The United States Virgin Islands

TERRITORIAL CORAL REEF MONITORING PROGRAM

ANNUAL REPORT

2019

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A collaboration between:

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

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MISSION STATEMENT

Mission

OUR VISION

To provide critical information on the status and threats to all Virgin Islands coral reef ecosystems in order 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 facing a dramatic decline and are at a crossroads. Management decisions made today will affect the goods and services that 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 and has identified threats that will influence the 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 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: MANGEMENT 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). This event surpassed all known modern impacts from physical damage (storms and anchoring), ecosystem changes (fishing and disease), and pollution (terrestrial sediments and toxins). These events are predicted to increase with a warming planet, troubling news for the USVI.

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).

Overfishing. There are clear indications that reefs of the USVI are suffering the effects of overexploitation of reef resources, although there are also positive signs. 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, tiger, and yellowfin groupers, as well as the federally protected parrotfish species blue, midnight, and rainbow. A study by Randall (1963) also found high relative abundances of groupers and threatened parrotfish on the south coast of St. John. Rebuilding these fish stocks will require 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. Positive signs of an increasing recruiting and spawning population of Nassau groupers in the northern USVI 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 rare in shallow waters. This suggests viable populations still exist as a base 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 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 (Henderson et al. in press).

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, perhaps uniquely for the Caribbean, 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") reefs of the USVI are the best developed in the Caribbean from what is currently known. Mesophotic Coral Ecosystem (MCE) bank 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 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). 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 grouper spawning aggregation site there have been increasing numbers of Nassau grouper present for annual spawning (Kadison et al. 2010; Jackson et al. 2014) and 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. Olsen, pers. comm.). In 2015 there was a recruitment pulse of juvenile Nassau grouper to shallow nearshore environments of St. Thomas and St. John in 2015. 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. Although uncommon, Nassau grouper have been recorded at various TCRMP sites around St. Croix since 2011, a positive sign. 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 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. 2019). Unpaved road segments have been implicated as the worst culprits in the production of sediment-laden run-off (Ramos-Scharrón and MacDonald 2007b) 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 19th year of monitoring on reefs surrounding St. Croix, St. John, and St. Thomas (years 2001-2019). Monitoring sites were distributed across the insular platform in depths from 5 to 63 m (16 – 220') in an effort 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.

EXECUTIVE SUMMARY

The TCRMP website describes the program

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

With data updated and housed in an auxillary website

https://sites.google.com/site/usvitcrmp20112015/data-archive

Data can also be requested directly from the research team by contacting Rosmin S. Ennis at rosmin.ennis@uvi.edu

The Impact of Stony Coral Tissue Loss Disease on the Northern USVI

Figure 2. The visual impacts of the stony coral tissue loss disease on coral diversity and large and old colonies.
Clockwise from left: Active SCTLD lesions and recently dead colonies on a range of coral species (Flat Cay, February 2019), 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)

Stony coral tissue loss disease (SCTLD) is a rapidly spreading disease in the USVI that is causing dramatic loss of coral cover and declines in species diversity (Fig. 2). SCTLD was first sighted in the US Virgin Islands in January 2019 at the Flat Cay TCRMP monitoring site (Fig. 3). The disease was identified by its characteristic stony coral species-specific susceptibility characteristics. By March 2019 the disease had spread to the north side of St. Thomas and by January 2020 had spread eastward to the St. Thomas East End Reserves.

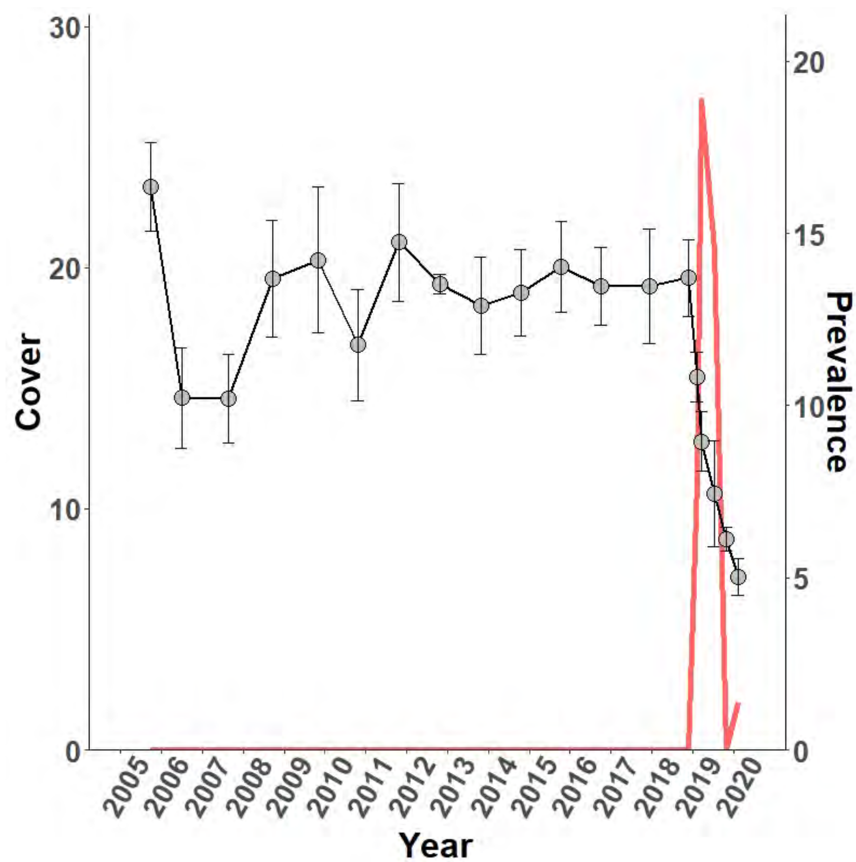


Figure 3. Mean Coral cover (±SEM; gray circle) and prevalence of SCTLD (red line) at the Flat Cay monitoring location.

Numerous local teams at the University of the Virgin Islands, the Department Planning and Natural Resources, the National Park Service, the Caribbean Oceanic Restoration & Education (CORE) Foundation and The Nature Conservancy have been coordinating monitoring, research, and response with national collaborators, such as the Florida

Department of Environmental Protection, Woods Hole Oceanographic Institution, University of Texas Arlington, Louisiana State University, Mote Marine Lab, Rice University, and the National Oceanic and Atmospheric Administration. Updated details concerning SCTLD can be found at the following website: https://www.vicoraldisease.org

Detailed early impacts at TCRMP sites can be found in the site descriptions. Notable sites covered in this report that are showing impacts from SCTLD are Black Point, Botany Bay, Brewers Bay, Flat Cay, and Savana Island.

Impacts of the 2019 Coral Bleaching Event and Comparison with Previous Events

In 2019 the USVI suffered its third mass coral bleaching event in the last 15 years (Fig. 4). Sea surface temperatures of the USVI have been increasing at a rate of about 0.2°C per decade since the 1980's (Fig. 5), increasing the incidence of coral thermal stress, measured as degree heating weeks (DHW), and coral bleaching. Major bleaching events, with heat stress values above 8 DHW, have occurred in 2005, 2010, and 2019. Weekly average sea surface temperatures in 2019 peaked at 29.8°C during the week of Sep. 8., compared with 30.4°C in 2005 and 30.1°C in 2010. Combined with the duration of heat stress this caused max DHW values of 15.5, 9.8, and 8.9 for 2005, 2010, and 2019, respectively (Fig. 4).

Figure 4. UVI graduate student Dan Mele conducts coral health surveys during thermal stress at the Brewers Bay monitoring location, October 29, 2019 (photo credit: R.S. Ennis).

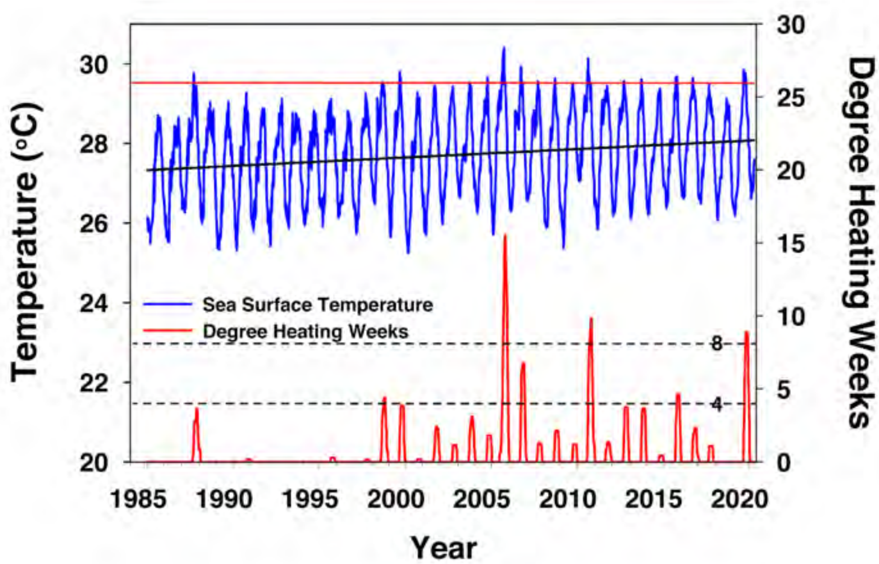


Figure 5. Sea surface temperatures and coral degree heating weeks of the US Virgin Islands from 1984 – 2020.
Optimum Interpolation Sea Surface Temperature (OISST; blue line, left vertical axis) and degree heating weeks (red line, right vertical axis) for the USVI. The black line is a linear fit of the OISST data and shows about 0.007°C increase in temperature per year (y = 0.000669/year*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.)

The bleaching response of corals at TCRMP sites followed a trajectory across years that reflected the different relative severity of the events (Fig. 6). The year 2005 showed the highest prevalence of bleaching (75% of colonies across sites) and also the most dramatic mean extent (82% of the colony surfaces affected). The peak of beaching was sometimes missed at a given site in 2005 and, thus, sites-specific values are underestimated in some cases.

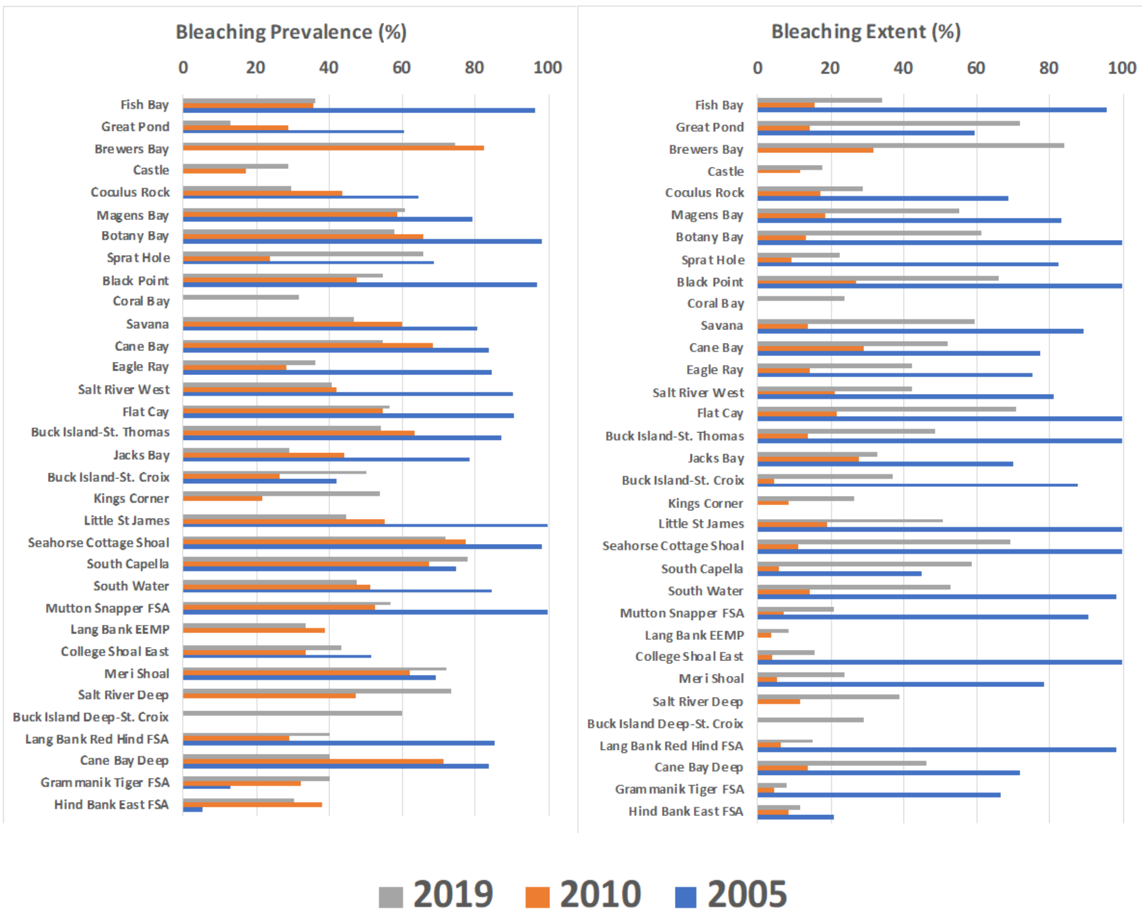


Figure 6. Maximum measured coral bleaching prevalence and extent for TCRMP in 2005, 2010, and 2019.
Beaching prevalence is the proportion of the community showing some level of stark white bleaching. Bleaching extent is the mean proportion of the colony area affected by stark white bleaching. Not all sites were sampled prior to 2019. Not all sites were sampled at the peak of the heat stress and may have underestimated bleaching responses for a given year (see individual site data). Sites are organized by increasing depth.

