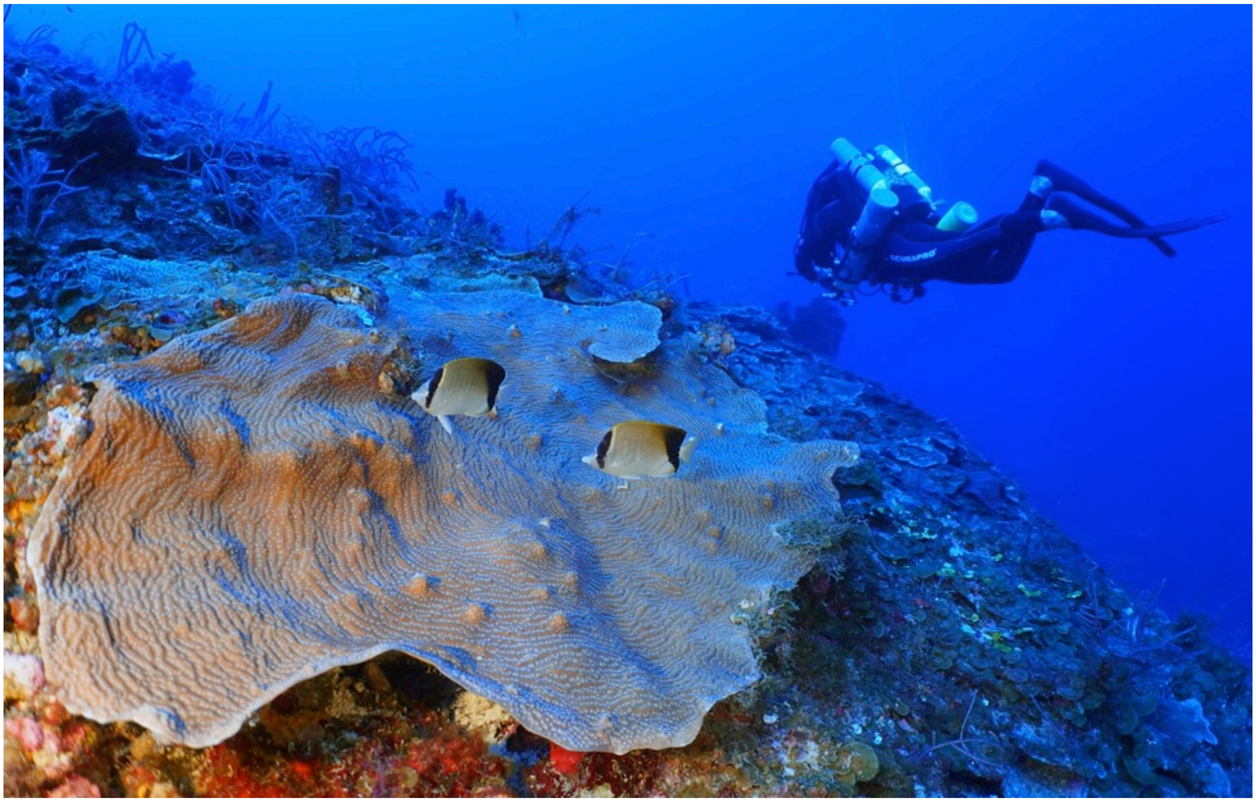
METHODS



A TCRMP research diver (T. Smith) on closed circuit rebreather records a fish transect at the lower mesophotic coral reef site Ginsburgs Fringe at 63m/220' depth (April 20, 2017; photo credit: V.W. Brandtneris).

Methods

BENTHIC ASSESSMENTS

The University of the Virgin Islands determined the benthic composition at 33 long-term monitoring sites between 2001 and 2015 (Fig. 16). All data is now available at the TCRMP website and updated annually after quality control:

https://sites.google.com/site/usvitcrmp/home

Around St. Croix the following 14 sites were assessed: Buck Island-St. Croix, Cane Bay, Cane Bay Deep, Castle, Eagle Ray, Great Pond, Jacks/Isaacs Bay, Kings Corner, Lang Bank East End Marine Park (Lang EEMP), Lang Bank Red Hind Fish Spawning Aggregation (Lang Hind), Mutton Snapper, Salt River, Salt River Deep, and Sprat Hole. Four of these sites are within the St. Croix East End Marine Park boundary (Castle, Great Pond, Jacks Bay, Lang EEMP), three sites are within National Park Service boundaries (Buck Island-St. Croix, Salt River West, and Salt River Deep), two sites are within federal fisheries marine protected areas (Lang Hind, Mutton Snapper), and four sites can be considered mesophotic coral reefs (Cane Bay Deep, Lang Bank EEMP, Lang Hind, Salt River Deep; sensu Ginsburg 2007) . Salt River Deep transects 1-4 established at 40 m depth in April 2009 sampling were relocated upslope to 30 m in the January 2010 sampling due to low coral cover in the deeper transects.

Around St. John-St. Thomas the following 19 sites were assessed: Black Point, Botany Bay, Brewers Bay, Buck Island-St. Thomas, Coculus Rock, College Shoal East, Coral Bay, Fish Bay, Flat Cay, Ginsburgs Fringe, Grammanik Tiger FSA, Hind Bank FSA, Little St. James, Magens Bay, Savana Island, Seahorse Cottage Shoal (Seahorse), Meri Shoal, South Capella, and South Water Island. One site is the within the St. Thomas East End Reserve (Coculus Rock), four sites are within federal fisheries marine protected areas (College Shoal, Ginsburgs Fringe, Grammanik Tiger, Hind Bank), and five sites can be considered mesophotic coral reefs

(College Shoal, Ginsburgs Fringe, Grammanik Tiger, Hind Bank, Meri Shoal). Four sites were also part of the Ciguatera Fish Poisoning Monitoring Program and were surveyed monthly for benthic structure and coral health from 2010-2016 (Black Point, Coculus Rock, Flat Cay, Seahorse). Because of its deep depth, Ginsburgs Fringe at 60-66m was only sampled for benthic cover and some fish transects.

Benthic Cover. At each site benthic cover and coral health surveys were conducted along six 10 m long permanent transects marked with steel or brass rods. In 2016 video sampling consisted of one diver traversing each transect videotaping the benthic cover using a high definition video cassette recorder (Sony FX-7 in Light and Motion housing) or an HD digital video recorder with wide angle lens (Canon XF in Light and Motion housing). The diver swam at a uniform speed, pointing the camera down and keeping the lens approximately 0.4 m above the substrate at all times. A guide wand or dropper weight attached to the camera housing was used to help the diver maintain the camera a constant distance above the reef. After taping, approximately 20 - 50 non-overlapping images per transect were captured and saved as JPEG files (Fig. 17). Captured images represented an area of reef approximately 0.31 m^2 (0.64 m x 0.48 m). Coral Point Count with Excel Extension software (Kohler and Gil 2006) was used to superimpose randomly located dots on each image. The number of points varied with the evolution of the video camera systems and was 10 points from 2001-2011, 15 points from 2012-2013, and 20 points from 2014 onwards. The substrate type located under each of the dots was then identified to the most descriptive level possible and entered into a database. Where multiple benthic cover categories fell under a single point, for example macroalgae over bedrock, the upper benthic category was assessed. For each transect, the percent cover of coral, epilithic algae (formerly called dead coral with turf algae), macroalgae, sponges, gorgonians, and sand/sediment were calculated by dividing the number of random dots falling on that substrate type by the total number of dots for that transect. Epilithic algae (sensu Hatcher and Larkum 1983) are diminutive turfs and filamentous algae without thallus structure that cover all rock surfaces of coral reefs not occupied by larger epibenthic organisms. They can also be considered to be grazed surfaces and are often an indicator of healthy grazing communities and high sessile animal cover.

Figure 17. A screen grab of benthic video used for the determination of percent cover of coral reef organisms and non-living substrate.

Table 1. TCRMP site reef complex type, location coordinates (decimal degrees; WGS 1984), and depths. FSA = Fish Spawning Aggregation. EEMP = East End Marine Park.

Island	Site	Reef Complex	Lat	Long	Depth (m)
St. Croix	Buck Island-St. Croix	Offshore-Shallow	17.78500	-64.60917	15
	Cane Bay	Nearshore	17.77388	-64.81350	10
	Cane Bay Deep	Offshore-MCE	17.77661	-64.81522	38
	Castle	Offshore-Shallow	17.76278	-64.59743	7
	Eagle Ray	Offshore-Shallow	17.76150	-64.69880	10
	Great Pond	Nearshore	17.71097	-64.65221	6
	Jacks Bay	Nearshore	17.74337	-64.57160	14
	Kings Corner	Nearshore	17.69116	-64.90008	17
	Lang Bank EEMP	Offshore-MCE	17.72145	-64.54706	27
	Lang Bank Red Hind FSA	Offshore-MCE	17.82372	-64.44943	33
	Mutton Snapper FSA	Offshore-Shallow	17.63660	-64.86240	24
	Salt River Deep	Offshore-MCE	17.78523	-64.75917	30
	Salt River West	Nearshore	17.78530	-64.75940	11
	Sprat Hole	Nearshore	17.73400	-64.89540	8
St. John	Coral Bay	Nearshore	18.33797	-64.70402	9
	Fish Bay	Nearshore	18.31417	-64.76408	6
	Meri Shoal	Offshore-MCE	18.24433	-64.75832	30
St. Thomas	Black Point	Nearshore	18.34450	-64.98595	9
	Botany Bay	Nearshore	18.35845	-65.03330	8
	Brewers Bay	Nearshore	18.34403	-64.98435	6
	Buck Island-St. Thomas	Offshore-Shallow	18.27883	-64.89833	14
	Coculus Rock	Nearshore	18.31257	-64.86058	7
	College Shoal East	Offshore-MCE	18.18568	-65.07677	30
	Flat Cay	Offshore-Shallow	18.31822	-64.99104	12
	Ginsburgs Fringe	Offshore-MCE	18.18770	-64.95998	63
	Grammanik Tiger FSA	Offshore-MCE	18.18885	-64.95659	38
	Hind Bank East FSA	Offshore-MCE	18.20217	-65.00158	39
	Magens Bay	Nearshore	18.37425	-64.93438	7
	Savana	Offshore-Shallow	18.34064	-65.08205	9
	Seahorse Cottage Shoal	Offshore-Shallow	18.29467	-64.86750	20
	South Capella	Offshore-Shallow	18.26267	-64.87237	20
	South Water	Offshore-Shallow	18.28068	-64.94592	20
	St James	Offshore-Shallow	18.29459	-64.83238	15

Table 2. TCRMP site sampling data (benthic/health) and type of sampling. Pre and post-storms sample dates refer to surveys completed prior to the passage of Hurricanes Irma (9/6/17) and Maria (9/19/17). Incomplete surveys indicated by "-" while completed surveys indicated by "X".

