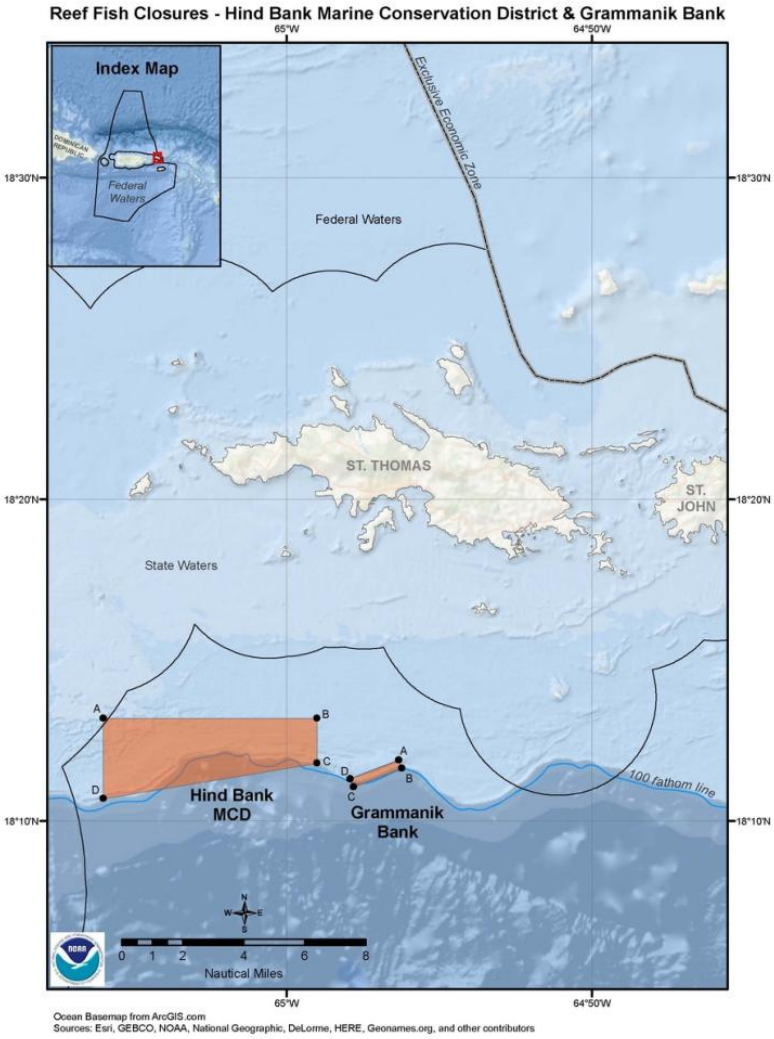


Figure 1. Map of the closure locations at Grammanik Bank and Hind Bank Marine Conservation District, St. Thomas, USVI. Image from NOAA.

The seasonal closure for Grammanik Bank was first implemented in 2005 via Amendment 3 to the Reef Fish Fishery Management Plan (FMP). Then, the additional prohibition of select gear types was implemented via Amendment 2 to the Spiny Lobster FMP in 2005 and as part of the Caribbean Sustainable Fisheries Act (Final Rule 70 FR 62073).

The Hind Bank MCD was first established in 1990 through Amendment 1 of the Reef Fish FMP. The area was closed seasonally from December 1 through February 28 as requested by fishers of St. Thomas and St. John where the use of any fishing gear capable of capturing reef fish, such as fish traps, hook and line, and spear was prohibited during this time. Then in 1999, an amendment to the Coral FMP brought about the current status of Hind Bank MCD as a fully closed area prohibiting fishing of any kind and prohibiting anchoring.

REVIEW RATIONALE

The purpose of this review was to gather and collate a database of all relevant biological, physical and geological research (survey reports, published literature, theses, and past and current projects), socio-economic research (evaluations of economic impacts), and management and governance aspects (meeting minutes, management plans, regulations) from both MPAs. These indicators have been shown to provide an outline for gathering relative materials and data that can be used to evaluate MPAs (Pomeroy et al. 2004). In this case, the categories were used to provide a framework for data mining. This report describes the information obtained and identifies any significant knowledge gaps.