The year 2010 had a moderate prevalence of bleaching (47%) with low extent on colonies (14%). In 2019 the prevalence of bleaching was similar to 2010 (49%), but the extent on colonies was higher (44%). This is interesting as the years had similar peak DHW values. With the exception of Cane Bay and Cane Bay-Deep, all St. Croix sites were completed in late August to early September 2010, before peak heat stress and, potentially, maximum bleaching response. However, even at sites that were sampled at or after peak heat stress, such as St. Thomas and St. John sites, the extent was low. More research is needed to understand why 2010 was milder when colonies did show bleaching.

The coral community response to the 2019 thermal stress is not yet known. St. Thomas and St. John sites were resurveyed between mid-February and early March 2020 to assess impacts from bleaching. Sites unaffected by stony coral tissue loss disease (SCTLD) appeared to show little change in coral cover up to March 2020, suggesting that there was limited mortality from bleaching alone. All sites will be resurveyed in 2020 and the territory-wide impacts will be assessed as a research highlight in the 2020 report.

INTRODUCTION

Introduction

The U.S. Virgin Islands consists 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 of 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, famous for white sand beaches that give way to clean, clear marine waters. The diverse marine life of the coral reefs and other habitats attracts thousands of skin 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 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). 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 has the ability to 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 invasive red alga *Ramicrusta* has increased in abundance at some locations and is killing coral tissue through competitive overgrowth (Eckrich and Engel 2013; Ballantine David et al. 2016).

INTRODUCTION

High thermal stress and coral bleaching events affected the northeastern Caribbean in 2005, 2010, and 2012, but these events had contrasting signatures in the United States Virgin Islands. These 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) 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 33 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 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.

INTRODUCTION

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.

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 sample reefs below 30m at this point, and therefore misses the dominant habitat in the northern USVI, which is only sampled in the TCRMP.

This report presents monitoring results from 2001-2018 in St. Croix and from 2003-2018 in St. Thomas and St. John. For both islands, temporal changes from year to year in the conditions of the reef communities are assessed.

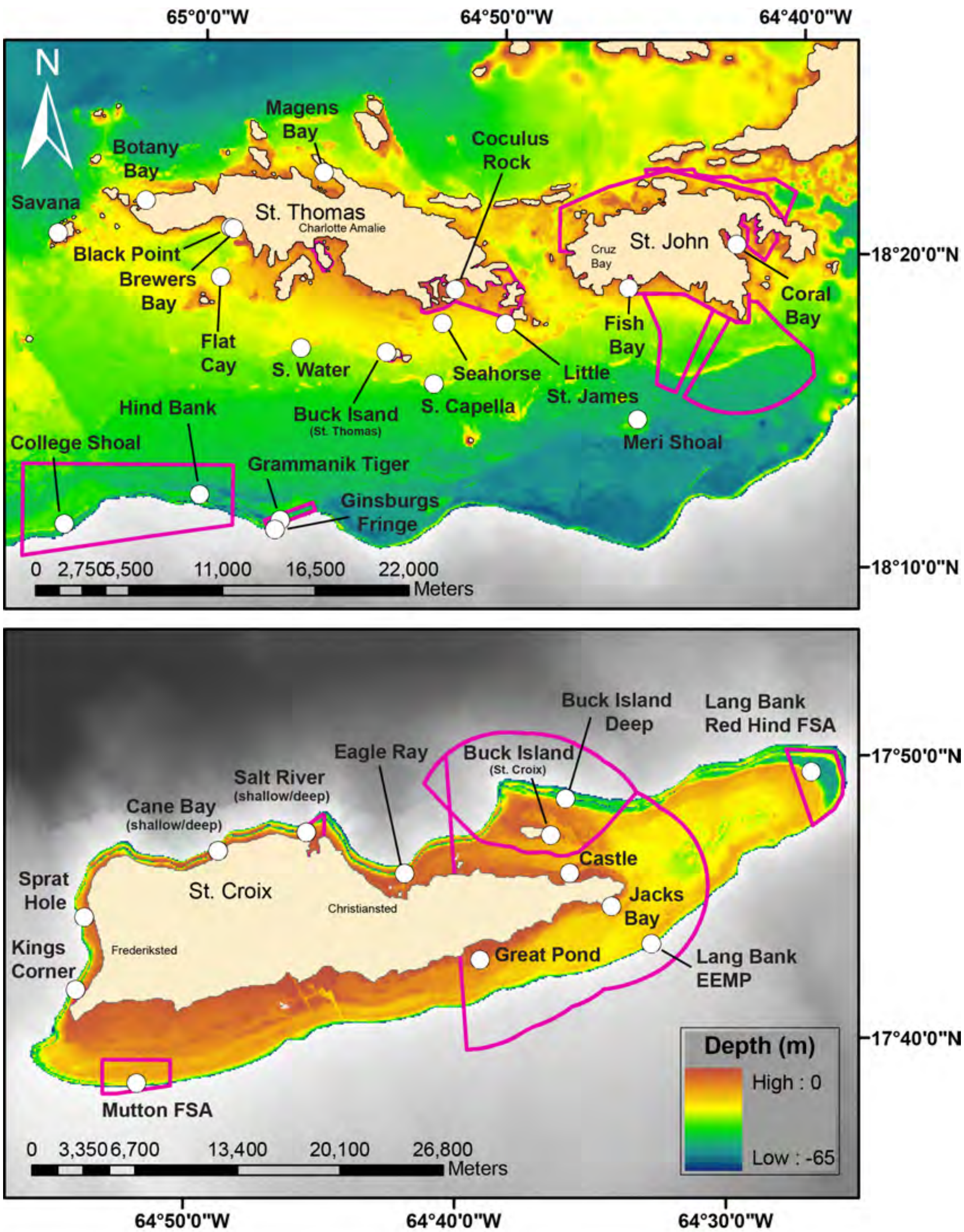


Figure 7. Locations of Territorial Coral Reef Monitoring Sites in the US Virgin Islands. Boundaries indicate federal and territorial marine protected areas.

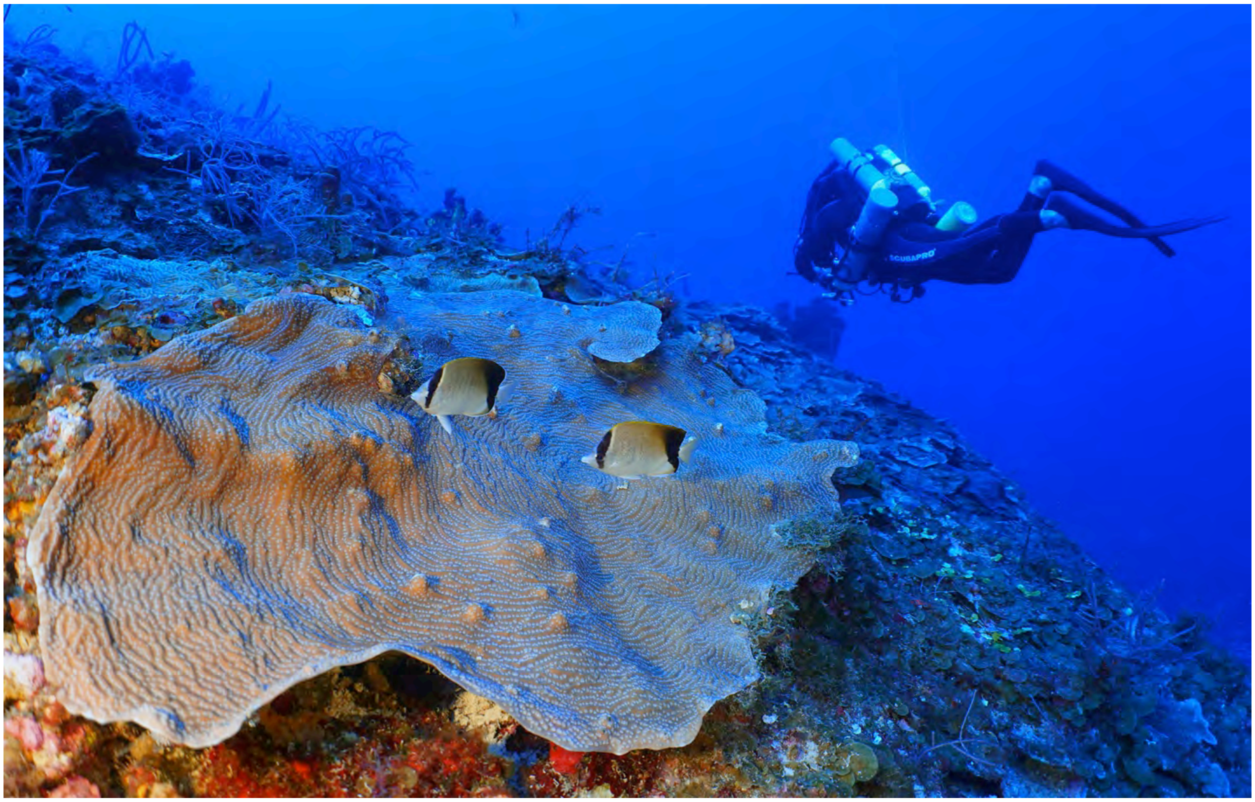


Figure 8. A TCRMP research diver (T. Smith) on closed circuit rebreather records a fish transect at the lower mesophotic coral reef site Ginsburgs Fringe at 63m/220’ depth (April 20, 2017; photo credit: V.W. Brandtneris).

METHODS

Methods

BENTHIC ASSESSMENTS

The University of the Virgin Islands determined the benthic composition at 34 long-term monitoring sites between 2001 and 2018 (Fig. 7; Table 1; Table 2). All data is now available at the TCRMP website and updated annually after quality control:

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

https://sites.google.com/site/usvitcrmp20112015/data-archive

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, Coculus Rock, College Shoal East, Coral Bay, Fish Bay, Flat Cay, Ginsburgs Fringe, Grammanik Tiger FSA, Hind Bank FSA, Little St. James, Magens Bay, Savana Island, Seahorse Cottage Shoal (Seahorse), Meri Shoal, South Capella, and South Water Island. One site is the within the St. Thomas East End Reserve (Coculus Rock), four sites are within federal fisheries marine protected areas (College Shoal, Ginsburgs Fringe, Grammanik Tiger, Hind Bank), and five sites can be considered mesophotic coral reefs (College Shoal, Ginsburgs Fringe, Grammanik Tiger, Hind Bank, Meri Shoal). Four sites were also part of the Ciguatera Fish Poisoning Monitoring Program and were surveyed monthly for benthic structure and coral health from 2010-2016 (Black Point, Coculus Rock, Flat Cay, Seahorse). Because of its deep depth, Ginsburgs Fringe at 60-66m was only sampled for benthic cover and some fish transects.

Benthic Cover. At each site benthic cover and coral health surveys were conducted along six 10 m long permanent transects marked with steel or brass rods. 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 m^2 (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, 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.

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	18.18885	-64.95659	38
	Hind Bank East FSA	Offshore-MCE	18.20217	-65.00158	39
	Magens Bay	Nearshore	18.37425	-64.93438	7
	Savana	Offshore-Shallow	18.34064	-65.08205	9
	Seahorse Cottage Shoal	Offshore-Shallow	18.29467	-64.86750	20
	South Capella	Offshore-Shallow	18.26267	-64.87237	20
	South Water	Offshore-Shallow	18.28068	-64.94592	20
	Little St James	Offshore-Shallow	18.29459	-64.83238	17

Table 2. TCRMP site sampling date and type of sampling. Bleaching and post-bleaching sample dates refer to surveys completed during and after thermal stress, respectively. Select St. Croix locations were resampled for the peak thermal stress. Surveys not completed are indicated by (-) while completed surveys are indicated by (X).

Island	Site	Bleaching Sample Date		Post-Bleaching Sample Date	Benthic	Health	Fish + Urchin
St. Croix	Buck Island STX	10/15/19	12/3/19	-	X/X/-	X/X/-	X/-/-
	Buck Island STX Deep	10/15/19	12/3/19	-	X/X/-	X/X/-	X/-/-
	Cane Bay	10/18/19	12/2/19	-	X/X/-	X/X/-	X/-/-
	Cane Bay Deep	10/18/19	12/2/19	-	X/X/-	X/X/-	X/-/-
	Castle	10/16/19	-	-	X/-/-	X/-/-	X/-/-
	Eagle Ray	10/16/19	-	-	X/-/-	X/-/-	X/-/-
	Great Pond	10/21/19	-	-	X/-/-	X/-/-	X/-/-
	Jacks Bay	10/16/19	-	-	X/-/-	X/-/-	X/-/-
	Kings Corner	10/17/19	-	-	X/-/-	X/-/-	X/-/-
	Lang Bank EEMP	10/20/19	-	-	X/-/-	X/-/-	X/-/-
	Lang Bank Red Hind FSA	10/20/19	-	-	X/-/-	X/-/-	X/-/-
	Mutton Snapper FSA	10/17/19	-	-	X/-/-	X/-/-	X/-/-
	Salt River Deep	10/19/19	12/2/19	-	X/X/-	X/X/-	X/-/-
	Salt River West	10/19/19	12/2/19	-	X/X/-	X/X/-	X/-/-
	Sprat Hole	10/17/19	-	-	X/-/-	X/-/-	X/-/-
St. John	Coral Bay	12/5/19	-	2/24/20	X/-/X	X/-/X	X/-/X
	Fish Bay	12/5/19	-	3/5/20	X/-/X	X/-/X	X/-/X
	Meri Shoal	11/21/19	-	2/24/20	X/-/X	X/-/X	X/-/X
St. Thomas	Black Point	10/30/19	-	2/11/20	X/-/X	X/-/X	X/-/X
	Botany Bay	11/8/19	-	2/21/20	X/-/X	X/-/X	X/-/X
	Brewers Bay	10/29/19	-	2/11/20	X/-/X	X/-/X	X/-/X
	Buck Island STT	10/29/19	-	2/26/20	X/-/X	X/-/X	X/-/X
	Coculus Rock	12/5/19	-	2/26/20	X/-/X	X/-/X	X/-/X
	College Shoal East	11/25/19	-	3/2/20	X/-/X	X/-/X	X/-/X
	Flat Cay	10/30/19	-	2/11/20	X/-/X	X/-/X	X/-/X
	Ginsburgs Fringe	1/28/20	-	-	X/-/-	X/-/-	X/-/-
	Grammanik Tiger FSA	12/6/19	-	2/25/20	X/-/X	X/-/X	X/-/X
	Hind Bank East FSA	11/25/19	-	2/25/20	X/-/X	X/-/X	X/-/X
	Magens Bay	11/8/19	-	2/21/20	X/-/X	X/-/X	X/-/X
	Savana	11/8/19	-	2/21/20	X/-/X	X/-/X	X/-/X
	Seahorse Cottage Shoal	11/20/19	-	2/4/20	X/-/X	X/-/X	X/-/X
	South Capella	11/20/19	-	2/4/20	X/-/X	X/-/X	X/-/X
	South Water	11/14/19	-	3/2/20	X/-/X	X/-/X	X/-/X
	Little St James	12/5/19	-	3/5/20	X/-/X	X/-/X	X/-/X

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

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

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

FISH CENSUS

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

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

TCRMP MONITORING SUMMARY

Territorial Coral Reef Monitoring Summary

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).