Island	Site	Pre-storms Sample Date	Post-storms Sample Date	Benthic	Health	Fish + Urchin
St. Croix	Buck Island STX	-	2/25/18	- / X	- / X	- / X
	Cane Bay	-	2/27/18	- / X	- / X	- / X
	Cane Bay Deep	-	2/27/18	- / X	- / X	- / X
	Castle	-	2/28/18	- / X	- / X	- / X
	Eagle Ray	-	2/27/18	- / X	- / X	- / X
	Great Pond	-	3/1/18	- / X	- / X	- / X
	Jacks Bay	-	2/25/18	- / X	- / X	- / X
	Kings Corner	-	2/26/18	- / X	- / X	- / X
	Lang Bank EEMP	-	3/1/18	- / X	- / X	- / X
	Lang Bank Red Hind FSA	-	3/2/18	- / X	- / X	- / X
	Mutton Snapper FSA	-	2/26/18	- / X	- / X	- / X
	Salt River Deep	-	2/28/18	- / X	- / X	- / X
	Salt River West	-	2/28/18	- / X	- / X	- / X
	Sprat Hole	-	2/26/18	- / X	- / X	- / X
St. John	Coral Bay	8/29/17	1/18/18	- / X	- / X	X / X
	Fish Bay	8/29/17	6/5/18	- / X	- / X	X / -
	Meri Shoal	8/29/17	6/5/18	- / X	- / X	X / -
St. Thomas	Black Point	8/24/17	12/7/17	- / X	- / X	X / X
	Botany Bay	8/23/17	12/11/17	- / X	- / X	X / X
	Brewers Bay	8/31/17	11/28/17	- / X	- / X	X / -
	Buck Island STT	8/24/17	12/5/17	- / X	- / X	X / X
	Coculus Rock	8/24/17	12/2/17	- / X	- / X	X / X
	College Shoal East	8/25/17	4/17/18	- / X	- / X	X / -
	Flat Cay	-	12/12/17	- / X	- / X	X / -
	Ginsburgs Fringe	-	5/22/18	- / X	- / X	- / -
	Grammanik Tiger FSA	8/30/17	3/15/18	- / X	- / X	X / -
	Hind Bank East FSA	-	5/11/18	- / X	- / X	- / X
	Magens Bay	8/23/17	12/6/17	- / X	- / X	X / X
	Savana	8/23/17	12/4/17	- / X	- / X	X / X
	Seahorse Cottage Shoal	8/11/17	12/12/17	- / X	- / X	X / -
	South Capella	8/17/17	3/13/18	- / X	- / X	X / -
	South Water	8/31/17	3/13/18	- / X	- / X	X / -
	St James	-	1/18/18	- / X	- / X	X / X

METHODS

Coral Health. Coral health assessments followed methodologies outlined in (Calnan et al. 2008), Smith et al. 2008, and Smith et al. 2013 and are briefly described here. All coral colonies located directly under the transect lines were assessed in situ for signs of mortality and disease following a modified Atlantic and Gulf Rapid Reef Assessment protocol (Kramer et al. 2005). Starting in 2008 all colonies were assessed, regardless of size, in contrast to previous years where only colonies greater than 10 cm in maximum linear dimension were assessed. Partial mortality of coral colonies was broken into two categories. Recent partial mortality was characterized visually as skeleton not eroded (fine corallite structure still intact) and bare or with a thin veneer of sheeting or filamentous algae. Recent partial mortality is typically visible for up to three months following tissue loss. Old partial mortality was characterized as skeleton eroded and covered with turf or macroalgae. Old partial mortality is a transition from recent mortality and typically lasts up to 1–6 years (Smith et al. 2008, also see http://www.agrra.org/method/methodcor.html).

Diseases were conservatively categorized into recognized Caribbean scleractinian diseases and syndromes that included bleaching, black band disease, dark spots disease, white plague, and yellow band (blotch) disease (following Bruckner 2007). Acroporid corals were extremely rare at the study sites; thus, their associated diseases (white band and white pox) are not presented. Bleaching was assessed as abnormal paling of the colony, and, when present, the severity of the bleaching (paling or total whitening) and the area of the colony affected were assessed. A major bleaching event occurred between September and December 2005 affecting all sites monitored that year, a mild bleaching event occurred September and October 2010 affecting only shallow sites, and a mild bleaching event occurred in October and November 2012 and affected only mesophotic sites (Smith et al. 2013b; Smith et al. 2016a). On St. Croix, a subset of sites were assessed during the 2010 coral bleaching event, and included Cane Bay, Cane Bay Deep, and Jacks Bay.

For each transect, the prevalence of coral impairment categories was calculated as the number of colonies with partial mortality, disease, or bleaching divided by the number of colonies assessed. Also, for affected colonies in each transect the average three-dimensional surface area (%) of the colony affected was also estimated for each impairment category.

FISH CENSUS

Fish surveys were conducted on 17 sites in the northern USVI in 2017 before the two hurricanes, Irma and Maria, passed in September 2017 (Table 2). Unfortunately, the building housing the raw data was destroyed during the storms, before data entry, and all data sheets for two sites, Flay Cay and St. James were lost. Hind Bank East FSA was sampled post-storm in 2018 and nine sites were at least partially resampled. These sites included Buck Island STT, Botany Bay, Black Point, Coculus Rock, Megans Bay, Savana, Coral Bay and St. James. Several of these sites were sampled in December 2017, and again in March or April 2018. Fish surveys were conducted at 14 sites around St. Croix in early 2018. Ten replicate belt transects and three replicate roving dive surveys (RDS) were conducted at each site on St. Croix and during pre-storm sampling in the northern USVI. During post-storm sampling as many replicates were conducted as possible given time constraints (1-10). Belt transects were 25m x 4m and conducted in 15 minutes per replicate following protocols established by the NOAA Biogeography Branch (Menza et al. 2006; Friedlander et al. 2013). All transects were begun at a random location on the site and were swum in a random direction. RDS replicates were 15 min in duration. In previous years 30 minute RDS surveys were conducted in depths less than 20m. Because almost all diversity was captured in the first 15 minutes, for easier diving logistics, and to make deeper sites comparable, the methods were switched to 15 RDS at all sites in 2016. In addition to relative abundance data, specific total length estimates were made for each large grouper, large snapper, or hogfish (*Lachnolaimus maximus*) encountered. In all surveys, all species encountered were recorded except blennies and gobies. Data were transcribed to Microsoft Excel and Access spreadsheets and were analyzed for descriptive statistics of reef fish assemblage structure.

Divers also counted the number of *Diadema antillarum* sea urchins within 1 m on either side of a transect. From 2001 – 2008 this occurred along the 6 – 10 m long benthic transects. Starting in 2009, urchins were assessed along 25x2m belt transects corresponding to the return of the 10 fish transects. The mean number of sea urchins per 100 m^2 was calculated for each site.

TCRMP MONITORING SUMMARY

Territorial Coral Reef Monitoring Summary

TCRMP MONITORING SUMMARY

BENTHIC COMMUNITIES AND CORAL REEF HEALTH

Benthic cover was monitored at 33 monitoring sites and coral health was monitored at 32 sites in 2016. Benthic cover raw data is presented in electronic Appendix I. Coral health raw data is presented in electronic Appendix II. In addition, updated benthic cover for each site individually is presented in the "Site Summaries" section.

Coral Cover

The cover of hard corals decreased at most sites immediately after the 2005 coral bleaching event, but showed little or no change as the results of the 2010 and 2012 coral bleaching events (Fig. 18). Shallow (<25 m depth), nearshore and offshore sites with greater than about 20% coral cover showed declines in cover, but there was extreme variability in the degree of cover change. For example, the relative loss in coral cover of shallow *Orbicella* spp.[1] dominated reefs ranged from 87% at the Mutton Snapper site to less than 20% at the Brewers Bay site. Mesophotic coral monitoring sites that were sampled before and after the 2005 coral bleaching event showed lower relative losses of coral cover compared with shallow site. Losses ranged from 5.4% (Grammanik Tiger) to 36.0% (Meri Shoal).