Peppermint goby by Chelsea Harms-Tuohy

METHODOLOGY

The literature search was performed from April to December 2022 and included an extensive online search through a variety of outlets (Table 1). An organizational structure was created to categorize the information for storage and reference, using this structure as a means to focus both the search and the results obtained (Figures 1 and 2). Studies that focused specifically on direct aspects of the MPAs were the focal search, but those studies that also mentioned either MPA were included to highlight the interest, recognition, and/or spotlight of the MPAs outside of the US territorial science realm.

An online repository was created to house all information obtained. A spreadsheet was created to provide a quick reference to the various materials and where to find them. Following this extensive search, each item was reviewed, and a summary was created per item that briefly described the purpose and results.

Table 1. The various outlets that were searched to collate the research that has been conducted in Grammanik Bank and/or Hind Bank MCD.

Category	Mediums Searched	Products Sought
Scientific	Google Scholar Research Gate	Scientific Publications Technical Reports
Academic	Individuals contacted University archives	Theses Unpublished reports Current project summaries Presentations/Posters
Non-governmental organizations	SCRFA GCFI	Conference proceedings Abstracts
Federal	CFMC digital library NOAA Code of Federal Regulations	Technical reports Meeting minutes Fisheries bulletins Regulations
Media	News Websites	Local articles Newsletters

INDICATORS & DATA ORGANIZATION

OCEANOGRAPHY
BIOLOGICAL, PHYSICAL, GEOLOGICAL

MANAGEMENT
AND GOVERNANCE

SOCIOECONOMIC

Data Organization

1

Theme
Biological
Physical
Geological
Socio-economic
Management
Governance
News & Media

2

Type
Peer Reviewed
Proceedings
Abstracts
Presentations
Posters
Theses
Reports
Books/Chapters
NOAA Tech Memos
Minutes
Resources

