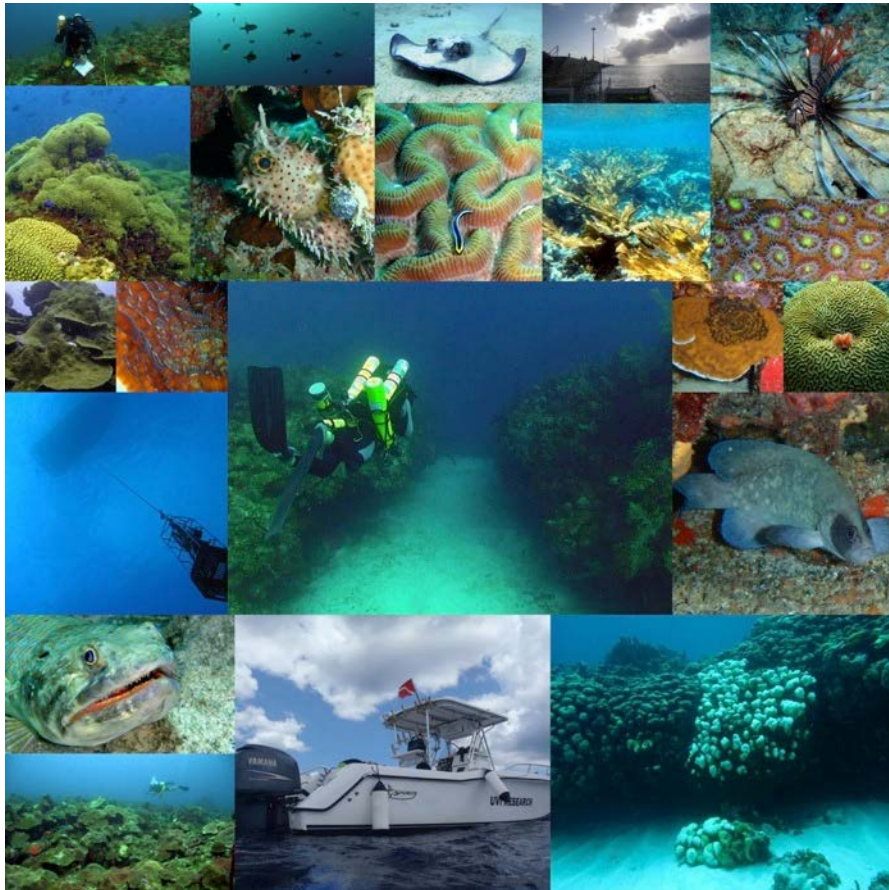


The United States Virgin Islands

TERRITORIAL CORAL REEF MONITORING PROGRAM



ANNUAL REPORT

2022

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INDEX

A collaboration between:

The Center for Marine and Environmental Studies, University of the Virgin Islands



**UVI Center for
Marine and
Environmental
Studies**

**The Division of Coastal Zone Management, USVI Department of Planning and
Natural Resources**



**The Coral Reef Conservation Program, National Oceanic and Atmospheric
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MISSION STATEMENT

OUR VISION

To provide critical information on the status and threats to all the U.S. Virgin Island's coral reef ecosystems to increase management effectiveness and improve basic and applied coral reef research



OBJECTIVES

- Monitor the **status and trajectories** of coral reefs across a majority of habitats and threats, including land-based sources of pollution & thermal stress
- Link changes in coral reef health with specific stressors, indicating specific **management interventions** most effective for preserving reefs
- Integrate assessments of understudied **mesophotic coral reef ecosystems** and **threatened species** in the USVI
- Provide data, outputs, and advice to stakeholders and create a **nexus of information** for reef research

EXECUTIVE SUMMARY

Executive Summary

Coral reefs in the Caribbean are at a crossroads facing a dramatic decline. Management decisions made today will affect the goods and services that coral reefs provide for decades to come. The government of the United States Virgin Islands (USVI), in coordination with the NOAA Coral Reef Conservation Program and the University of the Virgin Islands, implemented the **Territorial Coral Reef Monitoring Program (TCRMP)**. The TCRMP has established baseline conditions and temporal trends of coral reefs and fish populations in the USVI and has identified threats that influence future reef health and development.

A major focus of the TCRMP is to provide information that can lead to more effective management strategies that balance the immediate needs of the Virgin Island's population with the preservation and sustainability of coral reefs and the renewable goods and services they provide.

The intent of this report is to distill monitoring data into actionable information that can guide management decisions and inform the public and policy-makers about areas that need further effort. This executive summary presents information on threats to USVI reefs that require management intervention/action as well as positive signs that can inform our understanding of sustainability.

CORAL REEFS OF THE VIRGIN ISLANDS: MANAGEMENT ACTIONS NEEDED

The TCRMP data has identified threats to USVI coral reef ecosystems that need increased management attention if reef corals are to persist in a condition that is equal to or better than current conditions.

Coral Reef Bleaching. High thermal stress caused by climate change is currently the greatest threat to USVI coral reef ecosystems. The 2005 coral bleaching event caused the largest loss of coral in the documented history of the USVI, with a 50% decline in coral cover in shallow waters less than 25m/85' deep (Smith et al. 2013b; Smith et al. 2016a).

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This event surpassed all known modern impacts from physical damage (storms and anchoring), ecosystem changes (fishing and disease), and pollution (terrestrial sediments and toxins). Thermal stress and bleaching conditions are becoming more frequent.

While local management actions cannot remove impacts to reefs from global warming, reefs that are otherwise less stressed by land-based sources of pollution, fishing, and/or physical damage are known to recover more quickly from bleaching. Hence, local management actions that promote seascape-wide coral reef health offer the best strategy for sustainable reefs. We can also identify areas that are naturally more resistant to thermal stress and offer these areas further protection, since they offer insurance against the worst possible future outcomes for USVI reefs.



Figure 1. Partially bleached and recovering colony of *Siderastrea siderea* at Flat Cay, St. Thomas (Nov. 12, 2005).

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Overfishing. There are clear indications that reefs of the USVI are suffering the effects of overexploitation of reef resources. The entire district of St. Croix has an extremely low abundance of commercially important grouper species, including the threatened Nassau grouper (Kadison et al. 2017). In St. John and St. Thomas, many common species have completely or nearly disappeared from nearshore waters in the last 30 years. For example, a study conducted by Rogers et al. (1982) on the southwest coast of St. Thomas during the airport runway expansion (1979-1981) found a variety of species that are no longer encountered or are rare, including the black, Nassau, yellowfin, and tiger groupers, as well as the federally protected parrotfish species: blue, midnight, and rainbow. A study by Randall (1963) found high relative abundances of groupers and threatened parrotfish on the south coast of St. John. Rebuilding these fish stocks will require knowledge of comprehensive life-history information for target species, a willingness to find strategies to rebuild stocks, and partnerships between commercial and recreational fishers, community stakeholders, and managers. Signs of an increasing recruiting and spawning population of Nassau groupers in the northern USVI and more frequent sightings at TCRMP sites in St. Croix suggests that management actions, including no-take restrictions and protection of spawning aggregation sites, can have tangible, positive effects (Kadison et al. 2010). In addition, recent work under the Deep Coral Reef Monitoring Program, an extension of the spatially randomized National Coral Reef Monitoring Program in depths between 30-50 m (100-165 feet), is finding higher abundances of commercially important species that are rare in shallow waters (Grove et al. 2024; Heidmann et al. 2024). Therefore, for many species viable populations may still exist for rebuilding stocks.

Land-Based Source of Pollution. The steep hillsides of the USVI are natural conduits for run-off during heavy rain events and in many instances, there is little interception of materials before they reach the sea and impact coral reefs. When tropical soils are naturally disturbed or altered through human activity, they can erode and release fine-grained silt and clay particles. In the USVI, these fine-grained particles are quickly

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transported to coral reefs where they can block sunlight, directly smother corals, or increase the growth of organisms that compete with corals for space. There is evidence from the TCRMP that terrestrial sediments are having large negative impacts on nearshore coral reefs by increasing mortality of ecologically important corals (Ennis et al. 2016; Henderson et al. in prep.).

CORAL REEFS OF THE VIRGIN ISLANDS: POSITIVE SIGNS

Despite the incredible declines in reef health witnessed since the inception of the TCRMP in 2001, there are many positive signs for the USVI that should be highlighted. These successes offer lessons that can be applied to troubled reefs and may indicate refuge areas where we might “double-down” on current management strategies.

Reef Refuges. The USVI is blessed with extensive areas of deep bank and slope reefs that may be buffered from the direct impacts of local pressures (Smith et al. 2019a, b). The mesophotic (pronounced: me-zo-photik; meaning; “middle-light”; Slaterry et al. 2024) reefs of the USVI are the best developed in the Caribbean from what is currently known. Mesophotic Coral Ecosystem (MCE) reefs with high populations of star corals (*Orbicella* spp.), which have recently been listed as threatened on the United States Endangered Species List (NOAA 2014), form extensive tracts on the south shelf of St. John and St. Thomas, from the British Virgin Islands to Vieques, Puerto Rico. Well-formed, but patchier mesophotic boulder coral reefs also form on the Lang Bank, St. Croix and the northern Puerto Rican Shelf. The lower MCE consists mostly of lettuce corals (primarily *Agaricia undata*) and form a semi-continuous ring on steep slopes and walls at depths between 50-70m. These reefs are isolated from some, but not all, local impacts but may be susceptible to global climate change (see below).

In federal waters some of these areas are wholly or partly protected from fishing of ecologically important species that help maintain reef health. These include the Red Hind Marine Conservation District (est. 1999), the Grammanik Bank Seasonally Closed Area (est. 2005), and the Lang Bank Red Hind Seasonally Closed Area (est. 1993).

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However, extensively developed mesophotic reef in unprotected territorial waters also exist near the island of French Cap and Sail Rock, St. Thomas District. It is important that these areas are identified, their threats assessed, and they are incorporated into the territorial and federal management planning process.

Rebounding Fisheries Species. There are positive signs of recovery for certain fish species in some areas. At the Grammanik Bank, a multi-species fish spawning aggregation site, there have been increasing numbers of Nassau grouper during annual spawning (Kadison et al. 2010; Jackson et al. 2014), with about 800 individuals seen in 2021-2022 (R. Nemeth, unpub. obs). A red hind aggregation in the Red Hind Marine Conservation District (MCD) has dramatically rebounded (Nemeth 2005). Red hind caught in the fishery on the south side of St. Thomas are more numerous and larger (D Grove et al. 2024; Heidmann et al. 2024). In 2015 there was a recruitment pulse of juvenile Nassau grouper to shallow nearshore environments of St. Thomas and St. John. In Brewers Bay, St. Thomas over 70 juvenile Nassau grouper were recorded (R. Nemeth, unpub. data)—increasing evidence that the reproductive population is contributing to the recovery of the species. It is also the impression of the authors that stocks of grouper and snapper are increasing in the MCD, although TCRMP measurements are confounded to some degree by the rotating array of aggregating fishes. Other territorial and federal closed areas in St. Croix, St. John, and St. Thomas are more recently established and may not show effects for several years. In a positive sign on St. Croix, Nassau grouper have been recorded at TCRMP sites since 2011, and more recently up to half of the monitoring sites have this species present. For species that are completely protected from fishing (Nassau grouper and blue, midnight, and rainbow parrotfish), educational campaigns for recreational and commercial fisherman are critical, as awareness of regulations among the USVI residents appears to be lacking (Authors, unpub. obs.).

Land-based source of pollution. While development of steep island slopes has continued despite current regulations intended to prevent sediments from entering nearshore waters, research has identified key targets for restoration and some effective habitat

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restoration best-management practices. Results from TCRMP research suggest that there are certain levels of silt-laden terrestrial run-off that are damaging to corals, providing a target for reductions of sediment in the marine environment (Henderson et al. in prep.). Unpaved road segments have been implicated as the worst culprits in the production of sediment-laden run-off (Ramos-Scharrón and MacDonald 2007) and this provides a clear target for where management can be most effectively applied. Restoration of watersheds has shown that implementation of best-management practices and control structures can be effective in reducing sedimentation. For example, the American Recovery and Reinvestment Act project “USVI Coastal Habitat Restoration Through Watershed Stabilization” showed promising results (Virgin Islands Resource Conservation and Development Council; P.I. M. Taylor).

This report presents results of the 22nd year of monitoring on reefs surrounding St. Croix, St. John, and St. Thomas (years 2001-2022). Monitoring sites were distributed across the insular platform in depths from 5 to 63 m (16 – 220') to capture the diversity of reef types present in the Virgin Islands. Long-term data is presented from 34 sites. While not exhaustive, the TCRMP is generally representative of the geographic areas and variety of reef types in the USVI. Digital video and diver surveys were used to quantify benthic cover and coral health at 15 permanent sites surrounding the island of St. Croix and 19 permanent sites on the Puerto Rican Shelf surrounding the island of St. John and St. Thomas. In addition, at 33 of these sites, sea urchin density and fish community structure were evaluated.

The TCRMP website describes the program and houses updated data

<https://www.vitcrmp.org>

Data can also be requested directly from the research team by contacting Nicole Krampitz at nicole.krampitz@uvi.edu

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The Impact of Stony Coral Tissue Loss Disease in the USVI

Stony coral tissue loss disease (SCTLD) has caused dramatic declines in coral cover and species diversity across the Florida and the Caribbean. The disease was first noted in the U.S. Virgin Islands at the Flat Cay TCRMP monitoring site (Fig. 2; Fig. 3) in January of 2019 and was identified by its characteristic stony coral species-specific susceptibility hierarchy and its lesion progression rates. By January of 2020, the disease had spread eastward to the St. Thomas East End Reserve and St. John. In May of 2020, SCTLD reached southern St. Croix and continued to spread across the island. By 2022, the disease had progressed to almost every reef in the Virgin Islands and is now considered to be endemic rather than a growing epidemic.

During its spread, numerous local teams at the University of the Virgin Islands, the Department Planning and Natural Resources (DPNR), the National Park Service (NPS), the Caribbean Oceanic Restoration & Education (CORE) Foundation, and The Nature Conservancy (TNC) coordinated monitoring, research, and response with national collaborators to attempt to mitigate losses and slow the spread of the disease. Updated details concerning SCTLD can be found at the following website:

<https://www.vicoraldisease.org>

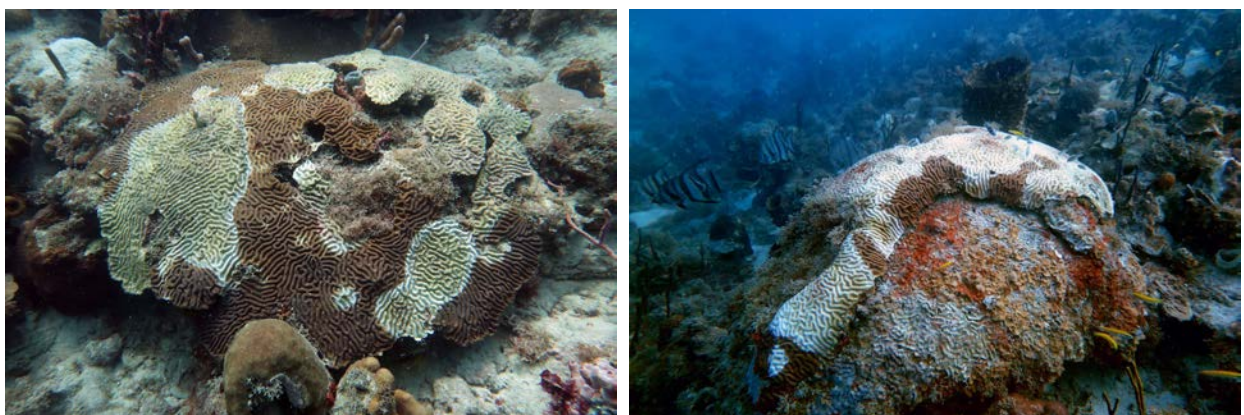


Figure 2. Left to right: a large colony of *Colpophyllia natans* with active SCTLD lesions (Black Point, October 2019), A large colony of *C. natans* with active SCTLD. The area of regrowth of the colony after the 2005 bleaching event is evident (Flat Cay, February, 2019). (credit: Marilyn E. Brandt)

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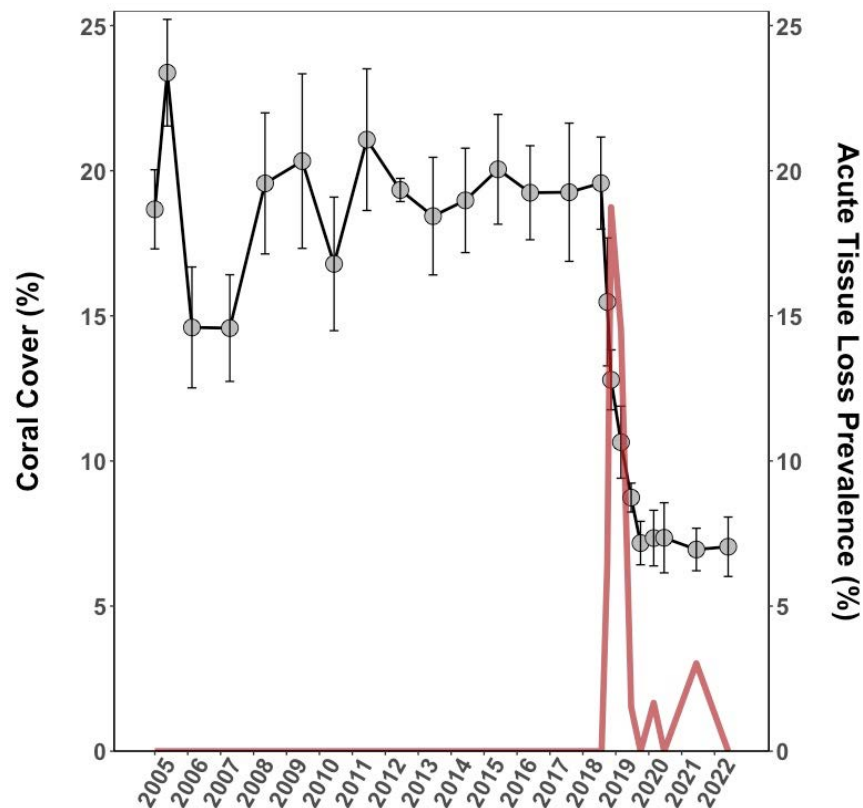


Figure 3. Mean coral cover ($\pm$ SEM; gray circle) and prevalence of acute tissue loss (red line) at the Flat Cay monitoring location. Acute tissue loss includes any colony with an identified Stony Coral Tissue Loss Disease infection or rapid tissue loss with associated bleaching resulting in at least 10% recent mortality.

The TCRMP locations most adversely affected by SCTLD include Kings Corner, Flat Cay (Fig. 4), and Brewer's Bay with relative coral cover losses since 2018 of 67%, 64%, and 59%, respectively (Fig. 4). Prior to the arrival of SCTLD, monitoring locations had relatively little change in coral cover since Hurricanes Irma and Maria (2017); however, since 2018, relative coral coverage at TCRMP sites have declined on average by $36.4 \pm 3.04\%$. The species-specific susceptibility and mortality rates of SCTLD also induced a shift in relative species coverage at TCRMP sites, with weedier corals such as *Porites astreoides* increasing in representation. Population structure analyses of demographic TCRMP plots suggest that while SCTLD has become endemic, the population growth rates

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of *Orbicella* spp. and *Siderastrea* spp. have yet to return to pre-SCTLD levels; thus, the full effects of this disease have yet to be realized (Krampitz 2023).

More detailed impacts at TCRMP sites can be found in the site summaries and other accounts of SCTLD research in the territory can be found in Brandt et al. (2021), Meiling et al. (2020), Costa et al. (2021), and Meiling et al. (2021). Research at UVI, led by Dr. Marilyn Brandt and informed by TCRMP, has made critical research discoveries into the causes and consequences of SCTLD in the Caribbean. A list of her publications can be found here:

https://scholar.google.com/citations?hl=en&user=s00xmmQAAAAJ&view_op=list_works&sortby=pubdate

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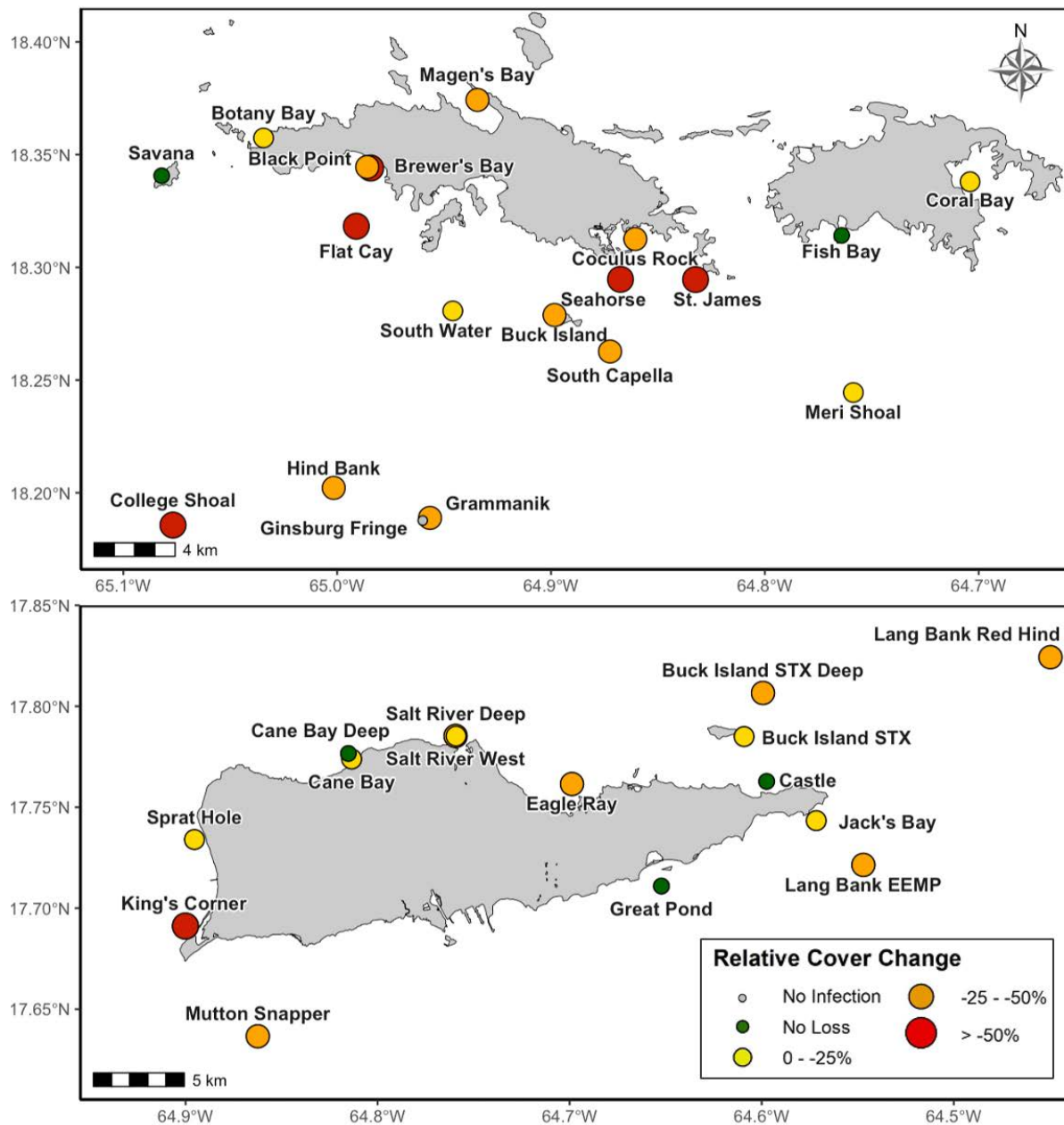


Figure 4. Relative coral cover loss at TCRMP locations in 2021 relative to pre-SCTLD monitoring.

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Mass Morality of *Diadema antillarum* in 2022 die-off Event

In late January of 2022, extensive die-offs of the long-spined sea urchin, *Diadema antillarum*, were first noticed off Flat Cay. Within a month, other reefs surrounding St. Thomas and St. John also experienced mass mortality of *D. antillarum* in what appeared to be a highly lethal disease event. Once affected, seemingly healthy individuals would begin to experience rapid spine loss and tissue necrosis (Fig. 5). Following the infrastructure created to track Stony Coral Tissue Loss Disease, a large effort was very quickly coordinated to investigate and track this disease (Diadema Response Network: <https://www.agrra.org/sea-urchin-die-off/>). This response network tracked the disease's rapid spread to nearby Caribbean islands and noted that the disease frequently first appeared close to harbors, suggesting primary dispersal has been through anthropogenetic mechanisms (Hylkema 2023). Mortality associated with this disease has an incredibly high rate (up to 99%; Hylkema 2023) and occurs very quickly, often within one to two days (AGGRA).

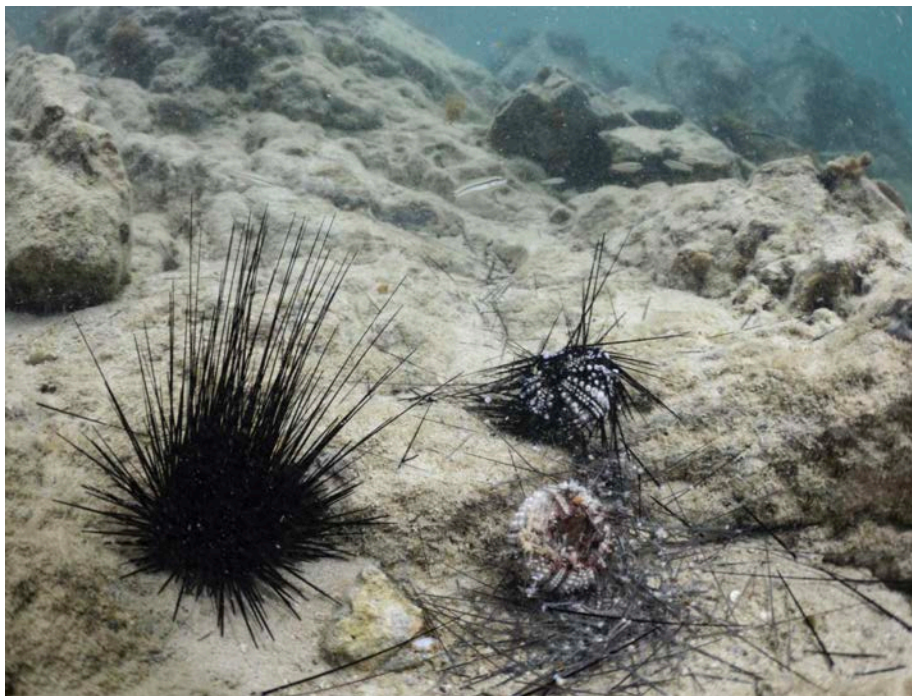


Figure. 5. Three long-spined sea urchins (*Diadema antillarum*) in mid-February of 2022 at Range Cay. One apparently healthy urchin (left) continues to graze while the other two (right) show advanced signs of the disease: spine flattening, spine loss, and tissue necrosis. (credit: Dan

— Mele)

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The causative agent for this disease has been identified as the scuticociliate *Philaster apondigitiformis*, and, in a rare occurrence for marine organisms, has fulfilled Koch's postulates (Hewson 2023). Scientists from the University of the Virgin Islands contributed to the identification of the disease agent. The severity of this die-off event mirrors that which occurred in 1983-1984 when *D. antillarum* population densities were reduced by 93-99% in the Caribbean (Lessios 1988). Despite decades passing since that mass mortality event, recovery of these sea urchins has been incredibly slow; it is estimated that after over thirty years, population densities have only reached 12% of their pre-die-off densities (Lessios 2016). Consequently, the current mass mortality event is expected to reduce population densities to even lower than those seen following the 83-84' die-off and, furthermore, recovery is expected to be very slow (Levitan 2023).

The loss of *D. antillarum* has detrimental effects on coral reef health due to the species' key role in controlling algal growth. As seen following the die-off in 1983 and 1984, the removal of these herbivores promotes turf and macroalgal overgrowth on coral reefs (Carpenter 1988). This growing macroalgal dominance limits settlement space for juvenile coral settlement and increases competition with adult colonies.

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Following the mass mortality event, TCRMP sites experienced a significant reduction in *D. antillarum* densities (Kruskal-Wallis rank sum; $p=0.03$) dropping from an average of 1.7 ± 0.87 urchins 100m^{-2} in 2021 to 0.24 ± 0.15 in 2022 (Fig. 6). Furthermore, the number of sites where the long spined sea urchin has typically been observed in the past decade was halved to only 6 of the 34 surveyed sites in 2022. Of those urchins that were observed, the majority were small juveniles, whose functionality as a key herbivore in controlling algal growth would be limited.

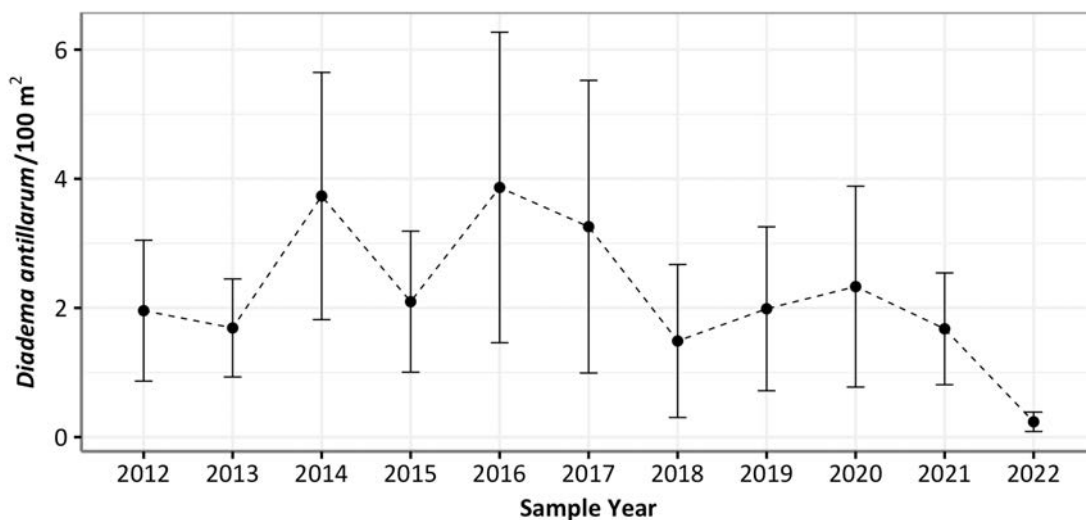


Figure 6. Mean density of *D. antillarum* per 100m^2 across all TCRMP sites from 2012-2022.

RESEARCH HIGHLIGHTS

LITERATURE CITED

- Brandt ME, Ennis RS, Meiling SS, Townsend J, Cobleigh K, Glahn A, Quetel J, Brandtneris V, Henderson LM, Smith TB (2021) The Emergence and Initial Impact of Stony Coral Tissue Loss Disease (SCTLD) in the United States Virgin Islands. *Frontiers in Marine Science* 8:1105
- Carpenter R (1988) Mass mortality of a Caribbean sea urchin: Immediate effects on community metabolism and other herbivores. *Proceedings of the National Academy of Sciences* 85:511-514
- Costa SV, Hibberts SJ, Olive DA, Budd KA, Long AE, Meiling SS, Miller MB, Vaughn KM, Carrion CI, Cohen MB, Savage AE, Souze MF, Buckley L, Grimes KW, Platenberg R, Smith TB, Blondeau J, Brandt ME (2021) Diversity and disease: the effects of coral diversity on prevalence and impacts of Stony Coral Tissue Loss Disease in Saint Thomas, U.S. Virgin Islands. *Frontiers in Marine Science* 8:682688
- Ennis RS, Brandt ME, Wilson Grimes KR, Smith TB (2016) Coral reef health response to chronic and acute changes in water quality in St. Thomas, United States Virgin Islands. *Marine Pollution Bulletin* 111:418-427
- Grove LJW, Blondeau J, Swanson DW, Heidmann SL, Smith SG, Brandtneris VW, Smith TB (in press) Expansion of an established fishery-independent survey into the U.S. Virgin Islands' upper mesophotic zone: feasibility and management implications. *Bulletin of Marine Science* <https://doi.org/10.5343/bms.2023.0013>
- Heidmann SL, Brandtneris VW, Ennis RS, Blondeau J, Grove LJW, Smith TB (2024) Depth and structure as environmental drivers of fish communities across a shallow to mesophotic gradient in the northern US Virgin Islands. *Bulletin of Marine Science* <https://doi.org/10.5343/bms.2023.0022>
- Hewson I, Ritchie IT, Evans JS, Altera A, Behringer D, Bowman E, Brandt M, Budd KA, Camacho RA, Cornwell TO, Countway PD, Croquer A, Delgado GA, DeRito C, Duermit-Moreau E, Francis-Floyd R, Gittens S, Henderson L, Hylkema A, Kellogg CA, Kiryu Y, Kitson-Walters KA, Kramer P, Lang JC, Lessios H, Liddy L, Marancik D, Nimrod S, Patterson JT, Pistor M, Romero IC, Sellares-Blasco R, Sevier MLB, Sharp WC, Souza M, Valdez-Trinidad A, van der Laan M, Vilanova-Cuevas B, Villalpando M, Von Hoene SD, Warham M, Wijers T, Williams SM, Work TM, Yanong RP, Zambrano S, Zimmermann A, Breitbart M A scuticociliate causes mass mortality of *Diadema antillarum* in the Caribbean Sea. *Science Advances* 9:eadg3200
- Hylkema A, Kitson-Walters K, Kramer PR, Patterson JT, Roth L, Sevier MLB, Vega-Rodriguez M, Warham MM, Williams SM, Lang JC (2023) The 2022 *Diadema antillarum* die-off event: Comparisons with the 1983-1984 mass mortality. *Frontiers in Marine Science* 9
- Krampitz NM (2023) Demographic Impacts of Stony Coral Tissue Loss Disease (SCLTD) Across a Caribbean Seascape. University of the Virgin Islands, p65pp
- Lessios HA (1988) Mass mortality of *Diadema antillarum* in the Caribbean: what have we learned? *Annual Review of Ecology and Systematics* 19:371-393
- Lessios HA (2016) The Great *Diadema antillarum* Die-Off: 30 Years Later. *Annual Review of Marine Science* 8:267-283
- Levitan DR, Best RM, Edmunds PJ (2023) Sea urchin mass mortalities 40 y apart further threaten Caribbean coral reefs. *Proceedings of the National Academy of Sciences* 120:e2218901120
- Meiling S, Muller EM, Smith TB, Brandt ME (2020) 3D photogrammetry reveals dynamics of Stony Coral Tissue Loss Disease (SCTLD) lesion progression across a thermal stress event. *Frontiers in Marine Science* 7:597643
- Meiling SS, Muller EM, Lasseigne D, Rossin A, Veglia AJ, MacKnight N, Dimos B, Huntley N, Correa AMS, Smith TB, Holstein DM, Mydlarz LD, Apprill A, Brandt ME (2021) Variable species responses to experimental Stony Coral Tissue Loss Disease (SCTLD) exposure. *Frontiers in Marine Science* 8:670829
- Ramos-Scharrón CE, MacDonald LH (2007) Measurement and prediction of natural and anthropogenic sediment sources, St. John, U.S. Virgin Islands. *Catena* 71:250-266

RESEARCH HIGHLIGHTS

Slattery M, Lesser MP, Rocha LA, Spalding HL, Smith TB (2024) Function and stability of mesophotic coral reefs. Trends in Ecology & Evolution <https://doi.org/10.1016/j.tree.2024.01.011>

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The U.S. Virgin Islands consist of three large islands, St. Thomas, St. John and St. Croix, and numerous smaller islands surrounded by a diverse, tropical marine environment that includes coral reefs, seagrass beds, and mangrove forests (Fig. 7). The islands of St. Thomas and St. John lie on the Puerto Rican Shelf, an extensive shallow water platform that connects them to Puerto Rico to the west and the British Virgin Islands to the east. St. Croix lies on an isolated platform sixty-five kilometers to the south of St. Thomas and St. John and separated by the 4000m deep Anegada Passage and the Virgin Islands Trough. This forms an effective barrier to the migration of adult coral reef fishes and invertebrates. The coral reefs of the Virgin Islands represent a wide range of characteristic coral reef habitats of the Caribbean, including patch reefs, fringing reefs, barrier reefs, shelf reefs, and extensive bank and slope mesophotic coral reef ecosystems. The area of a star coral bank mesophotic reef complex south of St. Thomas to Vieques covers more area than all the shallow water coral reefs of the USVI combined (Smith et. al 2019a).

The economy of the US Virgin Islands is reliant to a large extent on maintenance of vibrant marine ecosystems. Tourism drives the economy of the Virgin Islands, which are famous for white sand beaches that give way to clean, clear marine waters. The diverse marine life of the coral reefs and other habitats attract thousands of snorkelers and scuba divers each year. Sport fishing on charter boats and private vessels also makes an important contribution to the economy. In addition, the coral reefs and other habitats in the Virgin Islands are essential to the lives of hundreds of thousands of species including economically important queen conch, whelk, spiny lobster, snapper, and grouper. Over three hundred full-time or part-time commercial fishermen work in territorial and federal waters surrounding all three islands (Tobias 1997). In tough economic times and

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after natural disasters, fishing is an important means of supplemental income or extra protein for many people.

Over the last few decades, major hurricanes, coral disease outbreaks, mass coral reef bleaching, and invasive species introductions have caused extensive coral mortality to the coral reefs surrounding the Virgin Islands (Gladfelter 1982; Edmunds and Witman 1991; Rogers et al. 1991; Rothenberger et al. 2008; Woody et al. 2008; Miller et al. 2009; Smith et al. 2013b; Brandt et al. 2021). Recovery from these disturbances is hindered by a multitude of human impacts that affect coral reefs, such as overfishing of ecologically important species, physical damage to reef structure, and pollution (Hatcher 1984; Pastorok and Bilyard 1985; Rogers and Garrison 2001; Mumby 2006; Mumby et al. 2006; Mumby and Harborne 2010). Moreover, rapid development of steep island slopes has dramatically increased soil erosion and sedimentation into nearshore waters (Brooks et al. 2007; Gray et al. 2008; Smith et al. 2008), particularly below unpaved road surfaces (Anderson and Macdonald 1998; Ramos-Scharrón and MacDonald 2007a). Chronic sedimentation affects the abundance and diversity of corals and other reef organisms, increases coral stress and susceptibility to diseases and bleaching, and reduces the ability of corals and other reef organisms to recover and regenerate after natural disturbances such as hurricanes (Acevedo and Morelock 1988; Rogers 1990; Nemeth and Sladeck Nowlis 2001; Fabricius 2005; Sabine et al. 2015; Ennis et al. 2016). The first sightings of the invasive Indo-Pacific lionfish (*Pterois volitans*) occurred in the US Virgin Islands in 2009. This predator can dramatically alter coral reef fish community structure (Cote and Maljkovic 2010) and these alterations may have additional, indirect impacts on benthic communities (Albins and Hixon 2011). In addition, the aggressive and possibly introduced red alga *Ramicrosta textilis* has increased in abundance at many locations and is killing coral tissue through competitive overgrowth (Bramanti et al. 2017; Edmunds et al. 2019; Hollister et al. 2021; Williams and Edmunds 2021). Stony Coral Tissue Loss Disease (SCTLD), first observed at the Flat Cay monitoring location in early 2019, has led

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to widespread coral mortality and diversity losses throughout the Virgin Islands over the last several years (Brandt et al. 2021). In addition, losses of the black spined sea urchin to an epizootic scuticiliate outbreak in 2022 have greatly reduced the already impacted populations of this key Caribbean herbivore (Hylkema et al. 2023; Hewson et al. 2023).

High thermal stress and coral bleaching events affected the northeastern Caribbean in 2005, 2010, 2012, and 2019 but these events had contrasting signatures in the United States Virgin Islands. Earlier events and the species-specific responses of Caribbean corals are summarized in Smith et al. (2013) for shallow corals and Smith et al. (2016) for shallow and mesophotic corals. The year 2005 was the most severe high sea surface temperature (SST) event on record for the northeastern Caribbean (Eakin et al. 2010). In the Virgin Islands a peak of 10.25 Degree Heating Weeks (DHW) was registered from satellite SST records (NOAA, 2012; 50km satellite product) and a period of approximately 59 days above the local bleaching threshold of 29.5°C (Aug. 20 – Oct. 18); a level of thermal stress accumulation associated with severe coral bleaching and some mortality. The warm season of 2010 started as warm or warmer than 2005, with the bleaching threshold surpassed for 21 days between August 12 and September 2. In a clear example of ameliorative storm cooling (Manzello et al. 2007), the passing of the storm center of Hurricane Earl on August 30th, approximately 100 km to the northeast of the St. Thomas-St. John, caused a rapid decline in SST's below the bleaching threshold to 29.3°C, and then from October 5 - 8, the passage of Hurricane Otto caused windy and cloudy weather that further reduced SST below 29.1°C. Total DHW accumulated in 2010 began to decrease after the beginning of October, when it had reached 5.1 DHW (NOAA Coral Reef Watch, 50 km heritage product), a level associated with some bleaching and limited mortality. Recent research developed bleaching threshold temperatures for 24 of 34 TCRMP monitoring sites dominated by star corals of the genus *Orbicella* (Smith et al. 2016a). This research showed that mesophotic reefs bleached with shallow reefs in 2005 and then bleached when shallow reefs did not in 2012. The study concluded that mesophotic

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reefs of the USVI are unlikely to be long-term climate change refugia because they are not immune to high temperature thermal stress.

Most research around the Virgin Islands has focused on fringing reefs (5 – 30 m depth) located along the shoreline of the three main islands, St. Thomas, St. John, and St. Croix. In contrast, very little information exists for offshore and deeper reef systems, which can be quite extensive. These other reef systems include mid-shelf reefs (5 – 30 m depth) located 2 to 10 km from the shore of the main islands and mesophotic reefs (>30 m depth) located from 0.5 to 15 km offshore along the edge of the insular platform (Armstrong et al. 2002; Herzlieb et al. 2005; Armstrong et al. 2006; Armstrong 2007; Menza et al. 2007; Menza et al. 2008; Nemeth et al. 2008; Smith et al. 2010b; Smith et al. 2016b). Distance from shore may be a factor in the historical degeneration of coral reef systems in the Virgin Islands (Herzlieb et al. 2005; Calnan et al. 2008; Smith et al. 2008; Sabine et al. 2015; Ennis et al. 2016). A systematic approach to investigating these cross-shelf coral reef systems allows us to evaluate the variable impacts and synergistic effects of natural impacts and human-induced stress that influence the decline or recovery of Caribbean coral reef systems. The first two years of this project (2001 and 2002) concentrated on the fringing reefs surrounding St. Croix. In 2003, monitoring continued at St. Croix reefs and began at reef systems distributed across the insular platform surrounding St. Thomas. In 2004, 2005, and 2006 monitoring continued at reefs surrounding both islands, with additional reefs surrounding St. Thomas added in 2004, 2005, and 2011. Mesophotic coral reef monitoring sites were added to St. Croix during the 2008, 2009, and 2017 monitoring. In 2011, the TCRMP also expanded to include sites established under separate funding that will be continued in the core TCRMP monitoring activities funded by USVI DPNR and NOAA CRCP.

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OBJECTIVES FOR MONITORING CORAL REEFS

Effective management is necessary to maintain the resources in the territorial and federal waters of the Virgin Islands in an ecologically and economically sustainable manner. Monitoring programs are essential for successful management because they provide managers with fundamental information with which to make and reinforce decisions. Standards for resource protection can be measured by comparison to baseline data established by monitoring. Monitoring also provides the means to assess the status and trends of ecological resources, allowing managers to determine the effectiveness of current management and to develop effective management plans for the future. The Territorial Coral Reef Monitoring Program monitors the condition of coral reefs throughout the U.S. Virgin Islands and provides key information to better manage these ecosystems. The TCRMP is complimentary to the National Coral Reef Monitoring Program (NCRMP) that started in 2013 and is co-coordinated in the USVI by the University of the Virgin Islands. TCRMP focuses on fixed sites and repeatedly samples the same corals to generate the most in-depth metrics of change over time. NCRMP uses a stratified-random sampling design to spread out samples and gain an understanding of change through time, with predictions that can be applied spatially. NCRMP does not currently sample reefs below 30m, and therefore misses the dominant habitat in the northern USVI. The Deep Coral Reef Monitoring Program (DCRMP) was instituted in 2019 to sample reef fishes and basic benthic attributes in depths of 30-50 m on hardbottom areas south of St. Thomas and St. John (Grove et al. 2023; Heidmann et al. 2023). However, this program has no long-term sustained funding.

This report presents monitoring results from 2001-2022 in St. Croix and from 2003-2022 in St. Thomas and St. John. For both islands, temporal changes from year to year in the conditions of the reef communities are assessed.

INTRODUCTION

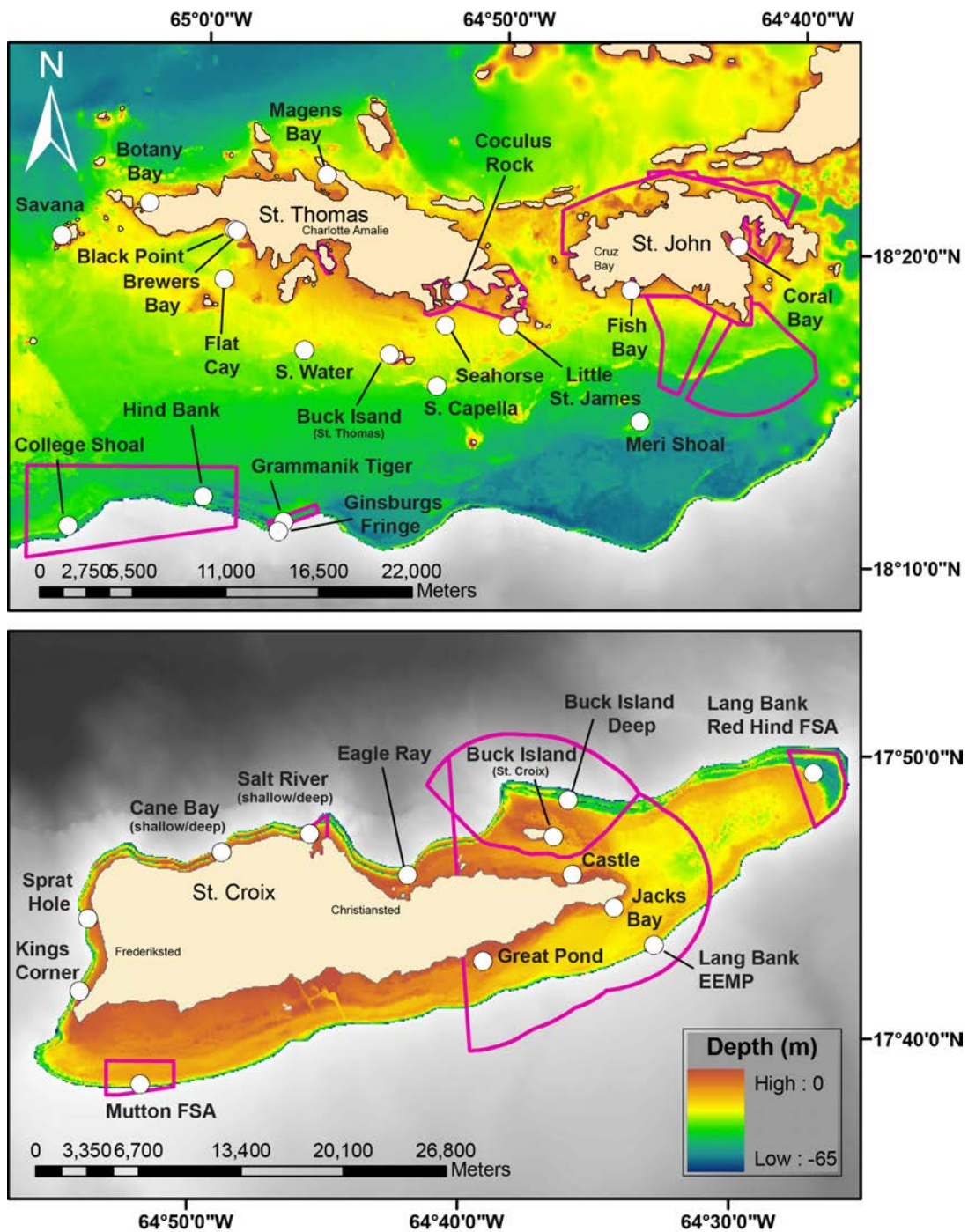


Figure 7. Locations of Territorial Coral Reef Monitoring Sites in the US Virgin Islands. Boundaries indicate federal and territorial marine protected areas.

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Figure 8. A TCRMP research diver (S. Heidmann) on closed circuit rebreather records a roving fish survey at the Salt River Deep wall site, 30m/100' depth (April 9, 2020; credit: S. Meiling).

Methods

BENTHIC ASSESSMENTS

The University of the Virgin Islands determined the benthic composition at 34 long-term monitoring sites between 2001 and 2022 (Fig. 8; Table 1; Table 2). All data is now available at the TCRMP website and updated annually after quality control:

<https://www.vitcrmp.org>

Around St. Croix the following 15 sites were assessed: Buck Island-St. Croix, Buck Island Deep, 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), two sites are in a territorially managed area associated with Salt River (Salt River West and Salt River Deep), Buck Island-St. Croix and Buck Island Deep are within National Park Service/National Monument boundaries, two sites are within federal fisheries marine protected areas (Lang Hind, Mutton Snapper), and five sites can be considered mesophotic coral reefs (Buck Island Deep, 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, Cocus 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 (Cocus

METHODS

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, Cocus 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. Video sampling consisted of one diver traversing each transect videotaping the benthic cover using a high-definition standard definition digital video camera (prior to 2007) or a high-definition digital camera (after 2007). TCRMP has attempted to continually upgrade video equipment through time to maintain the highest quality imagery possible for benthic analysis. 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. 9). Captured images represented an area of reef approximately 0.31 m² (0.64 m x 0.48 m). Coral Point Count with Excel Extension software (Kohler and Gil 2006; prior to 2019) or R Studio (RStudio Team 2015; 2019 onward) 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,

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

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Table 1. TCRMP site reef complex type, location coordinates (decimal degrees; WGS 1984), and depths.

Island	Site	Reef Complex	Lat	Long	Depth (m)
St. Croix	Buck Island-St. Croix	Offshore-Shallow	17.78500	-64.60917	15
	Buck Island Deep-St. Croix	Offshore-MCE	17.80659	-64.59935	33
	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	7
	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	18.18901	-64.95630	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
	Little St James	Offshore-Shallow	18.29459	-64.83238	17

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Table 2. TCRMP site sampling date and type of sampling. Multiple dates indicate fish and benthic surveys were not completed on the same day and the date of fish survey is listed first. Surveys not completed are indicated by (-) while completed surveys are indicated by (X).

Island	Site	Sample Date	Benthic	Health	Fish + Urchin
St. Croix	Buck Island STX	10/17/22	X	X	X
	Buck Island STX Deep	10/17/22, 10/19/22	X	X	X
	Cane Bay	11/18/22	X	X	X
	Cane Bay Deep	11/18/22	X	X	X
	Castle	10/19/22	X	X	X
	Eagle Ray	10/20/22	X	X	X
	Great Pond	10/21/22	X	X	X
	Jacks Bay	11/17/22	X	X	X
	Kings Corner	10/22/22	X	X	X
	Lang Bank EEMP	10/21/22	X	X	X
	Lang Bank Red Hind FSA	11/17/22	X	X	X
	Mutton Snapper FSA	10/22/22	X	X	X
	Salt River Deep	10/20/22	X	X	X
	Salt River West	10/20/22	X	X	X
	Sprat Hole	10/22/22	X	X	X
St. John	Coral Bay	9/08/22	X	X	X
	Fish Bay	9/08/22	X	X	X
	Meri Shoal	8/24/22, 11/30/22	X	X	X
St. Thomas	Black Point	8/4/22, 10/07/22	X	X	X
	Botany Bay	8/29/22, 10/03/22	X	X	X
	Brewers Bay	9/23/22	X	X	X
	Buck Island STT	8/16/22, 10/04/22	X	X	X
	Coculus Rock	9/08/22, 10/04/22	X	X	X
	College Shoal East	8/26/22, 11/08/22	X	X	X
	Flat Cay	7/06/22, 10/10/22	X	X	X
	Ginsburgs Fringe	12/02/22	X	-	-
	Grammanik Tiger FSA	8/11/22, 12/07/22	X	X	X
	Hind Bank East FSA	8/22/22, 11/08/22	X	X	X
	Magens Bay	8/29/22, 10/03/22	X	X	X
	Savana	8/29/22, 10/03/22	X	X	X
	Seahorse Cottage Shoal	8/15//22, 10/04/22	X	X	X
	South Capella	8/23/22, 11/29/22	X	X	X
	South Water	8/11/22, 12/07/22	X	X	X
	Little St James	8/23/22, 10/12/22	X	X	X

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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 and old. 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).

Diseases were conservatively categorized into recognized Caribbean scleractinian diseases and syndromes that included bleaching, black band disease, dark spots disease, white plague, stony coral tissue loss disease, 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.

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.

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FISH CENSUS

Fish abundance, size, and diversity were recorded along transects and in roving diver surveys. There have been changes in protocol through the years to make initial methods more comparable to other regional sampling programs, to increase detection of rare, commercially important species, and to streamline logistics. Fish species identity, abundance, and size were assessed along at each site conducted over 15 minutes per transect. Prior to 2009 belt transect were 30x2 m in size. Starting in sampling year 2009 belt transects were enlarged to 25 m x 4 m, increasing the survey area however from 2009 through 2011, two surveys were done per replicate, the first counting all non-site attached fish and the return survey along the transect line surveying smaller, site attached fish. In 2012, transects were again modified, and single surveys (25 m x 4 m) were conducted per transect replicate, counting both site attached and non-site attached fish on a single survey. This change brought TCRMP assessment methodologies in line with NOAA Biogeography Branch methods at that time (Menza et al. 2006; Friedlander et al. 2013). Before 2019 ten transects were conducted at each site. A retrospective analysis of running means of fish abundance showed that nine transects were sufficient to capture within-site variability, and so the number of transects was reduced to nine starting in 2019, which greatly assisted with field logistics.

All transects were begun at a random location on the site and were swum in a random direction. Fish were sized by fork length recorded into size-bin categories (cm): 1-5. 6-10, 11-20, 21-30, 31-40, etc.. This sampling strategy is not optimized for noting the presence and abundance of small (<5 cm) gobies and blennies and the species were inconsistently recorded.

Roving diver survey (RDS) were also conducted to estimate site fish diversity. Prior to 2016 RDS surveys in water depths less than 25 m were 30 minutes in duration and, because of restrictions in dive length, were 15 minutes in deeper water. Retrospective

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analysis of species accumulation curves showed that almost all diversity was captured in the first 15 minutes of the survey. Therefore, for easier diving logistics, and to make deeper sites comparable, the methods were switched to 15 minute RDS at all sites in 2016. 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. Data presented in individual site summaries represents data collected for the current report period only.

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 25 x 2 m belt transects corresponding to the return of the 10 fish transects. The mean number of sea urchins per 100 m² was calculated for each site.

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, Magens 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 (between 1-10) given time constraints.

Territorial Coral Reef Monitoring Summary

TCRMP MONITORING SUMMARY

TEMPERATURE

The general sea surface temperature for the USVI is presented here as background for overall coral condition and site-specific temperatures presented in the “Site Summaries” section (Fig. 10).

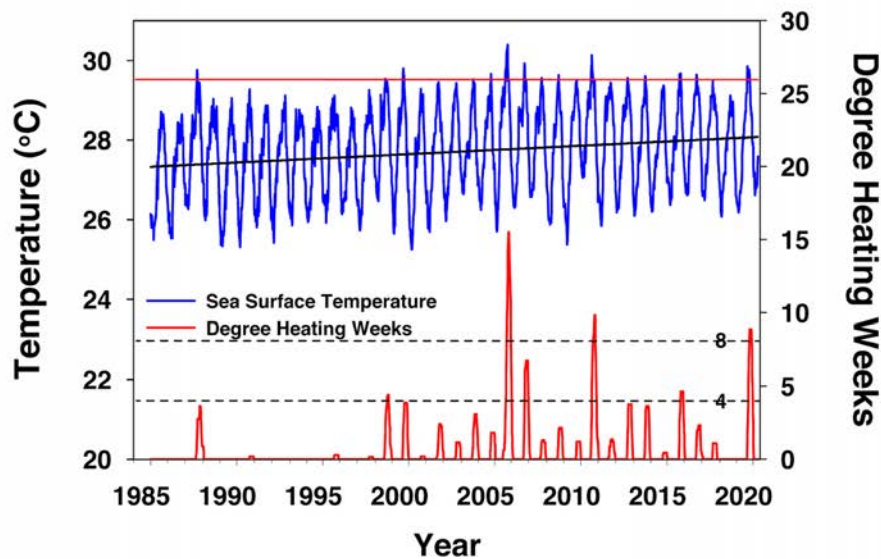


Figure 10. Sea surface temperatures and coral degree heating weeks of the US Virgin Islands from 1984 – 2020.

Optimum Interpolation Sea Surface Temperature (OISST; blue line, left vertical axis) and degree heating weeks (red line, right vertical axis) for the USVI. The black line is a linear fit of the OISST data and shows about 0.007°C increase in temperature per year ($y = 0.000669/\text{year} \cdot x - 25.545$). Degree heating weeks (DHW) are calculated as the 12 week rolling sum of temperatures exceeding 1°C over the monthly maximum mean temperature, which is estimated at 28.5°C for the USVI (NOAA 2006). DHW values above 4 are associated with the onset of bleaching, and above 8 with the onset of mass bleaching and coral mortality. OISST values averaged from coordinates 17.5N/65.5W, 17.5N/64.5W, 18.5N/65.5W 18.5N/64.5W from <https://www.ncdc.noaa.gov/oisst>; Accessed April 7, 2020 by Doug Wilson Ph.D..

TCRMP MONITORING SUMMARY

BENTHIC COMMUNITIES AND CORAL REEF HEALTH

Benthic cover was monitored at 34 monitoring sites and coral health was monitored at 33 sites in 2022. Raw data for benthic coverage, coral health, algae heights, and benthic temperature can be found at <https://www.vitcrmp.org/data-and-methods> . 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 a results of the 2010, 2012, and 2019 coral bleaching events (Fig. 11; Fig.12). 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 star coral (*Orbicella* spp.) 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, it is also true 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 showed no change, including Buck Island STT, Cocus 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 (19.6% prevalence with 62% of colonies displaying recent mortality).

TCRMP MONITORING SUMMARY

Recovery since bleaching in 2005 was marginal at most sites. Most sites had apparently level coral cover with recovery potentially inhibited by disease and increased interactions with other organisms. However, prior to impacts of SCTLD, slow and irregular upward trajectories were 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 to pinpoint, but the coral communities in these reefs are all diverse. This diversity may contribute to recovery as thermally sensitive, but fast-growing species, such as *Agaricites* spp. and *Porites porites*, may push 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 62% of its coral cover between 2011 and 2018, 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 (Smith et al. 2019b). A 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

TCRMP MONITORING SUMMARY

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 textilis*), which has been competing for benthic space and slowly decreasing coral cover by overtopping colony margins.

In December 2018 stony coral tissue loss disease (SCTLD) was first sited at the Flat Cay monitoring site. It has now spread to impact all reefs in the TCRMP, which is evident in many of the coral cover traces for individual sites.

TCRMP MONITORING SUMMARY

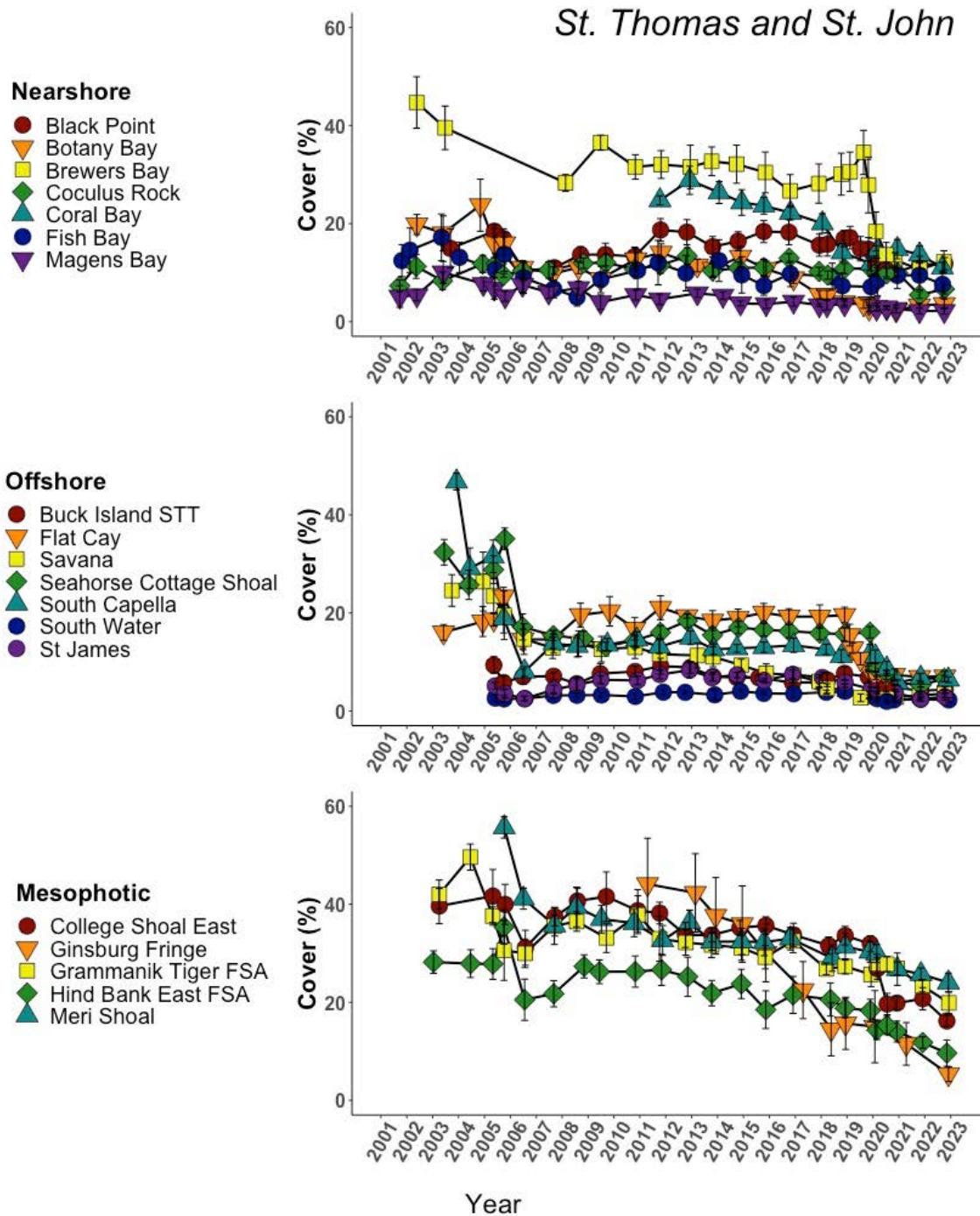


Figure 11. Coral cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2001 – 2022.

TCRMP MONITORING SUMMARY

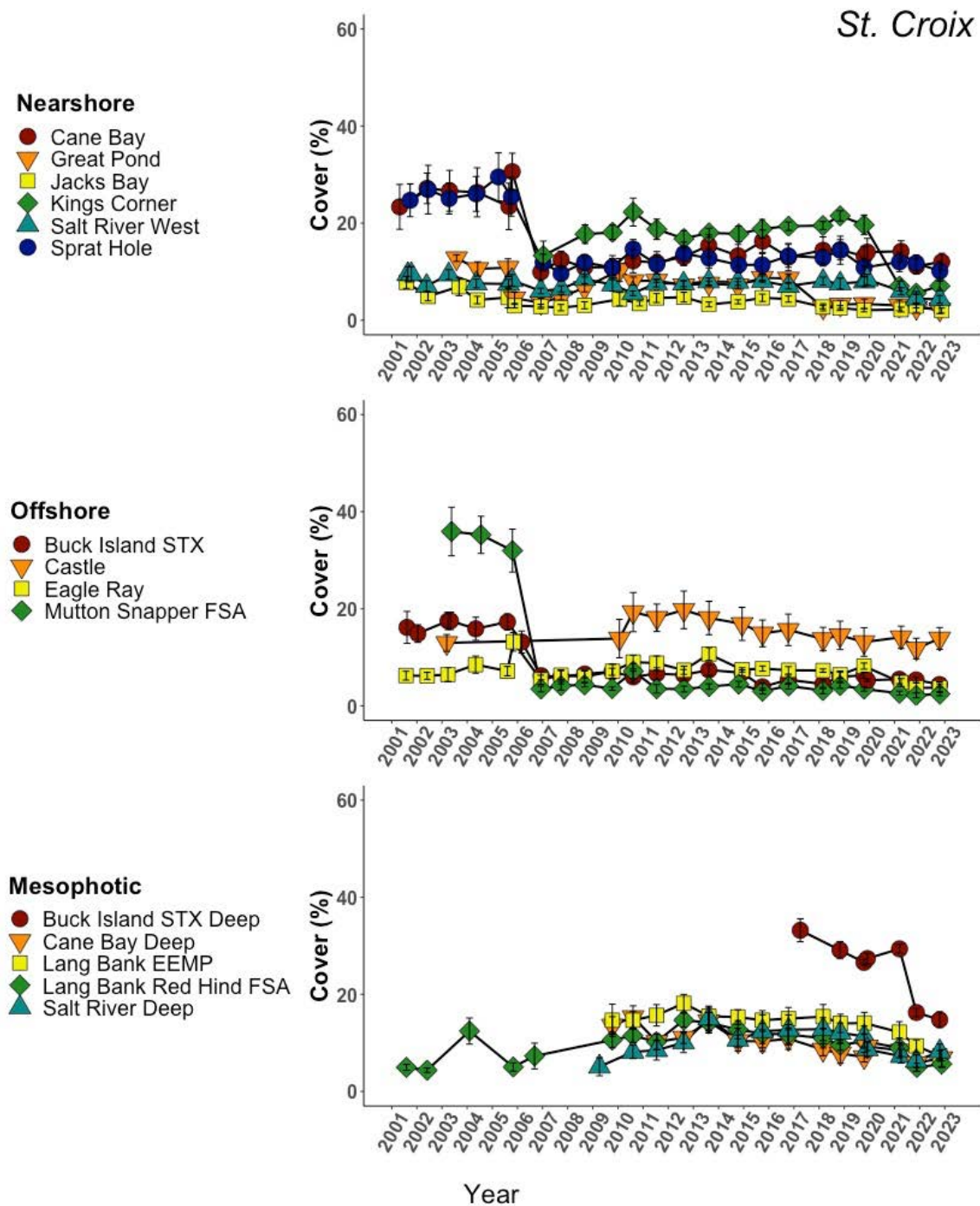


Figure 12. Coral cover ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2001 – 2022.

TCRMP MONITORING SUMMARY

Epilithic Algal Community Cover

Algae show the highest inter-annual variability of any group of benthic organisms (Fig. 13; Fig. 14). 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” *Ramicrosta* (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.

TCRMP MONITORING SUMMARY

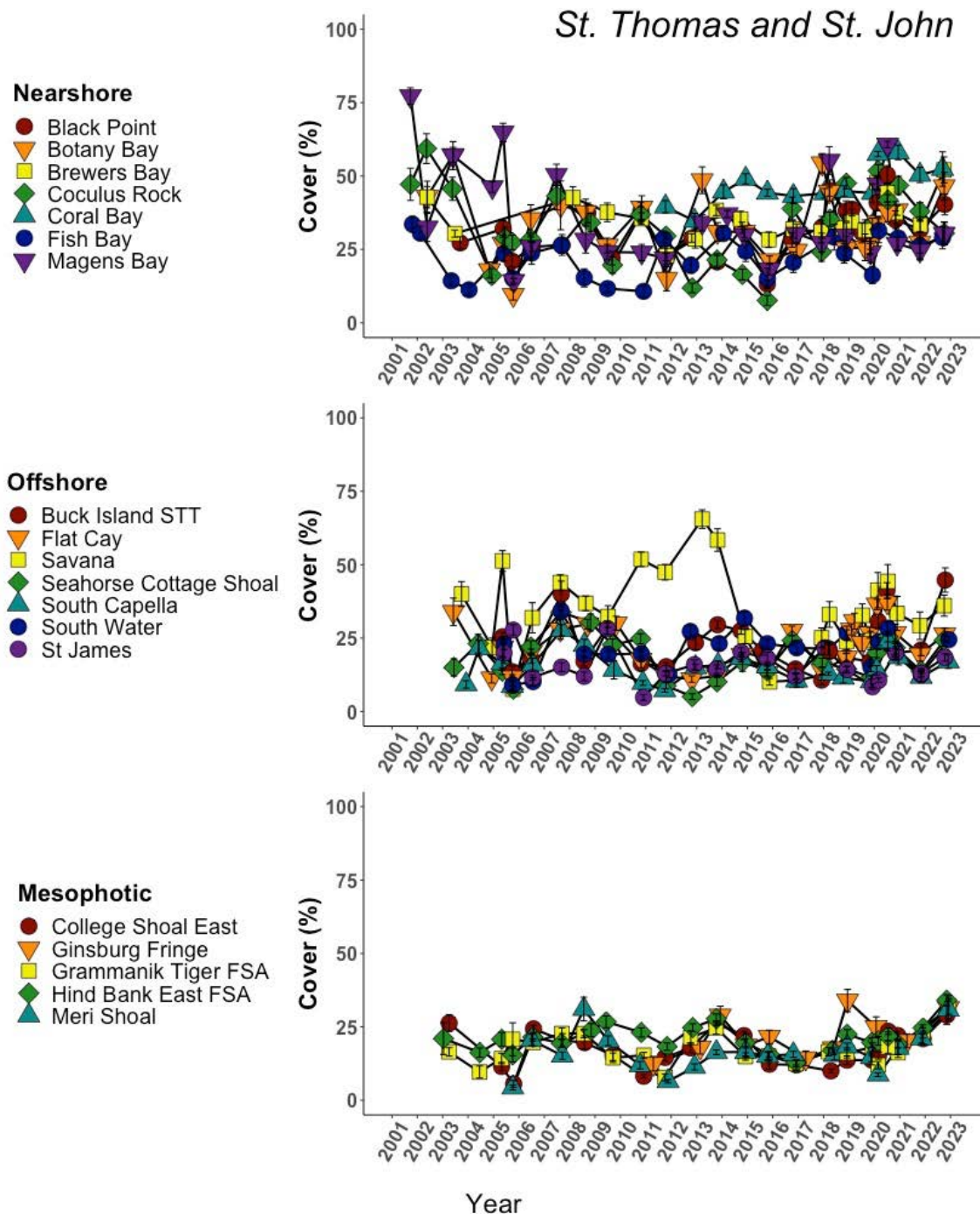


Figure 13. Epilithic Algal Community cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2001 – 2022

TCRMP MONITORING SUMMARY

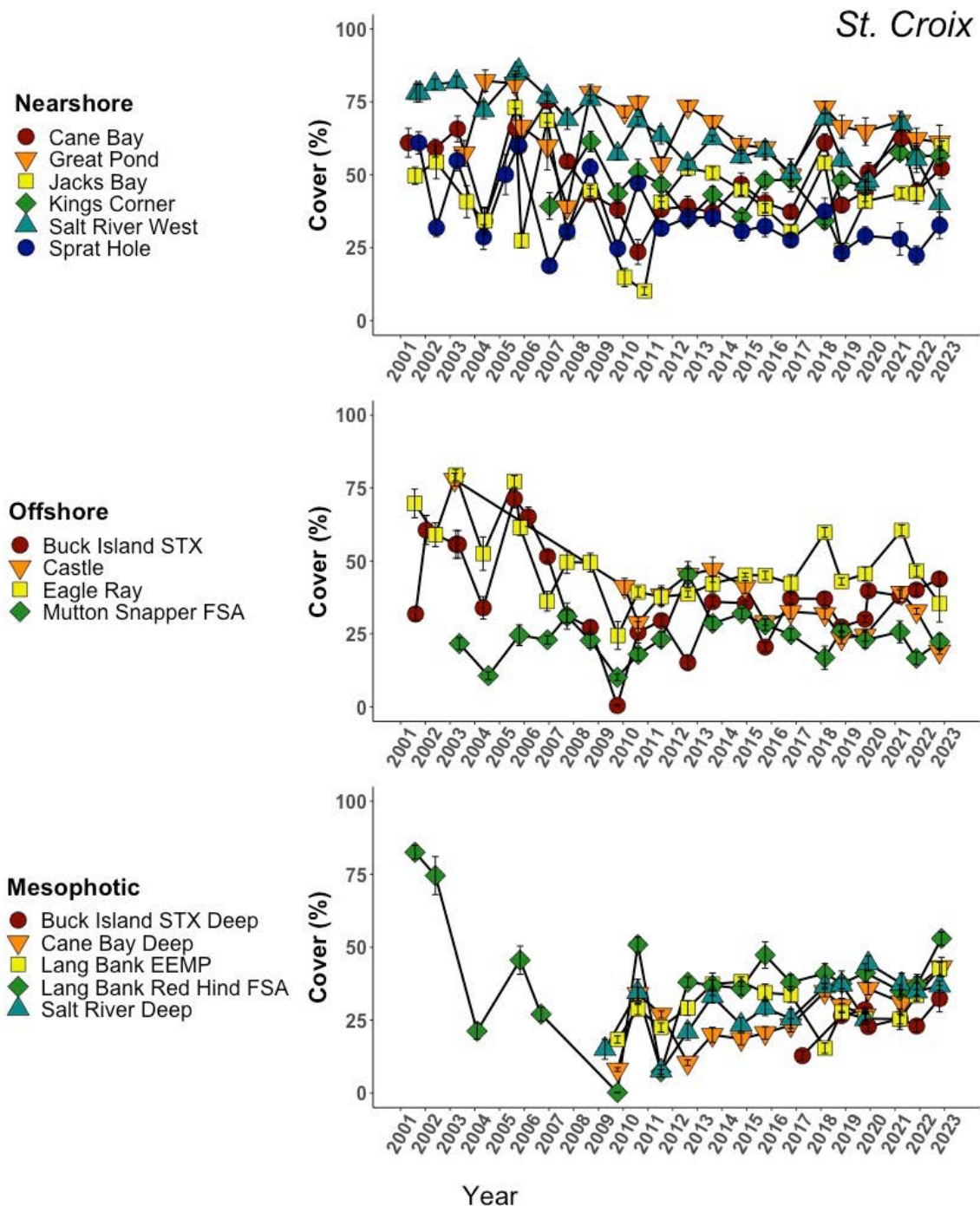


Figure 14. Epilithic Algal Community cover ($\pm$ SE) across St. Croix and TCRMP monitoring sites from 2001 – 2022

TCRMP MONITORING SUMMARY

Macroalgal Cover

Macroalgae have been increasing at many reefs, particularly after the 2005 bleaching event (Fig. 15; Fig. 16). 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 *Ramicrosta*, which was mentioned above as a cause of declining coral cover (*Ramicrosta* is classified with macroalgae in TCRMP data summaries despite its largely encrusting habitat). This increase in *Ramicrosta* sp. was also at the expense of epilithic algae.

TCRMP MONITORING SUMMARY

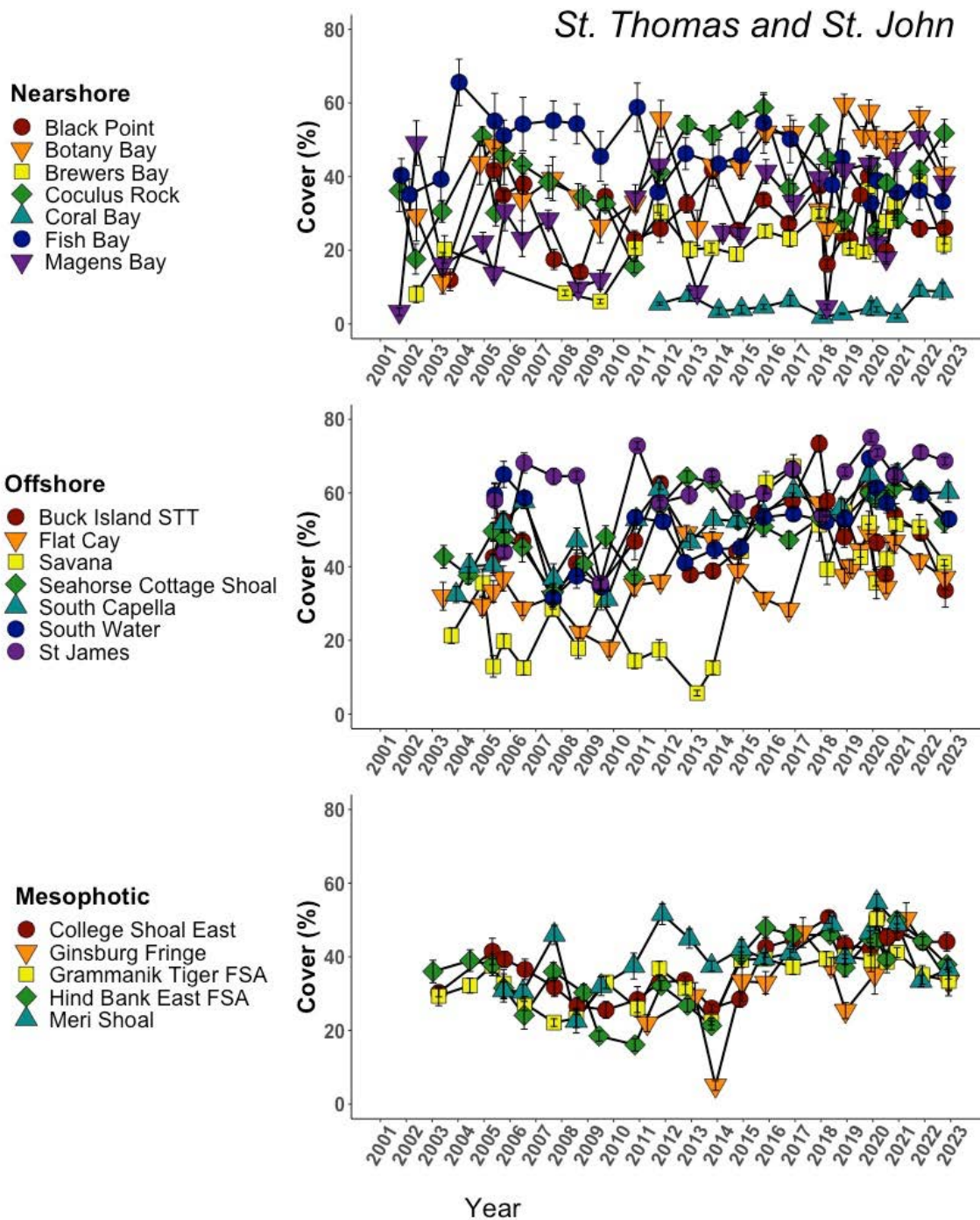


Figure 15. Macroalgae cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2001 – 2022.

TCRMP MONITORING SUMMARY

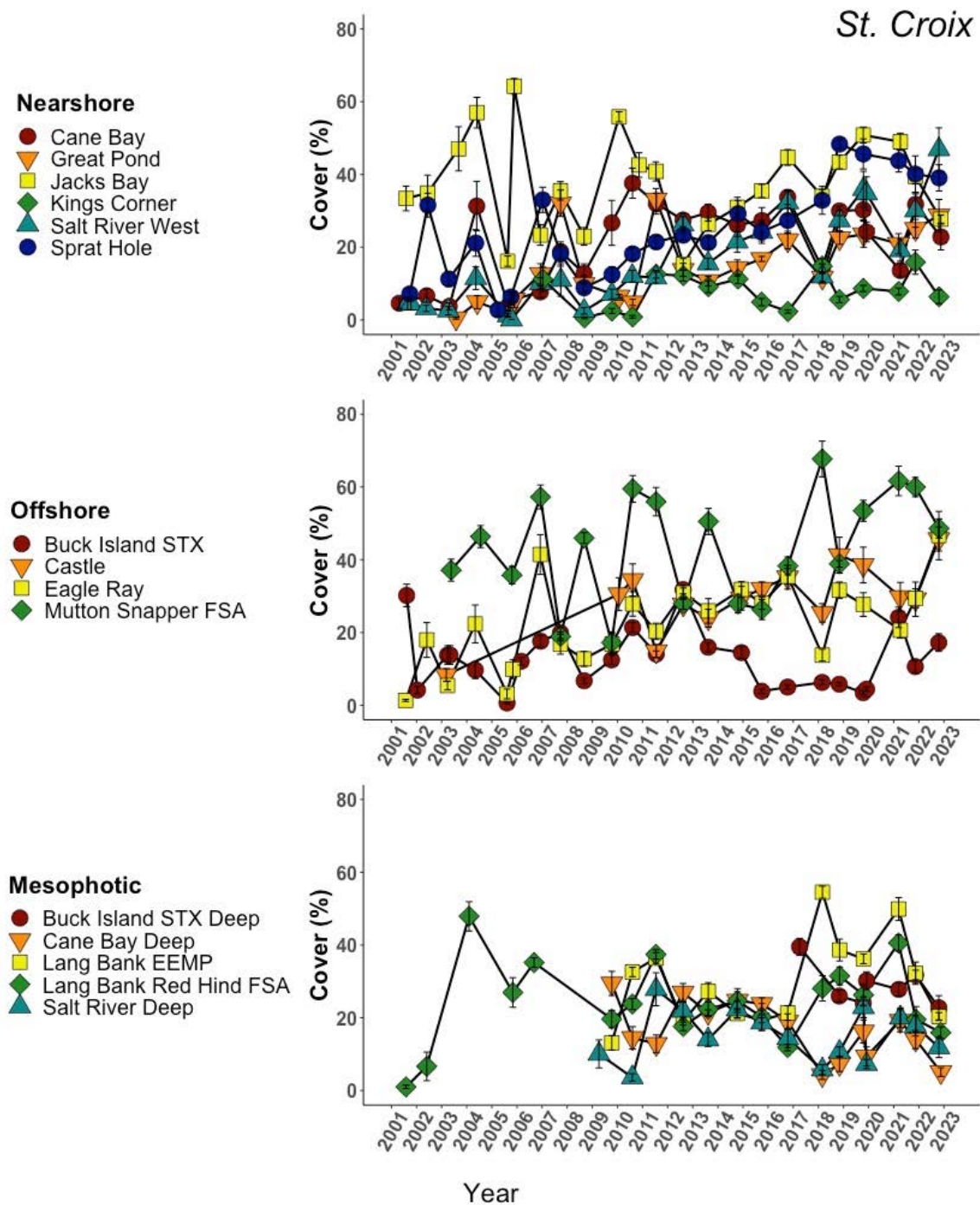


Figure 16. Macroalgae cover ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2001 – 2022.

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Filamentous Cyanobacteria

Filamentous cyanobacteria cover has been increasing at many sites in the TCRMP since the 2005 coral bleaching event (Fig. 17; Fig. 18). 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 often have secondary metabolites that deter grazing on the cyanobacteria and on palatable macroalgae coated with cyanobacteria (Fong et al. 2006; Smith et al. 2010a). Filamentous cyanobacteria can inhibit the recruitment of coral larvae (Kuffner et al. 2006) and has 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 to understand the factors influencing bloom formation and which reefs are most vulnerable.

TCRMP MONITORING SUMMARY

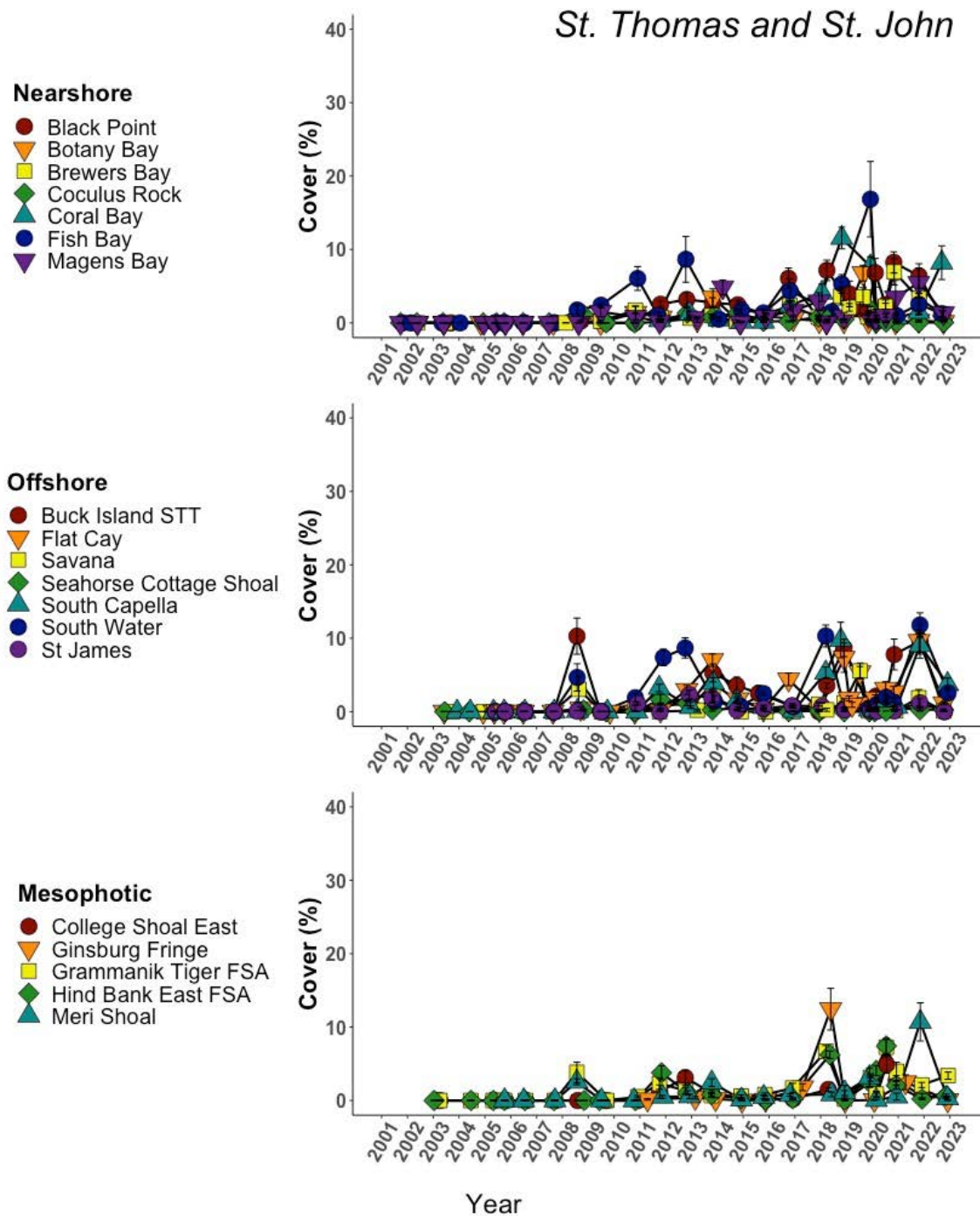


Figure 17. Filamentous cyanobacteria cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2003 – 2022

TCRMP MONITORING SUMMARY

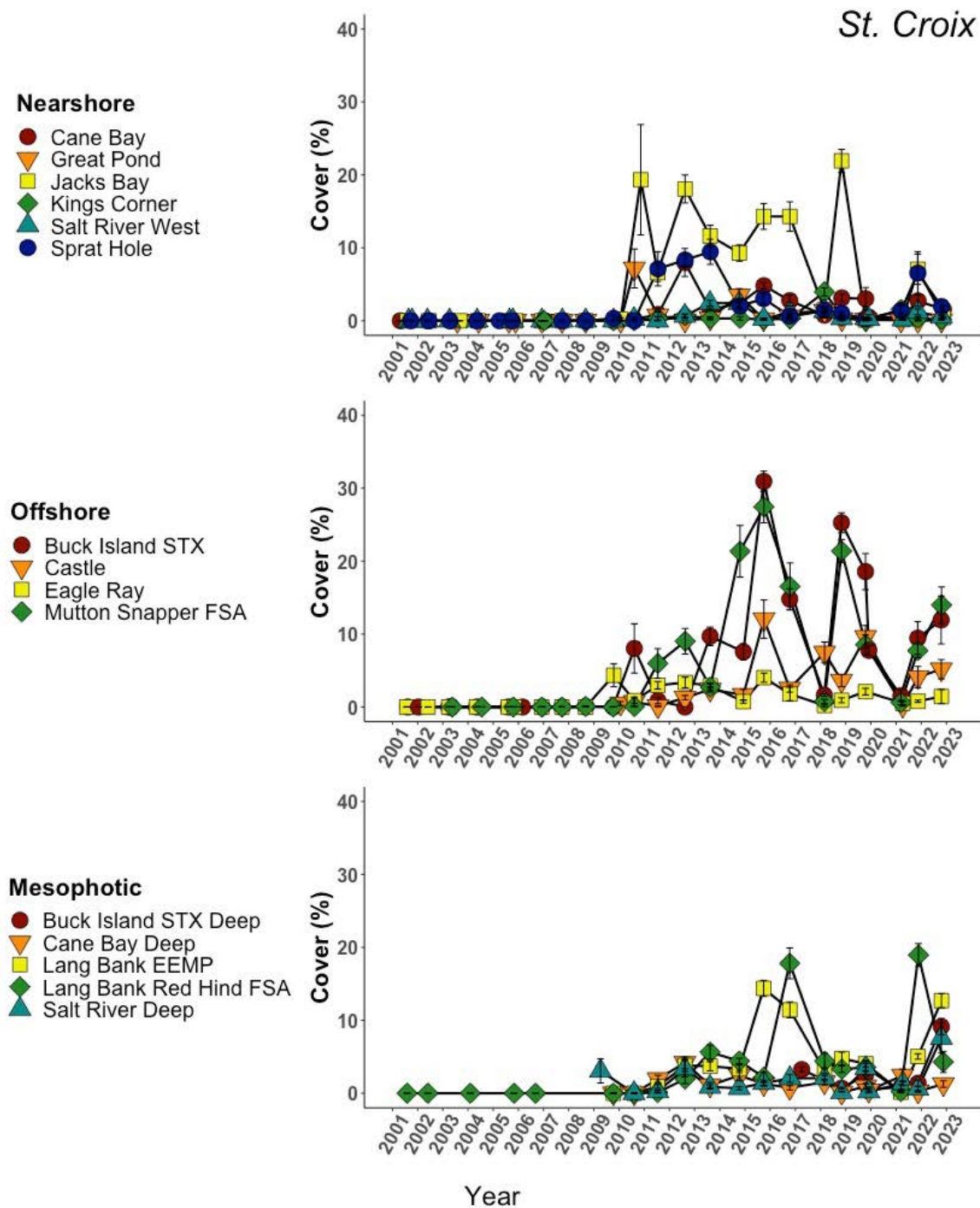


Figure 18. Filamentous cyanobacteria cover ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2011 – 2022.