Sites that had low coral cover prior to 2005 lost far less relative cover as the result of bleaching. While part of this may be due to detectability at coral cover values nearer to 0, and that these sites tend to be dominated by small massive species that are more resistant to bleaching and disease related mortality (Smith et al. 2013b). A few sites

[1] The genus for the species *Montastraea annularis*, *M. faveolata*, and *M. franksi* was changed to *Orbicella* Budd AF, Fukami H, Smith ND, Knowlton N (2012) Taxonomic reclassification of the coral reef coral family Mussidae (Cnidaria: Anthozoa: Scleractinia). Zoological Journal of the Linnean Society 166:465-529 and the TCRMP recognizes this change. Some figures still use "Montastraea" where they have not been converted from previous reports. Other genus revisions (e.g., *Pseudodiploria*) have not yet been incorporated.

showed no change, and included Buck Island STT, Coculus Rock, Jacks Bay, and South Water. However, the Buck Island STT site may be anomalous since transects were not permanently placed until 2007 and unprecedented prevalence of white disease was seen at this site in 2006.

Recovery since bleaching in 2005 was marginal at most sites. The majority of sites had apparently level coral cover with recovery potentially inhibited by disease and increased interactions with other organisms. However, slow and irregular upward trajectories are notable at some sites, including Black Point, Botany Bay, Cane Bay, Fish Bay, Lang Hind, Salt River West, Salt River Deep, Seahorse, and St. James. Generalities that might indicate why these sites are recovering are difficult, but the coral communities in these reefs are all diverse. This diversity may contribute to recovery as fast growing species, such as *Agaricites* spp. and *Porites porites* may lead increases in coral cover.

Some sites also showed degradation since 2007, when direct impacts of the 2005 bleaching abated. This was indicated by declines in coral cover and the sites include College Shoal, Ginsburgs Fringe, Grammanik Tiger, Magens Bay, Meri Shoal, and Savana. Four of six sites that were declining are mesophotic coral reefs, which may reflect the impact of generally higher prevalence of white diseases at high coral cover deep sites and a mild bleaching event that occurred in 2012.

In addition, the deep Ginsburgs Fringe site lost 50% coral cover between 2011 and 2016, in what appears to be a continuous decline. While lionfish are frequent at this site and there is high cover of the macroalgae *Lobophora variegata*, the most obvious cause of disturbance is anchoring. A recent derelict reef claw anchor with at least 30m of polypropylene line was seen embedded in the monitoring site in 2014. Since damage has been recurrent it is likely that one or a few people are repeatedly anchoring on the edge to fish the Grammanik Bank. The activities have broken large plates and overturned portions of a large section of the large *Agaricia* spp. colonies that compose this reef.

Ginsburgs Fringe is just along the border of the Grammanik Bank Federal Fisheries Managed Area and the site of a multi-species spawning aggregation, including Nassau grouper and yellowfin grouper (Kadison et al. 2006; Nemeth et al. 2006; Nemeth and Kadison 2013). Anchoring was likely for the purpose of fishing within the seasonal closed area, as there is little other obvious reason for anchoring at the shelf edge in deep water. Impacts to the corals and other essential fish habitat at this site may indirectly harm fishing in the US Virgin Islands.

Two nearshore shallow sites that are degrading since 2007 may be impacted for different reasons. Magens Bay is highly impacted by sedimentation since it is largely enclosed, is surrounded by steep hillsides under constant development (sediment run-off), and is susceptible to strong winter swells (Rothenberger et al. 2008). Degradation at this site may primarily be the result of sediment impacts. On the other hand, Savana is an offshore and uninhabited island next to the typically clear waters of the Virgin Passage. Degradation at this site can be largely attributed to encrusting alga (*Ramicrusta* sp.), which has been competing for benthic space and slowly decreasing coral cover by overtopping colony margins.

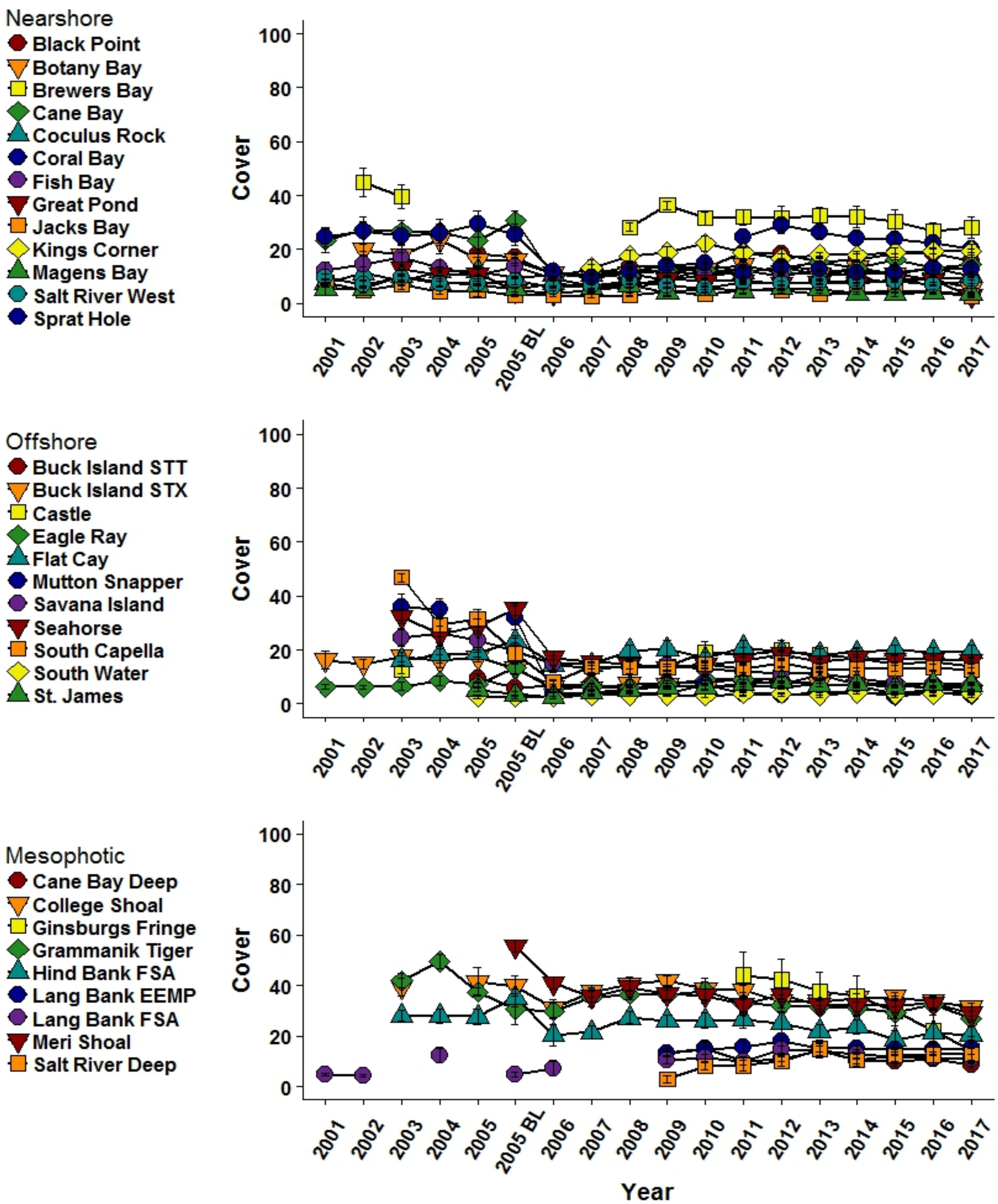


Figure 18. Coral cover (±SE) across TCRMP monitoring sites over time.

Epilithic Algal Community Cover

Algae show the highest inter-annual variability of any group of benthic organisms (Fig. 19). This is largely due to seasonality. The cover of epilithic algae is no exception, since it tends to negatively covary with more ephemeral macroalgae. Epilithic algae is important as it can indicate substrates grazed by herbivores and therefore open to the settlement of sessile epibenthic animals, including coral. Therefore, declines in the cover of epilithic algae (or increases in the cover of macroalgae and filamentous cyanobacteria) could be an early indication of declining herbivory at sites.

Some offshore sites, such as Eagle Ray, Buck Island-St. Croix, and Savana, appear to have a declining abundance of epilithic algae over the extent of the monitoring. Large recent declines in epilithic algae at Savana are due to increases in the "macroalgae" *Ramictrusta* (see next section). Nearshore and mesophotic sites typically showed little inter-annual trend in epilithic algal cover, although interannual variability was high at many nearshore monitoring sites.