3

Focus
Conducted in
Hind Bank or
Grammanik Bank

Mention of
Hind Bank or
Grammanik Bank

4

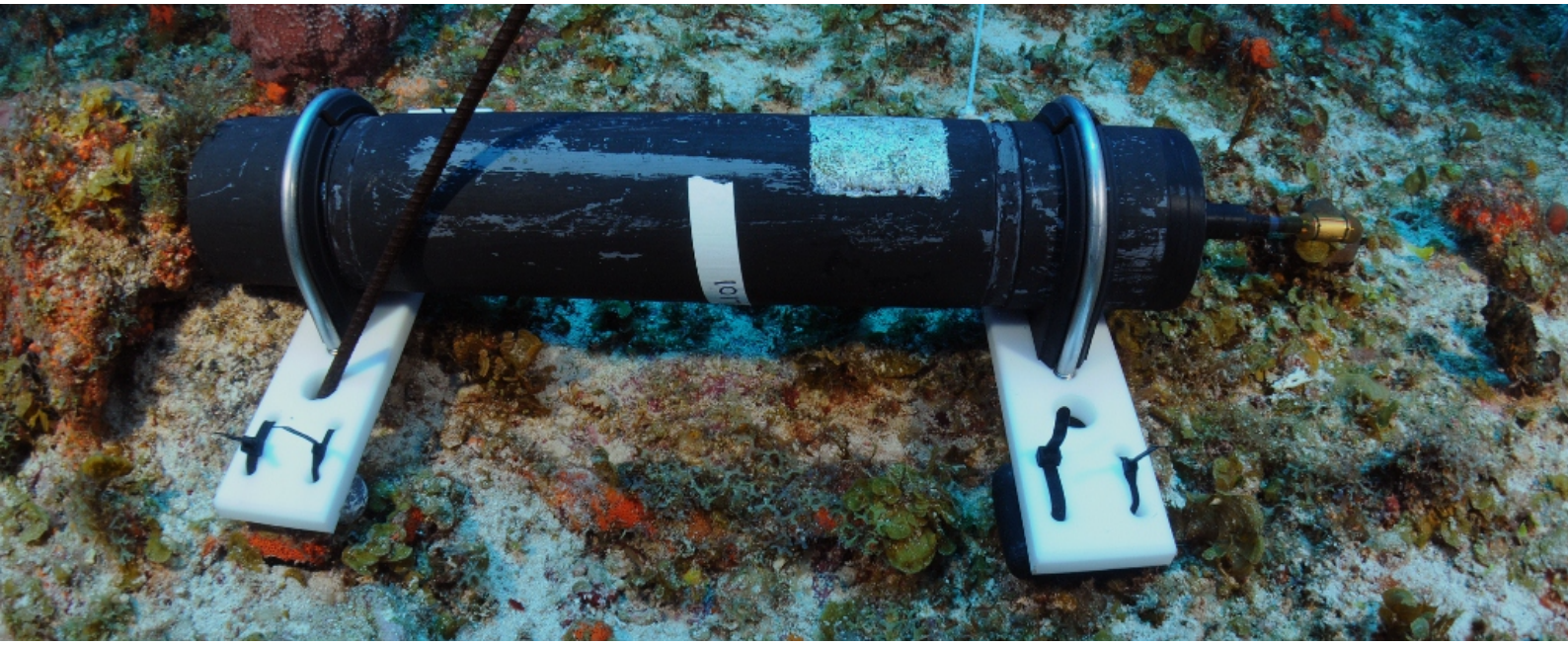
Item
.pdf
.ppt/pptx
URL

Figure 2 (Above). The categories of indicators used to direct the search and structure the review.

Figure 3 (Left). The organization of the data obtained, used to structure the Repository and organize the Directory.

RESULTS AND DISCUSSION

There were a total of 229 items that were discovered in the search that related to Grammanik Bank or Hind Bank in some capacity. A total of 59 peer-reviewed publications have focused on these two MPAs. These items are summarized below in a general context to describe the work that has been performed to date in these MPAs. However, a fully itemized summary (Directory) of each individual project or item reviewed in the search can be found in the Repository and outlined in the Directory spreadsheet.



Digital spectrogram recorder by JP Zegarra

SUMMARIES

Each theme is generally summarized, providing a simplified overview of the detailed summaries that can be found in the Directory. Key results have been specifically mentioned, with the reference linked to its document in the Repository. Many of the published studies have been presented at scientific conferences, the majority of which were presented at the Gulf and Caribbean Fisheries Institute annual conference and are summarized under Proceedings in the Directory document. Where no proceedings were available, other studies were categorized as Abstracts and Posters, and information was extracted for a summary. While these fall within the same realm related to Conferences, they were maintained separately for ease of separating in the Directory and Repository where detailed information was either available (Proceedings) or not available (Abstracts, Posters). This also served the purpose of documenting that research in these MPAs was presented at scientific conferences, even if the information was later published. The same can be said for student theses, which may or may not have also been recorded here as published, peer-reviewed work. Presentations were filed in the Directory to showcase work that has been presented at non-scientific conferences, noting the dissemination of information to other audiences such as fisher and manager stakeholders.

BIOLOGICAL

The Biological category represented the majority of the items that were reviewed for this report (n= 148), and where the most peer-reviewed literature was populated (n= 50). This category encompassed research that focused on benthic habitat mapping and characterization of the MPAs, fish community structure and connectivity, fish spawning aggregation (FSA) dynamics and characterization, and characterization of mesophotic coral reef ecosystems (MCEs), where the last two topics represented the major focal themes.

Nassau grouper spawning aggregation by Jim Hellemn

Those studies focused on characterizing the MCE habitat at Hind Bank report the coral cover estimated at 24%-43% and dominated by *Montastraea annularis* (Armstrong et al. 2006, Smith et al. 2010) with Grammanik Bank dominated by well-developed reefs of *Orbicella faveolata* and *Agaricia spp*. Interestingly, there were also studies that presented contradictory views on the MCE deep-reef hypothesis where one study that included Hind Bank (Smith et al. 2016) observed that deep reefs (30-75m) are just as vulnerable to coral bleaching as shallow water coral reefs and may not provide that refuge from environmental stress to shallow-water corals, while other studies state that MCEs may be serving as a reproductive refuge specifically for *M. cavernosa* (Bloomberg and Holstein 2021), *Orbicella faveolata* (Holstein et al. 2015), and *Porites asteroides* (Holstein et al. 2016). Several book chapters have also been devoted to MCEs at these MPAs, with one entire chapter strictly about the USVI and research conducted on MCEs at Hind Bank and Grammanik Bank (Smith et al. 2019). Extensive habitat mapping has provided reliable sources for benthic structure composition at these sites (Prada 2003).