TCRMP MONITORING SUMMARY

Gorgonian and Antipatharian Cover

The cover of gorgonians and antipatharians has been consistent or increasing at most monitoring sites throughout the years of monitoring (Fig. 19; Fig. 20). These groups did not seem sensitive to the thermal stress events in 2005, 2010, and 2012 (Tsounis and Edmunds 2017). In most cases they are a relatively minor component of cover because of their upright growth form and small branches which makes them less detectable in planar imagery. At Coral Bay and Fish Bay on the south side of St. John the cover of gorgonians has been increasing through the monitoring time series. This has also been shown by a separate research group for Lameshur Bay, in between these TCRMP sites on south St. John (Tsounis and Edmunds 2017). Magens Bay had previously shown increasing gorgonian cover, but this has reversed somewhat in later monitoring years. 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). Gorgonian cover decreased at the Savana monitoring site, which may be related to competition and recruitment limitation from increasing dominance of *Ramicrusta textilis*.

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

TCRMP MONITORING SUMMARY

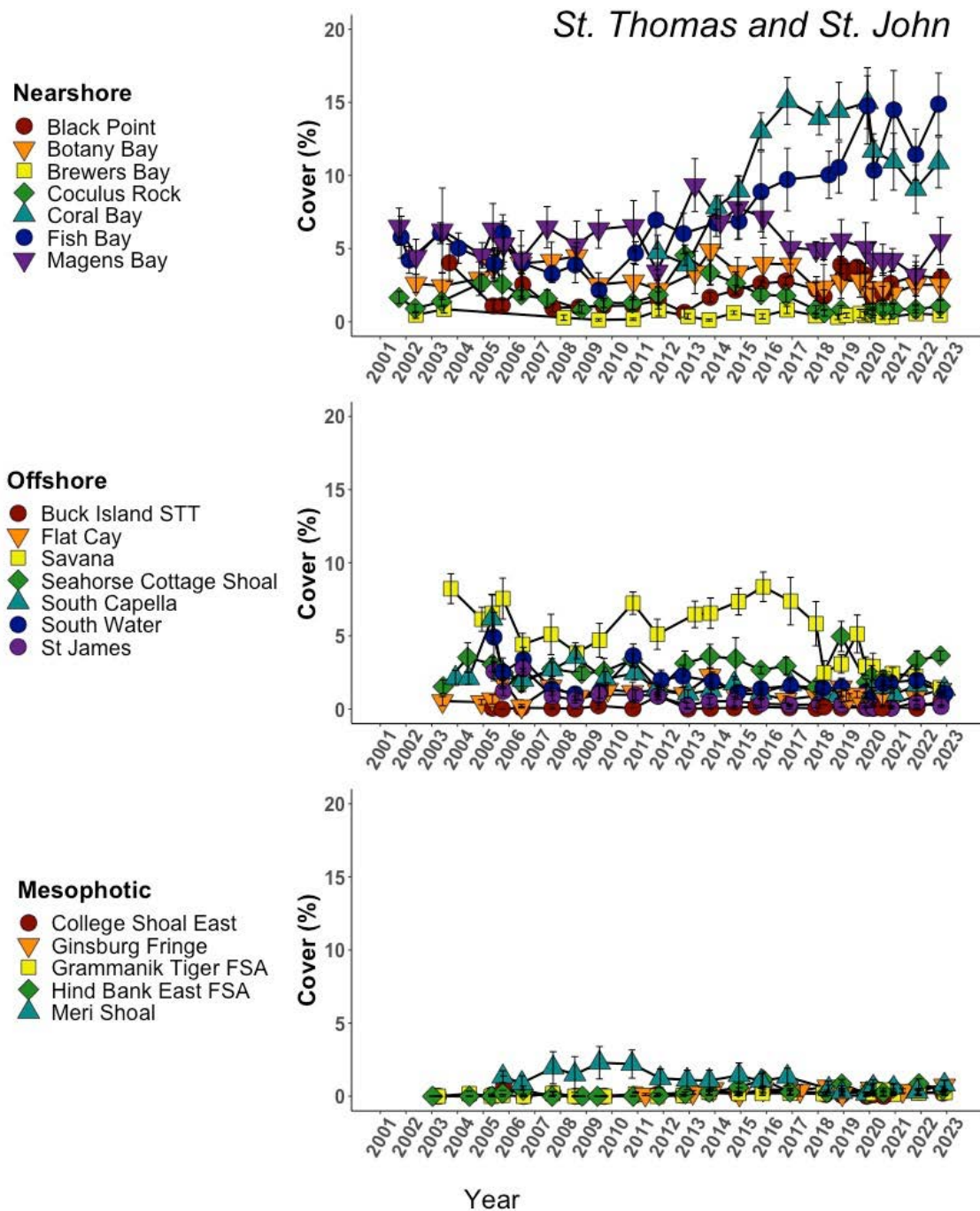


Figure 19. Gorgonian and Antipatharian cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2011 – 2022.

TCRMP MONITORING SUMMARY

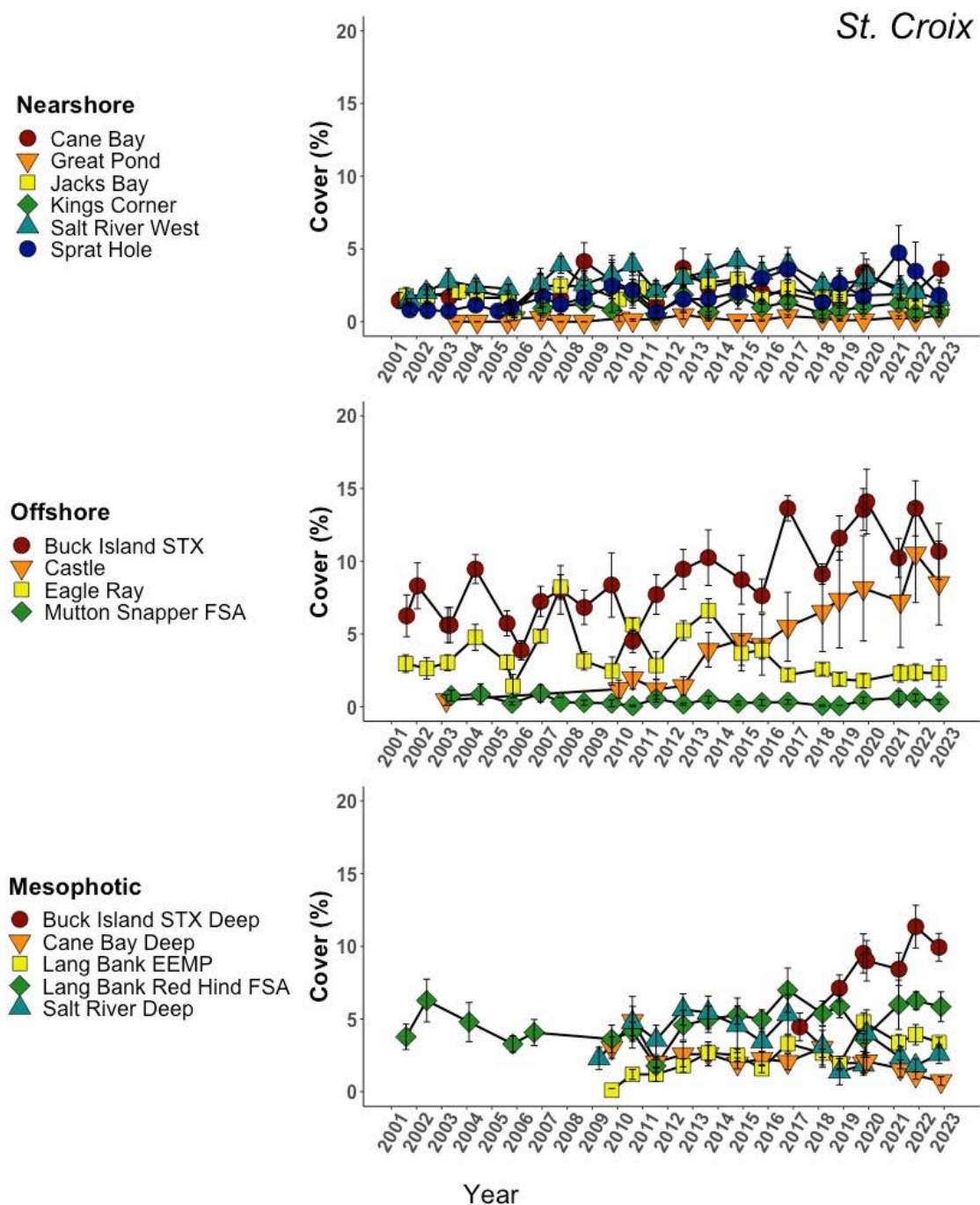


Figure 20. Gorgonian and Antipatharian cover ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2011 – 2022.

TCRMP MONITORING SUMMARY

Sponge Cover

There is an indication of slightly increasing sponge cover at some nearshore and offshore sites (Fig. 20; Fig 21.). Increases were most pronounced at Black Point, Buck Is. St. Thomas, Flat Cay, and Magens Bay. Sites such as Black Point and Flat Cay showed declines in sponge cover in the 2017 monitoring year, possibly due to the impacts of Hurricane Irma and Hurricane Maria (Gochfeld et al. 2020).

TCRMP MONITORING SUMMARY

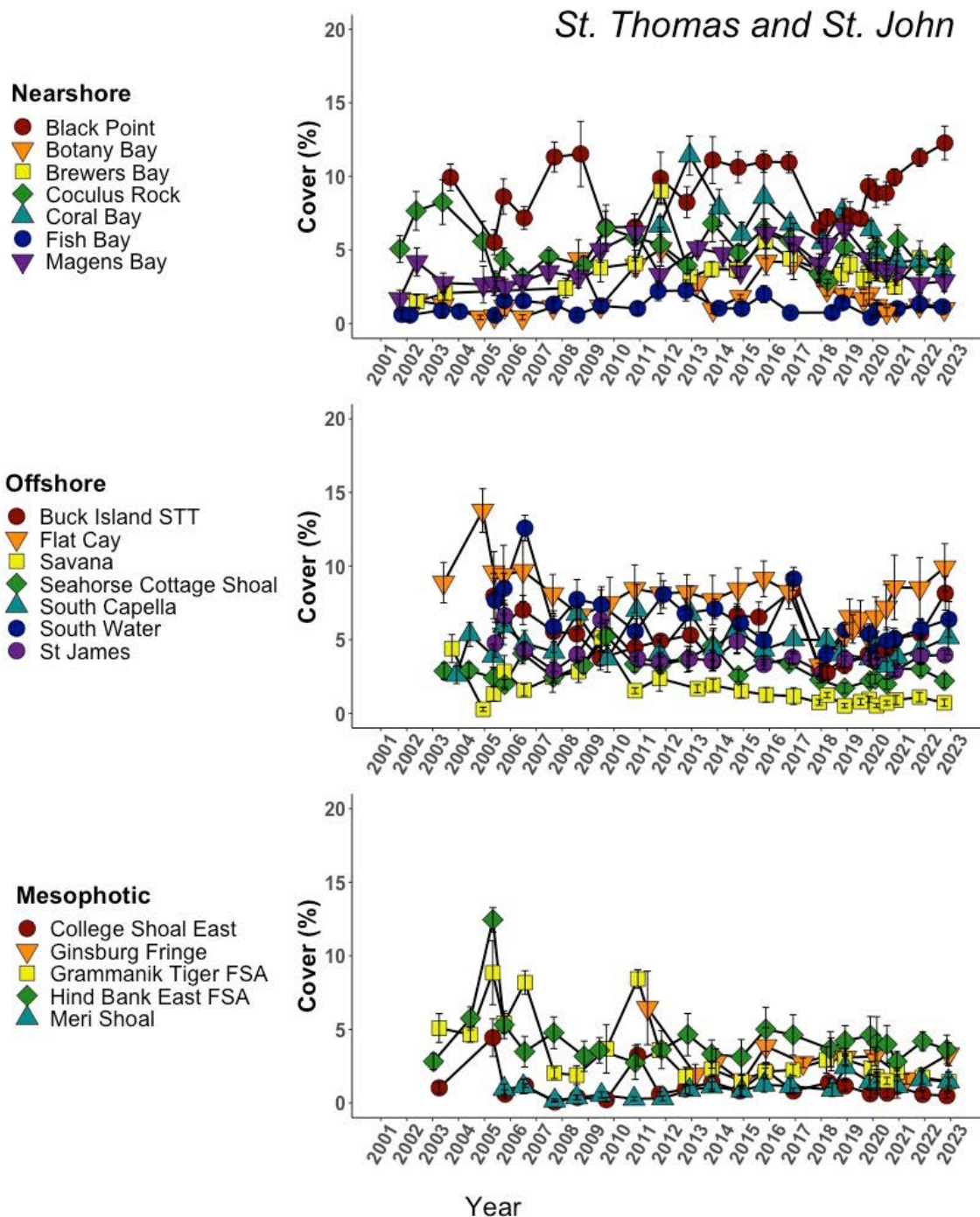


Figure 21. Sponge cover ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2011 – 2022.

TCRMP MONITORING SUMMARY

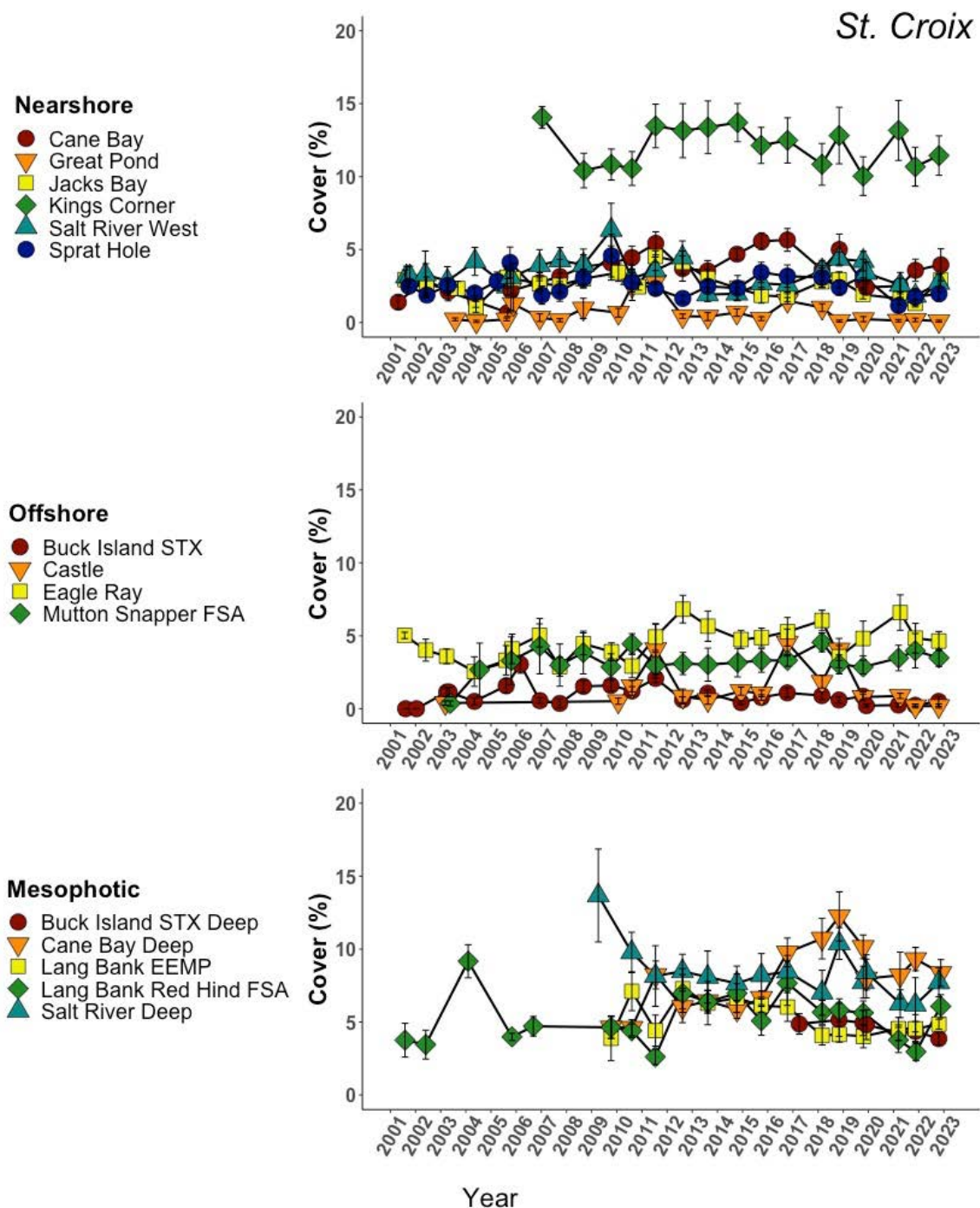


Figure 22. Sponge cover ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2011 – 2022

TCRMP MONITORING SUMMARY

FISH COMMUNITIES

Raw data for fish census data (transect and roving surveys) can be found at:

<https://www.vitcrmp.org/data-and-methods>

Northern USVI: The fish transect surveys conducted in 2022 on the 18 sites in the northern USVI's represented 145 species and 38 families. A total of 36,971 individuals were recorded with a mean abundance across all sites of 228 ± 48 100m⁻². The calculated biomass of fish surveyed across all sites totaled 1886 kg with a mean of 14 ± 6.50 kg 100m⁻².

On the seven nearshore sites in the northern USVI, a total of 13,004 fish were counted (mean= 206 ± 17 fish 100m⁻²), representing 110 species and 33 families. The total biomass of fish recorded on nearshore reefs in the northern USVI was 461 kg (mean 7.29 ± 2.19 kg 100m⁻²). On seven offshore sites of the northern USVI both diversity and abundance were higher than on nearshore reefs; 111 species representing 31 families were recorded and a total of 15,765 fish were counted (mean= 250 ± 18 fish 100m⁻²). The total fish biomass estimation on the offshore sites was 10.4 ± 1.2 kg 100m⁻². On mesophotic reefs diversity was lower than on shallow reefs; 98 species from 28 families were recorded. This represented 8,202 individuals (mean = 228 ± 26 fish 100m⁻²) and a total fish biomass of 66.8 kg (mean = 18.6 ± 2 kg 100m⁻²). Higher mean fish biomass across deeper mesophotic sites was largely due to the occurrence of schools of larger pelagic fishes on those shelf edge sites.

As in years past, in 2022 several ubiquitous species were found at relatively high abundance on all sites in the northern USVI. These species included two of the surgeonfishes: the blue tang (*Acanthurus coeruleus*), and ocean surgeon (*A. bahianus*); three wrasses: creole wrasse (*Clepicus parrae*), bluehead wrasse (*Thalasoma bifasciatum*) and yellowhead wrasse (*Halichoeres garnoti*); four parrotfishes: striped parrotfish (*Scarus iserti*), redband parrotfish (*Sparisoma aurolineatum*), stoplight parrotfish (*S.*

TCRMP MONITORING SUMMARY

viride) and princess parrotfish (*S. taeniopterus*); three chromis and damselfishes: blue chromis (*Chromis cyanea*), brown chromis (*C. multilineatum*), and threespot damselfish (*Stegastes partitus*); and the French grunt (*Haemulon flavolineatum*) and bar jack (*Caranx ruber*).

The most common species found on near shore sites in the northern VI's included the striped parrotfish (*S. iserti*) 24% and bluehead wrasse (*T. bifasciatum*) 10%. Three spot damselfish (*S. planifrons*), blue chromis (*C. cyanea*), and redband parrotfish (*S. aurolineatum*) were the next most common fish. These five species (three of which are herbivores) represented over 59% of all fish recorded on nearshore sites. Species contributing the most biomass to nearshore sites were primarily herbivores as well and included: bar jacks (*C. ruber*) 10%, french grunts (*H. flavolineatum*) 9%, stoplight parrotfish (*S. viride*) 8%, redband parrotfish (*S. aurolineatum*) 6%, striped parrotfish (*S. iserti*) 6%, and blue tang (*A. coeruleus*) 6%. These fish made up over 45% of the total fish biomass on nearshore reefs in the northern VI.

The most common fish on the offshore sites in the northern VI's included: blue chromis (*C. cyanea*) 17%, bluehead wrasse (*T. bifasciatum*) 11%, striped parrotfish (*S. iserti*) 10%, bicolor damselfish (*S. partitus*) 8%, and brown chromis (*C. multilineatum*) 5%. These species together represented over 51% of all 15,765 individuals recorded. The species contributing the highest biomass to fish communities on the offshore sites included: bar jack (*C. ruber*) 10%, blue striped grunts (*H. sciurus*) 9%, and four parrotfishes: stoplight parrotfish (*S. viride*) 8%, redband parrotfish (*S. aurolineatum*) 6%, striped parrotfish (*S. iserti*) 6% and yellowtail parrotfish (*S. rubripinnae*) 6%. These species constitute nearly 49% of biomass recorded on offshore reefs.

The most common species on the mesophotic sites in the northern Virgin Islands were creole wrasse (*Clepticus parrae*) 34%, blue chromis (*C. cyanea*) 9%, and bluehead wrasse

TCRMP MONITORING SUMMARY

(*T. bifasciatum*) 6% and scad (*Decapterus macarellus*). These four planktivorous species represented over 55% of all fish recorded on mesophotic sites. Species contributing the most biomass to the mesophotic sites in the northern USVI included two pelagic species: creole wrasse (*C. parrae*) 19% and ocean triggerfish (*Canthidermis sufflamen*) 6%, and two piscivorous species: cubera snapper (*Lutjanus cyanopterus*) 7%, and schoolmaster snapper (*L. apodus*) 7%. These two snapper species were probably in spawning groups on the mesophotic reefs, and so have artificially high abundance measures. Nevertheless, these four fish approximately 40% of the mesophotic site biomass.

St. Croix: On the 15 sites surveyed off St. Croix, an additional 29,280 fish representing 141 species and 45 families were recorded. The mean fish abundance across all sites off St. Croix was 217 ± 8 fish 100m^{-2} . The calculated total biomass across all sites was 1,584 kg with a mean biomass of 11.73 ± 0.94 kg/ 100m^2 . This is nearly 35% higher than the mean biomass of fish surveyed on the St. Croix sites in 2021.

Sites across St. Croix showed more variability in terms of fish abundance and biomass across depth strata than in previous years. Nearshore sites in St. Croix, had a total of 11,783 fish counted (mean = 218 ± 13 fish/ 100m^{-2}), representing 110 species and 34 families. The calculated total biomass of fish recorded on the six nearshore reefs in St. Croix was 484 kg (mean 8.97 ± 1.19 kg 100m^{-2}). On four offshore sites a total of 8651 fish were counted (mean = 240 ± 19 fish 100m^{-2}) representing 110 species and 37 families. The total fish biomass estimation on the offshore sites was 676 kg (mean = 18.76 ± 2.91 kg 100m^{-2}). On mesophotic reefs off St. Croix 99 species in 33 families were recorded. This represented 8,846 fish (mean = 196.58 ± 12.70 fish/ 100m^2) and a total fish biomass of 423.73 kg (mean = 9.42 ± 1.19 kg/ 100m^2). Fish diversity, abundance and biomass in St.

TCRMP MONITORING SUMMARY

Croix were highest on offshore reefs, as opposed to shallow or deeper mesophotic sites in 2022.

The most common species found on nearshore sites in St. Croix included: bluehead wrasse (*T. bifasciatum*) 17%, blue chromis (*C. cyanae*) 17%, bicolor damselfish (*S. partitus*) 14% and brown chromis (*C. multilineatum*) 7%. Other common nearshore species on St. Croix included creole wrasse, redband parrotfish, striped parrotfish, and blue tang. Unlike the most common species found on nearshore reefs in the northern USVI, which were primarily herbivores, the most abundant species on St. Croix shallow reefs were planktivorous. This possibly reflects the most available food type on the narrow shelf of the St. Croix insular platform. Species contributing the most biomass to nearshore sites in St. Croix included: four reef sharks (*Carcharhinus perezii*) 18%, stoplight parrotfish (*S. viride*) 9%, redband parrotfish (*S. aurofrenatum*) 7%, queen parrotfish (*S. vetula*) 6%, and blue tang (*A. coeruleus*) 4%.

The most common fish on the offshore sites in St. Croix included: bluehead wrasse (*T. bifasciatum*) 15%, blue chromis (*C. cyanae*) 10%, bicolor damselfish (*S. partitus*) 10%, brown chromis (*C. multilineata*) 7%, and mackerel scad (*D. macarellus*) 5%. As in previous years the top five species numerically are planktivorous and represent greater than 47% of individuals recorded on offshore reefs in St. Croix. The species contributing the highest biomass to fish communities on the mid-shelf offshore reef sites included: blackbar soldierfish (*Myripristis jacobus*) 19%, blue tang (*A. coeruleus*) 6%, horseeye jack (*C. latus*) 6%, yellowtail snapper (*O. chrysurus*) 5% and stoplight parrotfish (*S. viride*) 5%. This variety of trophic groups reflects the diversity of resources available on the narrow oceanic shelf of St. Croix.

TCRMP MONITORING SUMMARY

The most common species on the mesophotic sites in St. Croix included: blue chromis (*C. cyanae*) 32%, bicolor damselfish (*S. partitus*) 12%, creole wrasse (*C. parrae*) 9%, bluehead wrasse (*T. bifasciatum*) 7%, and princess parrotfish (*S. taeniopterus*) 6%. These five species (four of which are planktivores) represented 66% of all fish recorded on those sites. Princess parrotfish also made up 4% of fish abundance on northern USVI mesophotic reefs and was the most common herbivore. Species contributing the most biomass to the mesophotic sites in St. Croix included: four Caribbean reef sharks (*Carcharhinus perezii*) 11%, black durgelon (*Melichthys niger*) 11%, princess parrotfish (*S. taeniopterus*) 8%, yellow goatfish (*Mulloidichthys martinicus*) 4% and French grunt (*H. flavolineatum*) 4%.

TCRMP MONITORING SUMMARY

Table 3. The 2021 species richness for belt transects and roving diver surveys (RDS)..

		Belt Transects (25x4)		RDS
		Total Number of Species	Mean species per transect ($\pm$ SE)	Total Number of Species
Nearshore	Cane Bay	58	26.8 $\pm$ 0.7	54
	Great Pond	46	19.3 $\pm$ 1.9	67
	Jacks Bay	68	22.4 $\pm$ 1.7	54
	Castle	65	22.9 $\pm$ 2.1	76
	Salt River West	50	20.2 $\pm$ 1.6	50
	Sprat Hole	60	26.2 $\pm$ 0.8	65
	Coculus Rock	55	22.2 $\pm$ 1.2	53
	Black Point	58	23.1 $\pm$ 1.6	62
	Brewers Bay	51	23.7 $\pm$ 1.7	55
	Botany Bay	62	29.4 $\pm$ 2.0	65
	Coral Bay	45	16.8 $\pm$ 1.2	39
	Fish Bay	61	21.6 $\pm$ 1.3	60
	Magens Bay	55	27.6 $\pm$ 0.8	53
Offshore	Eagle Ray	64	27.3 $\pm$ 2.0	66
	Buck Island, St. Croix	57	25.0 $\pm$ 1.2	60
	Kings Corner	76	33.1 $\pm$ 0.9	83
	Mutton Snapper FSA	60	24.6 $\pm$ 2.6	59
	Buck Island, St. Thomas	59	27.3 $\pm$ 1.4	73
	Seahorse Cottage Shoal	60	27.2 $\pm$ 1.2	60
	South Capella	67	25.4 $\pm$ 1.7	60
	South Water	58	23.5 $\pm$ 1.3	62
	Flat Cay	68	30.3 $\pm$ 1.6	65
	Savana Island	60	23.7 $\pm$ 1.2	71
	St. James	62	25.0 $\pm$ 1.1	54
Mesophotic	Buck Island STX Deep	59	21.0 $\pm$ 2.2	52
	Cane Bay Deep	48	17.2 $\pm$ 0.8	47
	Lang Bank EEMP	63	25.9 $\pm$ 1.1	62
	Lang Bank Red Hind FSA	52	23.4 $\pm$ 1.4	46
	Salt River Deep	48	19.2 $\pm$ 1.1	45
	College Shoal East	59	22.1 $\pm$ 0.8	52
	Ginsburg's Fringe	-	-	-
	Grammanik Tiger FSA	58	26.2 $\pm$ 0.8	53
	Hind Bank East FSA	73	27.9 $\pm$ 1.5	65
	Meri Shoal	51	21.9 $\pm$ 0.7	51

TCRMP MONITORING SUMMARY

Fish Abundance

Total yearly fish abundances across nearshore, offshore, and mesophotic sites are shown in Figures 23 and 24. As in previous years, total fish abundance showed high variability across sites and strata. Total fish abundance was slightly lower in 2022 than 2021 across all northern VI sites combined (36,971 and 38,438 respectively) as well as all St. Croix sites combined (29,280 and 30,008 fish respectively). Abundance notably rose on the St. James and College Shoal East sites and dropped on Botany Bay and Grammanik Tiger MCD. These changes can be attributed to the presence or absence of the prolific small pelagic fishes, (most often the creole wrasse, *Clepticus parrae*) that vary annually and seasonally.

Sites with the highest overall fish abundance in 2022 were Kings Corner, Flat Cay and College Shoal. Fish abundance at Kings Corner was influenced strongly by large schools of mackerel scad (*Decapterus macarellus*) and red ear sardines (*Harengula humeralis*) observed during the surveys. The relatively high fish abundance at Flat Cay was largely due to huge numbers of glass gobies (*Coryphopterus personatus*) and newly settled chromis (*Chromis multilineata* and *C. cyanae*), and at College Shoal East to schools of creole wrasse (*C. parrae*). The sites with the lowest fish abundance in the northern VI's were the nearshore sites of Fish Bay, Cocus Rock and Magens Bay. The sites with the lowest fish abundance in St. Croix were the mesophotic sites Cane Bay Deep and Salt River Deep. These mesophotic sites, defined by agariciid corals and high silt loads, continued to also have low species richness values and low biomass.

TCRMP MONITORING SUMMARY

St. Thomas and St. John

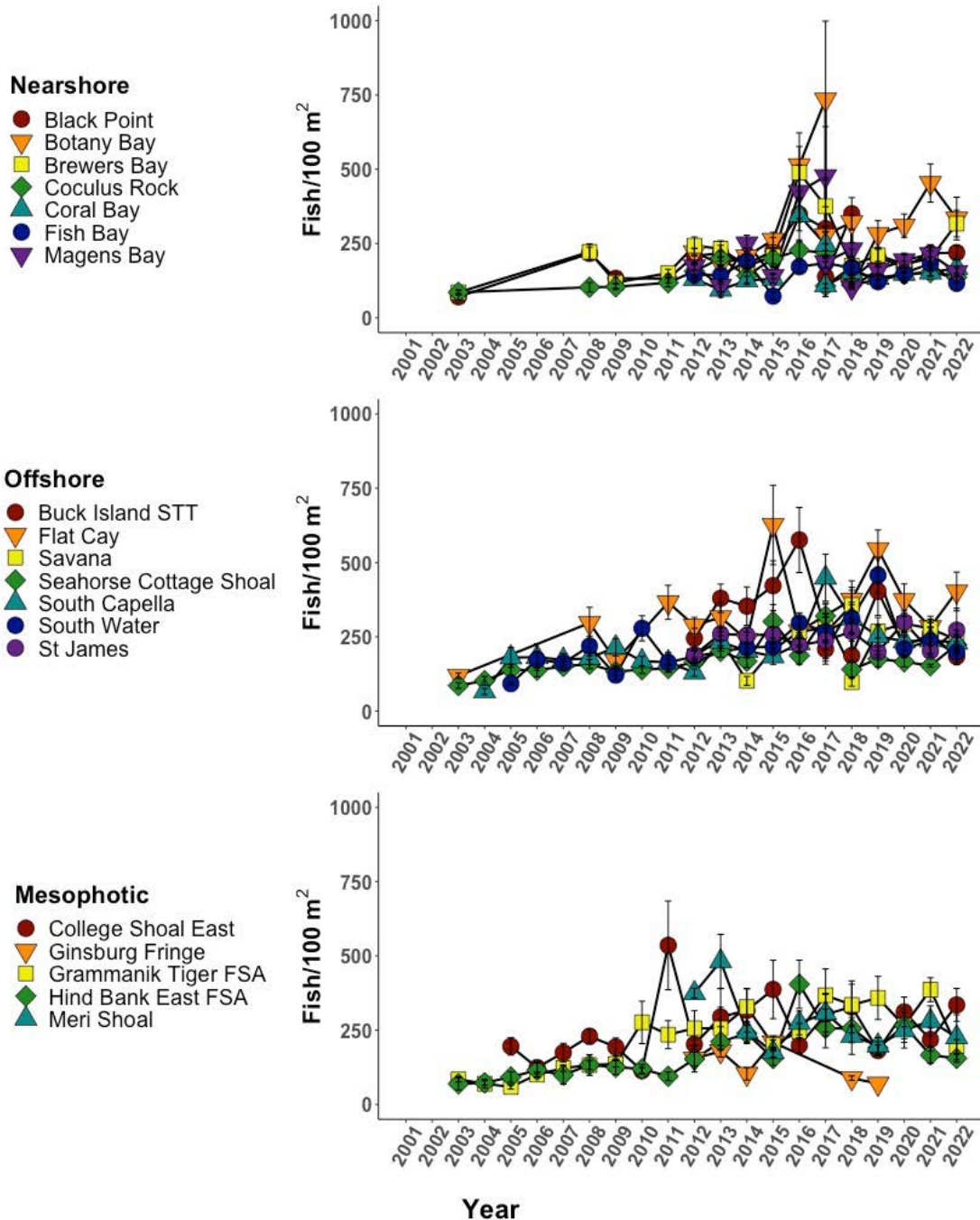


Figure 23. Fish abundance ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2003-2022.

TCRMP MONITORING SUMMARY

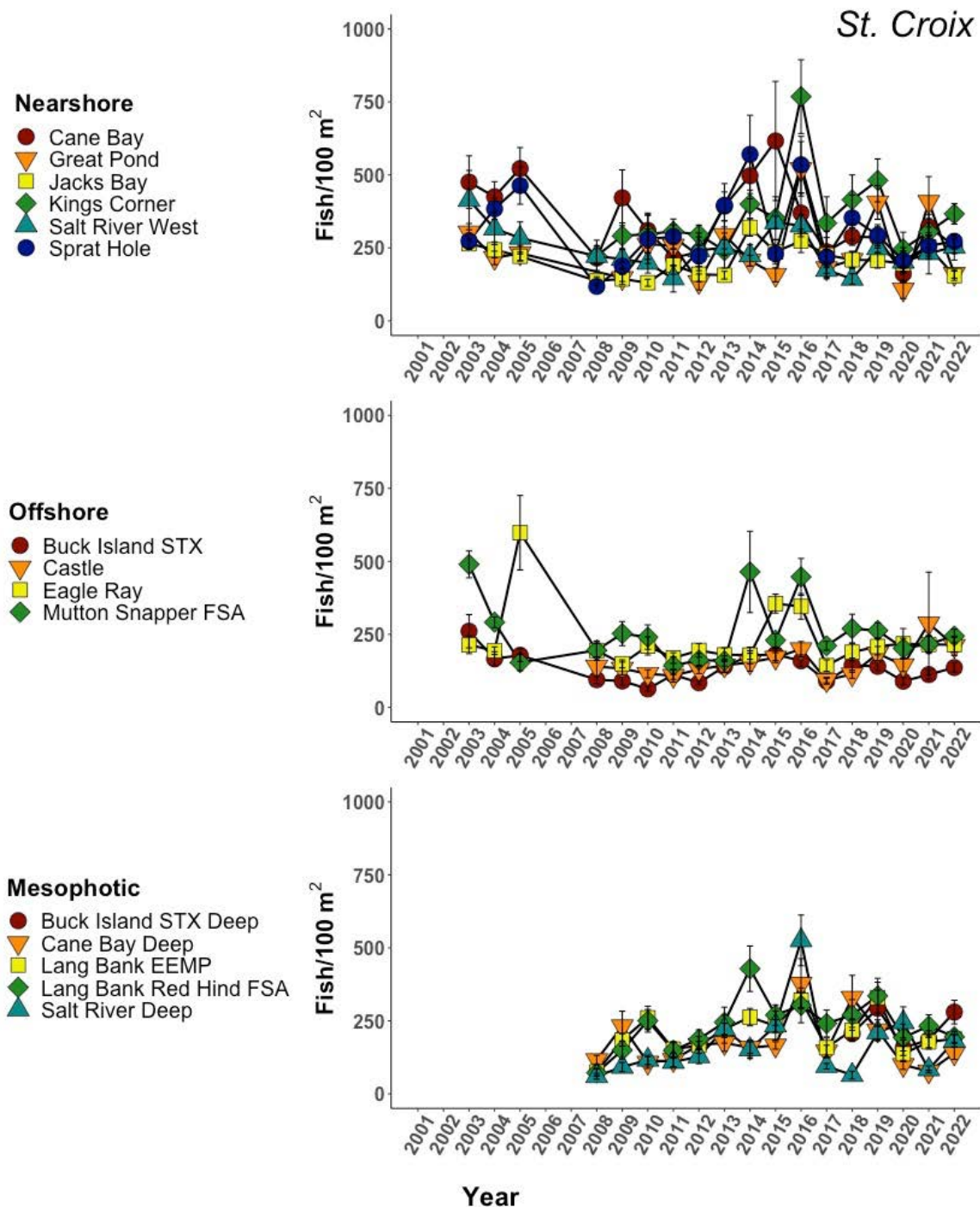


Figure 24. Fish abundance ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2003-2022.

TCRMP MONITORING SUMMARY

Fish Biomass

Total fish biomass for all sites and years is shown in Figures 25 and 26. As with abundance, biomass is highly variable across strata, sites, and years. No temporal pattern is obvious, and differences appear to be seasonal or natural variation. Overall total biomass, across all sites, was slightly lower in 2022 than in 2021 both in the northern VI's and St. Croix. St. James and King's Corner, showed the highest biomass values in 2022. These sites are both located offshore, receive significant current and flushing, and have a varied benthic cover that includes stony coral reef, sponge and gorgonian dominated hardbottom, sand, and adjacent sea grass. Both sites show high species richness and diversity as well as relatively high fish abundance and biomass every year. College Shoal, the mesophotic site in the northern USVI, has over time also shown high fish biomass values in the TCRMP sampling series. The other mesophotic sites in the northern VI's, Grammanik Tiger FSA and Hind Bank East FSA dropped in biomass in 2022, presumably due to the annual or seasonal absence of pelagic fishes which historically have been the primary influence on biomass values. Sites with the lowest biomass in 2022 included Coral Bay, Jack's Bay, Magen's Bay, Cane Bay West and Sprat Hole. These nearshore sites have lost much of their living coral cover due to many years of degradation by land-based sediment and pollutants as well as global sources of thermal stress and disease and continue to support primarily only juvenile and very small fishes.

TCRMP MONITORING SUMMARY

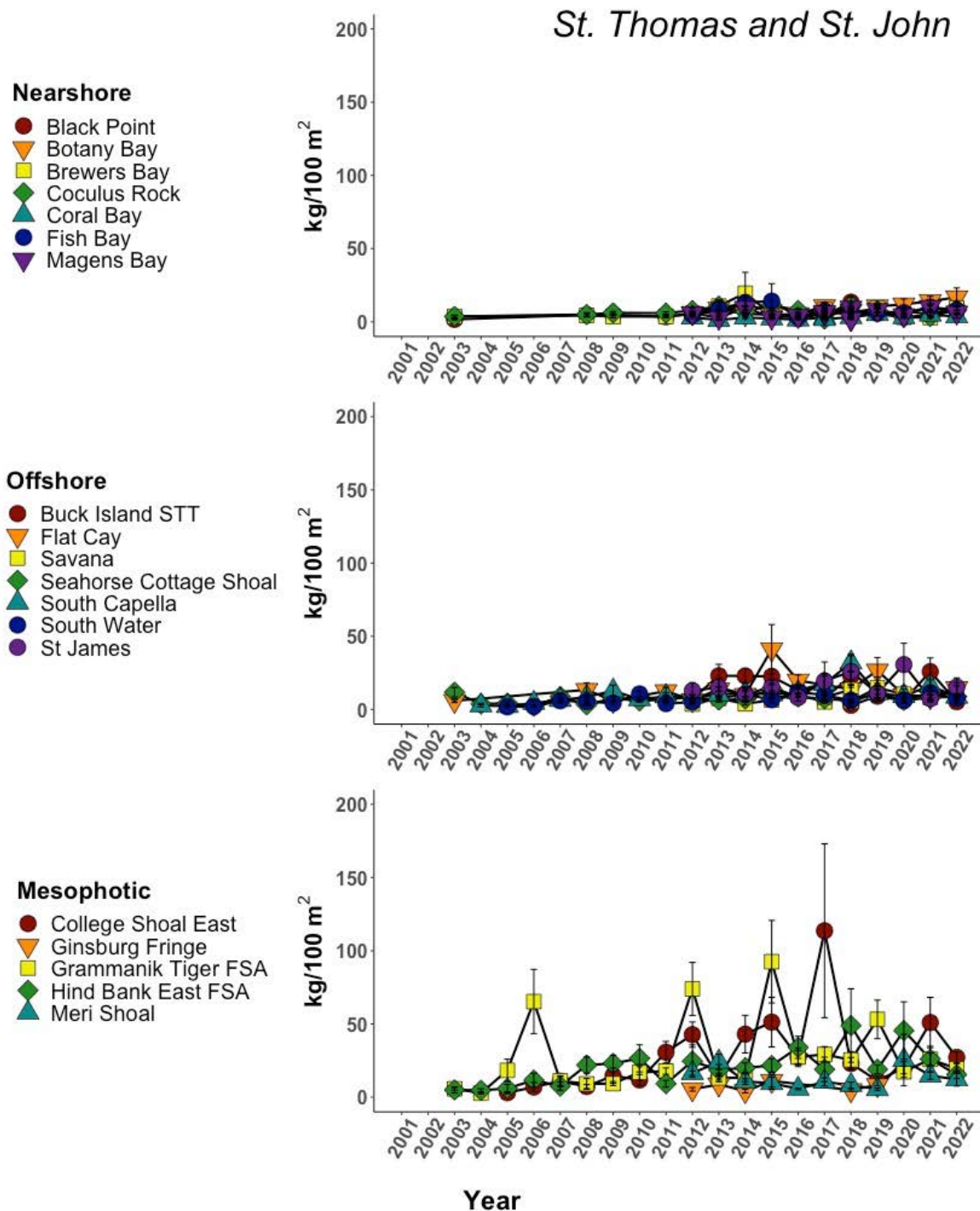


Figure 25. Mean fish biomass ($\pm$ SE) across St. Thomas and St. John TCRMP monitoring sites from 2003-2022.

TCRMP MONITORING SUMMARY

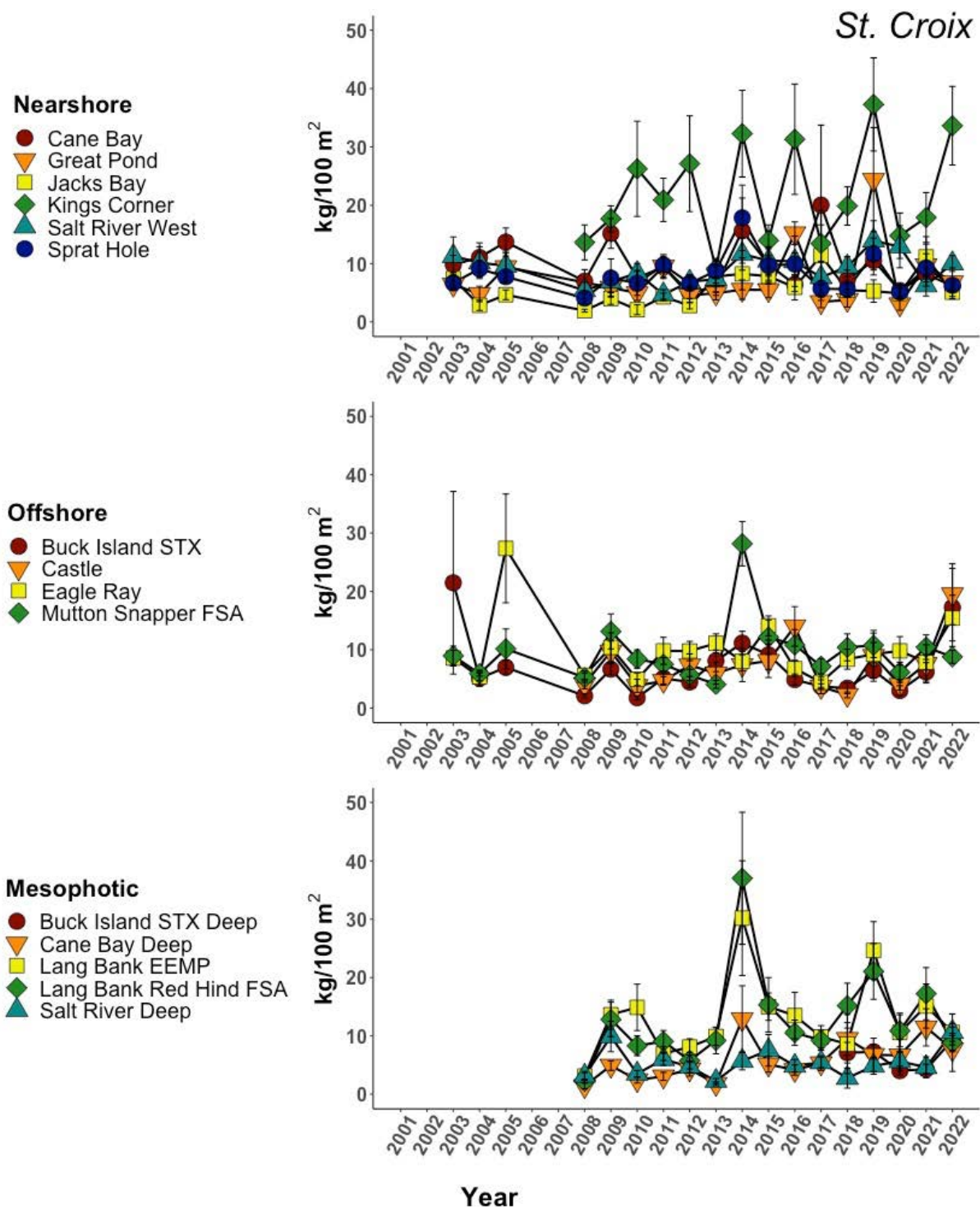


Figure 26. Mean fish biomass ($\pm$ SE) across St. Croix TCRMP monitoring sites from 2003-2022

TCRMP MONITORING SUMMARY

BLACK SPINED SEA URCHIN *DIADEMA ANTILLARUM*

In general, the shallowest sites, e.g., Great Pond, support the greatest abundance of *D. antillarum*. Trends are not presented here by year, as variability is generally low. At Coral Bay there was a high abundance of *Echinometra* spp. that has not been quantified, but the abundance seems to have declined after 2017. 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.

The abundance of the black spined sea urchin *Diadema antillarum* decreased in 2022 from previous years, likely due to the mass mortality event that was observed in spring of 2022. Average density of *Diadema* decreased average of 1.7 ± 0.87 urchins 100m^{-2} in 2021 to 0.24 ± 0.15 in 2022. Additionally, urchins were only observed at six sites during TCRMP sampling (Fig. 27) compared to 15 sites the previous year. However, since sampling in fall of 2022, juvenile *Diadema* have begun to reappear on many of these reefs (Authors, personal. obs.), indicating a recovery is possible. More information about this mass mortality and the effects of it event can be found in the research highlights section of this report.

TCRMP MONITORING SUMMARY

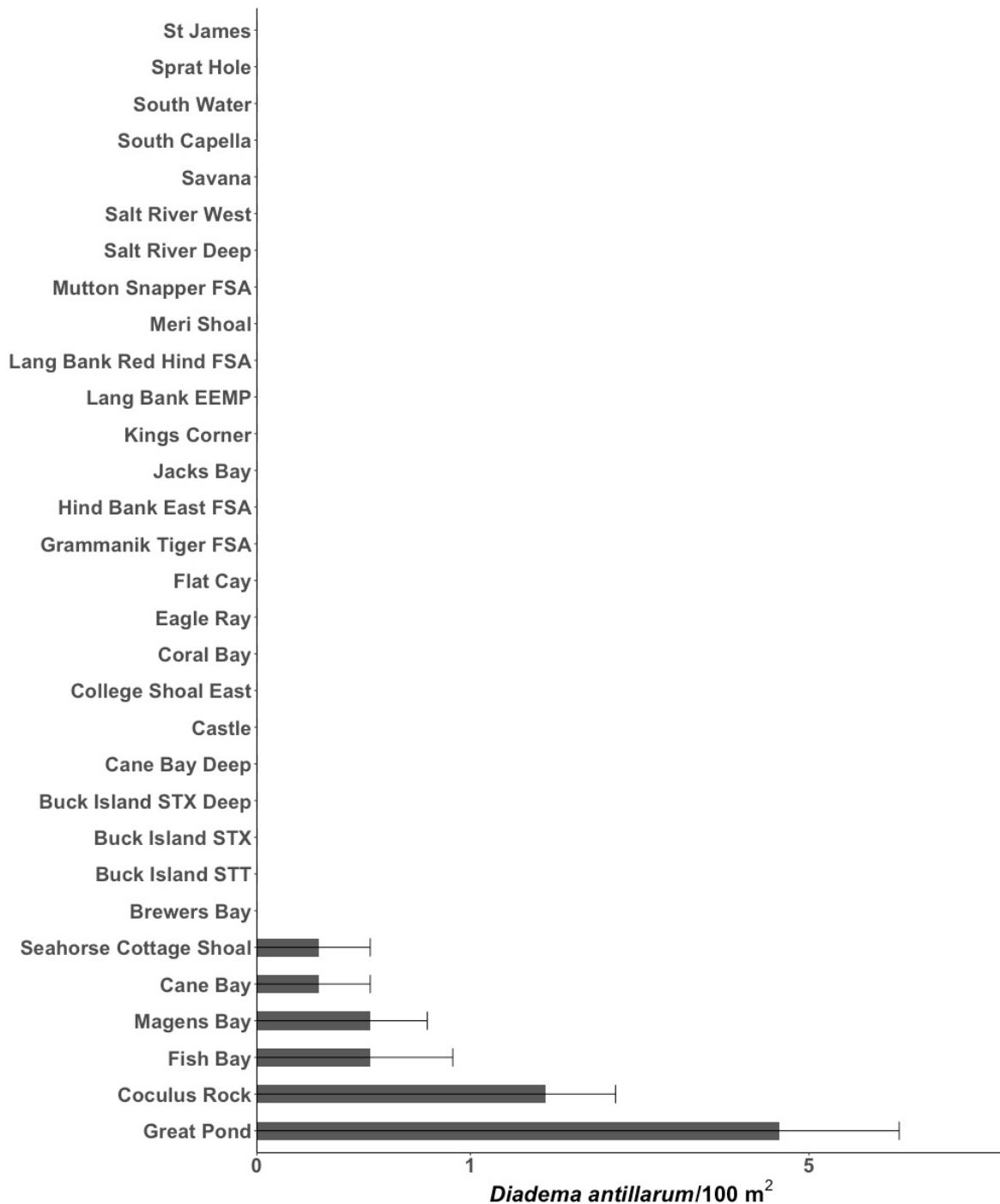


Figure 27. Average abundance (±SEM) of the black spiny sea urchin (*Diadema antillarum*) at TCRMP monitoring sites in 2022. Note the log scale

Site Summaries

RATIONALE

The purpose of this section is to provide a more comprehensive survey of TCRMP site characteristics than cannot be achieved in the overall data compilations. Each TCRMP monitoring site is unique and has had distinct responses to local and global stressors. Given the increase in sites included under this program and the inclusion of more information at each site, such as physical data, this section is designed to provide a summary that highlights each site's individual characteristics and serves as a quick reference guide for managers, policy makers, and academics. The duration of surveys at most sites now provides sufficient data from which to draw conclusions about longer term site dynamics and the processes that might be contributing to recent trajectories of health, development, and degradation.

SITE SUMMARY ELEMENTS

TCRMP site information is presented with a brief description of the setting and the potential susceptibility to local and global stressors and disturbances. Sub-sections include a description of (1) the physical environment, (2) the benthic community and (3) the fish community. The benthic and coral health data are updated in each annual report, whereas the fish and physical data are collected annually but updated periodically since they require more processing.

Benthic community structure is presented as the mean ($\pm$ SE) cover of coral, macroalgae, cyanobacteria, and epilithic algae. Epilithic algal communities are diminutive turf and filamentous algae that cover hardbottom surfaces, whilst macroalgae have identifiable thallus differentiation and structure. Any open hardbottom space is assumed to host an epilithic algal community even if algae cannot be resolved in video images. The loss of coral cover due to the 2005 bleaching event was calculated as the relative change in coral cover from 2005 to 2007, unless otherwise noted for sites not sampled in these years. In addition, the percent recovery from the 2005 bleaching event was calculated as the amount of coral cover regained by 2011 $(\text{Cover}_{2011} - \text{Cover}_{2007})/(\text{Cover}_{2005} - \text{Cover}_{2007})$. Change

SITE SUMMARIES

calculations must be treated with caution for sites where transects were not made permanent until after the 2005 bleaching event or where percent cover is low, since the conditions introduce an unknown amount of error. Trends are shown for all available years of monitoring. The sessile epibenthic animal community are also presented in benthic community structure summaries and include *Agaricia* spp., *Colpophyllia natans*, *Pseudodiploria strigosa*, *Orbicella* spp. (*O. annularis*, *O. faveolata*, *O. franksi*, + unidentified *Orbicella* spp.), *Montastraea cavernosa*, *Porites astreoides*, branching *Porites* species, *Siderastrea siderea*, other corals, sponges, and gorgonians. The algae/non-living substrata category presented include cyanobacteria, epilithic algae ("EAC"), *Lobophora variegata*, *Dictyota* spp., *Halimeda* spp. crustose coralline algae, and sand/sediment.

Coral Health is presented as the mean ($\pm$ SE) of coral bleaching prevalence (proportion of population affected) and extent (proportion of colony affected), disease prevalence, and partial mortality prevalence.

PHYSICAL CHARACTERISTICS

Currents. Water currents were recorded at a subset of sites and times with Nortek Aquadopp™ Acoustic Doppler Current Profilers (ADCPs). Profilers were set in bases on the seafloor and set to record current speed and direction within predefined depth bins above the substrate. The bin closest to the substrate and closest to the coral reef was selected for display. Compass rose figures were developed that show the frequency of current in magnetic directions 0, 22.5, 45, 67.5, 90, 112.5, 135, 157.5, 180, 202.5, 225, 247.5, 270, 292.5, 315, 337.5, 360°. Within each direction the frequency of current speed within bins of 0.1 m s^{-1} were plotted. For Flat Cay, current data was retrieved with an Aandaraa 2-D current meter that measured current speed and direction directly over the sensor head.

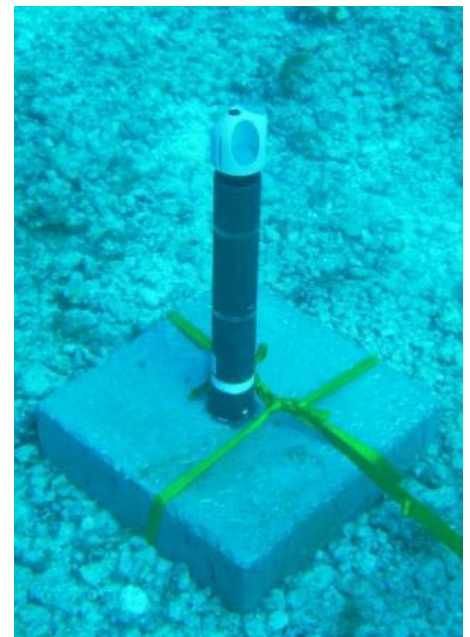
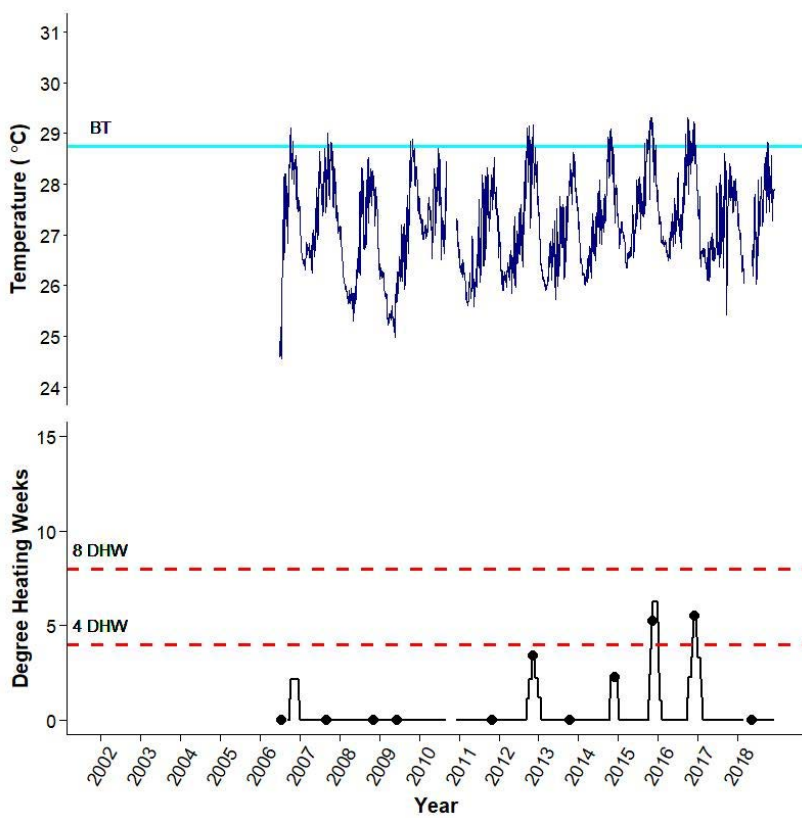


Figure 28. An Acoustic Doppler Current Profiler (ADCP) installed on the reef to measure currents.

SITE SUMMARIES

Chlorophyll and Turbidity. Continuous fluorometric measurements of chlorophyll and turbidity were conducted at some sites for short periods (Black Point, Grammanik, Magens Bay). Wetlabs ECOFLNT fluorometers with antifouling bio-wipers were deployed and set to record for one minute at hourly intervals. Water column chlorophyll measurements detect phytoplankton abundance. Fluorometric measurements of chlorophyll are proxies for true chlorophyll concentrations. Direct chlorophyll measurements to calibrate fluorometric measurements have not been conducted at the monitoring sites.

Temperature. Benthic temperatures were recorded at each site with a calibration checked HoboTemp™ thermistor data logger (Onset Computer Corporation, Bourne, Massachusetts). After 2011 sensors were only deployed if recorded temperatures did not deviate more than 0.2°C from actual, recorded in an ice bath for at least 2 hours. Thermistors were affixed within transects and set to record at intervals of 15 minutes. Records are presented as daily averages across months, February 29th excluded. Data for 2005 was taken from current profilers or federal data sources when available. See Temperature Figure Guide (following page) for interpretation of temperature data. Degree heating weeks was calculated based on the NOAA methodology (NOAA 2006) and using site-specific bleaching thresholds. As a rough estimate, 4 DHW is associated with the onset of widespread bleaching, and 8 DHW is associate with the onset of mass bleaching and the start of coral mortality.



Temperature Figure Guide

Temperatures in degrees Celsius and degree heating weeks. BT = Bleaching Threshold, calculated empirically or taken from linear relationship shown in Smith et al. (2016a). MMM = BT - 1°C, EMMM = Empirical MMM derived from non-bleaching years over period of observation. DHW = Degree Heating Week (NOAA 2006). Black dot on DHW line indicates the date of annual sampling to put the bleaching observations in context. Example taken from the Hind Bank Monitoring site.

St. Croix

SITE SUMMARIES: BUCK ISLAND STX

BUCK ISLAND, ST. CROIX

Description. The Buck Island, St. Croix site is a seaward extension of the southeast Buck Island barrier reef complex in water depth of 15 m. The reef is a low framework surrounded by a sand plain to the west and a rolling reef/hardbottom to the east. The Buck Island, St. Croix site is largely composed of large living and dead *O. annularis* heads surrounded by sand. The site has been monitored since 2001, with three permanent benthic transects installed in 2001, and three additional transects installed in 2003.

Outstanding Feature. The Buck Island, St. Croix site is within the expanded (2001) Buck Island Reef National Monument. The reef fish populations may show recovery due to the restriction of fishing.

Threats. Due to its protected area status and remoteness from land-based pollution Buck Island, St. Croix is primarily threatened by changing climate as its populations of *O. annularis* were shown to be susceptible during the 2005 bleaching event.

Figure 29. (top) The Buck Island, St. Croix position in the Buck Island Reef National Monument. (right) A representative photo (photo credit: V. W. Brandtneris).



SITE SUMMARIES: BUCK ISLAND STX

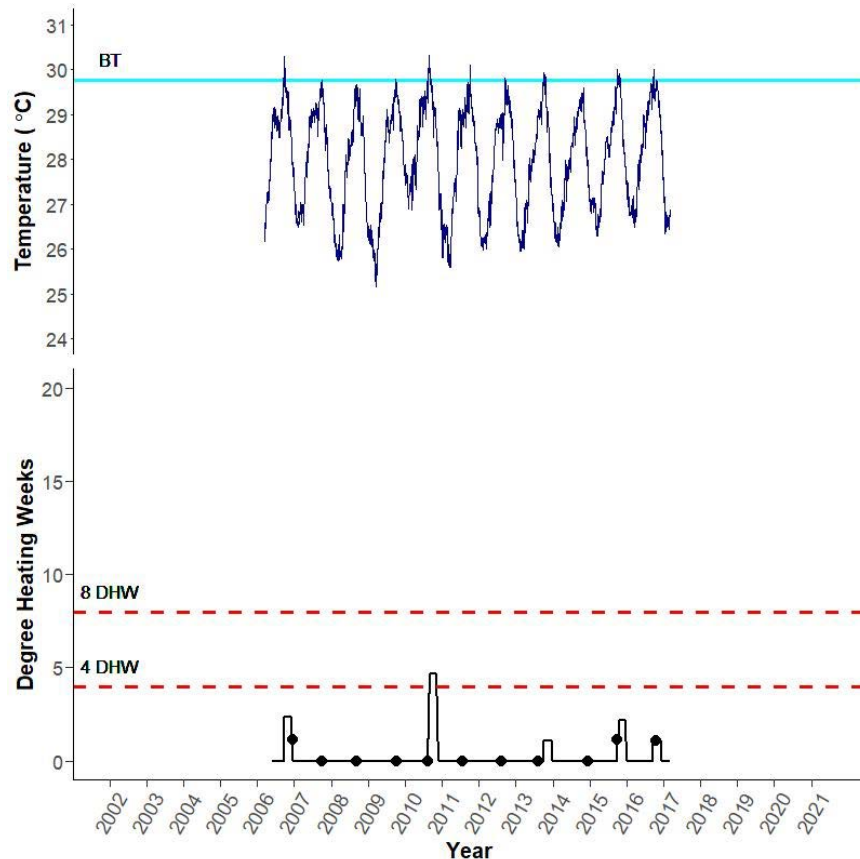


Figure 30. Buck Island, St. Croix benthic temperatures (14 m depth). Data provided by the National Park Service (site BUIS_SFR).

Physical Characteristics

Current. Currents have not been recorded at the Buck Island, St. Croix monitoring site. Unidirectional currents have always been light during monitoring. Oscillatory currents occasionally impact the site when swell is from the east.

Temperature. Temperatures at the Buck Island, St. Croix monitoring sites can get very warm and surpassed the bleaching threshold at or above 4 Degree Heating Weeks in 2005 (data from NOAA Coral Reef Watch, not shown) and 2010.

SITE SUMMARIES: BUCK ISLAND STX

Benthic Community. The Buck Island, St. Croix hard coral community is dominated by the boulder star coral *Orbicella annularis*; however, the most abundant sessile epibenthic animals are gorgonians. Epilithic algae dominate the algal community, with a low cover of macroalgae relative to other sites. There is a high proportion of sand.

This coral community lost 65.5% of its coral cover in the 2005 bleaching event and had only regained 6% of coral cover by 2011. Filamentous cyanobacteria showed very large increases in cover after the 2005 bleaching event.

Coral Health. Buck Island, St. Croix corals were likely severely affected during the 2005 bleaching event; however, bleaching health surveys were not completed until Jan. 13, 2006 when recovery had already commenced. Bleaching showed its second highest prevalence/extent in 2019 during surveys on Oct. 15 and Dec. 3. The prevalence of coral diseases was high on *O. annularis*, with frequent incidence of yellow band disease and white disease following the 2005 bleaching event. Old partial mortality was very prevalent after the 2005 coral bleaching event and then decreased, becoming stable over time in 2011. However, since 2015 coral cover has declined again for unknown reasons, but possibly related to diseases on *Orbicella* spp. Prevalence of disease increased in 2021 (November) with the arrival of Stony Coral Tissue Loss Disease at the Buck Island STX location.

SITE SUMMARIES: BUCK ISLAND STX

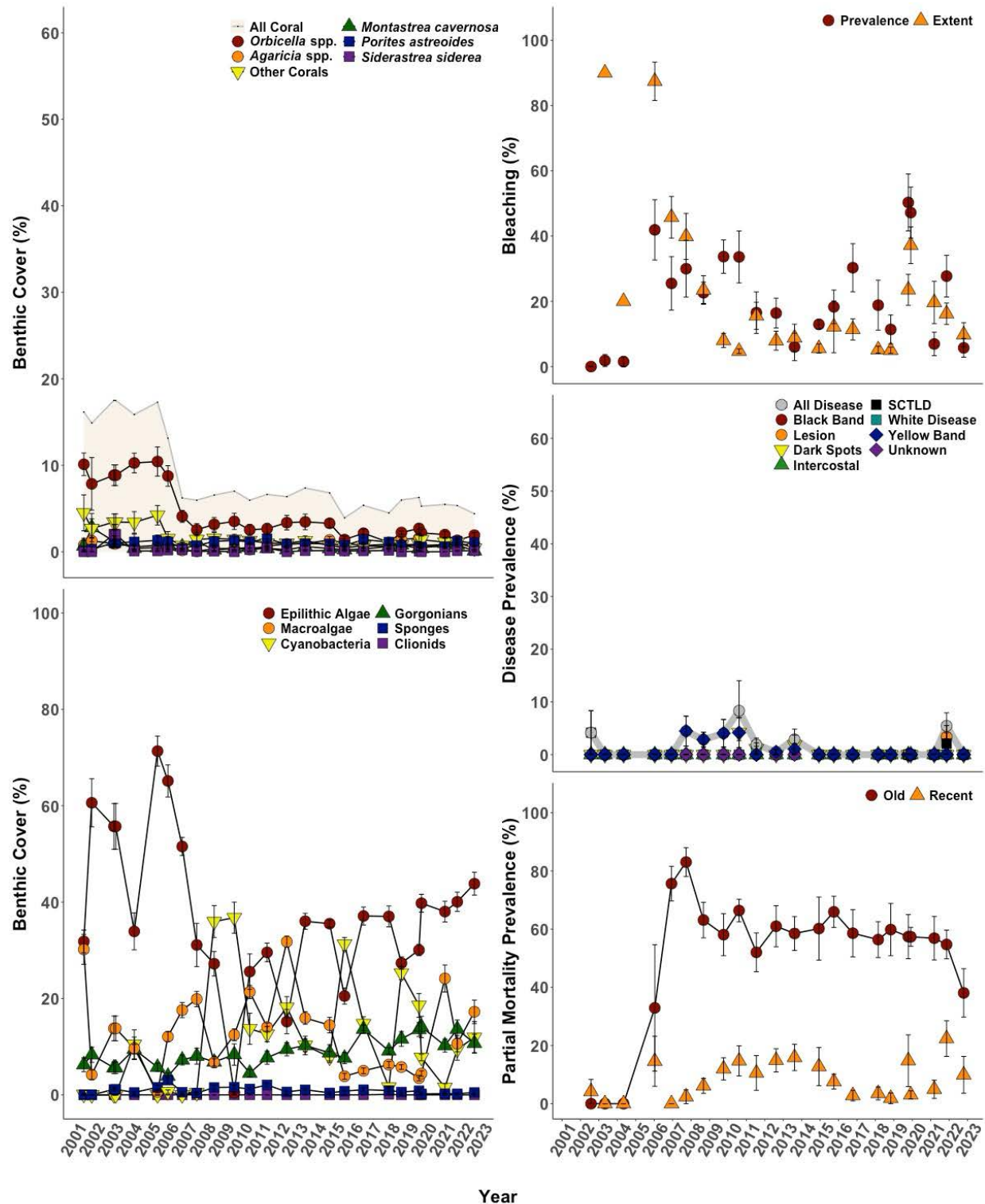


Figure 31. Buck Island, St. Croix benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: BUCK ISLAND STX

Fish Community. Buck Island is a low patchy reef community surrounded by and interspersed with sand. The fish community is highly dominated in biomass by herbivores, with large grazing schools of blue tang and an abundance of adult stoplight parrotfish. Close to the monitoring site are “the Haystacks”, large *Acropora palmata* skeletal remains that provide ample grazing area for large parrotfish. The Buck Island site is within the Buck Island Coral Reef National Monument and the fish inhabitants are theoretically protected from all fishing. Invertivore fishes at Buck Island also contribute a relatively high biomass to the community composition. Grunts (tomtate, French, Spanish, white, and bluestripe) and yellowhead wrasses dominate the guild, although the group is very diverse, utilizing the variety of resources available at the site. Conversely, piscivores are uncommon; the only serranids observed during TCRMP monitoring include small red hind, graysby, small basslets and hamlets. Snapper are limited to rare schoolmaster and mahogany snapper, although a subadult dog snapper was recorded at Buck Island in 2018. Other than this fish, no recovery has been noted for the fish populations on the site.

SITE SUMMARIES: BUCK ISLAND STX

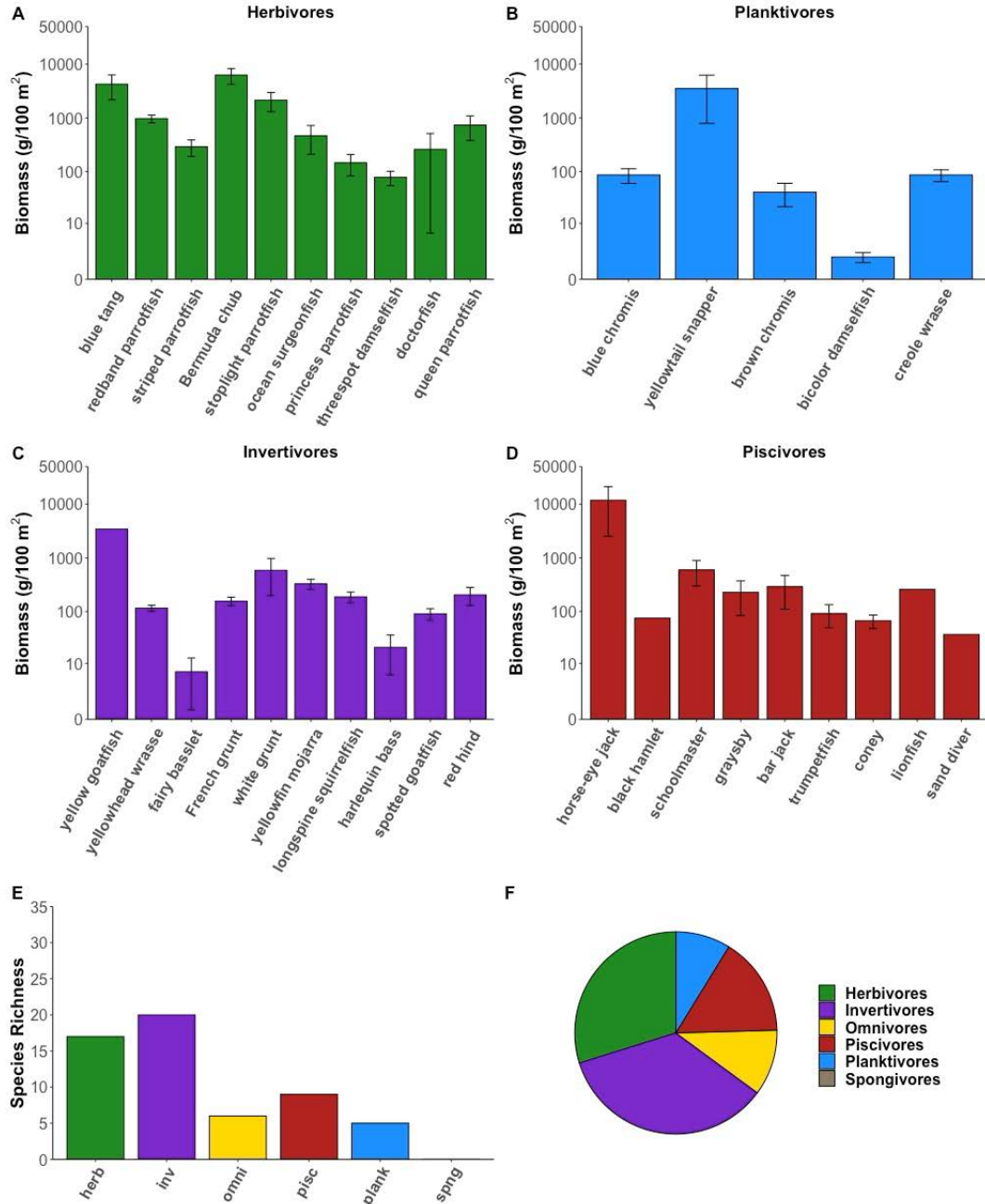
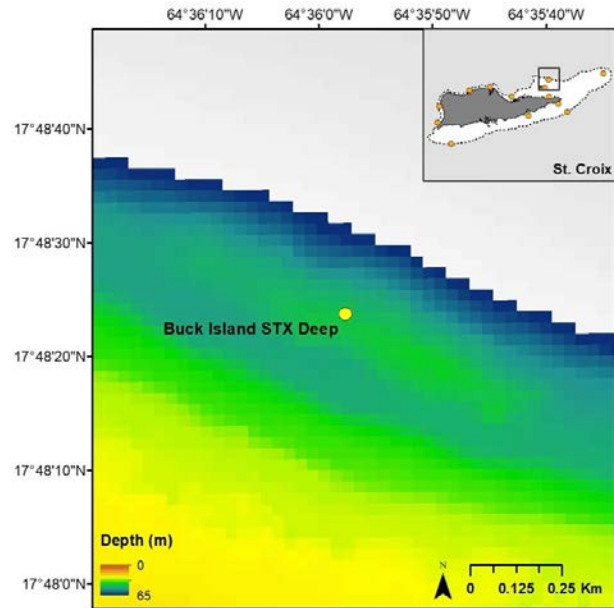


Figure 32. The Buck Island, St. Croix fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: BUCK ISLAND DEEP

BUCK ISLAND DEEP, ST. CROIX

Description. The Buck Island Deep, St. Croix site is an upper mesophotic bank reef northeast of Buck Island in water depth of 33 m. The reef is a low slope bank system similar in form to the mesophotic reefs systems south of St. Thomas. The Buck Island Deep reef site is dominated by plating growth forms of the *O. annularis* species complex. The site was first described in an exploratory mission following the 2016 TCRMP sampling. Six benthic transects were installed in collaboration with NPS in April 2017 and have been monitored since.



Outstanding Feature. The Buck Island Deep, St. Croix site was an exceptionally healthy mesophotic orbicellid bank system on the island of St. Croix. Recent disease outbreaks have substantially reduced coral abundance.

Threats. Due to its protected area status and remoteness from land-based pollution Buck Island Deep is largely threatened by global factors, like bleaching and disease.

Figure 33. (top) The Buck Island Deep, St. Croix position in the Buck Island Reef National Monument. (right) A representative photo (photo credit: J. Quetel).



SITE SUMMARIES: BUCK ISLAND DEEP

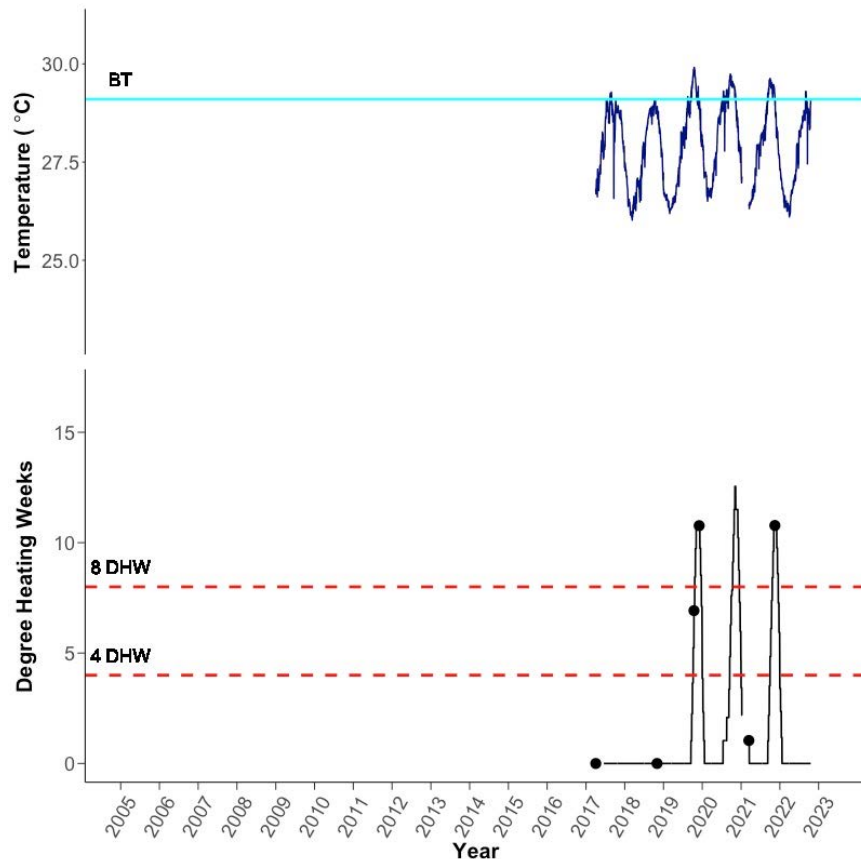


Figure 34. Buck Island Deep, St. Croix benthic temperatures (33 m depth).

Physical Characteristics

Current. Currents have not been recorded at the Buck Island Deep monitoring site. Unidirectional currents have always been light during monitoring. Oscillatory currents are not expected at this depth except during very strong storms.

Temperature. The bleaching threshold is based on the hypothetical formula of bleaching threshold with depth for the USVI from Smith et al. 2016a and not on empirical observations. The bleaching threshold is likely too low since the current threshold shows high levels of stress in years when no bleaching occurred. More observation will help provide a validated empirical threshold in the future.

SITE SUMMARIES: BUCK ISLAND DEEP

Benthic Community. Coral cover at the Buck Island Deep, St. Croix location was 33% in 2017, which is exceptionally high for St. Croix. However, the site lost about 27% of its relative cover in between the 2017 and 2018 monitoring, possibly due to an outbreak of white disease. The coral community is dominated by the boulder star coral *Orbicella franksi*. Stony Coral Tissue Loss Disease was first observed at the Buck Island STX Deep location in early 2021 and has resulted in substantial losses in coral cover since (about 50% relative cover). Epilithic algae and other macroalgae have shown an inverse relationship in monitoring data, and collectively account for the majority of living benthic cover. Sponge cover is high relative to other mesophotic bank locations, but below average for other types of mesophotic locations in St. Croix. Gorgonian cover is the highest of any other mesophotic monitoring site in the TCRMP.



Figure 35. Stony Coral Tissue Loss Disease at Buck Island STX Deep, November 2021 (Photo credit. K. Cobleigh).

SITE SUMMARIES: BUCK ISLAND DEEP

Coral Health. The Buck Island Deep, St. Croix location had the highest disease prevalence of any mesophotic location in the TCRMP during the first two years of monitoring. Disease prevalence was driven by both dark spot disease and white disease (possibly a type of white plague) before 2021. Disease prevalence peaked around 20% prevalence in November 2021 due largely to the arrival of Stony Coral Tissue Loss Disease. However, old and recent mortality and bleaching prevalence was average at this site compared to other mesophotic locations. In 2019, a high prevalence of bleaching with a modest extent on corals was recorded on Oct. 15 and Dec. 3.

SITE SUMMARIES: BUCK ISLAND DEEP

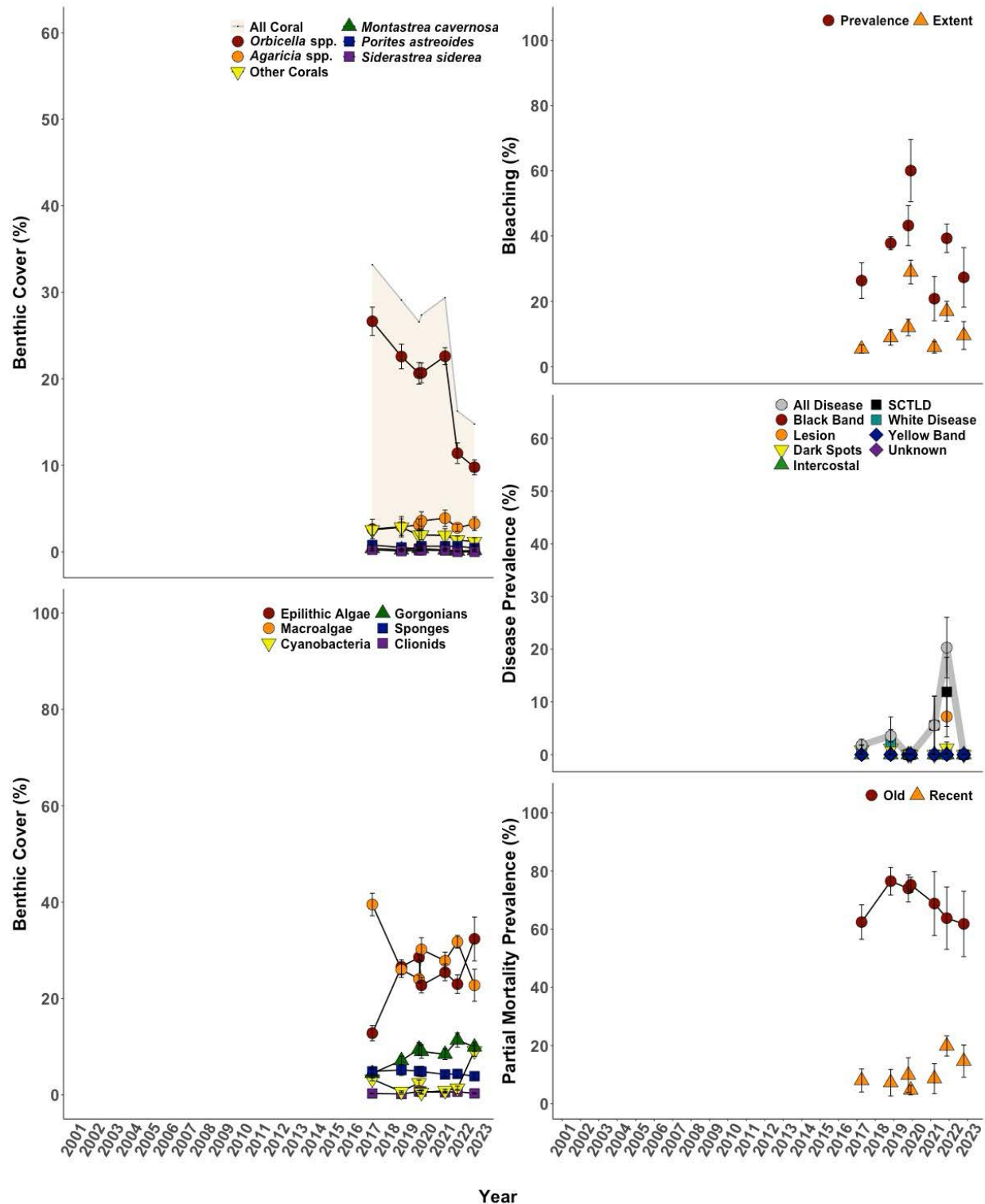


Figure 36. Buck Island Deep, St. Croix benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: BUCK ISLAND DEEP

Fish Community. Buck Island Deep has a rich upper mesophotic reef community that is largely dominated in biomass by invertivores and herbivores, primarily princess and stoplight parrotfishes. The planktivore guild is relatively high in biomass, but limited to a few species: creole wrasse, blue chromis and black durgelon. Benthic invertivore feeders are diverse and include significant numbers of adult red hind. Adult schoolmaster were also recorded at large sizes on the Buck Island Deep site, and in the first year of sampling, 2018, dog snapper, a rare fish on the St. Croix shelf, were observed in transects. Large serranids were not observed, however, since the site is now protected from all fishing, it is hoped that larger groupers will return to the deep water community.