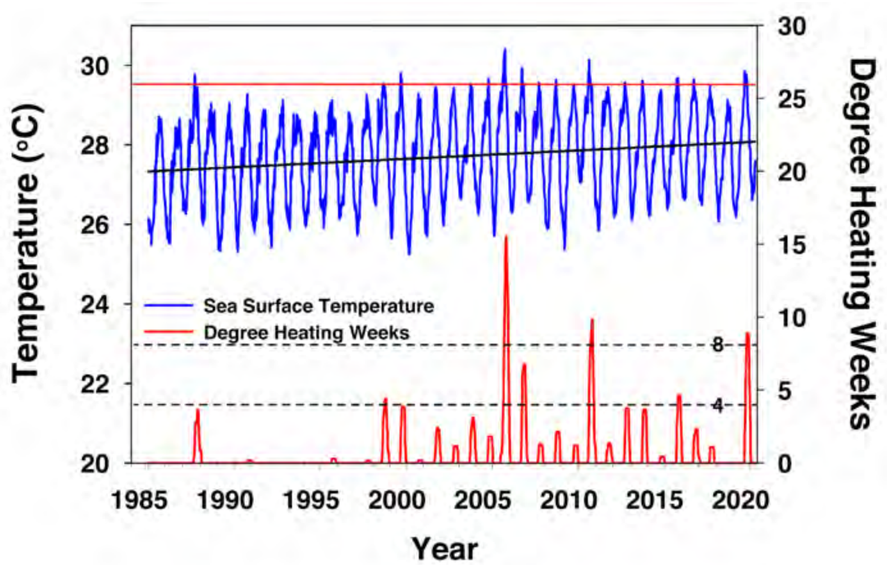


Figure 10. Sea surface temperatures and coral degree heating weeks of the US Virgin Islands from 1984 – 2020.

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/year*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 2018. Benthic cover raw data is presented in electronic Appendix I. Coral health raw data is presented in electronic Appendix II. In addition, updated benthic cover for each site individually is presented in the "Site Summaries" section.

Coral Cover

The cover of hard corals decreased at most sites immediately after the 2005 coral bleaching event, but showed little or no change as the results of the 2010, 2012, and 2019 coral bleaching events (Fig. 11). 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, and included Buck Island STT, Coculus Rock, Jacks Bay, and South Water. However, the Buck Island STT site may be anomalous since transects were not permanently placed until 2007 and unprecedented prevalence of white disease was seen at this site in 2006.

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

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

In addition, the deep Ginsburgs Fringe site lost 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 and Kadison 2013). Anchoring was likely for the purpose of fishing within the seasonal closed area, as there is little other obvious reason for anchoring at the shelf edge in deep water. Impacts to the corals and other essential fish habitat at this site may indirectly harm fishing in the US Virgin Islands.

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

In December 2018 stony coral tissue loss disease (SCTLD) was first sited at the Flat Cay monitoring site. In 2019 the disease had spread outward in all directions and affected the following sites (clockwise around St. Thomas): Flat Cay, Hind Bank, Savana Island, College Shoal, Botany Bay, Seahorse, South Capella, Buck Island, and Water Island.

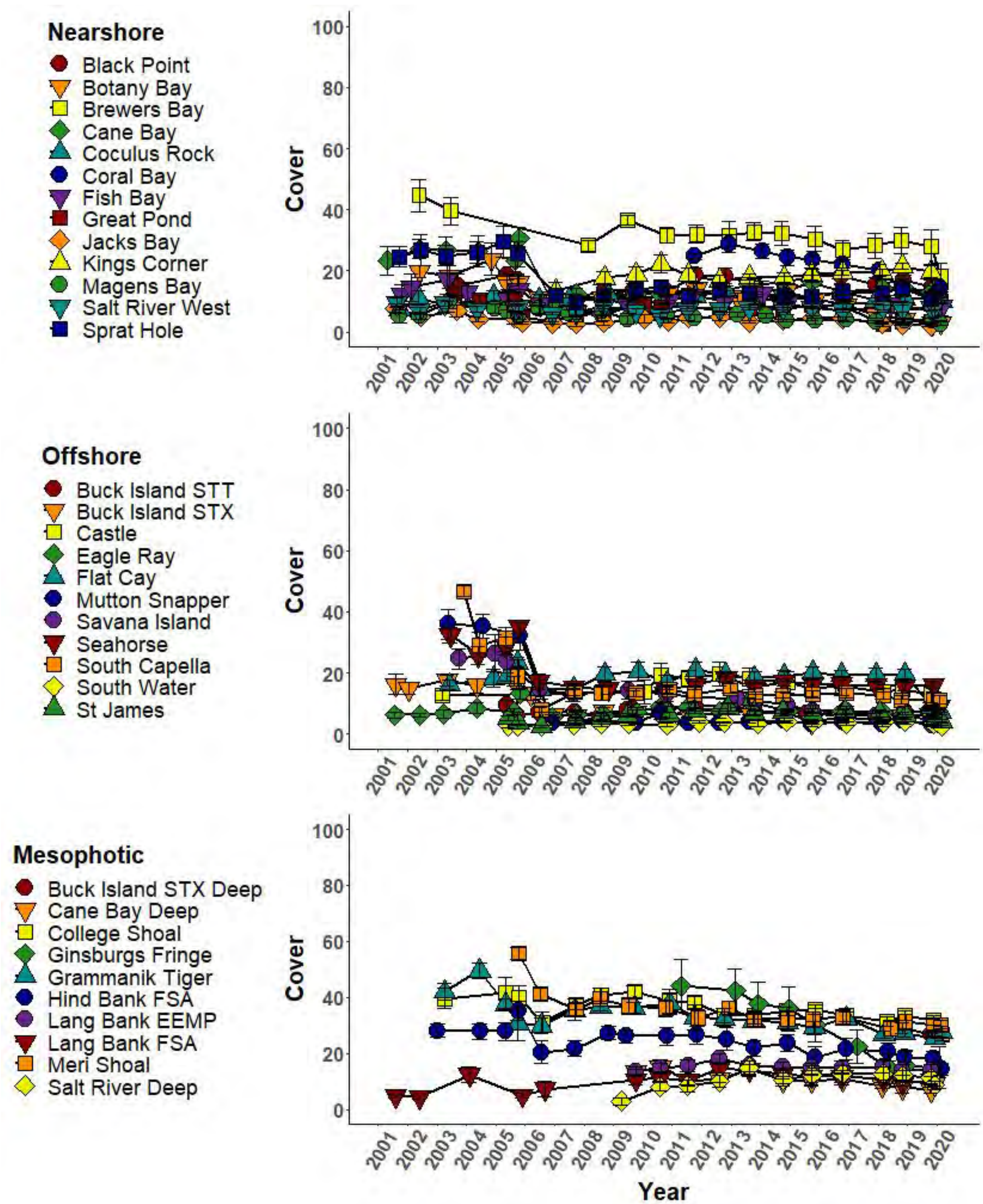


Figure 11. Coral cover (±SE) across TCRMP monitoring sites over time.

Epilithic Algal Community Cover

Algae show the highest inter-annual variability of any group of benthic organisms (Fig. 12). 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" *Ramicrusta* (see next section). Nearshore and mesophotic sites typically showed little inter-annual trend in epilithic algal cover, although interannual variability was high at many nearshore monitoring sites.

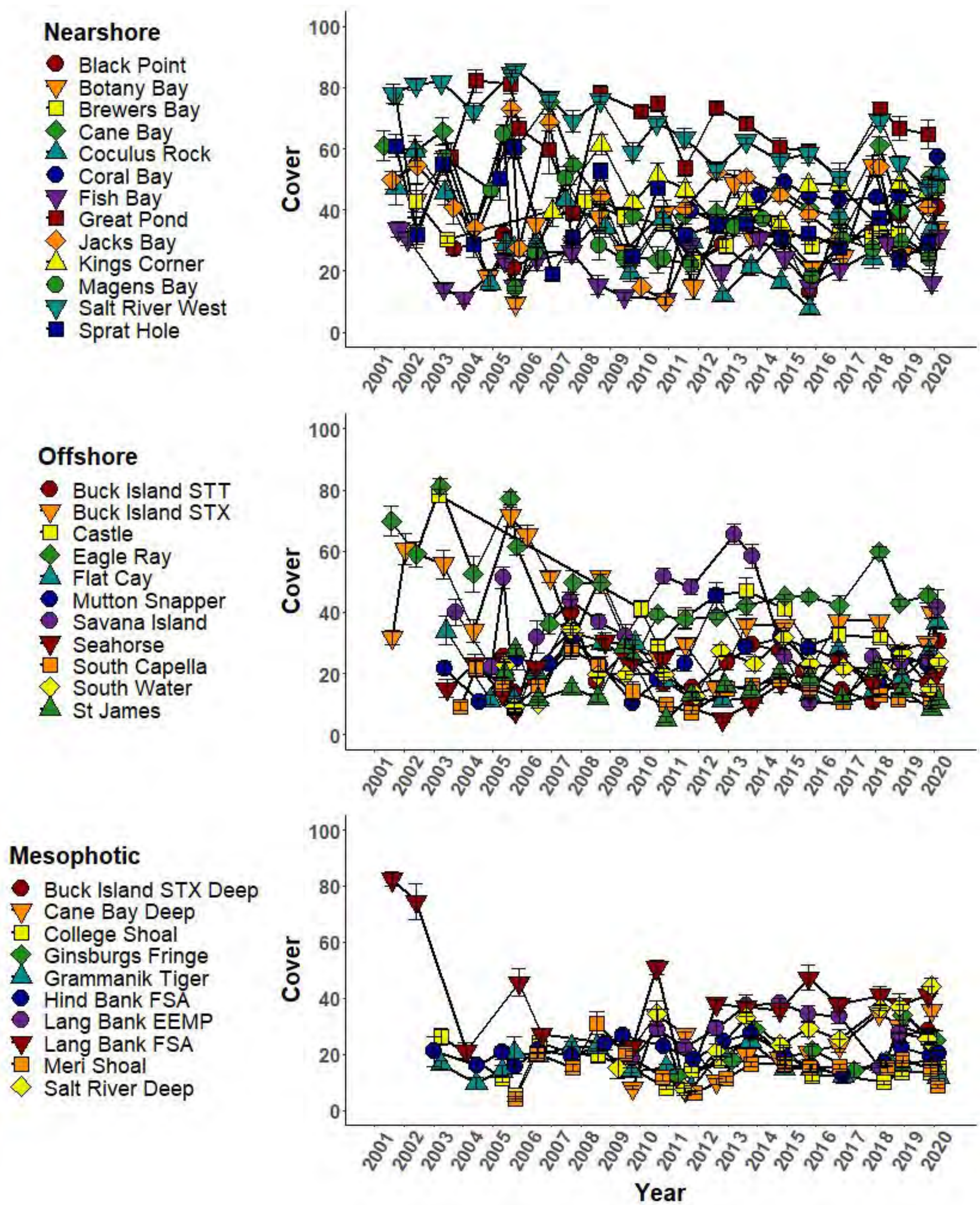


Figure 12. Epilithic Algal Community cover (±SE) across TCRMP monitoring sites over time.

Macroalgal Cover

Macroalgae have been increasing at many reefs, particularly after the 2005 bleaching event (Fig. 13). At sites where there was no loss of coral cover, increased macroalgae may be due to declining grazing, such as at Eagle Ray. At other sites where coral cover dropped after 2005, space opened for algal colonization by coral die-off may have been taken by macroalgae. This might occur where resident herbivores communities are already at the threshold of maximum grazing rates (Williams et al. 2001). This process could be enhanced where herbivores numbers are falling due to fishing. These reefs include: the Buck Islands (St. Thomas and St. Croix), Cane Bay, Meri Shoal, South Capella, and Sprat Hole. The same explanation may also apply for filamentous cyanobacteria (see following section). At Savana the large increase in macroalgae in 2014 and continuing to 2015 was due to a large increase in encrusting *Ramicrusta*, which was mentioned above as a cause of declining coral cover (*Ramicrusta* is classified with macroalgae in TCRMP data summaries despite its largely encrusting habitat). This increase in *Ramicrusta* sp. was also at the expense of epilithic algae.