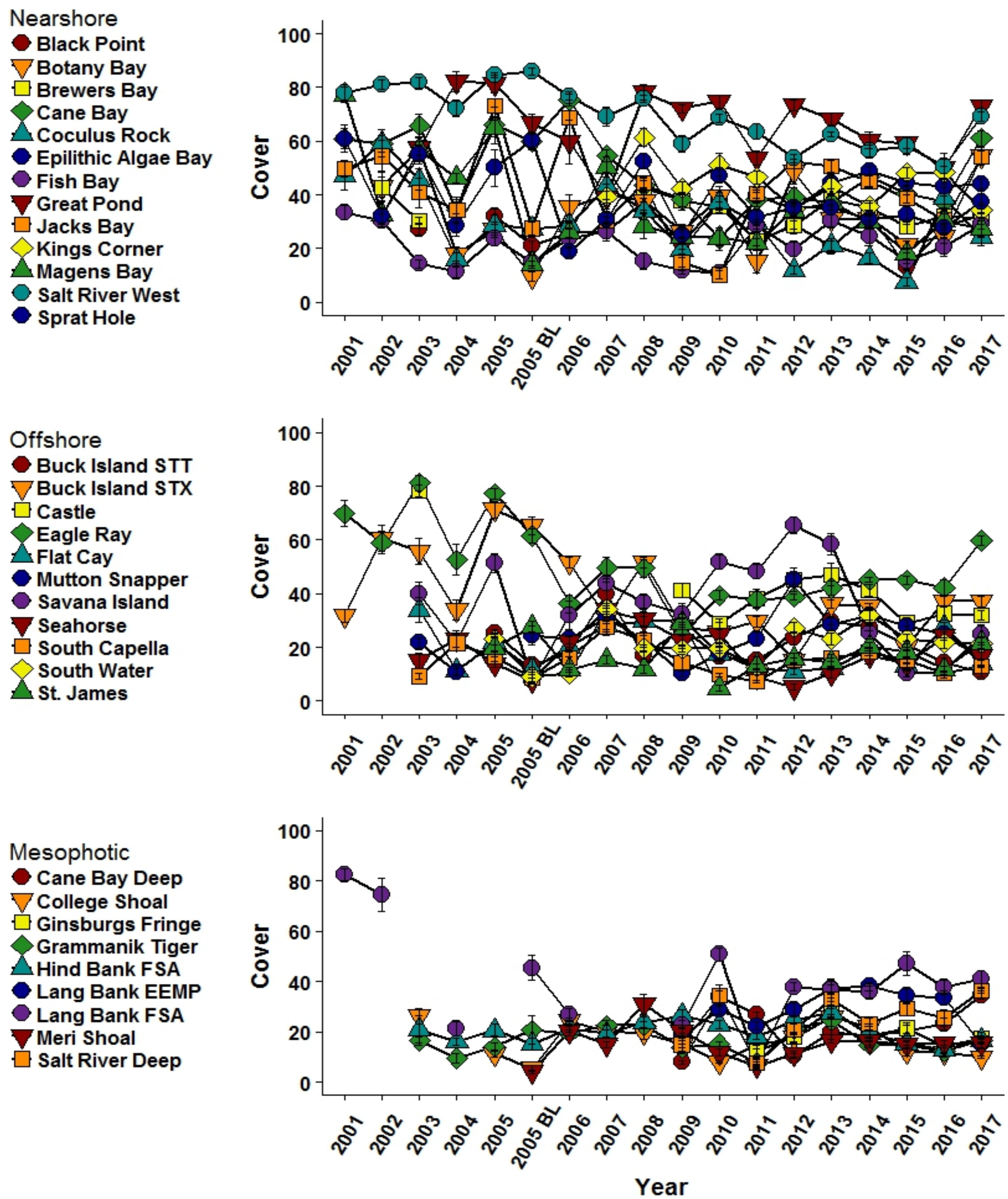


Figure 19. Epilithic Algal Community cover (±SE) across TCRMP monitoring sites over time.

Macroalgal Cover

Macroalgae have been increasing at many reefs, particularly after the 2005 bleaching event (Fig. 20). At sites where there was no loss of coral cover, increased macroalgae may be due to declining grazing, such as at Eagle Ray. At other sites where coral cover dropped after 2005, space opened for algal colonization by coral die-off may have been taken by macroalgae. This might occur where resident herbivores communities are already at the threshold of maximum grazing rates (Williams et al. 2001). This process could be enhanced where herbivores numbers are falling due to fishing. These reefs include: the Buck Islands (St. Thomas and St. Croix), Cane Bay, Meri Shoal, South Capella, and Sprat Hole. The same explanation may also apply for filamentous cyanobacteria (see following section). At Savana the large increase in macroalgae in 2014 and continuing to 2015 was due to a large increase in encrusting *Ramicrusta*, which was mentioned above as a cause of declining coral cover (*Ramicrusta* is classified with macroalgae in TCRMP data summaries despite its largely encrusting habitat). This increase in *Ramicrusta* sp. was also at the expense of epilithic algae.

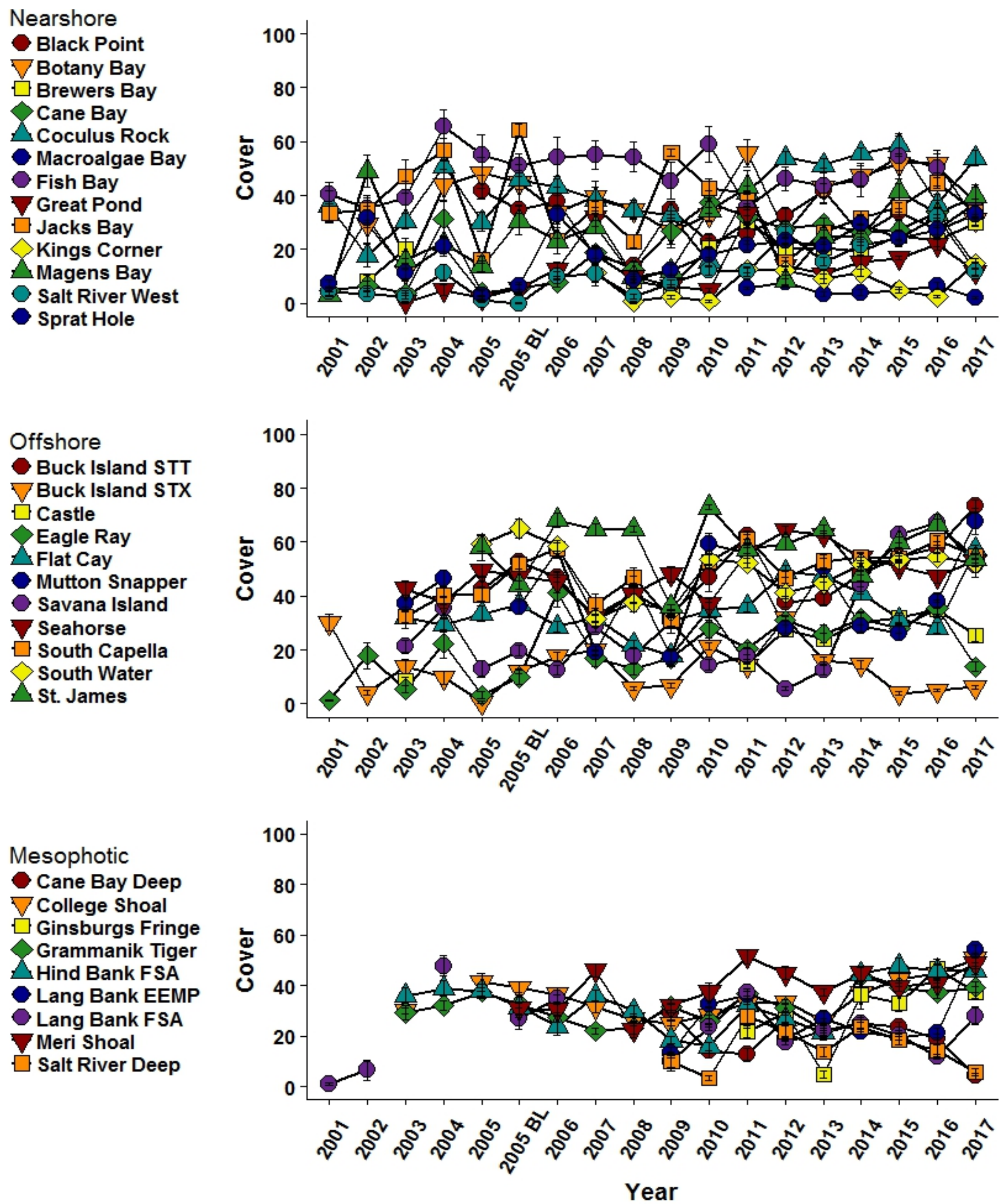


Figure 20. Macroalgae cover (±SE) across TCRMP monitoring sites over time.

Filamentous Cyanobacteria

Filamentous cyanobacteria cover has been increasing at many sites in the TCRMP since the 2005 coral bleaching event (Fig.15). In many cases this was a multi-year peak that has abated, but at some sites high cover relative to baseline has persisted until 2014. This is particularly true at many sites on St. Croix. For example, Salt River West, Jacks Bay, Cane Bay, Sprat Hole, Mutton Snapper, Buck Island-St. Croix, Eagle Ray, Lang Bank EEMP, and Lang Bank Hind have all seen cover of filamentous cyanobacteria from 10 – 60%, with 2009 as a particularly high abundance year for offshore sites.

The increased incidence of filamentous cyanobacteria can be an indication of disturbance, increased nutrient inputs, and insufficient grazing (Fong and Paul 2011). In addition, filamentous cyanobacteria can promote increases in palatable macroalgae in coral reefs by coating and protecting algae with secondary metabolites that deter grazing (Fong et al. 2006; Smith et al. 2010a). Filamentous cyanobacteria can inhibit the recruitment of coral larvae (Kuffner et al. 2006) and have been observed interacting at the borders of adult coral (TCRMP, unpub. data). Monitoring the trends of filamentous cyanobacteria in USVI reef systems will be increasingly important in future years in an effort to understand the factors influencing bloom formation and which reefs are most vulnerable.