SITE SUMMARIES: BUCK ISLAND DEEP

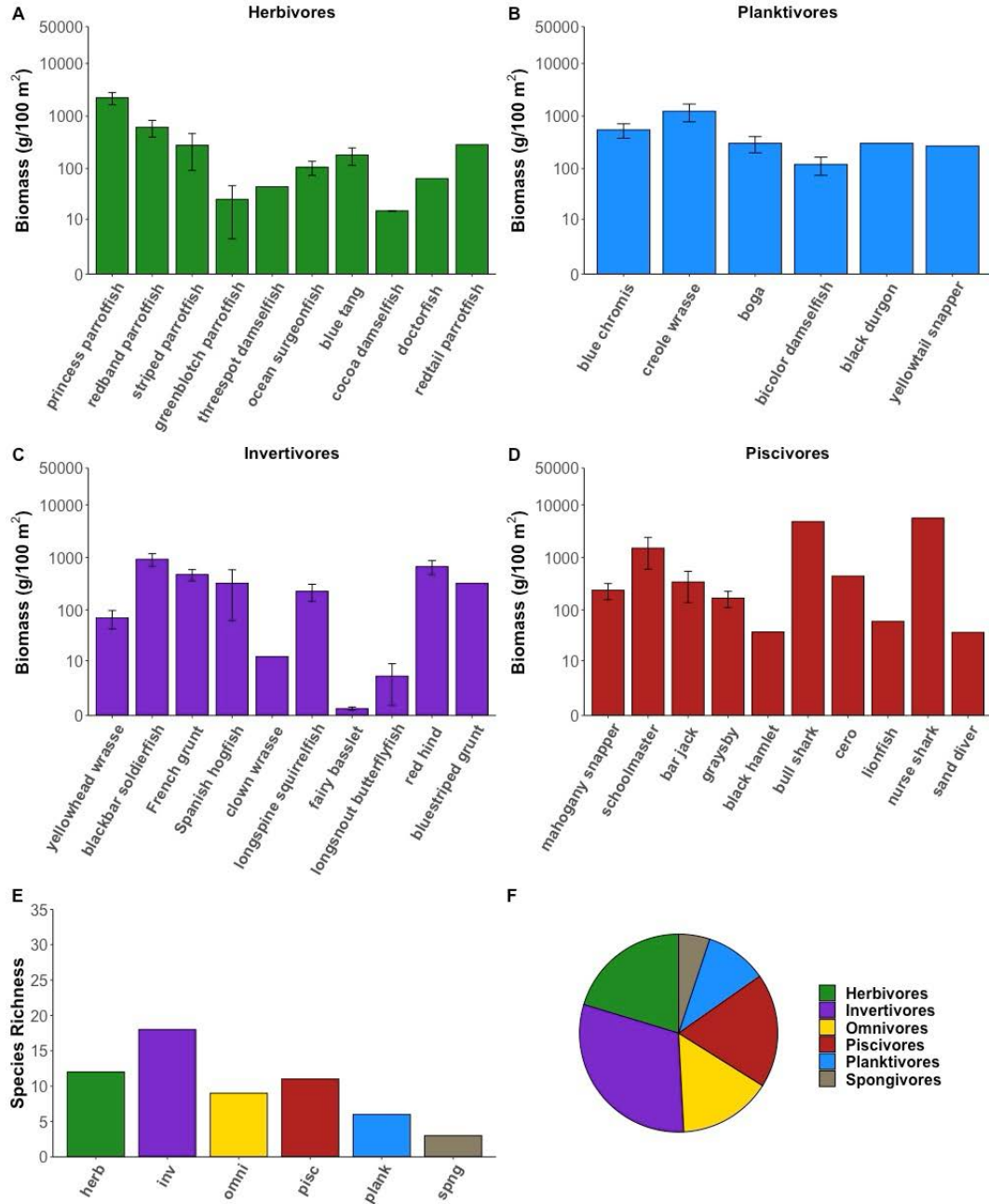


Figure 37. The Buck Island Deep, St. Croix fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: CANE BAY

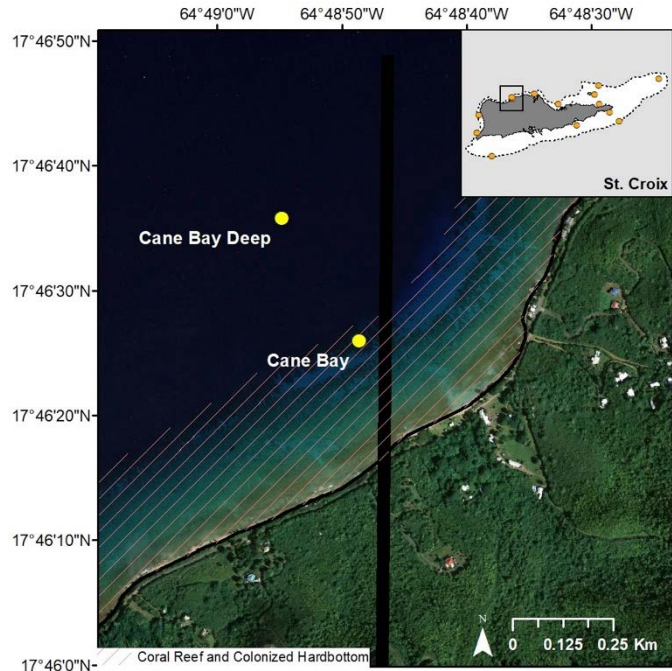
CANE BAY

Description. The Cane Bay monitoring site is a nearshore/shelf edge fringing reef on the northwest coast of St. Croix. Transects follow the trend of the leeward spur and groove formations. Cane Bay has been monitored since 2001.

Outstanding Feature. Cane Bay is one of the most well-developed nearshore reefs on St. Croix. It is also one of the most heavily visited dive sites by both tourists and residents in the Virgin Islands due to its proximity to the wall, considered by some to be the most precipitous submarine drop off in the world. The reef has been under scientific investigation since the 1970's.

Threats. Although the Cane Bay reef is a singular treasure for the Virgin Islands, it is threatened by pollution, fishing, climate change, and recreational overuse. The watershed above Cane Bay has been planned for residential development with potential for the influx of terrestrial sediment. The reef is also fished commercially, and teams of spearfishers on SCUBA have been observed. This reef also lost half its coral cover in the 2005 bleaching event, suggesting it is vulnerable to warming ocean temperatures.

Figure 38. (top) Cane Bay location. (right) A representative photo of the reef (photo credit: L. M. Henderson).



SITE SUMMARIES: CANE BAY

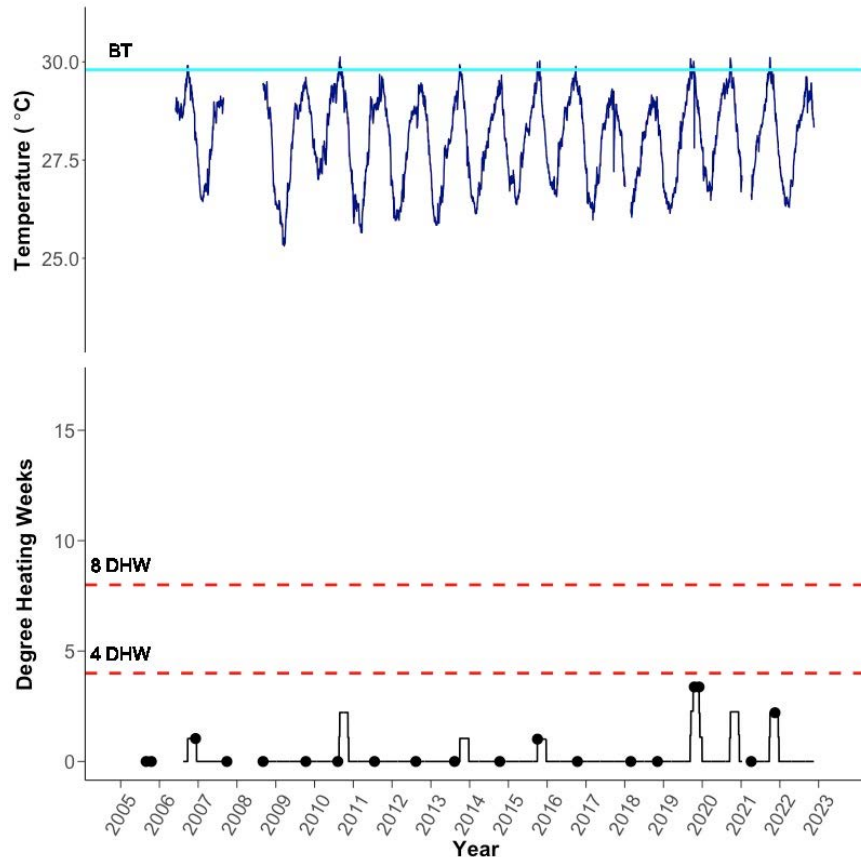


Figure 39. Cane Bay benthic temperatures (8 m depth)

Physical Characteristics

Current. Cane Bay currents have not been directly measured by the TCRMP. However, this site typically has moderate unidirectional currents with the occasional exposure to strong north swell. The current at the site may be part of an eddy formed by the dominant westward flowing current wrapping around the eastern point. Its downstream location from the entire north coast of St. Croix may also make this site a recruitment sink for larvae, potentially adding to the diversity.

Temperature. Cane Bay is a relatively open and clear environment, and the temperatures tend to stay cooler, but the propensity for bleaching may be increased by the high light transmission.

SITE SUMMARIES: CANE BAY

Benthic Community. Cane Bay supports a very diverse coral community, with dominance by *Orbicella* spp. Open substrates were mostly epilithic algal community; however, epilithic algae cover has declined since the 2005 bleaching event with increases in the cover of macroalgae and filamentous cyanobacteria. This indicates that the resident herbivore community was not able to effectively graze substrates opened by coral mortality. This coral community lost 46.8% of coral cover in the 2005 bleaching event and lost 6% more as of 2011. However, more recently coral cover has shown an increasing trend, led by recovery of the orbicellid community. Unfortunately, there were losses in coral cover (about 15% relative cover) largely driven by *Orbicella* sp. cover from 2019 to 2021 likely due to Stony Coral Tissue Loss Disease.

Coral Health. Cane Bay corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over 80% of the colony surface. The prevalence of bleaching was also high in 2010, yet at a low extent. In 2019, there was a high prevalence of bleaching at a moderate extent in surveys on Oct. 15 and Dec. 3. The prevalence of coral diseases was low before 2005, but outbreaks of white, yellow band, and dark spots disease have occurred more recently, another indication of declining health at this reef. Old and recent partial mortality became very prevalent after the 2005 coral bleaching event and have remained nearly steady or increased since. Stony coral tissue loss disease was recorded in transects in the 2020 year sampling (April 2021).

SITE SUMMARIES: CANE BAY

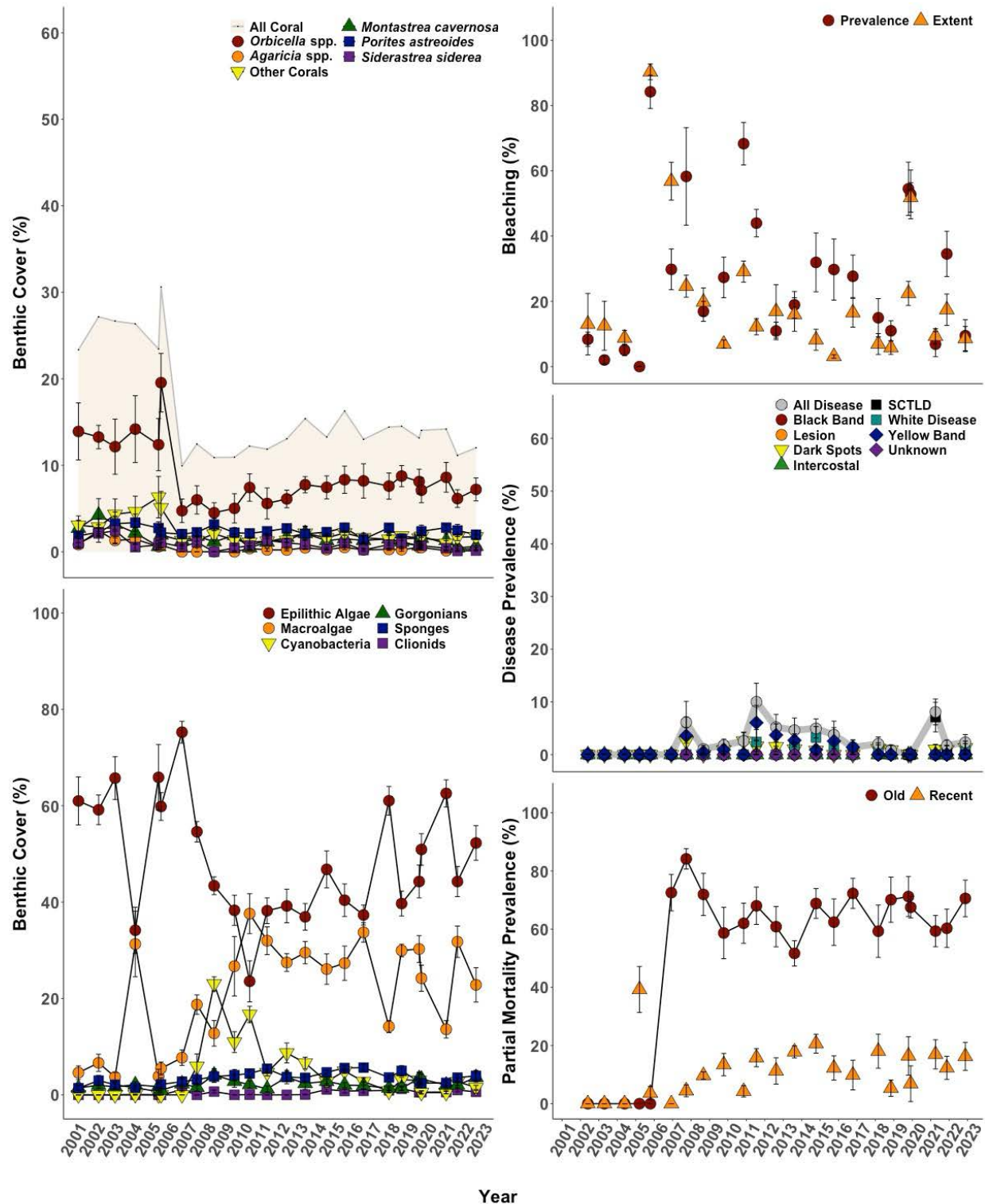


Figure 40. Cane Bay benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: CANE BAY

Fish Community. Cane Bay has a high diversity, abundance, and biomass of fish, reflecting the benthic diversity and high structural complexity of the reef. The trophic guilds are evenly split, illustrating the resources available. Herbivores are dominated both in abundance and biomass by the common Caribbean parrotfishes, which occur at the site as both juveniles and adults. Planktivores include both huge numbers of small chromis, and adult black surgeon, yellowtail snapper and black jacks, indicative of a shelf edge site. The piscivore guild is dominated both in abundance and biomass by schoolmaster and mahogany snapper, followed by coney and graysby. Large grouper and snapper are rare at the Cane Bay reef; however, tiger grouper and Nassau grouper (~30 cm total length each) have been sighted at the shelf break since 2018. The site is not protected from fishing, and spearfishing is popular along this northern wall of St. Croix. Nonetheless the site has a high diversity of fish and holds some of the deeper water species (sunshinefish, longsnout butterflyfish, and cherubfish) due to the site's close proximity to the northern wall drop.

SITE SUMMARIES: CANE BAY

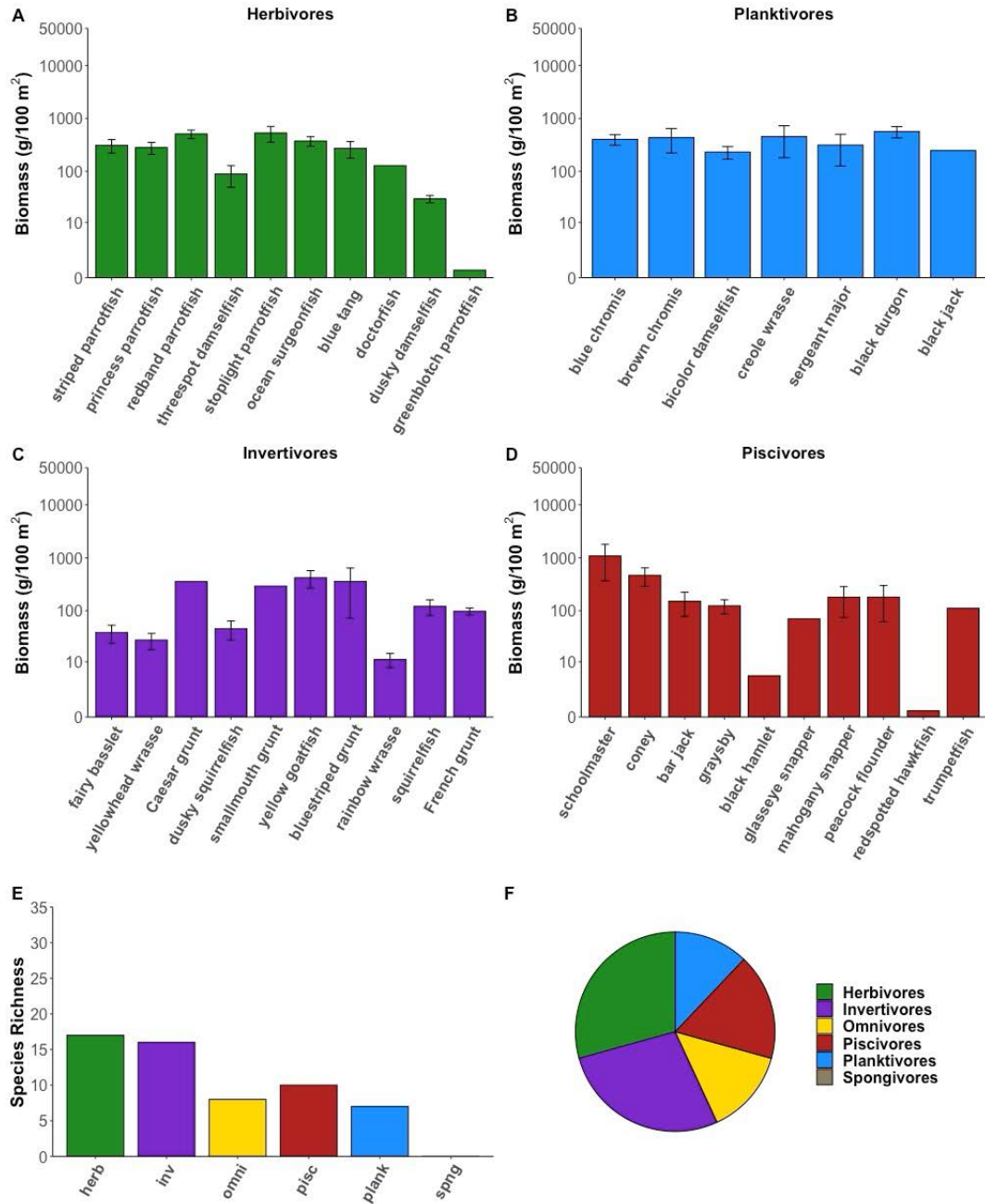


Figure 41. The Cane Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: CANE BAY DEEP

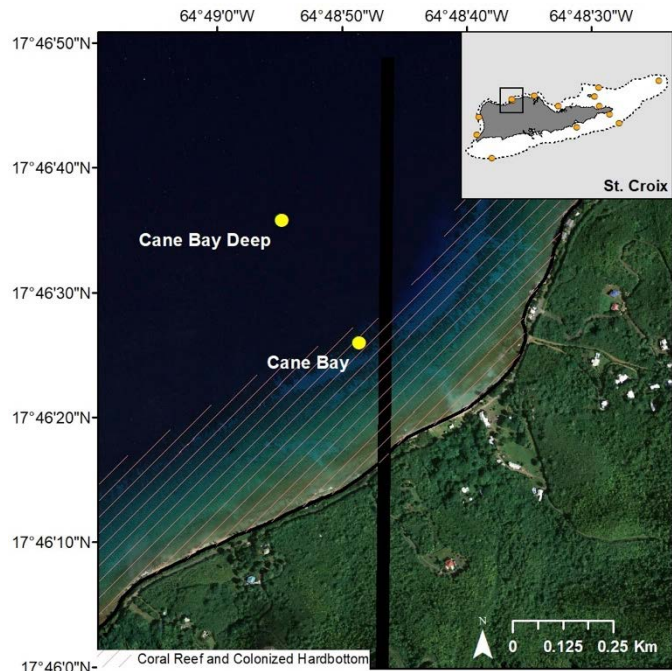
CANE BAY DEEP

Description. The Cane Bay Deep monitoring site is a mesophotic wall coral reef environment just downslope from the Cane Bay site. The reef is composed of deep spurs of coral interspersed with sediment. Cane Bay Deep was first surveyed during the 2005 coral bleaching event, but a permanent monitoring site was not established until 2009. Temperature monitoring was expanded to 67 and 100 m depths in 2018.

Outstanding Feature. Cane Bay Deep is one of the most impressive wall environments in the Caribbean and is the crown jewel for St. Croix dive tourism and biodiversity.

Threats. Although Cane Bay is economically important via dive tourism, it is under no special protection. Cane Bay Deep is threatened by sediment, fishing, climate change, and recreational overuse. Sediment cascades down from the shallow reef. Fishing occurs even at the deep reef evidenced by the presence of lost gear (monofilament and trap lines).

Figure 42. (top) Cane Bay Deep location. (right) A representative photo of the reef at the monitoring site (photo credit: J. Quetel).



SITE SUMMARIES: CANE BAY DEEP

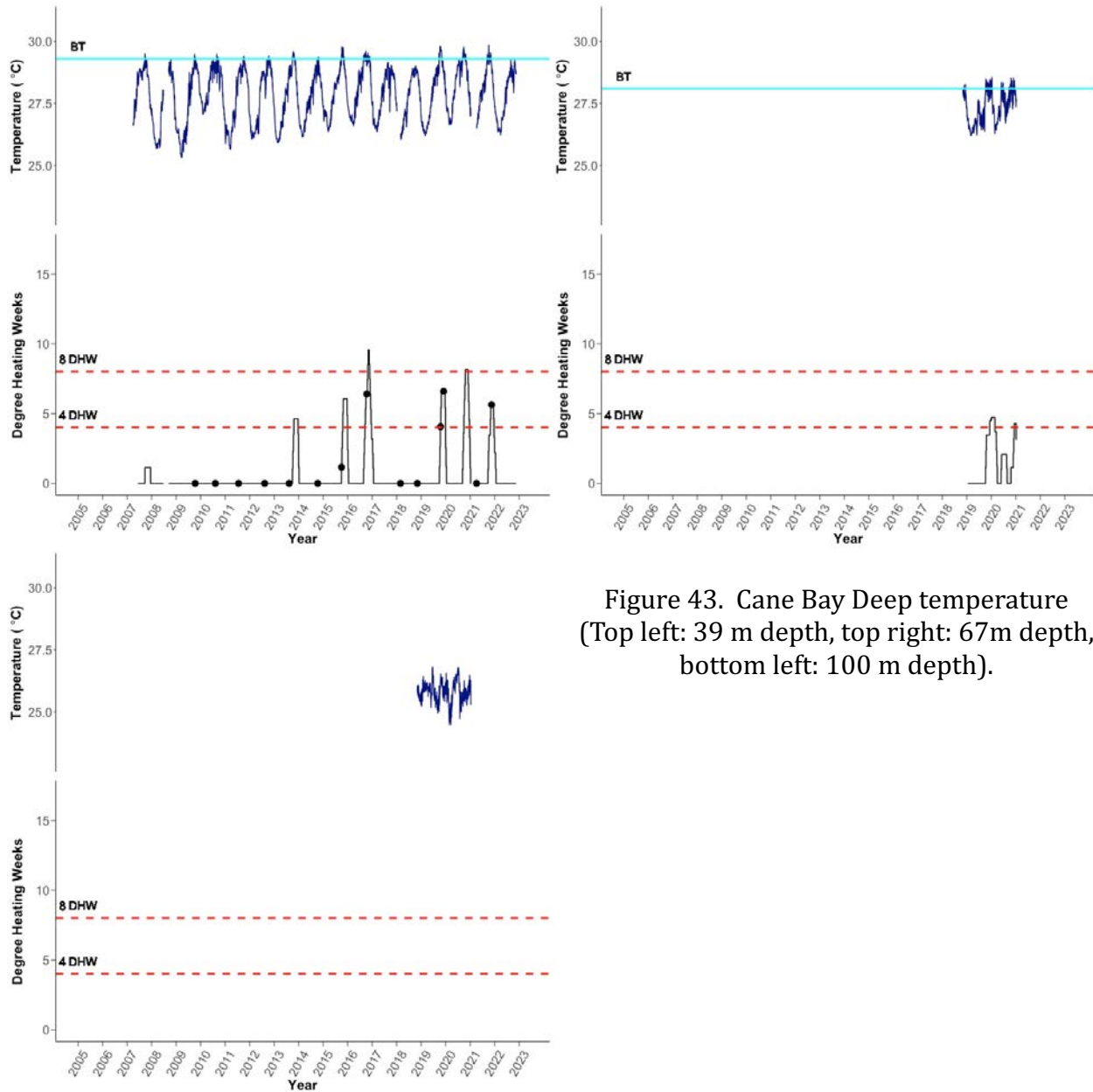


Figure 43. Cane Bay Deep temperature (Top left: 39 m depth, top right: 67m depth, bottom left: 100 m depth).

SITE SUMMARIES: CANE BAY DEEP

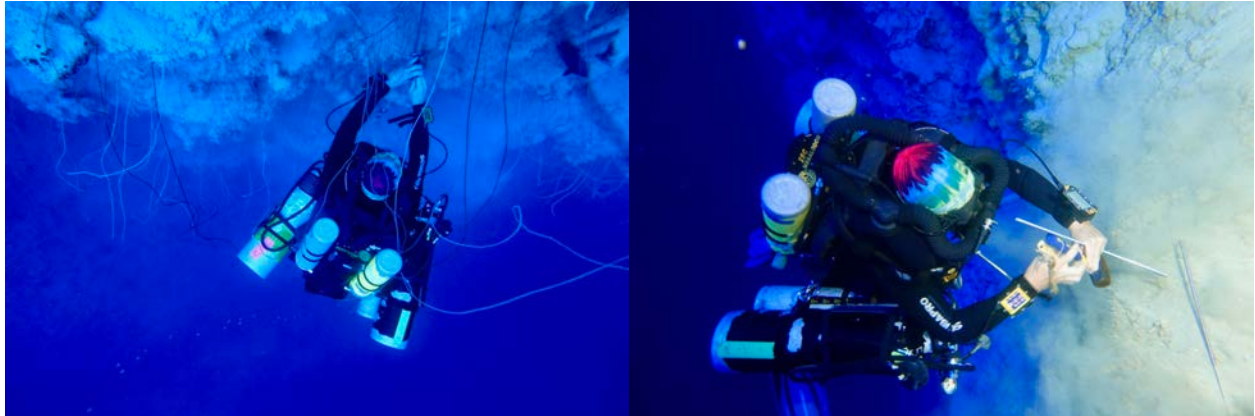


Figure 44. Installation of temperature monitoring stations at Cane Bay at 67 m (left) and 100 m (right) on the wall (credit: Viktor Brandtneris).

Physical Characteristics

Current. Cane Bay Deep is a calm wall environment that is buffered from water motion. However, it does receive sediment cascades from particles resuspended from the upper reef terrace. These flows are directed in the depressions between spurs.

Temperature. Cane Bay Deep temperatures are buffered in the warmest months by the presence of the thermocline. However, internal tide activity at this site is not as strong as in deep (~40 m) sites on the south shelf of St. Thomas, leading to less diurnal variability in temperatures. This may make the mesophotic wall environments more susceptible to bleaching than other mesophotic sites on the southern Puerto Rican shelf. The bleaching threshold is currently based on the Smith et al. (2016a) model; however, observations of elevated bleaching in 2016 and 2019 concomitantly with elevated hypothetical degree heating weeks suggest the bleaching threshold is reasonable. Temperatures at 67 and 100 m depths were much cooler than at 40 m.

SITE SUMMARIES: CANE BAY DEEP

Benthic Community. Cane Bay Deep is a mesophotic plating coral community dominated by lettuce corals (*Agaricia* spp.), sponges, gorgonians, and black coral. Coral cover declined after 2017, a possible effect of Hurricane Maria and relative coral cover decreased by nearly 40% from 2020 to 2021 likely due to the arrival of Stony Coral Tissue Loss Disease. The algal community is mostly epilithic algae, but there are also quantities of *Dictyota* spp. and *Lobophora variegata*. A high proportion of the substrate is soft sediment that flows from the upper shelf to deposit in grooves.

Coral Health. Surprisingly for a dim and cooler mesophotic reef, Cane Bay Deep corals bleached heavily in the 2005 coral bleaching event based on limited observations prior to establishment of the TCRMP site (Smith et al. 2016a). This site bleached heavily again in 2019, with nearly 80% of corals bleached at a level of about 50% of the colony surface. Low-extent coral bleaching is very prevalent even in years without thermal stress, a likely result of sediment deposition. Unknown diseases and dark spots diseases are prevalent in some years. Old partial mortality increased after 2005 and has remained high since. It is unclear if SCTLD was recorded in transects in the 2020 year sampling (April 2021), but a high abundance of lesions were present and SCTLD was present at the shallow site, so lesions may reflect SCTLD impacts.

SITE SUMMARIES: CANE BAY DEEP

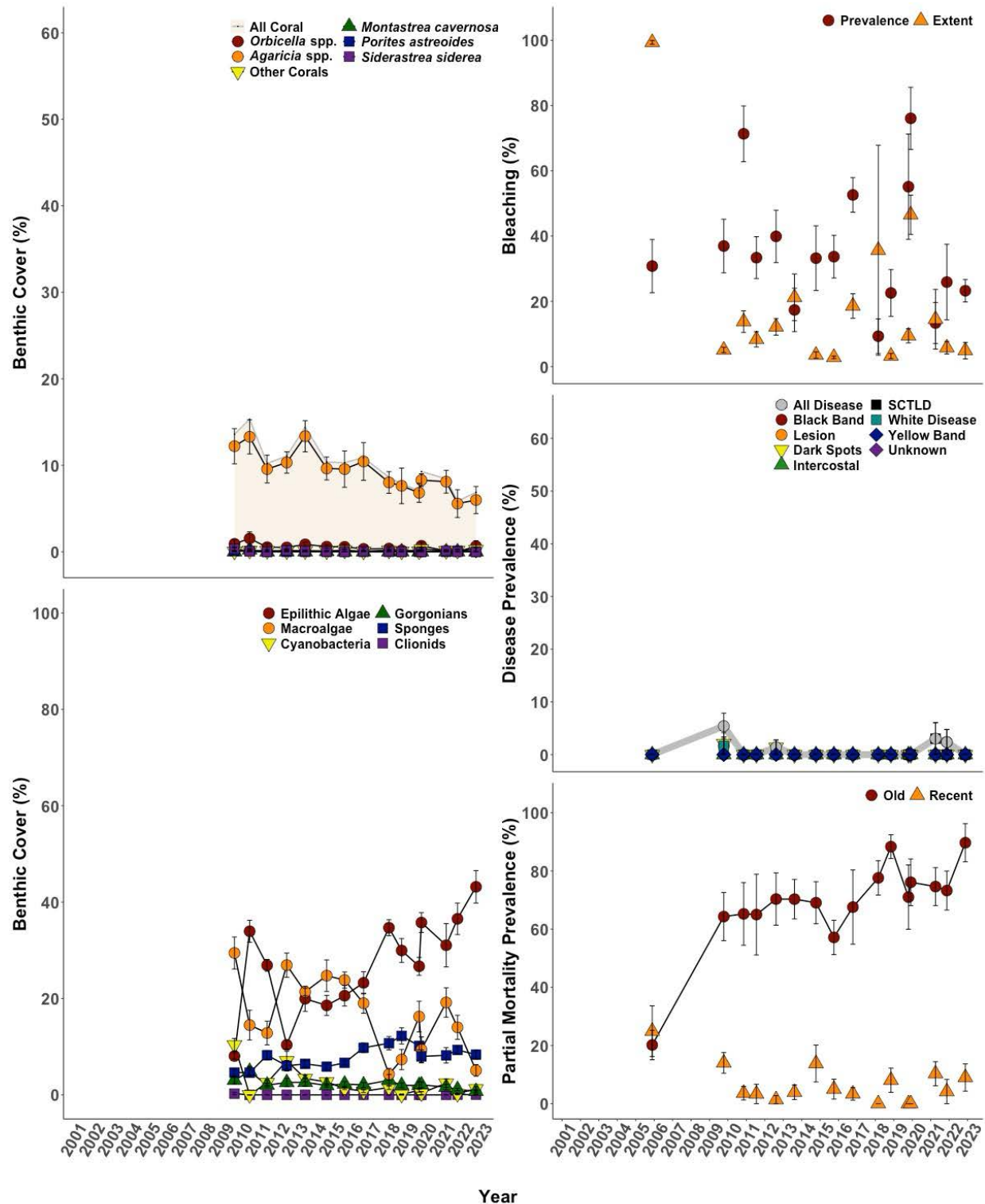


Figure 45. Cane Bay Deep benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: CANE BAY DEEP

Fish Community. Cane Bay Deep is characterized by a very low fish biomass compared to both other mesophotic sites across the TCRMP, and shallow and midshelf sites of St. Croix. The site is typically dominated by planktivores: creole wrasse, blue chromis, black durgelon and yellowtail snapper. The herbivore guild contributes little to the community composition, and is composed primarily of striped, princess, and redband parrotfish. Large stoplight parrotfish are recorded very occasionally. There is also very low biomass in the invertivore guild, which is made up primarily French and bluestriped grunts, goatfish and wrasse. Caribbean reef sharks cruise the wall, looking for a free lionfish handout from local divers. They have become quite bold because of this generosity; however, lionfish are now rare at the site in recreational diving depths. The Caribbean reef shark contributes highly to the piscivore trophic guild and is joined by other pelagics: the almaco jack, horse eye jack, barracuda and bar jack. Benthic piscivores are limited to graysby and small mahogany and schoolmaster snapper. The St. Croix northern wall is heavily fished by both commercial and sport spearfishermen, so large snappers and groupers are rare. Small deep water reef species such as the bantum bass, fairly basslet, cherubfish, and sunshine fish are recorded at the site. Peppermint bass are commonly observed in the 67-100 m depth range near the temperature recorders.

SITE SUMMARIES: CANE BAY DEEP

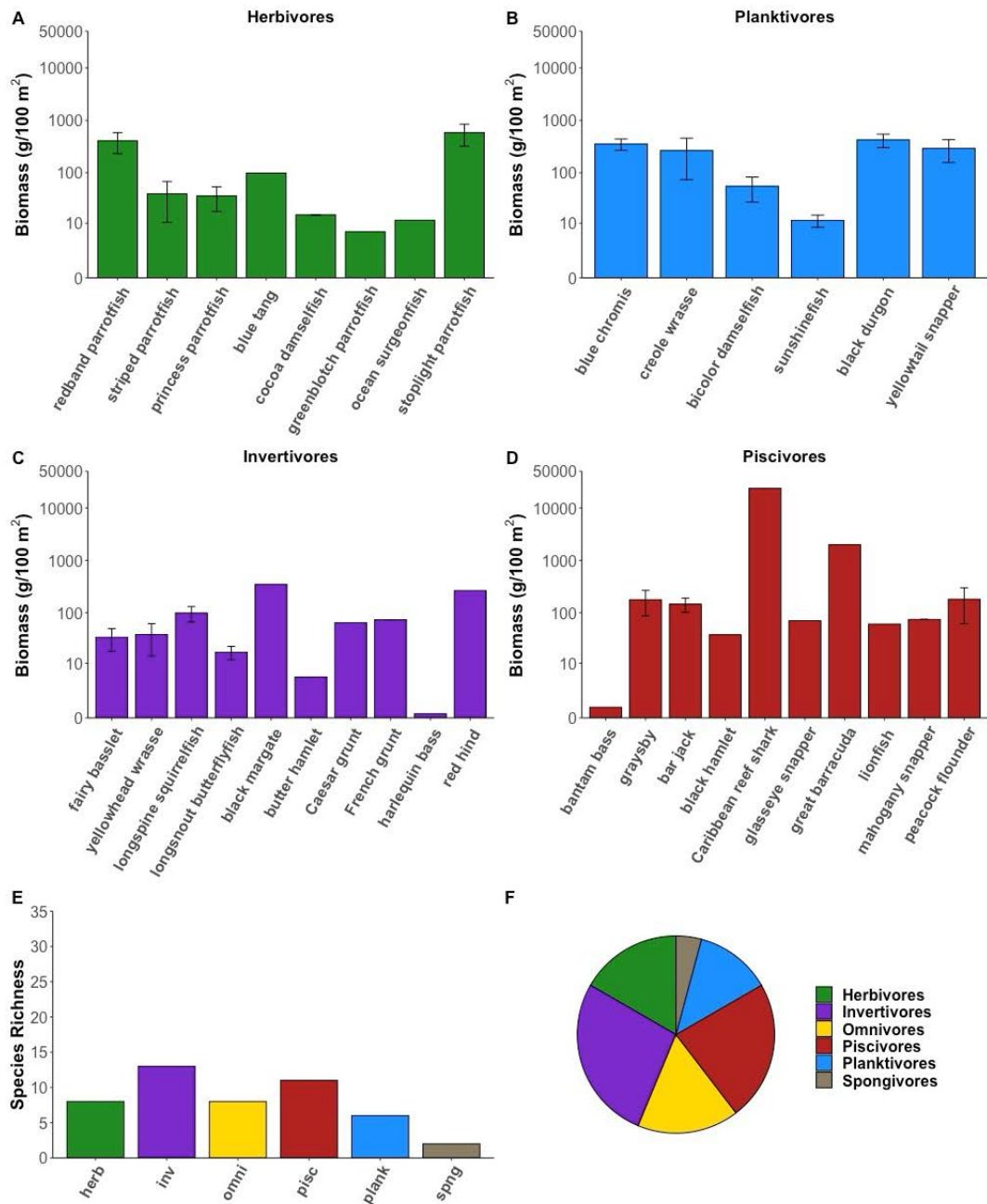
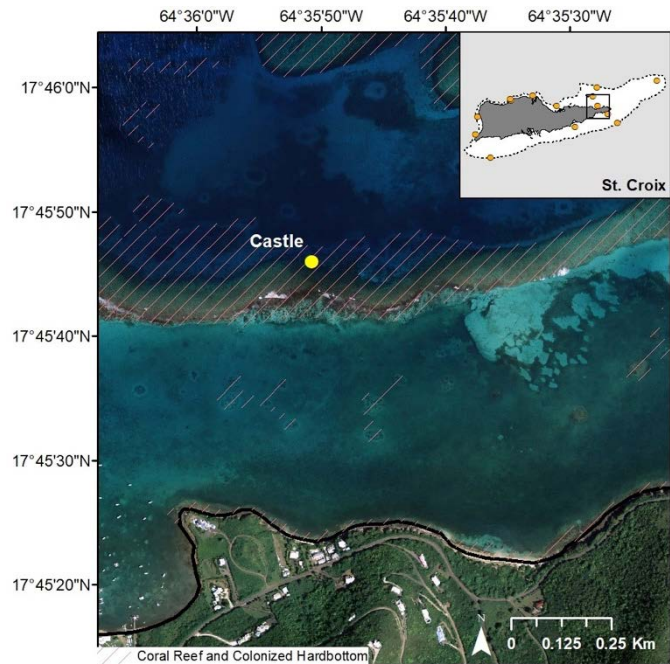


Figure 46. The Cane Bay Deep fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: CASTLE

CASTLE

Description. Castle (aka. West Indies Lab) is part of the seaward northeastern St. Croix barrier reef complex outside Teague Bay. The reef starts at sea level as a relict elkhorn coral reef and is dominated by boulder star corals along the seaward edge. The area around the Castle site was monitored initially in 2003, but permanent transect were not installed until 2008.



Outstanding Feature. Castle is part of the once luxurious living elkhorn coral barrier reef that protects the northeastern St. Croix shoreline. It was a research area of the former West Indies Laboratory of Farleigh Dickenson University, which was a seminal area for global coral reef research from the 1970's and 1980's.

Threats. The barrier reef outside Teague Bay is inside the St. Croix East End Marine Park, but is in the open fishing zone. There is relatively low potential for land-based sources of pollution due to the sites midshelf location in front of a lightly populated area. Clear water and warm temperatures make this an area of potential concern during bleaching events.

Figure 47. (top) Castle location. (right) A representative photo of the reef (photo credit: L. M. Henderson).



SITE SUMMARIES: CASTLE

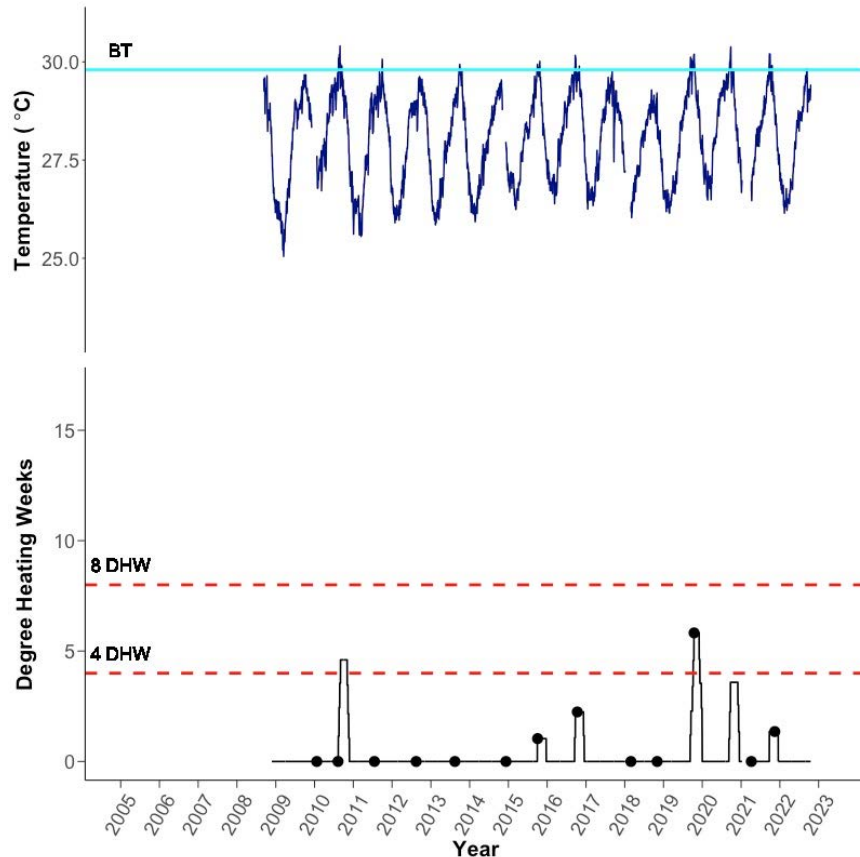


Figure 48. Castle benthic temperatures (9 m depth).

Physical Characteristics

Current. Little is known about the current at the Castle site. It is under the influence of wave-driven oscillatory flow in the shallows, but strong directional currents have not been experienced during monitoring activities.

Temperature. Castle has the potential to develop very warm temperatures and spent nearly a month above the bleaching threshold in 2010 (4.5 DHW) and reached 6 DHW in 2019.

SITE SUMMARIES: CASTLE

Benthic Community. The Castle site is unusual for its dominance of branching *Porites* corals along the slope and concentrations of *Orbicella* spp. corals at the outer fringe adjacent to sand. The algal community is dominated by epilithic algae, with lesser abundance of *Dictyota* spp.. Macroalgae and filamentous cyanobacteria are also common. The impacts of the 2005 bleaching event are not known since monitoring in 2003 was not necessarily in exactly the same spot as the location of permanent transects established in 2008.

Coral Health. Bleaching is mild at the site. Corals were assessed prior to but not during the 2010 coral bleaching event. During the 2019 beaching event corals were sampled near what might have been the peak of the shallow water heat stress based on the regional DHW. However, the beaching response at that time was not that different from non-bleaching years, illustrating resistance at this site. Old partial mortality is high in prevalence and steady. Recent partial mortality is particularly high at the site, and this may be a consequence of numerous damselfish (*Stegastes* spp.) and predatory snails (*Coralliophila* spp.) on large *Orbicella* spp. colonies. Stony coral tissue loss disease was not recorded in transects in the 2020 year sampling (April 2021), but was present at the location during the 2021 annual sampling (November 2021).

SITE SUMMARIES: CASTLE

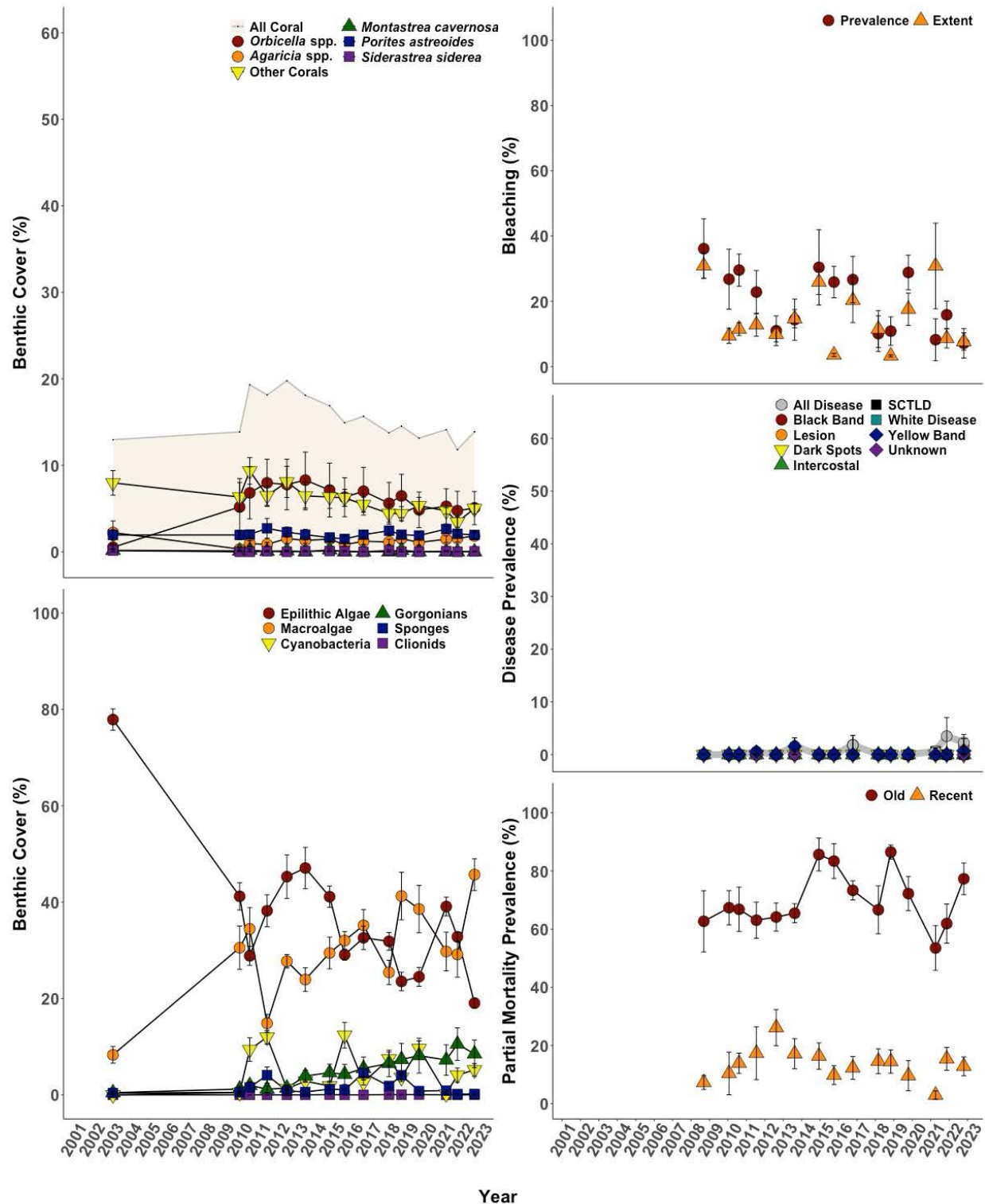


Figure 49. Castle benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: CASTLE

Fish Community. The Castle fish community is typically lower in overall abundance and biomass than most of the St. Croix offshore sites. It is dominated by herbivores in biomass, driven by schools of subadult striped parrotfish and mixed acanthurids. Invertivores are diverse and fairly high in biomass; the group is dominated by wrasses, French grunts and spotted goatfishes. Piscivores and planktivores contribute less to community structure and are limited to a few species. Juvenile yellowtail snapper and blue chromis contribute most to the invertivore biomass and bar jacks and yellow jacks contribute most to the piscivore guild. No serranids other than graysby, hamlets and tiny basslets have been recorded at Castle. Lionfish have been observed commonly over the past five years.

SITE SUMMARIES: CASTLE

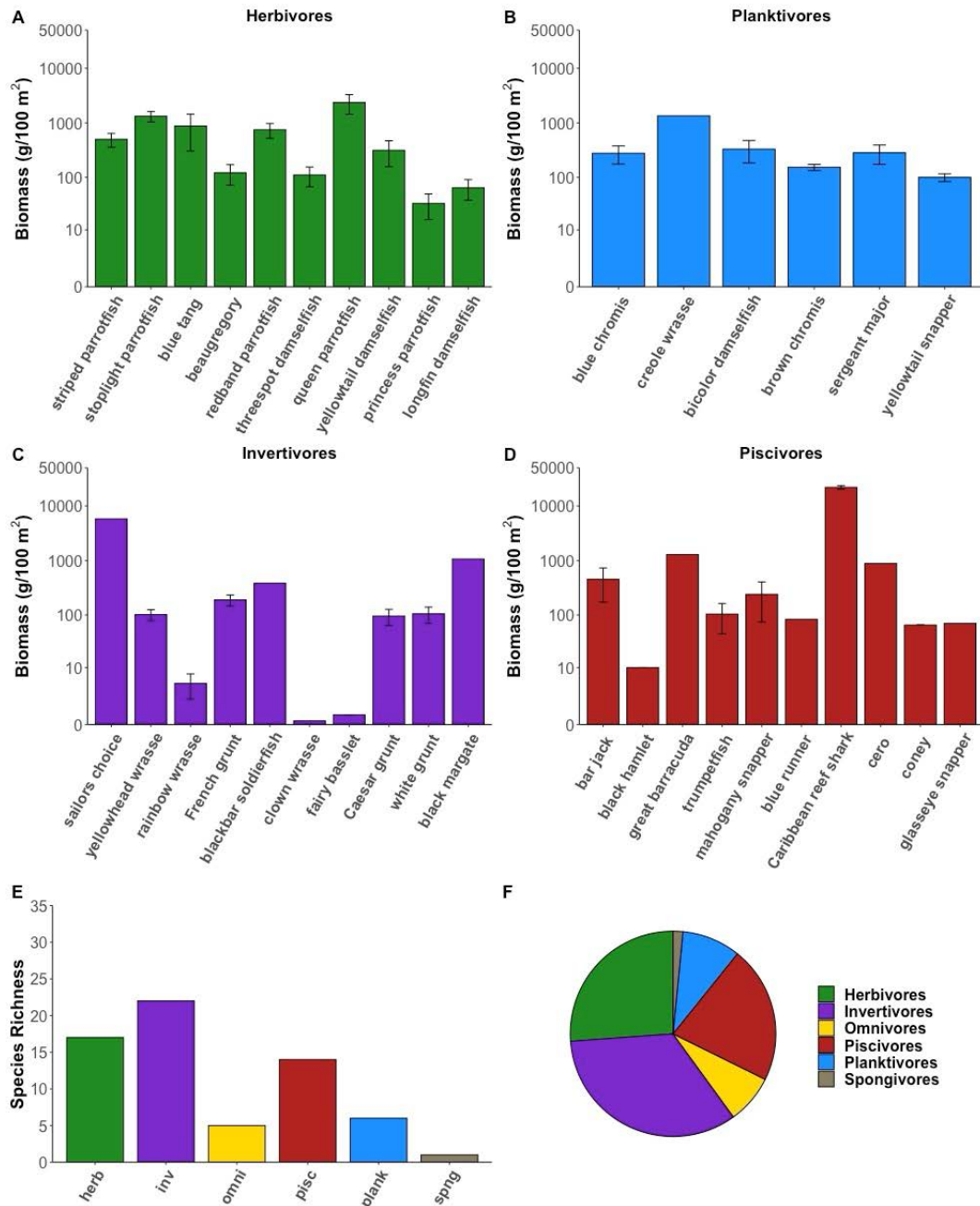


Figure 50. The Castle fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: EAGLE RAY

EAGLE RAY

Description. The Eagle Ray site is a shallow seaward barrier reef located at west dive buoy 1 outside the main Christiansted access channel. The monitoring site is colonized hardbottom to coral reef, with more extensive development of reef at the seaward edge. Eagle Ray has been monitored since 2001.

Outstanding Feature. Eagle Ray is one of the most visited dive sites due to its proximity to Christiansted.

Threats. Proximity to Christiansted increases the potential for land-based sources of pollution, such as sewage, run-off, and marine debris. The site is frequented by small fishing craft that venture just out of port, likely increasing the fishing pressure.



Figure 51. (top) Eagle Ray location. (right) A representative photo of the reef (photo credit: L. N. Henderson).



SITE SUMMARIES: EAGLE RAY

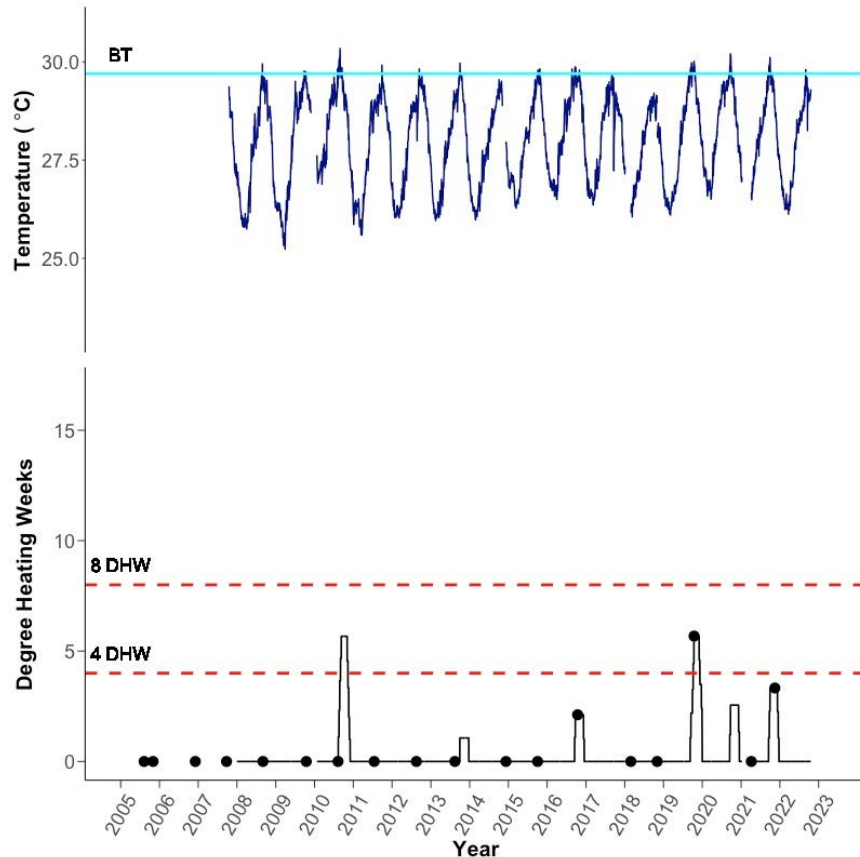


Figure 52. Eagle Ray benthic temperature at 9 m depth

Physical Characteristics

Current. Currents have not been measured at Eagle Ray; however, strong unidirectional currents seem rare. There are increased oscillatory currents near the shallow portion of the site.

Temperature. Eagle Ray is shallow but near deep water on two sides, which may potentially help to reduce the temperature relative to sites in more enclosed environments. Based on the bleaching response in 2019 an adjusted bleaching threshold of 29.70 °C was established for the site.

SITE SUMMARIES: EAGLE RAY

Benthic Community. Eagle Ray supports a diverse community of small coral colonies, but sponges and gorgonians compose half the sessile epibenthic animal community. Coral cover has been low (less than 10%) throughout the monitoring period. Coral cover decreased only slightly with the 2005 coral bleaching event, 11.7%, but cover rebounded and increased above pre-bleaching values. The limited response may be partly due to the high relative abundance of more thermally resistant coral species. However, coral cover has decreased by about 52% from 2019 to 2022, likely due to Stony Coral Tissue Loss Disease. The site was dominated with epilithic algae; however, this has declined after the 2005 bleaching event with a concomitant increase in macroalgae and filamentous cyanobacteria.

Coral Health. Eagle Ray corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over about 80% of the colony surface. Low-level bleaching is also common in years without thermal stress. The site was monitored in 2010 prior to the thermal stress event and bleaching is underestimated for that year. In 2019 the site showed moderate prevalence and extent of bleaching.

Diseases are a common feature of the site, with black band, yellow band, and dark spots disease having outbreaks in certain years. Lesions were also common during the 2005 coral bleaching event. Old partial mortality became very prevalent after the 2005 coral bleaching event and subsided in the following years. Stony coral tissue loss disease was recorded in transects in the 2020 year sampling (April 2021).

SITE SUMMARIES: EAGLE RAY

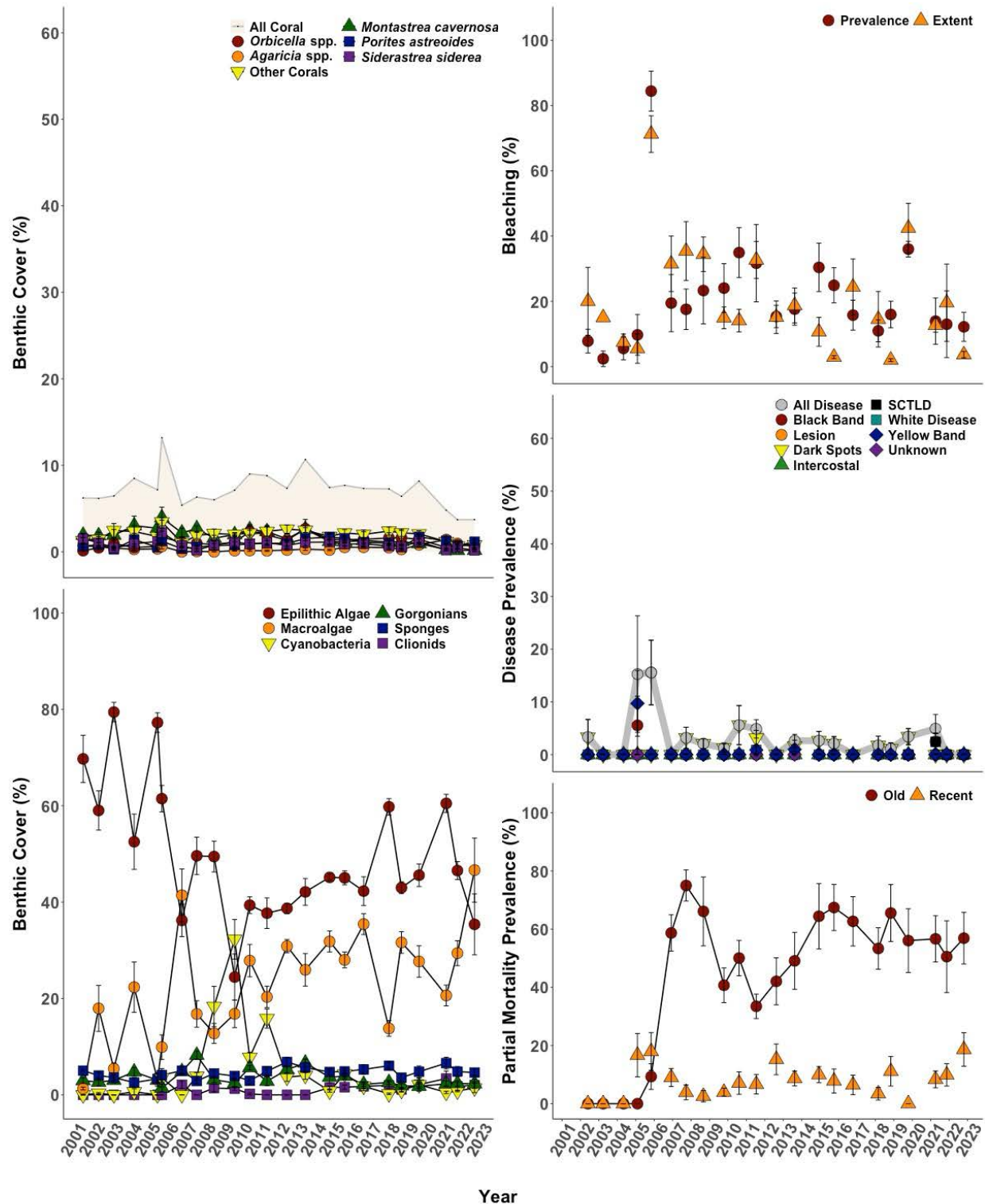


Figure 53. Eagle Ray benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: EAGLE RAY

Fish Community. Eagle Ray is a diverse and rich site; surprising considering the fishing and diving pressure it receives as well as the land source pollution due to the site's proximity to Christiansted Harbor. It is dominated by herbivores and invertivores, with a strong component of parrotfish, acanthurids and herbaceous damselfishes. Invertivores are led in both abundance and biomass by the nocturnal benthic feeder, the blackbar soldierfish. Proximity to open deep water is evidenced by the occurrence of high numbers of planktivorous creole wrasse, black durgelon, piscivorous large jacks, and great barracuda. Yellowtail snapper are large and plentiful, probably due to the divers that frequent the site with fish food. Graysby, coney, schoolmaster and mahogany snapper comprise the benthic piscivore guild. No large serranids or lutjanids are ever observed on Eagle Ray. However, Caribbean reef sharks are recorded at the site and the fish community remains high in overall biomass and species richness.

SITE SUMMARIES: EAGLE RAY

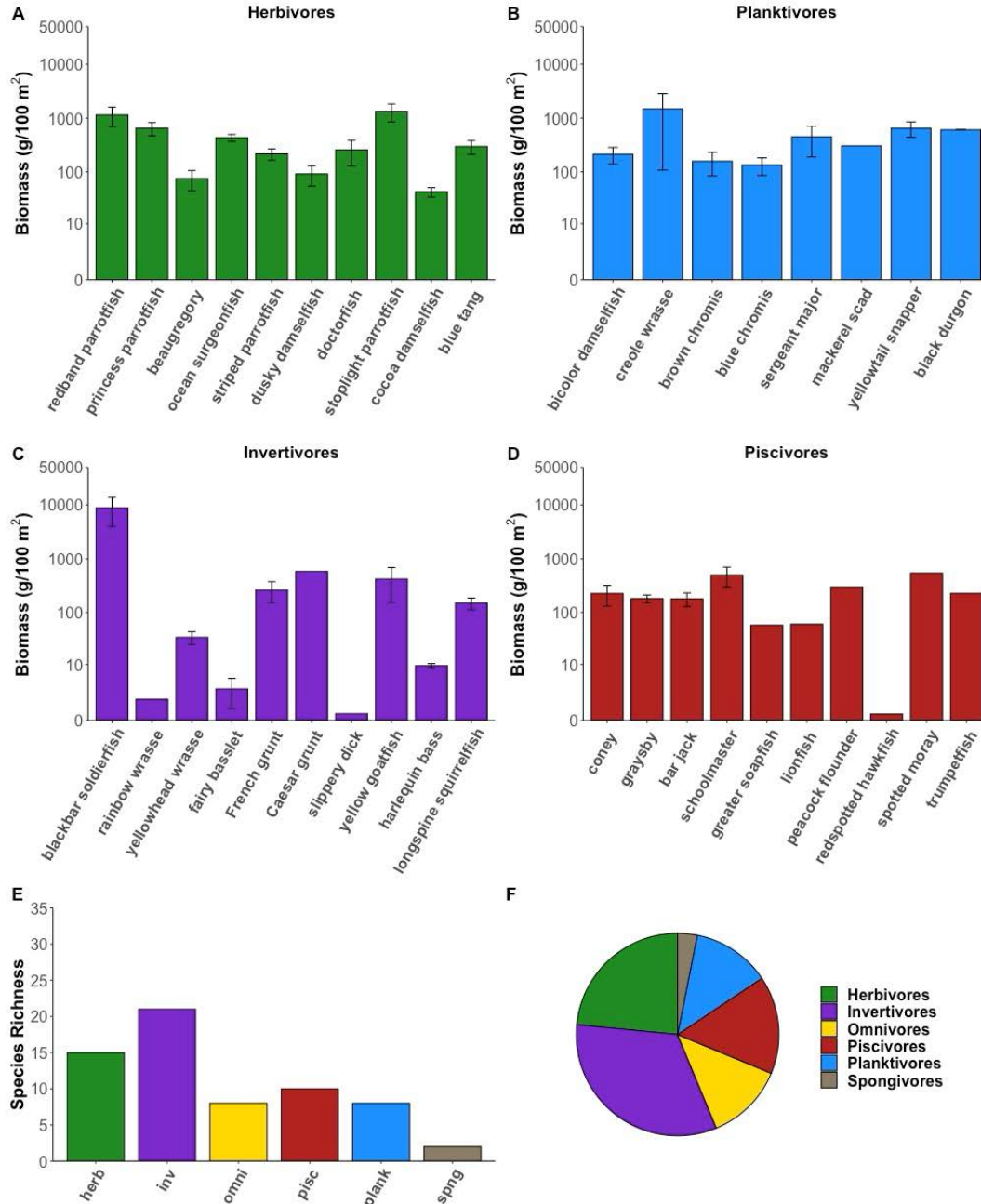


Figure 54. The Eagle Ray fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: GREAT POND

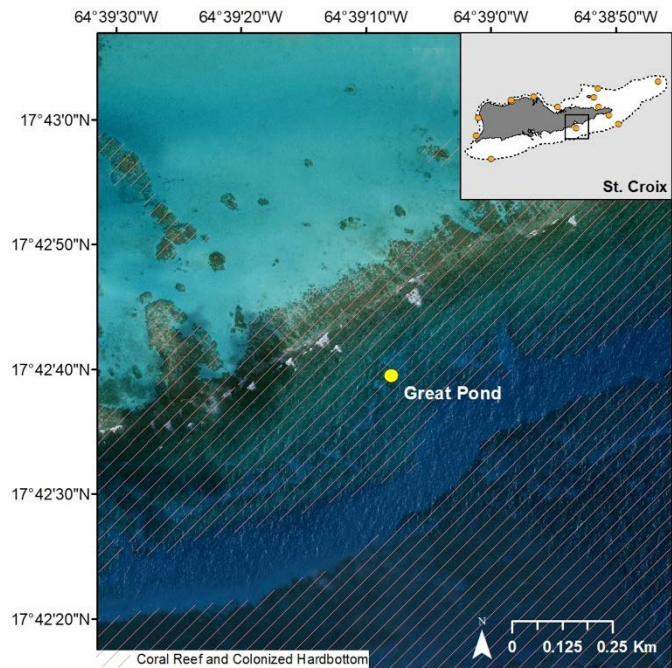
GREAT POND

Description. The Great Pond monitoring site is a wave-washed shallow barrier reef that was formerly an elkhorn coral reef in depths of 5-7 m. The reef is part of the barrier reef front surrounded by patch reefs and sand. Great Pond has been monitored since 2003.

Outstanding Feature. Great Pond hosts the largest population of the black spiny urchin *Diadema antillarum* of any TCRMP monitoring site, likely because of its shallow depth. It also hosts an abundance of large-bodied stoplight (*Sparisoma virde*) and yellowfin parrotfish (*Sparisoma rubripinne*) that likely spawn near the site.

Threats. The Great Pond monitoring site is located in the St. Croix East End Marine Park but outside the no-take fishery zone. If park rules are enforced, this site could see a return of fisheries species by spillover from adjacent protected areas. Because of high turbulence and low watershed development, sediment is not considered a problem; however, large industrial sites operate within 3-10 km westward and could contribute to pollution.

Figure 55. (top) Great Pond location. (right) A representative photo of the reef (photo credit: L. M. Henderson).



SITE SUMMARIES: GREAT POND

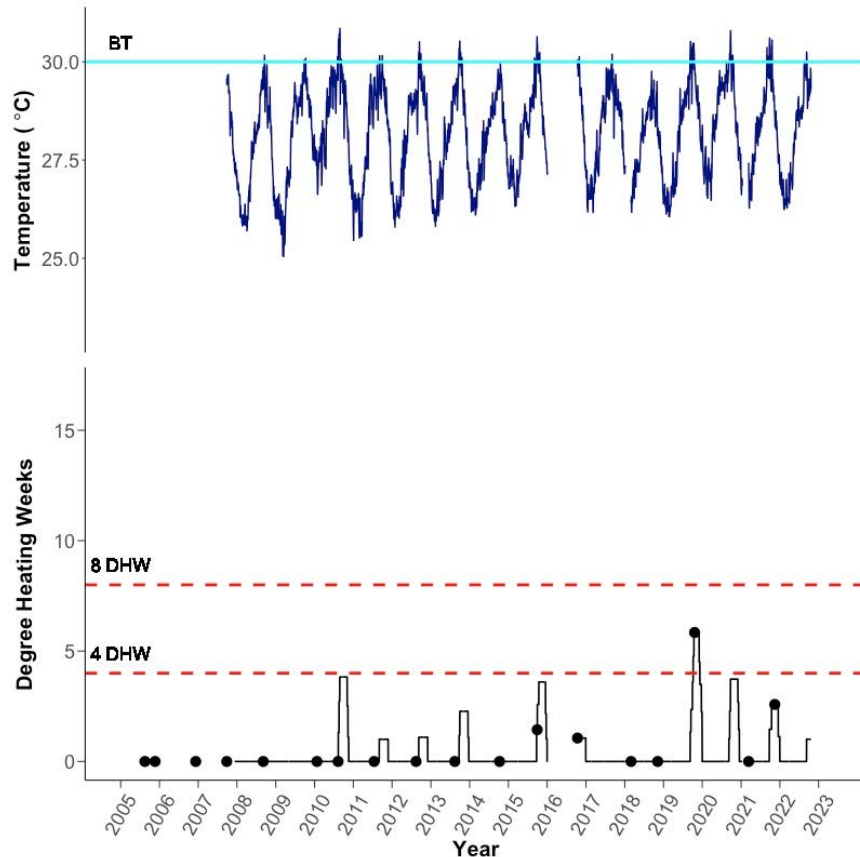


Figure 56. Great Pond benthic temperature (5 m depth).

Physical Characteristics

Current. Great Pond currents have not been measured directly. Wave-generated oscillatory currents dominate and this is the most regularly swell-influenced site in the TCRMP making work conditions difficult on all but the calmest day. Strong unidirectional currents have not been experienced.

Temperature. Great Pond typically experiences very high temperatures in August to October, with temperatures peaking at nearly 31°C in 2010. Temperatures surpassed the bleaching threshold in 2019 causing a minimum of 6 DHW when the sensor was pulled.

SITE SUMMARIES: GREAT POND

Benthic Community. The Great Pond site is unusually dominated with the mustard hill coral (*Porites astreoides*) and *Pseudodiploria strigosa*. It is also the only site with a relatively high abundance of *Pseudodiploria clivosa*. The site lost 55.9% of its coral cover in the 2005 bleaching event, but had regained about half by 2011. Hurricanes Irma and Maria caused damage to this location in 2017, resulting in a 65% drop in relative coral cover during the 2017 annual monitoring (March 2018) but coverage has remained steady since then. Macroalgal blooms occur occasionally (2007 and 2011), but the site is dominated by epilithic algae.

Coral Health. Great Pond corals were moderately affected during the 2005 coral bleaching event, which may reflect the high composition of resistant coral species and the regular exposure to high temperatures. The site was not monitored during the height of the 2010 coral bleaching event. In 2019 there were very few bleached colonies, but those that were affected had a high extent of bleaching on colony surfaces. Patchy, low-level bleaching is common in some years. Diseases have been almost non-existent at the monitoring site. Partial mortality is variable and has not shown consistent trends over years. Stony coral tissue loss disease was first recorded during the 2021 annual sampling (November 2021).

SITE SUMMARIES: GREAT POND

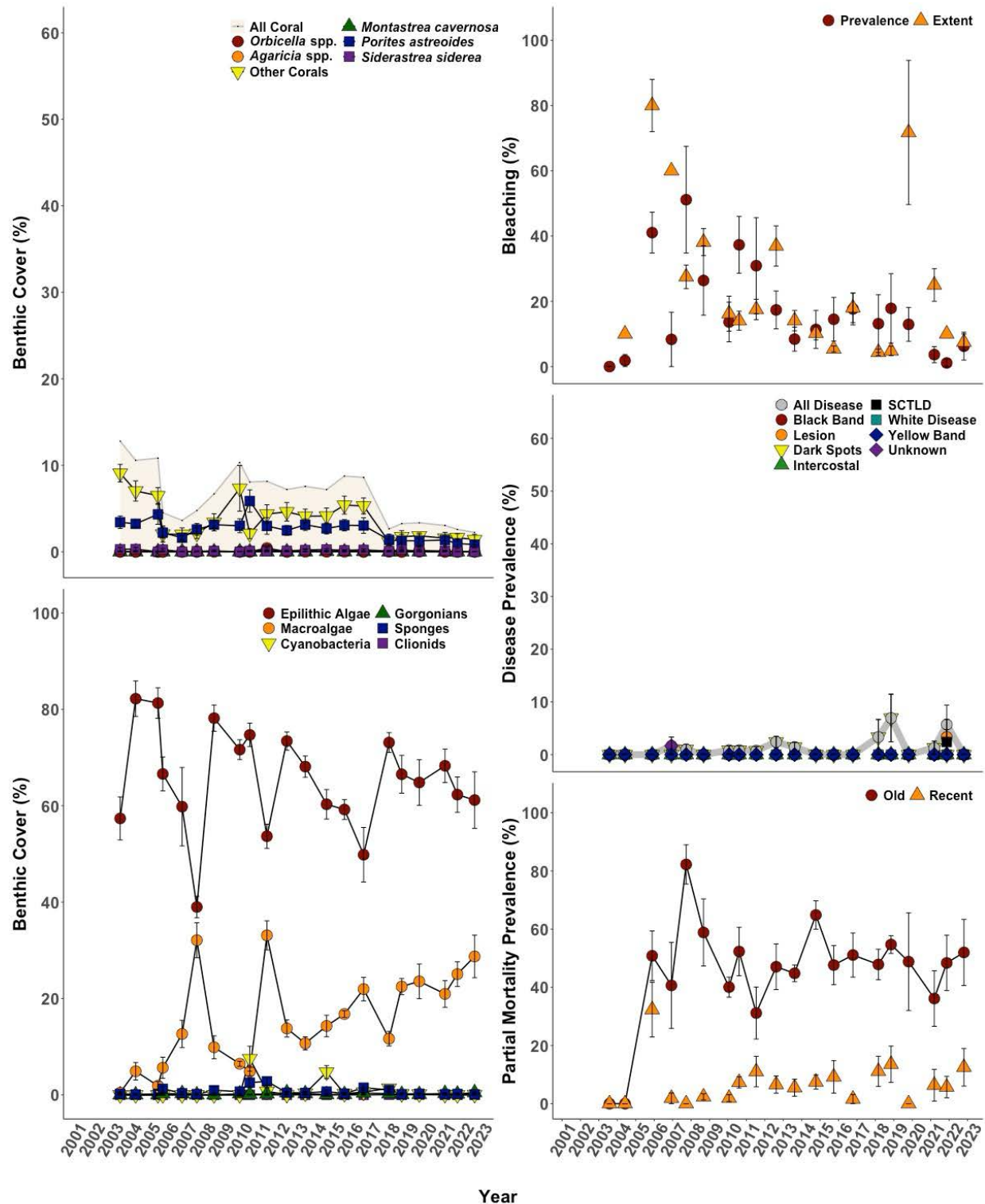


Figure 57. Great Pond benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: GREAT POND

Fish Community. The Great Pond fish community is highly dominated by herbivores. The primary herbivores at the site are the ocean surgeonfish and blue tang, which swim in foraging schools feeding on algae covering the relict elkhorn coral. Also present are the stoplight, yellowtail and queen parrotfish, which can also be seen foraging in large groups on old elkhorn skeletal remains. Quite possibly these fish are spawning in the late afternoon and evening hours at or near the site. Between the old relic *Acropora* stands the fish biomass is low and is primarily made up of yellow goatfish, wrasses, and schools of juvenile parrotfish. Piscivores at Great Pond are limited almost entirely to mahogany snapper and bar jacks, with the occasional mackerel or schoolmaster snapper. Benthic invertivores are dominated in biomass and abundance by wrasses. Wrasse diversity is high and includes the slippery dick, clown wrasse, yellowhead and bluehead wrasse, rainbow wrasse, puddingwife, and Spanish hogfish.

SITE SUMMARIES: GREAT POND

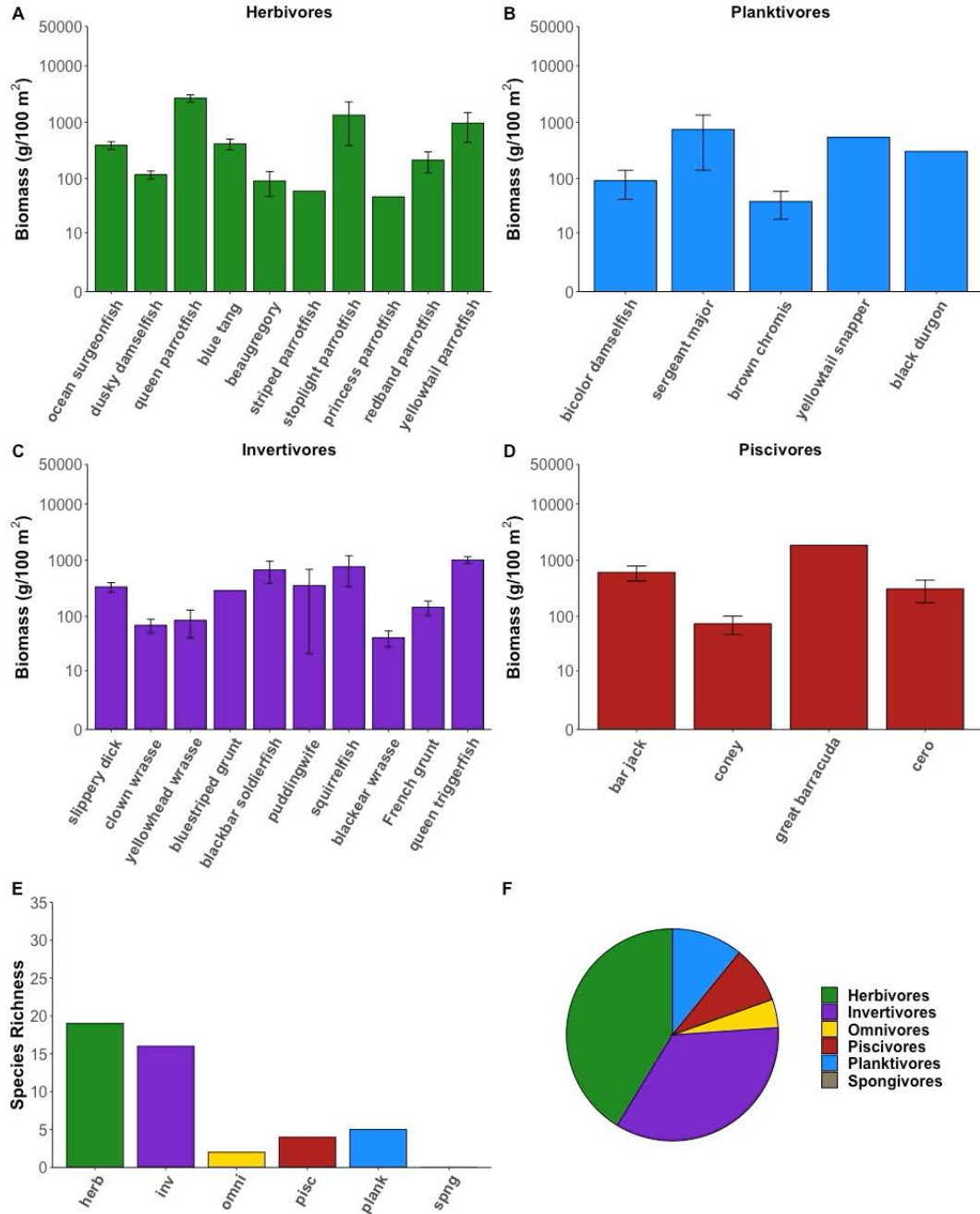


Figure 58. The Great Pond fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: JACKS BAY

JACKS BAY

Description. The Jacks Bay monitoring site (aka Jacks/Isaacs Bay) is part of fringing reef, colonized hardbottom on the southeast point of St. Croix in water depths of 13-16 m. The monitoring site is just inward from the shelf break and seaward reef slope, which terminates in a sand plain at about 20 m depth. Jacks Bay is largely a carbonate hardbottom with scattered hard coral, although there are some large coral heads seaward of the transects. Permanent transects were installed at Jacks Bay in 2001.

Outstanding Feature. Jacks Bay hosts a unique fish community with high abundance of small wrasses and the occasional occurrence of red hind (*Epinephelus guttatus*).

Threats. Jacks Bay is within the St. Croix East End Marine Park but lies just outside the restricted fisheries area and is open to fishing. High turbulence and no watershed development mean there is low threat of land-based sources of pollution at this nearshore site.

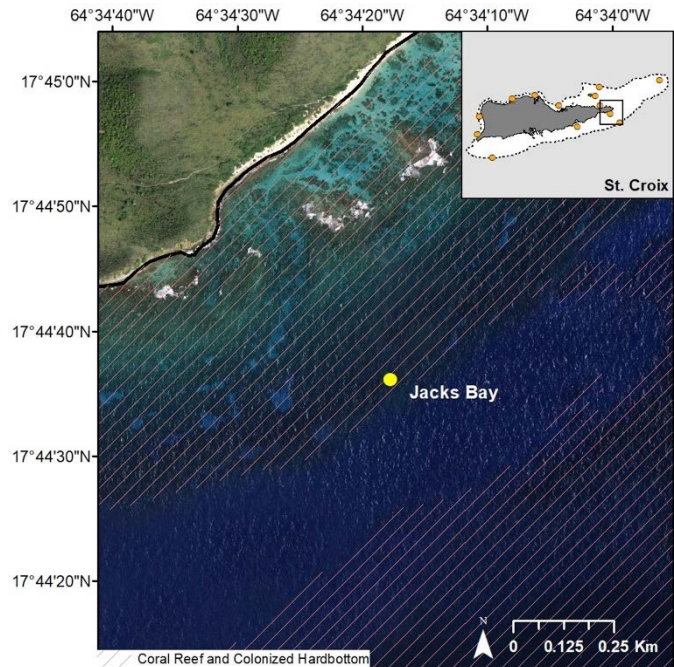


Figure 59. (top) Jacks Bay location. (right) A representative photo of the reef (photo credit: L. M. Henderson).



SITE SUMMARIES: JACKS BAY

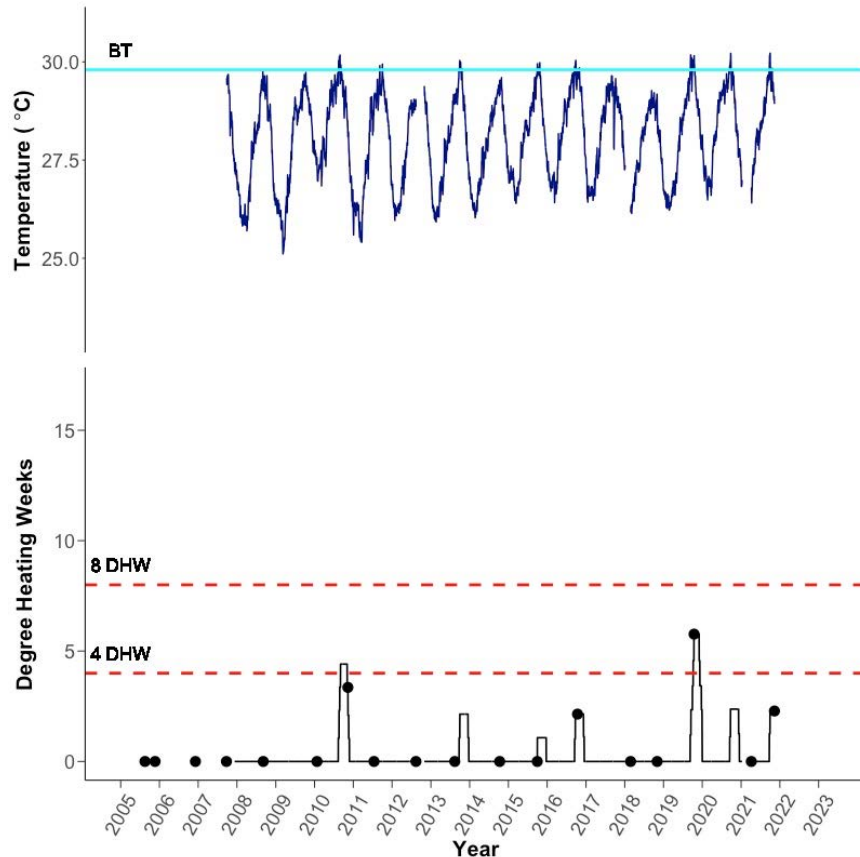


Figure 60. Jacks Bay benthic temperature at 12 m depth

Physical Characteristics

Current. Jacks Bay currents have not been measured directly. There are weak unidirectional currents, but there is a propensity for strong wave-generated oscillatory currents due the open coast southeast exposure.

Temperature. Jacks Bay can experience high temperatures during August to October. Heat stress in 2010 and 2019 was sufficient enough to cause coral bleaching.

SITE SUMMARIES: JACKS BAY

Benthic Community. The Jacks Bay site has low coral cover (<10%) and is the only TCRMP site dominated by the great star coral *Montastraea cavernosa*. Jacks Bay lost 44.7% of its coral cover in the 2005 coral bleaching event, but had regained about 32% of the loss by 2011. Over half of the sessile epibenthic community is composed of gorgonians and sponges and the site might be considered more a colonized hardbottom than true coral reef. The algal community is composed of high proportions each of epilithic algae, macroalgae, and filamentous cyanobacteria. The site also shows a high degree of sand intermixed with filamentous algae, an important deterrent for coral larval settlement (Bellwood and Fulton 2008). This site is often colonized by fleshy upright brown algae, such as *Turbinaria turbinata* and *Sargassum hystrix* (species unconfirmed). Very large beach wrack of these brown algae can often accumulate on the windward beaches behind the site.

Coral Health. The Jacks Bay site was strongly affected during the 2005 bleaching event and was moderately affected during the 2010 and 2019 bleaching event. Disease prevalence was low and only dark spots disease was present. Recent partial mortality was high during the 2005 bleaching event, likely reflecting the fact that surveys were conducted in November 2005 when mortality had begun. Old partial mortality increased greatly after the 2005 bleaching and then declined to stable levels in 2009-2011, with an increase in 2018 for unknown reasons. Stony coral tissue loss disease was first recorded in the 2021 annual sampling (November 2021).

SITE SUMMARIES: JACKS BAY

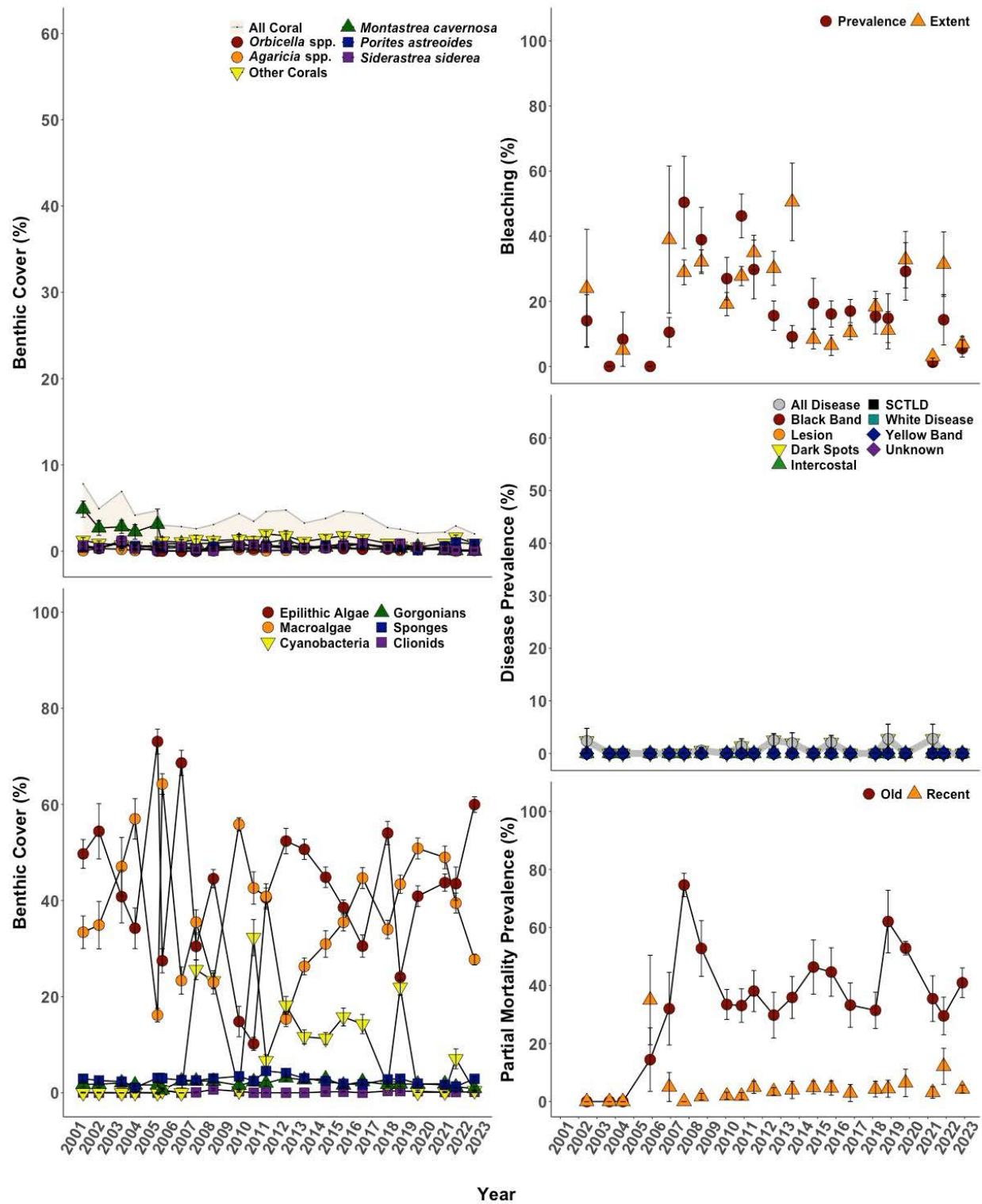


Figure 61. Jacks Bay benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: JACKS BAY

Fish Community. The Jacks Bay fish community is characterized by very low fish biomass and abundance but relatively high diversity. Total fish biomass is disproportionately made up of small herbivores. The site is primarily hard bottom, adjacent to more developed coral reef on the seaward edge, over which some larger fishes are observed. The hardbottom community is highly dominated numerically by blue chromis, yellowhead wrasse, and bicolor damselfish. Juvenile wrasse and parrotfish swim and hover in mixed schools among the rubble and gorgonians. Slippery dicks, clown wrasse, rainbow wrasse, and blackear wrasse are common. Piscivores are always rare and are usually limited to small coney, graysby, schoolmaster, mahogany snapper and a few jacks. Medium to larger sized benthic species are very rare overall, and when observed at Jacks Bay they are generally seen in the juvenile life history stage.