Many acoustic and conventional fish tagging studies have been conducted in both MPAs. One study analyzed 10 years of shark tagging data from tagged juvenile and young-of-the-year blacktip sharks (*Carcharhinus limbatus*) and lemon sharks (*Negaprion brevirostris*) in the USVI, reporting an instance of a sighting in Hind Bank for blacktip (Legare et al. 2020). Another shark study of 30 tagged sharks observed that lemon sharks demonstrated a marked increase in activity around grouper FSAs during the spawning months while tiger and Caribbean reef sharks did not exhibit this orientation (Pickard et al. 2016). Overall, the most extensive fish tagging studies have been those led by or collaborated with the Nemeth Lab at the University of the Virgin Islands (Nemeth 2005, Nemeth et al. 2007, Pittman et al. 2014, Rowell et al. 2015, Biggs and Nemeth 2016, Nemeth et al. 2020) that have tagged and monitored red hind (*Epinephelus guttatus*), Nassau grouper (*E. striatus*) and yellowfin grouper (*Mycteroperca venenosa*) extensively.

BIOLOGICAL CONTINUED

Several studies indicate the benefit of each MPA to FSAs, whether directly or indirectly. One study, a follow-up after the closure at Hind Bank, shows that red hind average density and biomass increased by 60% after the permanent closure, and that these fish also migrated out of the MPA thereby contributing to the fishery (Nemeth 2005) which was also supported early-on after the closure (Beets and Friedlander 1997). Another study recommended the year-round fishing closure of Grammanik Bank following the authors' study of the temporal dynamics of two snapper aggregations in the area (Kadison et al. 2006). Additionally, one fish tagging study observed connectivity via direct fish movements between nearshore protected waters and spawning aggregation sites on Grammanik Bank, indicating that this MPA network dispersed between non-MPA waters in the USVI is serving the intended purpose of providing protection corridors for fish species of interest (Pittman et al. 2014).

Several species of grouper aggregations (*E. striatus, E. guttatus, M. venenosa*) have been characterized at both MPAs using a variety of methods including passive acoustics (Schärer et al. 2012, Cherubin et al. 2020,), acoustic telemetry (Rowell et al. 2015), ultrasonic imaging (Whiteman et al. 2005) or combinations of multiple methods (Costa et al. 2014). The yellowfin grouper FSA at Grammanik Bank was recently evaluated and found to be currently stable (Nemeth et al. 2020). A very recent assessment of the closure at Hind Bank on the red hind FSA indicated significant improvement and recovery to the species where after 30 years of protection, the mean size of red hind at the FSA site increased by >35% and the population sex ratio of females to males was less skewed compared to those prior to protection (Rosemond et al. 2022).

But a recent presentation given to the CFMC about the Nassau grouper FSA at Grammanik Bank indicated that Nassau grouper are still present at the site after the seasonal fishing closure ends and suggests that the closure duration be extended as well as site closure boundaries (Kadison 2020).

Scientific reports from long-term monitoring via the USVI Territorial Coral Reef Monitoring Program (TCRMP) were abundant, with reports in existence from as early as 2001, however, Hind Bank and Grammanik Bank were mentioned for the first time in the 2003 report. In the report from 2011, high densities of lionfish are reported at both MPAs (Smith et al. 2012). Other occurrences, such as impacts from Hurricane Maria and the presence of *Ramicrusta* were reported in the 2017 monitoring season, with positive signs showing increases in grouper abundance including Nassau grouper at Grammanik Bank (Smith et al. 2017). The report from 2019 mentions the arrival of stony coral tissue loss disease (SCTLD) at both MPAs (Ennis et al. 2019).

A diver replaces equipment at Grammanik by Dan Mele

Then there were also several mentions of both or either MPA within other peer-reviewed literature, where the studies themselves did not necessarily take place or were focused on the MPAs, but perhaps had samples collected from the sites or the MPAs were mentioned for comparative purposes. These included studies such as identifying a new species of algae (Ballantine and Ruiz 2011), reviewing the global MPA effectiveness in protecting FSAs (Grüss et al. 2015), and assessing the biogeography of transient FSAs in the wider Caribbean (Kobara et al. 2013), and, importantly, many mentions of the success of Hind Bank MCD (Sadovy and Domeier 2005, Sadovy de Mitcheson et al. 2008, Sadovy de Mitcheson et al. 2013) among other mentions that can be reviewed in the Directory.

Finally, in discussion with active researchers, current work was summarized in the Directory. In particular, Dr. Reni Garcia-Sais discussed his current ROV work in the USVI by stating his recent findings that "*Grammanik is essentially a continuation of Hind Bank - different names - but it is the same shelf and slope system.*" He also noted that *"Grammanik may be the yellowfin grouper FSA site - but the 50-130m depth range did not appear to be their residential habitat*". There is one year remaining for this project after which a final report is expected.