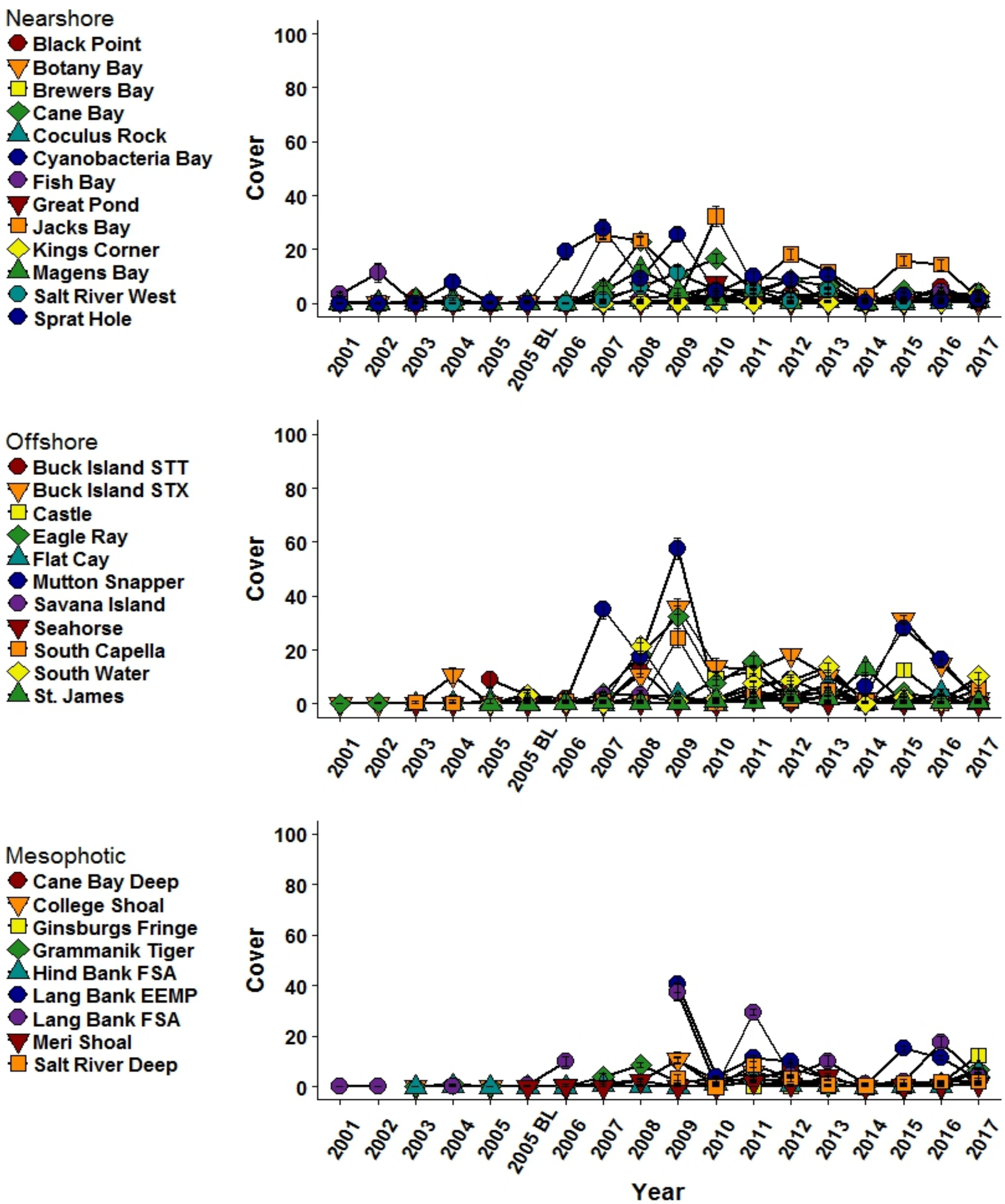


Figure 21. Filamentous cyanobacteria cover (±SE) across TCRMP monitoring sites over time.

Gorgonian and Antipatharian Cover

The cover of gorgonians and antipatharians has been fairly constant at most monitoring sites throughout the years of monitoring (Fig. 16). These groups did not seem sensitive to the thermal stress events in 2005, 2010, and 2012. In most cases they are a relatively minor component of cover because of their upright growth form and small branches. At Coral Bay, Fish Bay, and Magens Bay the cover of gorgonians has been increasing through the monitoring time series. These sites are known to have water quality issues and a high influx of terrestrial sediments. It is possible that inputs of nutrients from terrestrial run-off and poor sewage disposal are stimulating pelagic primary productivity (Furnas et al. 2005) and increasing the abundance of gorgonians that can feed heterotrophically on water column resources (De'ath and Fabricius 2010).

Note that Black Corals (antipatharians) are rare and when they occur tend to be more prominent in deep monitoring sites. For many gorgonians species their abundance tends to peak in shallow water where there is constant swell (benthic orbital turbulence).

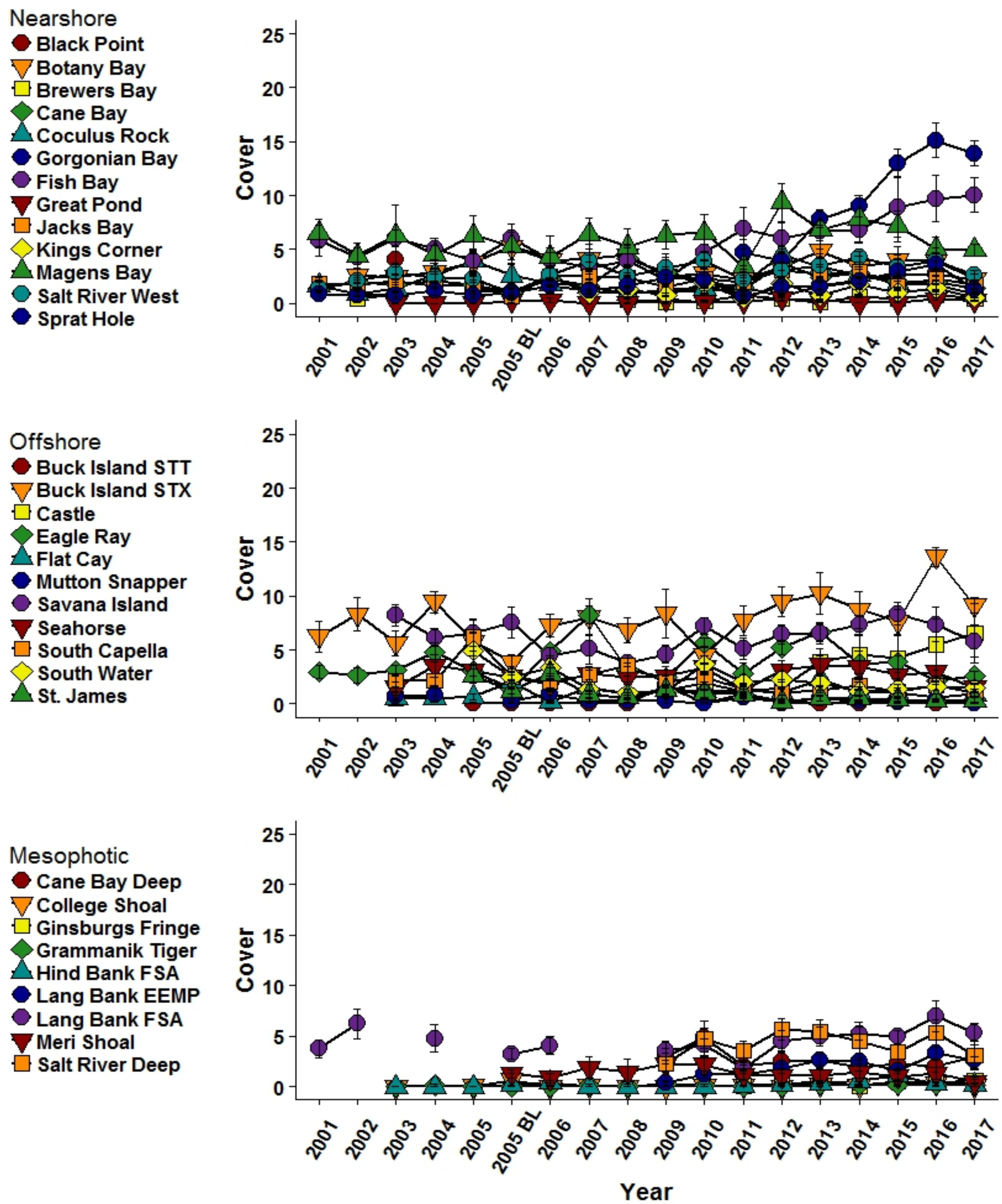


Figure 22. Gorgonian and Antipatharian cover (±SE) across TCRMP monitoring sites over time.

Sponge Cover

Sponge cover has been constant or variable at many offshore and mesophotic sites, but there is an indication of slightly increasing sponge cover at some nearshore sites (Fig. 17). Nearshore increases were most pronounced at Black Point, Coral Bay, and Magens Bay. This increase in epibenthic and boring sponges may indicate increasing supplies of food, such as bacteria and small eukaryotes, in nearshore environments. This may be a consequence of increasing nearshore nutrient pollution. Further study needs to be done to establish this linkage.