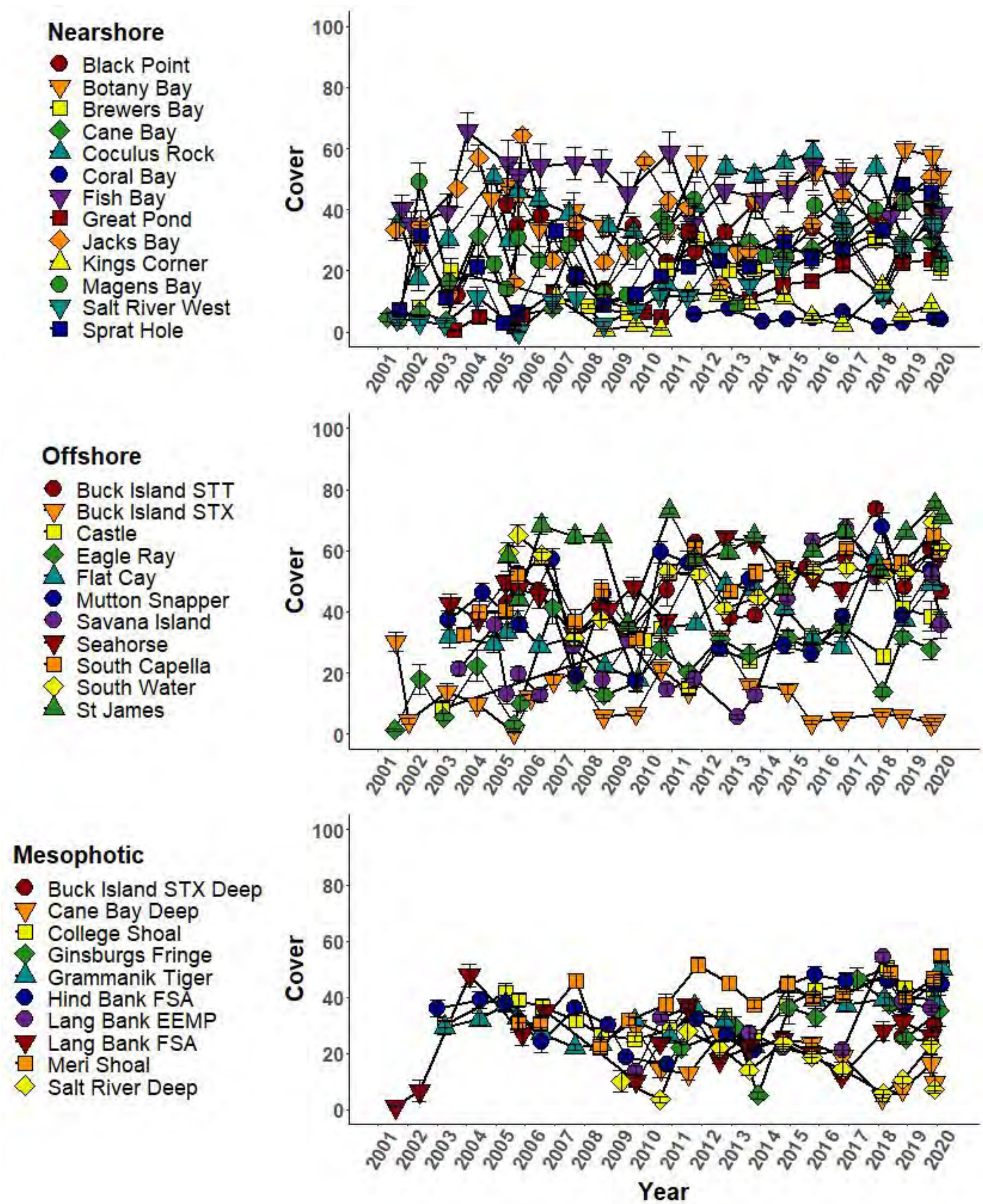


Figure 13. Macroalgae cover (±SE) across TCRMP monitoring sites over time.

Filamentous Cyanobacteria

Filamentous cyanobacteria cover has been increasing at many sites in the TCRMP since the 2005 coral bleaching event (Fig. 14). In many cases this was a multi-year peak that has abated, but at some sites high cover relative to baseline has persisted until 2014. This is particularly true at many sites on St. Croix. For example, Salt River West, Jacks Bay, Cane Bay, Sprat Hole, Mutton Snapper, Buck Island-St. Croix, Eagle Ray, Lang Bank EEMP, and Lang Bank Hind have all seen cover of filamentous cyanobacteria from 10 – 60%, with 2009 as a particularly high abundance year for offshore sites.

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

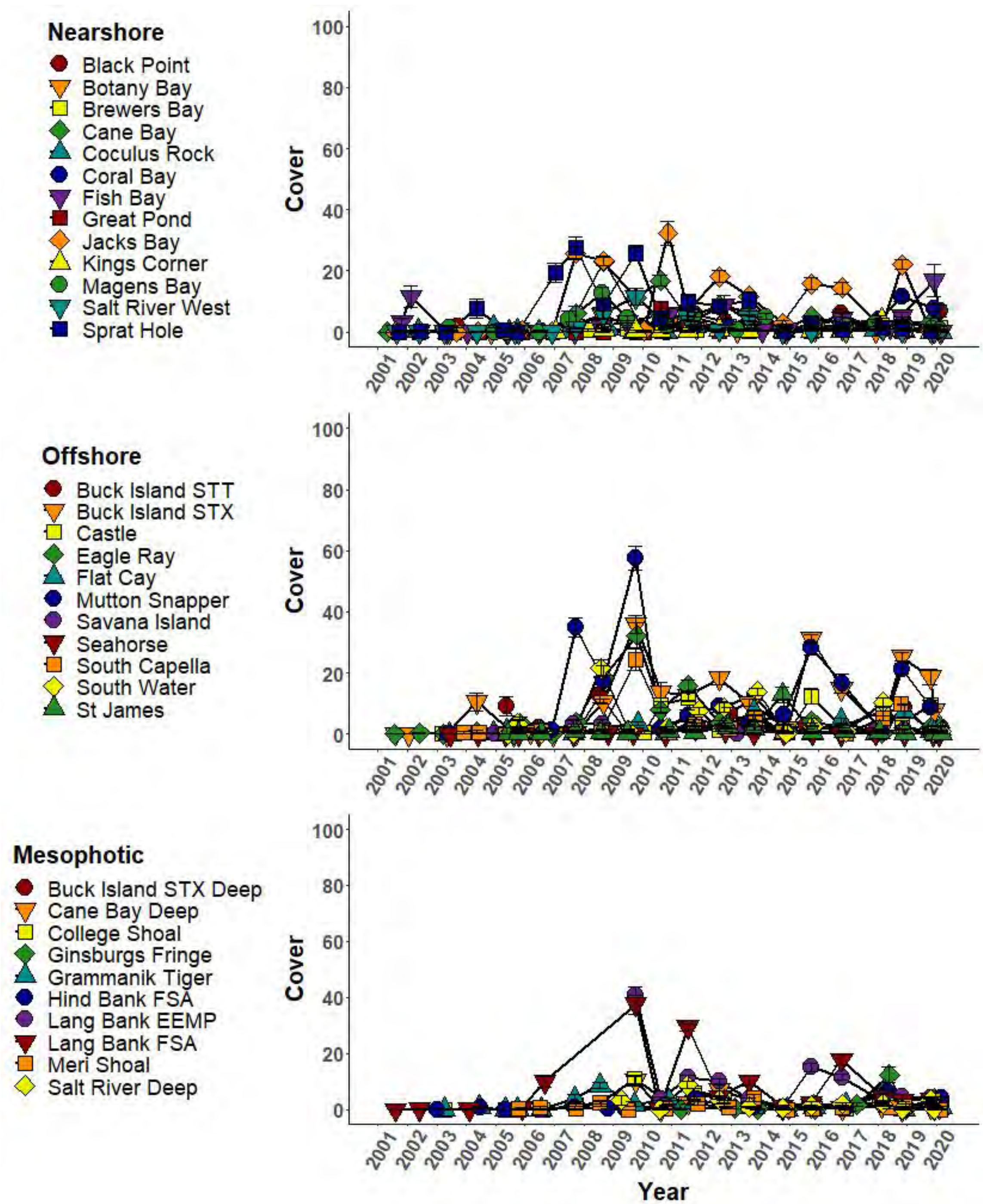


Figure 14. Filamentous cyanobacteria cover (±SE) across TCRMP monitoring sites over time.

Gorgonian and Antipatharian Cover

The cover of gorgonians and antipatharians has been fairly constant at most monitoring sites throughout the years of monitoring (Fig. 15). 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. At Coral Bay and Fish Bay the cover of gorgonians has been increasing through the monitoring time series. Magens Bay also showed 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). Increasing abundance of octocorals has also been detected at permanent monitoring sites in Lameshur Bay, St. John under investigation for 30 years (Tsounis and Edmunds 2017).

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

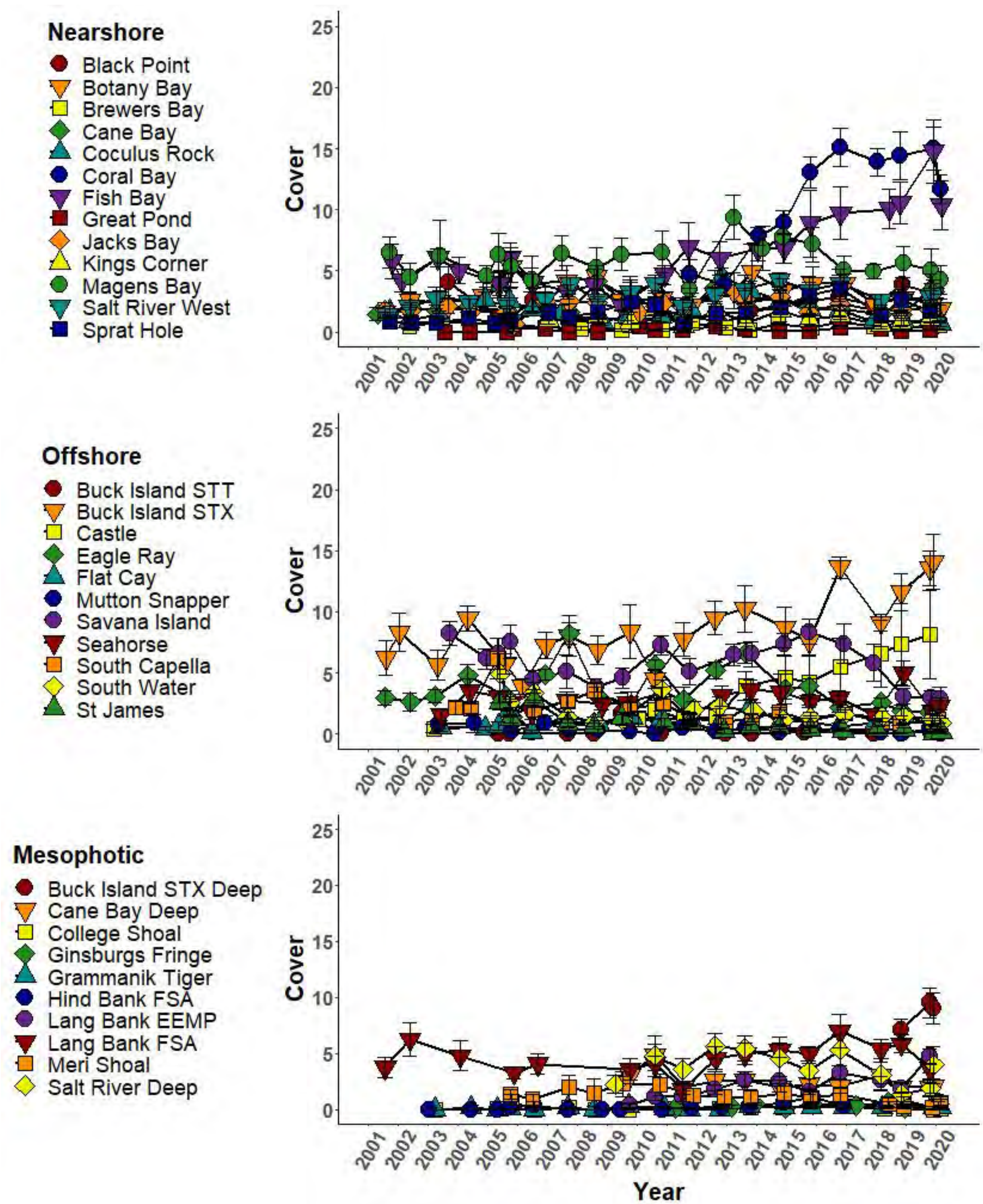


Figure 15. Gorgonian and Antipatharian cover (±SE) across TCRMP monitoring sites over time.

Sponge Cover

Sponge cover has been constant or variable at many offshore and mesophotic sites, but there is an indication of slightly increasing sponge cover at some nearshore sites (Fig. 16). Nearshore increases were most pronounced at Black Point, Coral Bay, and Magens Bay. This increase in epibenthic and boring sponges may indicate increasing supplies of food, such as bacteria and small eukaryotes, in nearshore environments. This may be a consequence of increasing nearshore nutrient pollution. Further study needs to be done to establish this linkage. 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.