SITE SUMMARIES: JACKS BAY

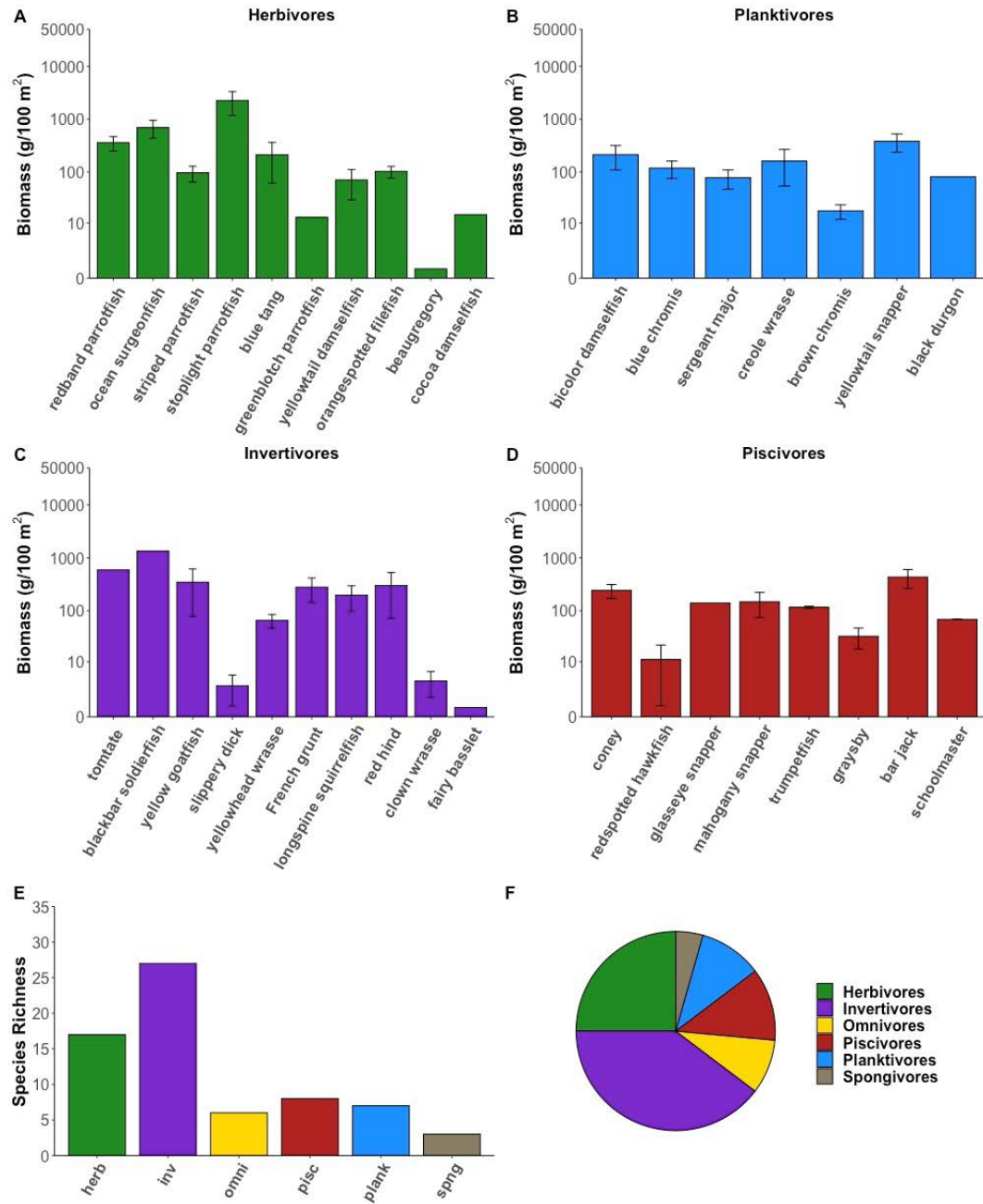


Figure 62. The Jacks Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: KINGS CORNER

KINGS CORNER

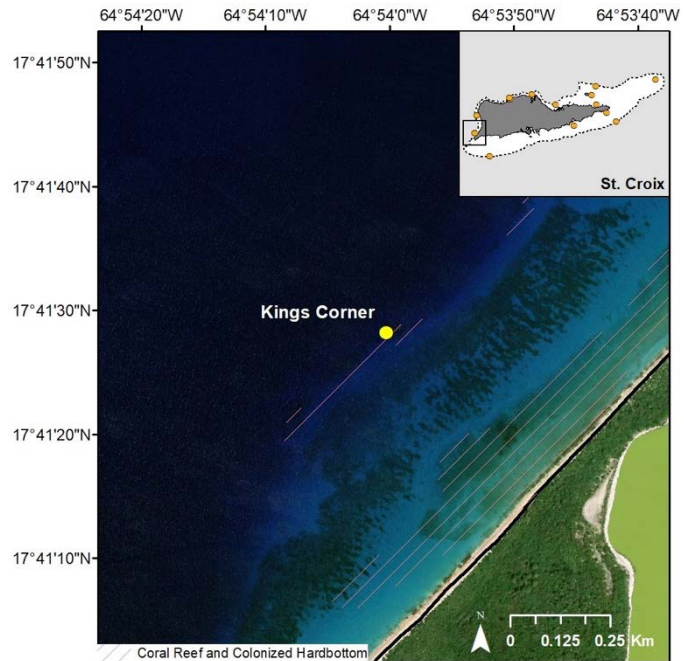
Description. The Kings Corner monitoring site is a part of a patchy reef complex along the steeply sloping west coast of St. Croix in depths of 15-25 m. The reef contains a high diversity of corals and sponges on mounds surrounded by sand. Kings Corner has been monitored since 2006, with permanent transects installed in 2007.

Outstanding Feature. Kings Corner is a commercially important recreational dive site. The site supports a high diversity and density of fishes. It is also a very aesthetically pleasing site with high topographic relief.

Threats. Kings Corner is open to fishing and is easily accessible as part of the calm lee of western St. Croix near Frederiksted. Derelict fishing lines, fish traps, fish weights, and other marine debris are in evidence in and around the site. Large plumes of sediment that wrap around Sandy Point from the south coast of St. Croix also periodically affect the site.

Plumes can drop visibility to near zero and lead to high incidence of sediment on coral and spotty bleaching.

Figure 63. Kings Corner. (top) Location. (right) A representative photo of the reef (photo credit: L. M. Henderson).



SITE SUMMARIES: KINGS CORNER

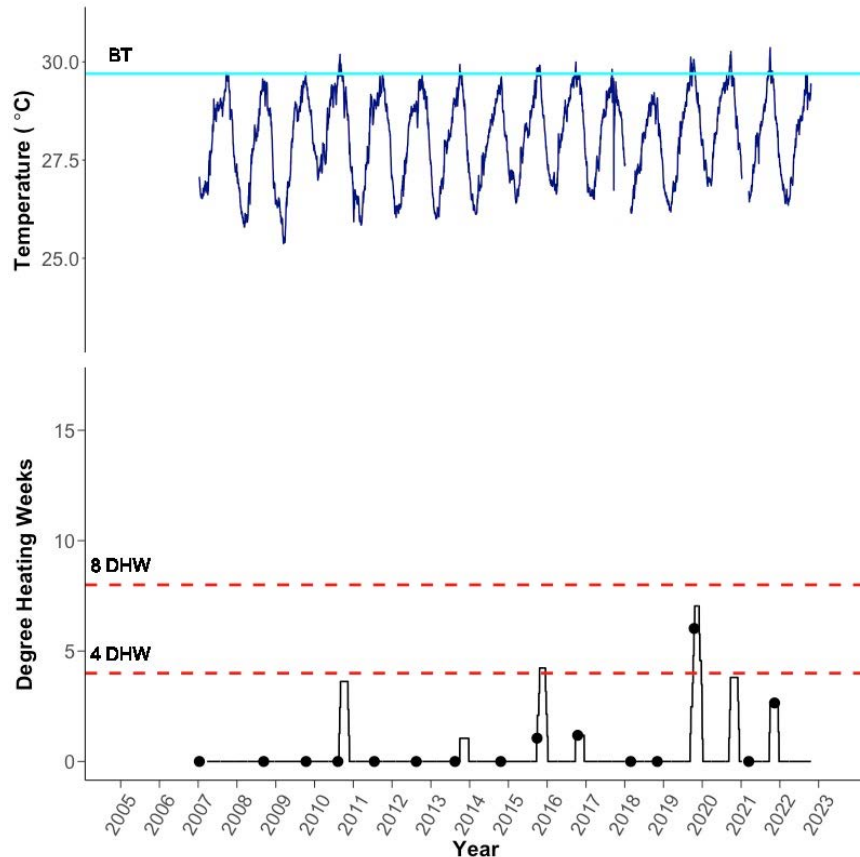


Figure 64. Kings Corner benthic temperature (17 m depth)

Physical Characteristics

Current. Kings Corner currents have not been measured directly. The site is protected from wave action, but can experience strong unidirectional currents at times, particularly at shallower depths.

Temperature. Kings Corner has moderately high temperatures. An adjusted bleaching threshold of 29.70 °C was established based on historical bleaching responses and 2019.

SITE SUMMARIES: KINGS CORNER

Benthic Community. The Kings Corner site supports a diverse community of hard corals dominated by *Orbicella* spp. The site also has a very abundant population of sponges. This site was not monitored until after the 2005 bleaching event, so the impacts on coral cover are not known. Indications of increasing coral cover after 2005 suggest bleaching related mortality, but then resilience after the disturbance. An outbreak of white disease in 2012 temporarily reduced coral cover. Relative coral cover dropped precipitously by 2021 (70.0%), likely due to the arrival of Stony Coral Tissue Loss Disease and diverse coral fauna that included many susceptible species. Epilithic algae dominate the algal community at Kings Corner, with very low abundance of macroalgae and filamentous cyanobacteria. Sand is prominently interspersed among the coral banks.

Coral Health. Non-thermal bleaching with moderate prevalence but low extent on colonies is a common feature at this site, likely as the result of chronic sedimentation. The prevalence of coral diseases has been low with dark spots disease predominating. Old partial mortality has been very high at this site and may be an indication of impacts from the 2005 coral bleaching event. The site bleached moderately in 2019. Old partial mortality has increased lately. Stony coral tissue loss disease was recorded at a high prevalence in transects in the 2020 year sampling (March 2021).

SITE SUMMARIES: KINGS CORNER

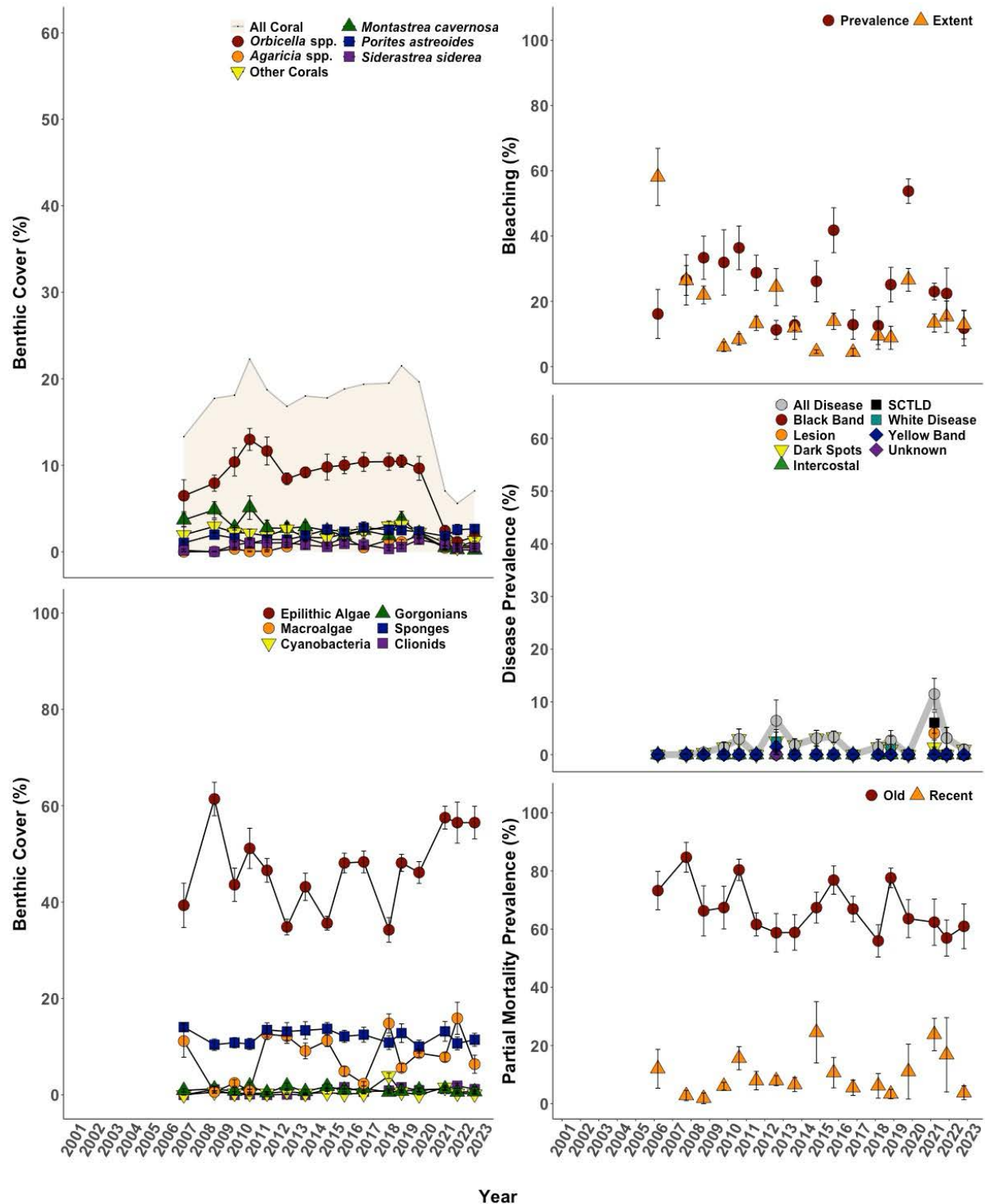


Figure 65. Kings Corner benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: KINGS CORNER

Fish Community. Kings Corner represents the most diverse fish community with the highest fish biomass in the TCRMP monitoring program on St. Croix, with a huge variety of resources available for foraging and habitat. The site is dominated by invertivores, where overall biomass is influenced highly by the large numbers of the nocturnal feeding blackbar soldierfish, a zooplanktivore, and the tomtate, a more opportunistic benthic feeder of invertebrates, zooplankton and benthic algae. Other common planktonic feeders at Kings Corner include the boga, black durgelon, and creole wrasse. Garden eels are ubiquitous on the sandy areas around the patchy reefs. Common benthic herbivores include the blue tang and ocean surgeonfish as well as the common Caribbean parrotfishes (stoplight, princess, redband, redfin, queen, and striped). A variety of grunts are common on the site as well as angelfishes and large green moray eels. Piscivores as a group are relatively low in biomass, and are represented by jacks (pelagic), glasseye snapper and bigeye (nocturnal feeders), and graysby, coney, lionfish, and small snappers (diurnal bottom feeders). Mutton snapper, cubera snapper, and dog snapper are occasional.

SITE SUMMARIES: KINGS CORNER

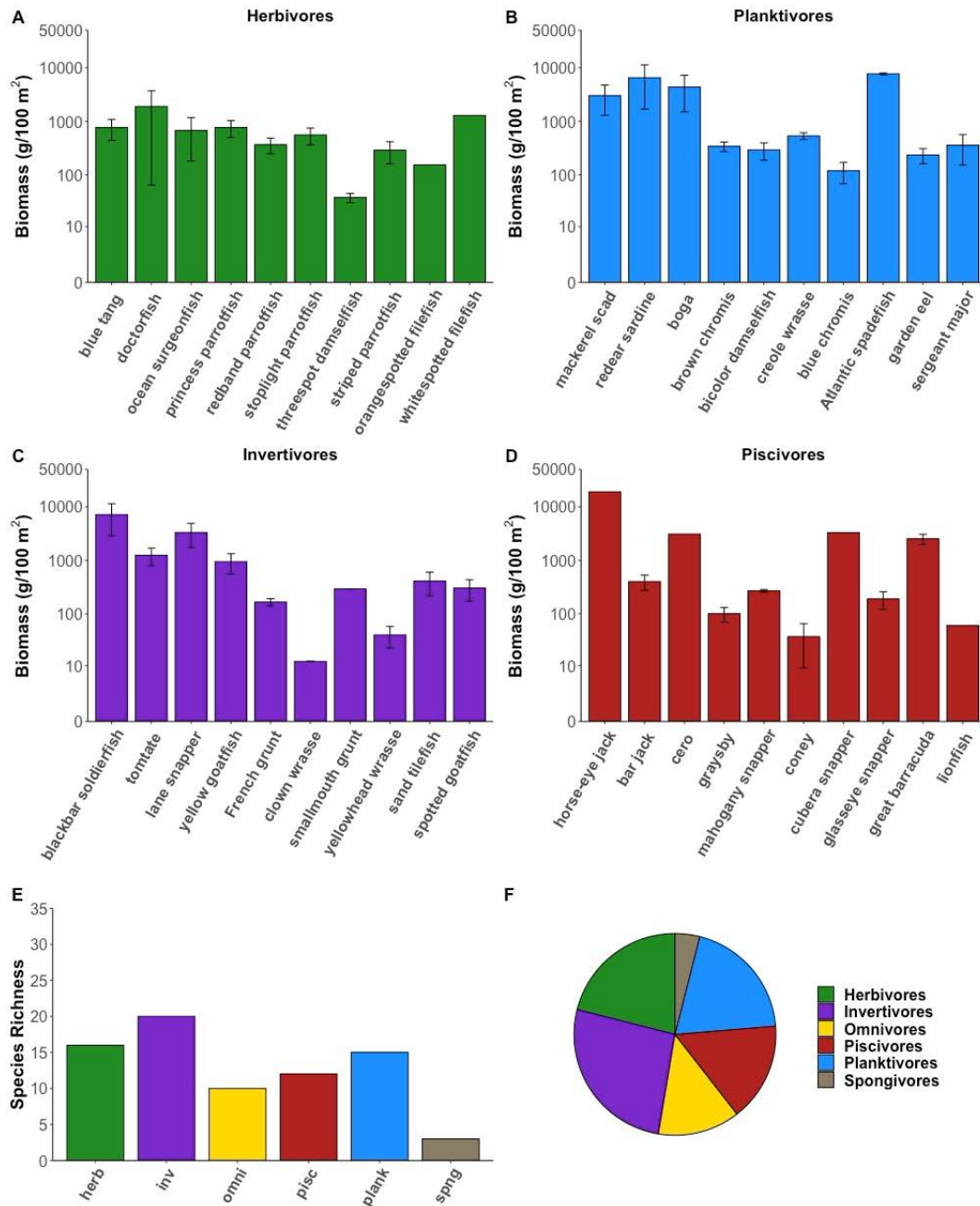


Figure 66. The Kings Corner fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: LANG BANK EEMP

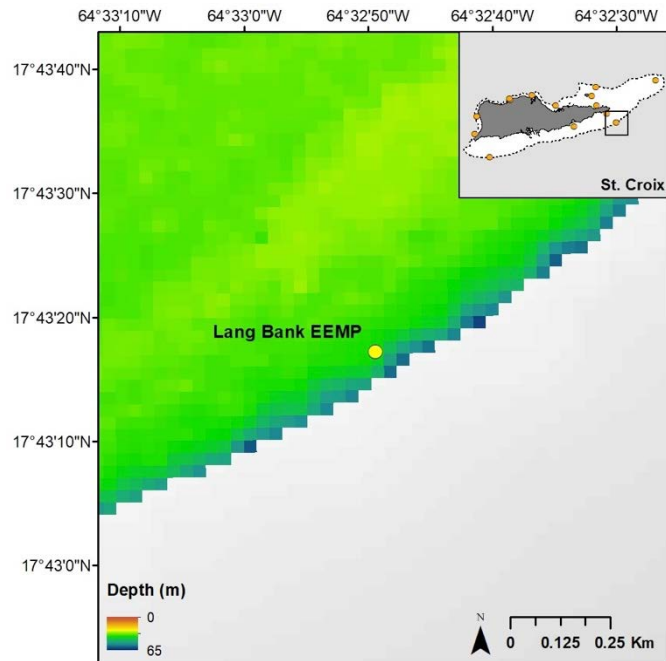
LANG BANK EAST END MARINE PARK

Description. The Lang Bank EEMP site is a shelf edge mesophotic coral reef located at a depth of 27 – 30 m. The monitoring site sits just above a steep shelf break and is composed of rolling coral knolls dominated by boulder star corals (*Orbicella* spp.). This site was established in 2009.

Outstanding Feature. The Lang Bank EEMP site appears to be a well-developed mesophotic boulder star coral reef on St. Croix, which may be relatively rare compared to St. Thomas. Large populations of fishes and spiny lobsters are often encountered.

Threats. The Lang Bank EEMP is in the outer park area and is open to fishing year-round. Its offshore location protects it from land-based sources of pollution.

Figure 67. Lang Bank EEMP. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: LANG BANK EEMP

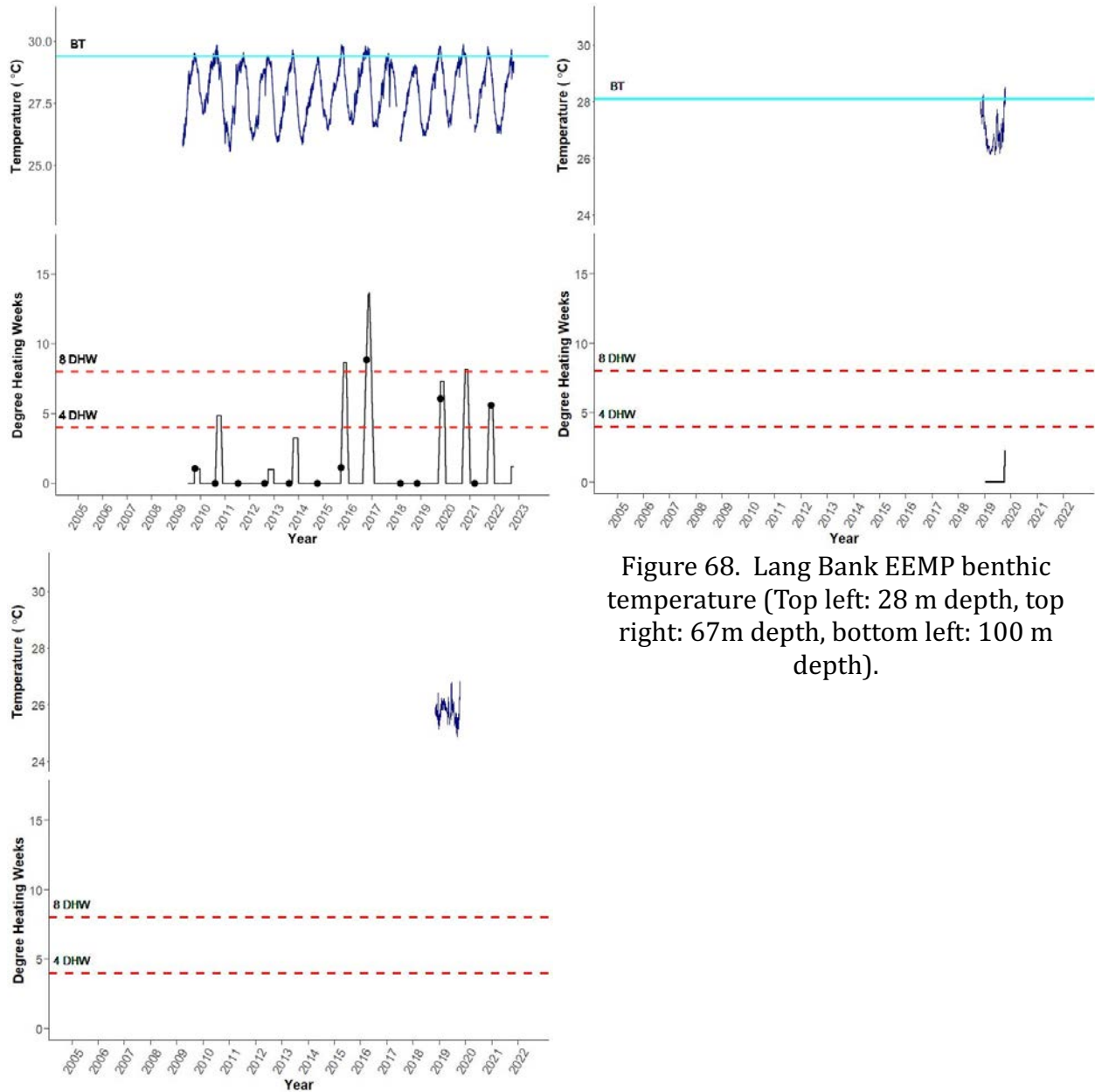


Figure 68. Lang Bank EEMP benthic temperature (Top left: 28 m depth, top right: 67m depth, bottom left: 100 m depth).

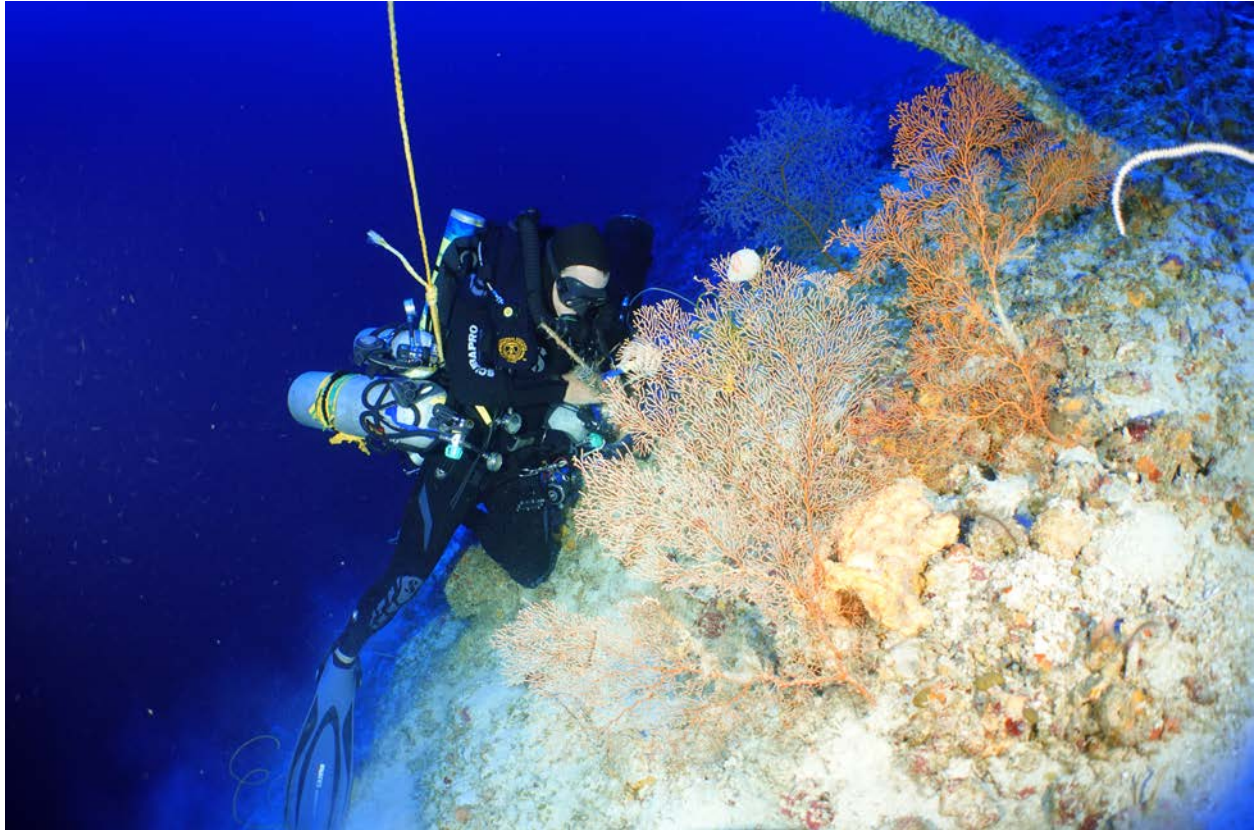


Figure 69. Changing of thermistors at Lang Bank EEMP at 100 m (credit: Viktor Brandtneris).

Physical Characteristics

Current. Direct current measurements have not been taken at Lang Bank EEMP. The depth buffers the site from wave-driven oscillatory currents. Only weak unidirectional benthic currents have been experienced at the site during monitoring; however, midwater and surface currents can be moderate to strong ($>10\text{cm s}^{-1}$).

Temperature. Lang Bank EEMP has temperature that is reduced relative to shallow water sites. However, the bleaching threshold has not been established and here is based on a relationship between depth (Smith et al. 2016a). Based on the response of corals to thermal stress in 2019 an adjusted bleaching threshold of $29.63\text{ }^{\circ}\text{C}$ was established.

SITE SUMMARIES: LANG BANK EEMP

Benthic Community. Lang Bank EEMP supports many coral species but is dominated by *Orbicella* spp.. Sponges are also quite prominent and make up a quarter of the sessile epibenthic animal community. Epilithic algae, *Lobophora variegata*, and filamentous cyanobacteria near equally represent the algal community. The prominence of filamentous cyanobacteria is quite striking and has reached almost 40% of the substrate in some years. There has been a relative decrease of nearly 50% coral cover from 2019 – 2022 likely due to Stony Coral Tissue Loss Disease.

Coral Health. Background, non-thermal bleaching prevalence is quite high at Lang Bank EEMP. White disease showed an outbreak in 2011. Lang Bank EEMP was not initially monitored until well after the 2005 coral bleaching event; however, a high prevalence of old partial mortality suggests that corals were impacted. Many of the large faviids show lesion patterns that are consistent with the large lunate dead areas caused by white diseases following bleaching in 2005.

SITE SUMMARIES: LANG BANK EEMP

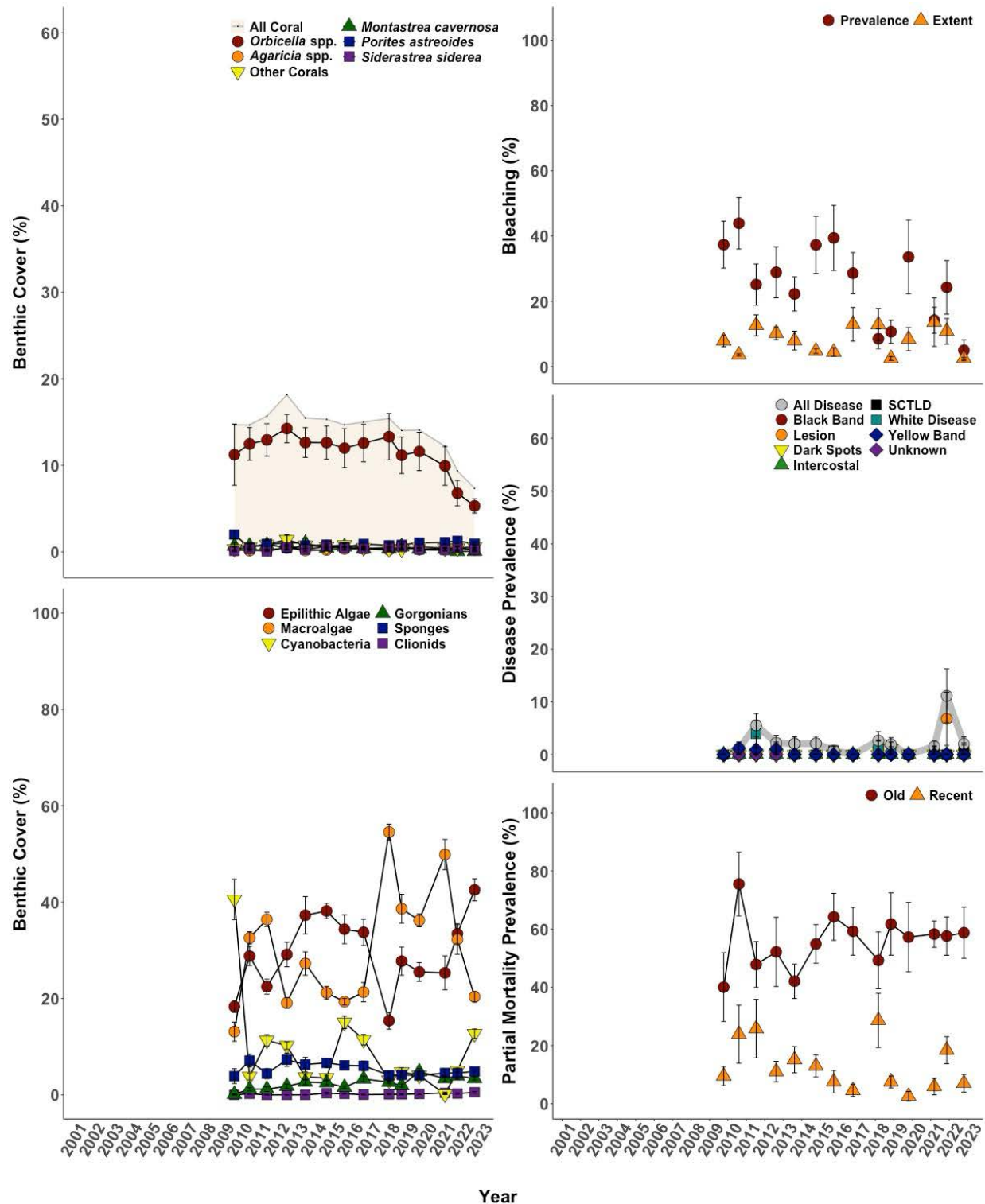


Figure 70. Lang Bank EEMP benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: LANG BANK EEMP

Fish Community. The Lang Bank East End Marine Park site represents a mesophotic reef community that is characterized by a high biomass of planktonic feeders and a low biomass of herbivores. The high overall biomass of planktivores is influenced by the ocean triggerfish and black durgelon, while numerically blue chromis and creole wrasse are dominant. Benthic herbivores are dominated both numerically and in biomass by the ocean surgeonfish, redband parrotfish, and stoplight parrotfish. Benthic invertivores at the site are diverse and include nocturnally feeding blackbar soldierfish and squirrelfish, as well as several species of grunt (French, tomtate, white, bluestriped, Caesar, and smallmouth), red hind and several wrasse species. Piscivores are generally dominated in biomass by jacks, barracuda and Caribbean reef sharks, however, coney, graysby, schoolmaster and mahogany snapper contribute as benthic piscivores. At least one Nassau grouper is typically encountered during monitoring.

SITE SUMMARIES: LANG BANK EEMP

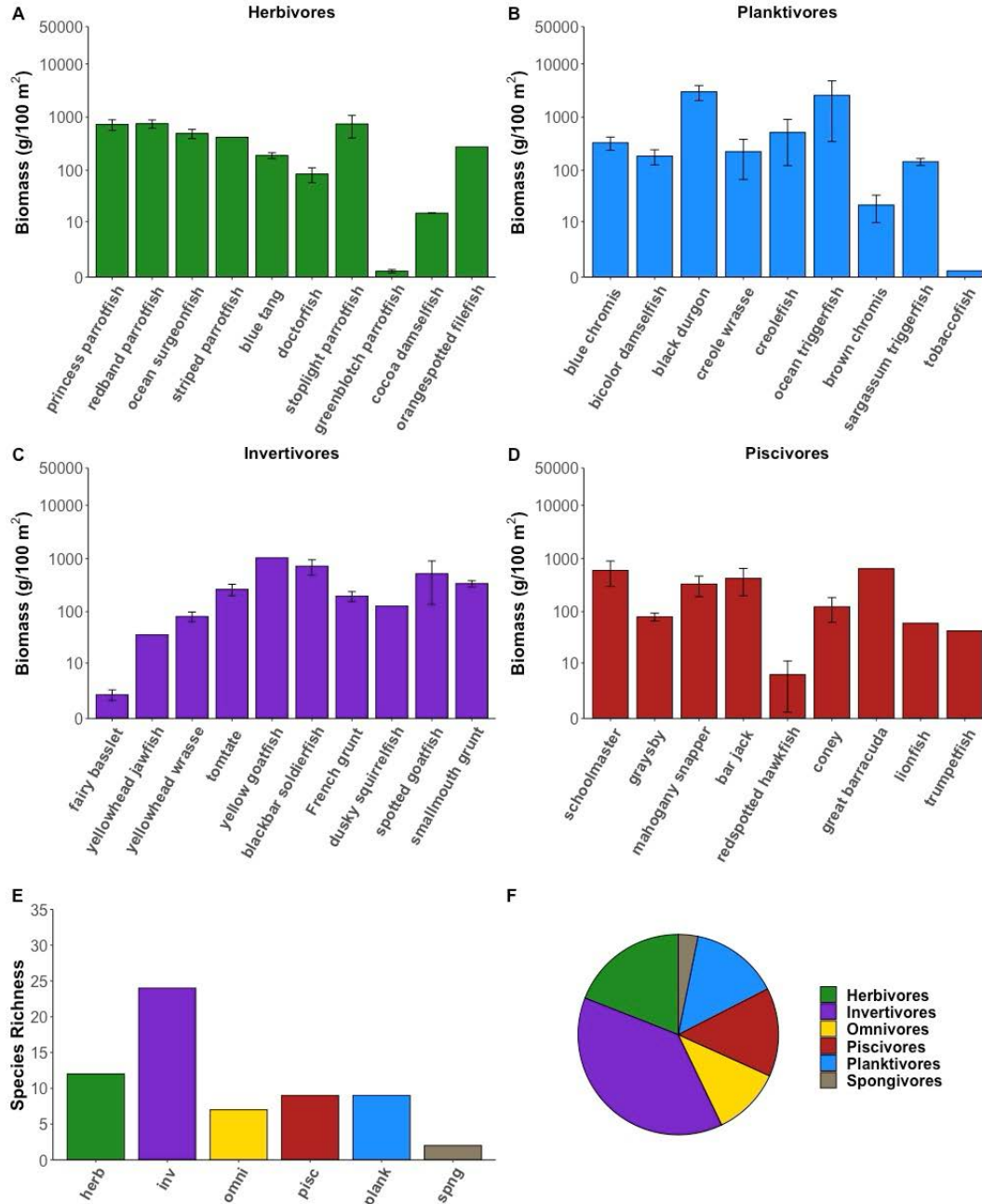


Figure 71. The Lang Bank EEMP fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: LANG BANK RED HIND

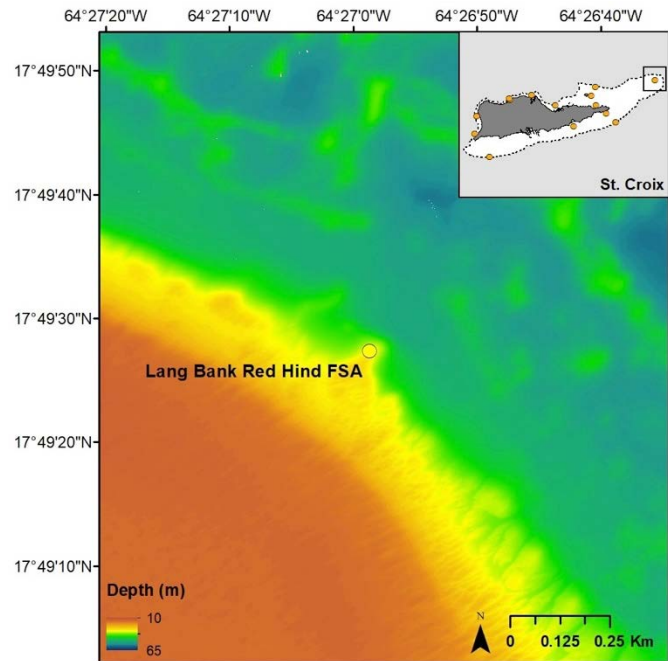
LANG BANK RED HIND FISH SPAWNING AGGREGATION

Description. The Lang Bank Red Hind Fish Spawning Aggregation (Lang Hind) monitoring site is a mesophotic reef of antecedent spur and groove structure at a depth of 30 – 35 m. The site is perched on the southeast side of the spur, which is a large finger that rises to 24 m to the west and drops on all other sides to a rhodolith/sand plain at about 50 m. Lang Hind was initially monitored in 2001 at a site on the shallower (24 m) portion of the bank to the west. Monitoring in 2004-2007 occurred along random transects in a deeper portion of the reef (~33 m depth) and benthic transects were made permanent in this area in 2009

Outstanding Feature. Lang Hind supports an annual fish spawning aggregation of the red hind (*Epinephelus guttatus*). This site also possesses high water clarity.

Threats. The Lang Hind site is removed from land-based stressors. Fishing of the red hind aggregation was common prior to closure of the area to fishing in 1993. However, the aggregation is near the closure boundary.

Figure 72. Lang Bank Red Hind FSA. (top) Location. (right) A representative photo of the reef in 2021. (photo: T. Smith)



SITE SUMMARIES: LANG BANK RED HIND

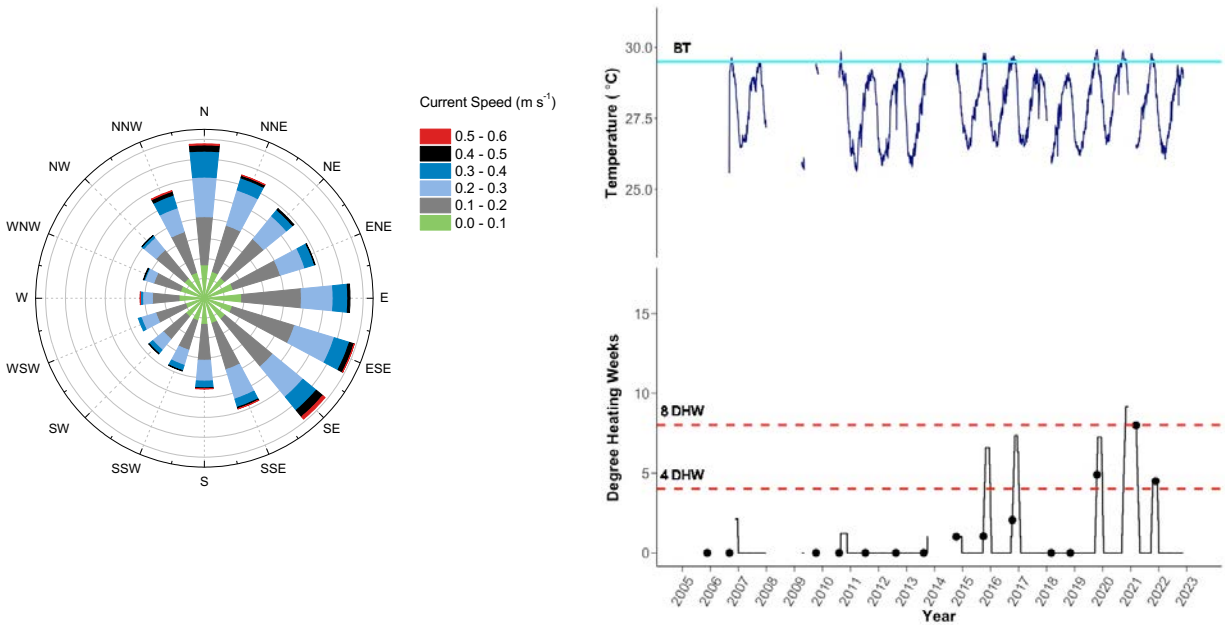


Figure 73. Lang Bank Hind current speed (left) and benthic temperature (right; 33 m depth).

Physical Characteristics

Current. Lang Hind had benthic currents recorded with ADCP every 30 minutes from 11/20/05 to 8/20/06, and 12/11/06 to 3/10/07. Bottom currents most typically alternate between north and southeast and can attain strong speeds periodically exceeding 0.4 m s^{-1} .

Temperature. Lang Hind has temperatures that are reduced due to the depth and proximity of the warm season thermocline. However, temperatures are not as cool or variable as sites on the southern Puerto Rican shelf, indicating that this site may be more susceptible to warming ocean temperatures. There is no empirically established bleaching threshold and the one displayed is based on a depth – bleaching threshold model (Smith et al. 2016a). The site-specific bleaching threshold is likely higher than the model because there was low-level bleaching when the site was monitored in 2016 and 2019, yet the model predicted ~8 DHW, which should have led to a mass bleaching response.

SITE SUMMARIES: LANG BANK RED HIND

Benthic Community. Lang Hind has a diverse sessile epibenthic community dominated by hard corals, predominantly *Orbicella* spp., gorgonians, and sponges. Coral cover actually increased by 110% between the coral bleaching event and re-monitoring in 2006, but this may reflect the fact that transects were laid in random, rather than permanent, locations prior to 2009. There has been about a 44% relative drop in coral cover (2019 – 2022) since Stony Coral Tissue Loss Disease was first observed. The algal community is largely open epilithic algal communities, but also contains large proportions of *Lobophora variegata* and filamentous cyanobacteria. The algal community shows high inter-annual variability.

Coral Health. Lang Hind FSA was heavily affected during the 2005 coral bleaching event, with a very high prevalence of corals that were 100% bleached over the colony surface. Non-thermal bleaching with moderate prevalence and low extent on colonies also occurred in later years. In particular, 2019 saw moderate prevalence of bleaching at a low extent. The site was heavily affected with white diseases after the coral bleaching event and has had high disease prevalence in all years of monitoring. Old partial mortality jumped after the 2005 bleaching event and was variable in later years. Recent partial mortality is unusually high at Lang Hind, largely as the result of fish bites and predation by the corallivorous snail *Coralliophila* spp. Stony coral tissue loss disease was recorded in transects in the 2020 year sampling (March 2021) and caused the largest decline in coral cover since permanent transects were installed.

SITE SUMMARIES: LANG BANK RED HIND

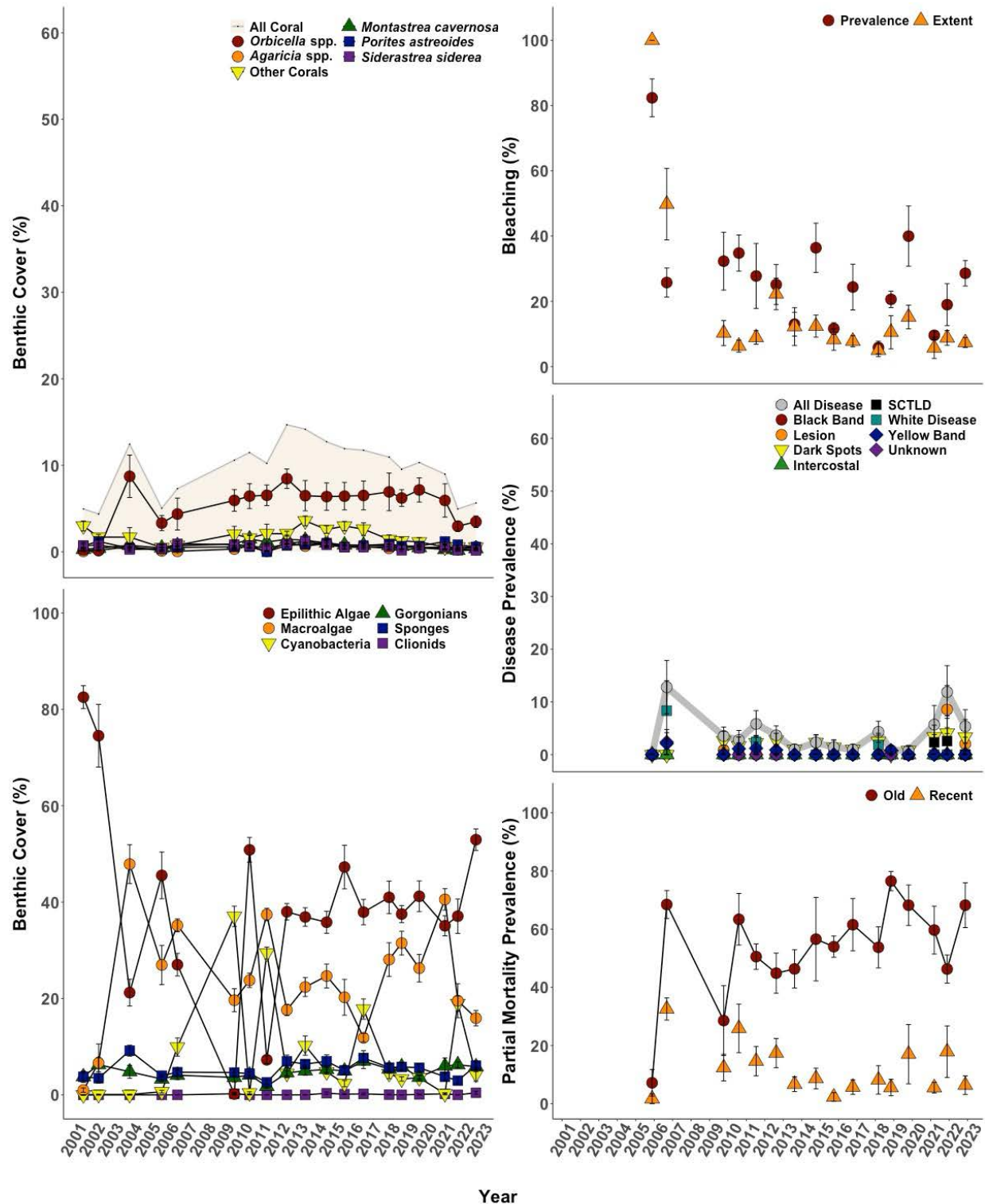


Figure 74. Lang Bank Red Hind FSA benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: LANG BANK RED HIND

Fish Community. The fish community at Lang Bank FSA is representative of a St. Croix mesophotic reef system. High water column planktonic feeders are abundant and include the black durgelon, creole wrasse, black jack, and creolefish. Bicolor damselfish are numerous while herbivorous damselfishes are uncommon. Benthic herbivores are relatively low in diversity, abundance and biomass compared to nearshore sites. Invertivores are diverse and include many planktivores as well as benthic feeders, utilizing the varied resources of the bank. Four species of angelfish were observed on transects reflecting the high sponge cover. Lang Bank FSA supports a red hind spawning site, active during December through February each year, and red hind are occasionally seen on both roving dives and transects. One Nassau grouper was observed on the bank in 2011, a first observation across all St. Croix monitoring sites. There is a historic Nassau grouper spawning site near the Lang Hind monitoring site, and with the bank now closed to trap fishing there is hope of some re-establishment of the species on St. Croix. In 2018 a yellowfin grouper was reported on Lang Bank FSA. This is also a new TCRMP St. Croix record. The mahogany snapper dominates in abundance the piscivorous fish community on Lang Bank FSA. Other important piscivores include the great barracuda, coney, graysby and Caribbean reef shark.

SITE SUMMARIES: LANG BANK RED HIND

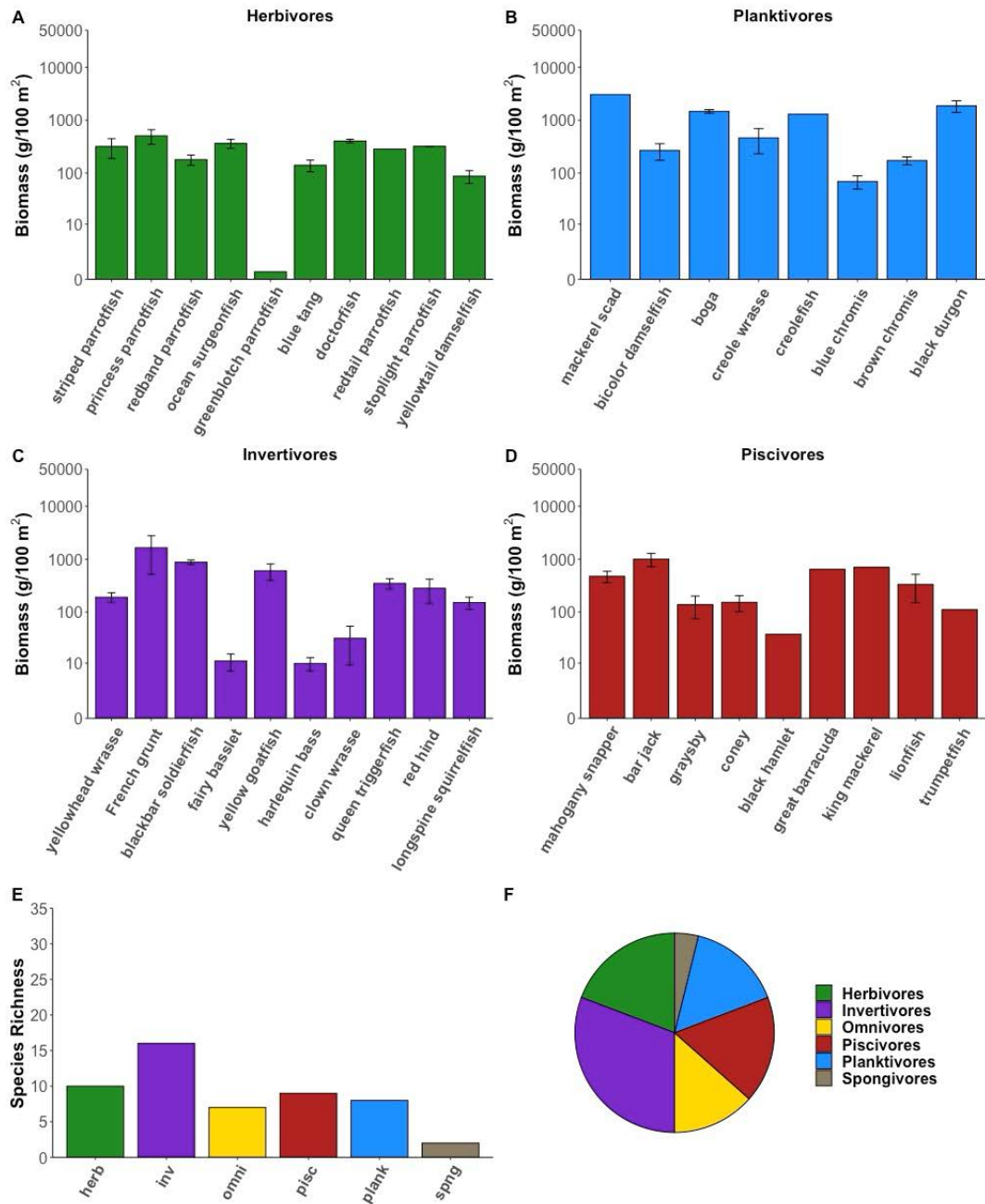
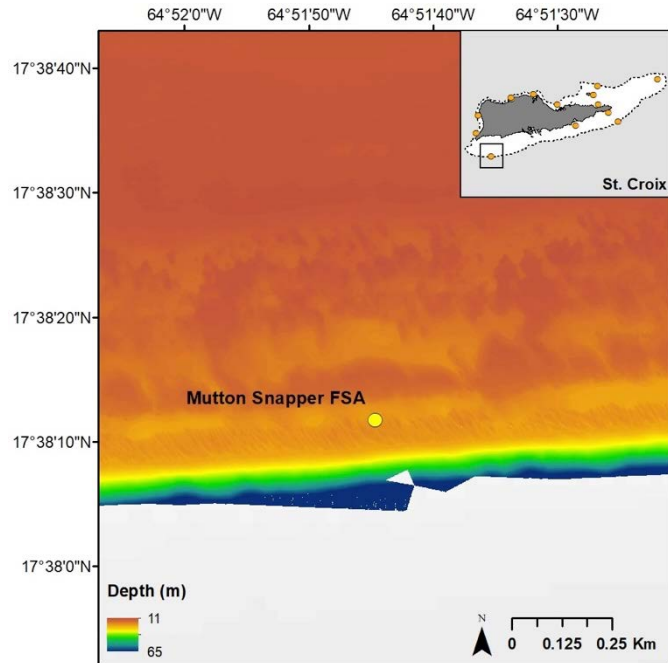


Figure 75. The Lang Bank Red Hind FSA fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: MUTTON SNAPPER

MUTTON SNAPPER

Description. The Mutton Snapper site is located on the landward side of a shelf edge spur and groove reef on the southwest shelf of St Croix in depths of 22-24 m. The reef was dominated by boulder star coral (primarily *Orbicella franksi*) until a mass coral die-off following the 2005 bleaching event. Mutton Snapper has been monitored since 2003.



Outstanding Feature. The Mutton Snapper site was located in conjunction with the possible proximity of a mutton snapper (*Lutjanus analis*) spawning aggregation. It is seasonally closed to fishing. The site was devastated by the 2005 coral bleaching event, with an 87% drop in coral cover and a concomitant increase in algae.

Threats. The Mutton Snapper site is threatened by fishing pressure as evidenced by the abundance of fishing line and fishing trap debris. This site is offshore and less likely threatened by land-based stressors. The clear waters and warm temperatures make this site vulnerable to long-term seawater warming.

Figure 76. Mutton Snapper. (top) Location. (right) A representative photo of the reef taken in 2017. (photo: L. Henderson)



SITE SUMMARIES: MUTTON SNAPPER

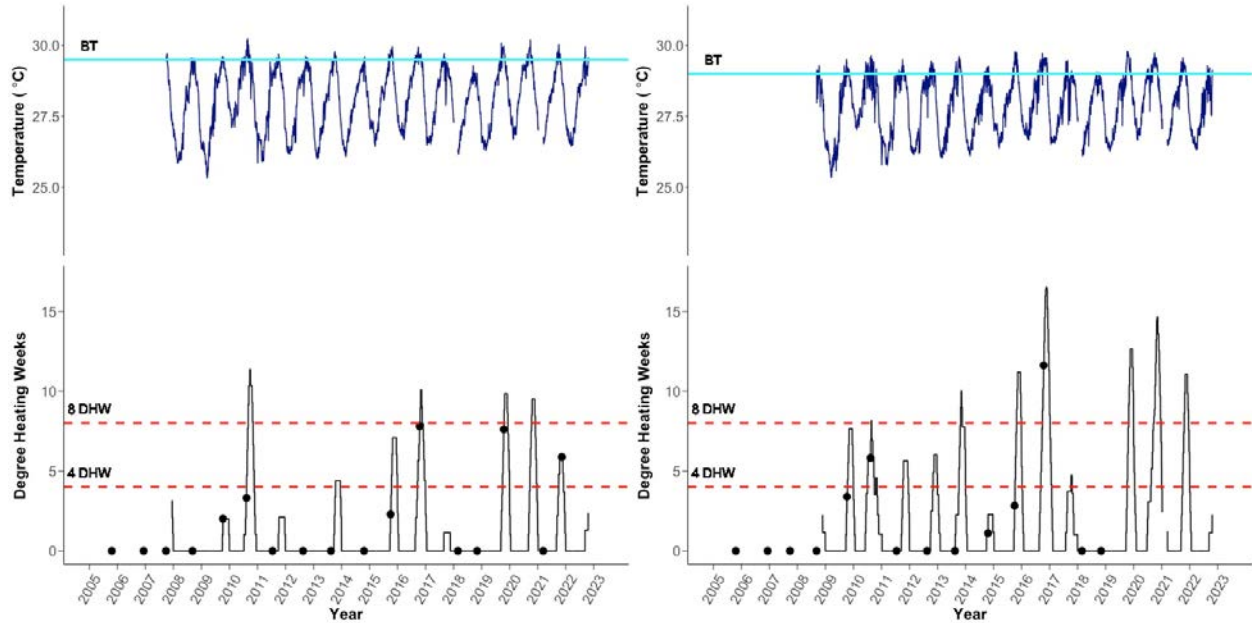


Figure 77. Mutton Snapper benthic temperature record at 24 m (left) and 40 m depth (right).

Physical Characteristics.

Current. Current records have not been taken at Mutton Snapper. There seems to be little wave-driven oscillatory flow. There are often strong unidirectional currents in a westward direction that penetrate to the bottom.

Temperature. Benthic temperatures at the Mutton Snapper site (24 m) showed warming above the regional bleaching threshold during 2010, 2016, and 2020. However, this may be an overestimation of the heat stress (bleaching threshold set to low) since empirical bleaching threshold has not yet been established for this site.

SITE SUMMARIES: MUTTON SNAPPER

Benthic Community. The Mutton Snapper site's sessile epibenthic animal community is dominated the boulder star coral (*Orbicella* spp.), with sub-dominance of sponges. This site lost an extreme amount of coral cover (87.0%) in the 2005 coral bleaching event and has not regained any cover (-2.3%) as of 2011. Since the first observation of Stony Coral Tissue Loss Disease, there has been a 30% decrease in relative coral cover at this location (2019 – 2022). *Lobophora variegata*, epilithic algae, and filamentous cyanobacteria dominate the algal community. Apparent is the rise in the abundance of macroalgae and filamentous cyanobacteria after 2005. Filamentous cyanobacteria reached extreme cover values (57.7%) in 2009. Current levels of herbivory no longer appear to be able to control algal abundance.

Coral Health. Mutton Snapper bleached heavily in the 2005, with 100% of corals bleaching over 90% of the colony surface. Bleaching prevalence has remained high for most years since 2005, but at low colony extent, indicating continued impairment of corals. There was an uptick in the percentage of corals experiencing bleaching in 2019 at a predicted 6 DWH. White disease has been at consistently high values through many years of monitoring. Old partial mortality increased after 2005, and then subsided as whole colonies were lost from the system. Impairment of this site is puzzling as stressors besides fishing appear to be low. Clear water and low genetic diversity of corals may increase susceptibility to environmental stress and white disease.

SITE SUMMARIES: MUTTON SNAPPER

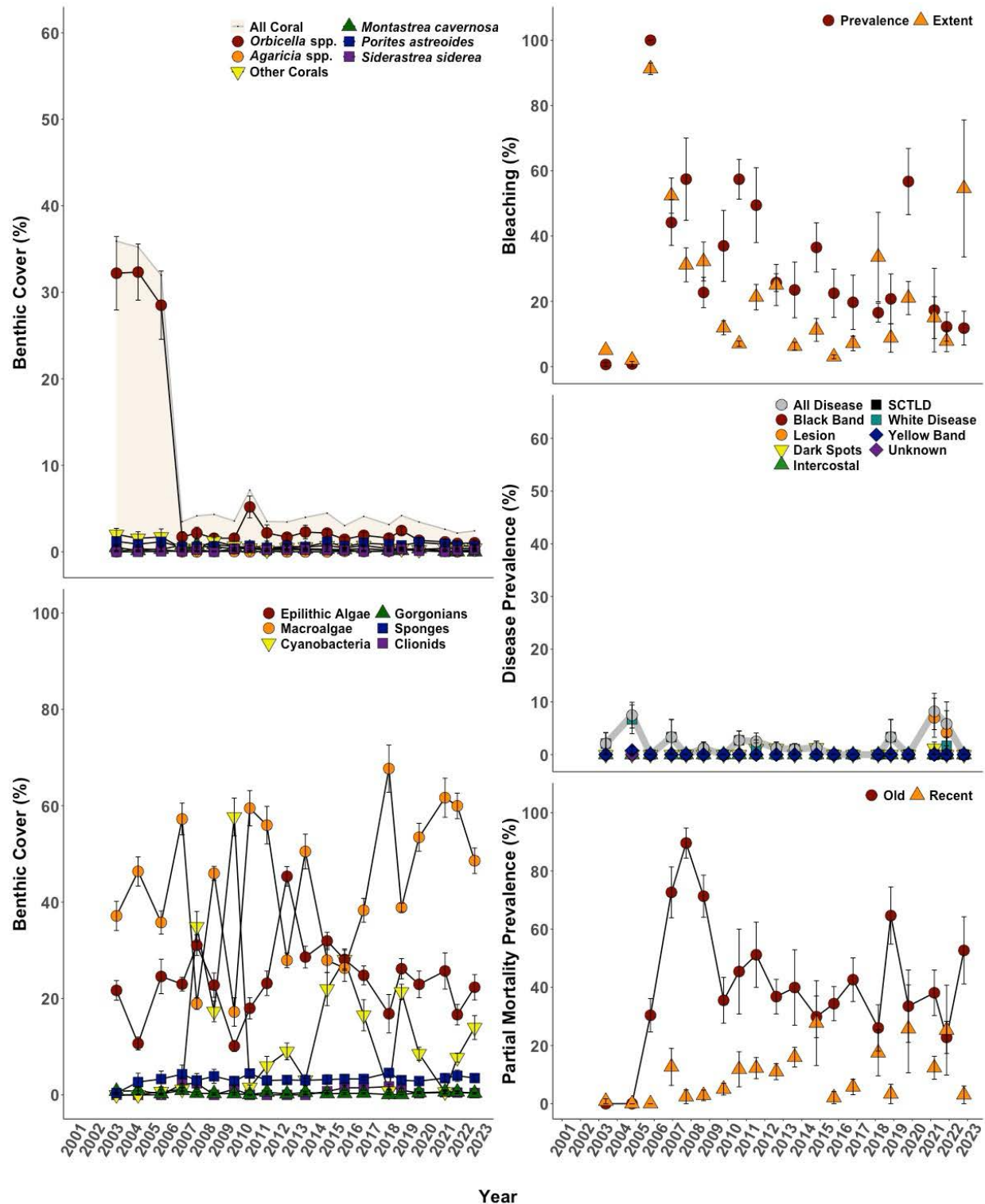


Figure 78. Mutton Snapper benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: MUTTON SNAPPER

Fish Community. The Mutton Snapper site is an offshore, shelf edge site with a diverse and rich fish community. Mutton Snapper is reportedly in an area that mutton snapper spawn, however this species has been rare in surveys conducted at the site over the past 8 years. The Mutton Snapper site has an equally divided community composition between herbivores, invertivores and piscivores. Planktivores are relatively low in biomass but are dominated by black durgon and yellowtail snapper. The herbivore trophic guild is numerically led by the very prolific threespot damselfish, but the biomass is primarily contributed by redband, striped and princess parrotfish. The majority of these fish encountered are in the juvenile and sub-adult phase. The invertivore group is diverse, and indicative of the variety of resources available on the reef. Blackbar soldierfish contribute most highly to invertivore abundance and biomass. Piscivores are not common on Mutton Snapper and in general the biomass of this group is made up of jacks, barracuda and mackerel. Piscivorous serranids and lutjanids are usually limited to the graysby and mahogany snapper, however in 2018 a cubera snapper was recorded. Red lionfish are observed regularly on Mutton Snapper, probably because the reef is offshore and does not receive the recreational diving and hunting pressure of nearshore sites.

SITE SUMMARIES: MUTTON SNAPPER

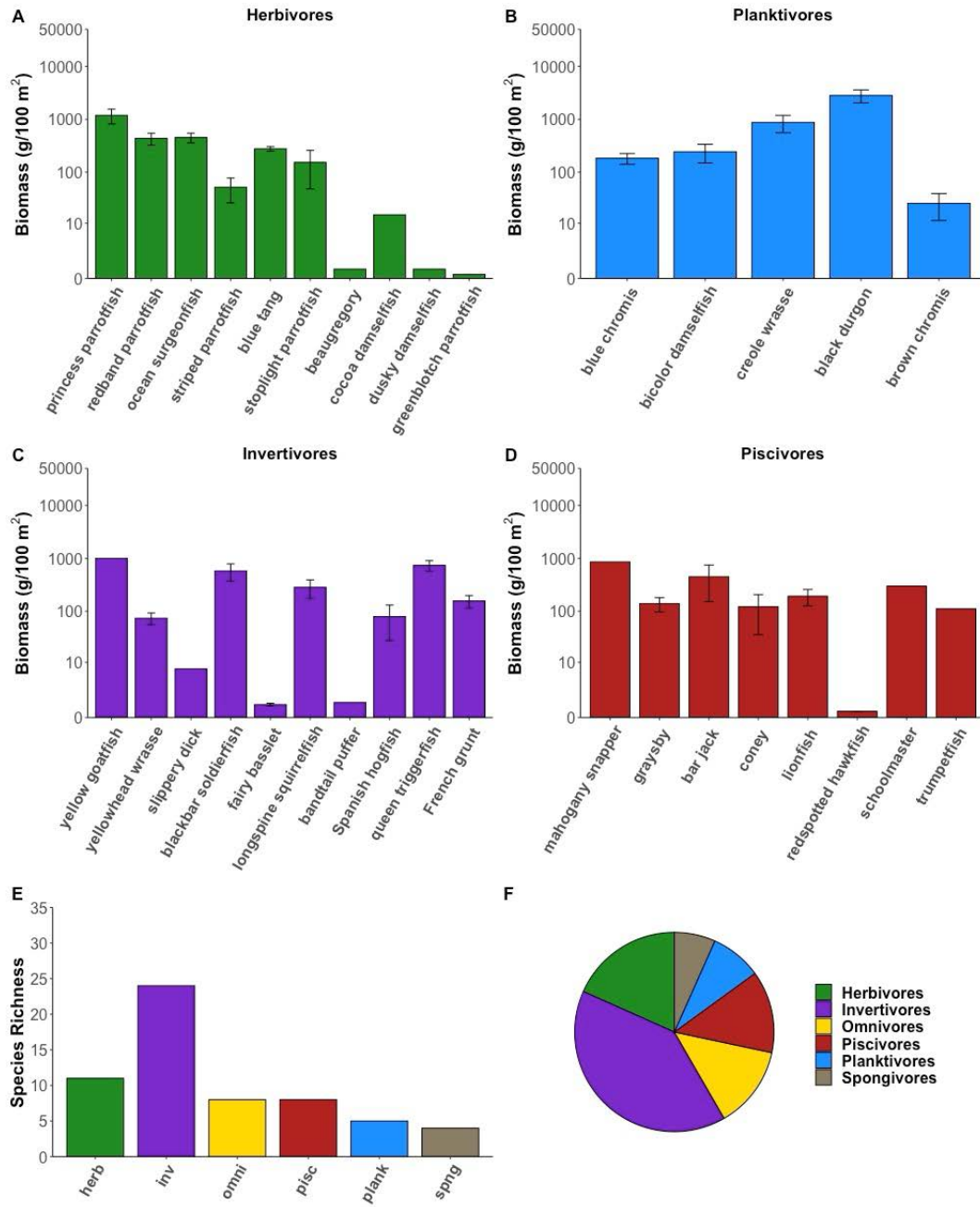


Figure 79. The Mutton Snapper fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SALT RIVER WEST

SALT RIVER WEST

Description. Salt River West lies just atop the Salt River Canyon west wall in a depth of 9 m. The reef is a flat colonized hardbottom/coral community atop ancient carbonates. Salt River West has been monitored since 2001.

Outstanding Feature. Salt River West is a popular tourist dive site with a unique sharp drop to the wall environment. This area has been under scientific investigation since the 1970s, beginning with the installation of the Hydrolab undersea habitat run by NOAA.

Threats. Salt River West is exposed to the outflow from the Salt River Canyon and resuspension of sediment from the Salt River eastern flats. The site is now adjacent the Salt River National Historic Park and Ecological Preserve with marine waters protected in a territorial park. This protection will hopefully increase the fish populations within the reserve in the coming decades.

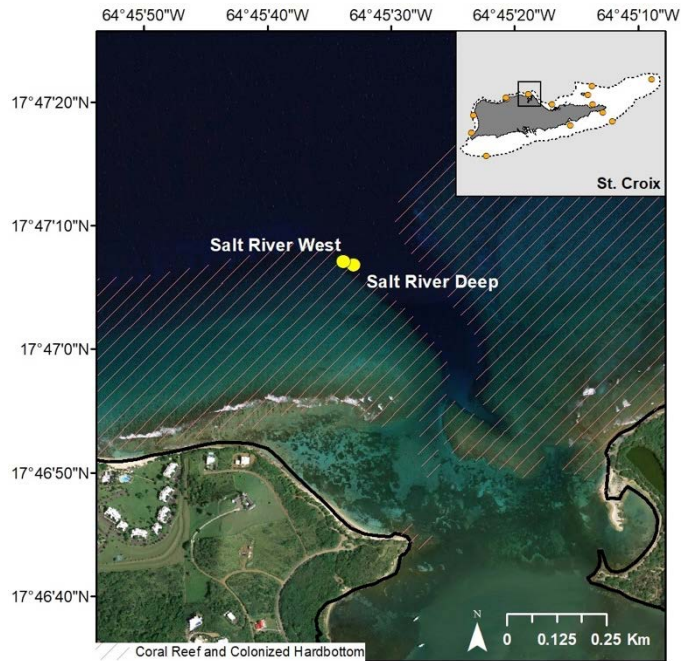


Figure 80. Salt River.
(top) Location.
(right) A
representative photo
of the reef (photo
credit: L.
Henderson).



SITE SUMMARIES: SALT RIVER WEST

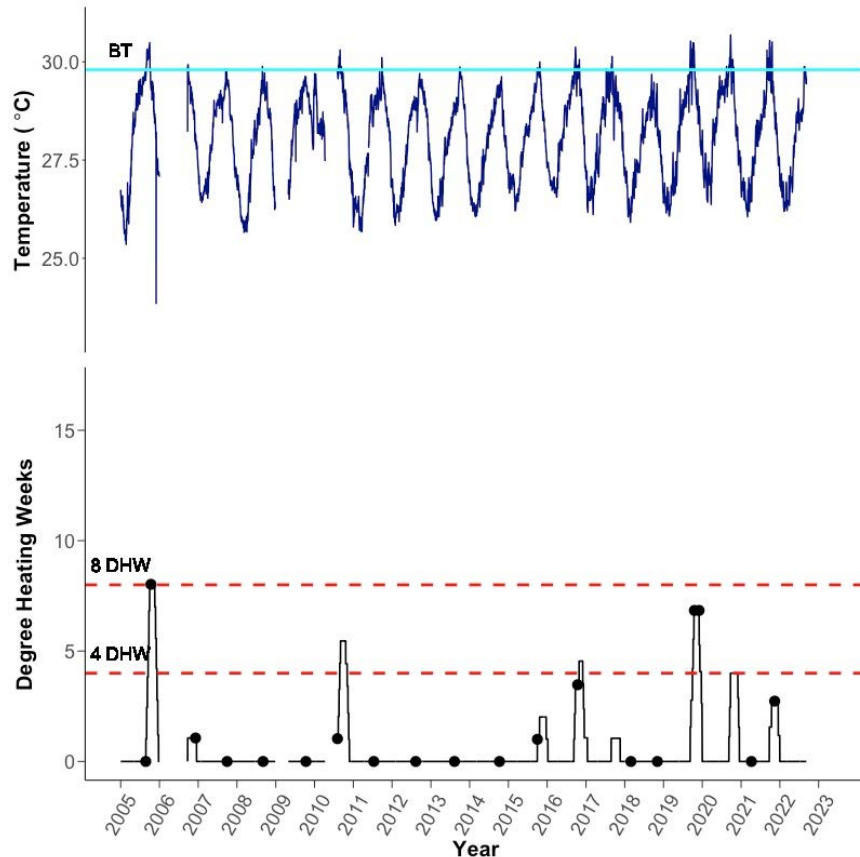


Figure 81. Salt River West surface-benthic temperature record 5m depths. Data provided by the NOAA ICON monitoring network and the Atlantic Oceanographic and Meteorological Laboratory (CRCP NCRMP Project number 7430).

Physical Characteristics.

Current. Currents have not been directly measured by the TCRMP. Due to the northern exposure and shallow depth, Salt River West experiences wave-driven oscillatory flow, which can be strong. Unidirectional benthic currents are typically weak to moderate ($<15\text{ cm s}^{-1}$).

Temperature. The temperature at Salt River West can be very warm and in 2005 surpassed the bleaching threshold (29.5°C) for approximately 2.5 months between August and October. This site is not monitored for temperature by TCRMP since it is a site of the physical monitoring for the National Coral Reef Monitoring Program.

SITE SUMMARIES: SALT RIVER WEST

Benthic Community. The Salt River West epibenthic sessile animal community has a diverse hard coral community of small massive corals and large proportions of sponges and gorgonians. The site lost an imperceptible amount of coral cover in the 2005 coral bleaching event (-13.6%) and had regained nearly half of that cover by 2011 (37.1%). However, there has been a 30% decrease in relative coral cover over 2019 – 2022, likely due to Stony Coral Tissue Loss Disease at this location. The algal community shows extreme dominance by epilithic algae and low abundance of macroalgae and filamentous cyanobacteria. However, the abundance of macroalgae has been increasing at this site since 2009 in concurrence with a decrease in epilithic algae, suggesting a change in herbivory.

Coral Health. Corals were severely bleached during the 2005 coral bleaching event, with over 90% of corals bleached over 80% of the colony surface. Corals were assessed just prior to the 2010 bleaching event in August but were showing increased prevalence of low colony extent bleaching by then. In 2019 there was moderate bleaching in October and early December, which likely captured the peak bleaching response. Diseases are typically low, with the outstanding case of dark spots disease, which attains some of the highest values seen in TCRMP sites. Of note, is the fact that dark spots disease actually decreased following severe bleaching and recovery in 2005 and 2006. Old partial mortality increased rapidly after the 2005 bleaching and then subsided somewhat by 2011. Recent partial mortality can be high and is primarily caused by fish biting, such as from parrotfish. However, extent is quite low (data not shown). Stony coral tissue loss disease was recorded in transects in the 2020 year sampling (April 2021).

SITE SUMMARIES: SALT RIVER WEST

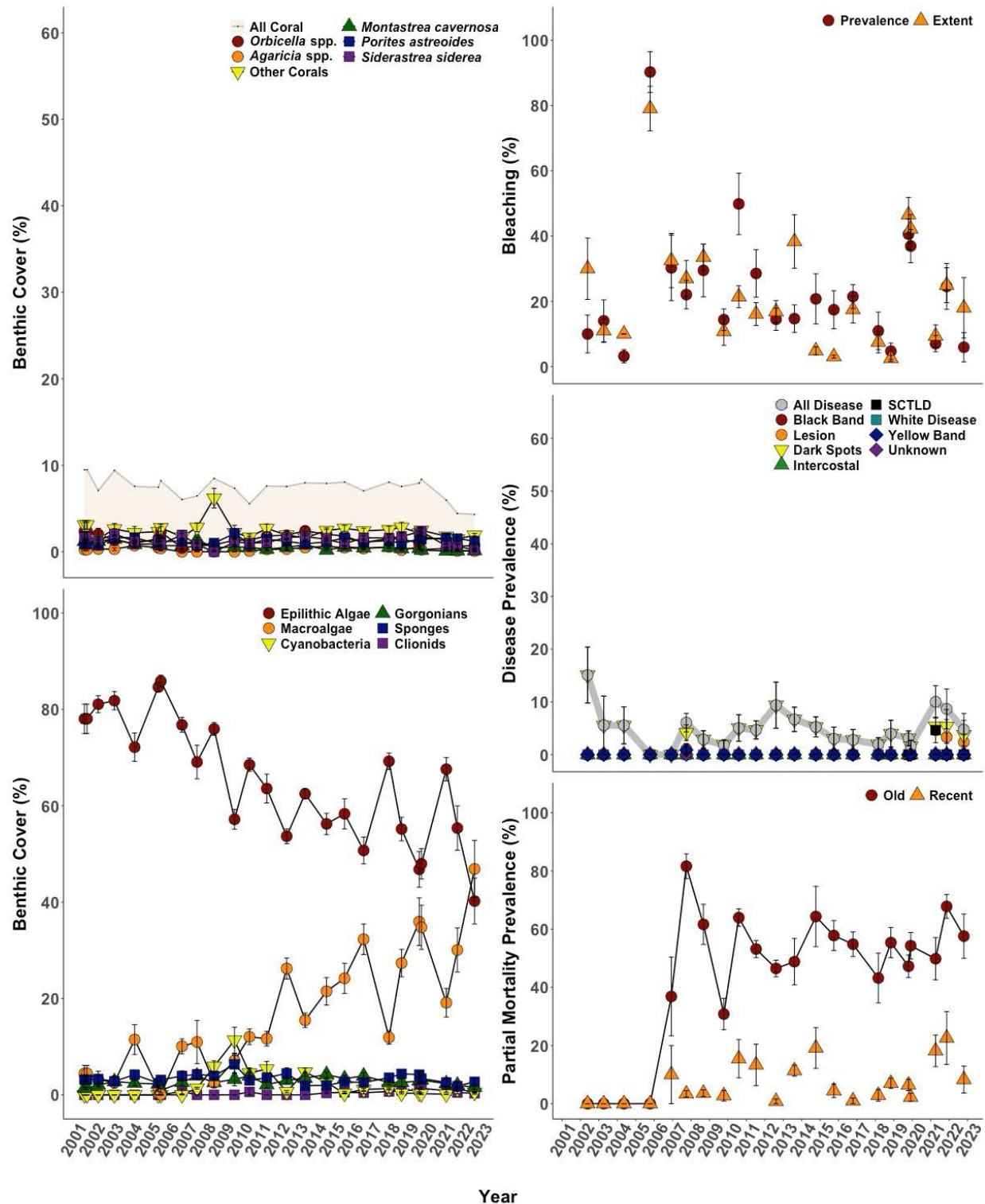


Figure 82. Salt River West benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: SALT RIVER WEST

Fish Community. Fish biomass is relatively low on the Salt River West site. More diversity and some larger fishes can be seen close to the edge of the site, near the Salt River wall; however, the top of the reef has little structure for larger fishes, with low lying coral heads, gorgonians, and sponges. Wrasses and damselfishes are both numerous and diverse; the most dominant species on the site is the bluehead wrasse followed closely by the bicolor damselfish. Black durgon, an opportunistic planktivore that feeds on zooplankton, phytoplankton and algae, dominates the Salt River West site in biomass, followed by the stoplight parrotfish, ocean surgeonfish, and very numerous creole wrasse. Piscivores are nearly non-existent; they include graysby, coney, barracuda and schoolmaster snapper. Occasional red lionfish are seen on a Salt River West.

SITE SUMMARIES: SALT RIVER WEST

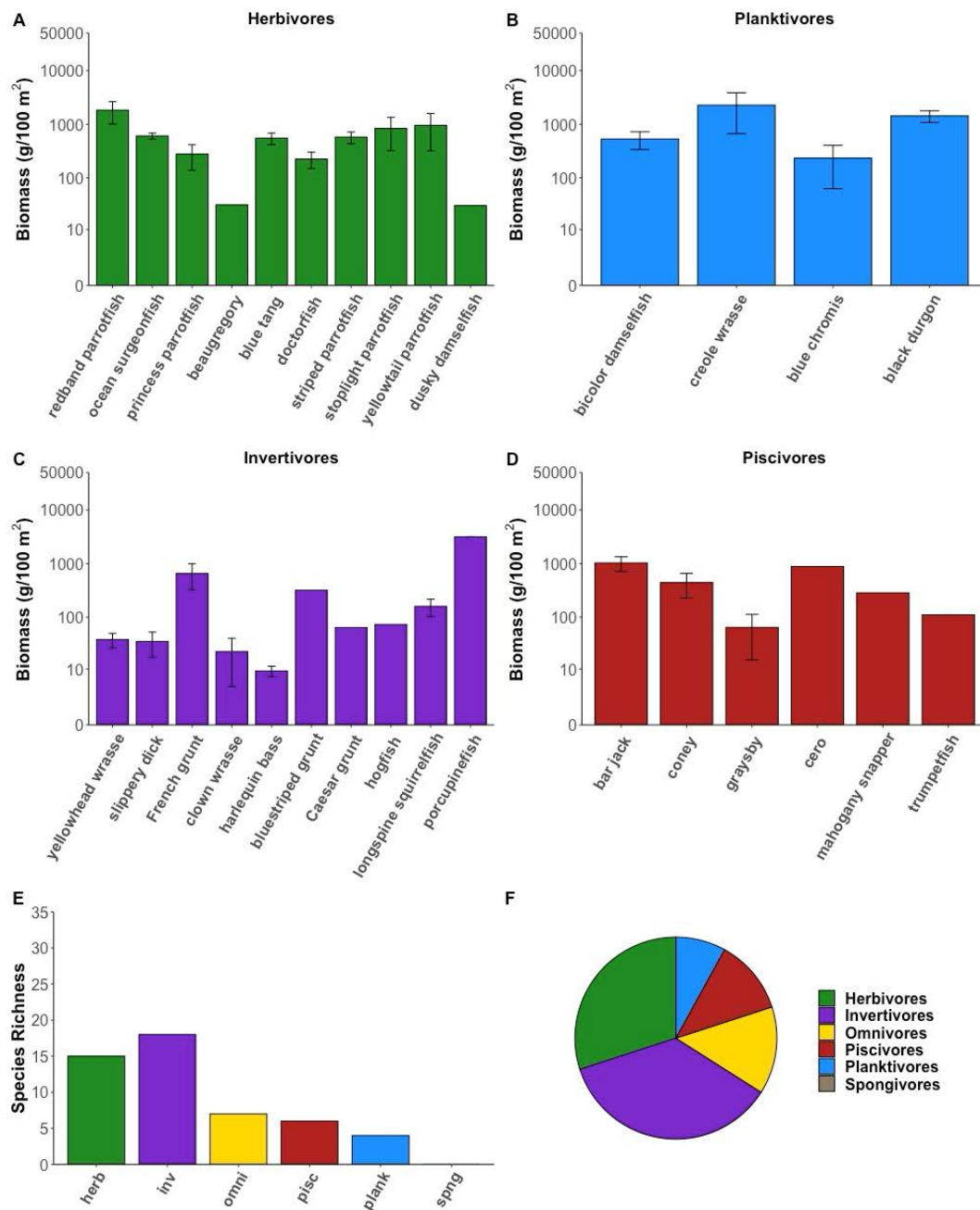
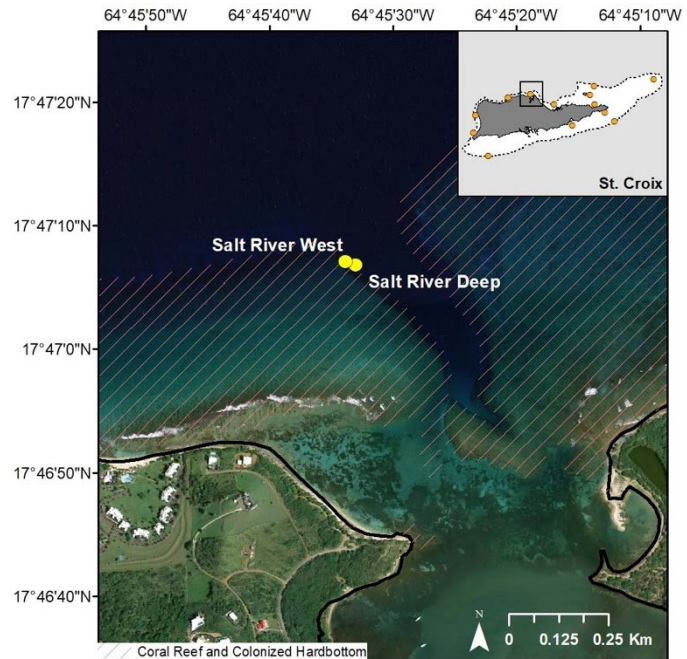


Figure 83. The Salt River West fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SALT RIVER DEEP

SALT RIVER DEEP

Description. The Salt River Deep site is located on the steep canyon wall just below the Salt River West monitoring site. The reef consists of vertical buttresses surrounded by extensive sand deposits. The reef is largely formed of plating coral at these deep, mesophotic depths. The initial site was deployed in 2009 with two transects at 30 m depth and 4 transects at 40 m. Due to low coral cover at 40 m transects were moved to 30m in 2010.



Outstanding Feature. Salt River Deep is a heavily visited recreational dive site. The site has been under scientific investigation since the 1970's. The underwater HYDROLAB habitat was maintained near the site from 1977 to 1985 and the Aquarius habitat from 1986 to 1989.

Threats. Salt River Deep is threatened by land-based sources of pollution due to its proximity to the Salt River Canyon outflow. The site may also be susceptible to warming temperatures.

Figure 84. Salt River Deep. (top) Location. (right) A representative photo of the reef (photo credit: L. Henderson).