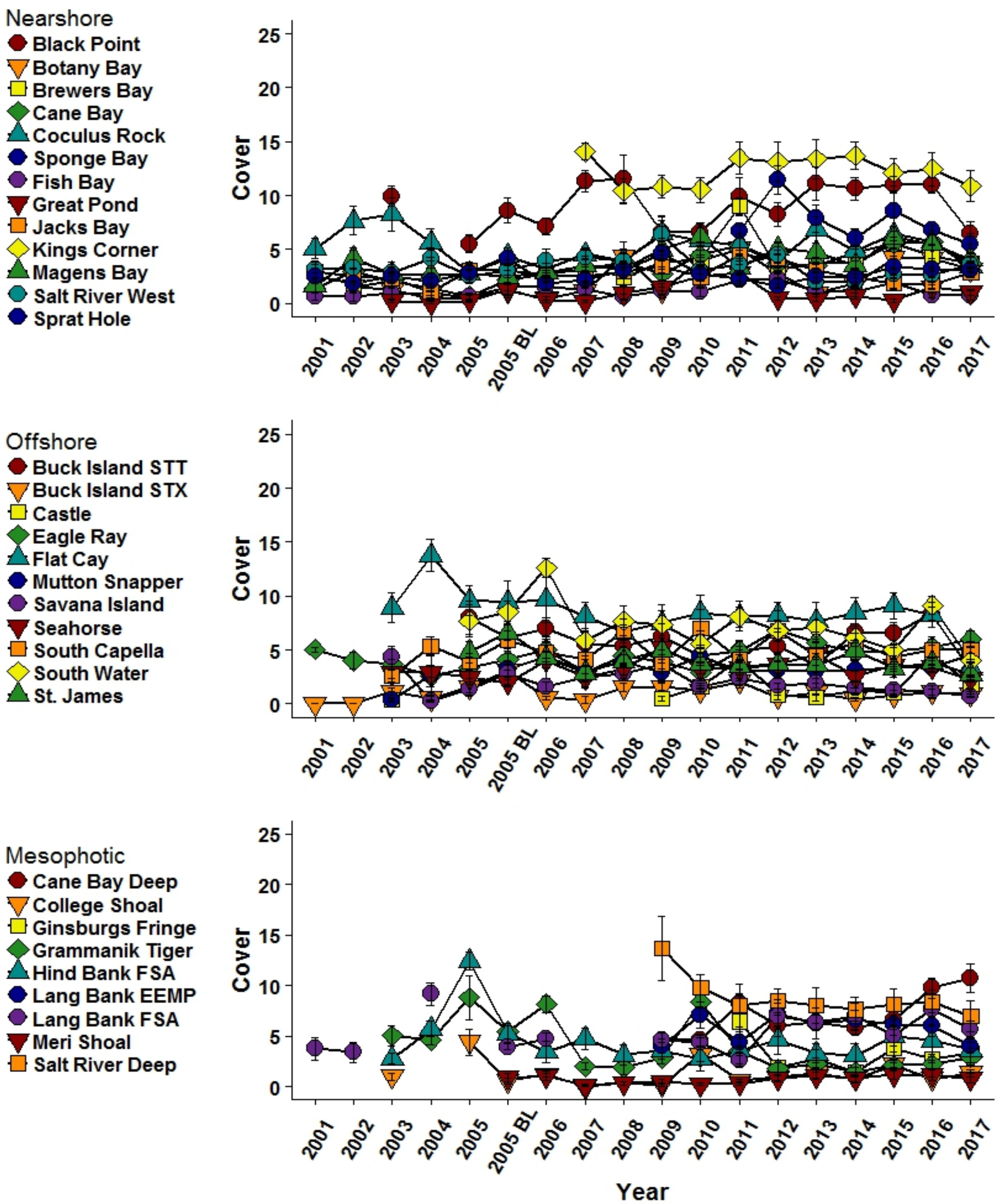


Figure 23. Sponge cover (±SE) across TCRMP monitoring sites over time.

TCRMP MONITORING SUMMARY

FISH COMMUNITIES

In 2017, before Hurricane Irma and Maria swept through the territory, a total of 40,243 fish representing 132 species and 36 families were recorded over 147 belt transects across 15 sites off the northern USVI. Data sheets were lost in the storms for two sites completed. Total calculated biomass on sites of the northern USVI was 2,710.93kg. An additional 25,170 fish representing 127 species and 43 families were recorded over 140 transects across all 14 sites off St. Croix, post-storm in 2018. The calculated biomass was 1,091.23 kg. Using roving diver surveys (RDS) 122 species representing 34 families were observed in 2017 off the northern USVI and 136 species representing 38 families off St. Croix in early 2018. Species richness was variable between sites but was similar between survey methods (transects and RDS). No differences in species richness were apparent between nearshore, offshore, and mesophotic sites (Table 3). As in previous years, sites with notably high species diversity in the northern USVI were Hind Bank East FSA, Savana Island, and Seahorse Cottage Shoal (26.4 ±2.2, 26.1±0.7 and 25.7 ± 1.3 species transect^{-1}, respectively). Lang Bank FSA and Sprat Hole off St. Croix had the highest diversity of sites on the St. Croix shelf (29.8 ± 4.0 and 27.9 ± 3.3 species transect^{-1}, respectively). On St. Croix, the sites with the lowest species richness were the two mesophotic sites Cane Bay Deep and Salt River Deep (18.8 ± 1.3 and 19.7 ± 1.2 species transect^{-1} , respectively), as well as the nearshore sites Jacks Bay and Castle (18.3 ± 1.1 and 19.2 ± 1.5 species transect^{-1}, respectively). These sites are shallow sites with very low living coral cover. Likewise, the shallow, low coral cover site in Coral Bay had the lowest species richness on the northern USVI shelf (15.8 ± 0.8 species transect^{-1}).

Overall fish size distribution in both the northern USVI and St. Croix followed trends seen in earlier years. Over 42% of all individuals counted off both the northern USVI and St. Croix were less than 5cm TL and over 70% were less than 10cm TL. Large fish (> 40cm TL) constituted 0.4% of the numeric total in the northern USVI (191 fish), and 0.1% in St. Croix (35 fish). Numerically the most dominant fish in the northern USVI were the bluehead wrasse (*Thalassoma bifaciatum*), blue chromis (*Chromis cyanae*), striped parrotfish (*Scarus iserti*), and creole wrasse (*Clepticus* *parrae*). These species were also the most abundant in the 2016 monitoring report and made up 50% of the numeric total. On St Croix reefs, bluehead wrasse, bicolored damselfish (*Stegastes partitus*), creole wrasse, and blue chromis contributed 46% to the numeric total of all sites. The four species that contributed most to biomass in the northern USVI included the bar jack (*Caranx ruber*), horseeye jack (*C. latus*), stoplight parrotfish (*Sparisoma viride*) and creole wrasse. These made up 50% of total biomass. In St. Croix the fish contributing most to biomass included the yellow goatfish (*Mugil martinicus*), creole wrasse, black durgun (*Melichthys niger*) and blackbar soldierfish (*Myripristis jacobus*). These species made up 35% of the biomass recorded.

Fish species richness was higher in post storm monitoring events at seven of the eight sites resurveyed. Only 25 species of fish were recorded at Megans Bay, however 71 were recorded at Botany Bay, and 74 at Buck Island STT. Of interest were fish normally characterized as deep water fish, that were observed at these nearshore sites. These include the cherubfish (*Centropyge argi*) and the sunshinefish (*Chromis insolata*). The cherubfish, a tiny Pomocanthid, is usually found on deep reef walls. It was present at four of the shallow sites after the storms, Botany Bay, Buck Island STT, Savana, and Black Point. The sunshinefish, also most commonly found on deep shelf reefs and walls, was seen in Botany Bay.

Table 3. The 2017/18 species richness for belt transects and roving diver surveys (RDS). Sites are divided into nearshore, offshore, and mesophotic sites as described in the text.

		Belt Transects (25x4)		RDS
		Total Number of Species	Mean species per transect (±SE)	Total Number of Species
Nearshore	Cane Bay	55	23.9±1.6	54
	Great Pond	50	21.9±2.6	44
	Jacks Bay	52	18.3±1.1	57
	Kings Corner	69	27.0±1.6	63
	Salt River West	56	20.4±1.6	56
	Sprat Hole	60	26.4±1.2	64
	Coculus Rock	45	22.3±0.9	40
	Black Point	50	21.0±1.1	43
	Brewers Bay	58	21.9±1.0	65
	Botany Bay	61	24.1±0.8	39
	Buck Island, St. Thomas	62	19.5±1.1	59
	Coral Bay	38	15.8±0.8	36
	Fish Bay	55	18.2±3.5	56
	Megans Bay	62	22.0±1.2	34
Offshore	Eagle Ray	62	23.5±1.6	53
	Buck Island, St. Croix	52	20.8±1.3	47
	Castle	49	19.2±1.5	54
	Mutton Snapper	57	25.3±1.6	51
	Seahorse Cottage	60	23.2±1.1	58
	South Capella	68	25.7±1.3	56
	South Water Island	62	24.1±1.3	56
	Flat Cay	-	-	-
	Meri Shoal	60	22.5±1.2	50
	Savana Cay	56	26.1±0.7	45
	Little St. James	-	-	-
Mesophotic	Cane Bay Deep	50	18.8±2.1	44
	Lang EEMP	71	24.7±1.6	59
	Lang Bank	59	29.8±4.0	59
	Salt River Deep	60	19.7±2.1	49
	College Shoal East	54	25.4±0.5	49
	Grammanik Bank FSA	66	24.7±1.8	50
	Hind Bank East FSA	70	26.4±2.2	52