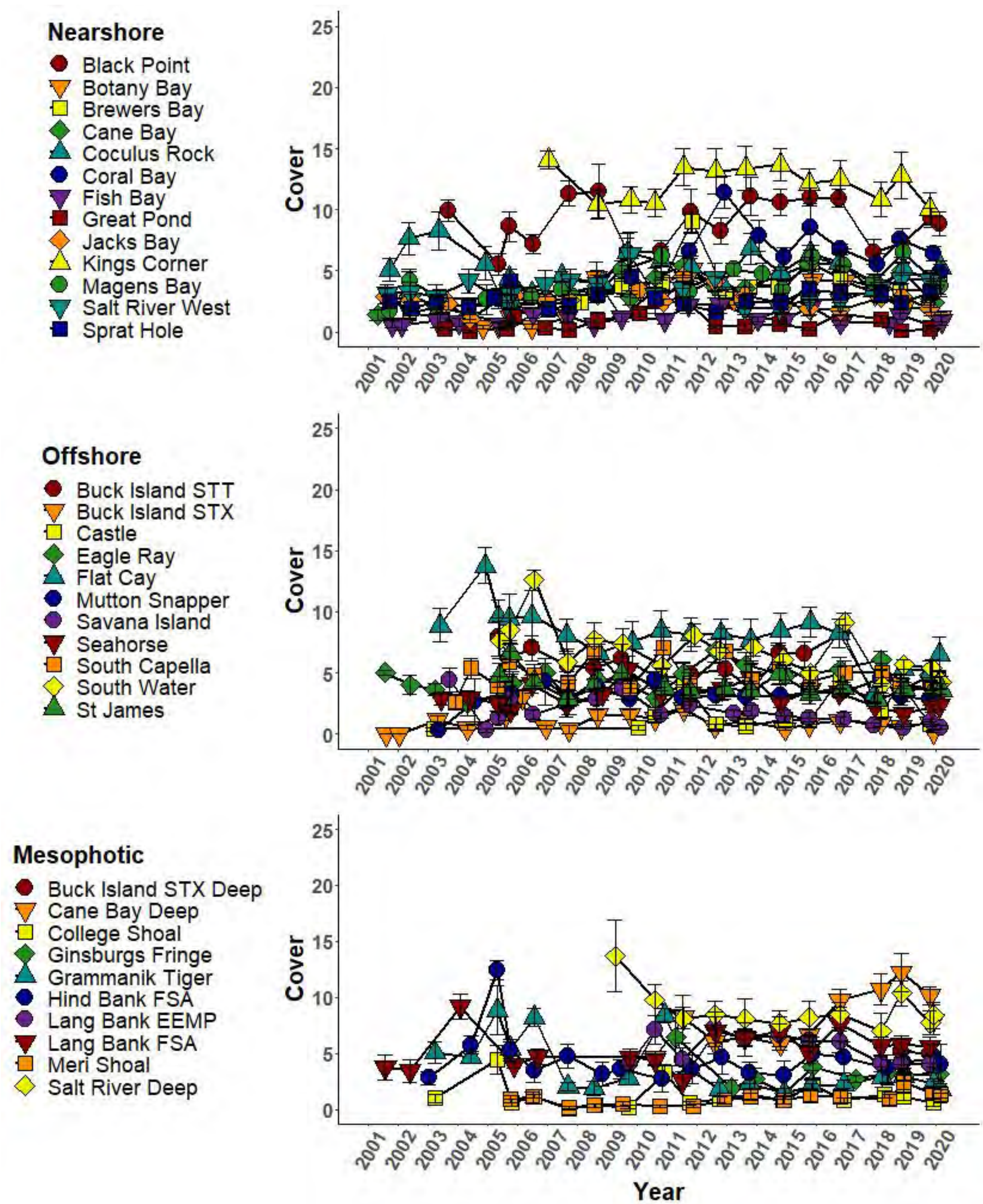


Figure 16. Sponge cover (±SE) across TCRMP monitoring sites over time.

TCRMP MONITORING SUMMARY

FISH COMMUNITIES

In 2018 a total of 58,044 fish representing 148 species and 38 families were recorded over 183 belt transects across 19 sites off the northern USVI. Total calculated biomass on sites of the northern USVI was 3219.04kg. An additional 33,984 fish representing 128 species and 45 families were recorded over 151 transects across all 15 sites off St. Croix. The calculated biomass was 1,198.54 kg. Using roving diver surveys (RDS) 141 species representing 36 families were observed in 2018 off the northern USVI and 126 species representing 38 families off St. Croix in 2018. Species richness was variable between sites but was similar between survey methods (transects and RDS). No differences in species richness were apparent between nearshore, offshore, and mesophotic sites (Table 3). As in previous years, sites with notably high species diversity in the northern USVI were Hind Bank East FSA, South Capella, and St. James (29.3 ±2.1, 30.9 ± 1.6 and 28.7 ± 3.3 species transect^{-1}, respectively). Cane Bay Shallow and Sprat Hole off St. Croix had the highest species richness of sites on the St. Croix shelf (27.2 ± 1.1 and 29.0 ± 1.4 species transect^{-1}, respectively). On St. Croix, the sites with the lowest species richness was the mesophotic site Salt River Deep (13.2 ± 3.4 species transect^{-1}), and the nearshore site Great Pond (17.4 ± 1.4 species transect^{-1}). This site is shallow with low living coral cover. Likewise, the shallow, low coral cover site in Coral Bay had the lowest species richness on the northern USVI shelf (18.0 ± 0.8 species transect^{-1}). The 65m site, Ginsberg's Fringe, also had a low species richness (17.5 ± 0.7). Only two transects were conducted on Ginsberg's Fringe.

Overall fish size distribution in both the northern USVI and St. Croix followed trends seen in earlier years. Over 42% of all individuals counted off the northern USVI and 53% in St. Croix were less than 5cm TL. Over 75% were less than 10cm TL. Large fish (> 40cm TL) constituted 0.5% of the numeric total in the northern USVI (265 fish), and 0.1% in St. Croix (35 fish). Numerically the most dominant fish in the northern USVI were the creole wrasse (*Clepticus parrae*), striped parrotfish (*Scarus iserti*), bluehead wrasse (*Thalassoma bifaciatum*), blue chromis (*Chromis cyanae*), and brown chromis (*C. multilineatum*). These species made up 50% of the numeric total of all fish reported. Four of these species were also the most abundant in the 2017 monitoring report. On St Croix reefs, blue chromis, creole wrasse, bicolored damselfish (*Stegastes partitus*), bluehead wrasse, and brown chromis contributed 63% to the numeric total of all sites. They species are ubiquitous and occurred on all sites. The four species that contributed most to biomass in the northern USVI included the creole wrasse, yellowtail snapper (*Ocyurus chrysurus*), and horseeye jack (*Caranx latus*). These made up 21% of total biomass. In St. Croix the fish contributing most to biomass included the creole wrasse, blackbar soldierfish (*Myripristis jacobus*) and Caribbean reef shark (*Carcharhinus perezi*). These species made up 24% of the biomass recorded.

Table 3. The 2018 species richness for belt transects and roving diver surveys (RDS). Sites are divided into nearshore, offshore, and mesophotic sites as described in the text.

		Belt Transects (25x4)		RDS
		Total Number of Species	Mean species per transect (±SE)	Total Number of Species
Nearshore	Cane Bay	70	27.2±1.1	59
	Great Pond	47	17.4±1.4	38
	Jacks Bay	66	24.9±2.0	56
	Kings Corner	72	29.0±2.6	50
	Salt River West	44	17.8±1.6	37
	Sprat Hole	75	29.0±1.3	62
	Coculus Rock	45	23.5±1.1	65
	Black Point	66	23.8±2.1	66
	Brewers Bay	63	24.4±150	55
	Botany Bay	72	27.1±1.3	76
	Buck Island, St. Thomas	60	23.7±0.8	72
	Coral Bay	54	18.0±1.7	38
	Fish Bay	58	20.7±3.5	57
	Magens Bay	57	27.2±1.2	71
Offshore	Eagle Ray	62	22.1±1.7	50
	Buck Island, St. Croix	61	21.8±1.9	50
	Castle	66	22.2±1.4	53
	Mutton Snapper FSA	65	23.9±1.7	51
	Seahorse Cottage Shoal	61	23.2±1.1	49
	South Capella	71	25.7±1.3	60
	South Water	63	24.1±1.3	55
	Flat Cay	74	24.6±1.0	65
	Meri Shoal	54	19.9±1.0	57
	Savana Island	78	26.8±1.6	69
	St. James	71	28.7±3.3	61
Mesophotic	Buck Island STX Deep	58	22.4±1.4	48
	Cane Bay Deep	61	21.3±1.9	47
	Lang Bank EEMP	63	24.1±2.3	57
	Lang Bank Red Hind FSA	65	23.9±2.3	51
	Salt River Deep	49	13.2±1.1	30
	College Shoal East	58	25.2±1.1	57
	Ginsburg's Fringe	24	17.5±0.7	-
	Grammanik Tiger FSA	65	27.7±2.0	72
	Hind Bank East FSA	69	29.3±2.1	64

Fish Abundance

Total fish abundances across nearshore, offshore, and mesophotic sites and years are shown in Fig. 17. As in previous, years total fish abundance was highly variable across sites and strata with no obvious patterns over time or space noted.

The sites with the highest overall fish abundance in 2018 were Black Point and Botany Bay. Black Point has high numbers of very small parrotfish and wrasse, raising the mean abundance of that site. Botany Bay is a site with high habitat diversity that supports many species in relatively high numbers. It is a reef that acts as juvenile habitat for grunts, which recruit there in very large schools. Other sites with relatively high fish abundance were Buck Island STT and Mutton Snapper. Sites with the lowest abundance included Salt River Deep and Ginsberg's Fringe. These mesophotic sites, dominated by agariciid corals, also had low species richness and biomass. Hurricanes of 2017 did not appear to affect the fish communities in a dramatic way. In general, mesophotic sites had a lower biomass than offshore or nearshore sites. Since mesophotic sites are not juvenile habit for many species, they lack the schools of smaller fishes like striped parrotfish. Wrasses are also notably less common on mesophotic reefs.

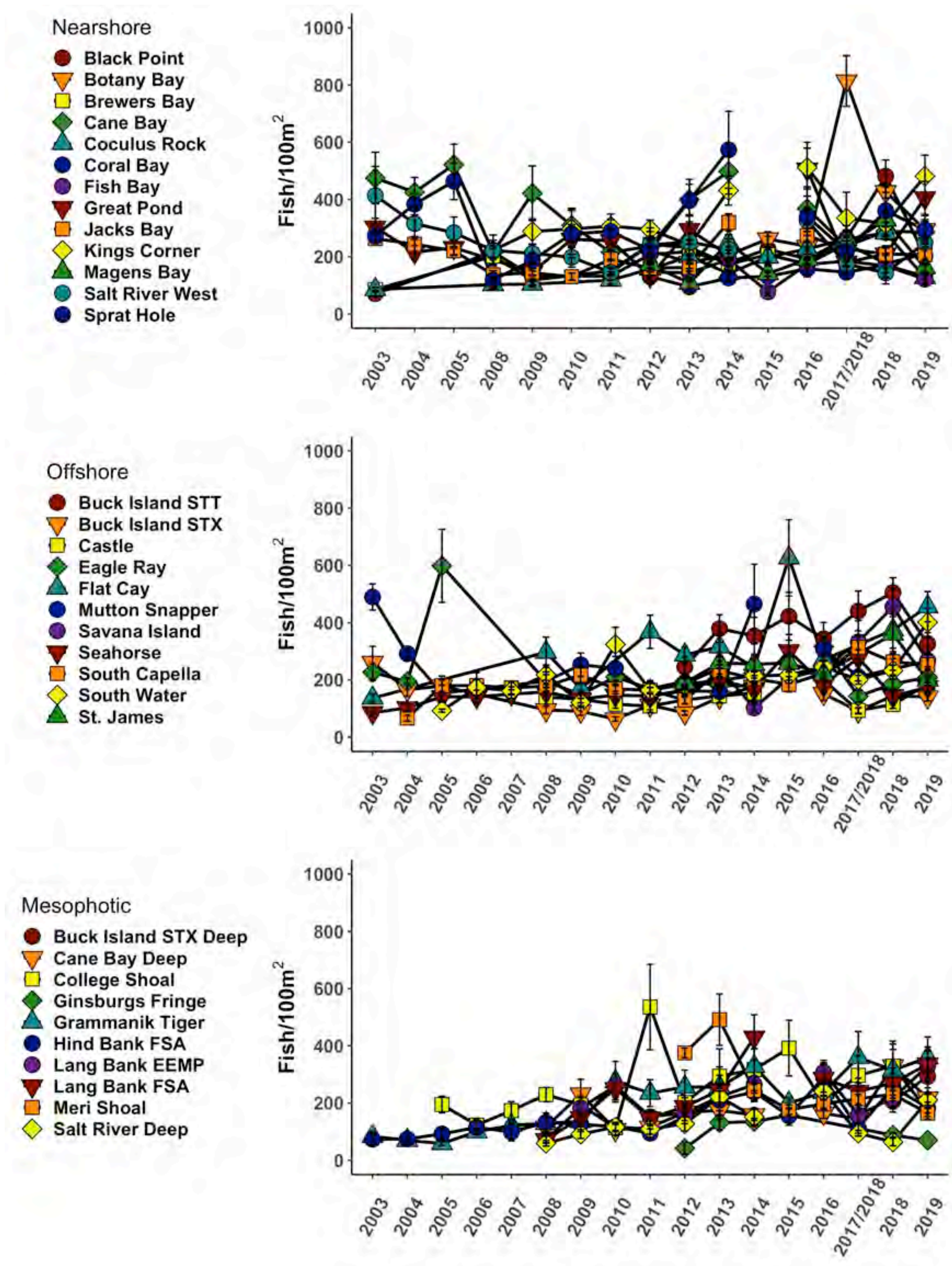


Figure 17. Fish abundance (±SE) across TCRMP monitoring sites over time.