SITE SUMMARIES: SALT RIVER DEEP

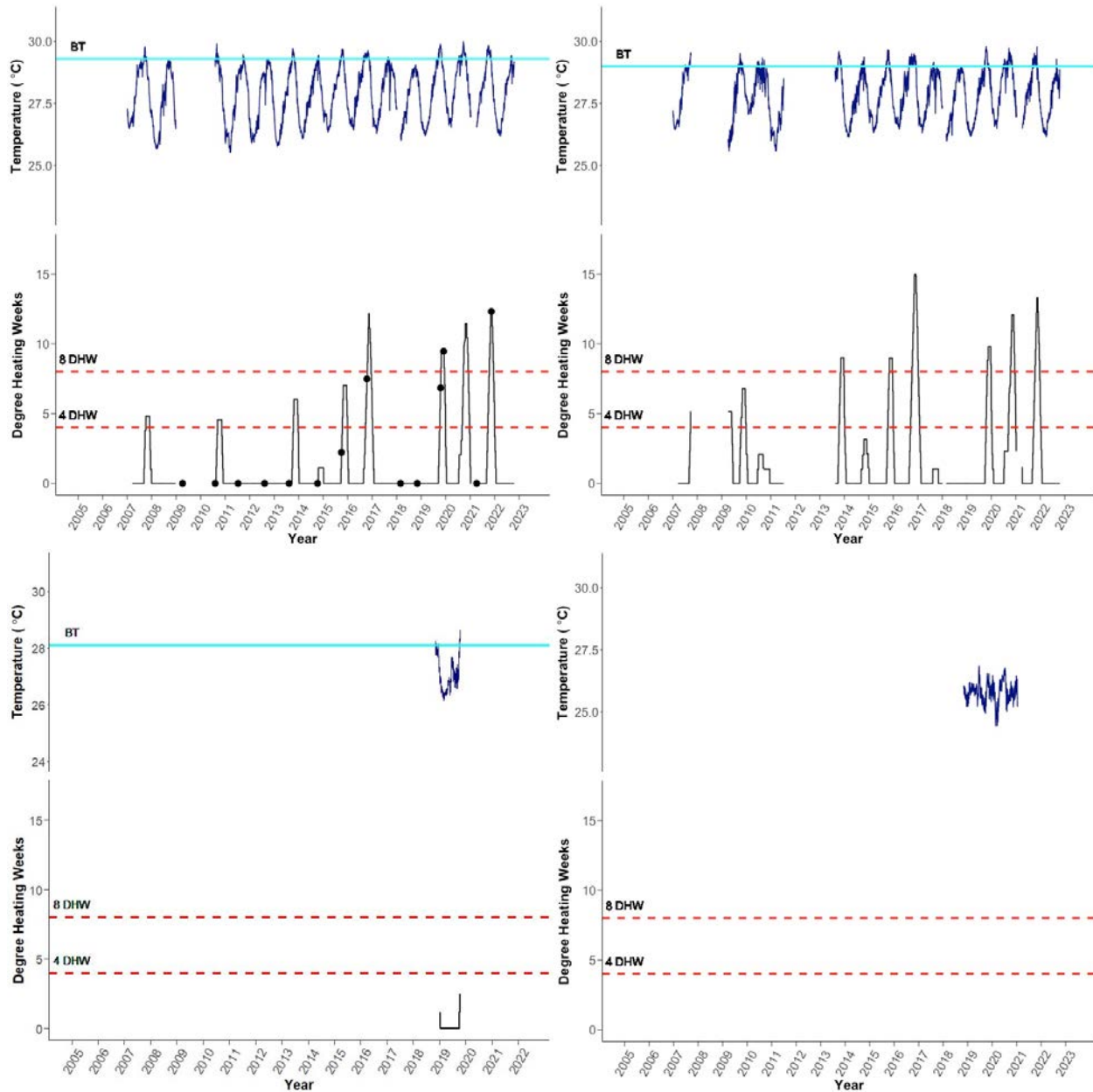


Figure 85. Salt River Deep benthic temperature (Top left: 30 m depth, top right: 41 m depth, bottom left: 67 m depth, bottom right: 100 m depth).



Figure 86. Installation of temperature monitoring stations at Salt River Deep at 100 m in the canyon (credit: Viktor Brandtneris).

Physical Characteristics.

Current. Salt River deep currents have not been measured directly by the TCRMP. Only very weak oscillatory and unidirectional currents have been experienced at the site.

Temperature. Temperatures on the wall have been measured at 30 and 41 m depths since 2017, with probes placed at 67 and 100 m in 2018. Both sites have temperatures that are much cooler than the shallow site. The 41 m site experiences even greater cooling and experiences more diel variability (not shown) and day-to-day variability due to the influence of internal waves. Despite some interaction with the thermocline, cooling is not as great as at the mesophotic reefs at similar depths on the southern Puerto Rican Shelf. The empirical bleaching threshold has not been established at this site and the modeled bleaching threshold used here (Smith et al. 2016a).

SITE SUMMARIES: SALT RIVER DEEP

Benthic Community. Hard coral community of the Salt River Deep monitoring site is dominated by plating lettuce corals (*Agaricia* spp.); however, sponges, gorgonians, and black corals dominate the overall sessile epibenthic animal community. The site was not monitored during the 2005 bleaching event, but as with the Cane Bay Deep site, severe bleaching was observed down to depths of 40m. The algal community is dominated by epilithic algae and unidentified diminutive macroalgae. The site is notable for the high composition of sediment, which cascades from the upper reef between spurs and buttresses.

Coral Health. Low extent coral bleaching is typically in moderate to high prevalence at the Salt River Deep site. This may reflect bleaching sensitive taxa (e.g., *Agaricia* spp.) and the influence of down-canyon sedimentation impacts. There was a high prevalence of bleaching by December 2019 at a moderate extent. Interaction data (not shown) indicates that sediment and *Lobophora variegata* overgrowth are responsible for much of the bleaching. Old partial mortality is high on corals, which may be a reflection of the 2005 bleaching event and cumulative impacts from interaction with sediment and algae. There was an increase in the prevalence of lesions and rapid tissue loss during the 2021 sampling period (November 2021), likely a result of the Stony Coral Tissue Loss Disease outbreak, which marked our first observation of disease at this sample site.

SITE SUMMARIES: SALT RIVER DEEP

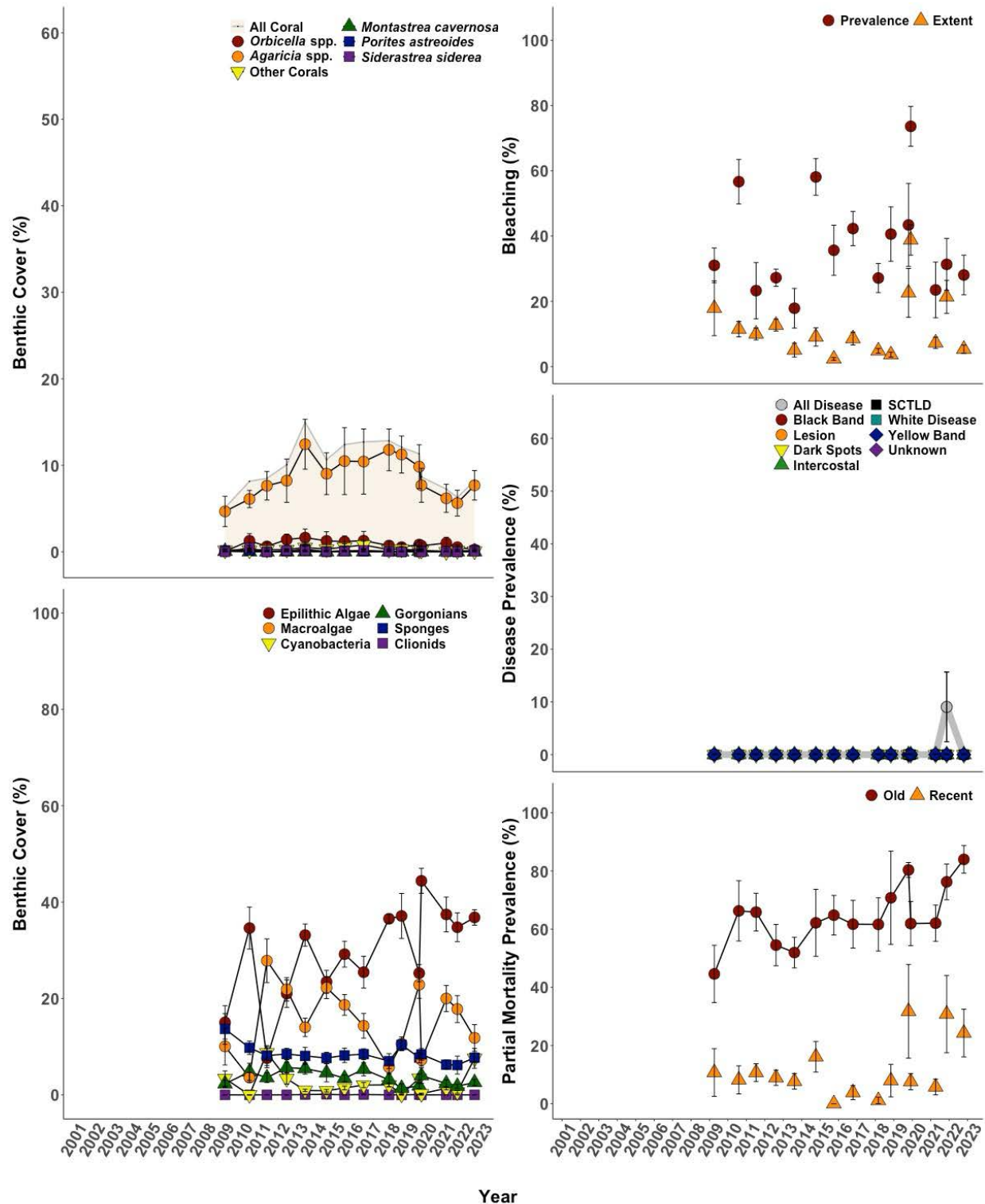


Figure 87. Salt River Deep benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: SALT RIVER DEEP

Fish Community. The relatively high turbidity and high composition of sand and silt bottom, as a consequence of river discharge, influences the fish community of Salt River Deep. The mesophotic reef wall site is characterized by a fish community of very low abundance and biomass in all trophic guilds. Planktivores are dominated numerically and in biomass by the creole wrasse. Yellowtail snapper are also present. The invertivore guild is led in biomass by the yellow and spotted goatfish, bottom feeders that capitalize on the silt and sediment. These fish swim in small schools along the steep wall. Schoolmaster snapper and graysby are common piscivores; however, piscivore biomass is generally very low. Characteristic deep water fishes observed commonly on Salt Water Deep include the sunshinefish, bantum bass, fairy basslet, and longsnout butterflyfish. As on the Cane Bay Deep site, occasional cubera snapper (*Lutjanus cyanopterus*), mutton snapper (*L. analis*), or southern stingrays (*Dasyatis americana*) are observed during roving dives on the wall, and commonly one or two small, curious Caribbean reef sharks (*Carcharhinus perezii*) are present. Deeper in the canyon in the 50 – 70 m depth range, resting schools of black margate have been observed on every dive.

SITE SUMMARIES: SALT RIVER DEEP

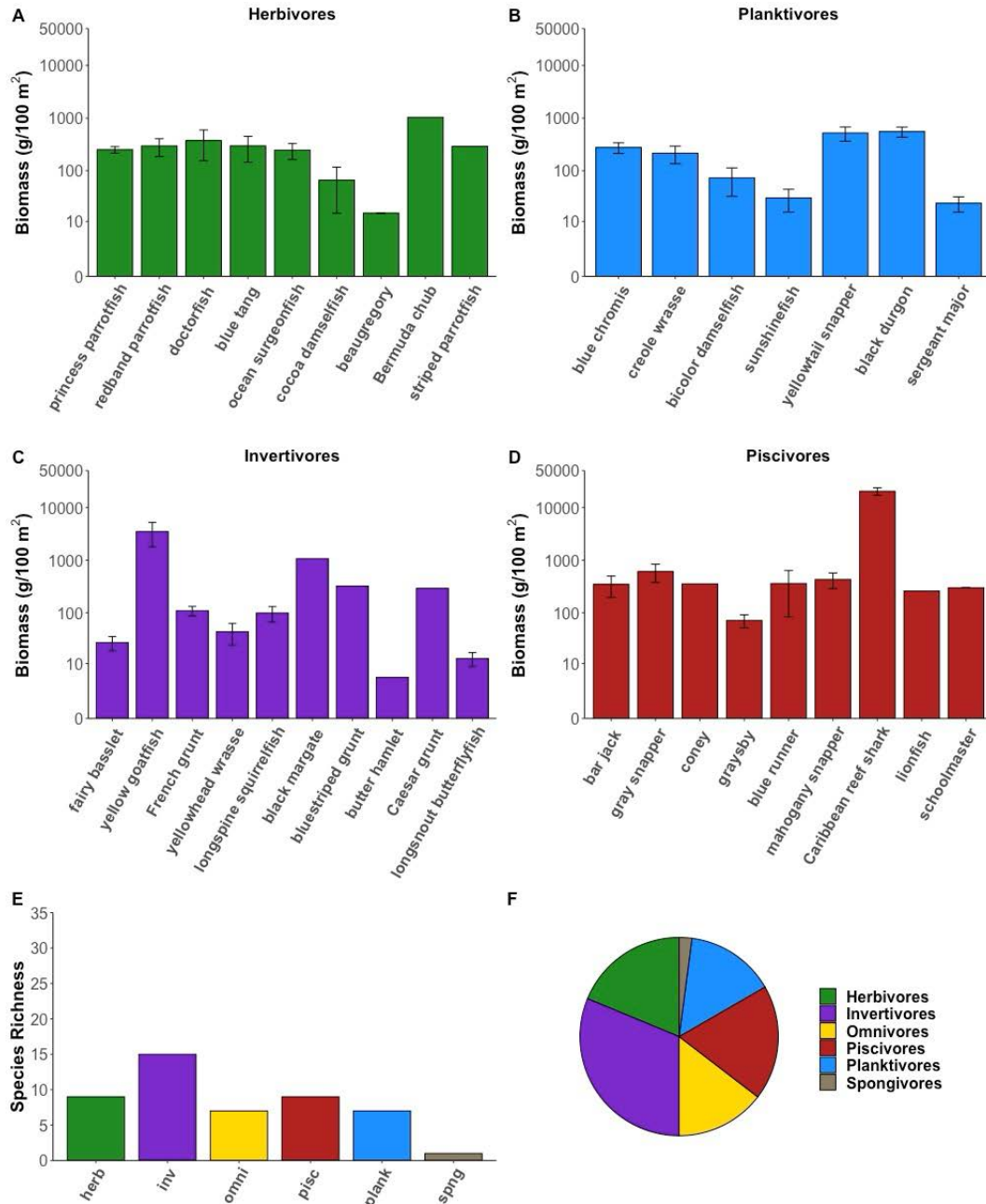


Figure 88. The Salt River Deep fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SPRAT HOLE

SPRAT HOLE

Description. The Sprat Hole site is a nearshore/shelf-edge fringing reef in depths of 7 – 10 m. The site is a rolling boulder star coral (*Orbicella annularis*) reef. The slope to the west drops off to an attractive mixed coral community with abundant fish where it meets sand at about 25 m. Sprat Hole has been monitored since 2001.

Outstanding Feature. Sprat Hole is a heavily visited reef for snorkel and dive tours. It supports a very diverse fish community.

Threats. The Sprat Hole reef is vulnerable to land-based sources of pollution if there is increased development of the watershed. Low wave action and light currents favor settling of small particles of terrestrial sediment that injure corals. The site is also frequently fished and there is derelict fishing gear in abundance. Recreational overuse may also be a threat.

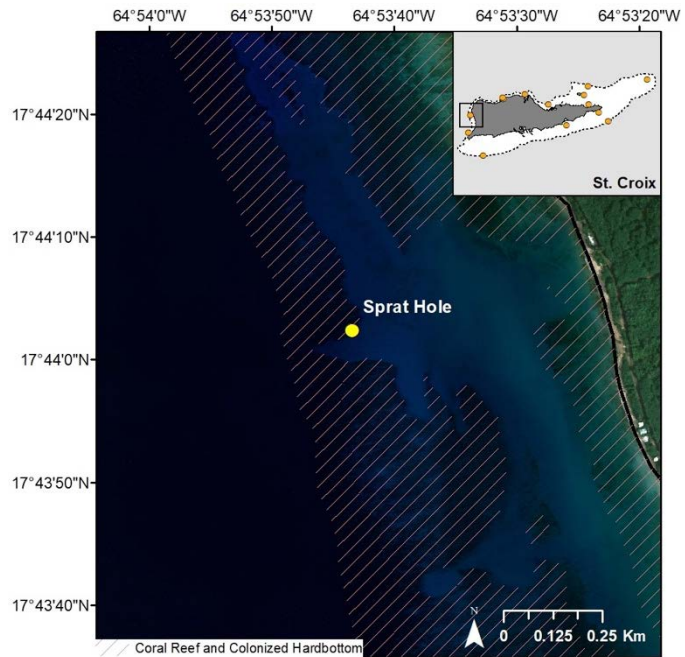


Figure 89. Sprat Hole.
(top) Location. (right)
A representative
photo of the reef
(photo credit: L. M.
Henderson).



SITE SUMMARIES: SPRAT HOLE

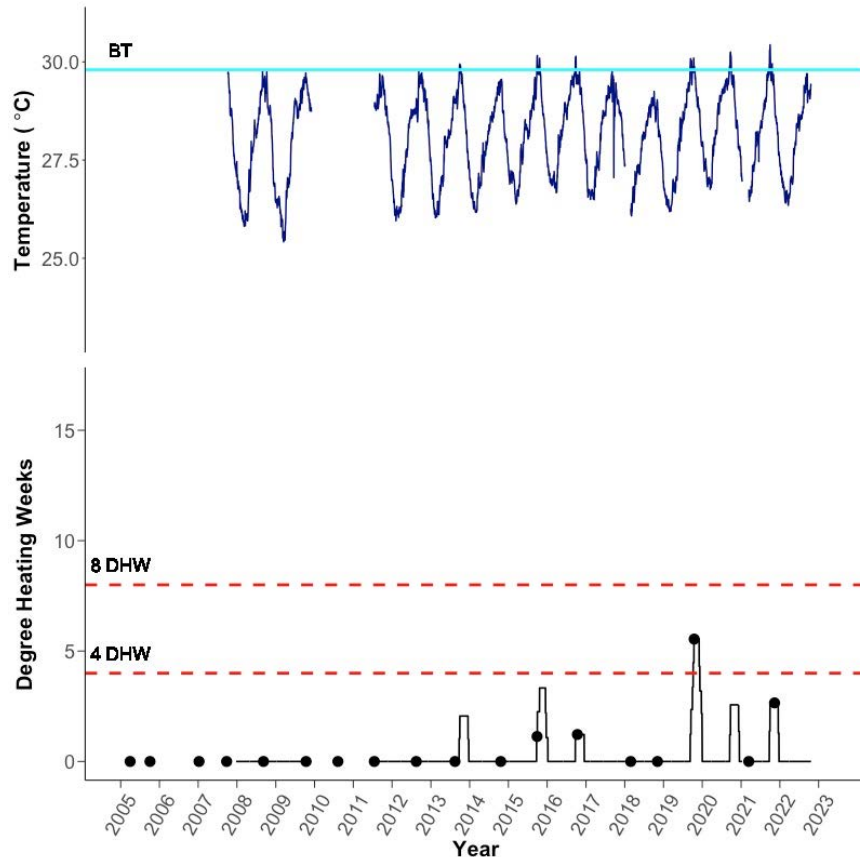


Figure 90. Sprat Hole benthic temperature (7 m depth).

Physical Characteristics.

Current. Currents have not been measured at Sprat Hole. Oscillatory currents are typically weak on the western lee of St. Croix. Unidirectional currents during monitoring have always been weak ($<10\text{cm s}^{-1}$).

Temperature. Sprat Hole temperature has not been monitored over many years due to loss of probes. This is likely due to the high exposure to recreational and commercial fishing divers. Since 2013 temperature probes of the National Coral Reef Monitoring Program have been co-located at this site. In general Sprat Hole appears to be a warm site. It does not have an empirically derived bleaching threshold temperature, but observations of moderate bleaching in 2019 suggest that the current threshold of 29.8°C is reasonable.

SITE SUMMARIES: SPRAT HOLE

Benthic Community. Sprat Hole is a fringing *Orbicella annularis* dominated reef, with a good diversity of other coral species. There was a 62.3% decline in coral cover due to the 2005 coral bleaching event, with a regain of 11.9% of cover by 2011. Although not reflected in coral cover and partial mortality, the site did suffer damage due to Hurricane Maria on September 20, 2017, as evidenced by broken and toppled lobes of *O. annularis*. Epilithic algae dominate the algal community, with smaller amounts of a diverse group of macroalgae, including *Dictyota* spp. and *Halimeda* spp. There has been variable, but increasing cover of filamentous cyanobacteria since 2005.

Coral Health. The coral community at Sprat Hole was heavily affected during the 2005 coral bleaching event, with a high prevalence of bleaching at a very high extent. Bleaching prevalence has tended to be higher since the event. There was high prevalence of low extent bleaching in 2019 at a predicted 6 DHW. Disease prevalence can be quite high, particularly for white disease. Dark spots disease has also been in high prevalence in certain years. Old partial mortality was high on colonies from 2005 to 2011, and low when recorded in 2002. In this case, old partial mortality is a very common feature of *O. annularis* and it is likely that low values are due to observer bias and a different method for estimating partial mortality. Recent partial mortality is consistently very high at Sprat Hole, due in part to the high abundance of territorial damselfish (*Stegastes* spp.) forming algal lawns on *O. annularis*. Stony coral tissue loss disease was first recorded in transects in the 2020 year sampling (March 2021).

SITE SUMMARIES: SPRAT HOLE

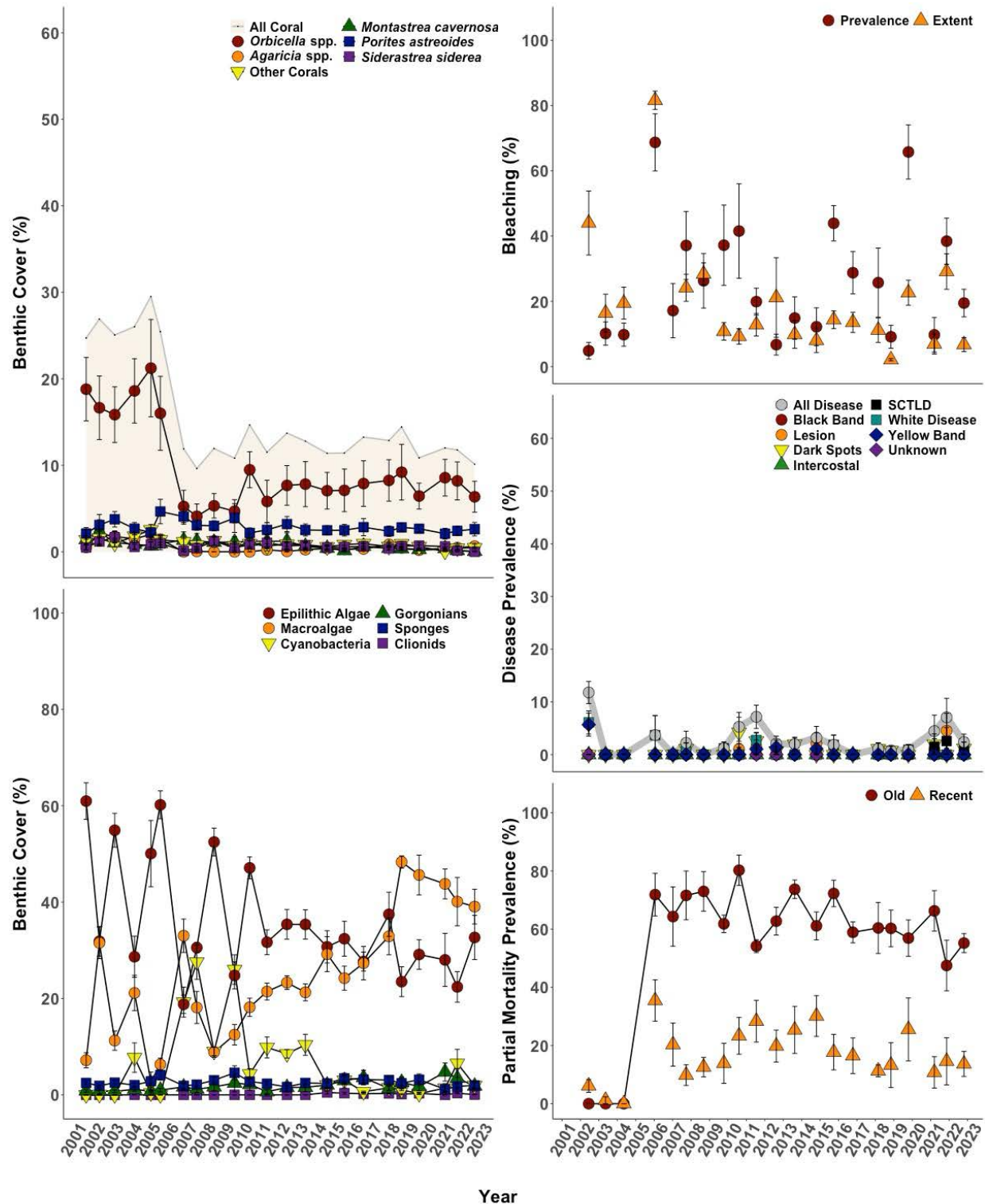


Figure 91. Sprat Hole benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: SPRAT HOLE

Fish Community. Sprat Hole exhibits typical fish community structure for a nearshore developed coral reef ecosystem receiving some amount of terrestrial runoff from the watershed. Fish biomass is moderate, and the site is dominated numerically by the creole wrasse and blue chromis, planktivorous invertivores. Benthic herbivores are common and include all common Caribbean species of parrotfish and all three acanthurid species. Most of these fish are in a juvenile or subadult phase. Invertivores are diverse and include both planktivores and benthic feeders; mostly small fish in small numbers. Grunts, goatfish and a variety of wrasse are common. Mutton snapper have been recorded on the sight sporadically. Numerically and by biomass the graysby and schoolmaster snapper contribute most to the benthic piscivore group. A juvenile tiger grouper was recorded in 2013, and a yellowfin grouper was seen in 2014. Lionfish have been observed on the Sprat Hole site since 2012. Bar jacks and cero mackerel, nearshore pelagic piscivores, round out the piscivore trophic guild.

SITE SUMMARIES: SPRAT HOLE

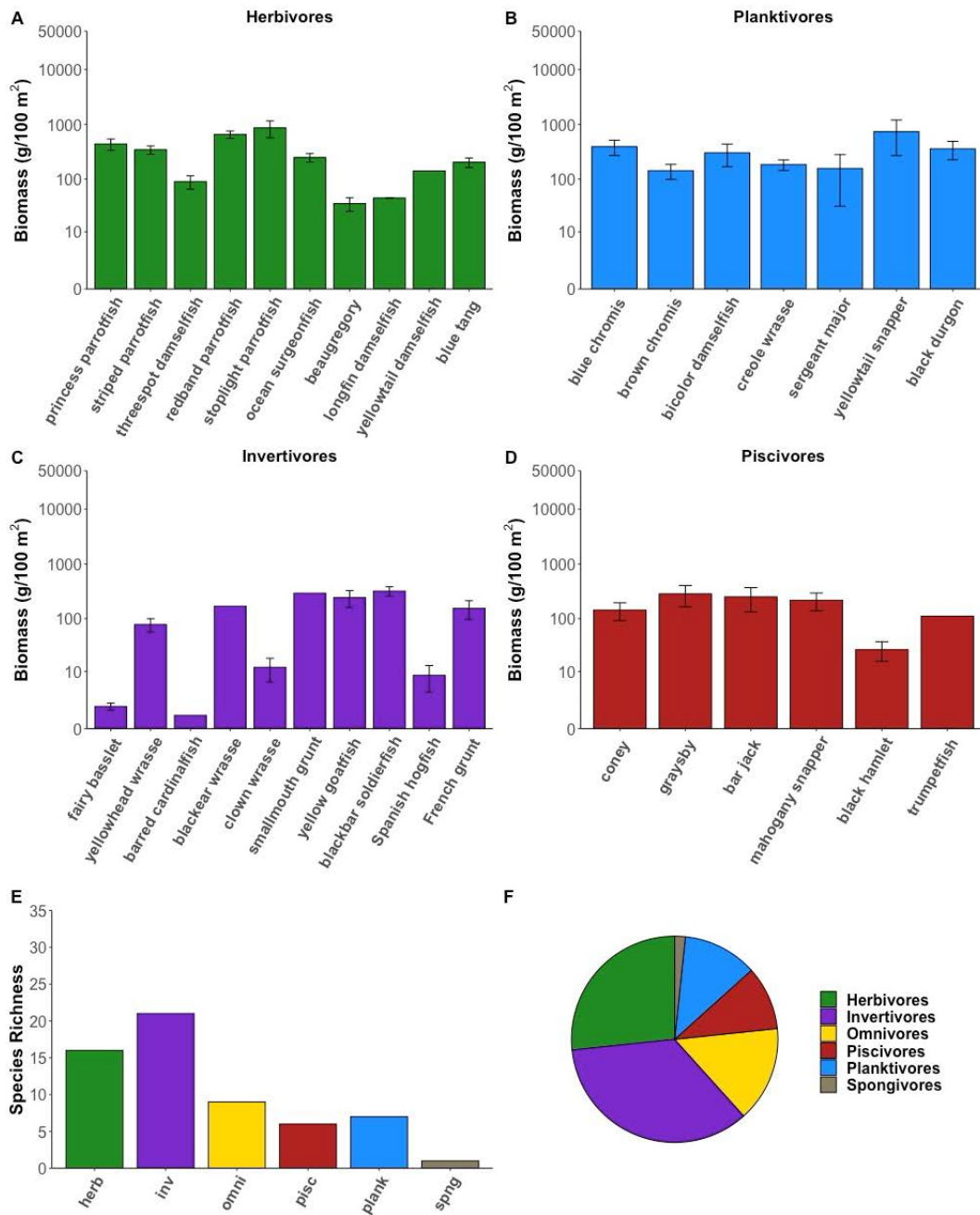


Figure 92. The Sprat Hole fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

St. John

SITE SUMMARIES: CORAL BAY

CORAL BAY

Description. The Coral Bay site is atop a patch reef complex at the southeast mouth of Coral Harbor. The reef is a low carbonate build up with high coral diversity. Coral Bay appears to be a true reef with a well-developed carbonate framework over bedrock. Coral Bay monitoring was initiated in 2011.

Outstanding Feature. Coral Bay supports a high diversity of coral and an apparent high rate of coral recruitment.

Threats. Coral Bay is subject to land-based sources of pollution, primarily as sediment influx from the large and steep Coral Bay watershed. Coral Bay may also be threatened by maritime activities within Coral Harbor. Turbidity at the site is usually very high, with underwater visibility usually <4 m. Proximity to land makes this site in territorial waters potentially vulnerable to fishing.

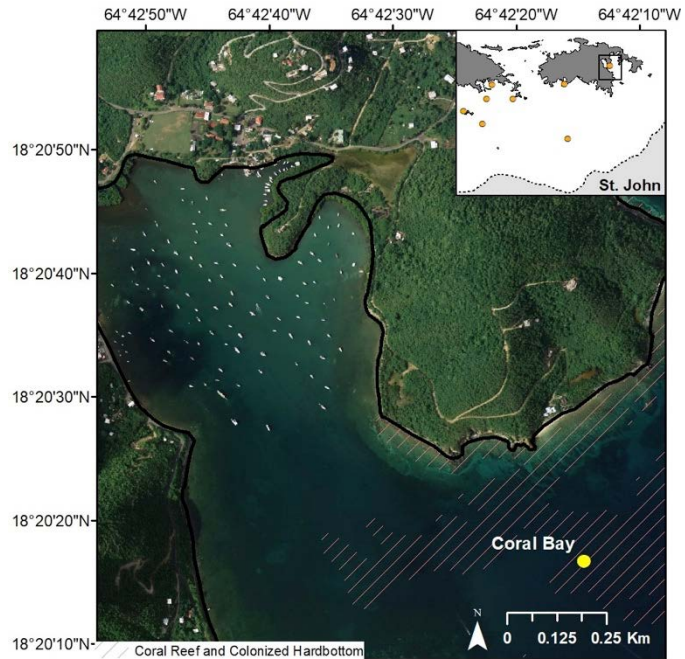
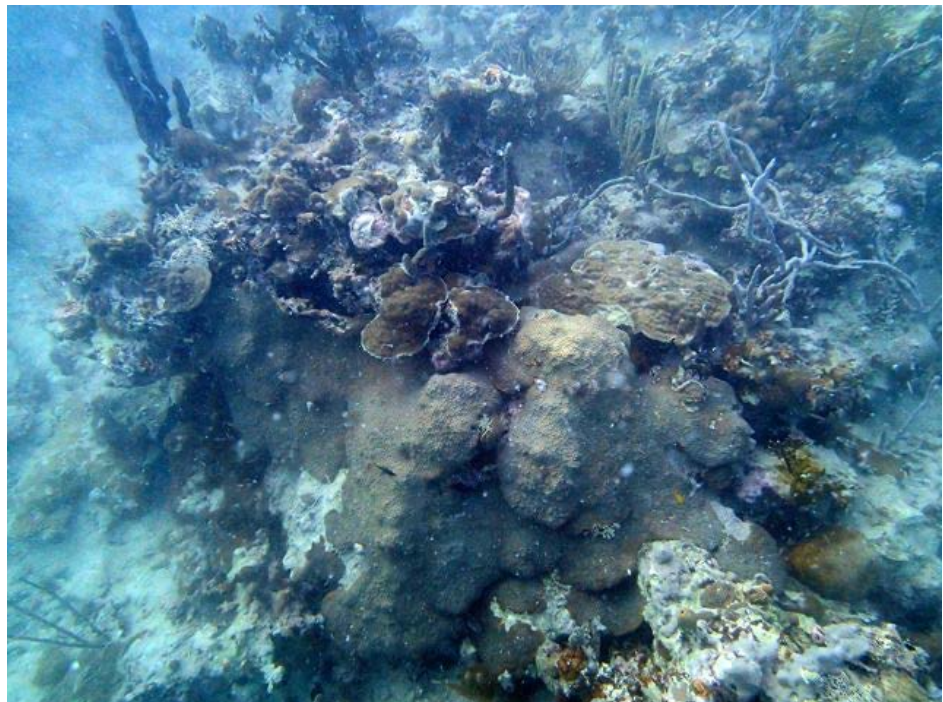


Figure 93. Coral Bay.
(top) Location.
(right) A
representative photo
of the reef.



SITE SUMMARIES: CORAL BAY

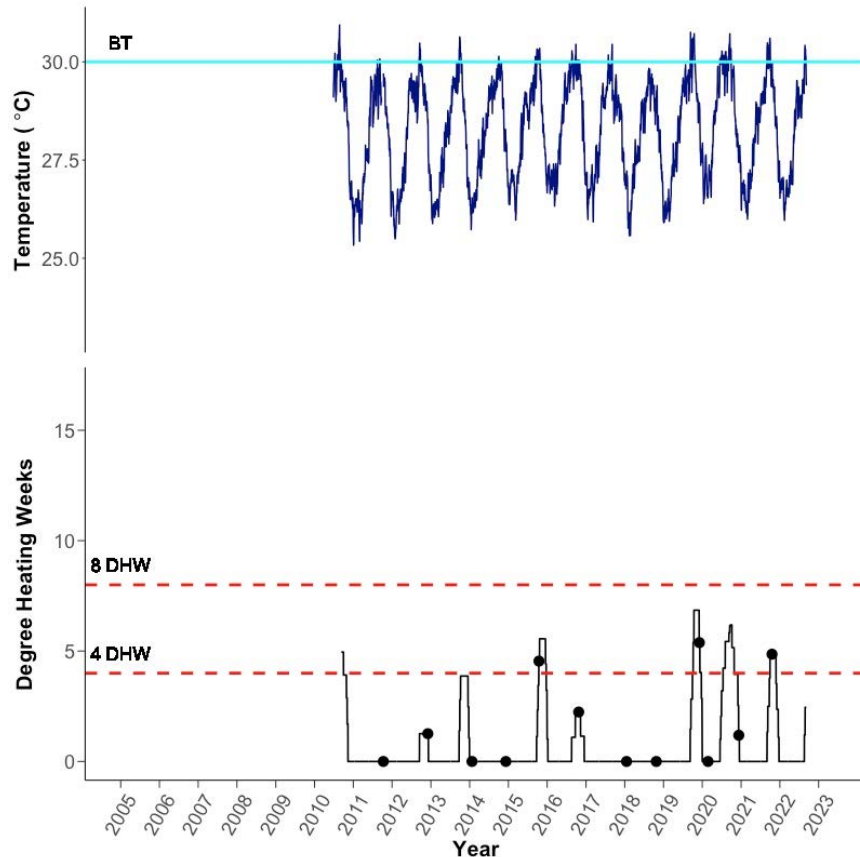


Figure 94. Coral Bay benthic temperature (9 m depth)

Physical Characteristics.

Current. Currents have not been measured by the TCRMP, however, Dr. Sarah Gray (University of San Diego) has measured 2-D near bottom measurements for some years between 2009-2011. Oscillatory currents are expected to be light and only weak unidirectional currents have been experienced.

Temperature. Coral Bay may have restricted water circulation and had very high temperatures during the 2010 bleaching event. There is no empirically established bleaching threshold and the modeled bleaching threshold (Smith et al. 2016a) is likely too low, given high DHW values with limited observed bleaching, especially in 2019.

Other. This site and the wider Coral Bay area have been under investigation for land-based sources of pollution impacts since 2009 (Smith et al. 2013a).

SITE SUMMARIES: CORAL BAY

Benthic Community. Coral Bay has a very diverse coral community, with no clear dominance of cover. In contrast to most sites, the mustard hill coral *Porites astreoides* has the greatest cover among coral species. Coral cover has been declining since 2015, with a precipitous decline in the year 2018. Increasing impacts of land-based sources of pollution may be contributing to the degradation. Sponges and gorgonians are also very common at this site. Gorgonians have been increasing in cover at this site, following a possible island-wide trend for St. John (Tsounis and Edmunds 2017). Epilithic algae and a high abundance of crustose coralline algae dominate the algal community, with very low abundance of macroalgae. This is surprising at this turbid reef site that likely receives high inputs of particulate and dissolved nutrient sources and indicates that grazing is quite high. There is not a high abundance of herbivorous fish and only the occasional occurrence of *Diadema antillarum*. However, there is a great abundance of the rock boring urchin *Echinometra* spp. that appears to be the dominant grazer. This genus is not monitored in TCRMP protocols, but perhaps should be included in future years.

Coral Health. It is not known how corals were affected by bleaching in 2005. There was a low prevalence of low extent bleaching in 2019. In 2019 there was an increase in bleaching prevalence and extent, but to a low level. This bleaching was not evident in February 2020, when the site was resurveyed. The arrival of SCTLD to Coral Bay seemed to be delayed relative to other sites around St. John, but was present during the 2021 sampling period and disease prevalence (both Dark Spot Disease and white disease) rose during the 2022 sampling period.

SITE SUMMARIES: CORAL BAY

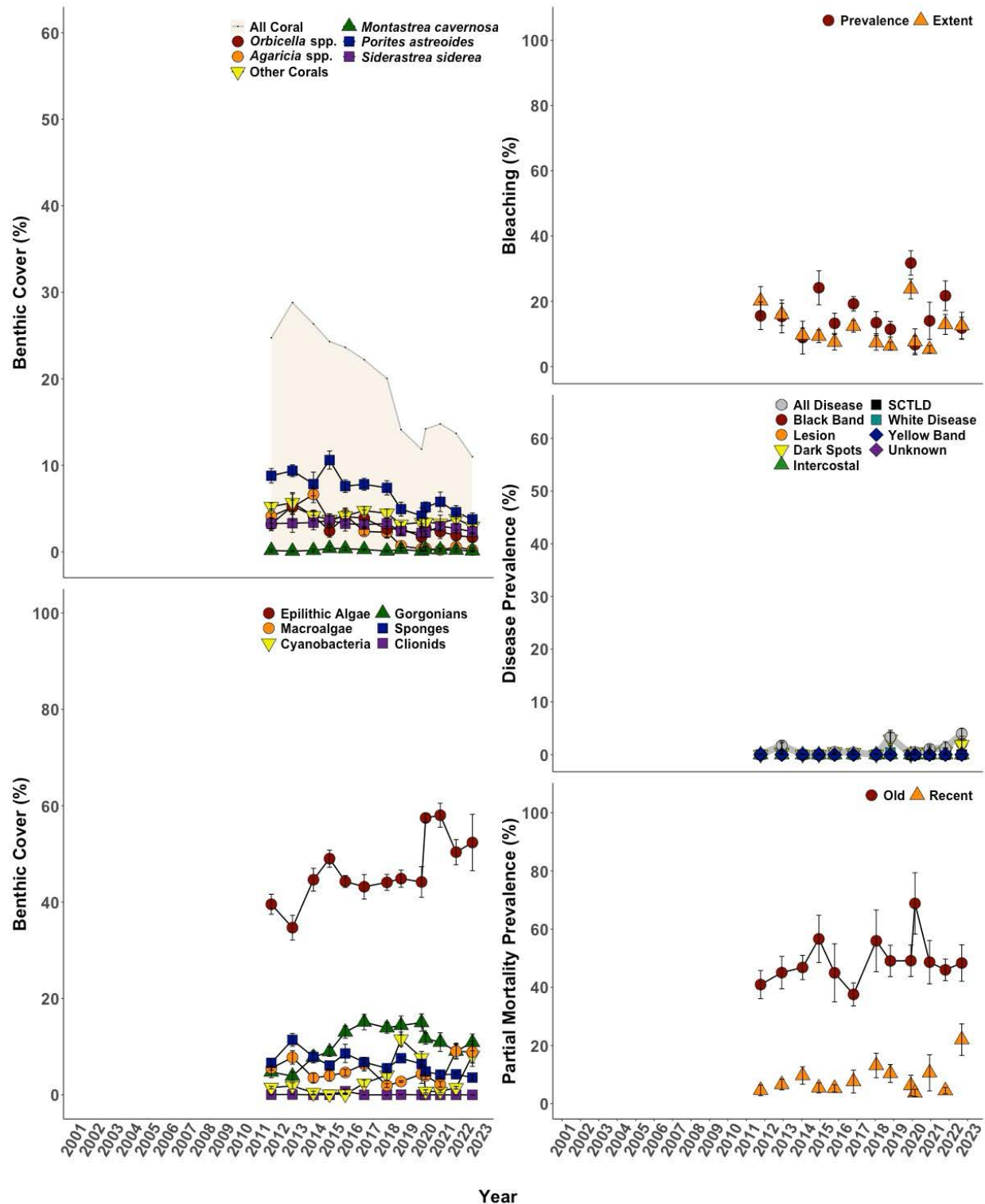


Figure 95. Coral Bay benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: CORAL BAY

Fish Community. The Coral Bay site is low in fish diversity, biomass and abundance.

Although epilithic algae are prolific, large grazers are nearly absent. Three spot damselfish dominate the group in abundance and juvenile striped and redband parrotfish in biomass. Acanthurids are present but only in the juvenile phase. Planktivores in the high turbidity habitat are limited to a few juvenile yellowtail snapper and bicolor damselfish. Although benthic invertivores are more prolific and diverse, only a few individuals comprise each species group and most fish are juveniles. Likewise, piscivores have a very low biomass and are limited to a very few individuals that appear to be moving across the reef rather than residing there.

SITE SUMMARIES: CORAL BAY

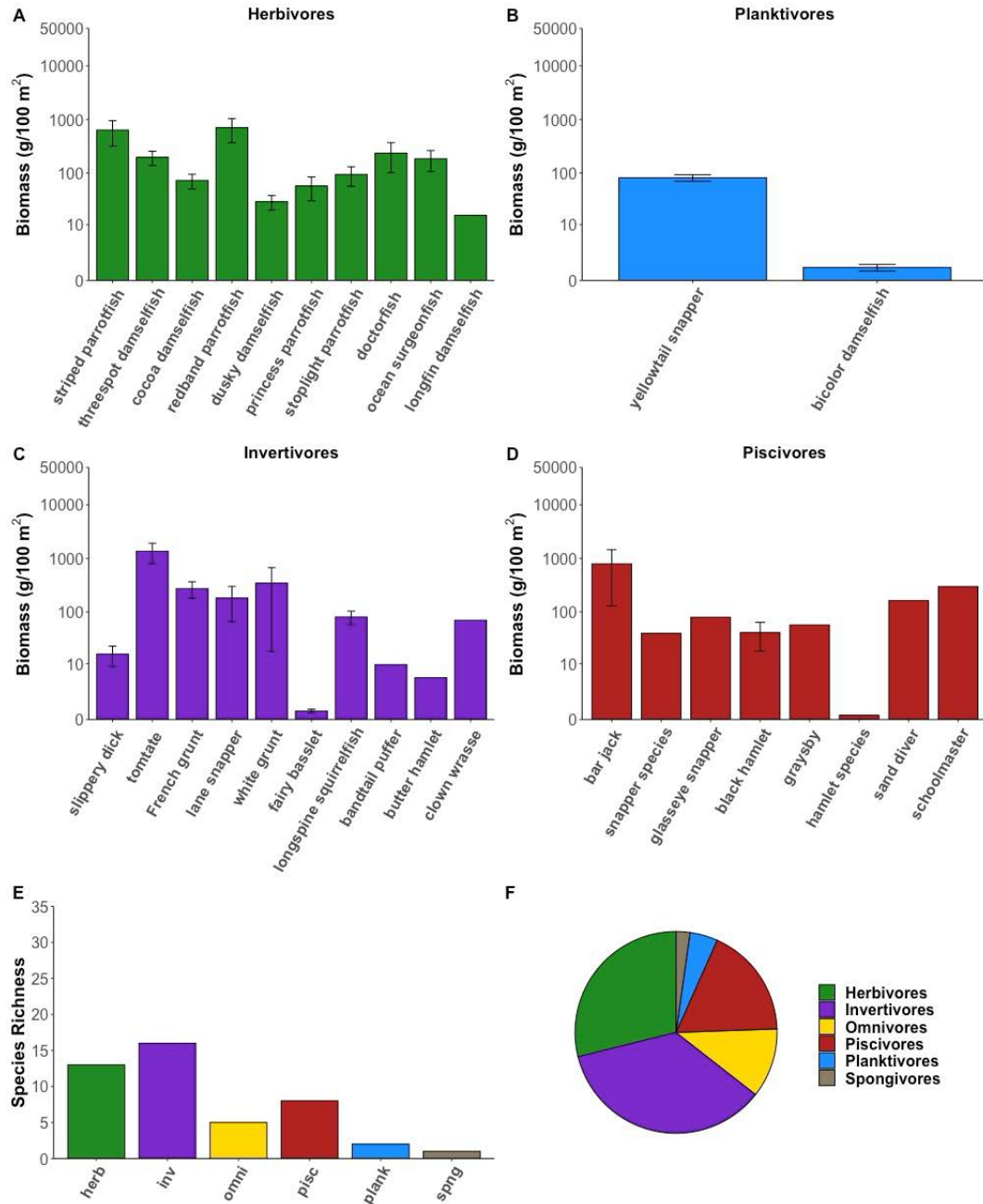


Figure 96. The Coral Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: FISH BAY

FISH BAY

Description. Fish Bay is a nearshore Fringing Reef in territorial waters. The monitoring site is a sharp edge of a shallow water coral community dropping to sand at 7 m depth. The site has been monitored since 2001.

Outstanding Feature. Fish Bay inner transects (1 – 3) are heavily sediment impacted, while outer transects (4-6) support large boulder star corals (*Orbicella faveolata*). The site lies just outside the southwestern boundary of the Virgin Islands National Park.

Threats. Fish Bay is subjected to land-based sources of pollution.

Inner bay transects tend to have turbid water and overgrowth by macroalgae. This site may also be vulnerable to fishing impacts.

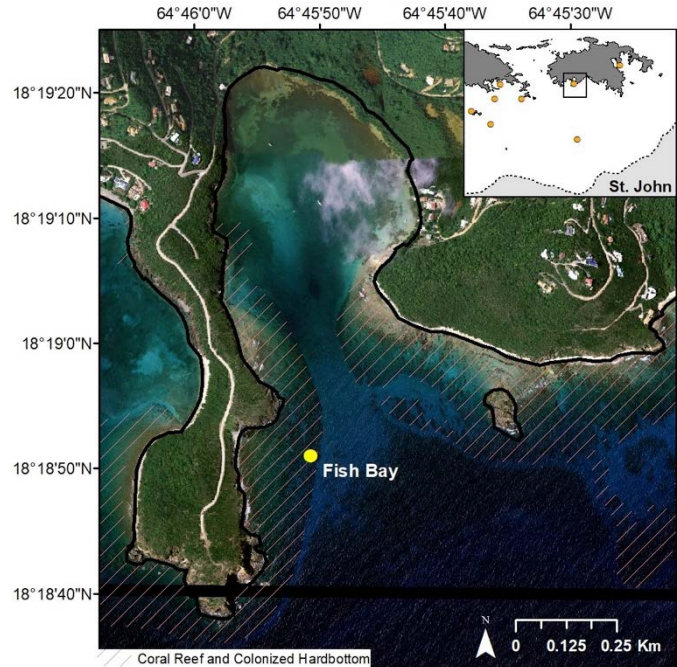


Figure 97. Fish Bay. (top) Location. (right) A representative photo of the reef (photo credit: S. Kadison).



SITE SUMMARIES: FISH BAY

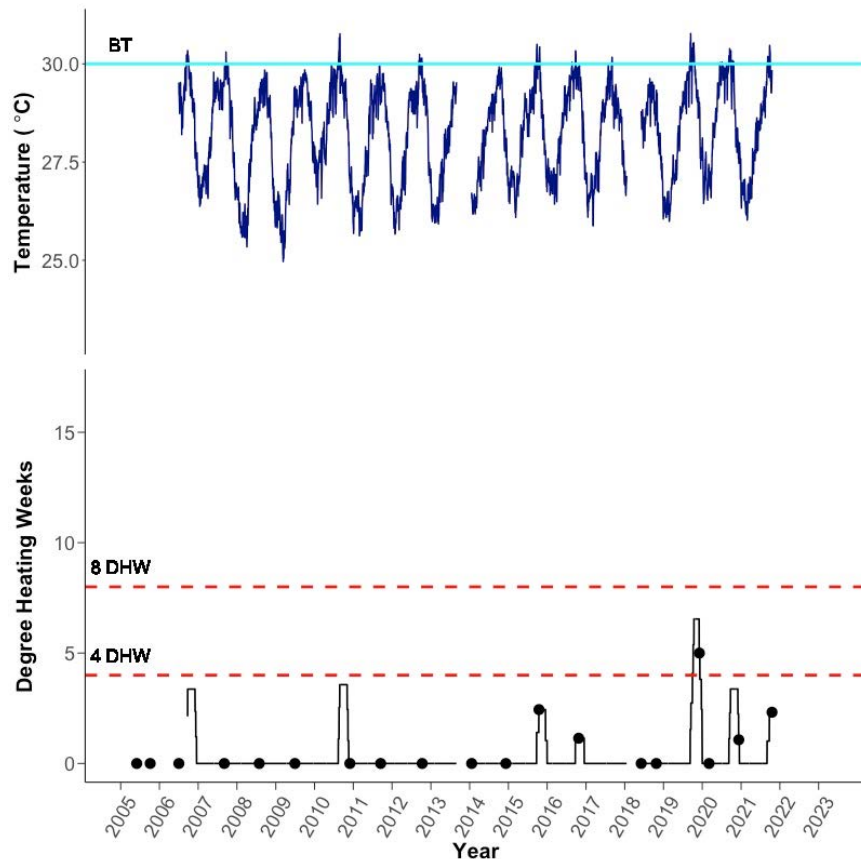


Figure 98. Fish Bay benthic temperature record (6 m depth).

Physical Characteristics.

Current. Fish Bay currents have not been measured directly by the TCRMP. Unidirectional currents are mild to slack. Because of the southeast exposure, wave driven oscillatory currents can be quite intense, particularly on the outer transects.

Temperature. Fish Bay has relatively high mean temperatures and a high bleaching threshold.

SITE SUMMARIES: FISH BAY

Benthic Community. The coral community of Fish Bay is dominated by the boulder star coral *Orbicella* spp.. Large (>2m wide) colonies of *O. faveolata* are common on the seaward transects (4-6). The inner transects (1-3) are mostly depauperate of coral (< 4% cover as of 2011). The site lost 37.1% of its cover due to the 2005 coral bleaching event, but had regained 136.1% of cover by 2011. Gorgonians are also very common on the wave-washed outer transects. Gorgonians have been increasing in cover at this site, following a possible island-wide trend for St. John (Tsounis and Edmunds 2017). Equal parts epilithic algae and the macroalgae *Dictyota* spp. dominate the algal community. The site also has a high abundance of *Halimeda opuntia*, which can smother coral on inner bay transects closest to land-based sources of pollution.

Coral Health. Fish Bay corals were very severely affected in the 2005 bleaching event with 100% of corals showing almost 100% bleaching. In 2019 bleaching prevalence stayed consistent, but thermal stress evidently increased bleaching extent. Bleaching is also normally high at this site even in years without thermal stress, a likely consequence of sediment and macroalgal interactions. Diseases, particularly dark spots disease and white disease, can have very high prevalence at Fish Bay. SCTL D affected corals in 2020, particularly on the outer transects with a more abundant and diverse coral community. This site has been the focus of SCTL D treatment with antibiotic pastes, which has likely rescued many of the large *O. faveolata* colonies in the near term. Old partial mortality did increase after the 2005 coral bleaching event, with a decline in 2010 and resurgence in 2011. Recent partial mortality can also be relatively high compared with other sites, largely as the results of bites from site-attached damselfish (*Stegastes* spp.).

SITE SUMMARIES: FISH BAY

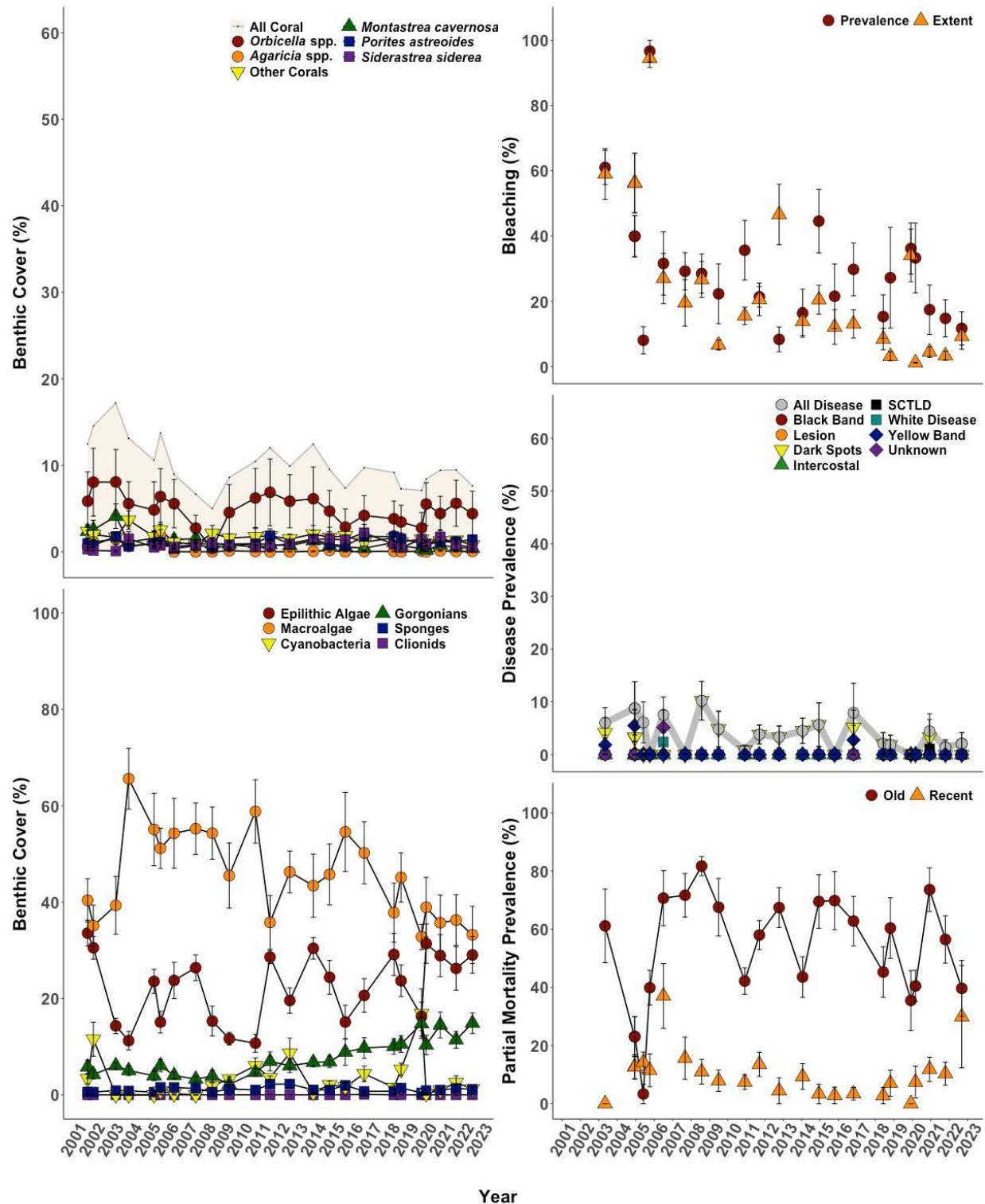


Figure 99. Fish Bay benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: FISH BAY

Fish Community. The Fish Bay fish community is typical of a nearshore reef habitat that receives moderate to heavy sedimentation. The site is dominated by herbivores that include all the common Caribbean parrotfishes, large schools of mixed acanthurids, and herbivorous pomacentrids. The common planktivores in the turbid water are limited to juvenile yellowtail snapper and a few small pomacentrids. Benthic invertivores and piscivores are more diverse and have a higher biomass, but generally fish are juveniles or subadults; large fish are rare in the bay. Invertivores are comprised primarily of grunts, goatfish and wrasses, and piscivore biomass is dominated annually by jacks. Large serranids and lutjanids are generally absent from Fish Bay although in 2018 a dog snapper was recorded and in 2022 a large cubera snapper was seen. Both Caribbean reef sharks and lemon sharks are known to pup in Fish Bay, and juvenile lemon sharks are sometimes seen in the murky water.

SITE SUMMARIES: FISH BAY

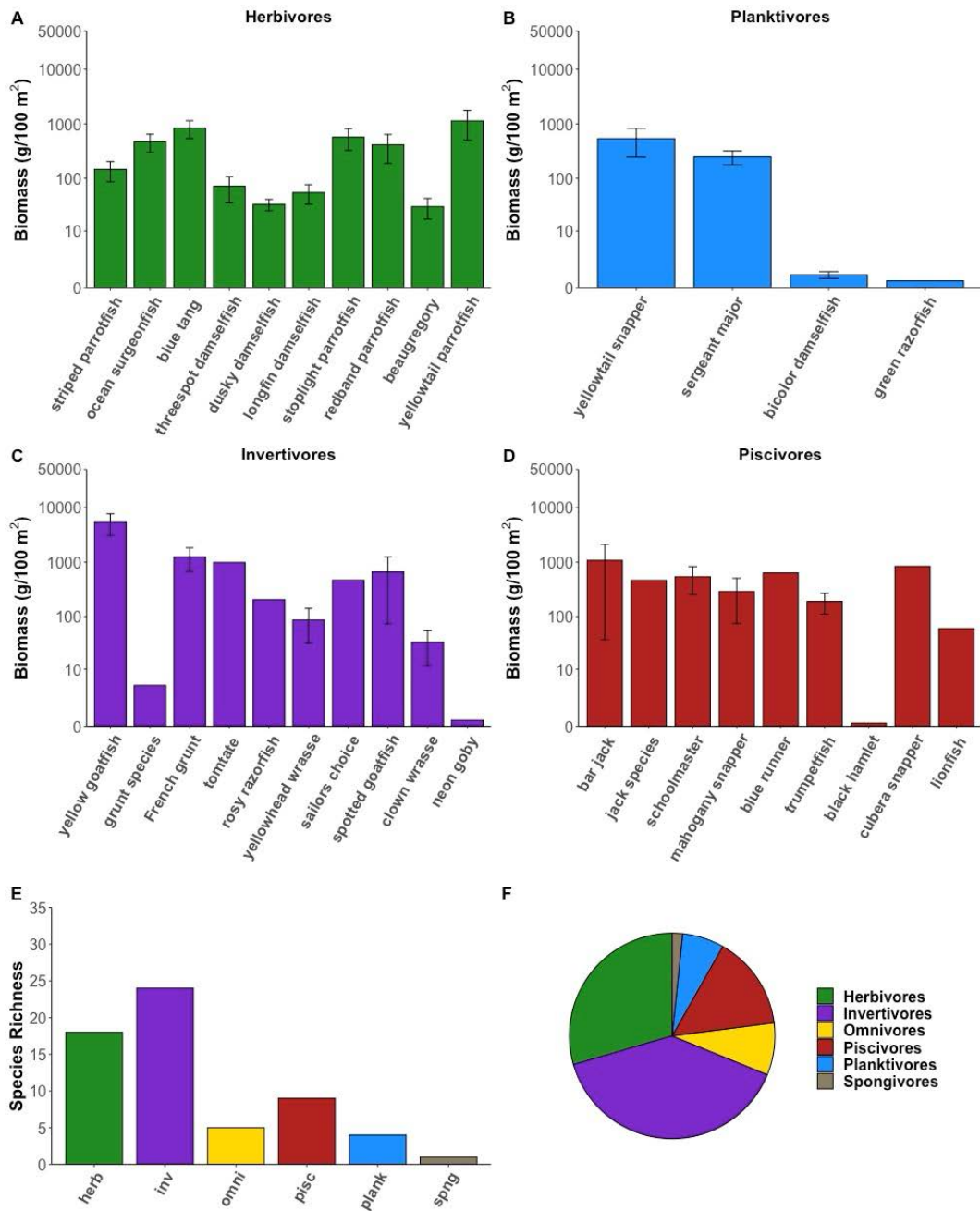
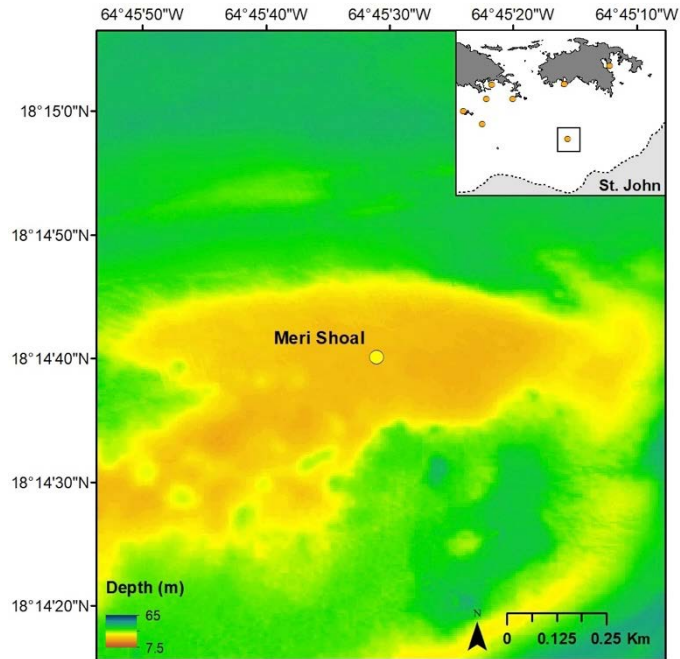


Figure 100. The Fish Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: MERI SHOAL

MERI SHOAL

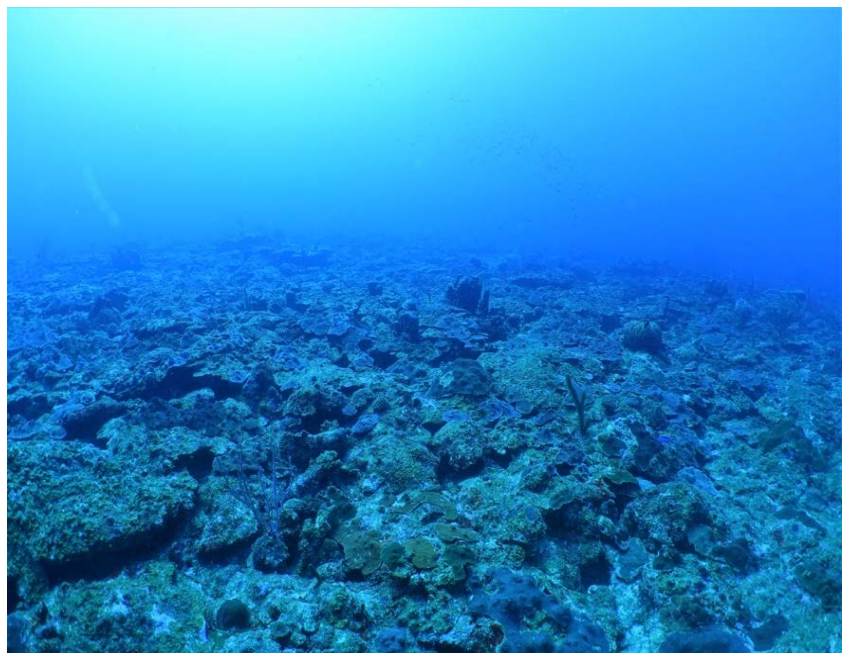
Description. Meri Shoal is an offshore mesophotic coral bank 30 m depth. The reef is located four miles south of St. John and is on the southernmost of two impressive midshelf coral banks. The reef is dominated by interlocking colonies of boulder star corals (*Orbicella* spp.). The reef top is very flat coral plain. The site is named for Dr. Meri Whitaker, former director of the VI EPSCoR Program who passed away in 2009. Meri Shoal has been monitored since 2005.



Outstanding Feature. Meri Shoal has the highest star coral abundance of any site in the TCRMP and is bathed in clear, clean water.

Threats. Meri Shoal is vulnerable to fishing impacts, as it is outside any marine protected area. The high density of corals may also make this site vulnerable to disease impacts.

Figure 101. Meri Shoal. (top) Location. (right) A representative photo of the reef (photo credit: S. L. Heidmann).



SITE SUMMARIES: MERI SHOAL

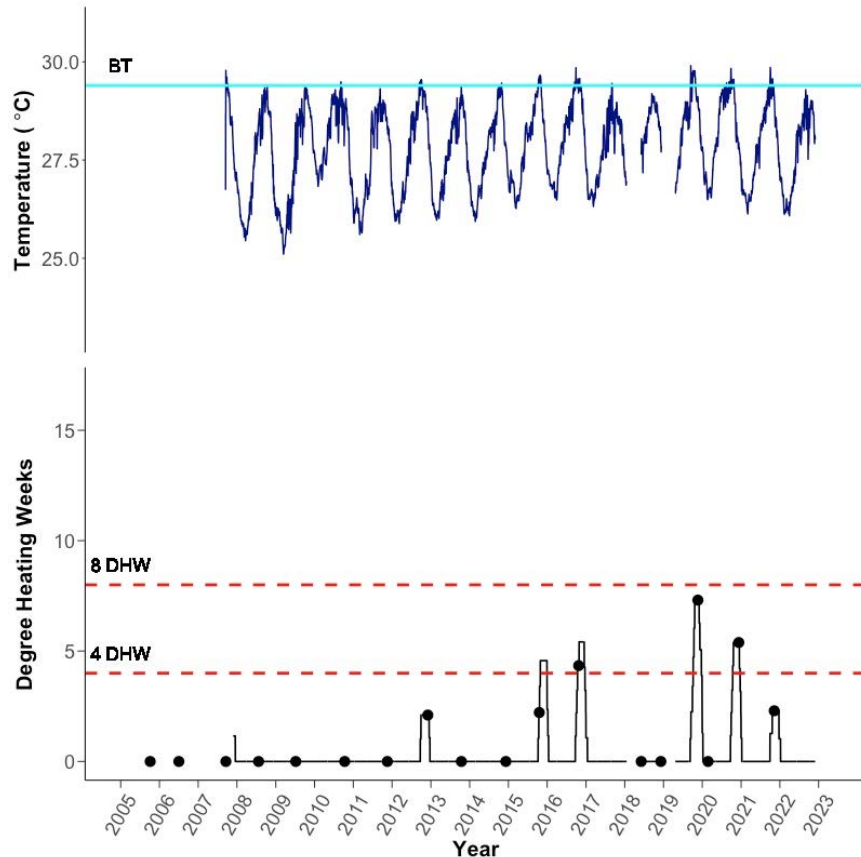


Figure 102. Meri Shoal benthic temperature record (30 m depth).

Physical Characteristics.

Current. Currents have not been measured directly at the Meri Shoal site, although the Caribbean Regional Association buoy VI 1 is located within 700 m and its downward focused ADCP has been recording data since April 2011.

Temperature. Meri Shoal has relatively low temperatures that are more similar to other mesophotic sites.

SITE SUMMARIES: MERI SHOAL

Benthic Community. The Meri Shoal site is exceptional for its dominance by boulder star corals (*Orbicella* spp.). Cover of this and other coral species was exceptionally high when the site was first monitored during the 2005 coral bleaching event, but declined by 36.0% after bleaching and had not recovered any cover as of 2011 (-9.6%). Since then, it has been steadily declined in cover, dropping to ~24% in 2022. Losses of coral cover from 2019-2022 were likely driven by the impact of SCTL D or other white plagues to *O. franksi*, which dominates the reef. Surprisingly, given the high coral cover, *Lobophora variegata*, and not epilithic algae, dominate the algal community and there has been a trend of increasing macroalgal cover since 2008.

Coral Health. Coral bleaching was relatively high for a mesophotic site during the coral bleaching event in 2005. Bleaching was again at high prevalence, but low extent in the thermal stress of 2010 and 2019. Disease, particularly white disease and lesions that are likely the remnants of white disease, are highly prevalent, particularly in years following high thermal anomalies, such as 2006 and 2011. SCTL D was recorded in transect in 2020 and had reached nearly 10% prevalence. Old partial mortality climbed steeply from the 2005 coral bleaching event onwards and reached very high levels by 2006. Recent partial mortality has also been consistently high as the result of white disease and disease lesions.

SITE SUMMARIES: MERI SHOAL

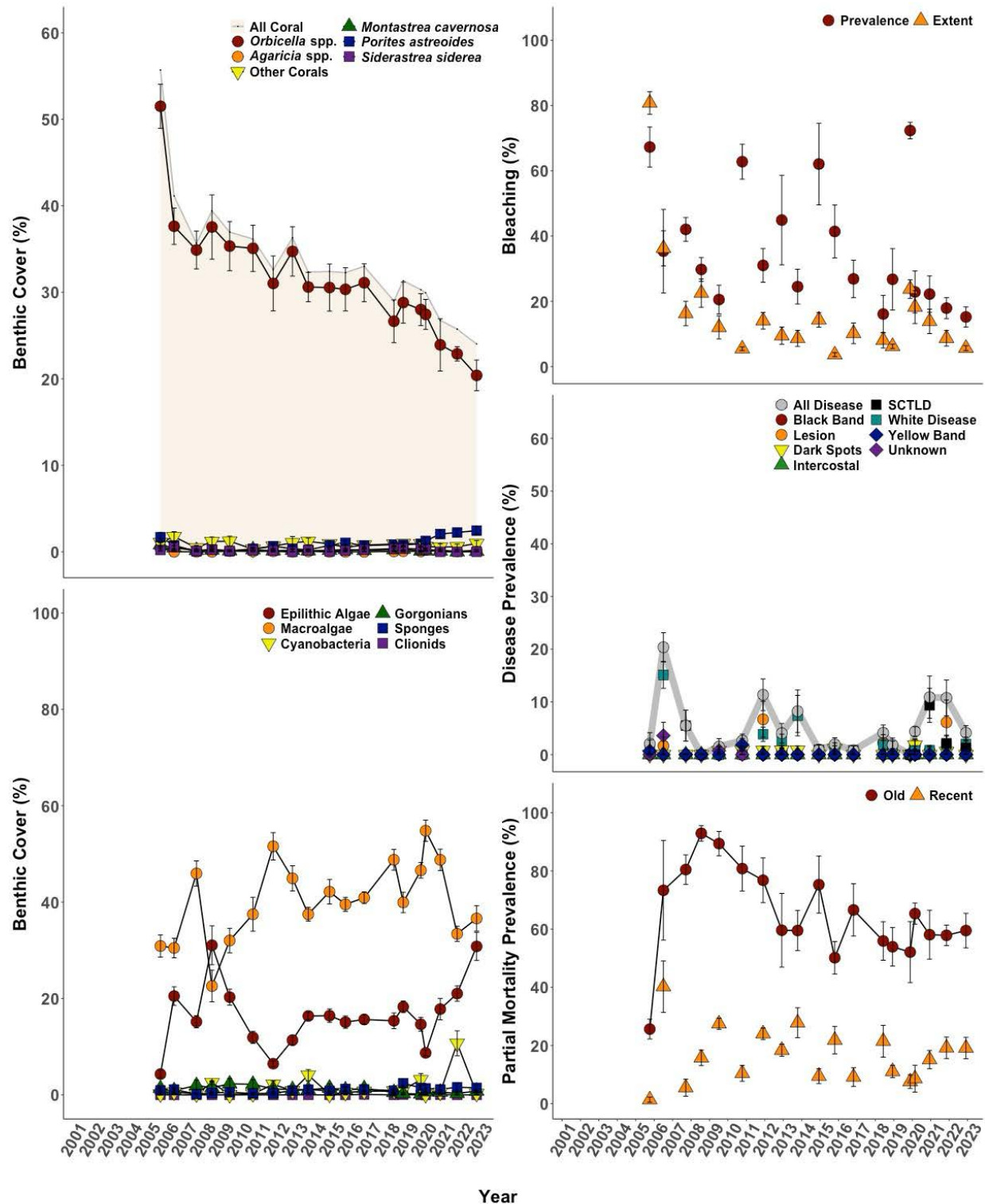


Figure 103. Meri Shoal benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: MERI SHOAL

Fish Community. Meri Shoal is a beautiful site in relatively deep water and holds a dynamic fish community of high biomass. Important planktivores include the very prolific creole wrasse, feeding on tiny jellyfish, invertivore larvae and phytoplankton, and the black surgeon, primarily a zooplankton feeder. Herbivores observed on the site include large stoplight parrotfish, as well as the three common smaller Caribbean parrotfish (redband, striped and princess), and all three acanthurids. Ocean surgeonfish are especially in high abundance. Queen triggerfish and red hind are both common at Meri Shoal. In 2012 a tiger grouper was observed on a belt transect and another on a roving dive. A Nassau grouper was also observed on a roving dive in 2013. These are rare but exciting encounters as the site is not protected from traps or any bottom fishing. Large jacks, mackerels, and barracuda are also regularly observed in the water column at Meri Shoal.

SITE SUMMARIES: MERI SHOAL

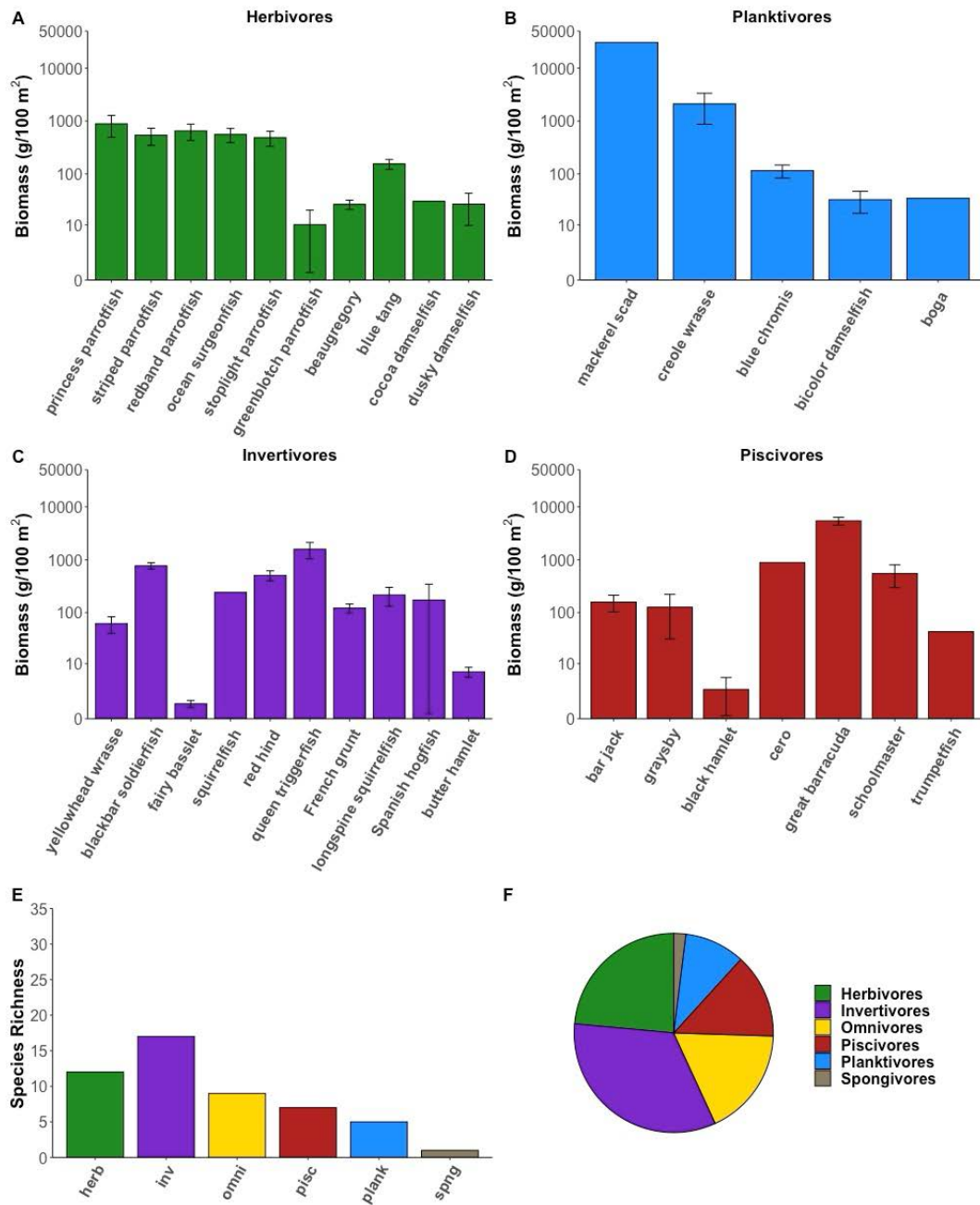


Figure 104. The Meri Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

St. Thomas

SITE SUMMARIES: BLACK POINT

BLACK POINT

Description. Black Point is a nearshore fringing reef located at the mouth of Brewers Bay along the southwest coast of St. Thomas in water depths of 7 – 17 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sediment plain at the reef base. Black Point appears to be a true reef with a well-developed carbonate framework over bedrock. Black Point has been monitored since

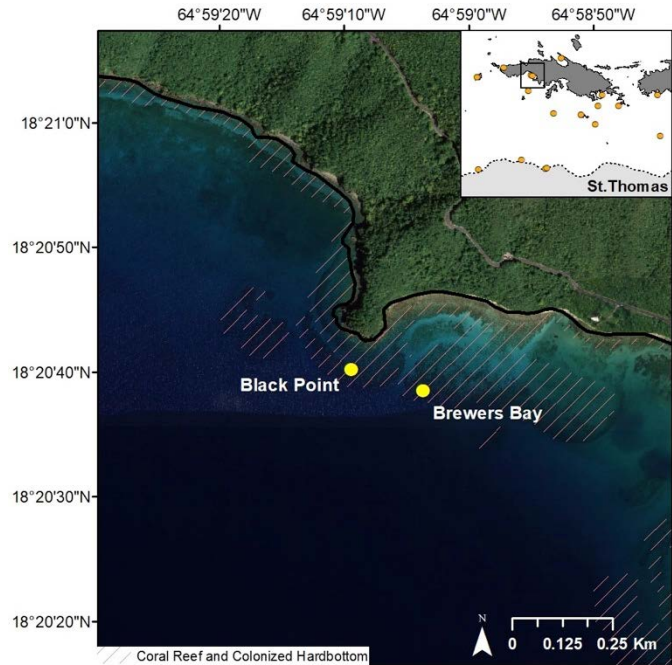
2003, with permanent benthic transects installed in 2007. A ciguatera fish poisoning study with monthly sampling has been ongoing since 2009.

Outstanding Feature. Black Point supports a fish spawning aggregation of striped parrotfish (*Scarus iserti*) with daily afternoon mating at the edge of the upper reef break.

Threats. Black Point is subjected to land-based sources of pollution and tends to have turbid water and overgrowth by heterotrophic organisms, such as sponges.

Recreational/artisanal fishers with handline and spear frequently fish this site.

Figure 105. Black Point. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: BLACK POINT

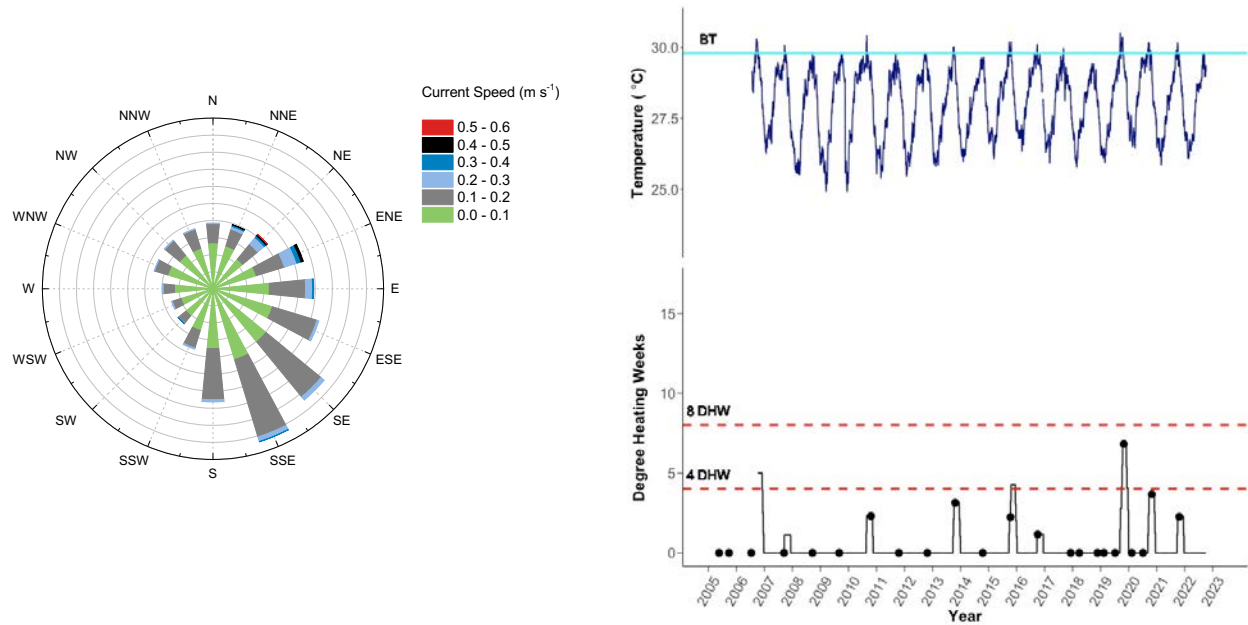


Figure 106. Black point current speed and benthic temperature record (8 m depth).

Physical Characteristics.

Current. Black Point has restricted water flow dominated by weak currents running counter or orthogonally to the left of the dominant wind direction. This may indicate that there is a counter flowing eddy from Perseverance Bay to the west that impinges on the headland. Current data are based on average data taken every 30 min. (11/29/06 to 3/1/2007) and hourly (4/19/07 to 9/5/07).

Temperature. Black Point has low circulation and relatively high mean temperatures with very low day-to-day variability.

SITE SUMMARIES: BLACK POINT

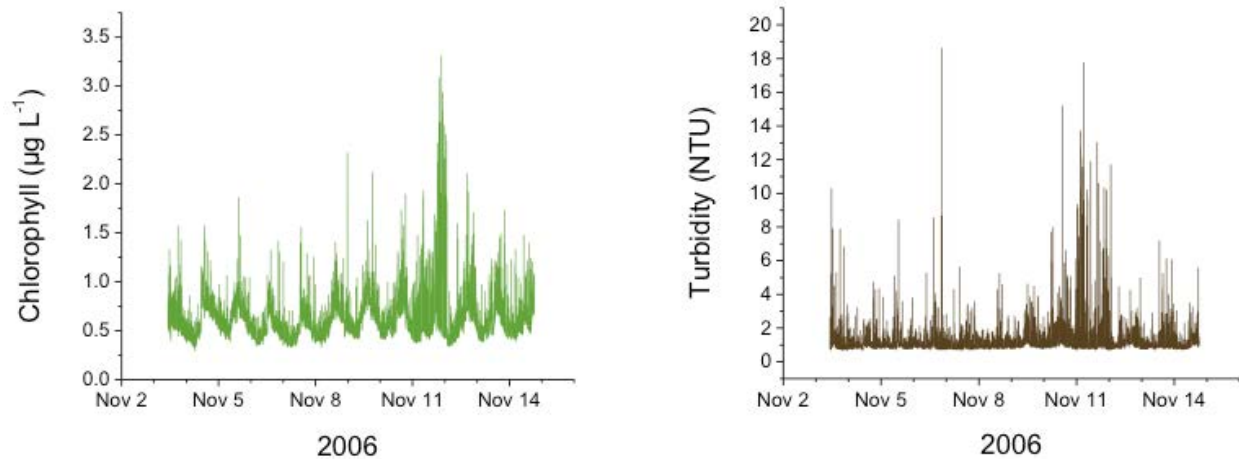


Figure 107. Black Point chlorophyll (left) and turbidity (right) record (16 m depth).

Chlorophyll & Turbidity. Chlorophyll tends to be high at Black Point, likely due to inputs of land-based nutrients that fuel pelagic productivity. There also exists a very prominent tidal signature that reflects switching source currents at the reef.

SITE SUMMARIES: BLACK POINT

Benthic Community. Black Point supports a very diverse coral community with very equal representation by many coral species. However, large colonies (> 100 cm diameter) of *Orbicella annularis* and *Orbicella faveolata* occur on the eastern edge of the site, with a few occurring within transects. This coral community lost 40.5% of its coral cover in the 2005 bleaching event; however, by 2011 it had regained 103.5% of its coral cover. The appearance of SCTLD in 2019 and a thermal stress event caused about a 30% decline in coral cover. The sponge community was damaged and cover lost in the major hurricanes of 2017 (Gochfeld et al. 2020), with slow recovery thereafter. The algal community at Black Point is co-dominated by epilithic algae and the macroalga *Dictyota* spp.

Coral Health. Black Point corals were severely affected during the 2005 bleaching event with nearly all colonies bleached over 100% of the colony surface. In 2019 bleaching prevalence and extent was elevated. Prior to the appearance of stony coral tissue loss disease, the prevalence of coral diseases was moderate with dark spots disease predominating. However, white disease outbreaks occurred at least twice over the sampling period. Old partial mortality became very prevalent after the 2005 coral bleaching event and subsided in the following two years.