A Nassau grouper swims over the reef at Grammanik by Dan Mele

PHYSICAL

The Physical category refers to research that addressed physical oceanographic dynamics at the two MPAs (n= 13 items[1]), such as currents and hydrodynamic connectivity, characterization of flow and transport and physical structuring of the benthos.

Physical dynamics at FSA sites on Hind Bank were characterized, illustrating that currents at the time of red hind spawning are vertically sheared (Cherubin et al. 2011). At Grammanik Bank, an acoustic telemetry study identified the environmental factors that affect acoustic detections, including current speed, direction, and water temperature gradient (Jossart et al. 2017). Despite some of these finer-scale characterizations, one recent study pointed out that there is still relatively little known about the interaction of the water masses between the two MPAs and the USVI Trough (Seijo-Ellis et al. 2019), even though the MPAs themselves are biologically shown to have some connectivity. Additionally, the physical drivers of MCE community structure at Grammanik Bank were also assessed using TCRMP temperature data (Groves 2016).

A presentation given at the 168th CFMC meeting presented goals and project status of addressing larval connectivity through hydrodynamic conditions between Eastern Puerto Rico and the two MPAs for red hind and mutton snapper (*Lutjanus analis*) larvae (Canals 2020). The results were later presented at the 177th CFMC meeting where the main oceanographic pathways were modeled and detected for larval transport between Puerto Rico and the USVI MPAs (Xu et al. 2022).

[1] Some items are reporting the same or similar information but were presented in different formats or venues.

GEOLOGICAL

The Geological category includes research and work (n= 5 items) that identifies the geological components of one or both MPAs, including research on sediment composition, geomorphology, bathymetry and bioerosion. Most information available was from a student thesis and resulting work on deep reef bioerosion with both MPAs as study sites. In particular, the thesis explored these MCEs to identify basic sedimentary processes integral to the development, modification, and sustainability of mesophotic coral reef structure (Weinstein 2014). Later work discussed the use of sediment grain composition to record the distribution and abundance of coral and macroalgae communities present at MCEs (Weinstein et al. 2015).

Two studies that review the management practices of MPAs highlight the success of Hind Bank and Grammanik Bank in supporting the recovery of FSAs (Grüss et al. 2014, Appeldoorn 2018). One study indicated that Hind Bank had seen a five-fold increase in grouper populations since the protection (Munro and Blok 2005). Another study reported on the fisher's perspectives to the MPAs and associated regulations by evaluating the impacts of these on their livelihoods (Kojis and Quinn 2012). A significant aspect of MPA success in St Thomas lies in the agreement reached by fishers and management, whereby both realized they were aiming for the same goal (more fish) and agreed to area closure at Hind Bank (Olsen et al. 2007) and a seasonal

Moored vessel in St. Thomas by Brendan Stephens

MANAGEMENT

The Management category includes research and work (n= 48 items) that pertain directly to the management of the MPAs, with focal themes like addressing overfishing, the effectiveness of the MPA regulations, stakeholder perspectives, and management plan goals and meeting minutes.

closure at Grammanik Bank (Magras and Olsen 2013). The inclusion of fishers in the management decisions has proven successful for MPA management, and for the grouper populations to recover within the MPA areas, spilling out to the adjacent fishable areas. The Hind Bank MCD was even used as a model for Puerto Rico's seasonal red hind closure (Marshak and Appeldoorn 2008).

MANAGEMENT CONTINUED

One study identified that although the USVI has a similar number of registered fishers per island, the fishable area of St Thomas and St John is much greater. By comparing the abundances of commercially important fish, the study notes that fishing pressure is driving the differences in those abundances. They suggest that the use of scuba for commercial spearfishing should be closely examined for its potential role in the overexploitation of large-bodied snappers and groupers. They also suggest a ban on the harvest of all large-bodied grouper species to help to reestablish populations and self-sustaining spawning aggregations (Kadison et al. 2017). Furthermore, although Hind Bank has been named a habitat of particular concern (HAPC), a recent study evaluated regional management councils' propensity to enact protection on essential fish habitat (EFH) or HAPC, and identified that there have been only two cases where this has occurred, with one being Hind Bank MCD (Sewell and Masterson 2021).

Many presentations to the CFMC focused on management actions within the MPAs, including Office of Law Enforcement (OLE) reports, outreach reports, regulation overviews, and literature reviews. These presentations that are cataloged in the Repository and described in the Directory were those that were digitally available for review (i.e., recent years), and this report recognizes that there is a multitude of past presentations that were not made available and therefore not included here.