Fish Biomass

Total fish biomass for all sites and years is shown in Fig. 18. As with abundance, biomass is highly variable across strata, sites and years. No temporal pattern is obvious, and differences in time appear to be seasonal or natural variation. The biomass of fish at mesophotic sites off the northern USVI (Grammanik Bank FSA, Hind Bank FSA, and College Shoal) have had the highest biomass values throughout the TCRMP sampling series. These are protected reefs on the insular shelf edge, and fish spawning occurs on both the Grammanik Bank FSA and Hind Bank FSA. Although TCRMP sampling occurs outside of the spawning season, higher numbers of large fish may inhabit these sites due to their roles as aggregation areas. College Shoal does not host spawning events however, and biomass is also generally high on this site. In 2017 total biomass was higher on College Shoal than on any other site sampled. This was due primarily to large numbers of bar jacks, horseeye and black jacks (*C. lugubris*) that were present. Biomass on the mesophotic sites on St. Croix were low as in past years. Although now protected from fishing, Lang Bank does not seem to attract the large pelagics that are present on the southern edge of the northern USVI shelf. As with abundance, biomass appeared to be slightly lower on most St. Croix sites, possibly due to the passing of Hurricane Maria five months earlier. The St. Croix nearshore site, Kings Corner, generally has high biomass when compared to the other nearshore and offshore sites, however in 2018 biomass was very low. Northern USVI nearshore sites, Coral Bay, Magens Bay, Fish Bay and Botany Bay all had usual low fish biomass in 2017. These sites are along shorelines of developing residential areas and sustain high turbidity levels. They are also far from the deeper water near the shelf edge, and so these sites appear to support only juvenile fishes, and small species and at very low abundances.

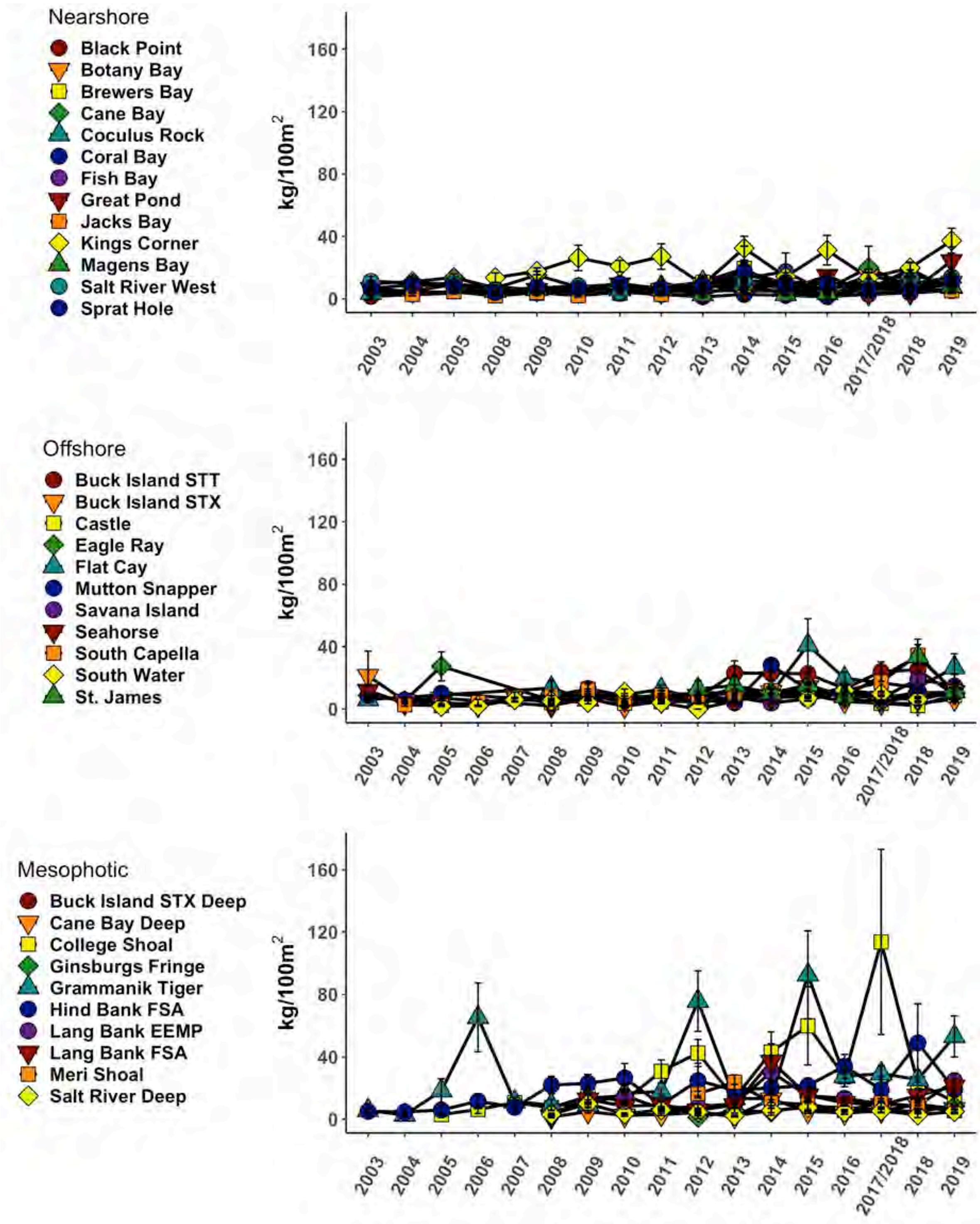


Figure 18. Mean fish biomass (±SE) across TCRMP monitoring sites over time.

BLACK SPINED SEA URCHIN *DIADEMA ANTILLARUM*

The abundance of the black spined sea urchin *Diadema antillarum* shows tremendous site-to-site variability (Fig. 19). 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 is a high abundance of *Echinometra* spp. that has not been quantified. This species seems to be the dominant grazer and effectively removes most macroalgal cover, but also contributes apparently high bioerosion (gnawed coral bases). Future monitoring might consider targeted monitoring of these species at certain sites.

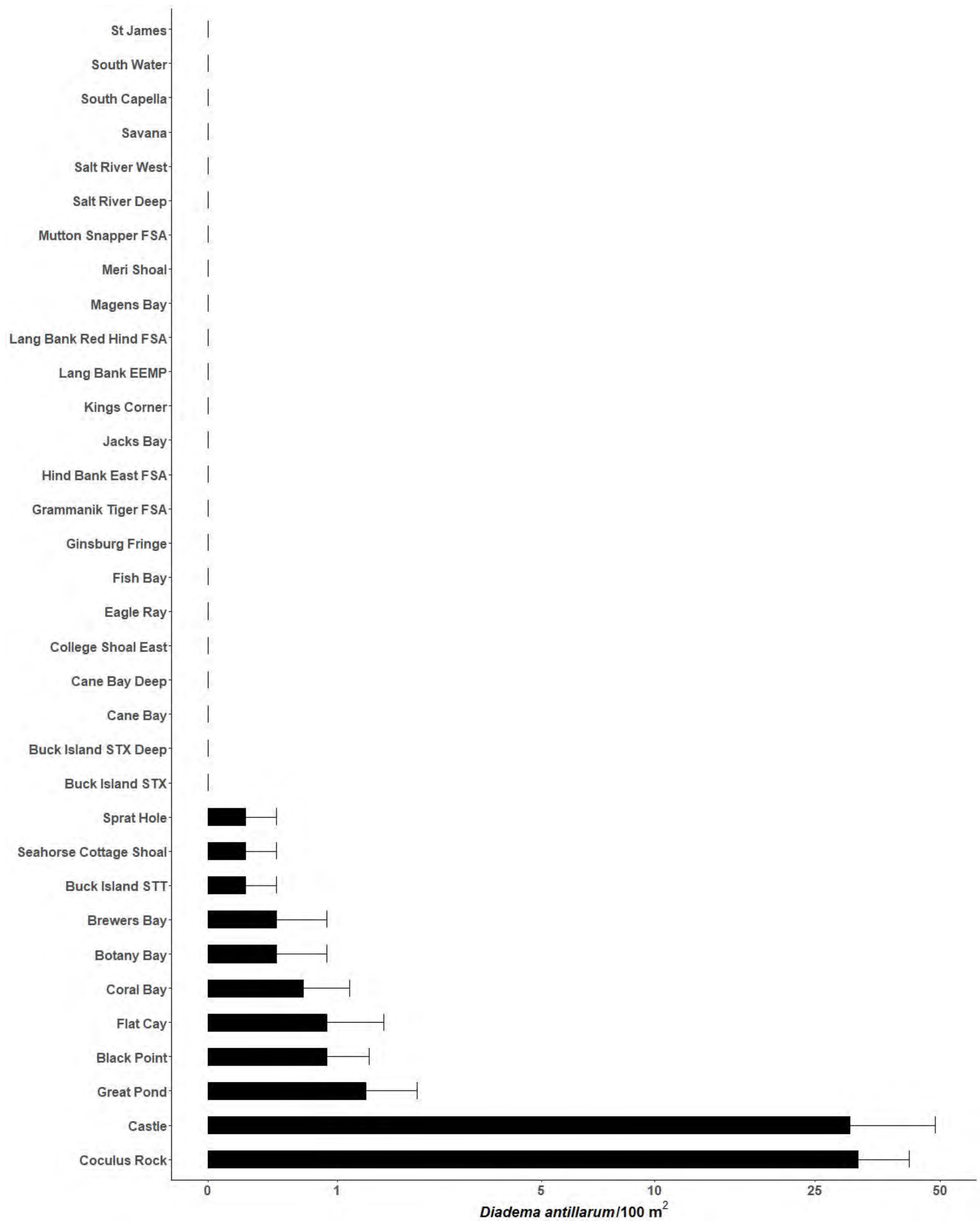


Figure 19. Average abundance (±SEM) of the black spiny sea urchin (*Diadema antillarum*) at TCRMP monitoring sites across all years. Note the log scale.

SITE SUMMARIES

Site Summaries

RATIONALE

The purpose of this section is to provide a more comprehensive survey of TCRMP site characteristics than can 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 also 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 SUMMMARY ELEMENTS

TCRMP site information is presented in a few pages that provide 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 data and coral health are updated in each annual report, whereas the fish summaries and physical data are updated periodically.

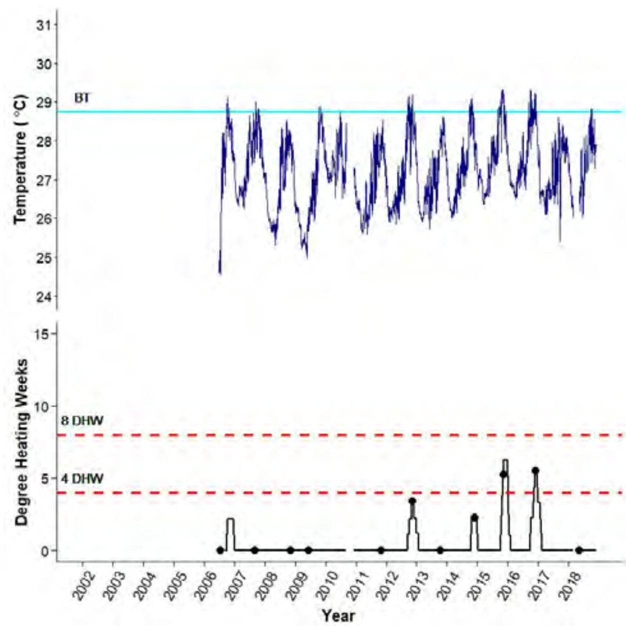
Benthic community structure is presented as the mean (±SE) cover of coral, macroalgae, cyanobacteria, and epilithic algae. Epilithic algal communities are diminutive turf and filamentous algae that cover hardbottom surfaces, whilst macroalgae have identifiable thallus differentiation and structure. Any 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 ($Cover_{2011}$ - $Cover_{2007}$)/($Cover_{2005}$- $Cover_{2007}$). Change calculations must be treated with caution for sites where transects where 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.

Benthic community pie charts were constructed from all years of data. The sessile epibenthic animal community includes *Agaricia* spp., *Colpophyllia natans*, *Pseudodiploria strigosa*, *Orbicella annularis*, *Orbicella spp.* (*O. faveolata*, *O. fransksi*, + unidentified *Orbicella* spp.), *Montastraea cavernosa*, *Porites astreoides*, branching *Porites* species, *Siderastrea siderea*, other corals, sponges, and gorgonians. The algae/non-living substrata category includes cyanobacteria, epilithic algae ("DCA"), *Lobophora variegata*, *Dictyota* spp., *Halimeda* spp. crustose coralline algae, and sand/sediment. These figures not are updated every annual report, since relative composition tends to change slowly. Figures are changed every five years or after a major disturbance, such as a coral bleaching event.

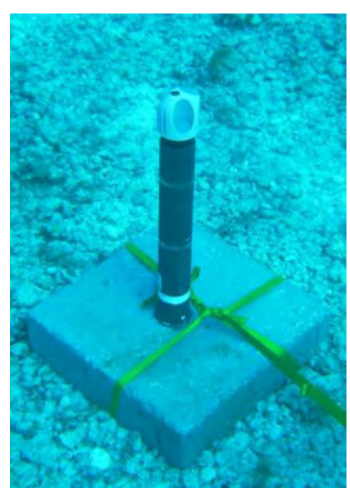
Coral Health is presented as the mean (±SE) of coral bleaching prevalence (proportion of population affected) and extent (proportion of colony affected), disease prevalence, and partial mortality prevalence.

PHYSICAL CHARACTERISTICS

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.