SITE SUMMARIES: BLACK POINT

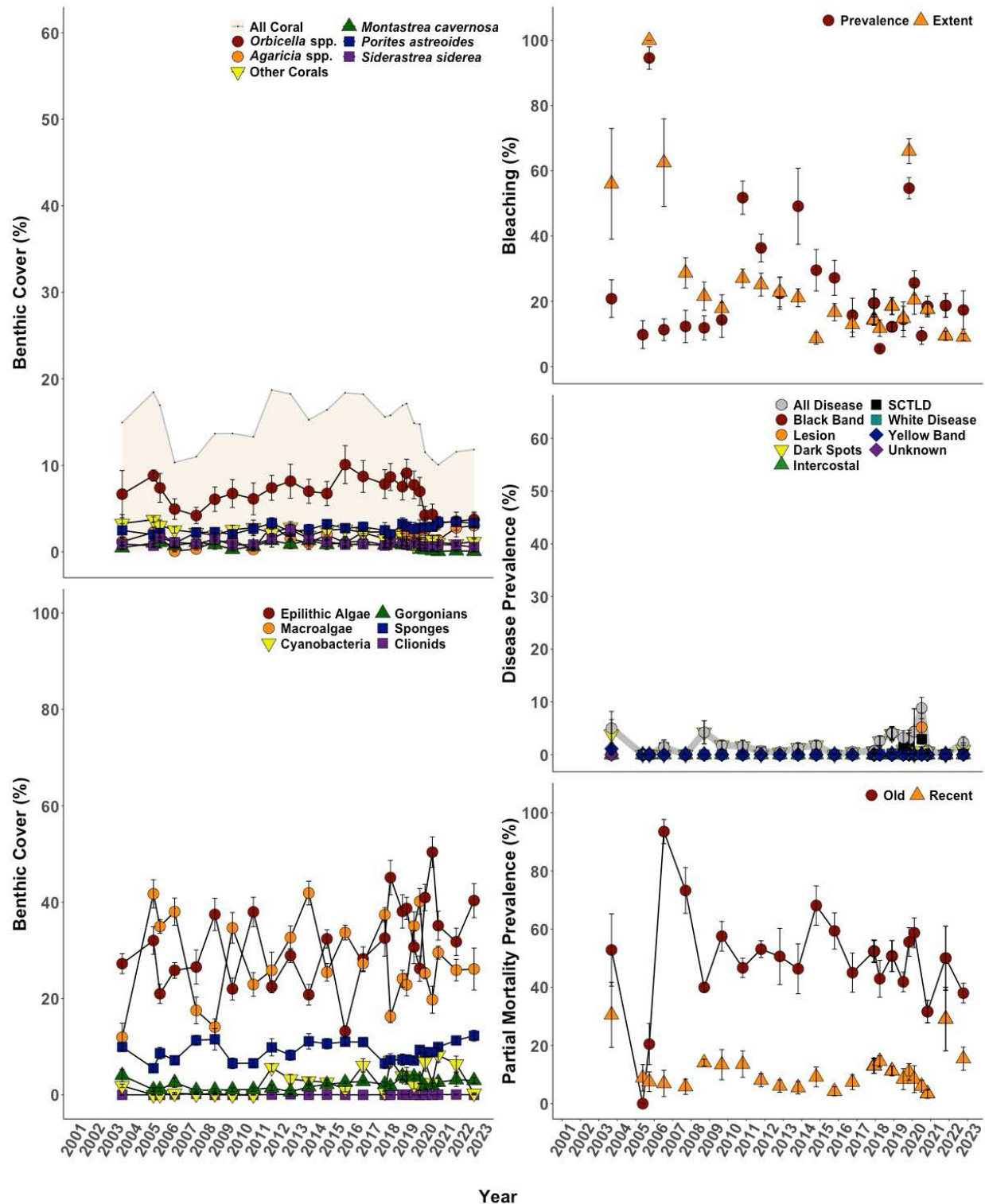


Figure 108. Black Point benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: BLACK POINT

Fish Community. Black Point fish abundance is highly dominated by herbivores. Juvenile parrotfish, wrasse and damselfish are numerous. Brown chromis and schools of creole wrasse are equally abundant in the turbid, plankton filled water. In 2018 a very large school of southern sennets shared the water column with these planktivores. The site holds very few large fish, although cubera snapper, Nassau grouper, and yellowfin grouper have been recorded in TCRMP surveys over the years. These rare fish are normally observed near the eastern edge of the site where the reef is undercut and caves have formed. Mutton snapper are seen regularly on roving dives, cruising the bottom of the reef where it meets the sand/hardbottom plain. Hamlets are especially diverse and numerous on Black Point. In the mid to late afternoon, striped parrotfish (*Scarus iserti*) spawn at the western end of the site. They can be seen swimming along the reef edge in large groups beginning in the early afternoon. Spawning goes into the late afternoon and involves tens of fish. Black Point is close to shore and is not fished by commercial traps often; however, like Brewers Bay reef, divers can swim to the site from the public beach to spearfish. It is notably lacking resident large fish.

SITE SUMMARIES: BLACK POINT

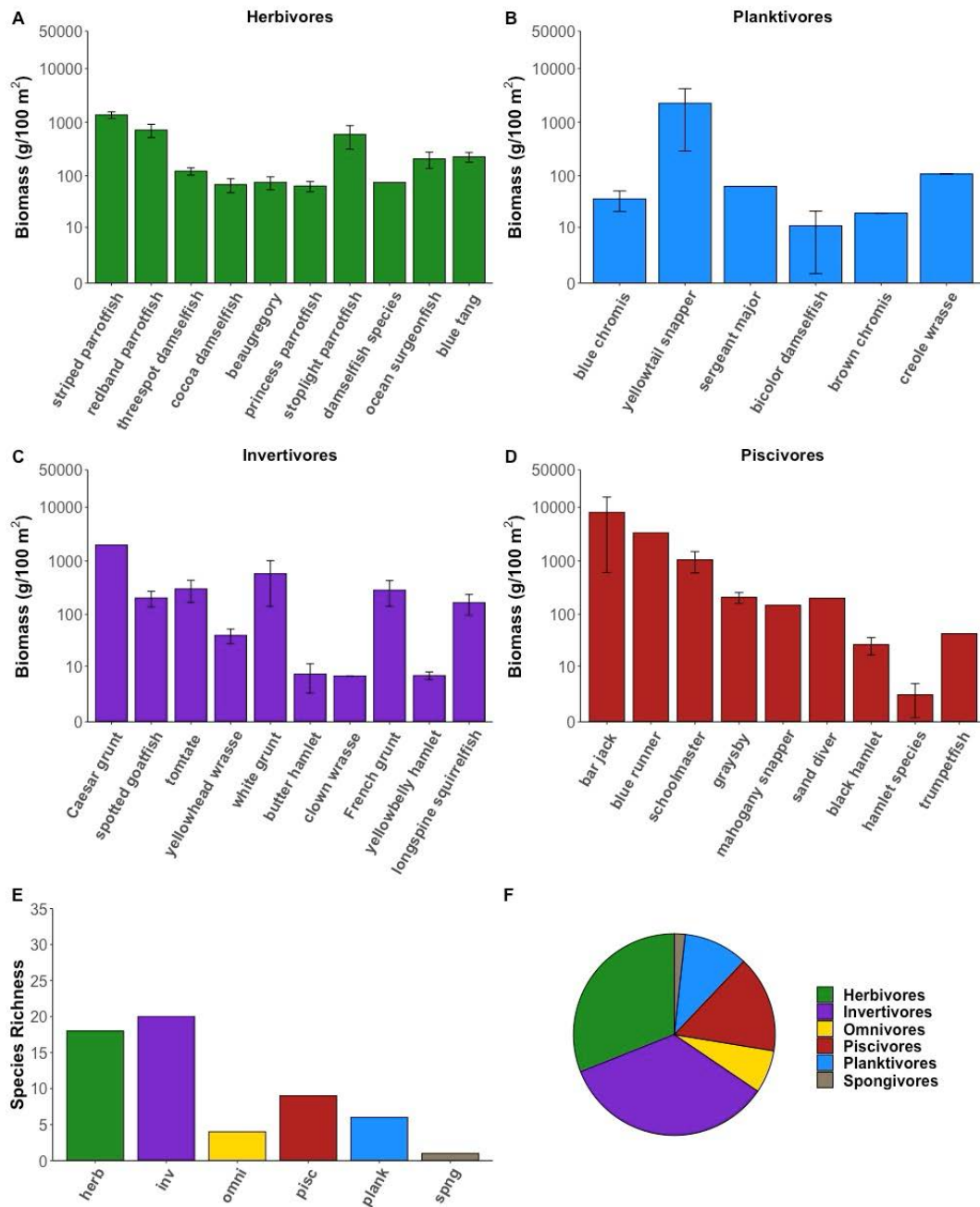


Figure 109. The Black Point fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: BOTANY BAY

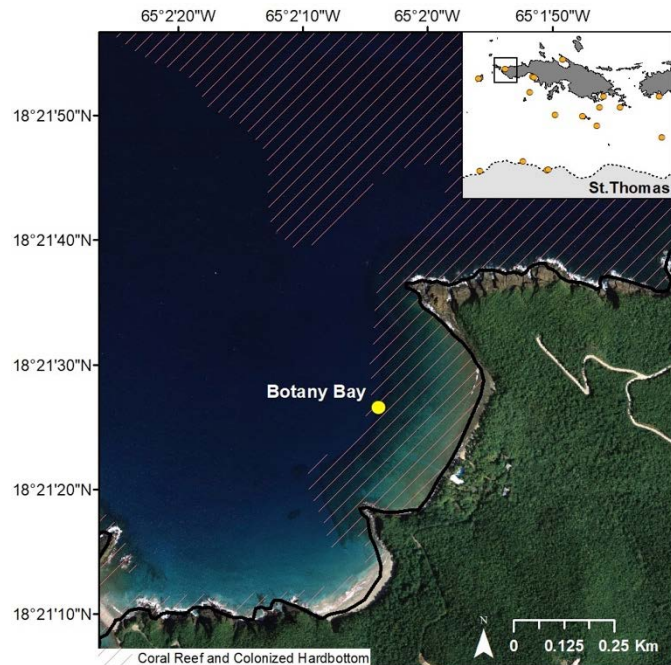
BOTANY BAY

Description. The Botany Bay site is located on the fore slope of a nearshore fringing reef in water depths of 5 – 17 m. The reef crest is a distinct spur-and-groove, with a sharp break in slope leading to an escarpment that terminates in a sand/sediment plain at the reef base. Botany Bay has been monitored since 2002.

Outstanding Feature. Botany Bay supports a diverse and productive reef that is one of the prettiest nearshore reefs in the Virgin Islands.

Threats. Botany Bay is threatened by development of the previously fully vegetated watershed and increased land-based sources of pollution. Cuts in the hillsides for construction of roads for luxury homes has left large areas without vegetation. The area is open to fishing. Increased residential development in the watershed may lead to increased recreational use of the reef, including fishing and collecting. The area is also occasionally impacted by large Atlantic swells, causing breakage of corals.

Figure 110. Botany Bay. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: BOTANY BAY

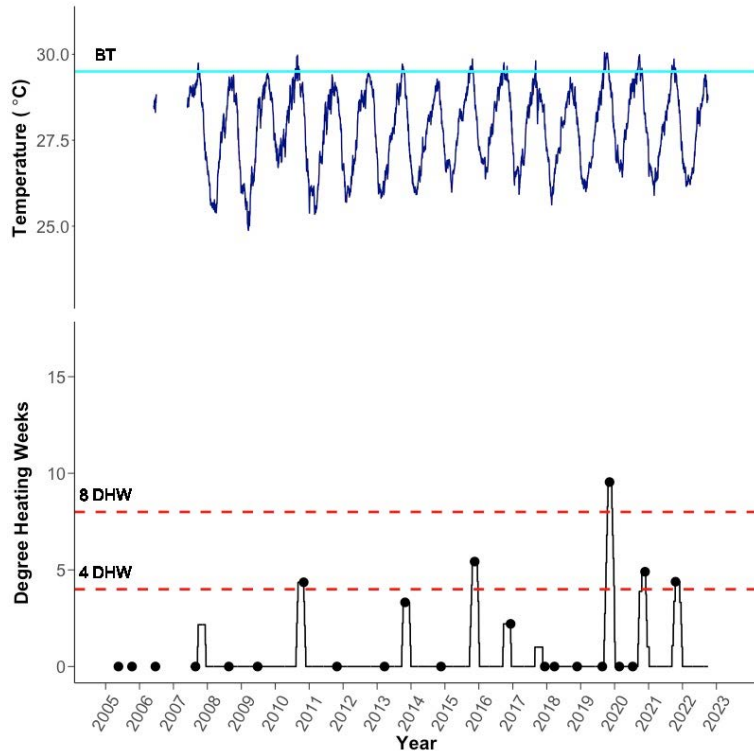


Figure 111. Botany Bay benthic temperature record (11 m depth).

Physical Characteristics.

Current. Currents have not been measured directly at Botany Bay. Unidirectional currents do not tend to be strong. Wave-driven oscillatory currents can impact the reef crest and fore reef. The site is vulnerable to impacts from large Atlantic swells. Many corals were broken and toppled during the 2009 March swell event when offshore swells reached heights to 4 m (Bright et al. 2016).

Temperature. Botany Bay tends to have slightly cooler temperatures than other nearshore sites, likely owing to its open position facing the Atlantic. However, in recent years it has surpassed the bleaching threshold each year, though bleaching extent has been minimal.

Figure 112. A large colony of pillar coral (*Dendrogyra cylindrus*) dislodge, toppled, and diseased after the 2009 swell event (Botany Bay, June 25, 2009).



SITE SUMMARIES: BOTANY BAY

Benthic Community. The Botany Bay site coral community is unique for the dominance of branching *Porites porites*. The site lost 38.9% of its coral cover in the 2005 bleaching event and had regained 10.6% by 2011. However, beginning in 2015 coral cover began to decline at this site for unknown reasons, but potentially related to sediment impacts from development. Botany Bay was heavily impacted by the passage of Hurricane Irma just to the north of St. Thomas on September 6th, 2017. The *P. porites* fields were stripped and *Orbicella* spp. colonies were dislodged or removed. SCTLD was first encountered here in 2019 and has continued to impact coral cover. There is a high abundance of gorgonians on the seaward slope exposed to wave swell. The Botany Bay algal community is co-dominated by epilithic algae and the macroalga *Dictyota* spp., which tend to negatively covary.

Coral Health. Bleaching was extremely severe during 2005, with nearly 100% of corals bleached or pale over 100% of their surface. There was also a high prevalence of bleaching in 2002 at an unknown extent, in 2010 at a low extent, and elevated prevalence and extent of bleaching in 2019. Non-thermal stress years have seen variable bleaching. Coral diseases can be high at Botany Bay, with a preponderance of white and dark spots diseases, and lesions that are likely related to white disease. SCTLD and lesions likely associated with SCTLD reached over 10% prevalence in 2019 and 2020. Old partial mortality shows a pattern that is difficult to explain before 2005. During bleaching and afterwards consistent observers have done partial mortality assessments and this data is valid. There was a large increase in old partial mortality after the 2005 bleaching event, then some subsidence and leveling off after 2008. Recent partial mortality was high through most years of monitoring, largely due to biting by territorial damselfish (*Stegastes planifrons* and *S. adustus*; data not shown).

SITE SUMMARIES: BOTANY BAY

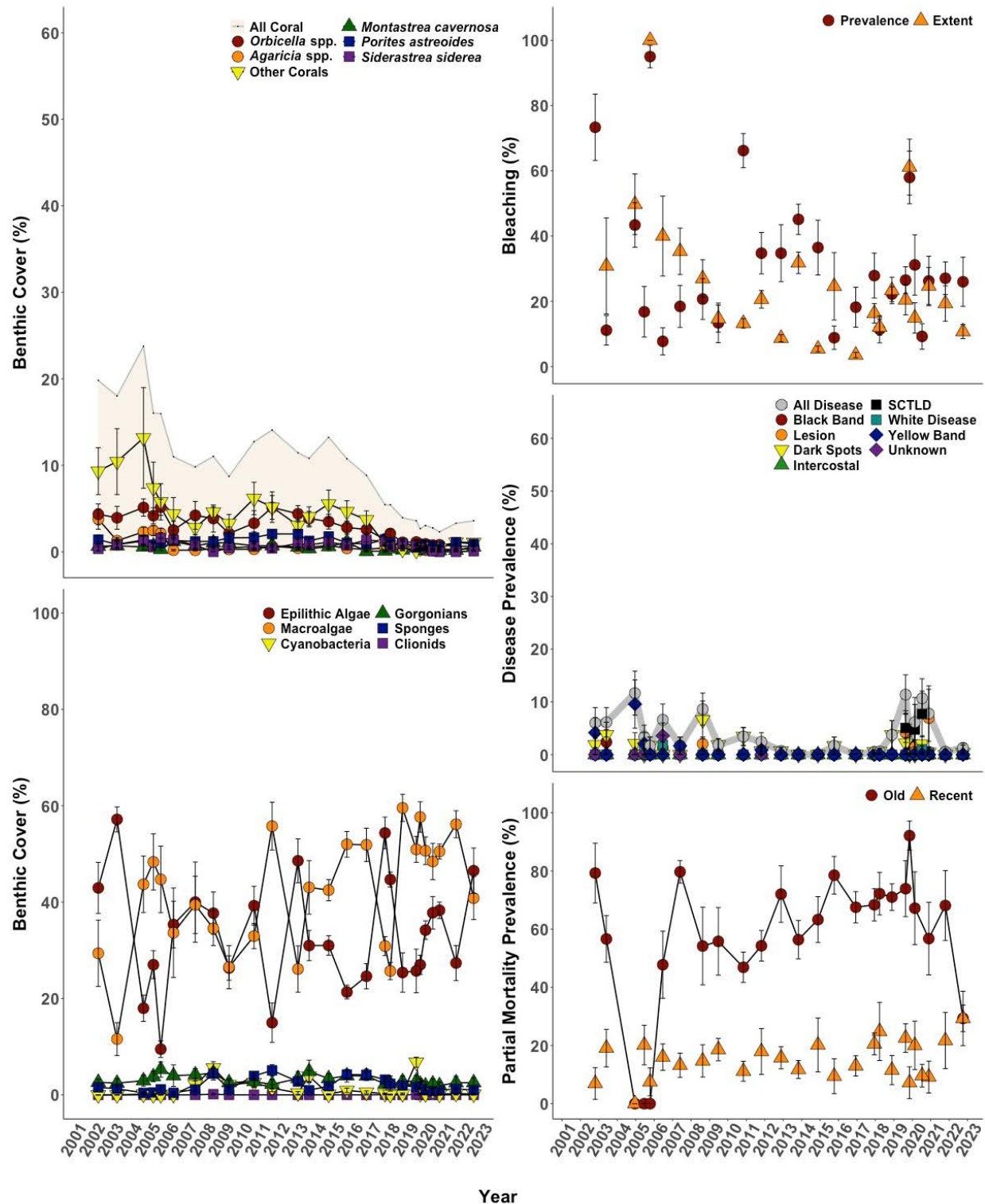


Figure 113. Botany Bay benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: BOTANY BAY

Fish Community. The fish community at Botany Bay is fairly typical of well-developed nearshore reefs around St. Thomas. The site is dominated by herbivores, equally split between the four common nearshore parrotfish species (stoplight, queen, redband and striped). In recent years, fish diversity and biomass has declined in Botany Bay, probably due to the continued degradation of the reef. In 2017, however, Nassau grouper were recorded at the site. Historically red hind and dog snapper contributed to the piscivore trophic guild; however, in recent years the major piscivores have been limited to graysby, coney and bar jacks. Coney are especially numerous in Botany Bay. The abundance of yellowtail snapper has also declined, and planktivores are now limited primarily to small chromis and damselfishes. Grunts and wrasses are numerous and diverse at the site, utilizing the variety of resources available for invertivores. Like most of the nearshore reefs in the northern USVI's, large jacks and mackerels are nearly absent from the site.

SITE SUMMARIES: BOTANY BAY

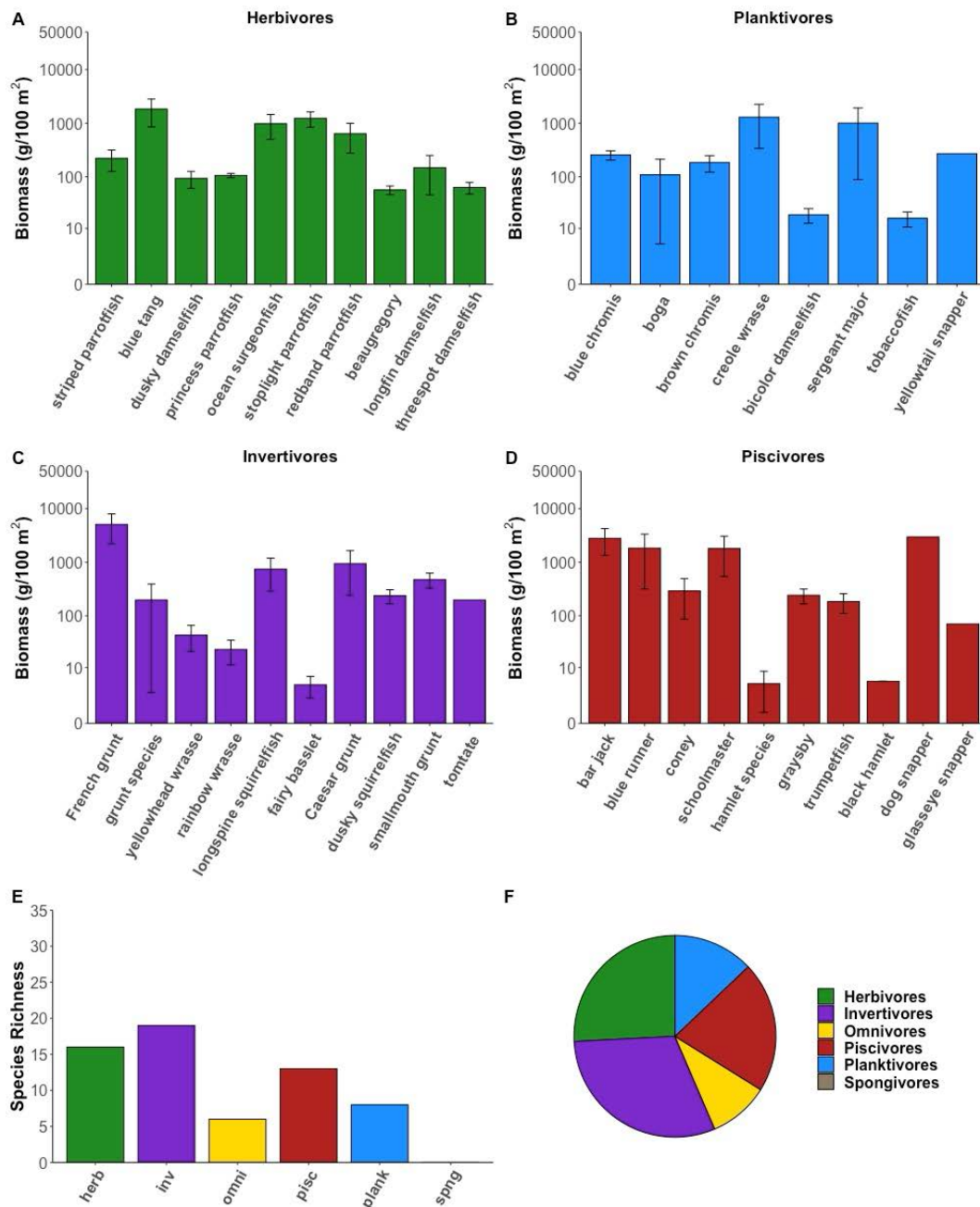


Figure 114. The Botany Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: BREWERS BAY

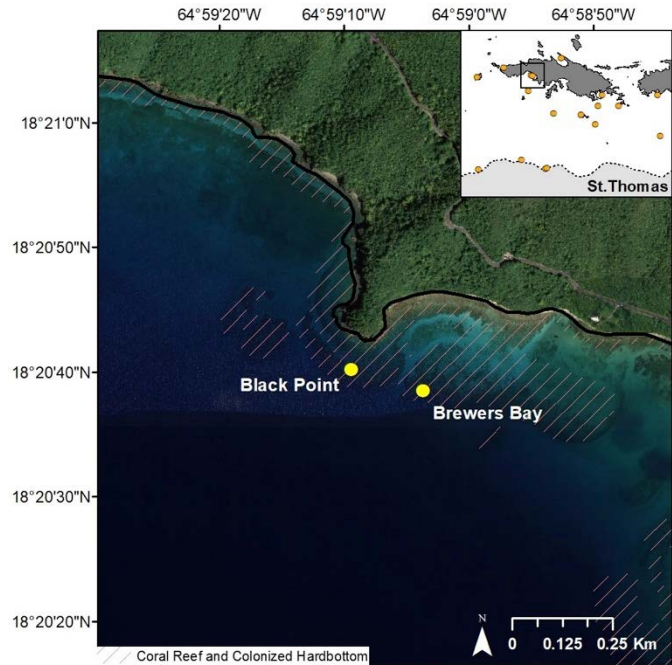
BREWERS BAY

Description. Brewers Bay is a nearshore fringing reef located along the southwest coast of St. Thomas in water depths of 7 – 17 m. Brewers Bay is a very well-developed boulder star coral (*Orbicella annularis*) dominated reef. Brewers Bay was initially monitored in 2002/2003, but was abandoned due to its proximity to the Black Point site. It was restarted in 2008 because it was resistant to the 2005 bleaching is one of the best preserved *O. annularis* reefs around St. Thomas.

Outstanding Feature. Brewers Bay is very good example of a nearshore boulder star coral fringing reef and has fared better than other reefs of this type over the 2005 mass coral bleaching event.

Threats. Brewers Bay is subjected to land-based sources of pollution and tends to have turbid water. Recreational/artisanal fishers frequently fish Brewers Bay with hand line and spear. The site has a great deal of marine debris, including boat hulls, rope, and metal pieces. Increased cruising boats in the bay since 2019 have led to anchor damage and parts of the reef.

Figure 115. Brewers Bay. (top) Location. (right) A representative photo of the reef in 2019. (photo: V. Brandtneris)



SITE SUMMARIES: BREWERS BAY

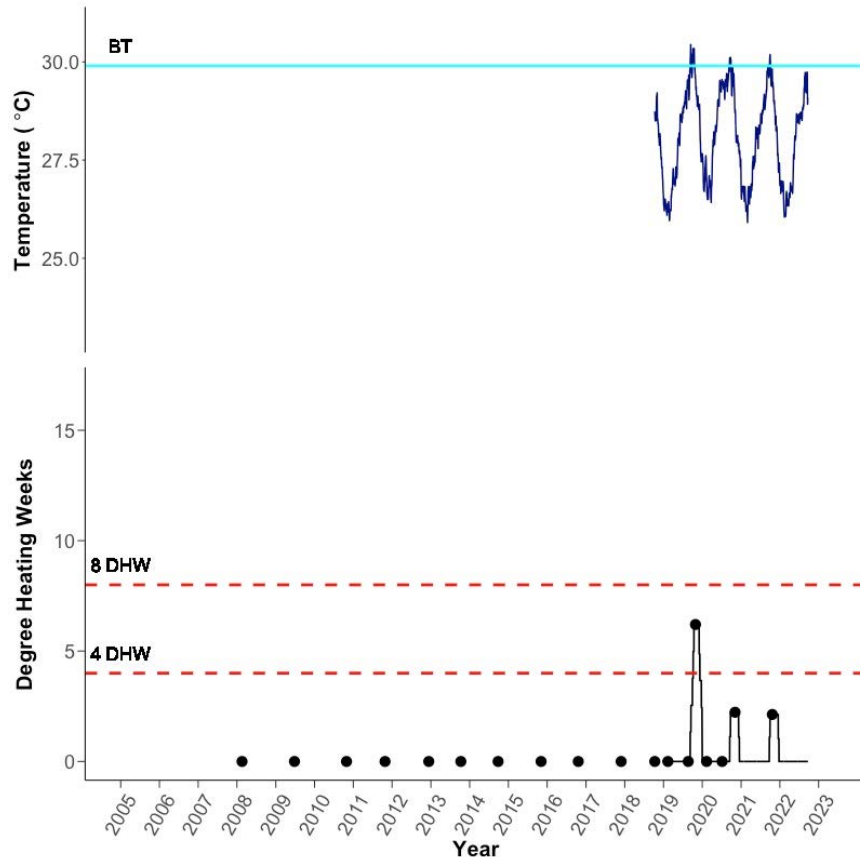


Figure 116. Brewers Bay benthic temperature record (8 m depth).

Physical Characteristics.

Current. Brewers Bay currents have not been measured directly, but both unidirectional and oscillatory currents are usually very low in magnitude. See also the Black Point physical data, which was taken within 500 m distance.

Temperature. Brewers Bay temperatures began to be recorded in 2018, but previous records from Black Point are a decent proxy for historical temperatures. The site is also co-located with a physical oceanography monitoring station of the National Coral Reef Monitoring Program.

SITE SUMMARIES: BREWERS BAY

Benthic Community. The Brewers Bay site is highly dominated by the boulder coral *Orbicella annularis* and exhibited the highest coral cover of any nearshore site in the TCRMP, with a coral cover of 32% in 2013. Coral cover was not monitored between 2003 and 2008; however, there was a 28.4% decline in cover that could largely be attributed to the 2005 coral bleaching event. Recently coral cover has declined dramatically with the arrival of SCTLD and bleaching in 2019. This disease has already caused a catastrophic decline in coral cover from 30% in 2018 to 10.6% by 2021. In 2022, cover appeared to rebound somewhat, reaching ~12%. The algal community at Brewers Bay is dominated by epilithic algae, with lesser amounts of the macroalga *Dictyota* spp..

Coral Health. Corals at the Brewers Bay site were not monitored for health over the 2005 bleaching event. However, corals exhibited some of the highest prevalence of bleaching during the 2010 coral bleaching event, albeit at a low extent. In 2019 there was high prevalence of high extent bleaching. In other years, bleaching prevalence remained high, with a low extent. Yellow band disease outbreaks were severe and affected the *O. annularis* community in 2002 and 2003. The 2019 monitoring period saw the emergence of SCTLD at the Brewers Bay reef and impacts at the monitoring site were extremely severe. The prevalence of lesions likely associated with SCTLD and recovery from heat stress surpassed 35%. Old partial mortality is a prominent and persistent feature of the large *O. annularis* colonies. Recent mortality is very high and largely attributable to the biting of large populations of the territorial three-spot damselfish (*Stegastes planifrons*; data not shown).

SITE SUMMARIES: BREWERS BAY

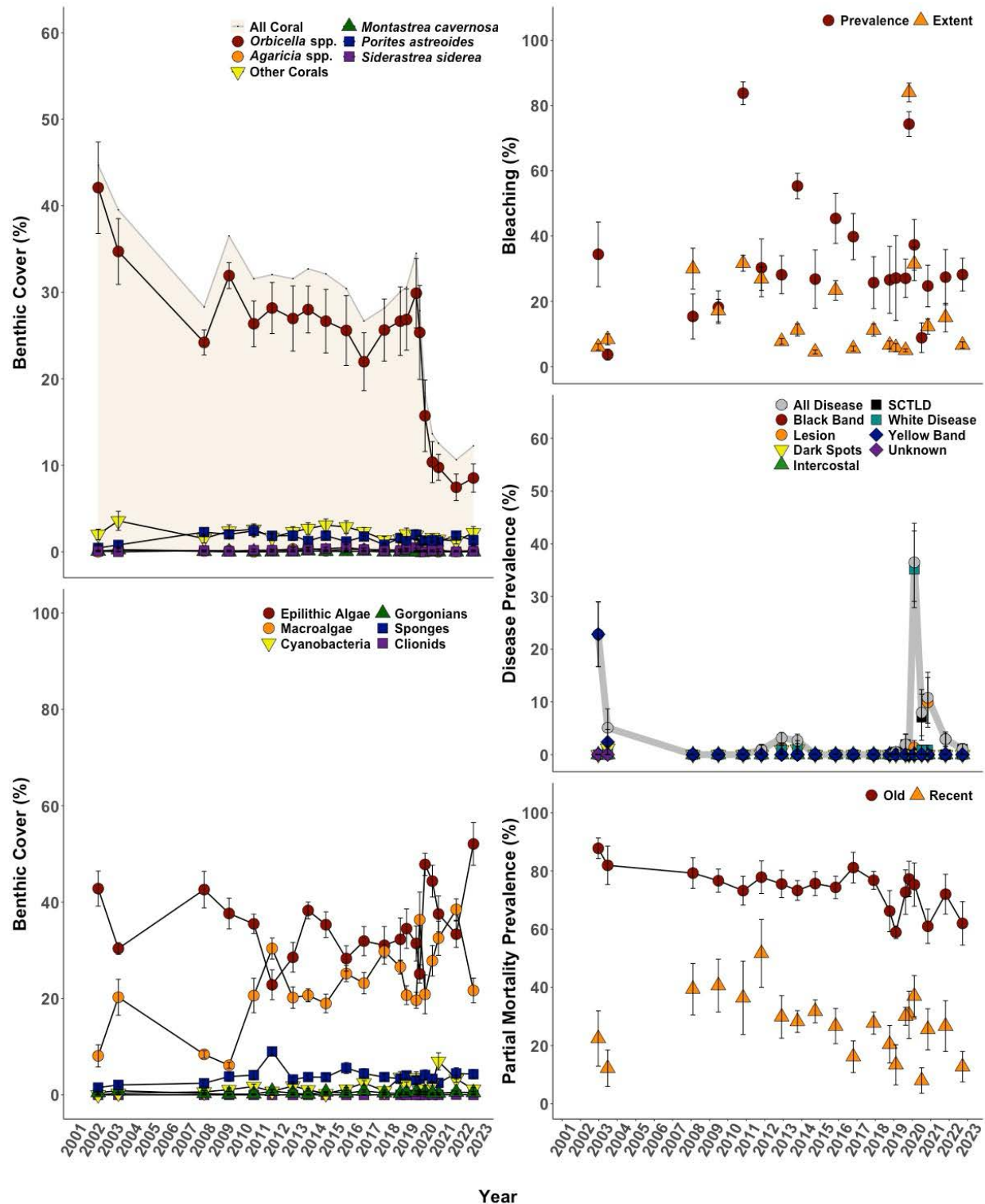


Figure 117. Brewers Bay benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: BREWERS BAY

Fish Community. Brewers Bay is characterized by a high fish abundance dominated by herbivores. The site holds large numbers of parrotfish. Numerically, the herbivores are dominated by juvenile striped parrotfish that swim over the reef in groups of mixed parrotfish, acanthurids and wrasse. Both yellowhead and bluehead wrasse are prolific and school with the juvenile parrotfish. There are also larger stoplights and queen parrotfish grazing the reef. Piscivores are limited in biomass but are fairly diverse and generally include inshore pelagics such as cero mackerel and bar jacks or yellow jacks. Hamlets (*Hypoplectrus*) are very common and diverse, represented by 6 to 7 species in each annual survey. The occasional large snapper (schoolmaster, dog, mutton, and cubera) are sighted on the reef periphery or around large coral heads. The reef is spearfished regularly, so these sightings are becoming more and more rare. Nassau, black, and yellowfin grouper and the now rare blue and rainbow parrotfish were present in Brewers Bay forty years ago (Rogers 1982). Nassau and yellowfin grouper are rarely seen at the reefs today; the other species are no longer observed.

SITE SUMMARIES: BREWERS BAY

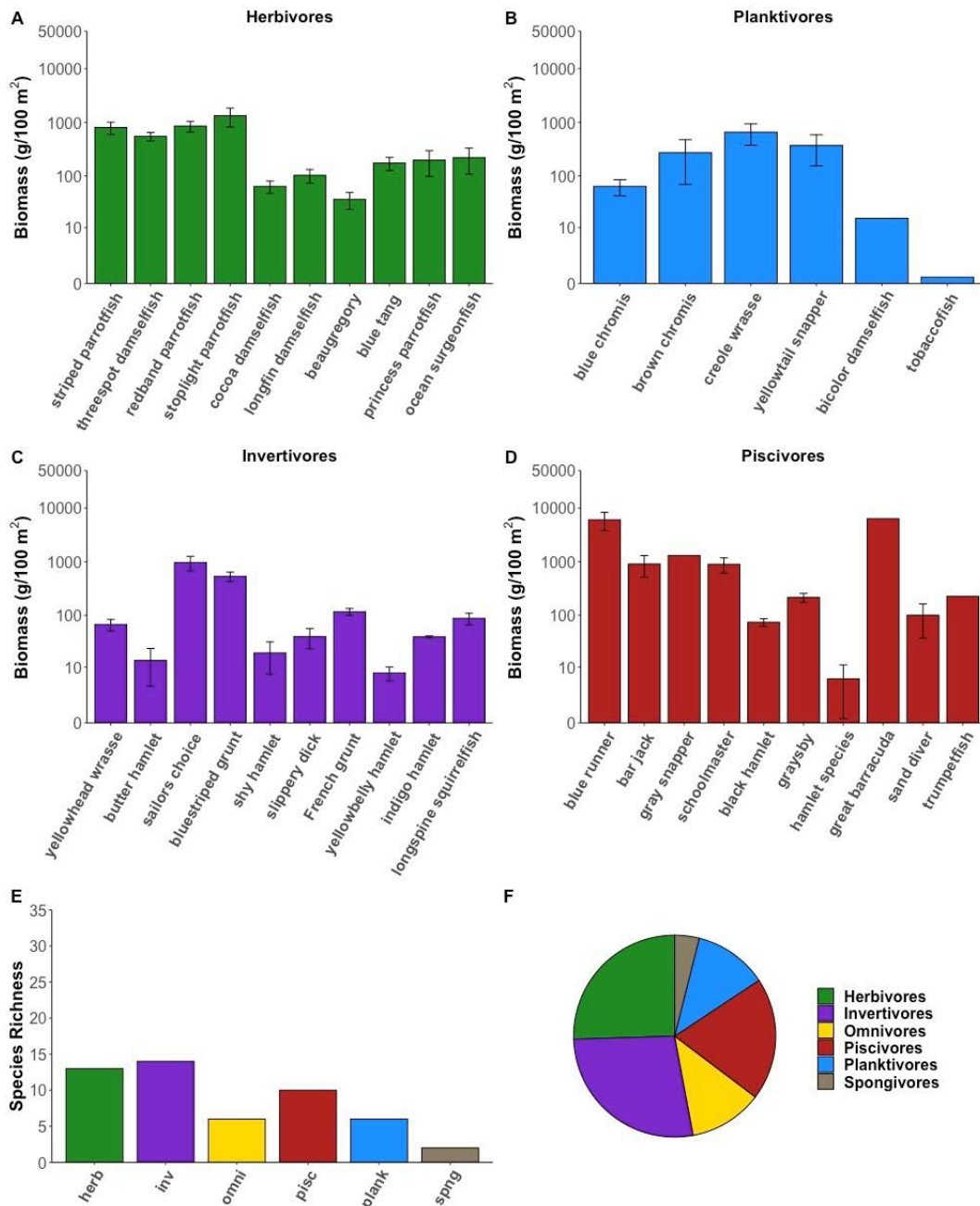
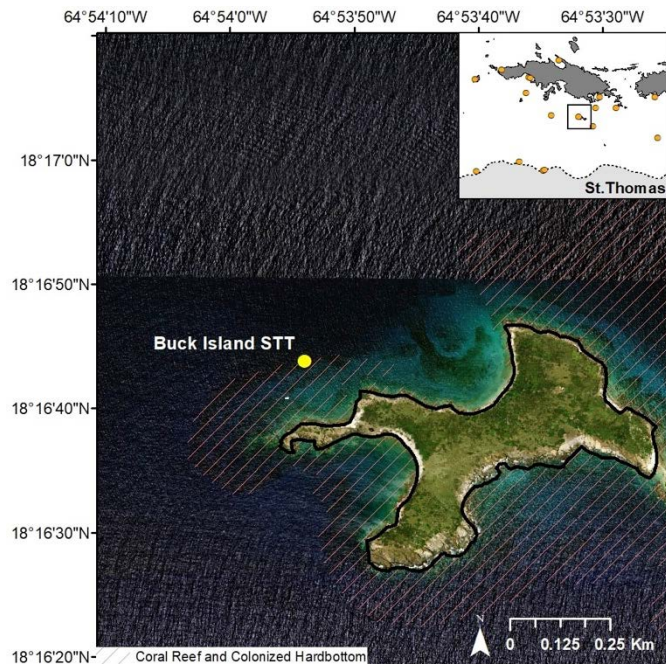


Figure 118. The Brewers Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: BUCK ISLAND STT

BUCK ISLAND, ST. THOMAS

Description. Buck Island, St. Thomas is a midshelf reef fringing the northwest coast of an uninhabited offshore island in water depths of 7 – 20 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. The monitoring site is located on that slope. Buck Island, St. Thomas has been monitored since 2005, with permanent benthic transects installed in 2007.



Outstanding Feature. Buck Island, St. Thomas is one of the most important tourist sites in the Virgin Islands, with frequent visitation by cruise ship passengers on day boats.

Threats. Buck Island, St. Thomas is very heavily used as a recreational dive site with the potential for cumulative impacts. The water surrounding Buck Island, St. Thomas is open to fishing. Commercial trap fishermen frequently target this site, and trap strings have been laid over the monitoring transects. Federally protected Nassau Grouper (*Epinephelus striatus*) have been observed within traps at the monitoring site. In addition, derelict traps are common around the site.

Figure 119. Buck Island, St. Thomas. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: BUCK ISLAND STT

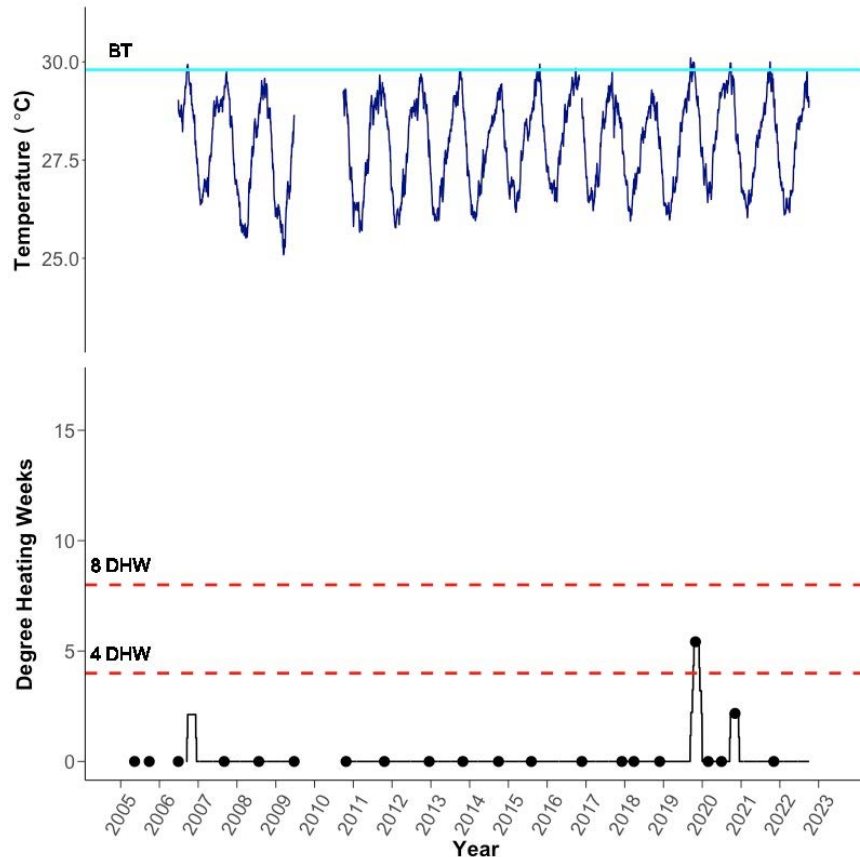


Figure 120. Buck Island, St. Thomas benthic temperature record (12 m depth).

Physical Characteristics.

Current. Buck Island, St. Thomas currents have not been measured directly. Moderately strong unidirectional currents occasionally influence the site; however, in general currents are very weak.

Temperature. Buck Island, St. Thomas may develop high temperatures. Unfortunately, the temperature probe placed during the 2010 coral bleaching event was lost, causing a gap in data.

SITE SUMMARIES: BUCK ISLAND STT

Benthic Community. The Buck Island, St. Thomas site coral community is dominated by the boulder star coral (*Orbicella* spp.) but shows high and even representation of other species. Coral cover declined by 23.4% due to the 2005 coral bleaching event and the site had regained 13.4% of this cover by 2011. Coral cover again dipped with the arrival of SCTLTD in 2019, but not as severely as at other sites. Among sessile epibenthic animals a high proportion of the community is composed of sponges. The algal community is dominated by epilithic the macroalgae *Dictyota* spp. and *Lobophora variegata*, which are in very high abundance. Typical macroalgal cover is about 50%, but it reached 70% after Hurricane Irma on September 6, 2017, largely the result of increases in *Dictyota*. Filamentous cyanobacteria can also be abundant at times.

Coral Health. The Buck Island, St. Thomas site was severely bleached in the 2005 coral bleaching event, with over 80% of colonies bleached over 100% of the colony surface. Bleaching was also high during the 2010 bleaching event, but at a low extent on colonies. A similar prevalence of bleaching was evident in 2019, but at a higher extent on colonies. Low prevalence of low-extent bleaching was common in other years of study. Coral diseases were usually low in prevalence with the striking exception of 2006, when white diseases and lesions consistent with recent white disease reached extremely high prevalence, and in 2019 when SCTLTD reached the monitoring site. Old partial mortality increased rapidly after the 2005 bleaching event and then declined steadily in following years.

SITE SUMMARIES: BUCK ISLAND STT

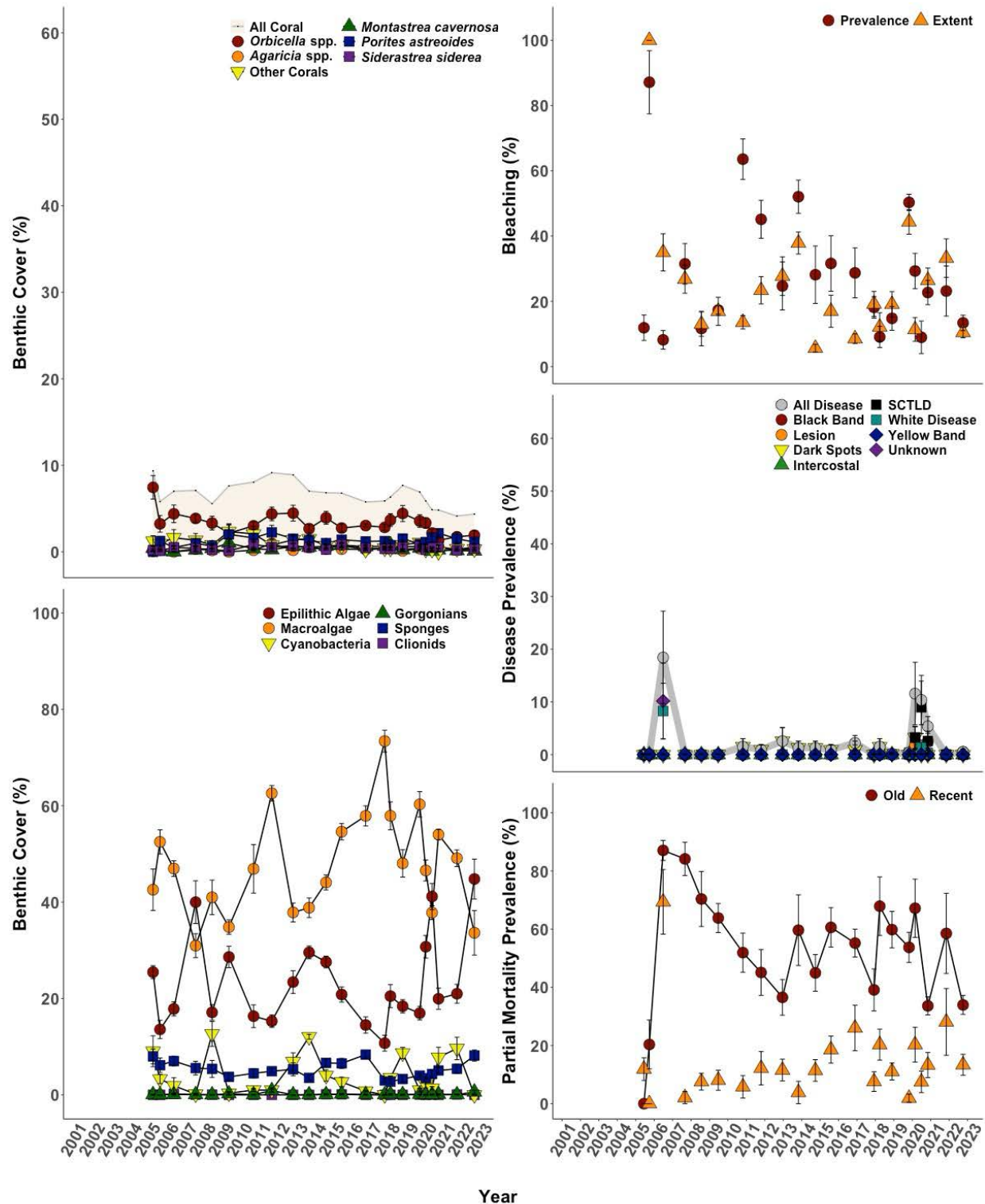


Figure 121. Buck Island, St. Thomas benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: BUCK ISLAND STT

Fish Community. The fish community at Buck Island, St. Thomas is very diverse and represents the utilization of many habitats and resources. The site is dominated in biomass by planktivores, primarily yellowtail snapper and creole wrasse. Tourists and commercial dive operators feed fish at Buck Island and gregarious yellowtail snapper are large and numerous. Herbivores are represented by large stoplight parrotfish as well as the other common parrotfish species, blue tang, and ocean surgeonfish. Invertivores are diverse and very common. Both spotted and yellow goatfish roam the top of the reef and large wrasses, including the Spanish hogfish and puddingwife, are prolific. In addition to goatfish and wrasses, a variety of grunts inhabit the Buck Island Reef, including French, white, bluestriped, Ceasar, tomtate, and cottonwick. Schoolmaster, grey and mahogany snapper dominate the piscivores community on the site. Occasional pelagic jacks (yellow, almaco and bar) swim in the water column above. Seaward of Buck Island the reef has a steep 10m drop to a sand plain below and numerous species of fish can be seen swimming this deep reef edge including jolthead and saucereye porgies, mutton snapper, white and black margates and Caribbean reef sharks. Two Nassau grouper were observed in belt transects in 2018. No other large groupers have been observed at Buck Island. Although a Territorial Park on land, the area is fished with hook and line, traps, and speargun. Two Nassau grouper were noted in fish traps just off the site in 2009. It is also a very heavily dove SCUBA and snorkel site.

Figure 122. A threatened Nassau grouper in an Antillean fish trap just off the Buck Is., St. Thomas TCRMP site. A second Nassau grouper was in another trap nearby. Aug. 12, 2008 (Credit: T. Smith)



SITE SUMMARIES: BUCK ISLAND STT

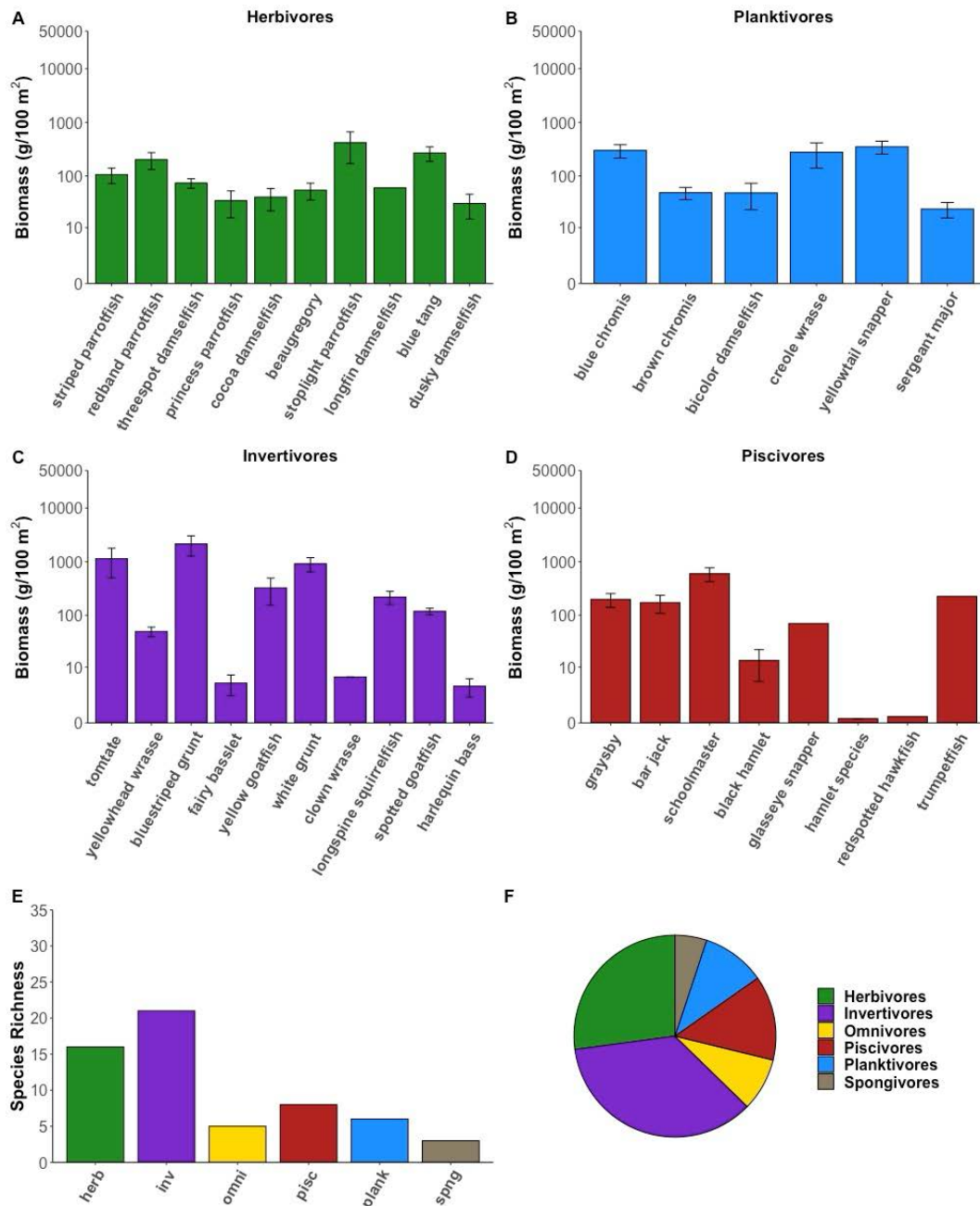
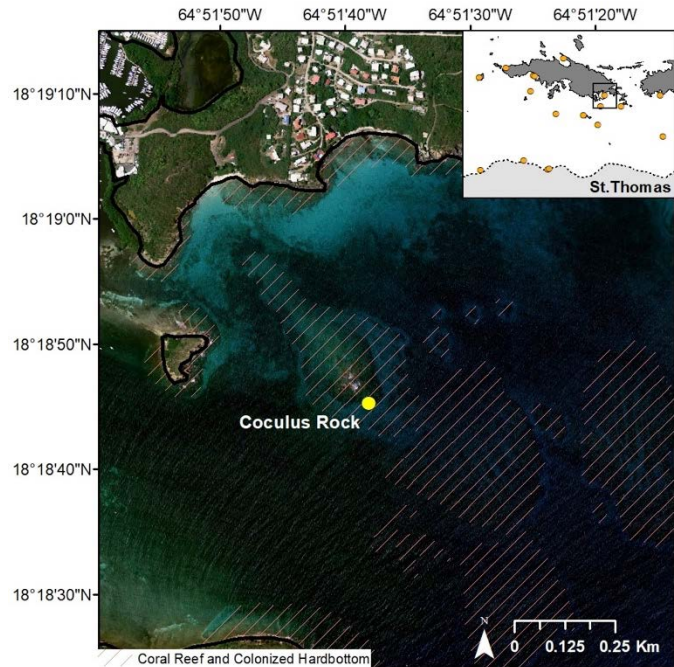


Figure 123. The Buck Island, St. Thomas fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: COCULUS ROCK

COCULUS ROCK

Description. The Coculus Rock site is a coral community on bedrock and pavement in depths of 4 – 7 m. The reef is formed between emergent rocks and a sand plain at 7m. Coculus Rock has been monitored since 2001, with fish community assessment starting in 2009. A ciguatera fish poisoning study with monthly sampling has been ongoing since 2009.



Outstanding Feature. Coculus Rock is in the St. Thomas East End Reserve and is closed to fishing. The site supports a fish spawning aggregation of yellowtail parrotfish (*Sparisoma rubripinne*). These 100+ fish engage in daily afternoon mating at southeast reef corner. A ciguatera study with monthly sampling was conducted from 2009 - 2017.

Threats. Coculus Rock is subject to land-based sources of pollution from the large Turpentine Gut drainage of the Tutu watershed and the numerous industrial maritime activities in Benner Bay.

Figure 124. Coculus Rock. (top) Location. (right) A representative photo of the reef showing the aggregation of yellowfin parrotfish.



SITE SUMMARIES: COCULUS ROCK

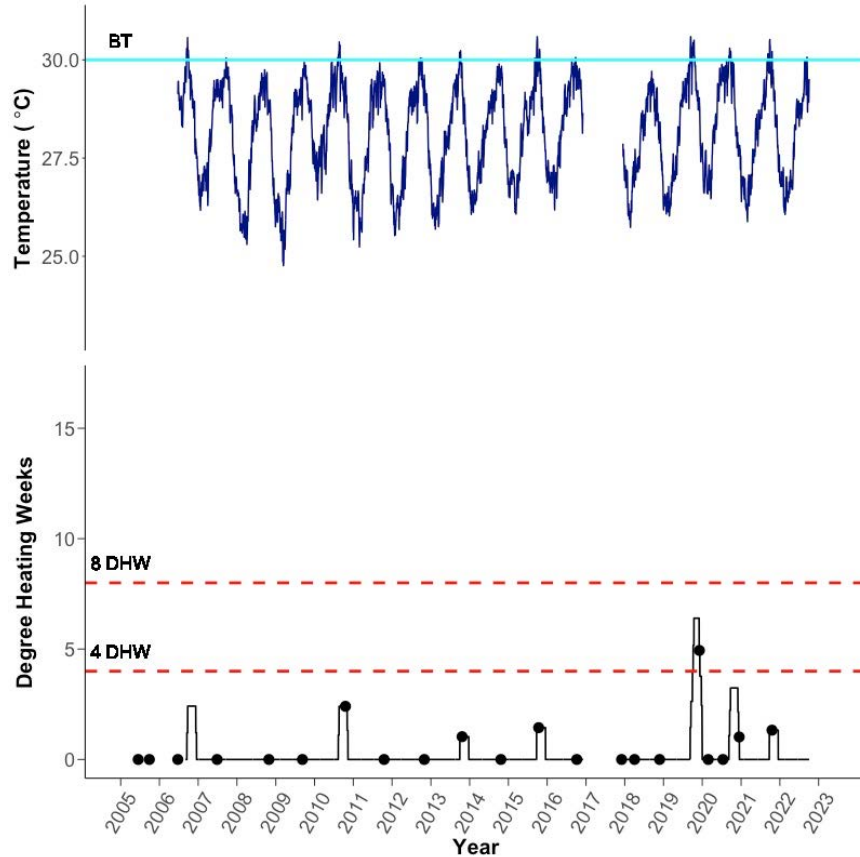


Figure 125. Coculus Rock benthic temperature record (7 m depth).

Physical Characteristics.

Current. Coculus Rock currents have not been measured directly. Only weak unidirectional currents have been experienced. Wave-driven oscillatory currents can be intense from swells coming from the southeast.

Temperature. Coculus Rock can experience very high temperatures during the peak warm season. The site sensor was lost in September 2017 hurricanes causing a gap in the record.

SITE SUMMARIES: COCULUS ROCK

Benthic Community. The Cocus Rock site is a coral community on bedrock and thin carbonate pavement that supports a very diverse coral community with no dominance by any species. The site lost 10.7% of its coral cover in the 2005 bleaching event but had regained 76.0% of this lost cover by 2011. This location has lost about 44% relative coral cover (2019 – 2021) since the arrival of Stony Coral Tissue Loss Disease but in the past year has started to recover. Sponges are a very prominent component of the sessile epibenthic animal community. The algal community is co-dominated by epilithic algae and the macroalga *Dictyota* spp., which tend to covary.

Coral Health. Corals at Cocus Rock were relatively moderately impacted by the 2005 coral bleaching event in both prevalence and extent on colonies. This may be due to a coral species assemblage composed of small, massive-morphology species that tend to be less susceptible to bleaching (Smith et al. 2013b). A modest prevalence of low extent bleaching was also evident in the 2010 coral bleaching event, whereas in 2019 the bleaching response was indistinguishable from years without heat stress. In years without high thermal stress, there tends to be a relatively high prevalence of bleaching relative to other sites, and prior to 2004 this was at high extent over colonies. Coral diseases, represented almost exclusively by dark spots disease, can be quite high in some years. SCTLD reached the site in 2020 but the impacts are ongoing. Old partial mortality has been fairly high and consistent over time, with a slight increase after the 2005 and 2010 bleaching events. Recent partial mortality tends to be quite low in prevalence.

SITE SUMMARIES: COCULUS ROCK

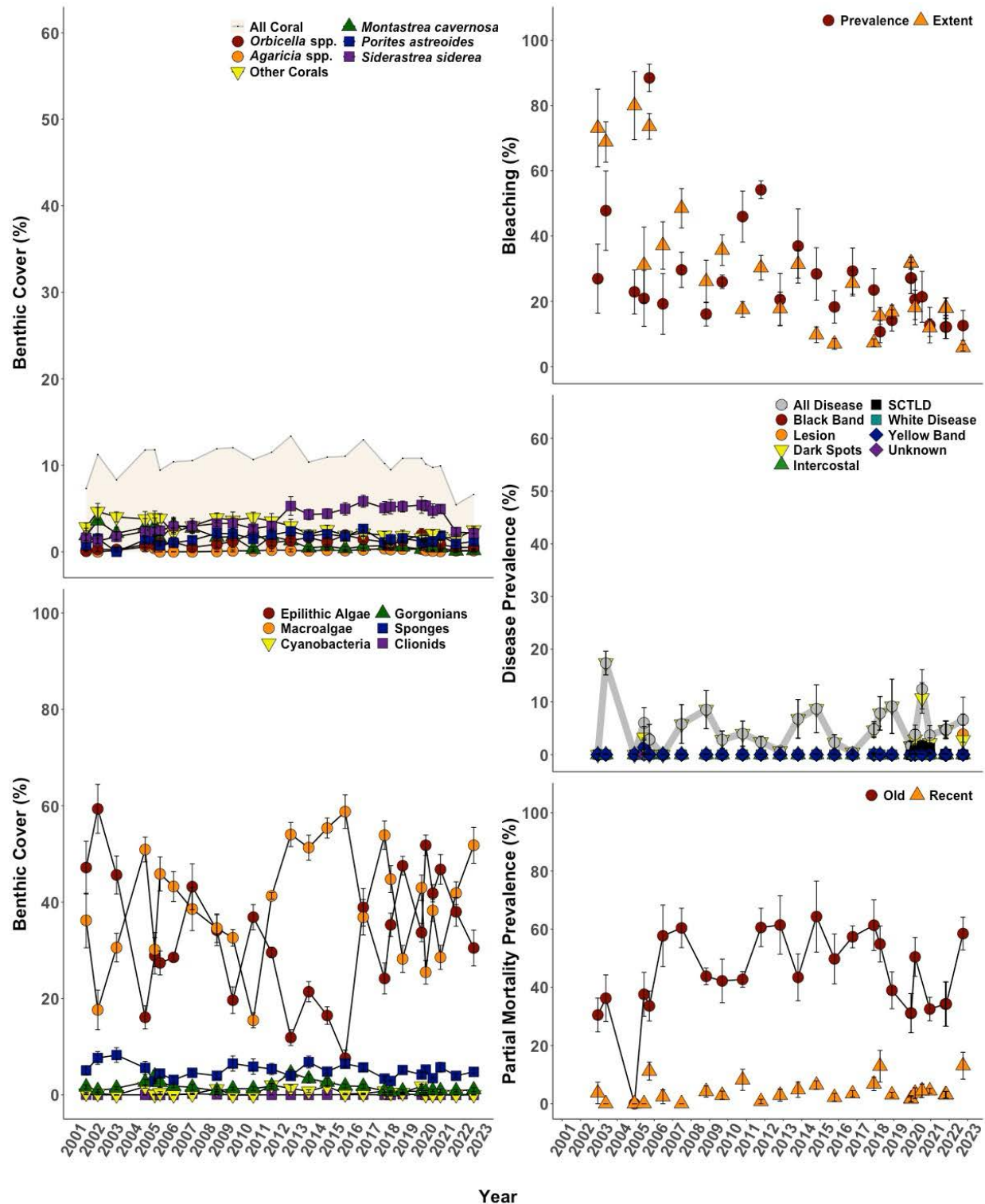


Figure 126. Coculus Rock benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: COCULUS ROCK

Fish Community. The Cocus Rock fish community is interesting in several ways. It represents an inshore promontory that serves as an aggregation and spawning site for yellowtail parrotfish (*Sparisoma rubripinne*) in the afternoon, apparently year-round. The top of the bedrock reef, emergent at points, is turbid and rough with breaking waves, but large parrotfish, jacks, doctorfish, and damselfishes swim in the milky, turbulent water. At the bottom of the rock promontory, where coral and bedrock meet the sand, small ledges run along the southeast edge of the reef. Red hind and an occasional Nassau grouper have been observed hiding in the dark of the undercut. There are generally a dozen or more juvenile lobster using the ledges as well. Juvenile grunts can be particularly common at Cocus Rock, “hanging” in large schools on and under limestone rocks and ledges on the western side of the site. Otherwise, the fish community inhabiting the steep walled rock and algae covered limestone site is primarily wrasses, juvenile parrotfishes, and acanthurids. Except for the occasional red hind or Nassau grouper, piscivores are limited to juvenile schoolmaster, mahogany and gray snappers. The planktivore guild is dominated in biomass by juvenile yellowtail snapper and the invertivore guild is made up of juvenile grunts and a variety of small wrasses. Cocus Rock is part of the territorial Saint Thomas East End Reserve (STEER) and fishes are protected from all harvest year-round.

SITE SUMMARIES: COCULUS ROCK

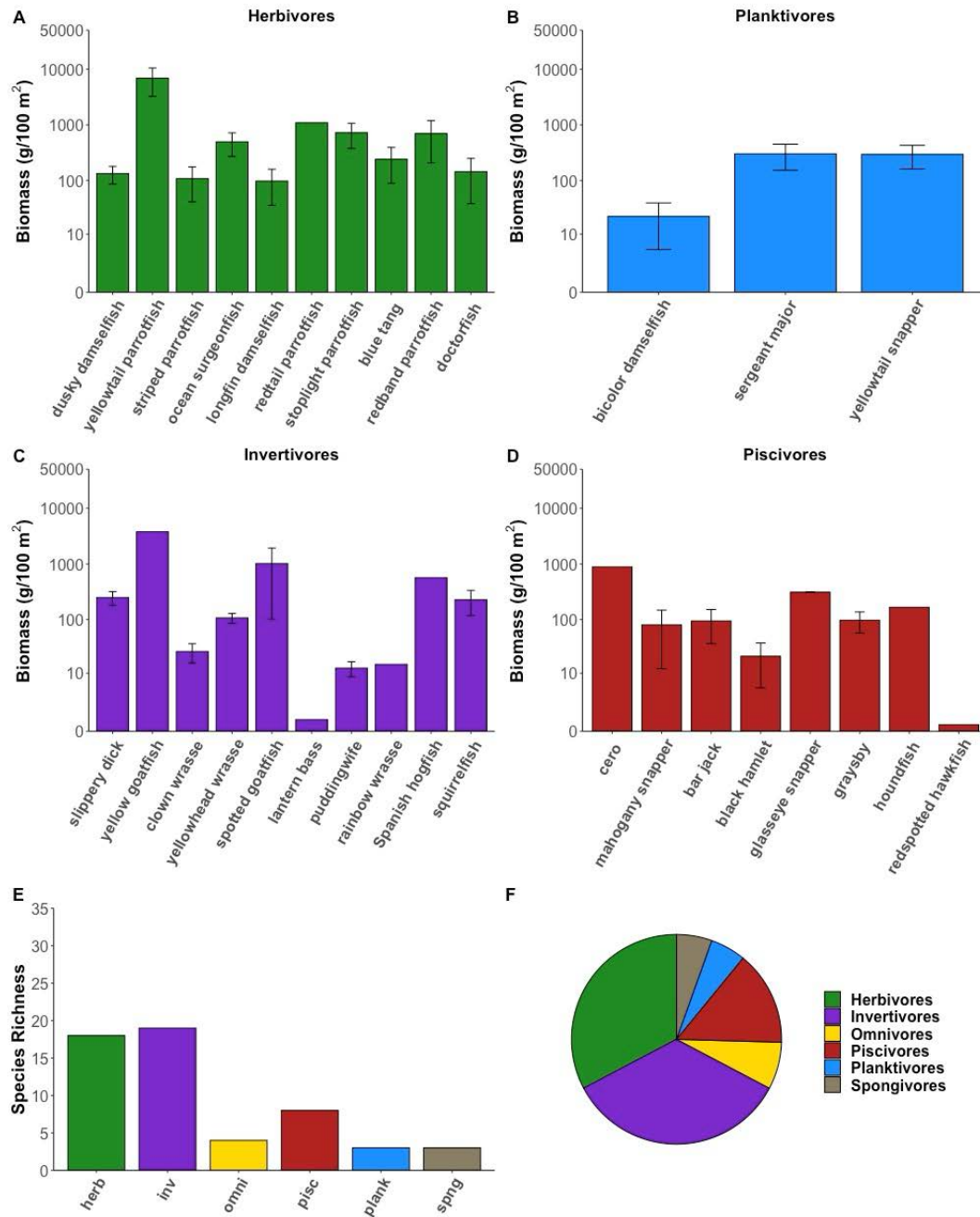


Figure 127. The Coculus Rock fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: COLLEGE SHOAL EAST

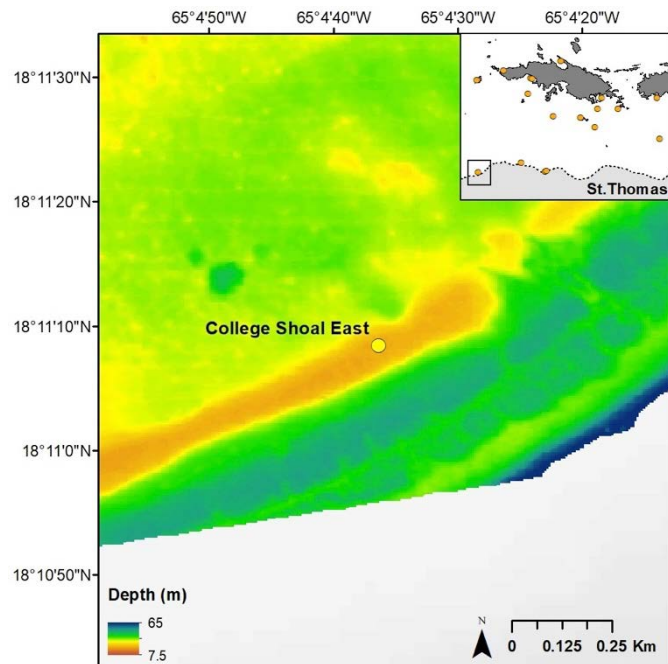
COLLEGE SHOAL

Description. College Shoal is part of a mesophotic bank located in the Red Hind Marine Conservation District (est. 1999) in depths of 28 – 33 m. The densely populated coral reef is surrounded by continuous reef structure dominated by star corals (*Orbicella* spp.). College Shoal has been monitored since 2003, with permanent benthic transects installed in 2007.

Outstanding Feature. College Shoal is notable for possessing high water clarity, relatively strong currents, a high density of corals (>30% coral cover historically), and a great abundance of fishes, including commercially important groupers and snappers. College Shoal is one of the most aesthetically pleasing reefs for diving due to its high coral abundance, and high fish abundance.

Threats. College Shoal has experienced coral white diseases at chronically high levels (> 1% prevalence). This reef also supports a high abundance of the invasive Indo-Pacific Lionfish (*Pterois volitans*).

Figure 128. College Shoal. (top) Location. (right) A representative photo of the reef in 2018 (photo: V. Brandtneris).



SITE SUMMARIES: COLLEGE SHOAL EAST

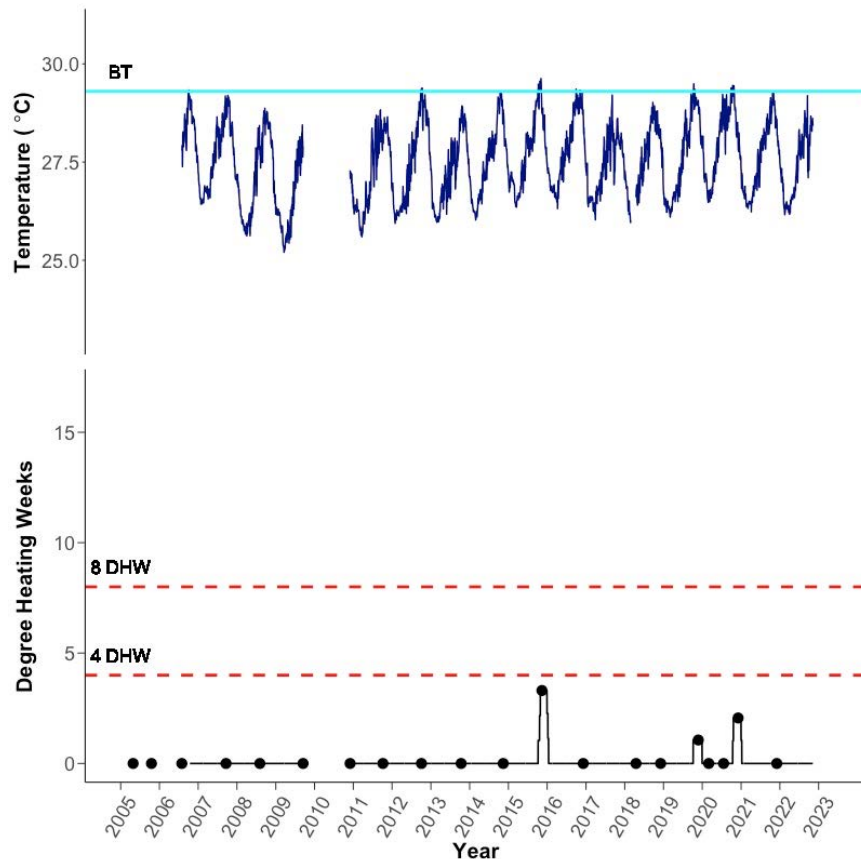


Figure 129. College Shoal benthic temperature record (29 m depth).

Physical Characteristics.

Currents. College Shoal has strong unidirectional driven currents that seem to be tidally driven and follow a pattern of increasing strength during spring tides. Current data has been collected and will be presented in a future report.

Temperature. Benthic temperatures are ameliorated in the warm season by the proximity of the thermocline. The presence of the thermocline causes temperatures that are cool and diurnally variable from May to October. Unfortunately, the thermistor re-initialized improperly in 2009 and the 2010 coral bleaching event temperatures were missed at this site.

SITE SUMMARIES: COLLEGE SHOAL EAST

Benthic Community. College Shoal is among the TCRMP sites with the highest coral cover (38.2% in 2011) and, like other bank mesophotic sites south of the St. Thomas, is dominated by the boulder star coral (*Orbicella* spp.). This site lost only 10.1% of its coral cover in the 2005 bleaching event, but had not regained cover since then; however, these estimates have some additional error since transects were not made permanent until 2007. SCTLTD arrived at this site in 2019 and has already contributed to a decline in coral cover from 33% to below 16% by 2022. Sponges and gorgonians are in very low relative abundance. The algal community is dominated by the macroalga *Lobophora variegata* and lesser representation by epilithic algae. There is also a relatively high proportion of crustose coralline algae.

Coral Health. College Shoal bleached at a relatively low prevalence during the 2005 mass coral bleaching event, although corals that were bleached tended to lose color over their entire surface. The 2010 coral bleaching event had no apparent effect above background bleaching levels. Bleaching in years without thermal stress tends to be moderate. Diseases were dominated by white disease, which reached very high prevalence after the 2005 bleaching event, with an outbreak that lasted for two years in 2006 and 2007. This disease was again very prevalent in 2011 after the 2010 bleaching event, even without apparent thermal bleaching. The impacts of SCTLTD were very severe in 2019, with about 25% of colonies displaying disease signs. Old partial mortality was elevated on corals after the mortality from the 2005 bleaching event, and this level has remained stable through 2011. Recent partial mortality is always relatively high, much of it attributable to fish bites.

SITE SUMMARIES: COLLEGE SHOAL EAST

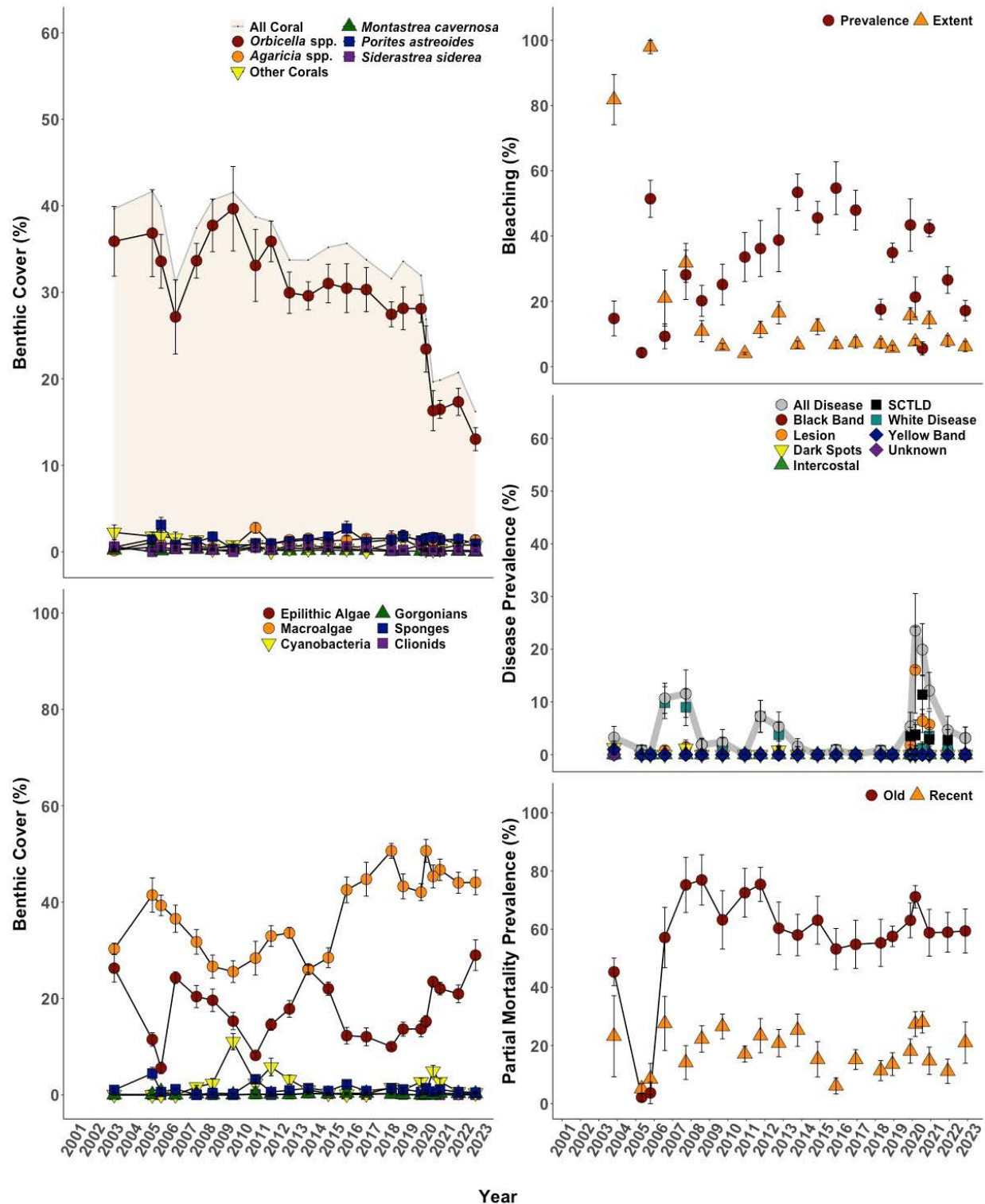


Figure 130. College Shoal benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: COLLEGE SHOAL EAST

Fish Community. College Shoal is characterized by a high overall fish abundance and diversity, and an especially high planktivore biomass. Large planktivorous species including ocean triggerfish, Atlantic spadefish, black jacks, and yellowtail snapper contribute to this biomass, as well as large schools of the smaller creole wrasse and boga. The mesophotic, high coral cover reef supports more herbivores than the deeper Hind Bank FSA and Grammanik Bank FSA sites. This guild is split equally between the common parrotfish species (princess, striped, redband, stoplight and queen) and the blue tang and ocean surgeonfish. Piscivores have a relatively high relative biomass as well, made up primarily of jacks, mackerels, barracuda and large snappers. Invertivores are diverse but contribute much less biomass to the community composition, College Shoal lies within the Marine Conservation District (MCD) and is protected year round from all fishing. Nassau, yellowfin, and yellowmouth grouper are occasionally observed on the site and tiger grouper are seen there regularly.

SITE SUMMARIES: COLLEGE SHOAL EAST

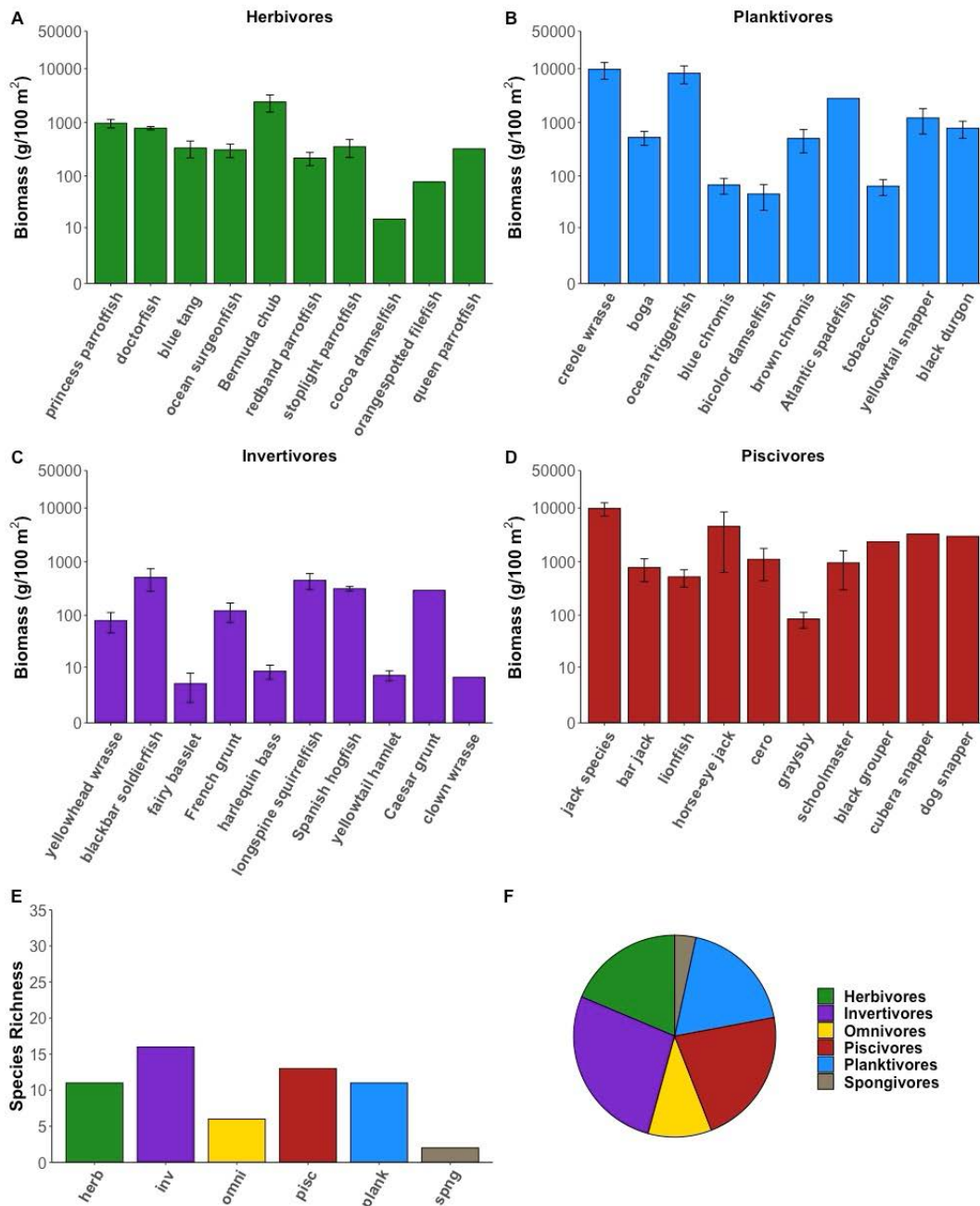


Figure 131. The College Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: FLAT CAY

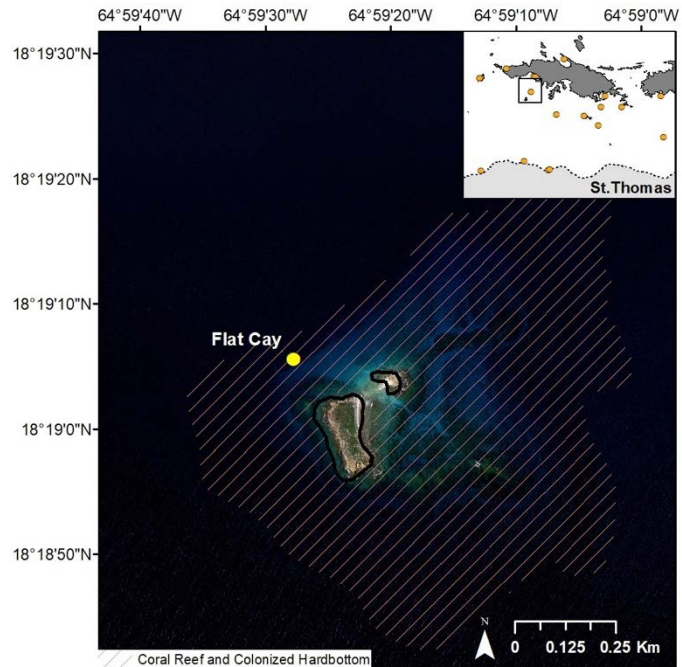
FLAT CAY

Description. This monitoring site wraps around the northwest corner of Flat Cay in depths of 10 – 17 m. Flat Cay has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera fish poisoning study with monthly to quarterly sampling occurred from 2009-2021.

Outstanding Feature. Flat Cay supports a lush coral community, including dense populations of the endangered elkhorn and staghorn corals (*Acropora* spp.) outside the TCRMP monitoring site. The site is a popular tourist dive site and is an important site for research by local and international investigators.

Threats. Flat Cay is down current of industrial port activities and a major sewage outfall. Mollusks, including the commercially important queen conch (*Strombus gigas*) show sterility (imposex) as a likely result of exposure to hormone mimics released from boat hulls coated with marine antifouling paint containing Tributyltin (Strand et al. 2009). The area experiences heavy fishing and damage from anchoring within the reef. This site was the first location where SCTLD was discovered in the USVI (December 2018).

Figure 132. Flat Cay. (top) Location. (right) A representative photo of the reef in 2018. (photo: E. Kadison)



SITE SUMMARIES: FLAT CAY

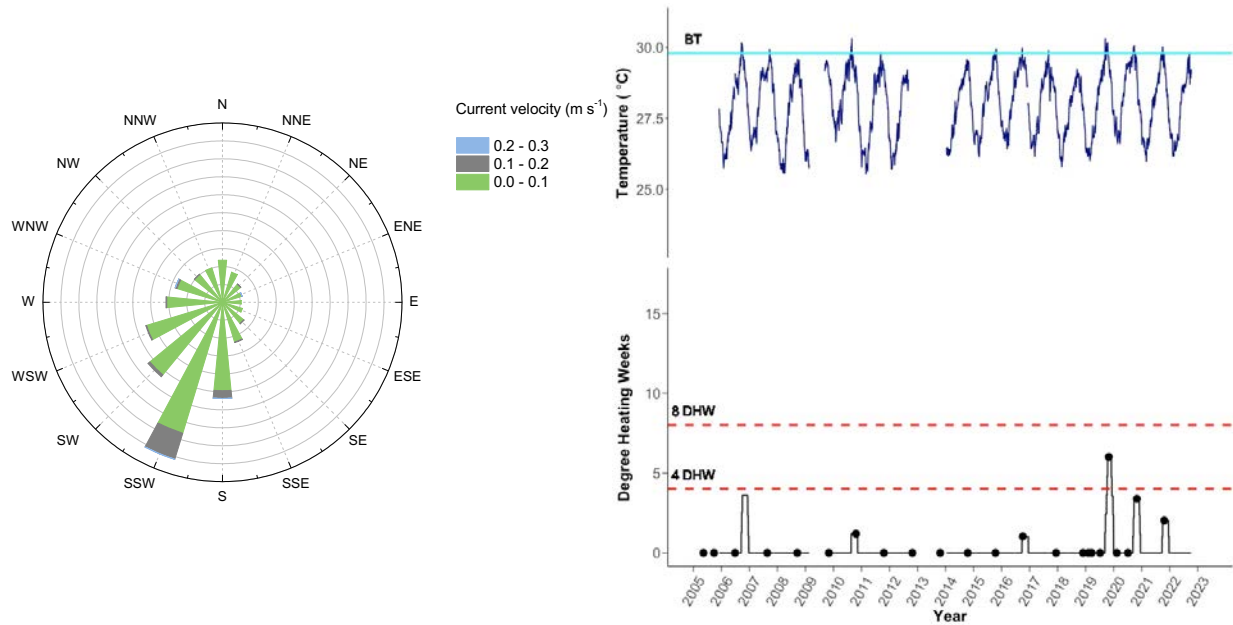


Figure 133. Flat Cay benthic current speed (left) and temperature record (right) (14 m depth).

Physical Characteristics.

Current. The benthic current at the Flat Cay site is weak and dominated by a south-southwesterly flow. This may be an effect of the wrapping of the generally westward and occasionally strong surface current. Currents were measured with an Aandaraa 2-D current meter measuring 1m above the seafloor.

Temperature. Flat Cay experiences moderate warming for a shallow water site and rapid cooling with the passage of tropical storms.