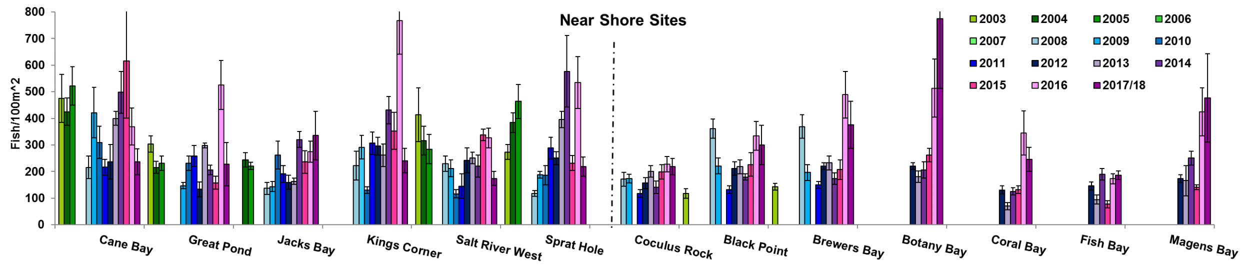
FISH COMMUNITIES

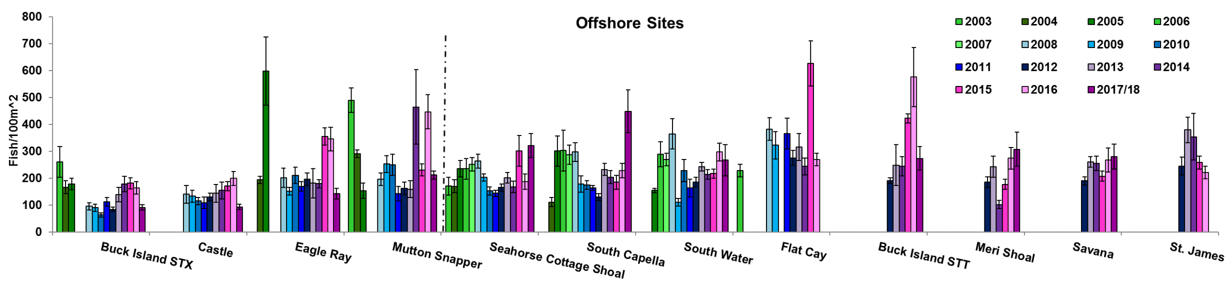
Fish Abundance

Total fish abundances across nearshore, offshore, and mesophotic sites and years are shown in Fig. 18. Total fish abundance was highly variable across sites and strata with no obvious patterns over time or space noted.

The site with the highest overall fish abundance in 2017/18 was Botany Bay. Abundance at the site was higher than in earlier years. This was due to schools of juvenile French grunts (*Haemulon flavolineatum*) that schooled on the reef. Over 1000 of these fish less 10cm were recorded, indicating a recruitment event that was seasonal. Other sites with relatively high fish abundance was Megan's Bay and Seahorse College Shoal. Several sites on St. Croix had lower fish abundance than recorded in previous years. This could possibly have been due to Hurricane Maria, which may have affected recruitment and, or reproduction. The sites with lowest fish abundance include all the mesophotic sites on St. Croix as well as three offshore sites on that shelf: Buck Island STX, Castle, and Eagle. Although Buck Island STX and Castle typically have low fish abundance, Eagle Ray is variable, and has had high fish abundance during several monitoring events.

Fig. 20 shows the fish abundance at nine sites resampled after the two major hurricanes crossed the territory. Fish abundance dropped at most of the sites after the storm, a trend similar to that seen in St. Croix.





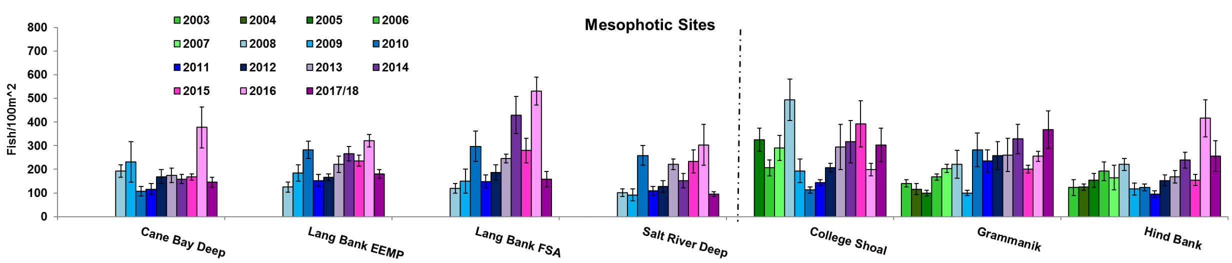


Figure 24. Fish abundance (±SE) across TCRMP monitoring sites over time. St. Croix sites are to the left and northern USVI to the right on the x-axis.

Fish Biomass

Total fish biomass for all sites and years is shown in Fig. 19. As with abundance, biomass is highly variable across strata, sites and years. No temporal pattern is obvious, and differences in time appear to be seasonal or natural variation. The biomass of fish at mesophotic sites off the northern USVI (Grammanik Bank FSA, Hind Bank FSA, and College Shoal) have had the highest biomass values throughout the TCRMP sampling series. These are protected reefs on the insular shelf edge, and fish spawning occurs on both the Grammanik Bank FSA and Hind Bank FSA. Although TCRMP sampling occurs outside of the spawning season, higher numbers of large fish may inhabit these sites due to their roles as aggregation areas. College Shoal does not host spawning events however, and biomass is also generally high on this site. In 2017 total biomass was higher on College Shoal than on any other site sampled. This was due primarily to large numbers of bar jacks, horseeye and black jacks (*C. lugubris*) that were present. Biomass on the mesophotic sites on St. Croix were low as in past years. Although now protected from fishing, Lang Bank does not seem to attract the large pelagics that are present on the southern edge of the northern USVI shelf. As with abundance, biomass appeared to be slightly lower on most St. Croix sites, possibly due to the passing of Hurricane Maria five months earlier. The St. Croix nearshore site, Kings Corner, generally has high biomass when compared to the other nearshore and offshore sites, however in 2018 biomass was very low. Northern USVI nearshore sites, Coral Bay, Magens Bay, Fish Bay and Botany Bay all had usual low fish biomass in 2017. These sites are along shorelines of developing residential areas and sustain high turbidity levels. They are also far from the deeper water near the shelf edge, and so these sites appear to support only juvenile fishes, and small species and at very low abundances.

Fish biomass at nine sites resampled after the two major hurricanes is shown in Fig 21. Like fish abundance, biomass dropped at most of the sites after the storms, but rebounded to pre-storm levels when sites were sampled six or seven months after the events.

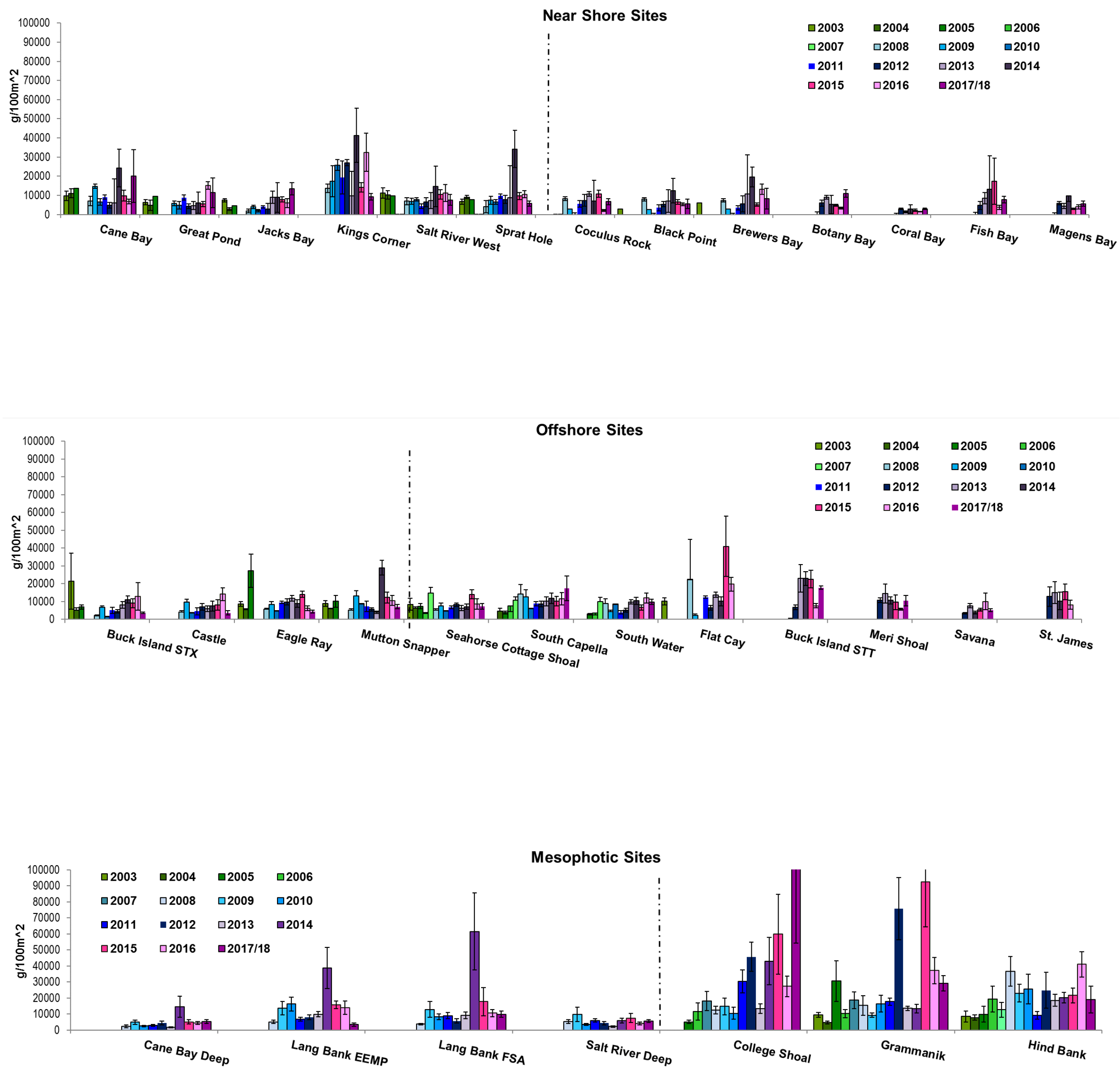


Figure 25. Mean fish biomass (±SE) across TCRMP monitoring sites over time. St. Croix sites are to the left and northern USVI to the right on the x-axis.