GOVERNANCE

This category collated the various management plans and associated amendments (n= 12 items), Federal Code of Regulations documents, and associated CFMC management material for both MPAs. This category was most useful in documenting the timeline of the development of the MPAs, which was outlined in the Introduction.

SOCIOECONOMIC

The Socioeconomic category did not contain any peer-reviewed literature, only reports by NOAA and reports developed for the CFMC (n= 3 items). This category assessed the impacts of the MPA closures on the fishing communities of St Thomas and St John. Specifically, one report from 2007 identified that the year-round closure of Hind Bank did result in crowding in other fishable areas and indicated that fishers feel that additional closed areas will heighten fishing pressure in the region with limited fishable grounds (Agar and Stoffle 2007). This report has also been the most recent evaluation of the fisher's perspective on the closures in terms of their impact on the socioeconomic aspect.

OTHER ITEMS

Many media resources were also identified. These included local news articles, bulletins, announcements, and research showcases. Several websites house data and information related to research that has been conducted in both MPAs. These items were outlined in a separate document from the Directory since these links are often not considered permanent.

Lastly, the available CFMC meeting minutes were also reviewed to identify stakeholder perspectives regarding both MPAs. Comments from the scientific community were focused on discussing the research that has been conducted on primarily red hind, Nassau and yellowfin groupers at these sites. Over the years of meeting minutes (2008-2021), research was presented that focused on addressing questions of fish movement in and around the MPAs, target fish abundance and biomass within the MPAs, and connectivity between the two sites and eastern Puerto Rico. In general, comments from fishers were negative towards the Grammanik Bank seasonal closure, and especially towards any suggestion to increase the size of the closure area at this site. In particular, in 2014, fishers requested that the Grammanik Bank seasonal closure effectiveness be evaluated. In regard to Hind Bank, the sentiments were initially negative, but in later meetings it became apparent that fishers did support this closure and were able to see the benefits of the increase in red hind abundances outside of the closed area. They indicate that the success of this MPA is largely due to the support and compliance of fishers. In most recent meetings (2019-2021), fishers were requesting the Council to provide evidence of the success of both MPAs aside from single-species accounts of improvement in abundance and biomass.

Additionally, fishers also requested that more outreach be generated and geared towards non-commercial fishers that visit Grammanik Bank, as they explained that enforcement issues are occurring from recreational charters or fishers that are not familiar with the area. Compliance with MPA regulations was stated to be high for both MPAs by commercial fishers. Finally, fishers commented in 2019 that they want to know more about what other species of interest use these MPAs besides red hind, Nassau and yellowfin. Recently (2020), fishers expressed their desire to have both MPAs reopened to fishing.

St. Thomas by Andy Feliciotti

CONCLUSIONS

This review was designed to present an overview of various aspects of research that have been conducted directly in – or provide some mention of – the Grammanik Bank and Hind Bank MCD marine protected areas in St Thomas, USVI. This review was not designed to evaluate the effectiveness of either MPA.

The scientific and oceanographic components (Biological, Physical, and Geological) were the most abundant sources of research. The benthos of both sites (bathymetry, geological composition, biological habitat characterization) and information on key target fish species' FSAs at the sites have been well documented. Connectivity (such as migration potential) between both MPAs has also been demonstrated for some fish species.

Larval connectivity and transport potential have been recently explored and could be expanded upon to model other target fish species besides red hind. The benefits of both MPAs for protecting FSAs have also been clearly defined and demonstrated.

Additional work should be focused on evaluating the Socioeconomic, Management, and Governance aspects that are critical to understanding how MPAs are impacting the communities around them. These aspects are often the more difficult components to address and require well-developed project designs to ensure that the appropriate information is being collected and evaluated in the most effective way.

RECOMMENDED STUDIES

The following recommended studies are suggested to help reduce the knowledge gaps that were identified in this review.

- An evaluation of enforcement (governance stakeholders) and compliance (fisher stakeholders) using an objective and standardized approach.
- A multi-faceted evaluation of the socioeconomic influence of both MPAs on stakeholders.
- A review of the effectiveness of outreach to stakeholders regarding the initial development and current status of each MPA and the community response
- An in-depth review of the effectiveness of each MPA as structured by Pomeroy et al. 2004

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