SITE SUMMARIES: FLAT CAY

Benthic Community. Flat Cay supports a diverse coral community with dominance of boulder star corals (*Orbicella* spp.). The sessile epibenthic animal community also shows a high abundance of sponges. The site lost a moderate 21.9% of cover in the 2005 bleaching event and had regained 159.3% of this cover by 2011. A caveat is that transects were not made permanent until 2007. Impact of 2018-2019 SCTL D were catastrophic, with a decline in coral cover from 23% in 2018 to 7% in February 2020. Effects were particularly severe for *Orbicella* spp.. Since then, coverage at Flat Cay has remained relatively stable at ~7%. Epilithic algae and the macroalga *Dictyota* spp., with lesser amounts of *Lobophora variegata*, dominate the algal community. Sand in pockets between coral also makes up a fair amount of the non-living substrate.

Coral Health. Corals were severely affected during the 2005 coral bleaching event, with over 90% of corals bleached at 100% extent of the colony surface. Bleaching was also moderately prevalent in the 2010 bleaching event, but at low extent. Bleaching was relatively severe in 2019, and this may relate to thermal stress combined with SCTL D stress. Coral diseases, particularly dark spots disease can be very prevalent at Flat Cay. There was an unusual outbreak of black band disease in 2004. This disease is rare at the depths of the Flat Cay site. White disease was somewhat prevalent after the 2005 bleaching. SCTL D and related lesions had a relatively high prevalence in 2019. Old partial mortality increased rapidly after the 2005 bleaching event and has not decreased in the intervening years. Recent mortality can be moderate and is due to a variety of causes.

SITE SUMMARIES: FLAT CAY

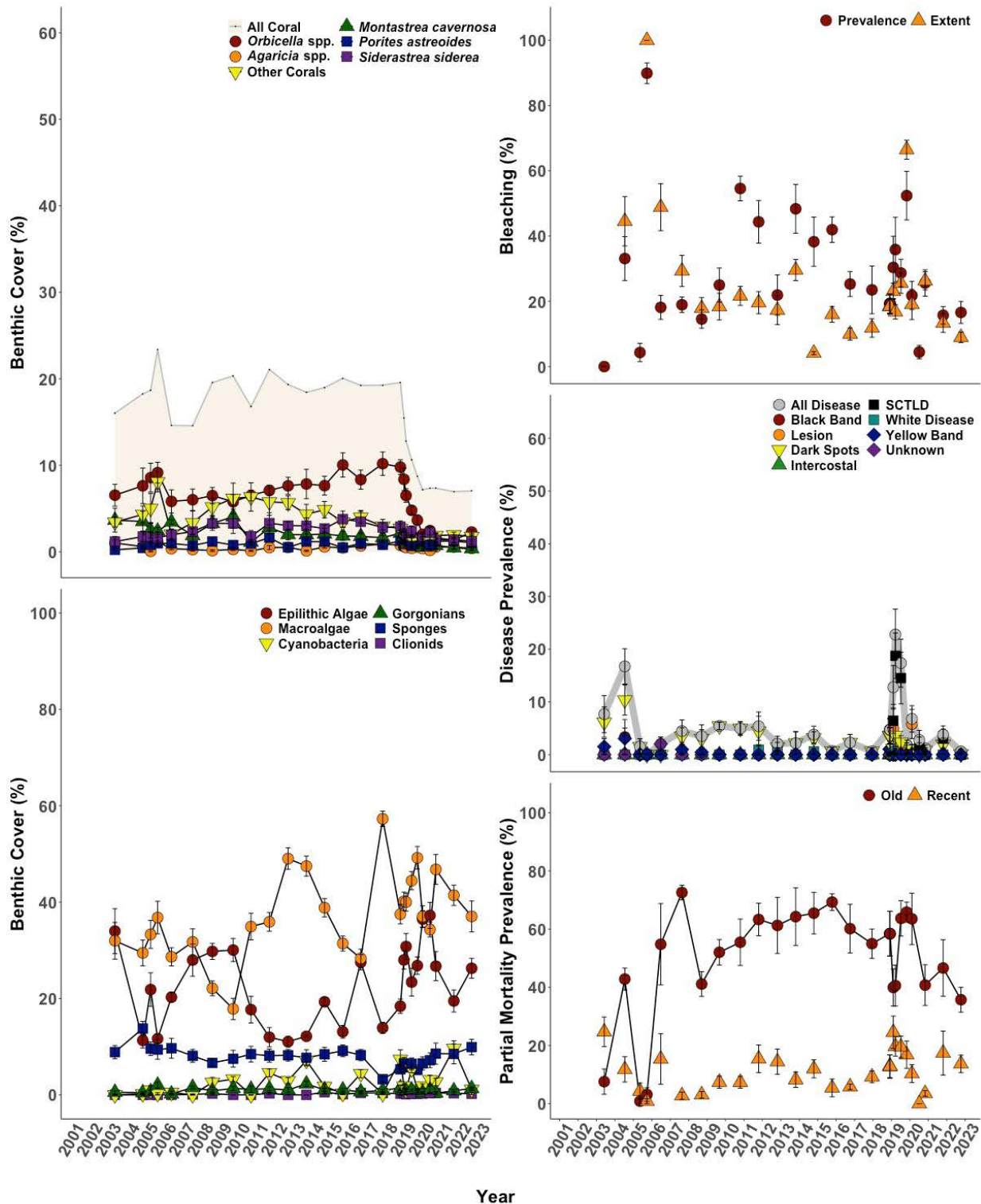


Figure 134. Flat Cay benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: FLAT CAY

Fish Community. Flat Cay is characterized by a large diversity of fish evenly distributed across trophic guilds. There is generally a high biomass of planktivores due to relatively high densities of yellowtail snapper and large schools of chromis and creole wrasse. Invertivores are very diverse and common, reflecting the huge variety of resources available in the sand and hard bottom bordered reef community. Herbivores make a relatively moderate contribution to community composition and are equally represented by the common parrotfishes and acanthurid species. Schools of tiny juvenile parrotfish are prevalent mixed with yellowhead wrasse and juvenile acanthurids across the reef. A variety of jacks frequent the site and dominate the piscivore trophic guild. Very occasional large groupers (Nassau, yellowfin, black) have been observed on Flat Cay over the past nine years. The occurrence of black grouper in 2017 is notable; this species is extremely rare throughout the territory. In 2018 three subadult Nassau grouper were found on the site. Where the reef meets the seaward sand plain, large schools of white, French and blue-striped grunts, as well as gray snapper, squirrelfish, and goatfish swim. Small reef sharks are seen out over the sand regularly and in 2018 a hammerhead was observed cruising the edge of the reef. The Flat Cay reef is heavily used as a recreational dive site and spearfishing occurs there regularly.

SITE SUMMARIES: FLAT CAY

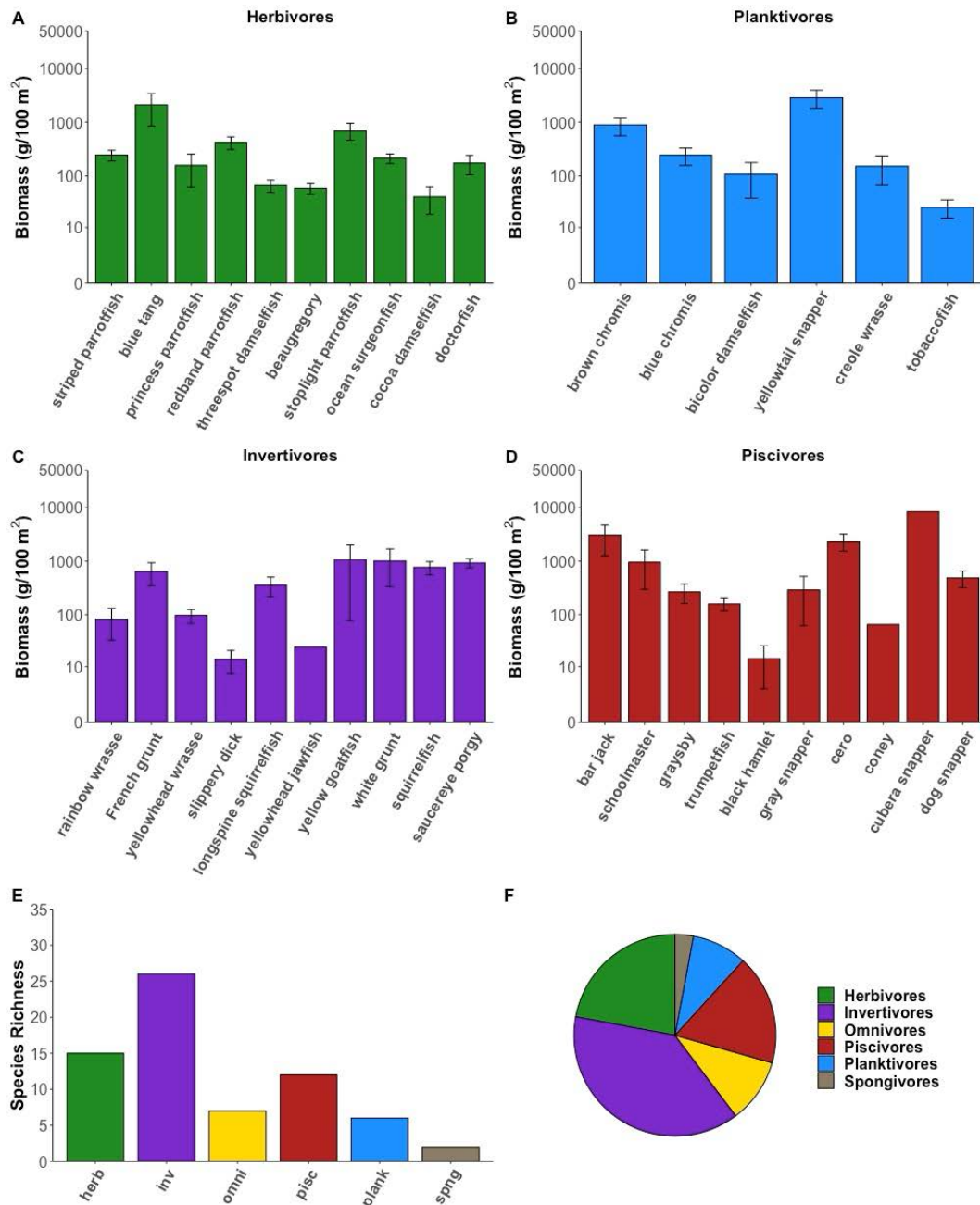


Figure 135. The Flat Cay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: GINSBURGS FRINGE

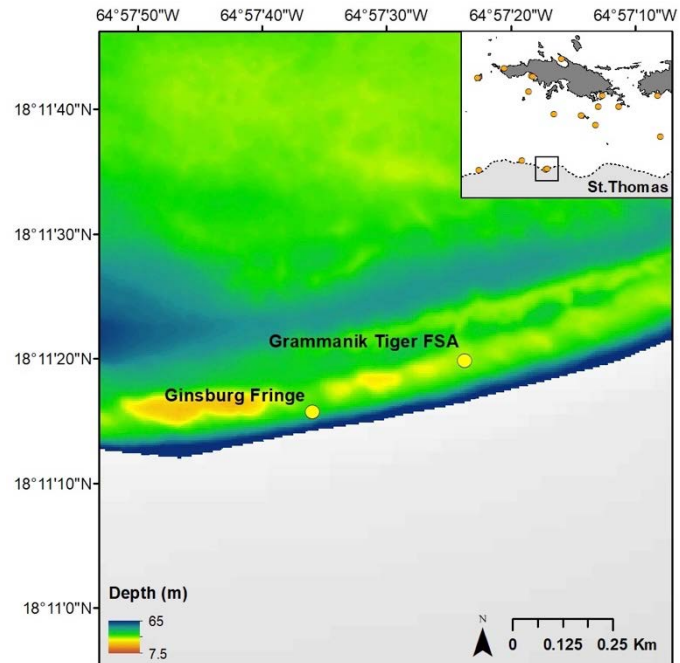
GINSBURGS FRINGE

Description. Ginsburgs Fringe is a lower mesophotic lettuce coral (*Agaricia undata*.) reef at depths of 60-75 m (established in 2011). The reef is on a steep escarpment dropping into the abyssal Virgin Islands trough.

Outstanding Feature. Ginsburgs Fringe had the highest 2011 coral cover among all TCRMP monitoring sites (44%), with living colonies of lettuce corals over 6m (20') wide. Coverage has declined dramatically since then however, dropping over 85%. In 2022, total coral cover was estimated to be only around 5%. This site is the epicenter of a multispecies fish spawning aggregation, including the threatened Nassau grouper (*Epinephelus striatus*). The site name honors the father of comparative sedimentology and mesophotic coral studies, Dr. Robert N. Ginsburg.

Threats. Although little is known about conditions in deep mesophotic lettuce coral reefs, Lettuce corals at these depths are potato chip thin at edges and fragile. Reef claw-type anchors appear to be responsible for a 50% drop in coral cover in the last few years. The site is being heavily invaded by red lionfish (*Pterois volitans*).

Figure 136. Ginsburgs Fringe. (top) Location. (right) A representative photo of the reef showing whorled lettuce coral colonies up to 7m in width in 2018 (Photo: V. Brandtneris).



SITE SUMMARIES: GINSBURGS FRINGE

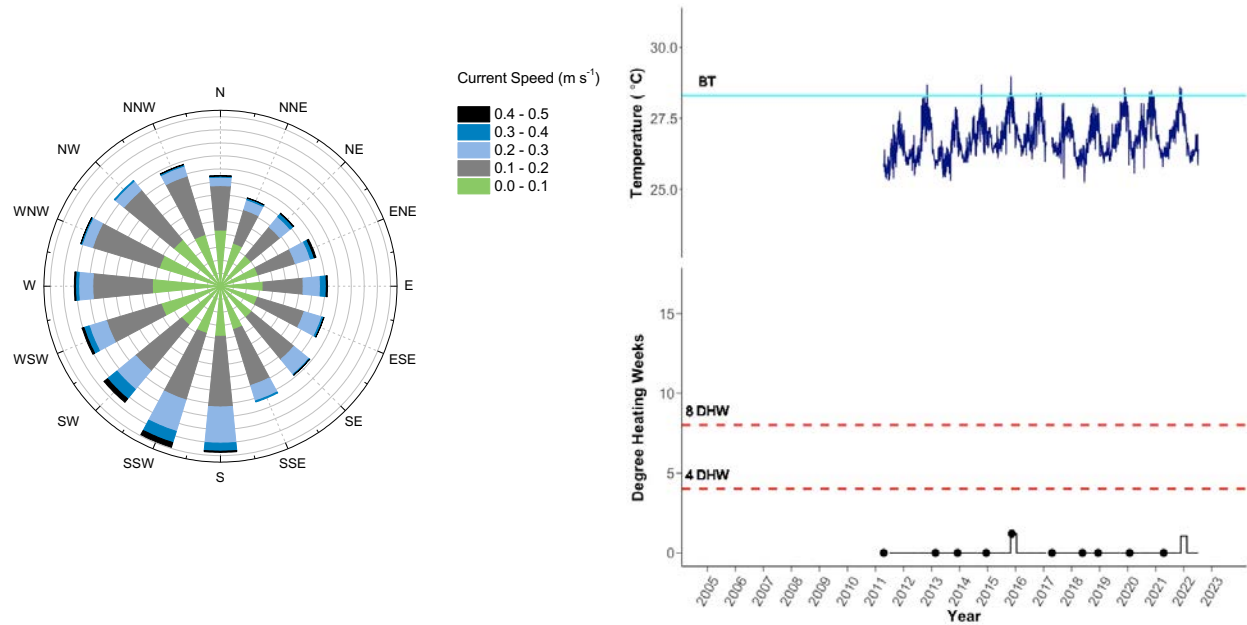


Figure 137. Ginsburgs Fringe current speed (50 m depth) and benthic temperature (63 m depth). BT = bleaching threshold ; DHW = degree heating weeks.

Physical Characteristics.

Current. Currents have been measured above the site in 50 m depth. There is a strong offshelf-downwelling (southward) that occurs just above the site, potentially carrying larvae and heterotrophic food supplies to the site.

Temperature. Temperatures are much cooler at Ginsburgs Fringe than any other TCRMP site, but still quite suitable for healthy Caribbean stony corals. There is no established empirical bleaching threshold for Ginsburgs Fringe. The site showed bleaching in 2012 (Smith et al. 2016a), suggesting it was above at least 4 DHW. Since this is not reflected in the modeled DHW, it suggests that the bleaching threshold is lower than predicted.

SITE SUMMARIES: GINSBURGS FRINGE

Benthic Community. The coral community at Ginsburgs Fringe is almost exclusively lettuce corals of the genus *Agaricia*; in particular, *Agaricia undata* comprises > 90% of the coral cover. *A. grahamae* and *A. lamarcki* are also commonly found at this site, while *A. agaricites* and *A. fragilis* have not been recorded on the transects. These species identifications are tentative however, as voucher specimens have not been collected. Although not well represented in cover, individual colonies of *Montastraea cavernosa* and *Siderastrea siderea* also occur at the site. The site has experienced extreme loss of 88% of its relative coral cover, likely due to anchoring (Smith et al. 2019b) but also more recently potentially from bleaching and disease. The algal community is dominated by the macroalga *Lobophora variegata*, which is surprising for these depths, and epilithic algae. Crustose coralline algae are also in high abundance, as well as a variety of unidentified algal species, including what appears to be *Peyssonnelia iradescens* (Ballantine and Ruiz 2010).

Coral Health. Coral health is not directly monitored at Ginsburgs Fringe due to the depth and difficulties assessing colonies greater than 3m width. However, some observations have been made. What appears to be warm season bleaching has been observed (Smith et al. 2016a; Smith et al. 2019b). Colonies have a fair degree of partial mortality and recent mortality is very common. In some cases, it appears that shaded colony portions die back due to lack of light. The corallivorous snail, *Coralliophila abbreviata*, has been observed feeding on lettuce corals.

SITE SUMMARIES: GINSBURGS FRINGE

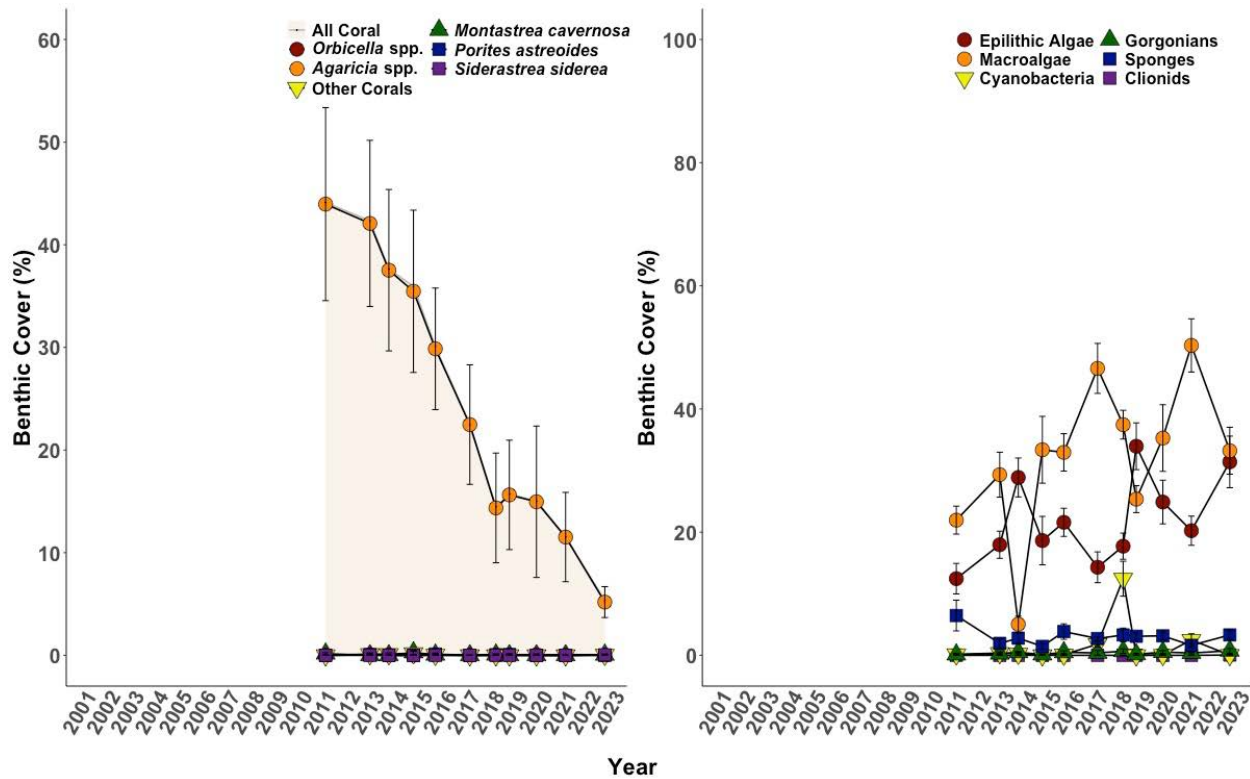


Figure 138. Ginsburgs Fringe benthic cover through time (mean $\pm$ SE).

SITE SUMMARIES: GINSBURGS FRINGE

Fish Community. Fish abundance, biomass and diversity are low on Ginsburgs fringe, the deep mesophotic lettuce coral reef. Herbivores are in notably low abundance and piscivores make up the bulk of fish biomass encountered. Blackfin snapper, a deeper water species, are the most common piscivore. Dog snapper are occasionally observed, and in 2018 a yellowmouth grouper was seen on a transect. A deeper water silk snapper (*Lutjanus vivanus*) was even seen at the site in 2022. In 2016 lionfish were abundant on the deep water shelf edge site. They were not observed in the following two years, however only four transects were completed each year. Deep-water fishes, including cherubfish and sunshinefish are found on Ginsburgs Fringe in addition to the blackfin snapper. During the grouper spawning aggregation period in the winter and spring months, large groups of Nassau and yellowfin grouper have been observed spawning over the reef at depths between 46-65 m. Historically, black grouper were caught off this reef in the spawning season, but they have not been observed spawning here in the last 25 years (Edmond Bryan, commercial fishermen).

SITE SUMMARIES: GINSBURGS FRINGE

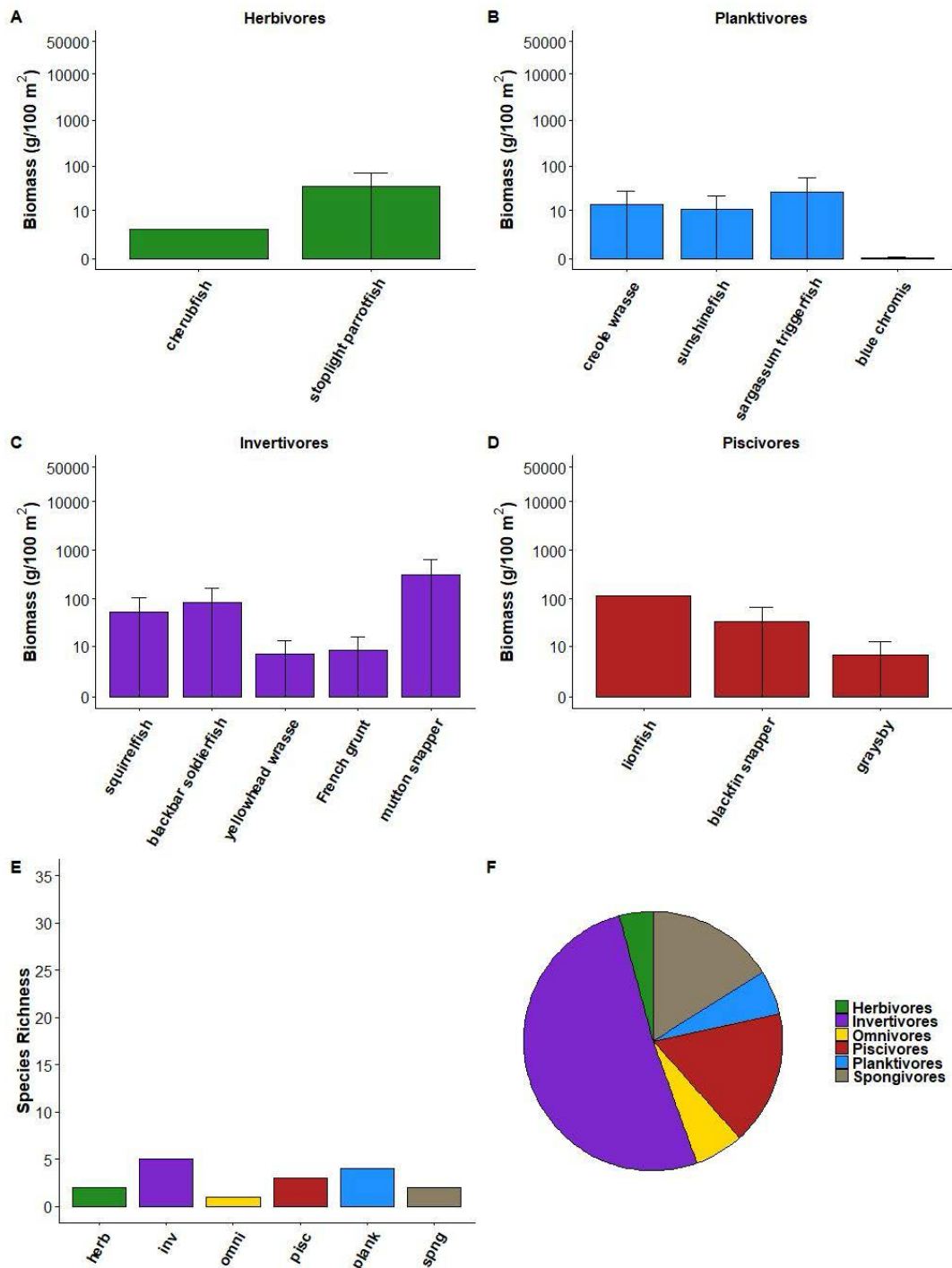


Figure 139. The Ginsburgs Fringe fish community in 2019 as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: GRAMMANIK TIGER

GRAMMANIK TIGER

Description. The Grammanik Tiger monitoring site is a primary bank mesophotic reef in depths of 37 – 41m. Star corals (*Orbicella* spp.) dominate the reef structure. Grammanik Tiger has been monitored since 2003, with permanent transects installed in 2007.

Outstanding Feature. The Grammanik Tiger monitoring site supports a dense coral community that is a staging area for annual multi-species fish spawning events, including the threatened Nassau grouper (*Epinephelus striatus*).

Threats. Although the Grammanik Tiger site and surrounding dense reefs are somewhat buffered from high thermal stress, but they are susceptible to chronic coral white diseases. Periodic disease outbreaks follow coral bleaching events. The Indo-Pacific lionfish (*Pterois volitans*) has formed dense populations within the study area and may be affecting native fish populations.

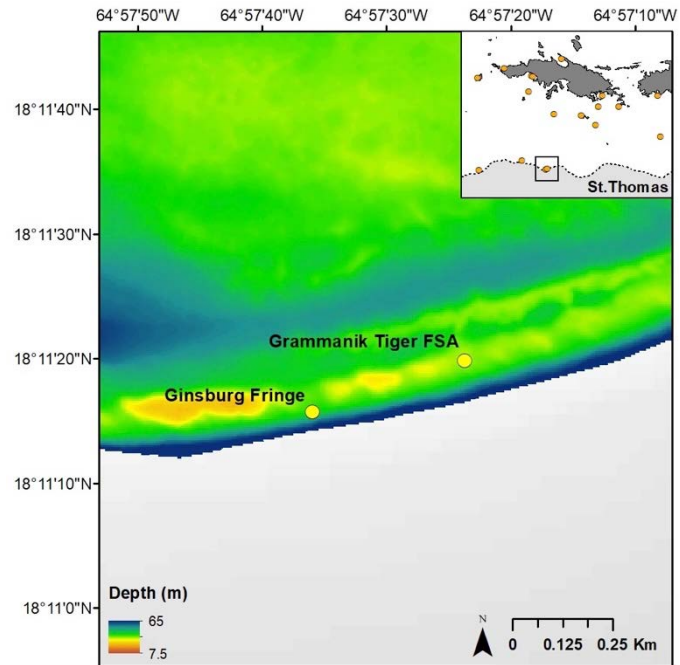


Figure 140.
Grammanik Tiger
(top) Location.
(right) A
representative
photo of the reef
in 2019. (photo:
V. Brandtneris)



SITE SUMMARIES: GRAMMANIK TIGER

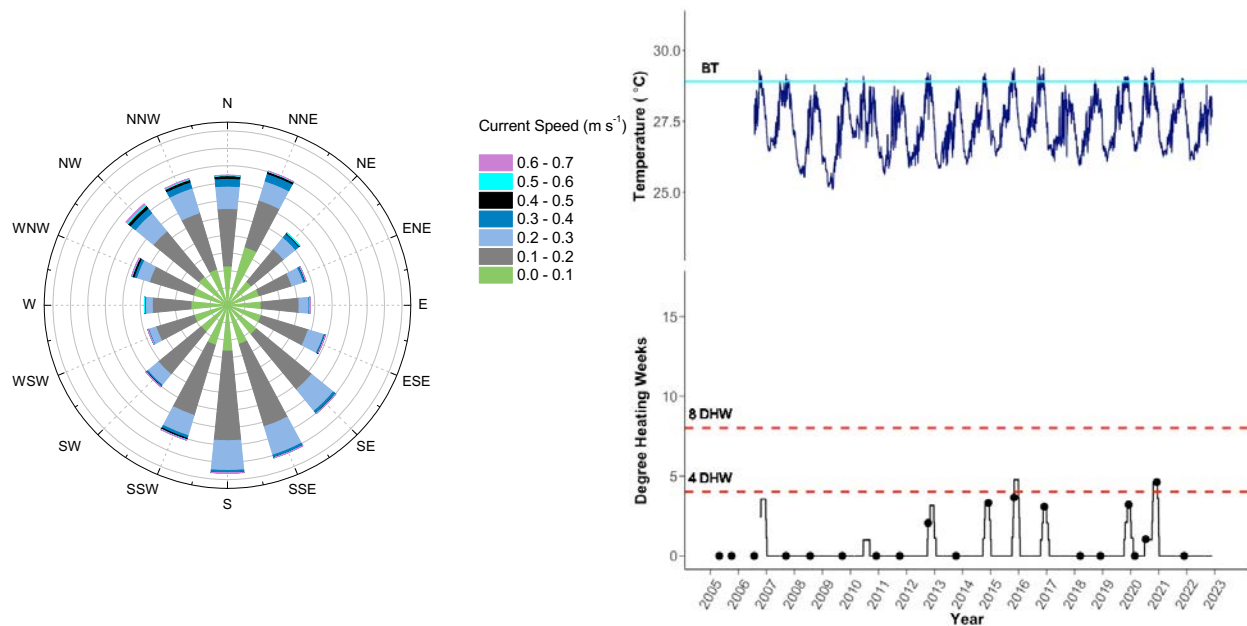


Figure 141. Grammanik Tiger benthic currents speed and temperature record (38 m depth).

Physical Characteristics.

Current. Unidirectional benthic currents at the Grammanik Tiger site are generally north-south, with the strongest current from the north-northeast to the northwest. Currents are typically weak to moderate, but occasionally reach strengths greater than 30cm s⁻¹. Current speeds are based on near-continuous ADCP deployments from February 2005 to April 2009, with measurements at 30 or 60 minute intervals.

Temperature. Benthic temperatures at Grammanik Tiger are ameliorated by the passage of tidally driven internal tides in the warm season (May-November). Inter-annual variability creates temperatures that can be up to 2°C different for the same Julian Day. The Grammanik Tiger site is a prime example of how cooler temperatures at depth decrease the coral bleaching threshold by acclimation and lead to potential bleaching even in moderate temperatures relative to shallow reefs (Smith et al. 2016a).

SITE SUMMARIES: GRAMMANIK TIGER

Benthic Community. Boulder star corals (*Orbicella* spp.) dominate the coral community of the Grammanik Tiger site; however, there is representation by a high number of other species that are also present in shallow water reefs. Grammanik Tiger lost only 5.4% of its coral cover in the 2005 bleaching event but had not regained any cover (-129.6%) by 2011. A caveat is that transects were not made permanent until 2007. SCTLD first appeared in February 2020 and relative coral coverage has dropped 28% since then. Other prominent members of the sessile epibenthic animal community are sponges. The macroalga *Lobophora variegata* and epilithic algae dominate the algal community. There are also a relatively high proportion of crustose coralline algae and various other macroalgae species.

Coral Health. Corals at Grammanik Tiger were very affected by bleaching in 2005, but were underestimated in surveys conducted when thermal stress was only about half (4 degree heating weeks) what it eventually reached (Smith et al. 2016a). The 2010 and 2019 bleaching events did not reveal bleaching detectible above background levels. High prevalence of bleaching in normal years is due largely to granular bleaching of *Orbicella* spp., where pigmented spots are surrounded by bleached areas. Coral diseases are very prevalent with high representation of white disease. Yellow band disease was reported at high prevalence in the first years of monitoring. SCTLD and lesions likely associated with SCTLD appeared at the site by February 2020 and had reached almost 20% prevalence by October 2020. Old partial mortality was low but increased rapidly after the 2005 coral bleaching event. Recent partial mortality is relatively high and is caused by disease lesions, predations, and fish bites.

SITE SUMMARIES: GRAMMANIK TIGER

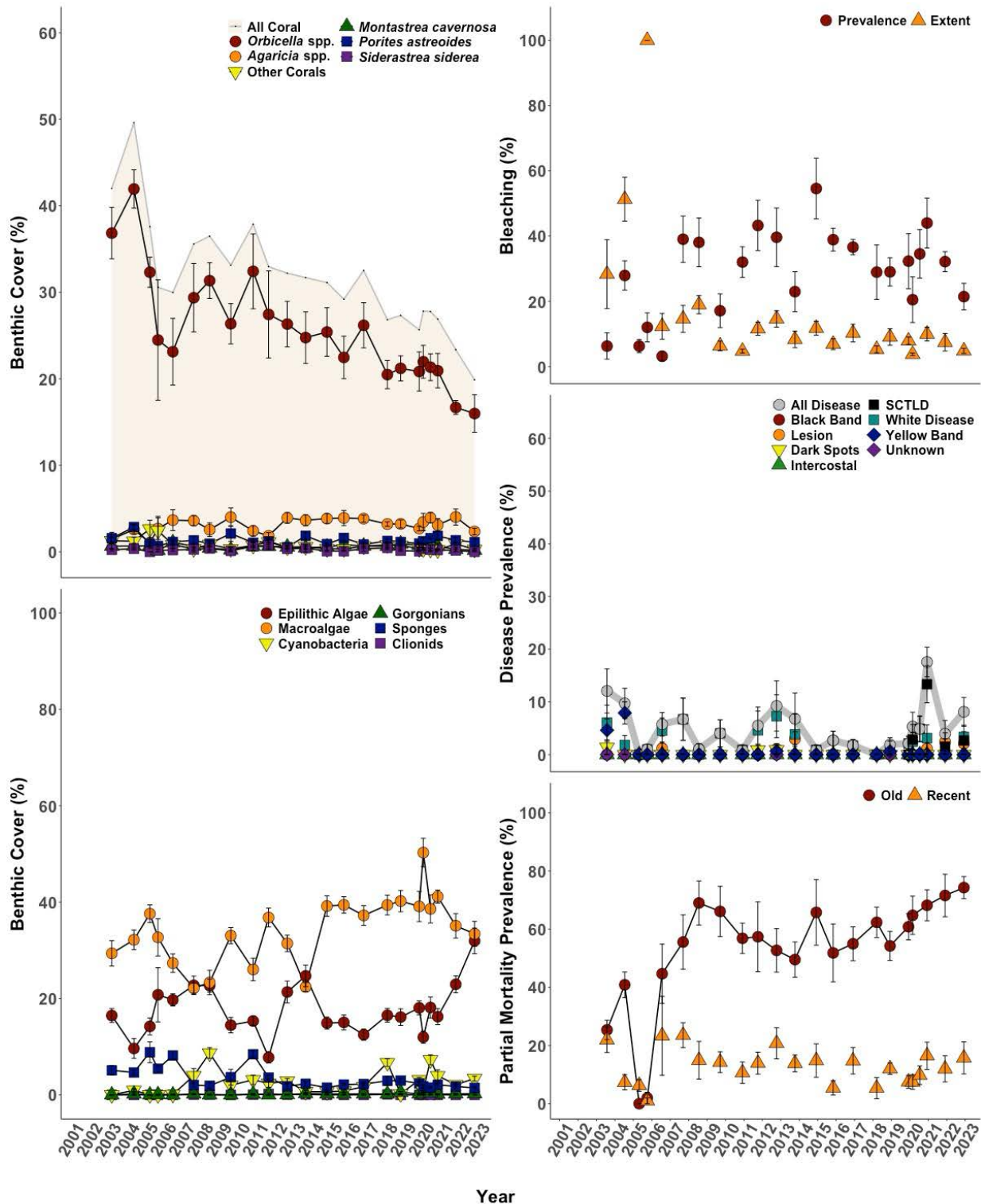


Figure 142. Grammanik Tiger benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: GRAMMANIK TIGER

Fish Community. The Grammanik Tiger site supports less herbivores and a greater number of piscivores than the shallower sites in the TCRMP. It is a staging area for the spawning site of several species of grouper and snapper and is within 0.5 km of that aggregation area. Given the annual range of spawning across multiple species on the site, surveys often coincide with the occurrence of fish aggregations, particularly those species with protracted spawning seasons (e.g., cubera and schoolmaster snapper). This drives up the relative piscivore biomass, however on the Grammanik Bank there are pelagic jacks as well as resident large grouper and snapper that are rarely found on near or offshore reefs of the USVI. Nassau, yellowfin, yellowmouth, and tiger grouper are present during non-spawning periods at the Grammanik Bank. This reef is protected from traps year round, and from all fishing gear from February through April. Sitting on the Puerto Rican shelf edge, with upwelling and strong tidal flow, planktivores dominate the relative community composition. Huge schools of creole wrasse and boga contribute to the large planktivore biomass. Black jacks, black durgelon and yellowtail snapper are also very common on this shelf edge site. The herbivore guild is generally dominated by large adult stoplight parrotfish. During some years the chub is found in small schools on the site, grazing on *Lobophora* and contributing significantly to herbivore biomass. Juvenile parrotfish and doctorfish are relatively uncommon on this and all the northern USVI mesophotic sites. Wrasse are also notably uncommon. In recent years the invasive red lionfish has become very prolific at the Grammanik Bank, with individuals commonly observed on any given dive. Although fishing pressure is low, potential lionfish predators are in relatively high abundance at the site, however they do not appear to be controlling the invasive fish. As well as large groupers and snappers, lemon, Caribbean reef and bull sharks are seen frequently on the reef. Nurse sharks and Nassau grouper have been observed killing and eating lionfish that had been collected to be tagged and were caged under clear nets on the bottom. Predators overturned the nets and ate the lionfish, so there is hope that this behavior occurs without the aid of divers.

SITE SUMMARIES: GRAMMANIK TIGER

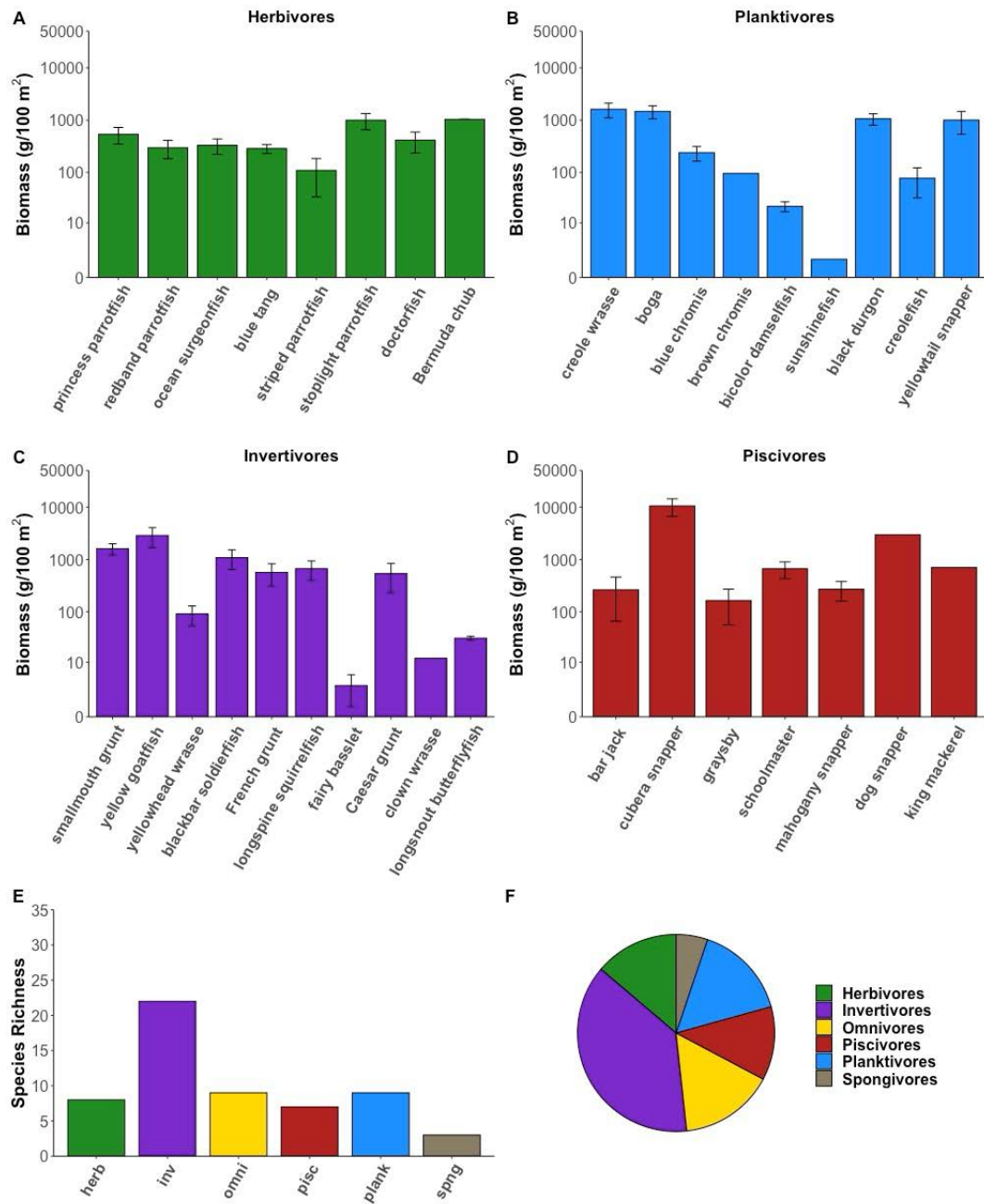


Figure 143. The Grammanik Tiger fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: HIND BANK EAST

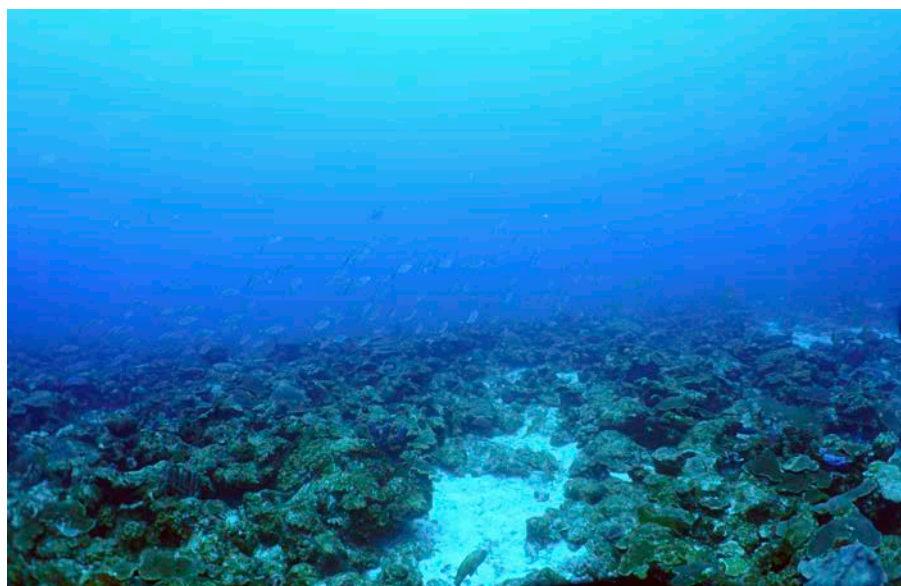
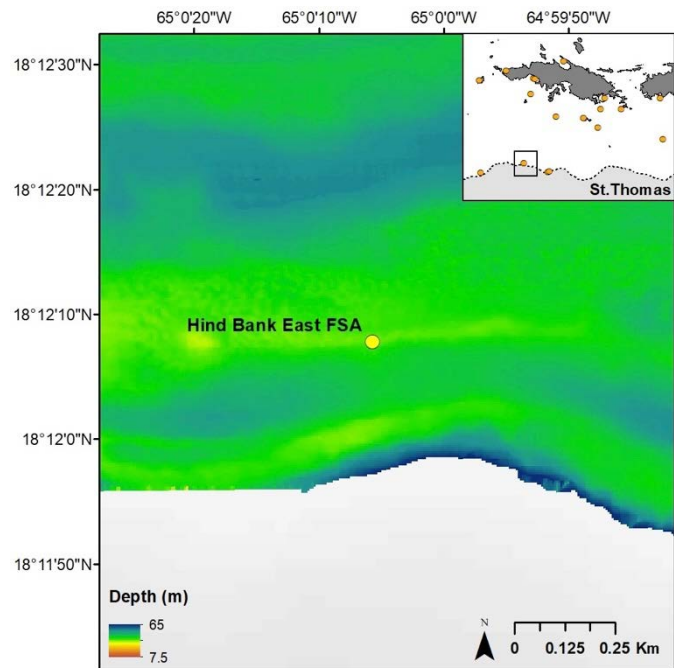
HIND BANK

Description. The Hind Bank is a mesophotic tertiary bank in depths of 38 – 42 m. The reef is part of a patchy complex of star coral (*Orbicella* spp.) dominated reefs that stretch across the eastern Red Hind Marine Conservation District. The Hind Bank has been monitored since 2003, with permanent benthic transects installed in 2007.

Outstanding Feature. The Hind Bank is within a no-take marine reserve and fish populations are recovering and robust. The Hind Bank monitoring site hosts a multispecies spawning aggregation, including a recovering population of the commercially important red hind grouper (*Epinephelus guttatus*).

Threats. The Hind Bank and surrounding dense reefs are somewhat buffered from high thermal stress, but they are susceptible to chronic coral white diseases. Periodic disease outbreaks follow high thermal stress. The Indo-Pacific lionfish (*Pterois volitans*) has formed dense populations within the study area and may be affecting native fish populations.

Figure 144. Hind Bank (top) Location. (right) A representative photo of the reef in 2018 (photo: L. Henderson)



SITE SUMMARIES: HIND BANK EAST

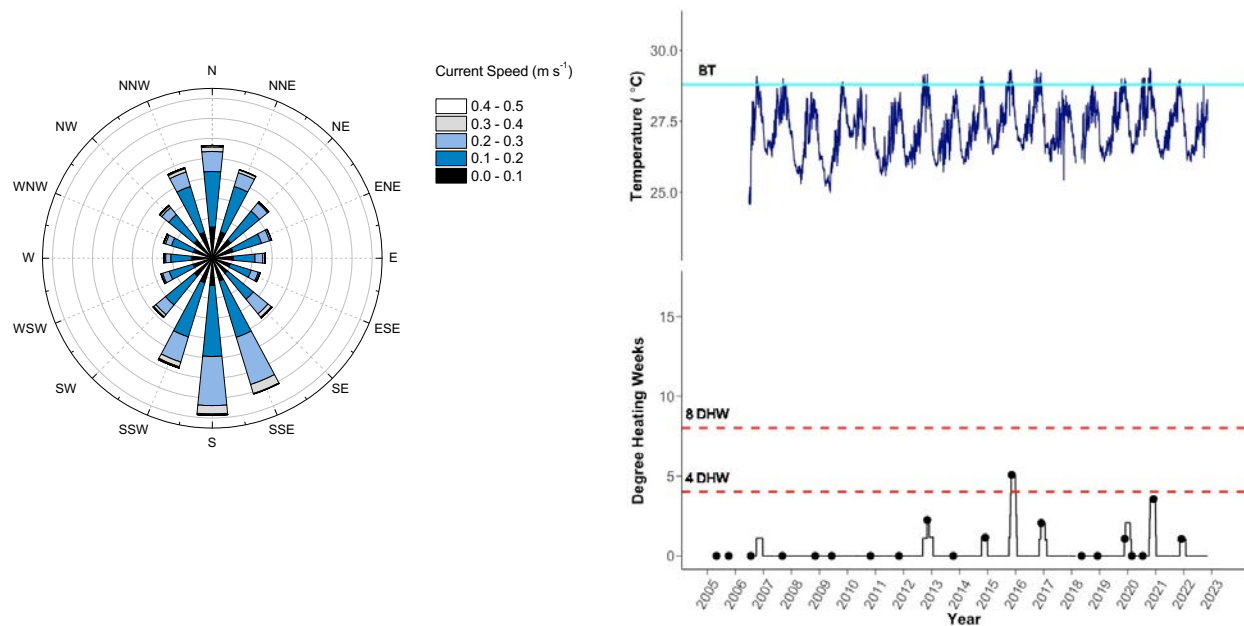


Figure 145. (top) Hind Bank benthic current speed (40m depth). (bottom) Benthic temperature record at 40 m depth.

Physical Characteristics.

Current. Hind Bank has moderately strong unidirectional near-benthic currents that are dominated by a north to south components. Currents can be moderate to strong ($>20\text{cm s}^{-1}$). Current speeds are based on near-continuous ADCP deployments from February 2005 to May 2012, with measurements at 30 or 60 min. intervals. Oscillatory currents are not known from the Hind Bank.

Temperature. Temperatures show much evidence of internal tides in the warm season and are notably cooler than shallow water sites in the upper mixed layer and nearshore embayments.

SITE SUMMARIES: HIND BANK EAST

Benthic Community. The Hind Bank site is dominated by boulder star corals (*Orbicella* spp.), but also has a high abundance of lettuce corals (*Agaricia* spp.). The Hind Bank site lost 21.8% of its coral cover in the 2005 bleaching event, but had regained 71.4% of this cover by 2011. The arrival of SCTLD in 2019 appeared to initiate a further decline of this site, reducing coverage by almost 50% in three years (2019-2022). This was largely driven by the loss of *Orbicella* spp. coverage. The algal community is co-dominated by epilithic algae and the macroalga *Lobophora variegata*. There is also high representation of crustose coralline algae and other unidentified macroalgal species.

Coral Health. Bleaching during the 2005 event was underestimated because sampling occurred before the peak in heat stress. Neither the 2010 nor 2019 events were detected in sampling. In later years, the high prevalence of moderate prevalence, low colony extent bleaching was often associated with granular bleaching. This bleaching pattern shows pigmented spots surrounded by bleached tissue. Coral diseases are somewhat common at the Hind Bank and may be increasing. White disease was the dominant disease, and 2011 showed a peak of disease signs. In 2009 there was a high prevalence of intercostal mortality syndrome, which is only known from mesophotic coral reefs (Smith et al. 2010b). SCTLD had begun to impact the site in 2019. Old partial mortality increased after the 2005 bleaching event and the high prevalence was not reduced until 2011. Recent partial mortality prevalence is often high and reflects the impacts of disease and predation.

SITE SUMMARIES: HIND BANK EAST

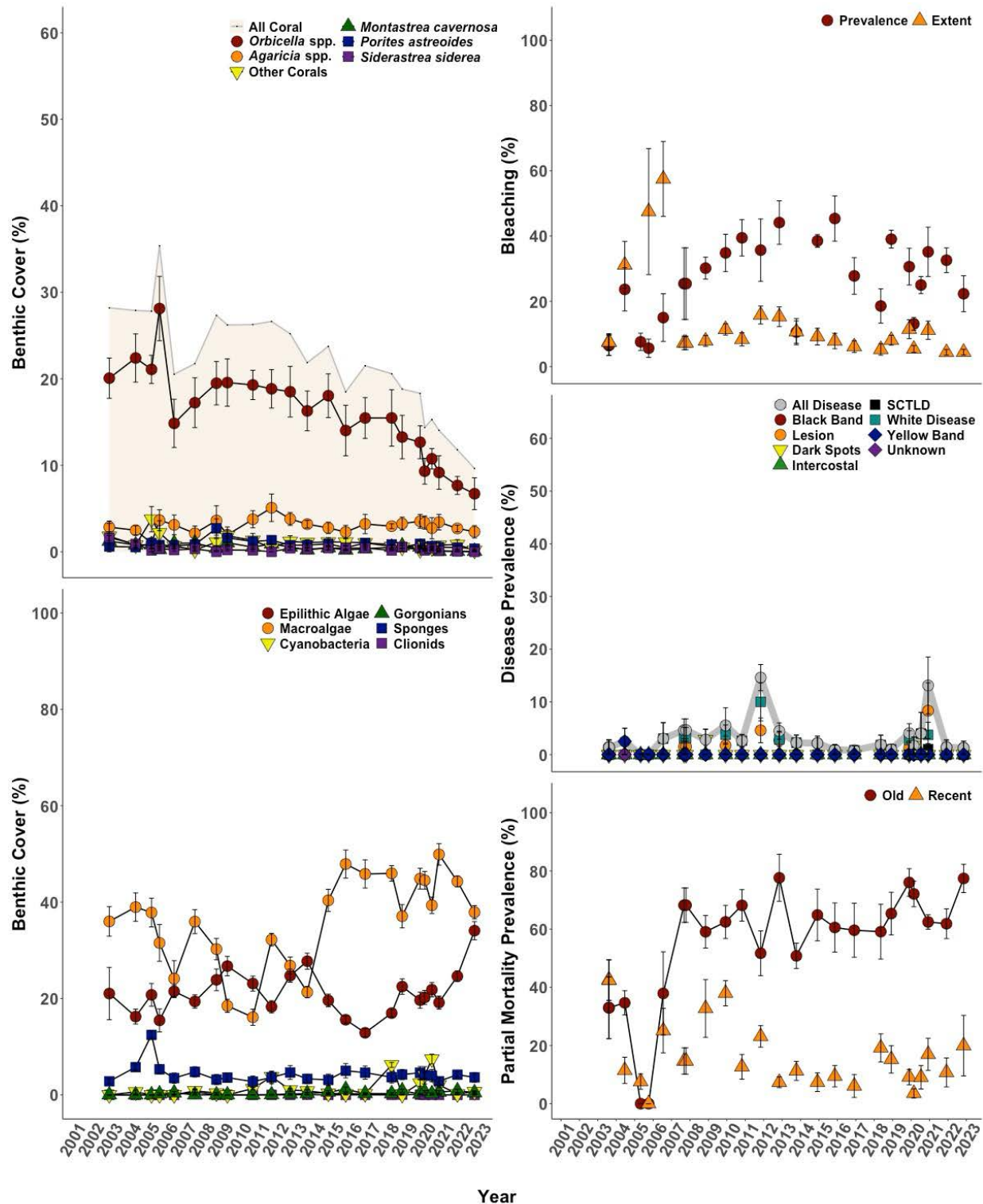


Figure 146. Hind Bank benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: HIND BANK EAST

Fish Community. Like the Grammanik Bank, the Hind Bank is characterized by a high number and biomass of piscivorous fish. The site is within the Marine Conservation District (MCD) and is protected year-round from all fishing, except surface trolling. It is the spawning site for several species including red hind, mutton snapper, tiger grouper, and schoolmaster snapper. It is also a corridor for large snappers and groupers swimming to and from the Grammanik Bank to spawn. Surveys often coincide with the occurrence of schoolmaster snapper, which has a protracted spawning season. Although this drives up the relative piscivore biomass, there are also jacks, large barracuda, and resident groupers and snappers that contribute. Occasional to common large groupers include the Nassau, yellowfin, tiger and yellowmouth. Herbivore biomass is relatively low on the Hind Bank, as on other mesophotic sites. Herbivores are dominated by adult or semi-adult princess, redband and stoplight parrotfish. Queen parrotfish are also commonly observed. Juvenile parrotfish are absent from the site. Benthic invertivores are dominated by blackbar soldierfish, queen triggerfish and goatfish. The site is surrounded by sand and hardbottom areas, supporting a variety of benthic resources for invertebrates. Planktivores observed at the Hind Bank vary with tide and current. Creole wrasse can be seen in large schools or may be absent. Large yellowtail snapper are generally present. Other planktivores found at the Hind Bank include the black jack, black durgon, boga and creolefish. Mesophotic species such as the fairy basslet, sunshinefish, and longsnout butterflyfish are also common. The red lionfish has become a regular resident of the reef and large sharks are seen occasionally.

SITE SUMMARIES: HIND BANK EAST

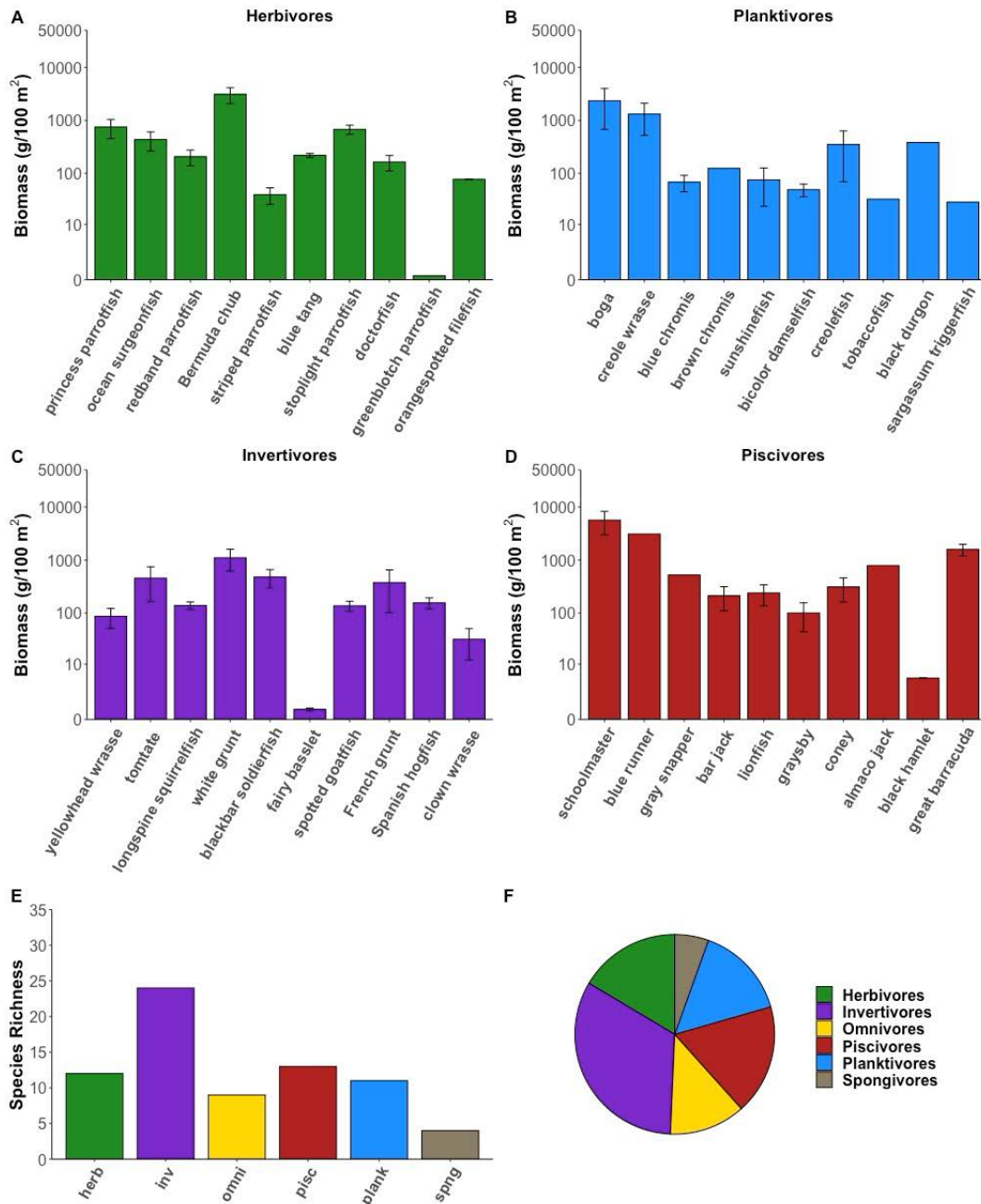


Figure 147. The Hind Bank East fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: LITTLE ST. JAMES

LITTLE SAINT JAMES

Description. The Little St. James site is a midshelf hardbottom reef in depths of 16-22 m. The site is a patch reef surrounded by sand/rhodolith plain. Little St. James has been monitored since 2005, with permanent benthic transects installed in 2007.

Outstanding Feature. The Little St. James site is just outside the St. Thomas East End Reserve and supports occasional high densities of snappers, grunts, and queen trigger.

Threats. Commercial fisherman target the Little St. James site and active and derelict fish traps are in high abundance. The site is down-current of development on Little St. James Island and is potentially threatened by land-based source of pollution.

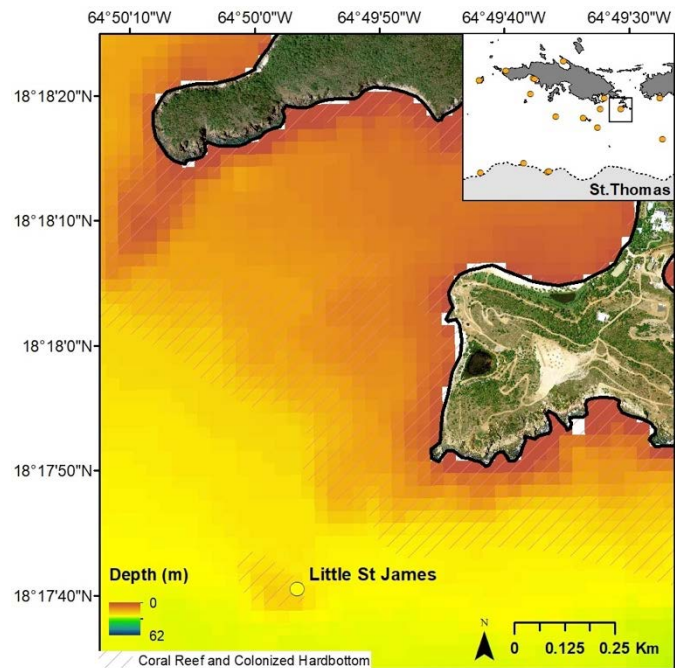


Figure 148. Little St. James. (top) Location. (right) A representative photo of the reef with derelict fish trap



SITE SUMMARIES: LITTLE ST. JAMES

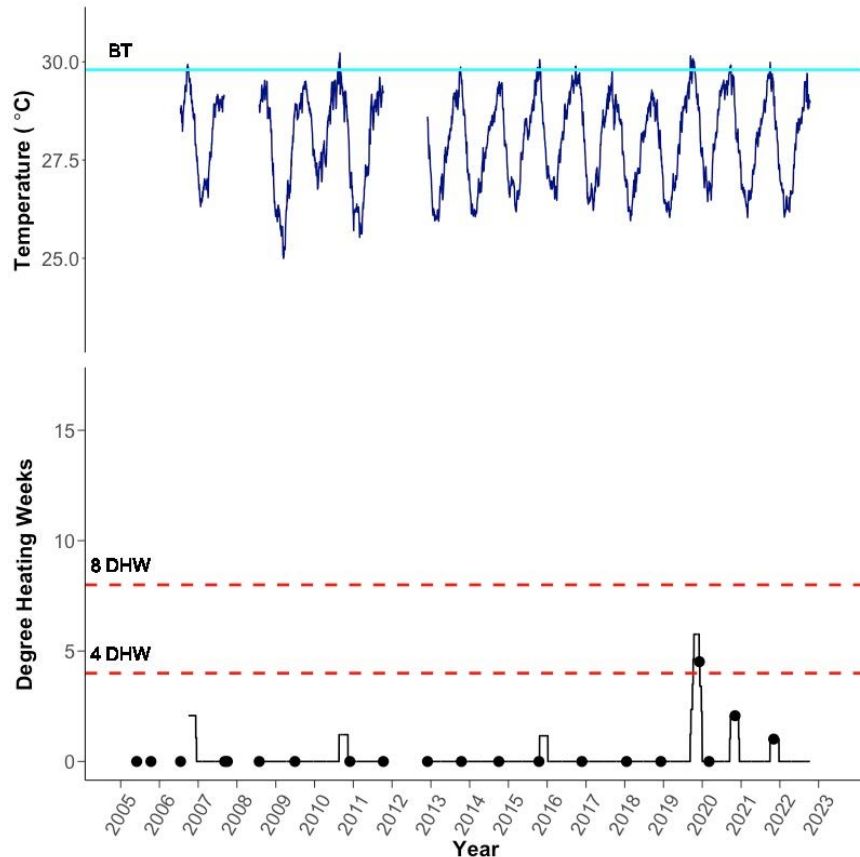


Figure 149. Little St. James benthic temperature record (19 m depth).

Physical Characteristics.

Current. Currents have not been directly measured at St. James. Unidirectional benthic currents have only been weak during monitoring. Strong wave-driven oscillatory currents may take place, as evidenced by the high proportion of gorgonians and *Sargassum* spp. at the site.

Temperature. Benthic temperatures at St. James can be high during warm years, such as 2019.

SITE SUMMARIES: LITTLE ST. JAMES

Benthic Community. The sparse coral community of the Little St. James site is diverse. There is a high proportion of rare species, such as *Eusmilia fastigiatum*, *Madracis* spp., and *Mycetophyllia* spp.. The site lost 16.5% of coral cover in the 2005 bleaching event but had apparently regained 376.2% of this loss by 2011. This large increase above bleaching losses may be explained by the fact that transects were not made permanent until 2007 and were then sited in areas with the densest coral. SCTLD arrived at Little St. James between October 2019 and February 2020 and may be contributing to the gradual decline in cover observed since 2016. The sessile epibenthic community overall is largely composed of sponges and gorgonians. The algal community is dominated by the macroalgae *Dictyota* spp. and the *Sargassum* spp.. *Lobophora variegata* and epilithic algae are also in high proportional abundance.

Coral Health. The coral community at Little St. James was highly affected by the 2005 coral bleaching event, with all corals assessed completely bleached. Half the corals were affected by low extent bleaching in 2010 and about half the corals had moderate prevalence and extent of bleaching in 2019. Low-level bleaching is a common feature of the site, as is low-level disease prevalence. A white disease outbreak preceded the coral bleaching event in June 2005 and dark spots disease can also be common, especially in recent years. Old partial mortality increased rapidly after the 2005 bleaching event. Recent partial mortality is not very prominent.

SITE SUMMARIES: LITTLE ST. JAMES

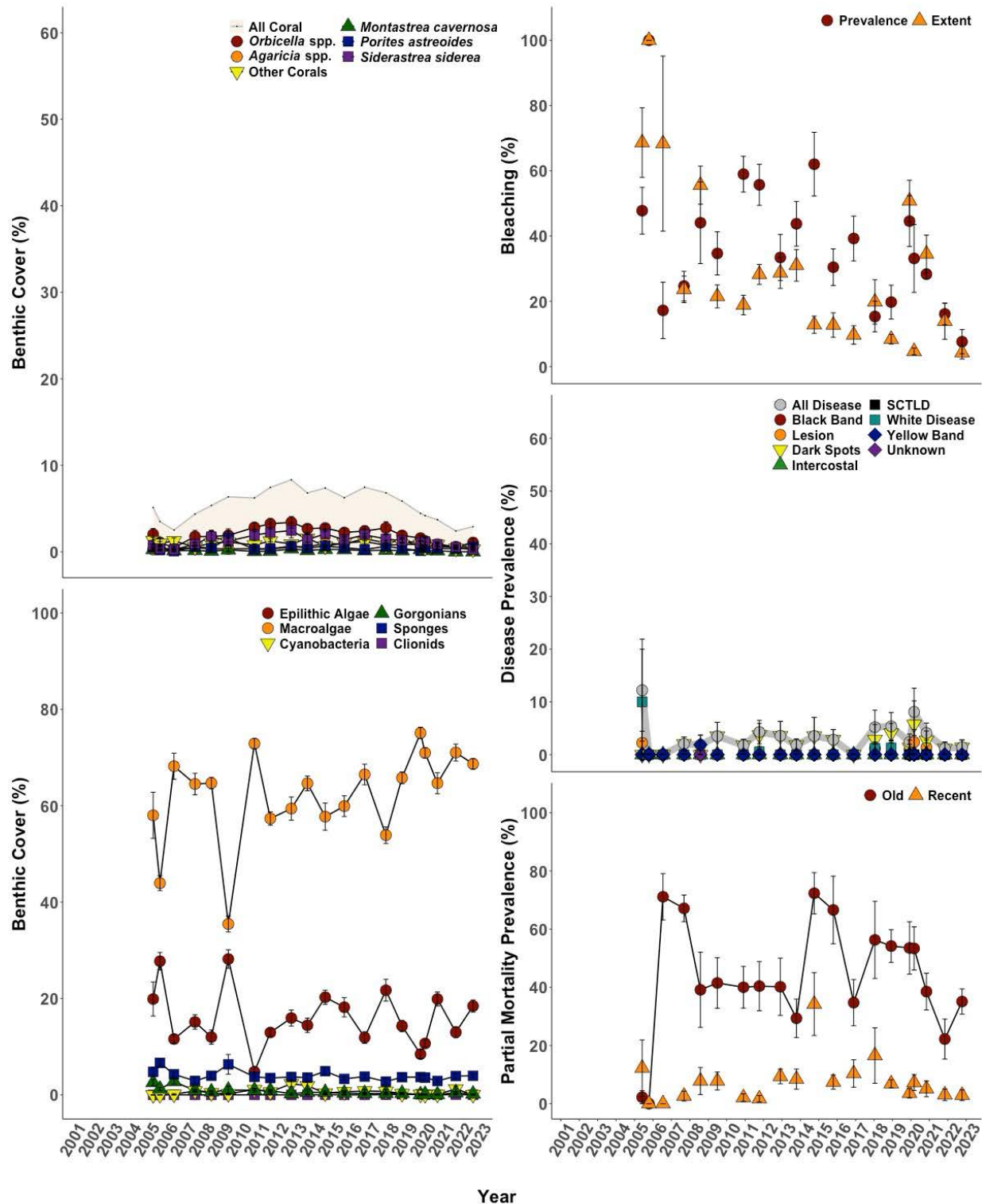


Figure 150. Little St. James benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: LITTLE ST. JAMES

Fish Community. The fish community of Little St. James differs from those of the more developed reef habitats, representing both a coral reef and hard bottom fish community. Queen triggerfish and mutton snapper are far more common on Little St. James than on other TCRMP sites. Large, adult hind and goatfish are also very common. These benthic invertivores are indicative of hard bottom/sandy sites. During parts of the year, grunts (French and white) have been observed in huge numbers and may use the site for spawning. The spongivores (angelfish) are well represented. Bar jacks, yellow jacks and almaco jacks are very common swimming in the water column at the Little St. James site, contributing to the high overall piscivore biomass. Schoolmaster, gray, and mahogany snapper are also common. All six of these species are considered ciguatoxic in this area and are not targeted by hook and line, trap, or spear fishermen. Herbivores are dominated by the tangs and surgeonfish, which swim and graze the site in large mixed schools. Most notable is the abundant queen triggerfish population that are present across a wide size-spectrum. Lobsters are also relatively dense. The Little St. James reef is outside of the boundaries of the St. Thomas East End Reserve and fish traps are observed regularly on the site and are presumably targeting lobster and queen triggerfish.

SITE SUMMARIES: LITTLE ST. JAMES

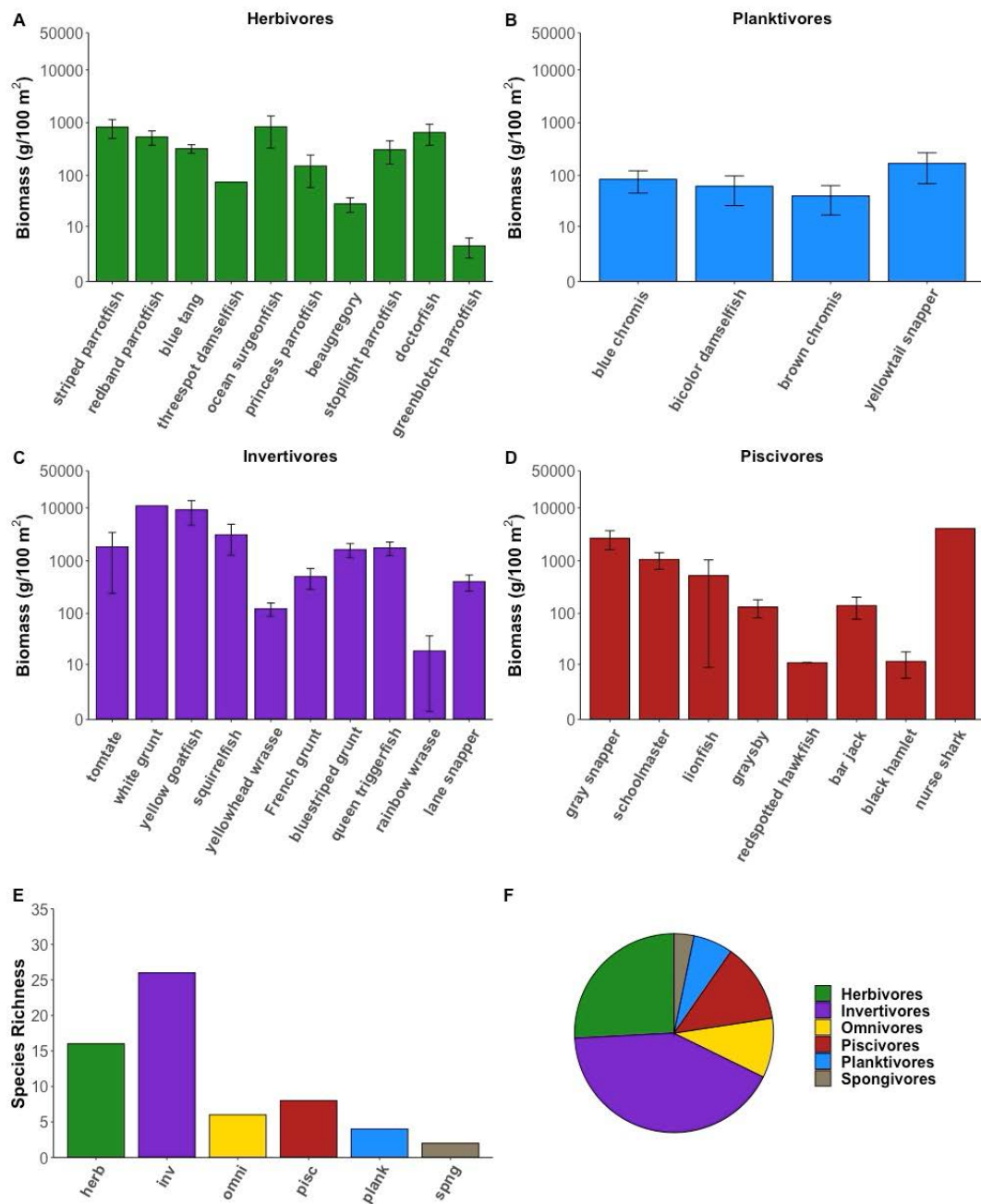


Figure 151. The Little St. James fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: MAGENS BAY

MAGENS BAY

Description. The Magens Bay site is a nearshore fringing reef located along Peterborg Point in depths of 7 – 14 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. Magens Bay has been monitored since 2001.

Outstanding Feature. The Magens Bay site is a well-protected northside St. Thomas reef near one of the most popular tourist beaches in the Caribbean.

Threats. Magens Bay is in a highly enclosed embayment receiving a very large and developed watershed. Sediment run-off is high and deposition on reefs is favored by slow current speeds. The turbidity after rain and swell events can be extreme in the bay and water visibility is often less and 3m. In addition, leaky septic systems may impair bay waters. Recreational/artisanal fishers frequently fish this site with hand line and spear.

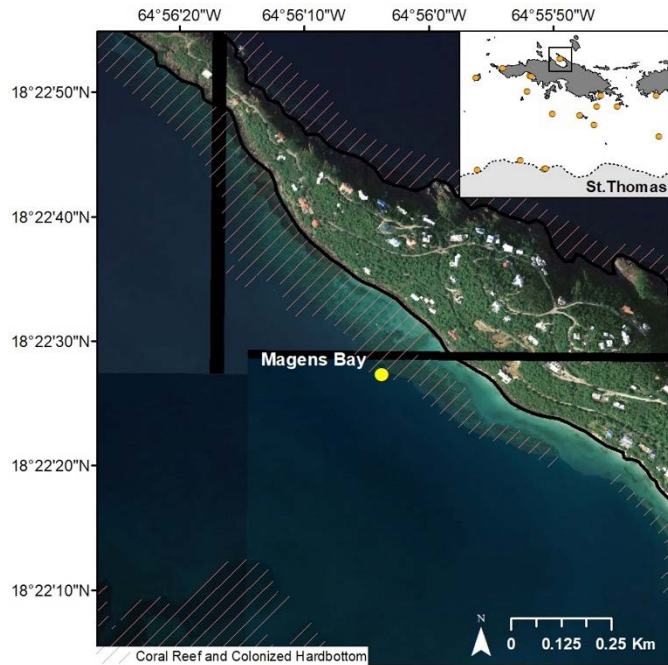


Figure 152. Magens Bay. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: MAGENS BAY

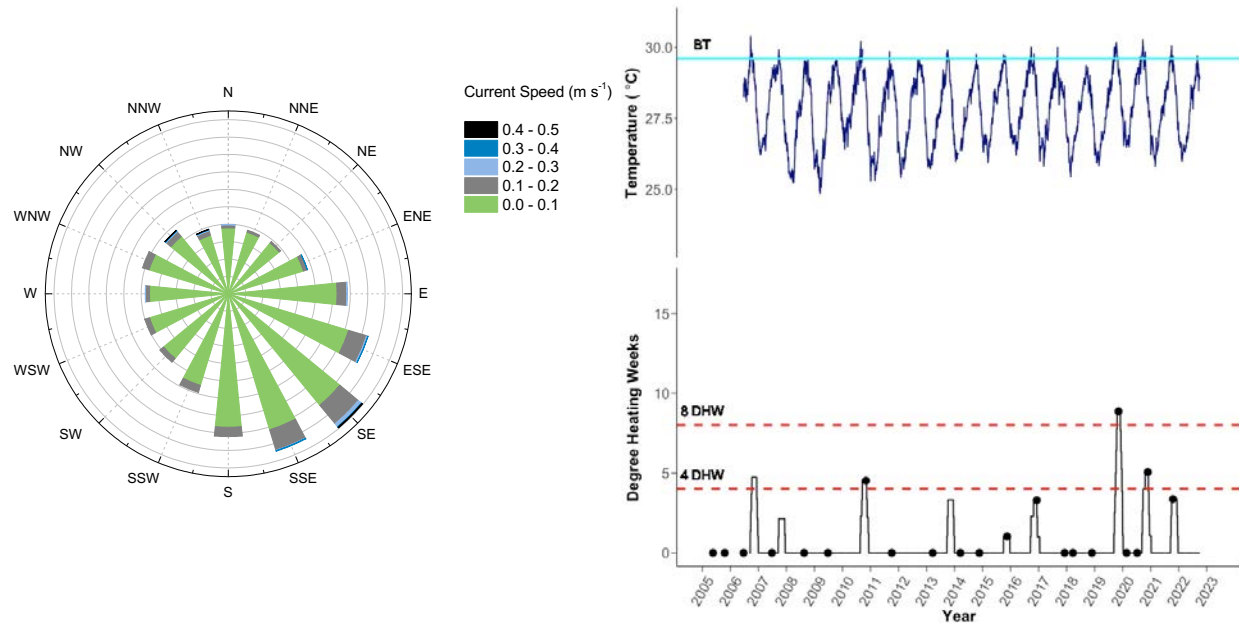


Figure 153. Magens Bay current speed and benthic temperature record (9 m depth).

Physical Characteristics.

Current. Magens Bay has restricted water flow dominated by weak currents running counter or orthogonally to the left of the dominant wind direction. This may indicate that there is a counter flowing eddy. Current data are based on average data from Dec. 2006-Oct. 2007 7.5 m above the sensor head.

Temperature. Magens Bay has low circulation, but temperatures are kept cooler by exposure to the Atlantic. In 2019 and 2020 temperatures surpassed the bleaching threshold and moderate to low bleaching was observed.

SITE SUMMARIES: MAGENS BAY

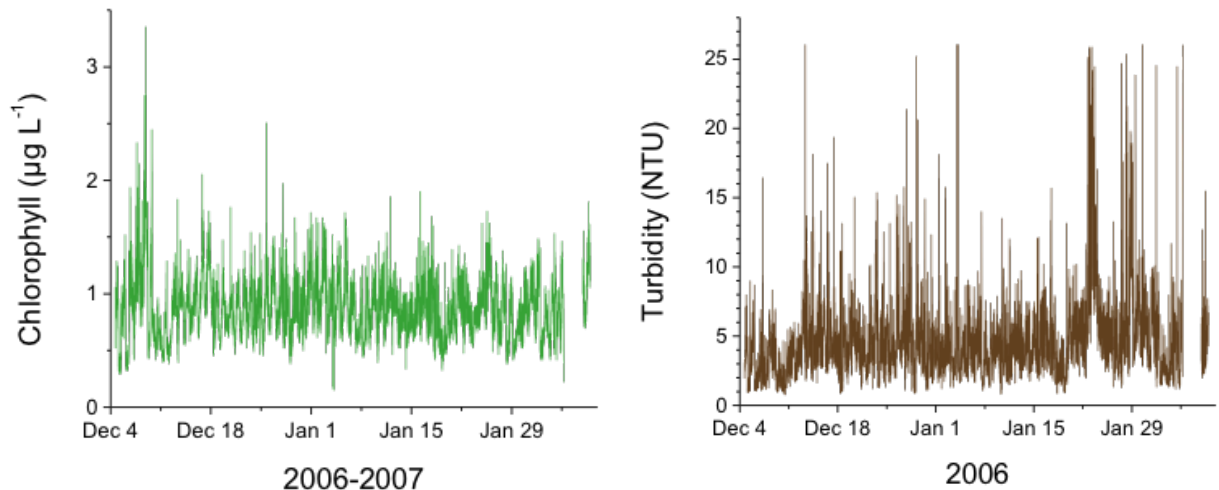


Figure 154. Magens Bay chlorophyll (left) and turbidity (right) record (16 m depth).

Chlorophyll & Turbidity. Magens Bay is susceptible to very high chlorophyll and turbidity values indicating very high productivity that is likely fueled by terrestrial run-off. Turbidity reduces light penetration and reduces the depth limits for coral growth and water column productivity favors heterotrophic organisms, such as sponges and gorgonians.

SITE SUMMARIES: MAGENS BAY

Benthic Community. The sparse coral community at Magens Bay is very diverse, with no real dominance by any one species. The site lost 12.4% of its coral cover in the 2005 bleaching and has continued to lose coral, with a cover loss of 33.1% from 2005 pre-bleaching to 2011. Gorgonians and then sponges dominate the sessile epibenthic community. Epilithic algae and the macroalga *Dictyota* spp. dominate the algal community. Filamentous cyanobacteria are also common. There is a high proportion of sand/sediment around corals at the Magens Bay site.

Coral Health. Corals were highly affected by the 2005 bleaching event, with about 80% of all corals about 80% affected across the colony surface. This site also showed a strong response to the 2010 bleaching event with about 60% of corals bleached at a low extent. In 2019 bleaching was moderate to severe in terms of prevalence and extent. Diseases can be high and are dominated by dark spots disease. SCTLD reached the site between October 2019 and February 2020, but has not spiked to high prevalence and has not had a large impact on the coral cover. Old partial mortality increased after the 2005 bleaching event and then declined, with a slight increase from 2009 to 2011. Recent partial mortality is common at the Magens Bay site, largely as the result of biting by territorial damselfish (*Stegastes* spp.; data not shown).

SITE SUMMARIES: MAGENS BAY

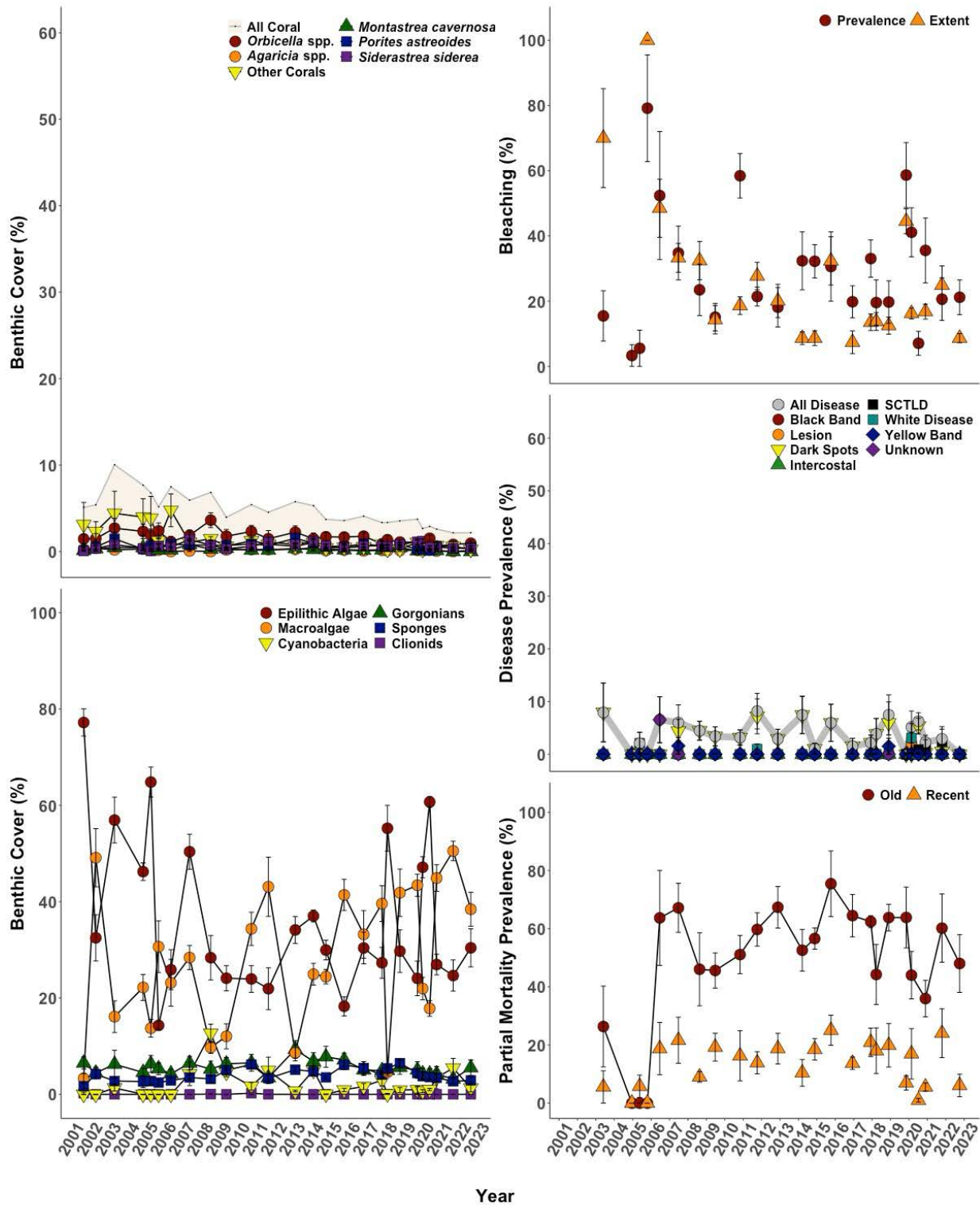


Figure 155. Magens Bay benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: MAGENS BAY

Fish Community. Magens Bay once supported its own rich fishery and was the notorious site of the only fatality by shark attack recorded in St. Thomas (Randall 1963a). The days of large, commercially important fish in Magens Bay have been gone since the 1970's; however, the bay is adjacent to the deep Puerto Rican shelf to the north and large sharks are known to frequent the bay. Tiger sharks are still caught commonly off either point defining the bay to the east or west. Anecdotaly, hammerheads mate in the middle of Magens Bay during one moon phase of the year, and along the mile long sandy beach it is not uncommon to see young of the year reef sharks swimming in the clear water, suggesting that the deep protected bay is the pupping ground for at least one species of shark. Along the reef on the eastern edge of the bay (the TCRMP monitoring site) large fish are rare, and herbivores make up the bulk of the fish biomass. On the reef edge, mahogany and lane snapper are found, along with grunts, goatfish, and larger parrotfishes. The top of the reef holds schools of wrasse mixed with juvenile parrotfish, along with high densities of damselfish (mainly bicolor) and juvenile yellowtail snapper. In 2017 a juvenile Nassau grouper was seen on a transect in Magens Bay. No other large groupers or snappers have been observed there throughout the survey period, although trap fishing does not occur in the bay anymore.