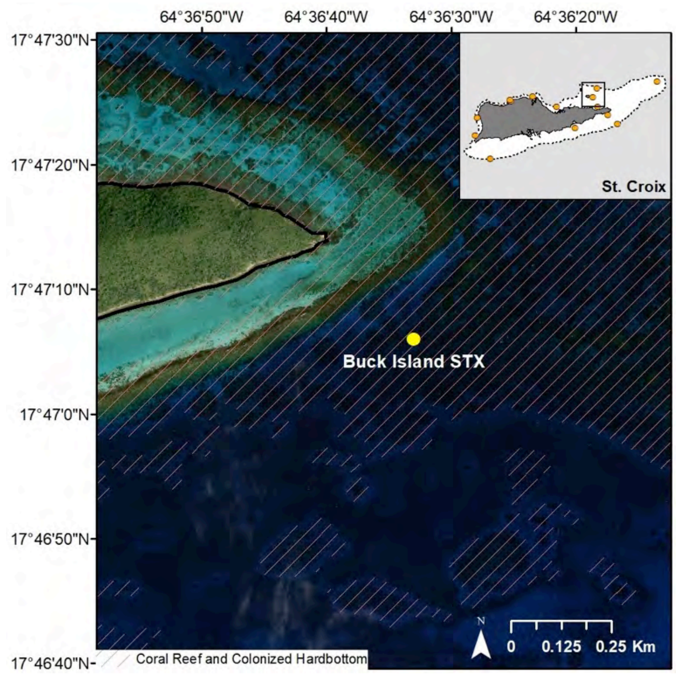


Currents. Water currents were recorded at a subset of sites and times with Nortek Aquadopp™ Acoustic Doppler Current Profilers (ADCPs). Profilers were set in bases on the seafloor and set to record current speed and direction within predefined depth bins above the substrate. The bin closest to the substrate 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.

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.

St. Croix

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

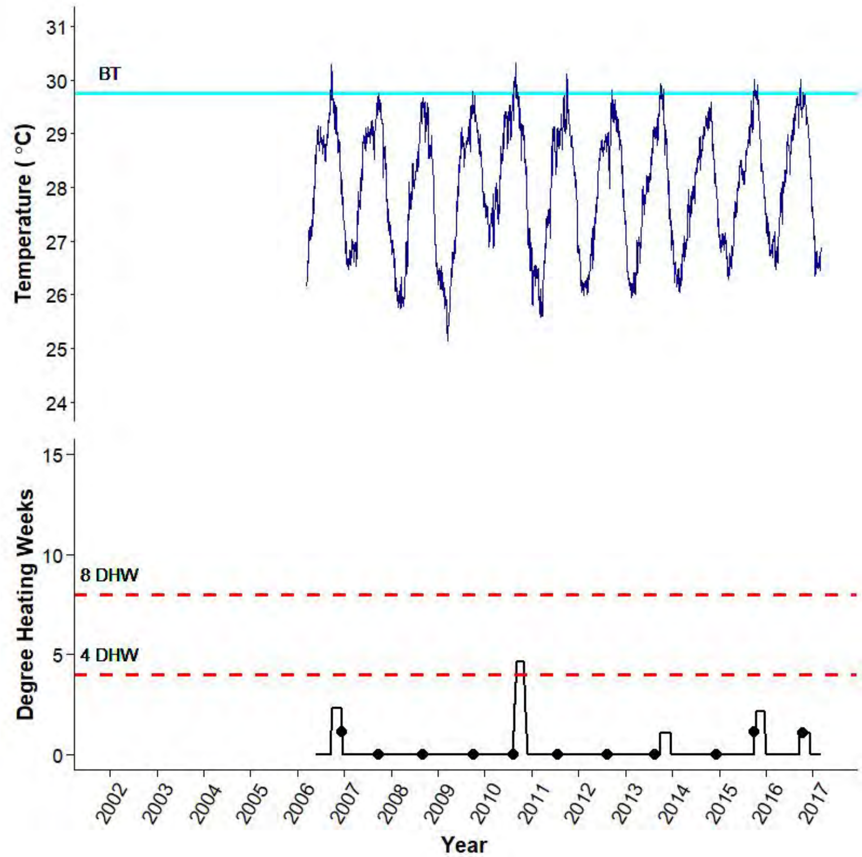


Figure 21. Buck Island, St. Croix benthic temperatures (14 m depth). Data provided by the National Park Service (site BUIS_SFR).

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

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 it 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.

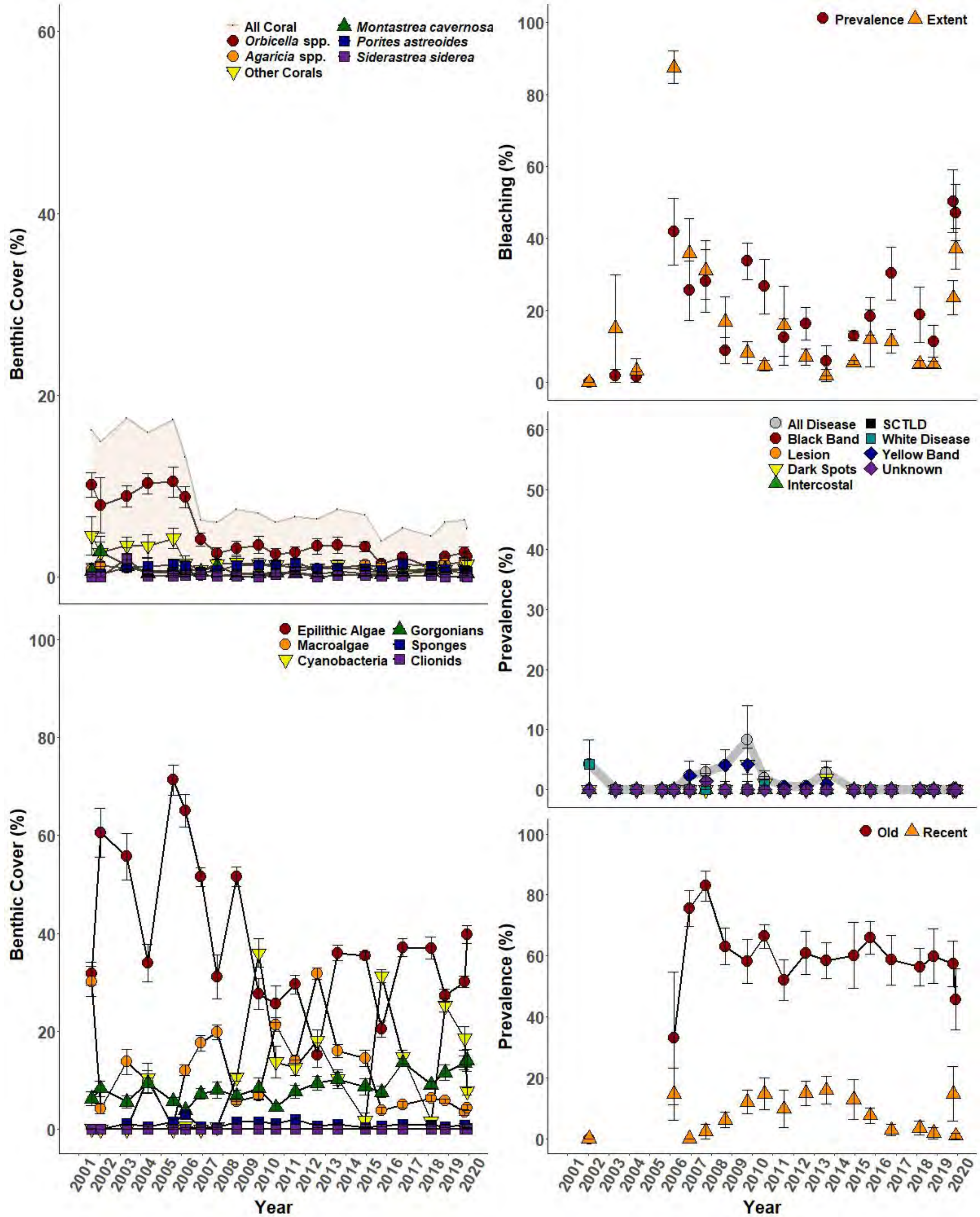


Figure 22. Buck Island, St. Croix benthic cover and coral health through time (mean ± SE).

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.

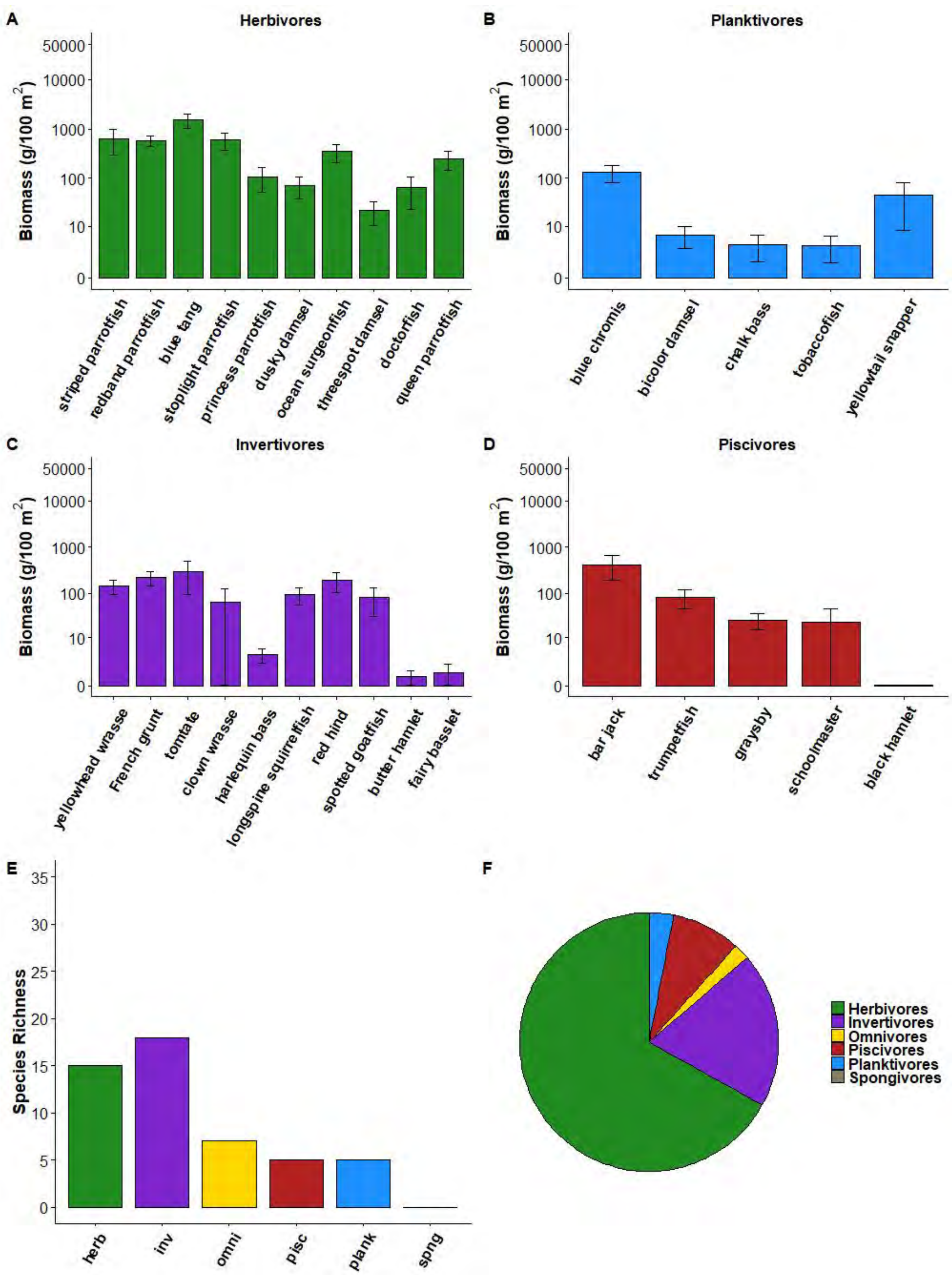
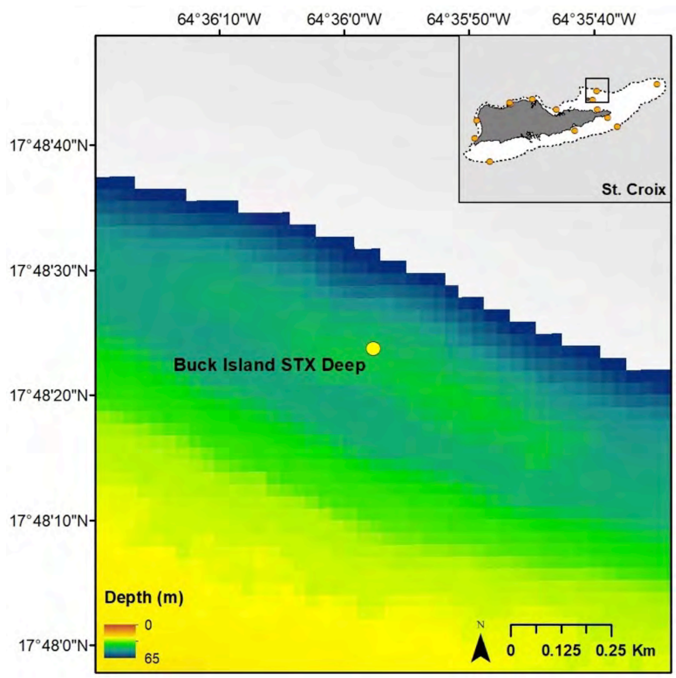


Figure 23. The Buck Island, St. Croix fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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 is an exceptionally healthy mesophotic orbicellid bank system on the island of St. Croix. The coral cover is double that of the next highest cover site in the TCRMP St. Croix monitoring program and large corals are largely intact with, high levels of coral-coral competition.