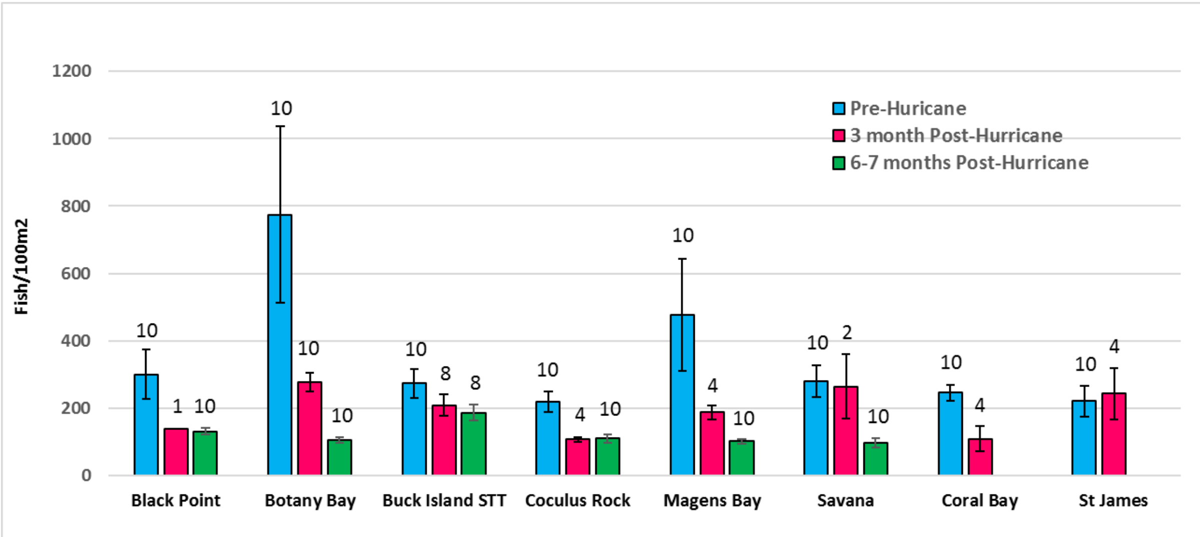


Figure 26. Mean abundance (±???) of fish counted on surveys conducted at eight sites before and after the 2017 hurricanes. Abundance was lower at most sites both directly after the storms and several months later. Pre-storm data for St. James is from 2016. Numbers above bars indicate sample size.

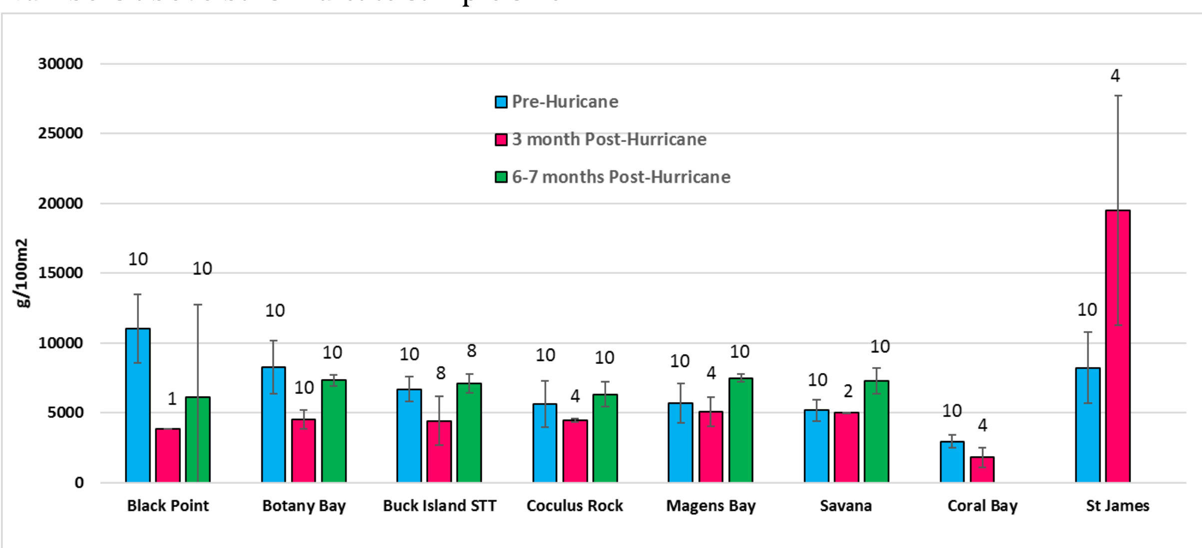


Figure 27. Mean biomass (±???) of fish on surveys conducted at eight sites before and after the 2017 hurricanes. Biomass appeared to drop after the storms but increased to pre-storm levels by April 2018. Pre-storm data for St. James is from 2016. Numbers above bars indicate sample size.

BLACK SPINY SEA URCHIN *DIADEMA ANTILLARUM*

The abundance of the black spiny sea urchin *Diadema antillarum* shows tremendous site-to-site variability (Fig. 24). In general the shallowest sites, e.g., Great Pond, support the greatest abundance of *D. antillarum*. These sites also tend to have very low macroalgal cover. Trends are not presented here by year, as variability is generally low. At Coral Bay there is a high abundance of *Echinometra* spp. that has not been quantified. This species seems to be the dominant grazer and effectively removes most macroalgal cover, but also contributes apparently high bioerosion (gnawed coral bases). Future monitoring might consider targeted monitoring of these species at certain sites.

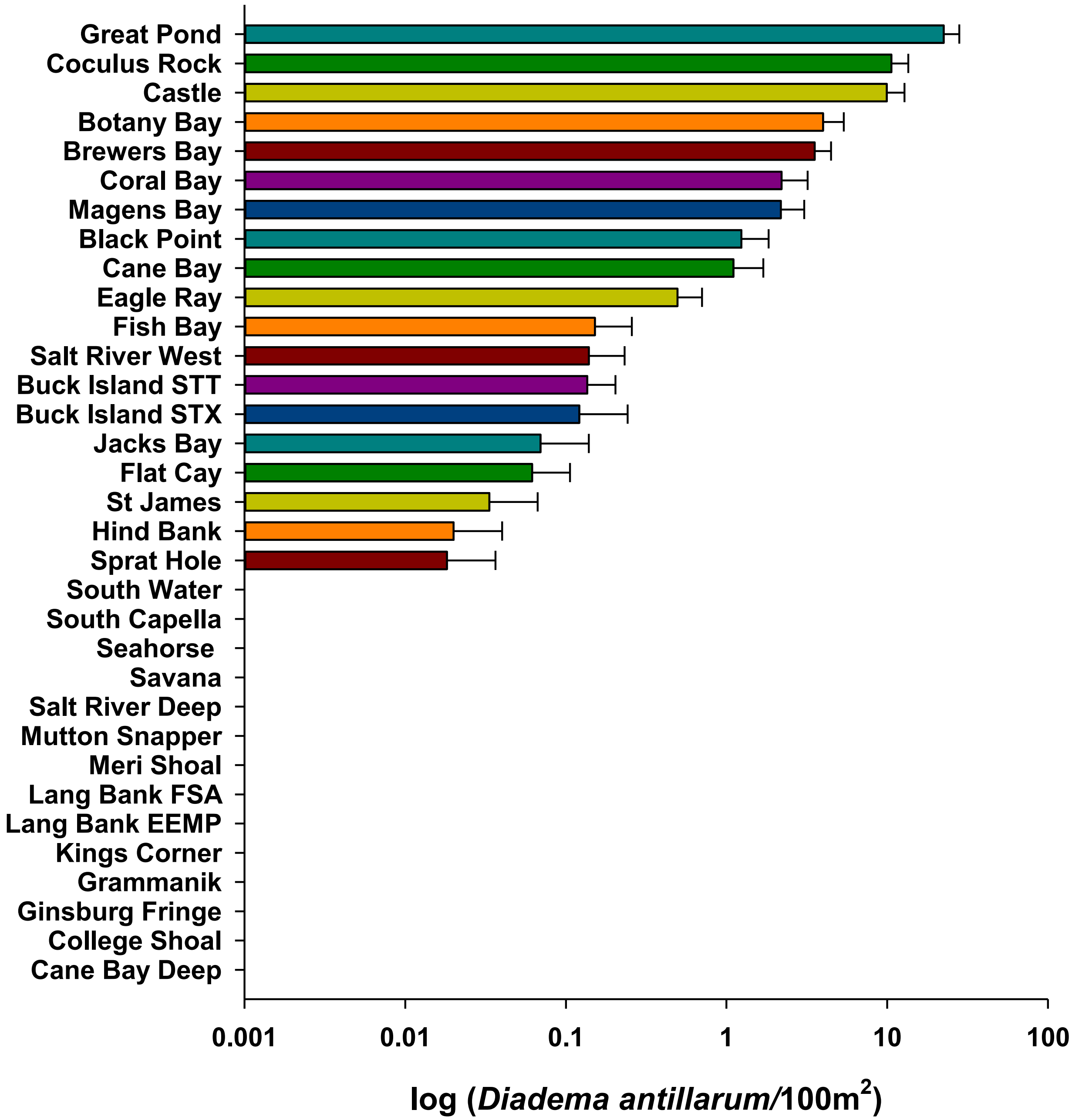


Figure 28. Abundance of the black spiny sea urchin (*Diadema antillarum*) at TCRMP monitoring sites. Note the log scale.