SITE SUMMARIES: MAGENS BAY

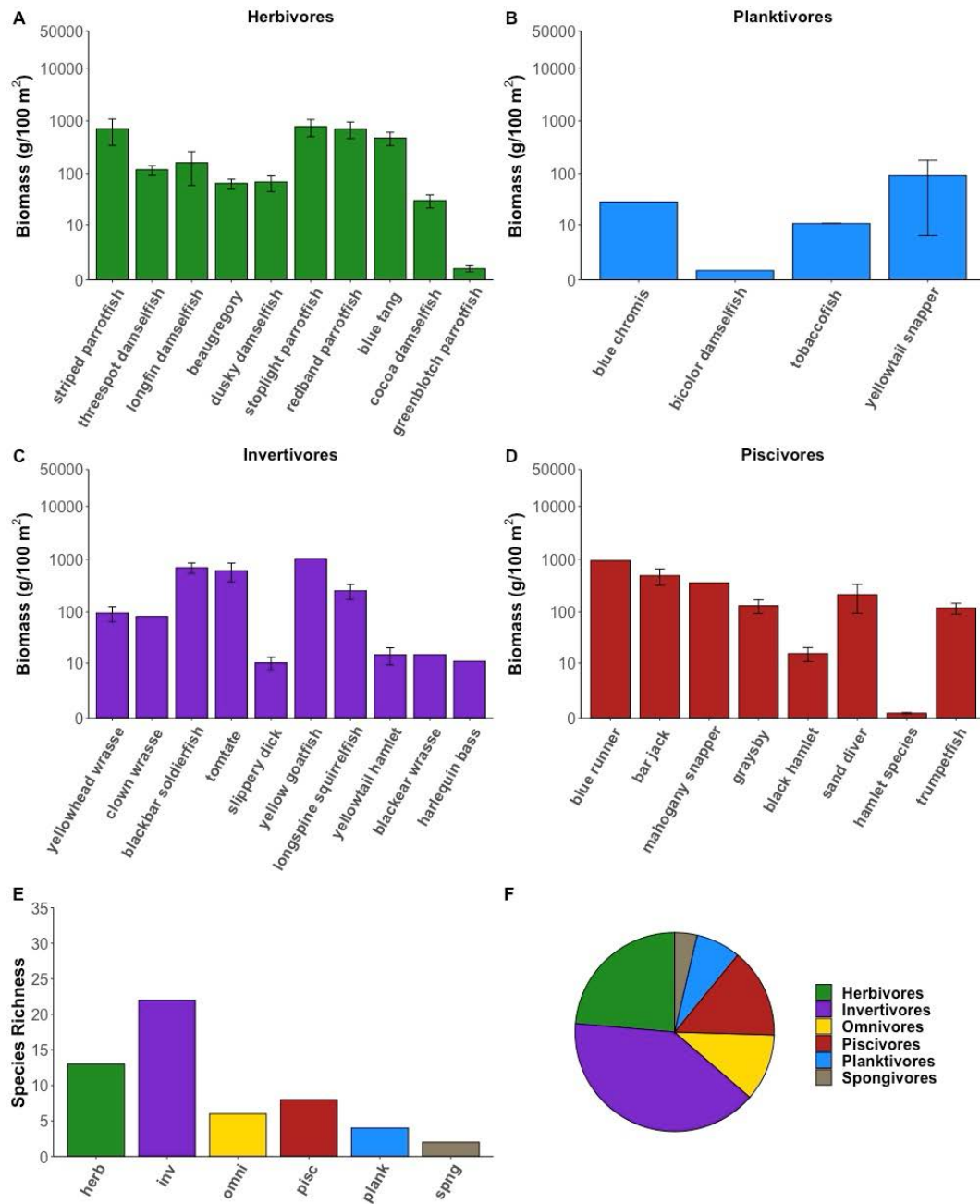


Figure 156. The Magens Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SAVANA

SAVANA ISLAND

Description. The Savana Island site is a midshelf fringing reef facing the Atlantic Ocean to the northwest in depths of 5 – 17 m. The reef is a well-developed coral community atop bedrock, with some insipient carbonate accumulation. Savana has been monitored since 2003, with permanent benthic transects installed in 2007.

Outstanding Feature. Savana harbors very large colonies of boulder star coral (*Orbicella faveolata*) and a diverse and abundant fish community.

Threats. Savana is threatened the invasive algae *Ramircrusta textilis* (Hollister et al. 2021) and by warming ocean temperatures, as *O. faveolata* can be susceptible to bleaching, disease, and partial mortality. The area is also open to fishing and the occasional accumulation of debris can be seen.

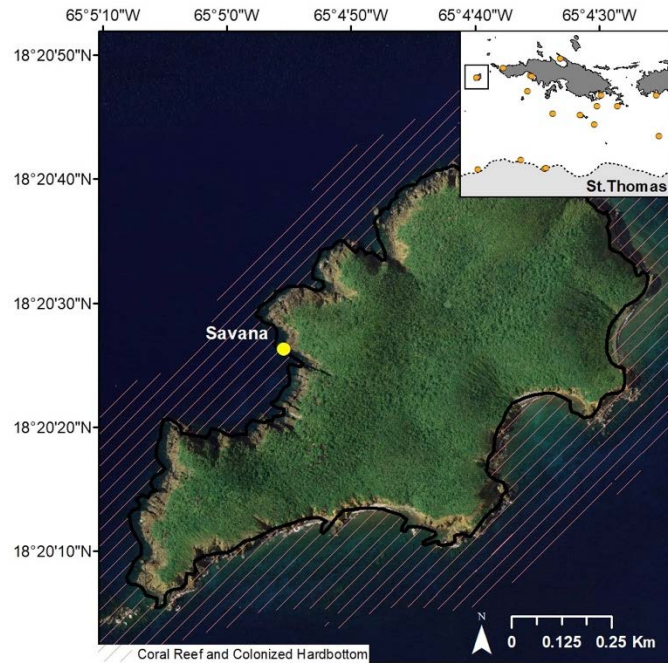


Figure 157. Savana.
(top) Location. (right)
A representative
photo of the reef
showing large colonies
of *Orbicella faveolata*
(Nov. 17, 2015).



SITE SUMMARIES: SAVANA

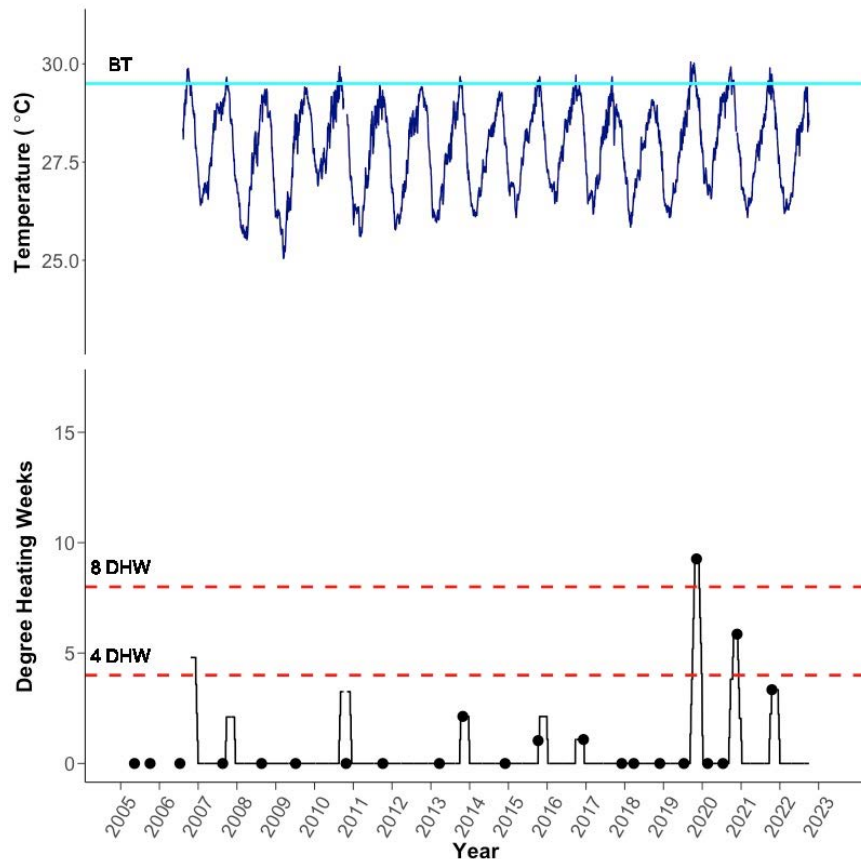


Figure 158. Savana benthic temperature record (10 m depth).

Physical Characteristics.

Current. Currents have not been measured directly at Savana. Strong unidirectional currents can influence the surface near the site. Wave-driven oscillatory currents are common and occasionally strong.

Temperature. Savana has temperatures cooler than other shallow sites, likely due to the proximity of the open Atlantic Ocean.

SITE SUMMARIES: SAVANA

Benthic Community. Boulder star corals, predominately large (>2m wide) colonies of *Orbicella faveolata*, dominate the coral community at the Savana monitoring site. The site lost 45.2% of its coral cover in the 2005 bleaching event. Coral cover has continued to decline, rather than recover, and this is related to a striking increase in the red encrusting algae *Ramircrusta textilis* to over 60% cover (this is responsible for the spike in “macroalgae” in benthic cover after 2005). This alga overtops coral edges leading a slow, creeping mortality. In addition, SCTLD appeared in 2019 and has also contributed to a decline in coral cover. This has especially impacted the remaining *Orbicella* spp., which have declined dramatically. Gorgonians and sponges are also prominent components of the sessile epibenthic animal community.

Coral Health. The coral community at Savana was highly affected in the 2005 bleaching event, with 80% of corals affected on almost 90% of the colony surface. Bleaching was also very prominent in 2006, but at a lower extent. Bleaching was moderate during the 2010 bleaching event, with over 50% of colonies bleached at a low extent. Coral diseases can reach high prevalence and are diversely represented. Particularly noticeable is the dramatic outbreak of white disease in 2006. Dark spots disease has also affected a high proportion of corals from 2008 onwards. Old partial mortality increased markedly after the 2005 coral bleaching event and has declined only slightly. Recent partial mortality after the 2005 coral bleaching event was unprecedented for any site.

SITE SUMMARIES: SAVANA

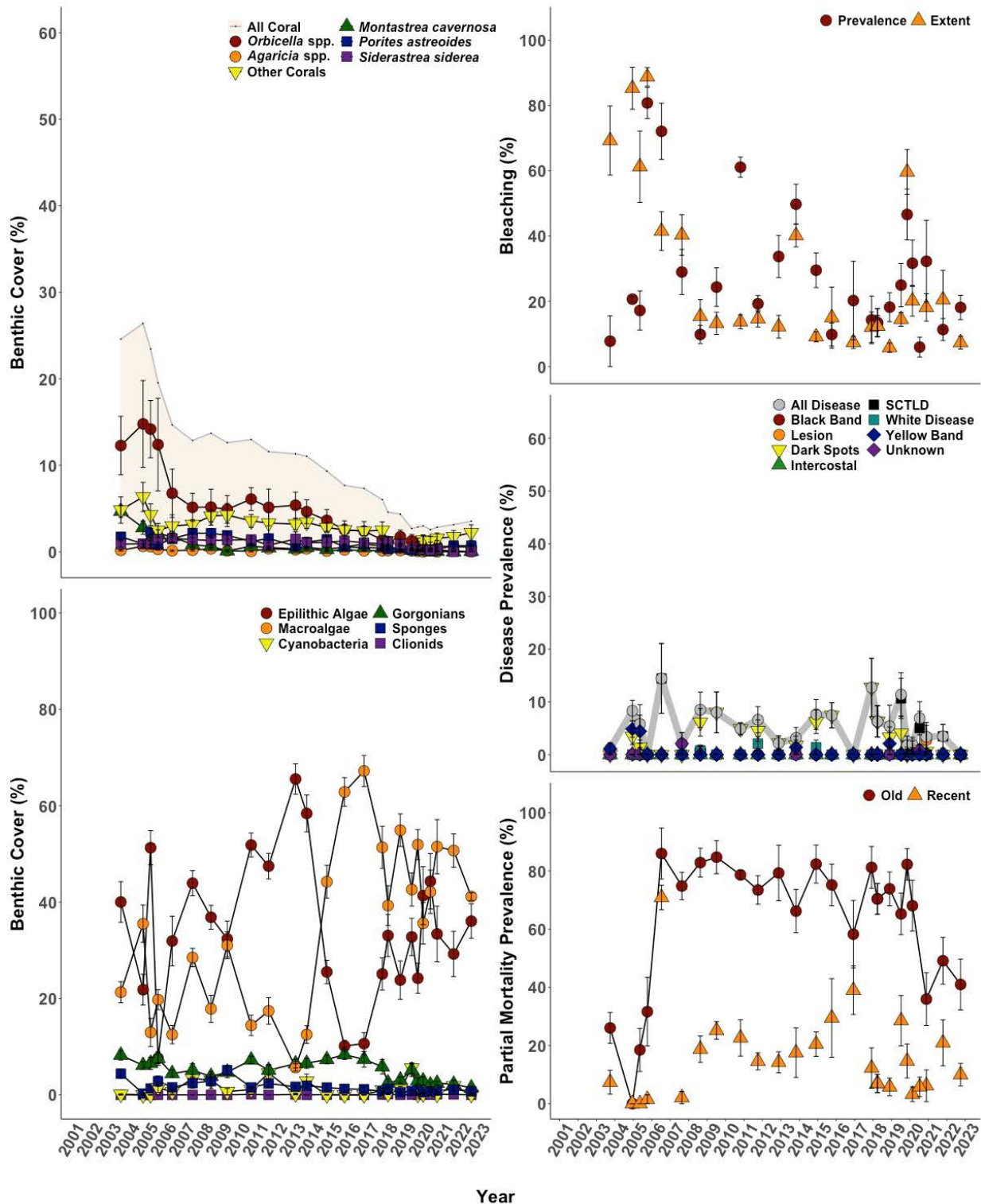


Figure 159. Savana Island benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: SAVANA

Fish Community. The Savana Island fish community is low in biomass, but is quite diverse, and highlights the variety of benthic resources available to fishes in the area. The site is dominated by numerically herbivores, but it also supports a diverse invertivore community and is dominated in biomass by planktivores. The quiet, relatively protected bay receives circulation and resulting plankton loads during parts of the tidal period, supporting large yellowtail snapper and schools of creole wrasse. Jacks and mackerels are commonly seen circling anchovies and other small bait fish. At other times, when the current is less favorable, planktivores are limited to small pomacentrids. Herbivore biomass is evenly split between the common parrotfish species and Acanthurids. Schools of mixed blue tang and surgeonfish are observed grazing the reef commonly. The most numerous piscivore observed at Savana is the coney. These are numerous near the bedrock periphery of the site along the island shoreline. One small yellowmouth grouper (11-20 cm) was observed on a belt transect in 2012, the first seen on a shallow site. Otherwise, no large snappers and groupers have been seen in the bay. The area is highly fished with fish traps.

SITE SUMMARIES: SAVANA

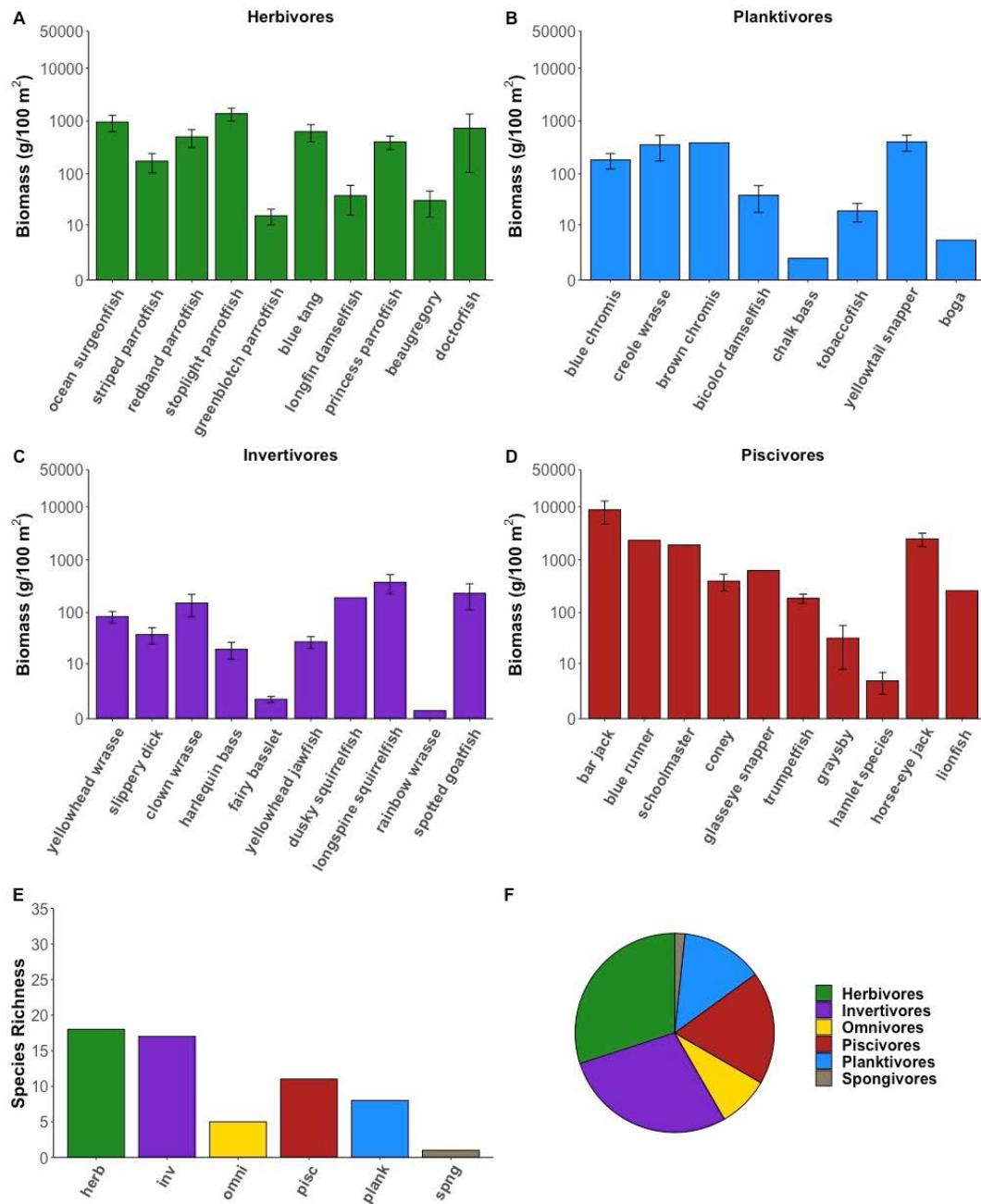
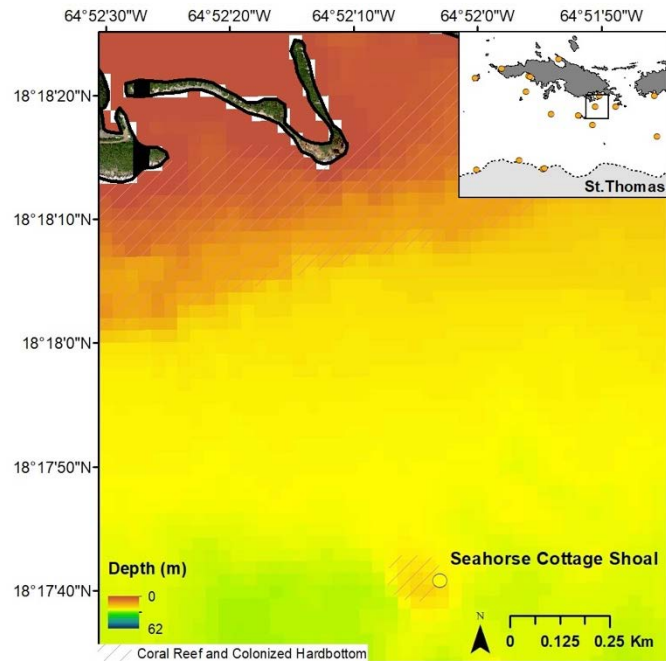


Figure 160. The Savana Island fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SEAHORSE

SEAHORSE COTTAGE SHOAL

Description. The Seahorse Cottage Shoal site is a large patch reef surrounded by sand and rhodolith in depths of 17 – 23m. The isolated reef is flat topped and dominated by *Orbicella* spp.. Seahorse has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera study with monthly to quarterly sampling occurred from 2009-2021.



Outstanding Feature. Seahorse supports a diverse and abundant coral and fish community adjacent to the St. Thomas East End Reserves.

Threats. Seahorse is buffered from land-based sources of pollution. The site is a targeted site in the St. Thomas trap fishery and trap strings have been observed over and adjacent to the site.

Figure 161. Seahorse Cottage Shoal. (top) Location. (right) A representative photo of the reef.



SITE SUMMARIES: SEAHORSE

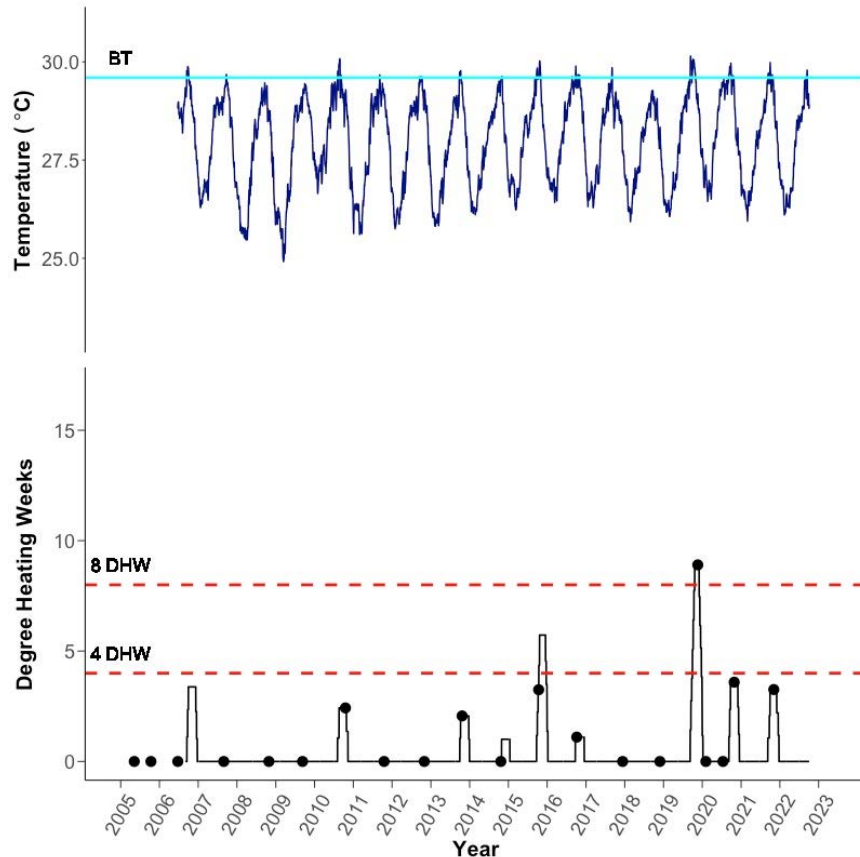


Figure 162. Seahorse benthic temperature record (21 m depth).

Physical Characteristics.

Current. Currents have not been directly measured at Seahorse Cottage Shoal.

Unidirectional benthic currents tend to be slow and wave-driven oscillatory currents only occur during heavy storm activity.

Temperature. Benthic temperatures are moderate to high during warming events.

SITE SUMMARIES: SEAHORSE

Benthic Community. The coral community of the Seahorse site is dominated by the boulder star coral (*Orbicella* spp.) but hosts a high diversity of other coral species. The site lost 46.6% of its cover in the 2005 bleaching event and had only regained 4.7% of this loss by 2011. SCTL D appeared in 2019 and caused a decline in coral cover from 16% in October 2018 to 5% in October 2020. Gorgonians and sponges are also common components of the sessile epibenthic animal community. The algal community is co-dominated by epilithic algae and the macroalgae *Lobophora variegata* and *Dictyota* spp..

Coral Health. The coral community bleached severely in the 2005 bleaching event with nearly 100% of corals bleaching over about 100% of their surface. Bleaching prevalence after 2005 was slow to decline due to delayed recovery in large *Orbicella* spp. colonies. The site also had a high prevalence of bleaching in the 2010 event, but at a low extent on colonies. Bleaching was also moderately prevalent in 2011. In 2019 bleaching was moderate to severe in terms of prevalence and extent. Coral diseases are common and diverse at Seahorse. White disease was also prevalent in 2004, which is rare for a site this shallow. SCTL D appeared in 2019 and reached very high prevalence. Dark spots disease is also ubiquitous. Old partial mortality increased to a very high prevalence after the 2005 bleaching event, but had declined by 2011.

SITE SUMMARIES: SEAHORSE

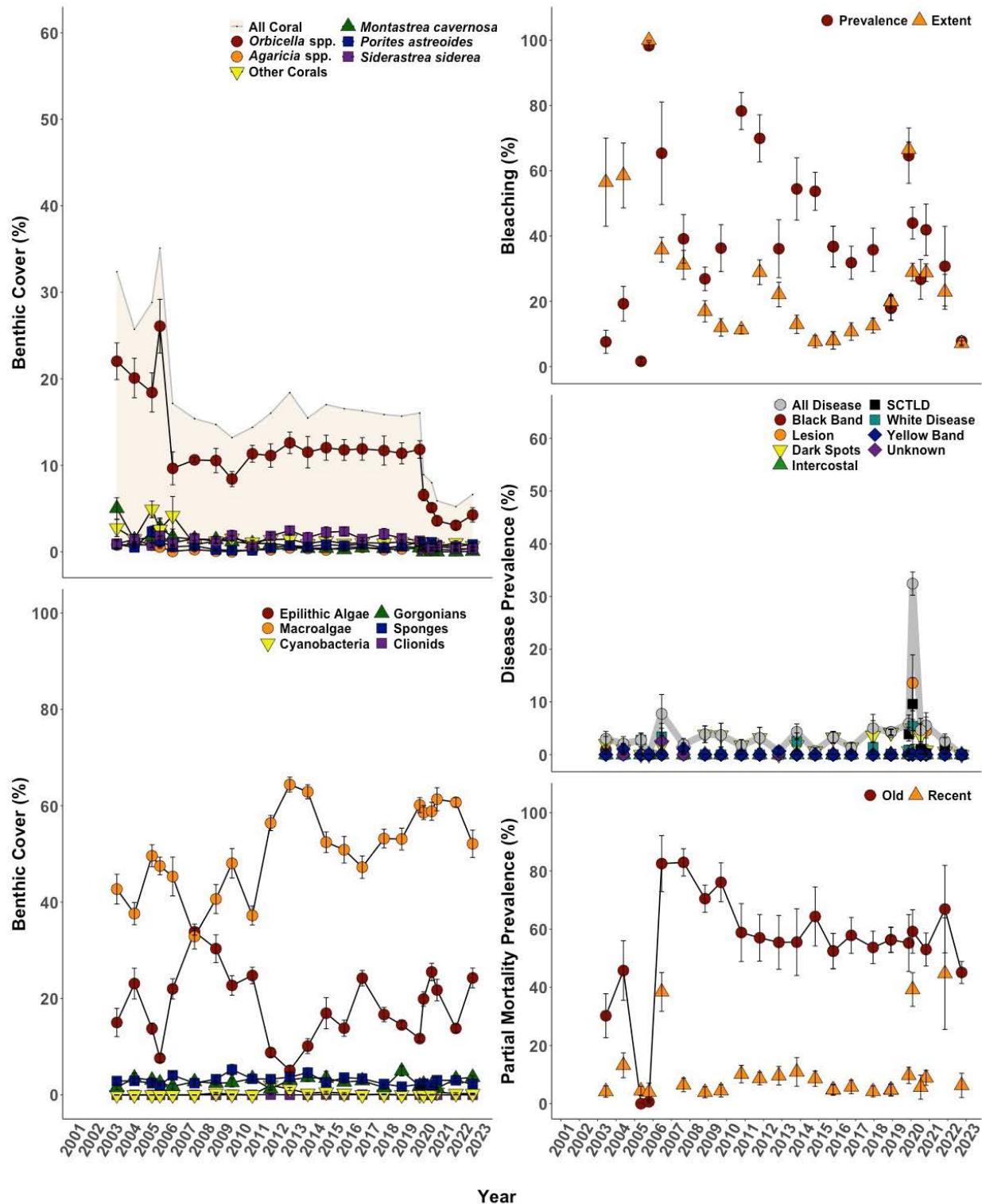


Figure 163. Seahorse Cottage Shoal benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: SEAHORSE

Fish Community. Seahorse Cottage Shoal supports a large variety of reef fish and hosts aggregations of gray snapper and lane snapper during the summer months. The trophic guilds on the offshore reef are split relatively evenly between herbivores and invertivores, with piscivores nearly as high in biomass during some years. This reflects the heterogeneity of reef substrate and the availability of unconsolidated sand and rhodolith habitat surrounding the reef. The orientation on the circular offshore reef determines the number and species of fish observed. On the western edge of the reef, schools of snapper and porgies can be found. Mutton snapper and queen triggerfish are also relatively common on this edge of the reef. The top of the low spur and groove reef on the other hand holds mainly glasseye snapper, wrasses, and parrotfish. Adult stoplight and redband parrotfish dominate herbivore biomass while glasseye snapper and graysby dominate the benthic piscivore trophic guild. Jacks and mackerels are common on the site. Seahorse Cottage Shoal is well known to fishermen and is heavily fished. Traps on the reef are common during surveys. Large groupers are occasional, including one sub-adult goliath grouper spotted in 2012. However, schoolmaster, lane, gray, and mahogany snapper are all common. This may reflect the proximity to nursery habitats in the St. Thomas East End Reserves and the mangrove habitats therein.

SITE SUMMARIES: SEAHORSE

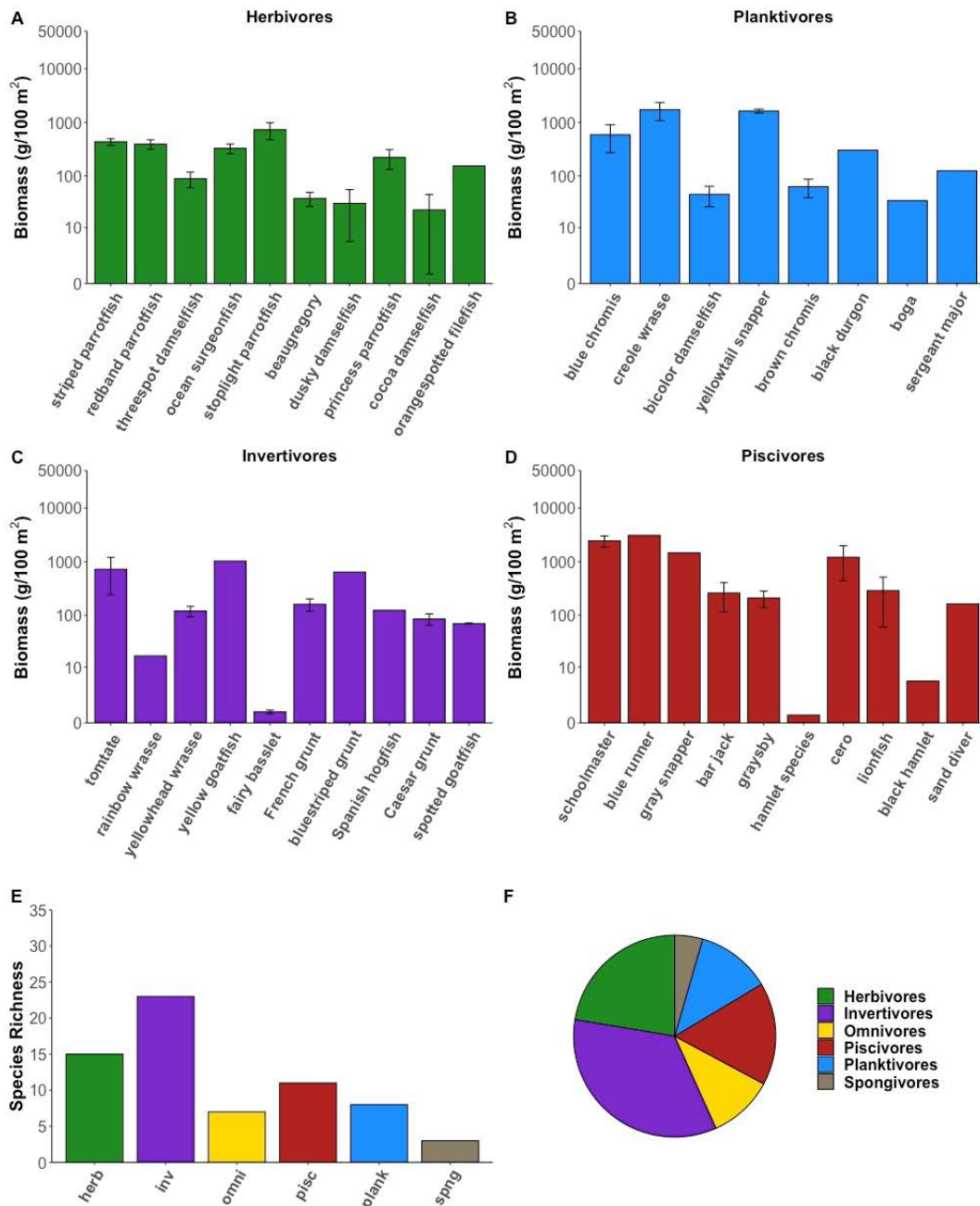


Figure 164. The Seahorse Cottage Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SOUTH CAPELLA

SOUTH CAPELLA

Description. The South Capella site is located on a rise of the St. Thomas-St. John midshelf reef complex in depths of 16 - 25 m. The reef is made of rolling ridges of coral and pavement interspersed with sand grooves. South Capella has been monitored since 2003, with permanent benthic transects installed in 2007.

Outstanding Feature. The South Capella site is part of an outstanding shallow water midshelf reef system that is essential fish habitat.

Threats. The St. Thomas trap fishery heavily targets South Capella. Active and derelict trap strings crisscross the site and a derelict trap appeared in permanent transect 1 in 2008 and has been degrading there since. The trap was still fully intact as of 2016 but not actively trapping. The reef was also highly affected by the 2005 coral bleaching event, suggesting a susceptibility to rising sea surface temperatures.

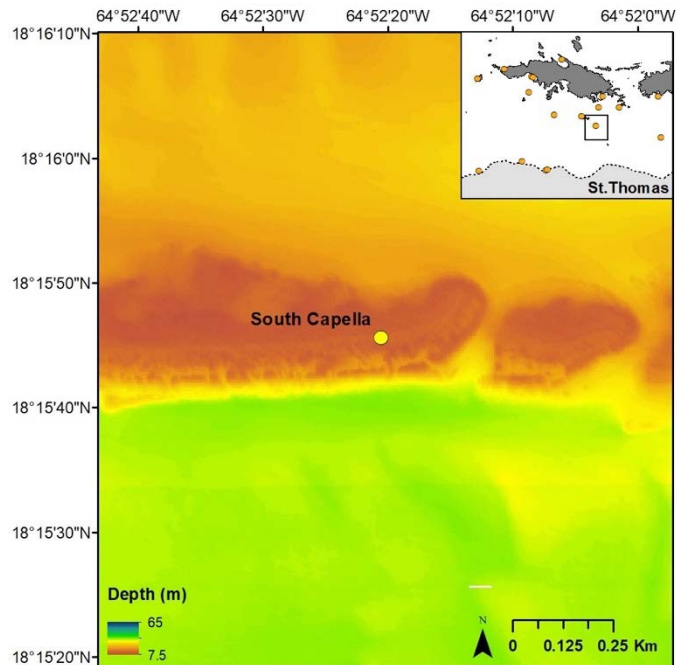
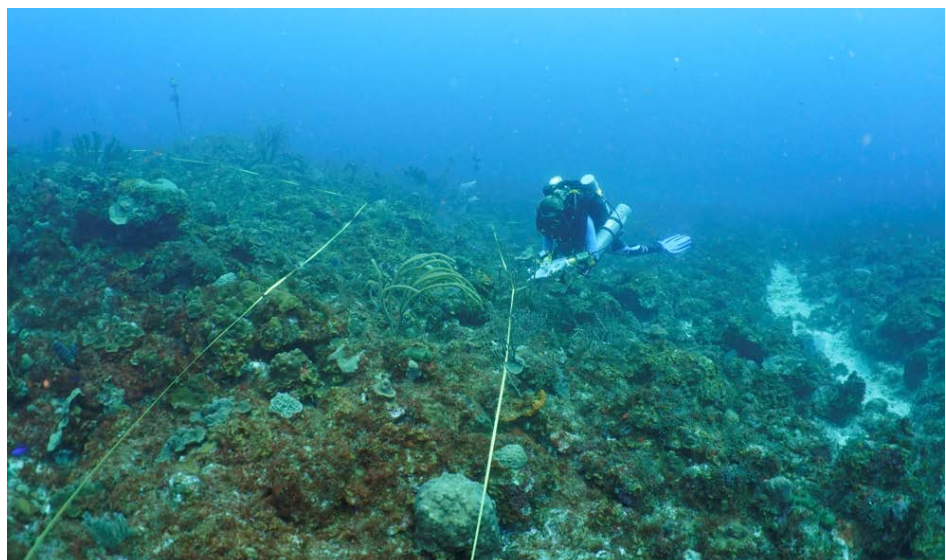


Figure 165. South Capella. (top) Location. (right) Representative photo of the reef (photo: V. Brandtneris).



SITE SUMMARIES: SOUTH CAPELLA

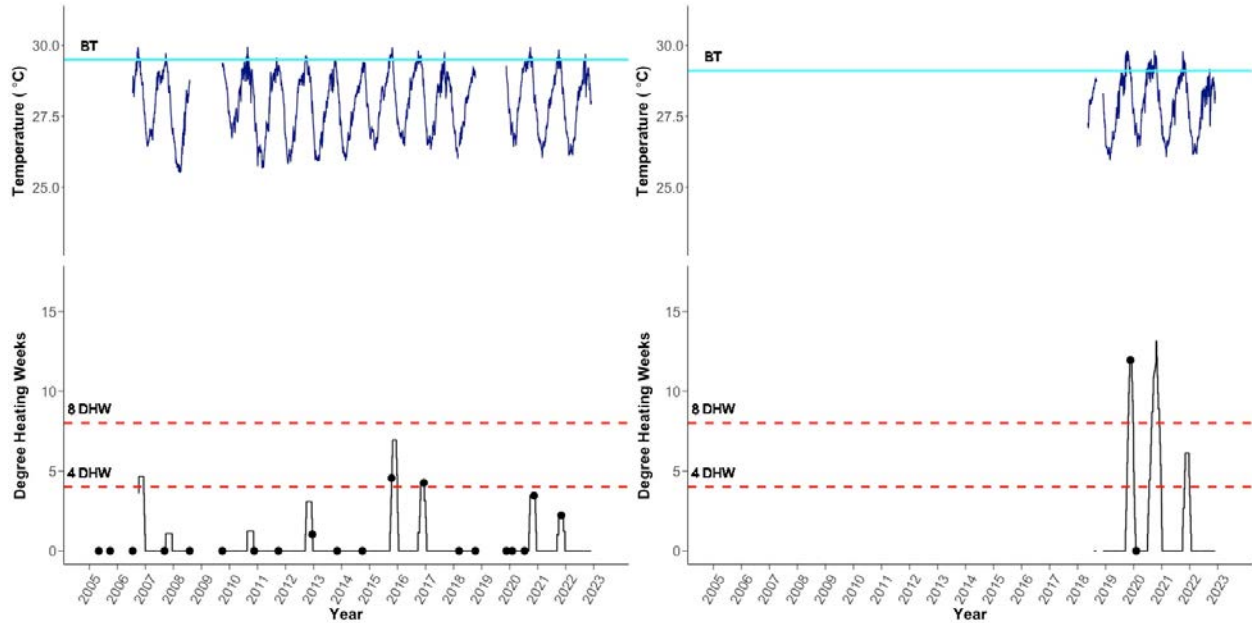


Figure 166. South Capella benthic temperature record (Top left: 24 m depth, top right: 35 m depth).

Physical Characteristics.

Current. Wave-driven oscillatory currents have not been experienced but are likely during swells and storms. Unidirectional benthic currents are usually weak, but strong currents can develop from the surface to midwater. Currents were directly measured at South Capella and this data is available upon request

Temperature. South Capella has relatively cool benthic temperatures for a shallow site during warm years, which may reflect its moderately deep depth and proximity to deep water to the south. The thermistor deployed for 2018-2019 failed to record data at the 24 m site.

SITE SUMMARIES: SOUTH CAPELLA

Benthic Community. Boulder star corals (*Orbicella* spp.) dominate the coral community at South Capella. These corals were very heavily affected by mortality due to the 2005 coral bleaching event and the arrival of Stony Coral Tissue Loss Disease. The site lost 56.4% of its cover following the 2005 bleaching event and had not regained any cover by 2011 (-3.7% recovery). SCTLD appeared in 2019 and caused a sharp decline in coral cover. Gorgonians and sponges are also common components of the sessile epibenthic animal community. The macroalga *Lobophora variegata* dominates the algal community, with epilithic algae and *Dictyota* spp. comprising the second largest shares. There was also a high abundance of crustose coralline algae and filamentous cyanobacteria.

Coral Health. Corals were moderately-heavily affected by the 2005 bleaching event, with a prevalence of 80%, but an extent on colonies of only about 50%. Bleaching prevalence also increased during the 2010 bleaching event, but at a low extent. In 2019 bleaching prevalence and extent was relatively severe. Bleaching is moderately prevalent at this site even in years without notable thermal stress. Coral diseases are common and diverse at South Capella. White disease was prevalent after the 2005 bleaching event in 2006, and then again in 2009 and 2011. Black band disease was found in 2002, which is unusual for a site at these depths. Dark spots disease was also typically present in most years. SCTLD appeared at the site in 2019. Old partial mortality increased after the 2005 bleaching event and has declined to 2011. Recent partial mortality was prevalent in most years of monitoring, particularly in 2006. In years not following thermal stress the highest identifiable source of recent partial mortality was biting from territorial damselfish (*Stegastes* spp.).

SITE SUMMARIES: SOUTH CAPELLA

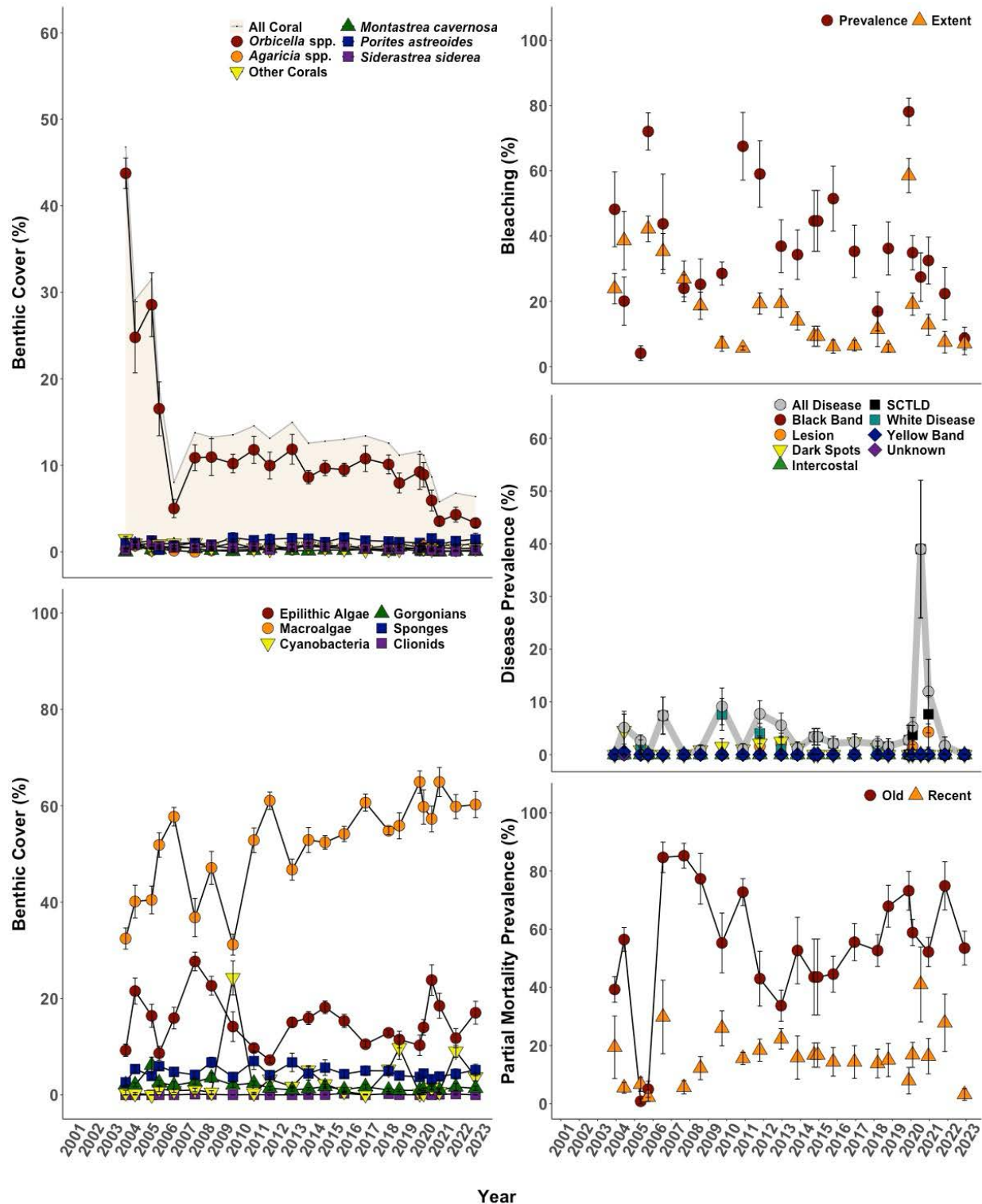


Figure 167. South Capella benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES: SOUTH CAPELLA

Fish Community. South Capella is characterized by a diverse fish community that is well split between trophic levels. Schools of schoolmaster snapper are observed regularly and usually dominate the piscivore biomass, however these schools may be small spawning aggregations and not typical of the daily fish community. The reef is spur and groove with complex reef edges and sand channels that support a large number and variety of invertivores. Grunts and goatfish comprise most of the invertivore biomass. Planktivores include the yellowtail snapper, as well as creole wrasse and black durgon, generally seen on shelf edge reefs. Benthic herbivores are dominated in biomass by striped parrotfish with redband, stoplight and queen parrotfish also common. The South Capella reef is a highly fished area and traps are commonly seen during our survey events. The rich, complex reef is noticeably bare of large snappers and groupers. The serranid group is represented only by the graysby and small hamlets, with an occasional red hind observed. Nassau grouper have never been observed at this site. Conversely, red lionfish continue to occur more commonly at the South Capella reef than any other mid-depth offshore site.

SITE SUMMARIES: SOUTH CAPELLA

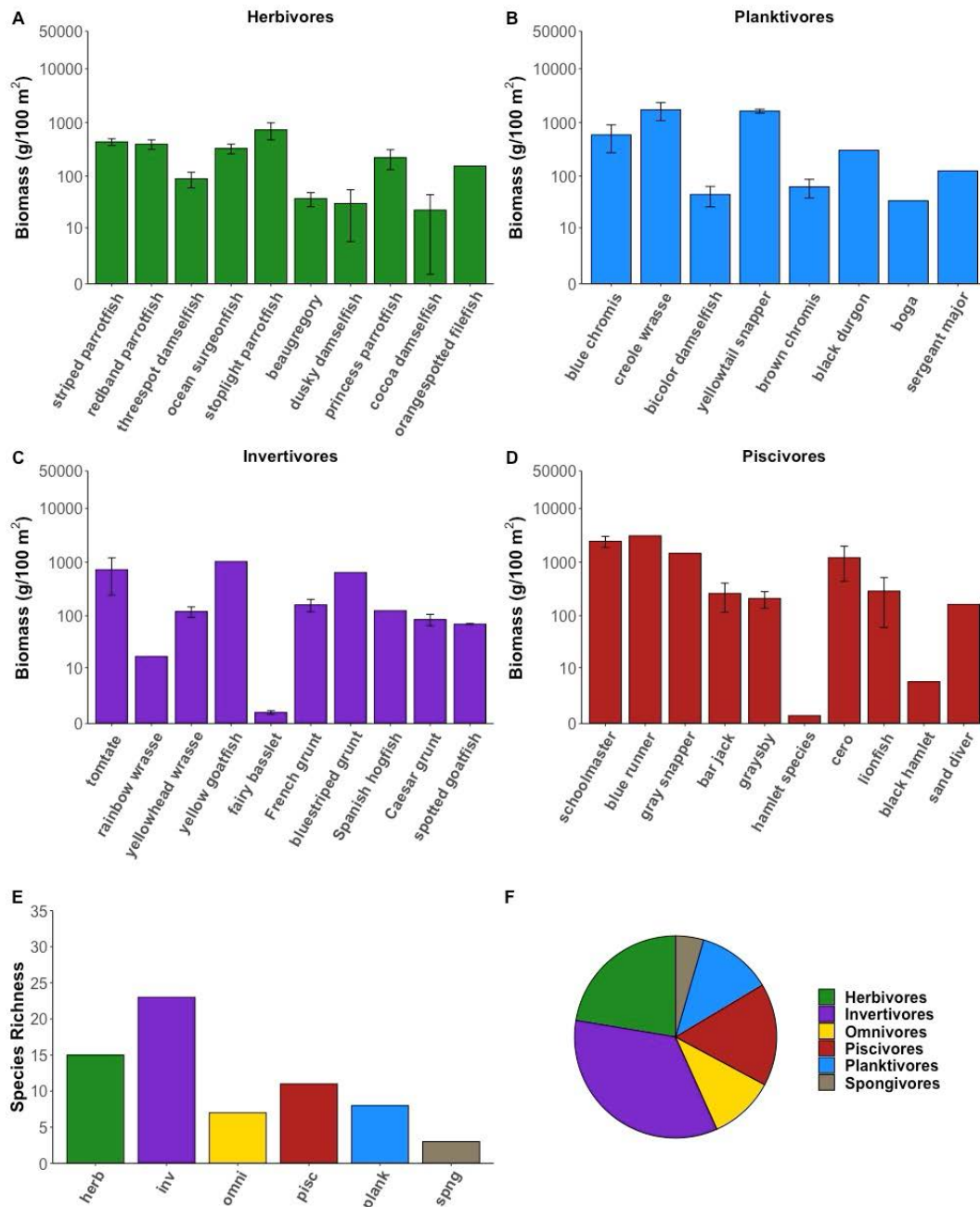
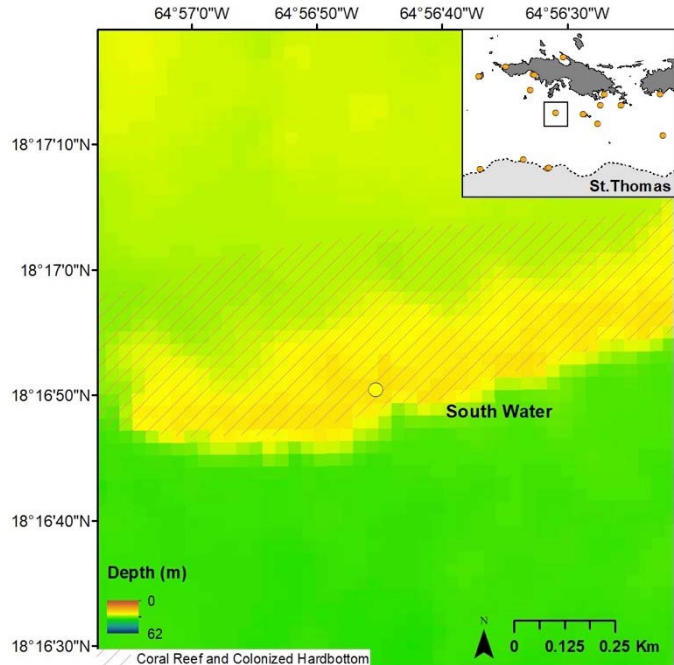


Figure 168. The South Capella fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SITE SUMMARIES: SOUTH WATER

SOUTH WATER

Description. South Water is a hardbottom coral community along the sharp break of a midshelf hardbottom reef complex in depths of 17 – 28 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. South Water has been monitored since 2005, with permanent benthic transects installed in 2007.



Outstanding Feature. South Water is a commercially important fishing ground for reef fishes and spiny lobster.

Threats. South Water is primarily threatened by fishing and strings of fish and lobster traps are common over the site.

Figure 169. South Water. (top) Location. (right) A representative photo of the reef (Photo: J. Quetel).



SITE SUMMARIES: SOUTH WATER

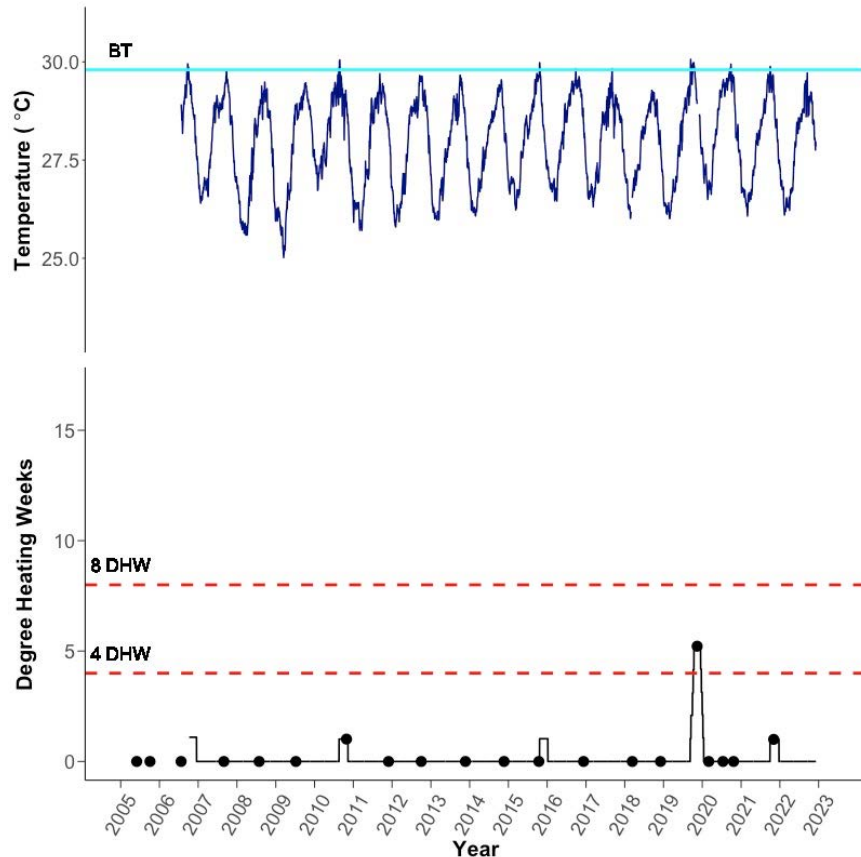


Figure 170. South Water benthic temperature record (24 m depth).

Physical Characteristics.

Current. Current measurements have not been taken at the South Water site.

Unidirectional benthic currents can be moderate on the hardbottom reef top and strong from the surface to midwater. Wave-driven oscillatory currents are likely to be felt on the reef top during swells and storms.

Temperature. South Water has relatively moderate temperatures compared with other shallow water sites during warm years. This may be due to the deeper depths of the site and the proximity of deep water.

SITE SUMMARIES: SOUTH WATER

Benthic Community. The sparse coral community at South Water is very diverse. Coral cover increased by 21.3% over the 2005 bleaching event and had increased by 42.6% between 2005 and 2011. However, permanent transects were not installed until 2007 and the low coral cover means that small variations in detection of corals can lead to large apparent year-to-year differences in cover. Sponges and gorgonians dominate the sessile epibenthic animal community. The algal community is nearly equally divided between *Lobophora variegata*, *Dictyota* spp., and epilithic algae. Crustose coralline algae and filamentous cyanobacteria are also very common.

Coral Health. Corals were severely affected by the 2005 coral bleaching event, with over 80% of corals bleaching over nearly the entire coral surface. Corals were moderately affected in the 2010 bleaching event, with just less than 50% of corals bleaching at a low extent. In 2019 bleaching prevalence and extent was moderate. Bleaching tends to be moderately prevalent even in non-thermal stress years. Coral diseases are not common, although there is a trend of increasing dark spots disease. SCTLD appeared at the site in 2019. Old partial mortality increased in prevalence after the 2005 bleaching event, but at a lower prevalence than most other sites. Recent partial mortality is rare.

SITE SUMMARIES: SOUTH WATER

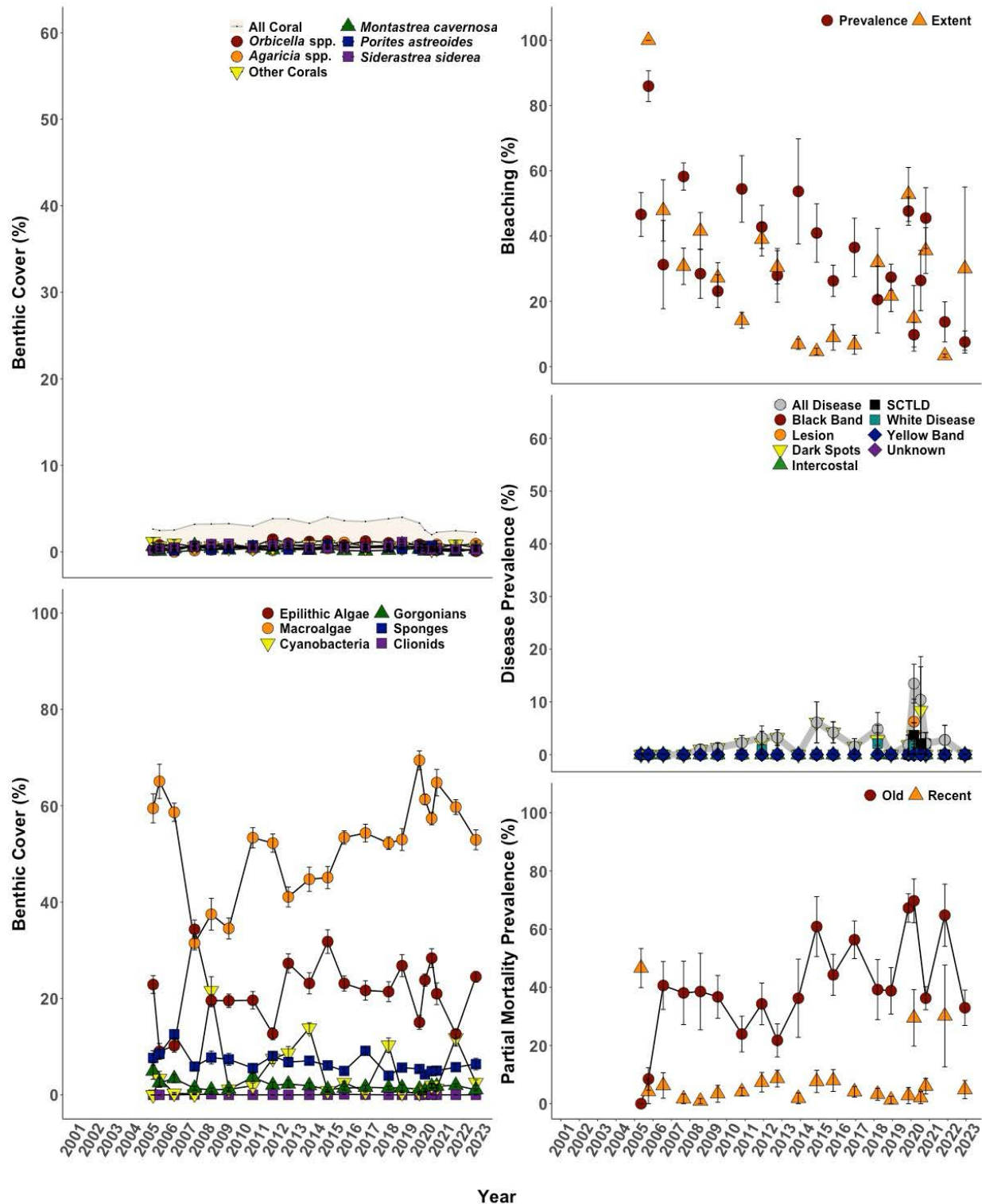


Figure 171. South Water benthic cover and coral health through time (mean $\pm$ SE).

SITE SUMMARIES: SOUTH WATER

Fish Community. South Water Island is a hard bottom reef crossed by sand channels that supports primarily invertivores and herbivores. Fish biomass is lower on this site than most other offshore and mesophotic sites of St. Thomas. The invertivore biomass is dominated by queen triggerfish, long-spine squirrelfish, and grunts. Mutton snapper are occasional off the southern edge of the reef. Stoplight and redband parrotfish dominate the herbivore biomass, and many juvenile and sub-adults of these species as well as striped and princess parrotfish occur across the site. Piscivores generally make up a very small percentage of the biomass on the South Water Island site; small mackerels and jacks are commonly observed, driving up average biomass, but the guild is primarily composed of graysby, coney and medium-sized snappers that school along the reef edge. The site lies several miles from the shelf edge, and planktivores are in general limited to yellowtail snapper and small chromis. South Water Island is highly fished, and traps are commonly seen during our survey events. Lobsters are common on this low-lying reef, hiding in the hard bottom ledges that extend across the site lining the sand channels. Apart from mutton snapper, the reef is devoid of large snappers and groupers.

SITE SUMMARIES: SOUTH WATER

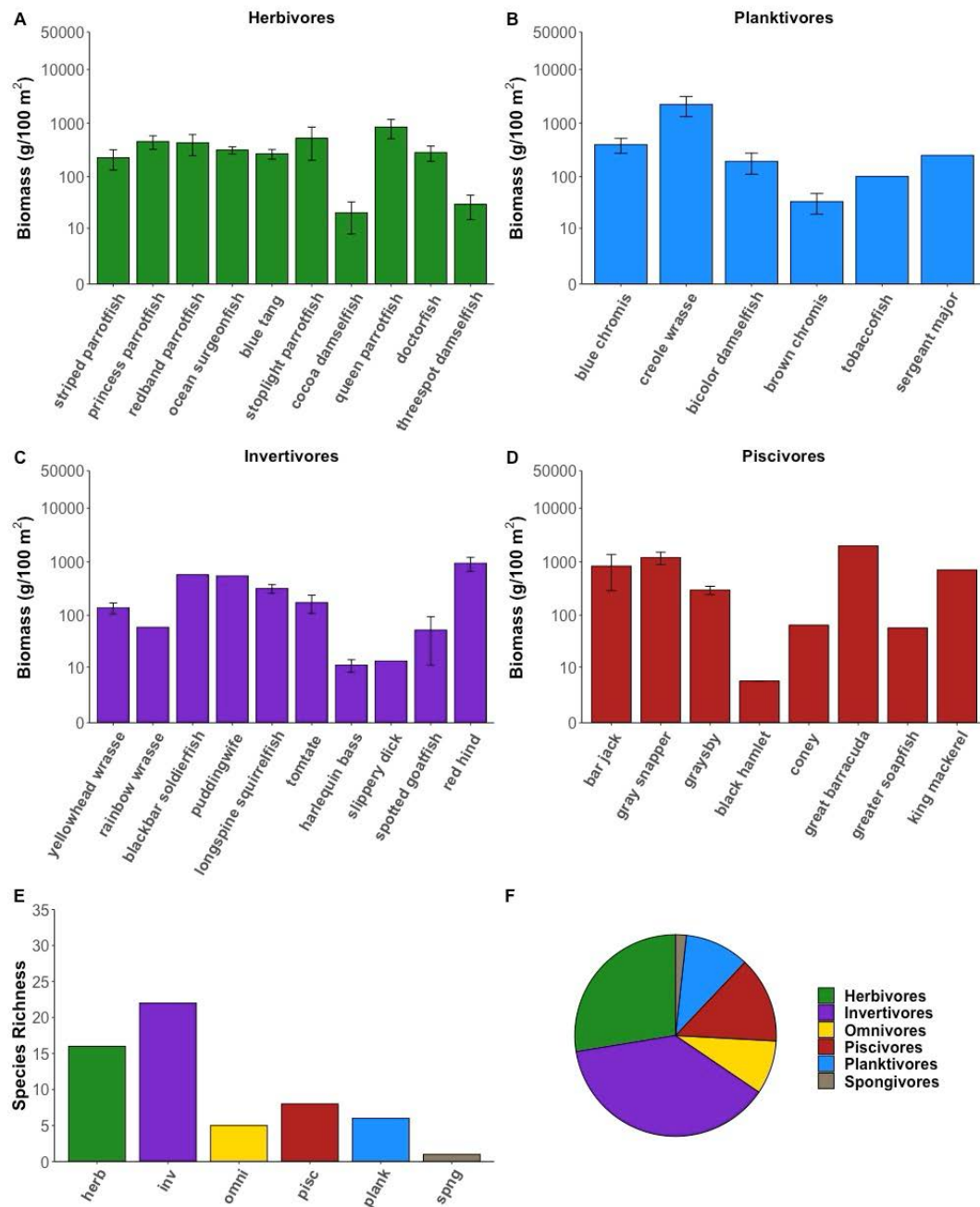


Figure 172. The South Water fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale

Literature Cited

- Acevedo R, Morelock J (1988) Effects of terrigenous sediment influx on coral zonation in southwestern Puerto Rico. *Proceedings of the Sixth International Coral Reef Symposium* 2:189-194
- Albins M, Hixon M (2011) Worst case scenario: potential long-term effects of invasive predatory lionfish (*Pterois volitans*) on Atlantic and Caribbean coral-reef communities. *Environmental Biology of Fishes*:1-7
- Anderson D, Macdonald L (1998) Modelling road surface sediment production using a vector geographic information system. *Earth Surface Processes and Landforms* 23:95-107
- Armstrong R, Singh H, Torres J (2002) Benthic survey of insular slope coral reefs using the Seabed AUV. *Backscatter* 13:22-25
- Armstrong RA (2007) Deep zooxanthellate coral reefs of the Puerto Rico: US Virgin Islands insular platform. *Coral Reefs* 26:945
- Armstrong RA, Singh H, Torres J, Nemeth RS, Can A, Roman C, Eustice R, Riggs L, Garcia-Moliner G (2006) Characterizing the deep insular shelf coral reef habitat of the Hind Bank marine conservation district (US Virgin Islands) using the Seabed autonomous underwater vehicle. *Continental Shelf Research* 26:194-205
- Ballantine David, L. and H. Ruiz. 2010. Two new deep water *Peyssonnelia* species, *Peyssonnelia iridescens* and *Peyssonnelia gigaspora* (Peyssonneliaceae, Rhodophyta) from Puerto Rico, Caribbean Sea. *Phycologia* 49:537-544.
- Bellwood DR, Fulton CJ (2008) Sediment-mediated suppression of herbivory on coral reefs: decreasing resilience to rising sea-levels and climate change? *Limnology and Oceanography* 53:2695-2701
- Betancur-R R, Hines A, Acero P A, Ortí G, Wilbur AE, Freshwater DW (2011) Reconstructing the lionfish invasion: insights into Greater Caribbean biogeography. *Journal of Biogeography* 38:1281-1293
- Bramanti L, Lasker HR, Edmunds PJ (2017) An encrusting peyssonnelid preempts vacant space and overgrows corals in St. John, US Virgin Islands. *Reef Encounter* 32:68-70
- Brandt ME, Ennis RS, Meiling SS, Townsend J, Cobleigh K, Glahn A, Quetel J, Brandtneris V, Henderson LM, Smith TB (2021) The Emergence and Initial Impact of Stony Coral Tissue Loss Disease (SCTLD) in the United States Virgin Islands. *Frontiers in Marine Science* 8:1105
- Bright AJ, Rogers C, Brandt M, Muller E, Smith T (2016) Disease prevalence and snail predation associated with swell-generated damage on the threatened coral, *Acropora palmata* (Lamarck). *Frontiers in Marine Science* 3:77
- Brooks GR, Devine B, Larson RA, Rood BP (2007) Sedimentary development of Coral Bay, St. John, USVI: a shift from natural to anthropogenic influences. *Caribbean Journal of Science* 43:226-243
- Bruckner AW (2007) Field Guide to Western Atlantic Coral Diseases and Other Causes of Coral Mortality. NOAA, UNEP-WCMC, PADI
- 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
- Calnan J, Smith T, Nemeth R, Kadison E, Blondeau J (2008) Coral disease prevalence and host susceptibility on mid-depth and deep reefs in the US Virgin Islands. *Revista Biología Tropical* 56 (suppl. 1):223-224
- Costa SV, Hibberts SJ, Olive DA, Budd KA, Long AE, Meiling SS, Miller MB, Vaughn KM, Carrión CI, Cohen MB, Savage AE, Souza MF, Buckley L, Grimes KW, Platenberg R, Smith TB, Blondeau J, Brandt ME (2021) Diversity and Disease: The Effects of Coral Diversity on Prevalence and Impacts of Stony Coral Tissue Loss Disease in Saint Thomas, U.S. Virgin Islands. *Frontiers in Marine Science* 8:747
- Cote IM, Maljkovic A (2010) Predation rates of Indo-Pacific lionfish on Bahamian coral reefs. *Marine Ecology Progress Series* 404:219-225
- De'ath G, Fabricius K (2010) Water quality as a regional driver of coral biodiversity and macroalgae on the Great Barrier Reef. *Ecological Applications* 20:840-850
- Dixon KR, Saunders GW (2013) DNA barcoding and phylogenetics of *Ramicrusta* and *Incendia* gen. nov., two early diverging lineages of the Peyssonneliaceae (Rhodophyta). *Phycologia* 52:82-108
- Eakin CM, Morgan JA, Heron SF, Smith TB, Liu G, Alvarez-Filip L, Baca B, Bartels E, Bastidas C, Bouchon C, Brandt M, Bruckner AW, Bunkley-Williams L, Cameron A, Causey BD, Chiappone M, Christensen TRL, Crabbe MJC, Day O, de la Guardia E, Díaz-Pulido G, DiResta D, Gil-Agudelo DL, Gilliam DS, Ginsburg

2022 ANNUAL TCRMP REPORT

- RN, Gore S, Guzmán HM, Hendee JC, Hernández-Delgado EA, Husain E, Jeffrey CFG, Jones RJ, Jordán-Dahlgren E, Kaufman LS, Kline DI, Kramer PA, Lang JC, Lirman D, Mallela J, Manfrino C, Maréchal J-P, Marks K, Mihaly J, Miller WJ, Mueller EM, Muller EM, Orozco Toro CA, Oxenford HA, Ponce-Taylor D, Quinn N, Ritchie KB, Rodríguez S, Ramírez AR, Romano S, Samhouri JF, Sánchez JA, Schmahl GP, Shank BV, Skirving WJ, Steiner SCC, Villamizar E, Walsh SM, Walter C, Weil E, Williams EH, Roberson KW, Yusuf Y (2010) Caribbean corals in crisis: record thermal stress, bleaching, and mortality in 2005. *PLoS ONE* 5:e13969
- Edmunds PJ, Witman JD (1991) Effect of Hurricane Hugo on the primary framework of a reef along the south shore of St. John, US Virgin Islands. *Marine Ecology Progress Series* 78:201-204
- Edmunds PJ, Zimmermann SA, Bramanti L (2019) A spatially aggressive peyssonnelid algal crust (PAC) threatens shallow coral reefs in St. John, US Virgin Islands. *Coral Reefs* 38:1329-1341
- Ennis RS, Brandt ME, Wilson Grimes KR, Smith TB (2016) Coral reef health response to chronic and acute changes in water quality in St. Thomas, United States Virgin Islands. *Marine Pollution Bulletin* 111:418-427
- Fabricius K (2005) The effects of terrestrial runoff on the ecology of corals and coral reefs: a review and synthesis. *Marine Pollution Bulletin* 50:125-146
- Fong P, Paul VJ (2011) Coral Reef Algae. In: Dubinsky Z, Stambler N (eds) *Coral Reefs: An Ecosystem in Transition*. Springer Science, pp241-272
- Fong P, Smith TB, Wartian MJ (2006) Epiphytic cyanobacteria maintain shifts to macroalgal dominance on coral reefs following ENSO disturbance. *Ecology* 87:1162-1168
- Friedlander AM, Jeffrey CFG, Hile SD, Pittman SJ, M.E. M, Caldwell C (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. NOAA, Silver Spring, MD 150pp
- Furnas M, Mitchell A, Skuza M, Brodie J (2005) in the other 90%: phytoplankton responses to enhanced nutrient availability in the Great Barrier Reef Lagoon. *Marine Pollution Bulletin* 51:235-265
- Gladfelter WB (1982) White-band disease in *Acropora palmata* - implications for the structure of shallow reefs. *Bulletin of Marine Science* 32:639-643
- Gochfeld DJ, Olson JB, Chaves-Fonnegra A, Smith TB, Ennis RS, Brandt ME (2020) Impacts of Hurricanes Irma and Maria on Coral Reef Sponge Communities in St. Thomas, U.S. Virgin Islands. *Estuaries and Coasts* 43:1235-1247
- Gray SC, Gobbi KL, Narwold PV (2008) Comparison of sedimentation in bays and reefs below developed versus undeveloped watersheds on St. John, US Virgin Islands. *Proceedings of the 11th International Coral Reef Symposium* 1:345-349
- Green SJ, Akins JL, Côté IM (2011) Foraging behaviour and prey consumption in the Indo-Pacific lionfish on Bahamian coral reefs. *Marine Ecology Progress Series* 433:159-167
- Hatcher BG (1984) A maritime accident provides evidence for alternate stable states in benthic communities on coral reefs. *Coral Reefs* 3:199-204
- Hatcher BG, Larkum AWD (1983) An experimental analysis of factors controlling the standing crop of the epilithic algal community on a coral reef. *Journal of Experimental Marine Biology and Ecology* 69:61-84
- Henderson LM, Blondeau J, Taylor M, Nemeth RS, Smith TB (in review) Terrestrial and silt-clay sediment flux affect stony coral health in the nearshore US Virgin Islands.
- Herzlieb S, Kadison E, Blondeau J, Nemeth RS (2005) Comparative assessment of coral reef systems located along the insular platform south of St. Thomas, US Virgin Islands and the relative effects of natural and human impacts. *Proc 10th Int Coral Reef Symp* 4-2:1144-1151
- Hewson I, Ritchie IT, Evans JS, Altera A, Behringer D, Bowman E, Brandt M, Budd KA, Camacho RA, Cornwell TO, Countway PD, Croquer A, Delgado GA, DeRito C, Duermit-Moreau E, Francis-Floyd R, Gittens S, Henderson L, Hylkema A, Kellogg CA, Kiryu Y, Kitson-Walters KA, Kramer P, Lang JC, Lessios H, Liddy L, Marancik D, Nimrod S, Patterson JT, Pistor M, Romero IC, Sellares-Blasco R, Sevier MLB, Sharp WC, Souza M, Valdez-Trinidad A, van der Laan M, Vilanova-Cuevas B, Villalpando M, Von Hoene SD, Warham M, Wijers T, Williams SM, Work TM, Yanong RP, Zambrano S, Zimmermann A, Breitbart M A scuticociliate causes mass mortality of *Diadema antillarum* in the Caribbean Sea. *Science Advances* 9:eadg3200
- Hinderstein L, Marr J, Martinez F, Dowgiallo M, Puglise K, Pyle R, Zawada D, Appeldoorn R (2010) Theme section on mesophotic coral ecosystems: characterization, ecology, and management. *Coral Reefs* 29:247-251

2022 ANNUAL TCRMP REPORT

- Hollister KJ, Ennis RS, Spalding HL, Gabrielson PW, Smith TB (2021) Caribbean corals exhibit species-specific differences in competitive abilities with an aggressive encrusting alga, *Ramicrostus textilis*. Coral Reefs <https://doi.org/10.1007/s00338-021-02177-9>
- Hylkema A, Kitson-Walters K, Kramer PR, Patterson JT, Roth L, Sevier MLB, Vega-Rodriguez M, Warham MM, Williams SM, Lang JC (2023) The 2022 *Diadema antillarum* die-off event: Comparisons with the 1983-1984 mass mortality. Frontiers in Marine Science 9
- Jackson A, Semmens BX, Sadovy Y, Nemeth RS, Heppell S, Chapman R, Aguilar-Perera A, Claydon J, Calosso M, Sealey K, Sharer M, Bernardi G (2014) Population structure and phylogeography in Nassau grouper (*Epinephelus striatus*), a mass-aggregating marine fish. PLoS ONE in press
- Kadison E, Nemeth R, Herzlieb S, Blondeau J (2006) Temporal and spatial dynamics of *Lutjanus cyanopterus* and *L. jocu* (Pisces: Lutjanidae) spawning aggregations on a multi-species spawning site in the USVI. Revista Biologia Tropical 54(suppl. 3):69-78
- Kadison E, Nemeth RS, Blondeau J, Smith TB, Calnan JM (2010) Nassau grouper (*Epinephelus striatus*) in St. Thomas, US Virgin Islands, with evidence for a spawning aggregation site recovery. Proceedings of the Gulf and Caribbean Fisheries Institute 62:273-279
- Kadison E, Brandt M, Nemeth R, Martens J, Blondeau J, Smith T (2017) Abundance of commercially important reef fish indicates different levels of over-exploitation across shelves of the U.S. Virgin Islands. PLOS ONE 12:e0180063
- Kohler K, Gill SM (2006) Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Computers and Geosciences 32:1259-1269
- Kramer P, Lang J, Marks K, Garza-Perez R, Ginsburg R (2005) AGRRA Methodology, version 4.0, June 2005. University of Miami, Miami
- Kuffner I, B., Walters L, J., Becerro M, A., Paul V, J., Ritson-Williams V, J., Beach K, S. (2006) Inhibition of coral recruitment by macroalgae and cyanobacteria. Marine Ecology Progress Series 323:107-117
- Manzello DP, Brandt ME, Smith TB, Lirman D, Hendee JC, Nemeth RS (2007) Hurricanes benefit bleached corals. Proceedings of the National Academy of Science 104:12035-12039
- Meiling S, Muller EM, Smith TB, Brandt ME (2020) 3D Photogrammetry Reveals Dynamics of Stony Coral Tissue Loss Disease (SCTLD) Lesion Progression Across a Thermal Stress Event. Frontiers in Marine Science 7:597643
- Meiling SS, Muller EM, Lasseigne D, Rossin A, Veglia AJ, MacKnight N, Dimos B, Huntley N, Correa AMS, Smith TB, Holstein DM, Mydlarz LD, Apprill A, Brandt ME (2021) Variable Species Responses to Experimental Stony Coral Tissue Loss Disease (SCTLD) Exposure. Frontiers in Marine Science 8:464
- Menza C, Kendall M, Hile S (2008) The deeper we go the less we know. Revista Biologia Tropical 56:11-24
- Menza C, Kendall M, Rogers C, Miller J (2007) A deep reef in deep trouble. Continental Shelf Research 27:2224-2230
- Menza C, Ault J, Beets J, Bohnsack J, Caldwell C, Christensen J, Friedlander A, Jeffrey C, Kendall M, Luo J, Monaco M, Smith S, Woody K (2006) A Guide to Monitoring Reef Fish in the National Park Service's South Florida/Caribbean Network. NOAA Technical Memorandum. NOS NCCOS 39 166
- Miller J, Muller E, Rogers C, Waara R, Atkinson A, Whelan K, Patterson M, Witcher B (2009) Coral disease following massive bleaching in 2005 causes 60% decline in coral cover on reefs in the US Virgin Islands. Coral Reefs 28:925-937
- Morris JAJ, Whitfield PE (2009) Biology, ecology, control and management of the Invasive Indo-Pacific Lionfish: An Updated Integrated Assessment. National Oceanographic and Atmospheric Administration, Washington D.C., NOAA Technical Memorandum NOS NCCOS 9
- Mumby PJ (2006) The impact of exploiting grazers (Scaridae) on the dynamics of Caribbean coral reefs. Ecological Applications 16:747-769
- Mumby PJ, Harborne AR (2010) Marine reserves enhance the recovery of corals on Caribbean reefs. PLoS ONE 5:e8657
- Mumby PJ, Dahlgren CP, Harborne AR, Kappel CV, Micheli F, Brumbaugh DR, Holmes KE, Mendes JM, Broad K, Sanchirico JN, Buch K, Box S, Stoffle RW, Gill AB (2006) Fishing, trophic cascades, and the process of grazing on coral reefs. Science 311:98-101

2022 ANNUAL TCRMP REPORT

- Nemeth R, Kadison E (2013) Temporal patterns and behavioral characteristics of aggregation formation and spawning in the Bermuda chub (*Kyphosus sectatrix*). *Coral Reefs* 32:1067-1076
- Nemeth RS (2005) Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection. *Marine Ecology Progress Series* 286:81-97
- Nemeth RS, Sladeck Nowlis J (2001) Monitoring the effects of land development on the near-shore reef environment of St. Thomas, USVI. *Bulletin of Marine Science* 69:759-775
- Nemeth RS, Kadison E, Herzlieb S, Blondeau J, Whiteman E (2006) Status of a yellowfin grouper (*Mycteroperca venenosa*) spawning aggregation in the US Virgin Islands with notes on other species. *Proc 57th Gulf Carib Fish Inst* 57:543-558
- Nemeth RS, Smith TB, Blondeau J, Kadison E, Calnan JM, Gass J (2008) Characterization of deep water reef communities within the marine conservation district, St. Thomas, U.S. Virgin Islands. Submitted to the Caribbean Fisheries Management Council. University of the Virgin Islands, St. Thomas 90 + appendices
- NOAA (2006) Tropical Ocean Coral Bleaching Indices. National Oceanic and Atmospheric Administration, Silver Springs, Maryland
- Pastorok R, Bilyard G (1985) Effects of sewage pollution on coral-reef communities. *Marine Ecology Progress Series* 21:175-189
- Pueschel CM, Saunders GW (2009) *Ramicrosta textilis* sp. nov. (Peyssonneliaceae, Rhodophyta), an anatomically complex Caribbean alga that overgrows corals. *Phycologia* 48:480-491
- Hollister KJ, Ennis RS, Spalding HL, Gabrielson PW, Smith TB (2021) Caribbean corals exhibit species-specific differences in competitive abilities with an aggressive encrusting alga, *Ramicrosta textilis*. *Coral Reefs* 40:1729-1740
- Ramos-Scharrón CE, MacDonald LH (2007a) Measurement and prediction of natural and anthropogenic sediment sources, St. John, U.S. Virgin Islands. *Catena* 71:250-266
- Ramos-Scharrón CE, MacDonald LH (2007b) Runoff and suspended sediment yields from an unpaved road segment, St John, US Virgin Islands. *Hydrological Processes* 21:35-50
- Randall JE (1963a) A fatal attack by the shark *Carcharhinus galapagensis* at St. Thomas, Virgin Islands. *Caribbean Journal of Marine Science* 3:201-205
- Randall JE (1963b) An analysis of the reef fish populations of artificial and natural reefs in the Virgin Islands. *Caribbean Journal of Marine Science* 3:31-47
- REEF (2012) Reef Environmental Education Foundation-Volunteer Fish Survey Project Database
- Rogers C, Garrison V (2001) Ten years after the crime: lasting effects of damage from a cruise ship anchor on a coral reef in St. John, U.S. Virgin Islands *Bulletin of Marine Science* 69:793-803
- Rogers CS (1982) The Marine Environments of Brewers Bay, Perserverence Bay, Flat Cay and Saba Island, St. Thomas, U.S.V.I., with Emphasis on Coral Reefs and Seagrass Beds, November 1978-July 1981 181
- Rogers CS (1990) Responses of coral reefs and reef organisms to sedimentation. *Marine Ecology Progress Series* 62:185-202
- Rogers CS, McLain LN, Tobias CR (1991) Effects of Hurricane Hugo (1989) on a coral reef in St. John USVI. *Marine Ecology Progress Series* 78:189-199
- Rothenberger J, Blondeau J, Cox C, Curtis S, Fisher B, Garrison G, Hillis-Starr Z, Jeffrey C, Kadison E, Lundgren I, Miller W, Muller E, Nemeth RS, Paterson S, Rogers CS, Smith TB, Spitzack A, Taylor M, Toller W, Wright J, Wusinich-Mendez D (2008) The State of Coral Reef Ecosystems of the U.S. Virgin Islands. In: Waddell JE, Clarke AM (eds) *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008*. NOAA Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD, pp567
- RStudio (2015) RStudio: Integrated development for R. RStudio, Inc., Boston, MA URL <http://www.rstudio.com/>
- Sabine AM, Smith TB, Williams DE, Brandt ME (2015) Environmental conditions influence tissue regeneration rates in scleractinian corals. *Marine Pollution Bulletin* 95:253-264
- Schofield PJ (2009) Geographic extent and chronology of the invasion of non-native lionfish (*Pterois volitans* [Linnaeus 1758] and *P. miles* [Bennett 1828]) in the Western North Atlantic and Caribbean Sea. *Aquatic Invasions* 4:473-479
- Smith TB, Fong P, Kennison R, Smith J (2010a) Spatial refuges and associational defenses promote harmful blooms of the alga *Caulerpa sertularioides* onto coral reefs. *Oecologia* 164:1039-1048

2022 ANNUAL TCRMP REPORT

- Smith TB, Nemeth RS, Blondeau J, Calnan JM, Kadison E, Herzlieb S (2008) Assessing coral reef health across onshore to offshore stress gradients in the US Virgin Islands. *Marine Pollution Bulletin* 56:1983-1991
- Smith TB, Brown K, Ennis R, Honisch B, Martens J, Wright V (2013a) United States Virgin Islands Department of Environmental Protection. Section 106 Research Program. Study of Nutrient Analysis and Distribution and Sedimentation Rate. Final Project Report (GC085DNR11). University of the Virgin Islands 79
- Smith TB, Gyory J, Brandt ME, Miller WJ, Jossart J, Nemeth RS (2016a) Caribbean mesophotic coral ecosystems are unlikely climate change refugia. *Global Change Biology* 22:2756–2765
- Smith TB, Blondeau J, Nemeth RS, Pittman SJ, Calnan JM, Kadison E, Gass J (2010b) Benthic structure and cryptic mortality in a Caribbean mesophotic coral reef bank system, the Hind Bank Marine Conservation District, U.S. Virgin Islands. *Coral Reefs* 29:289-308
- Smith TB, Brandt ME, Calnan JM, Nemeth RS, Blondeau J, Kadison E, Taylor M, Rothenberger JP (2013b) Convergent mortality responses of Caribbean coral species to seawater warming. *Ecosphere* 4:art87
- Smith TB, Brandtneris VW, Canals M, Brandt ME, Martens J, Brewer RS, Kadison E, Kammann M, Keller J, Holstein DM (2016b) Potential structuring forces on a shelf edge upper mesophotic coral ecosystem in the US Virgin Islands. *Frontiers in Marine Science* 3:115
- Smith TB, Brandt ME, Brandtneris VW, Ennis RS, Groves SH, Habtes S, Holstein DM, Kadison E, Nemeth RS (2019a) The United States Virgin Islands. In: Loya Y, Puglise KA, Bridge T (eds) *Coral Reefs of the World: Mesophotic Coral Ecosystems*. Springer,
- Smith TB, Brandt ME, Brandtneris VW, Ennis RS, Groves SH, Habtes S, Holstein DM, Kadison E, Nemeth RS (2019b) Disturbance in Mesophotic Coral Ecosystems and Linkages to Conservation and Management. In: Loya Y, Puglise KA, Bridge T (eds) *Coral Reefs of the World: Mesophotic Coral Ecosystems*. Springer,
- Strand J, Jørgensen A, Tairova Z (2009) TBT pollution and effects in molluscs at US Virgin Islands, Caribbean Sea. *Environment International* 35:707-711
- Tobias W (1997) Three Year Summary Report: Cooperative Fisheries Statistics Program #SF-42 (NA27FT0301-01). Department of Fish and Wildlife, United States Virgin Islands 41 pp
- Tsounis, G. and P. J. Edmunds. 2017. Three decades of coral reef community dynamics in St. John, USVI: a contrast of scleractinians and octocorals. *Ecosphere* 8:e01646.
- Williams ID, Polunin NVC, Hendrick VJ (2001) Limits to grazing by herbivorous fishes and the impact of low coral cover on macroalgal abundance on a coral reef in Belize. *Marine Ecology Progress Series* 222:187-196
- Williams MK, Edmunds PJ (2021) Reconciling slow linear growth and equivocal competitive ability with rapid spread of *peyssonnelid* algae in the Caribbean. *Coral Reefs* 10.1007/s00338-021-02052-7
- Woody K, Atkinson A, Clark R, Jeffrey C, Lundgren I, Miller J, Monaco M, Muller E, Patterson M, Rogers C, Smith TB, Spitzack T, Waara R, Whelan K, Witcher B, Wright A (2008) Coral Bleaching in the U.S. Virgin Islands in 2005 and 2006. In: Wilkinson C, Souter D (eds) *Status of Caribbean Coral Reefs After Bleaching and Hurricanes in 2005*. Global Coral Reef Monitoring Network, and Reef and Rainforest Research Center, Townsville, pp152