Threats. Due to its protected area status and remoteness from land-based pollution Buck Island Deep is largely threatened by climate change and disease.

Figure 24. (top) The Buck Island Deep, St. Croix position in the Buck Island Reef National Monument. (right) A representative photo (photo credit: J. Quetel).

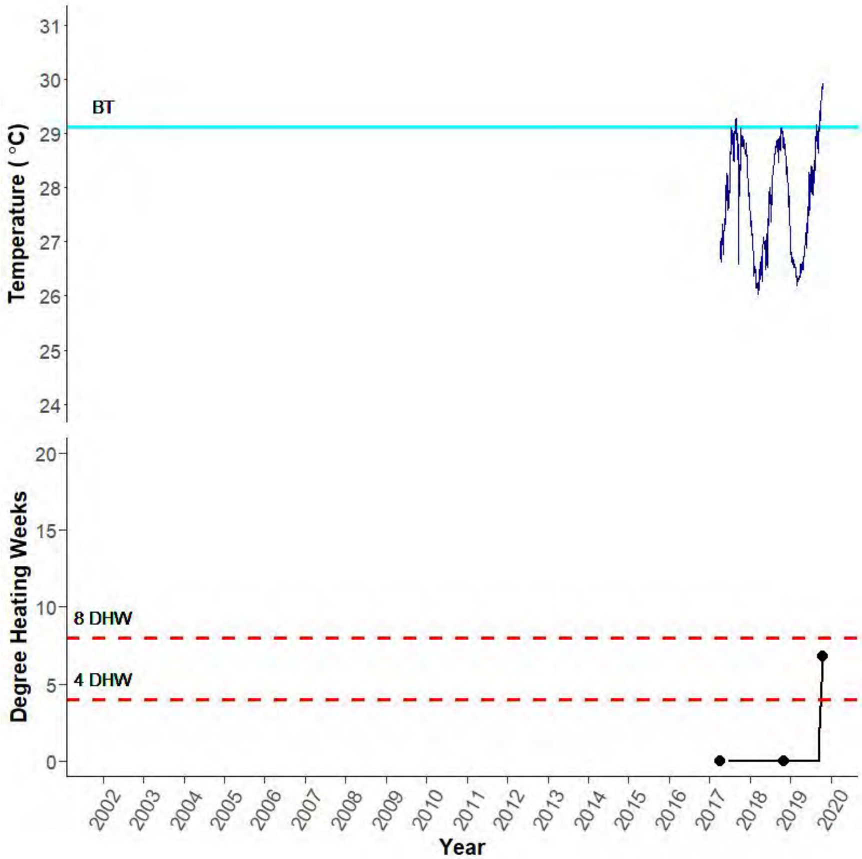


Figure 25. Buck Island Deep, St. Croix benthic temperatures (33 m depth).

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. Temperatures at the Buck Island Deep, St. Croix surpassed the bleaching threshold in 2019 and where still high when the probe was retrieved on Oct. 15. This led to at least 7 degree heating weeks. The beaching 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.

SITE SUMMARIES

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*. Epilithic algae and other macroalgae have shown an inverse relationship during the two years of available 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.

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). 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. This suggests the hypothetical bleaching threshold for the site is a reasonable approximation. Diseases declined in 2019, particularly white disease, which is perhaps a common feature during bleaching (Smith et al. 2013).

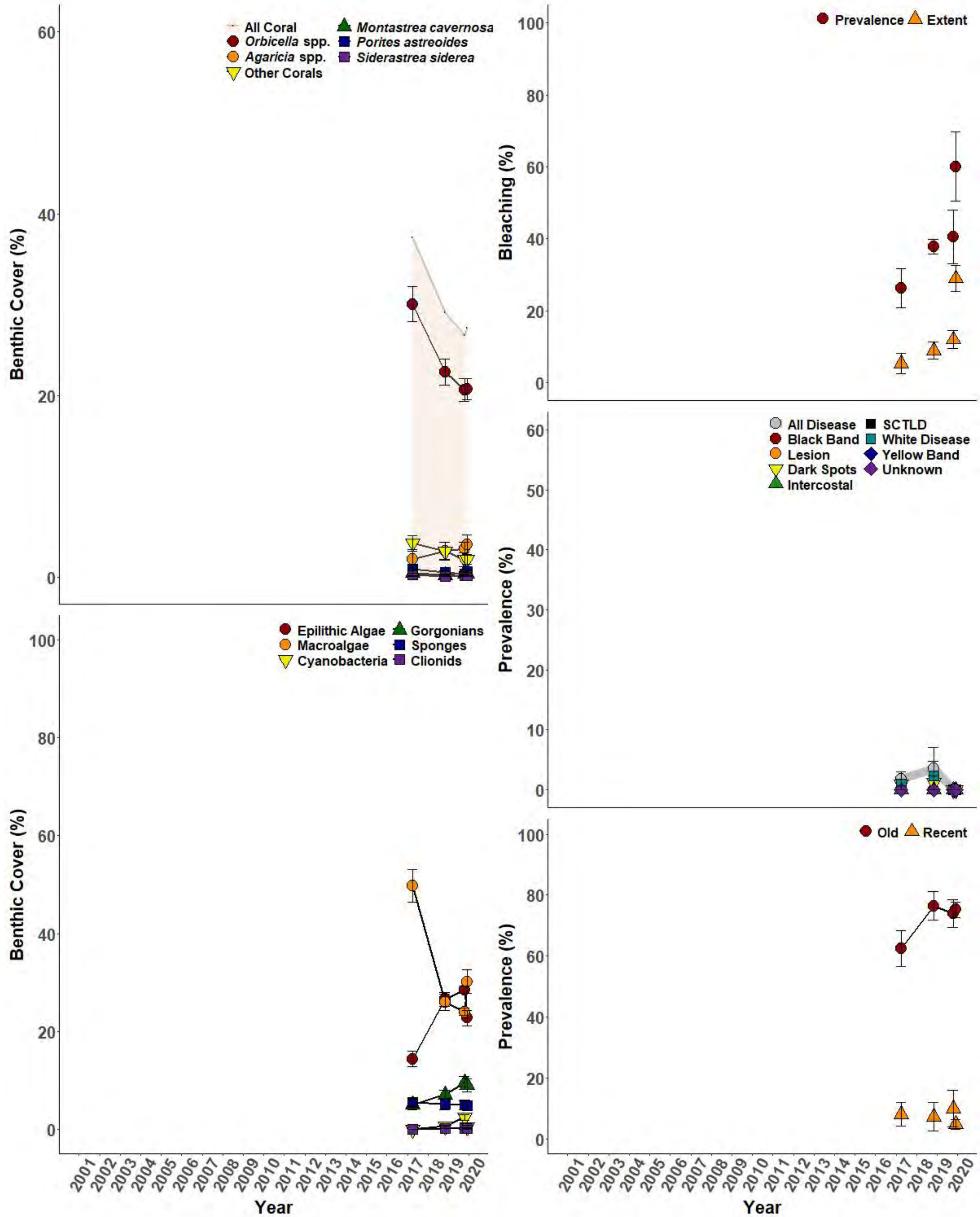


Figure 26. Buck Island Deep, St. Croix benthic cover and coral health through time (mean ± SE).

Fish Community. Buck Island Deep has a rich upper mesophotic reef community that is largely dominated in biomass by 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 durgeon. 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.

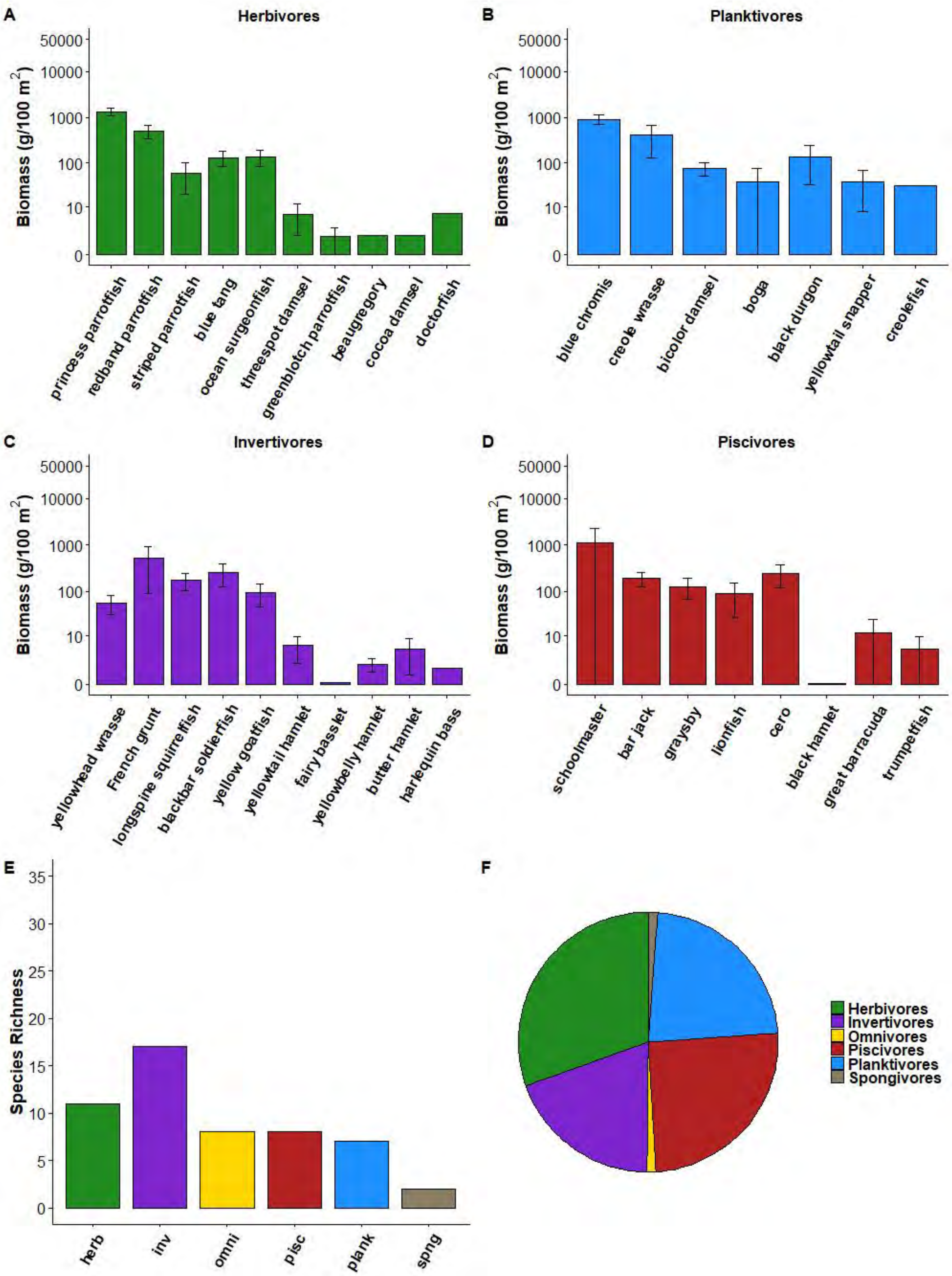
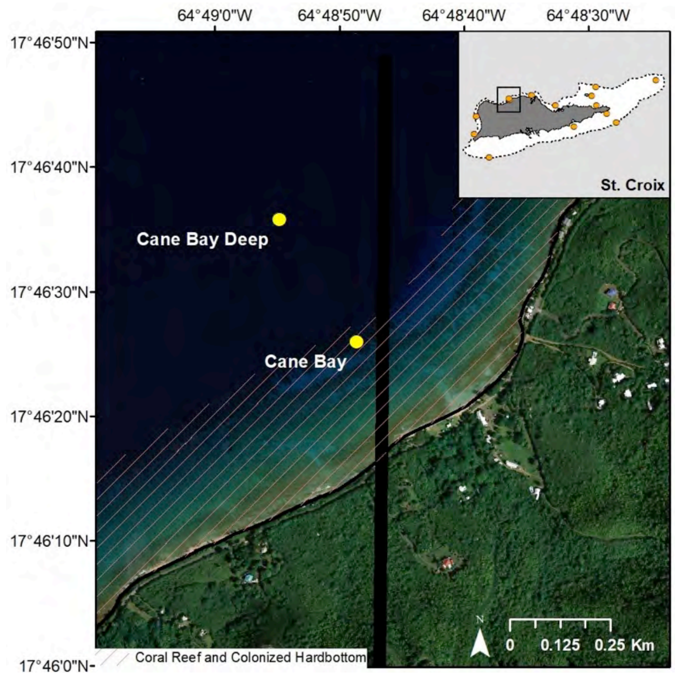


Figure 27. The Buck Island Deep, St. Croix fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



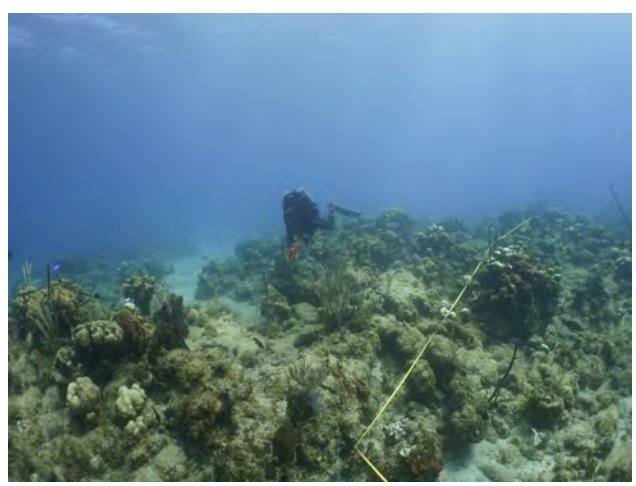
CANE BAY

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



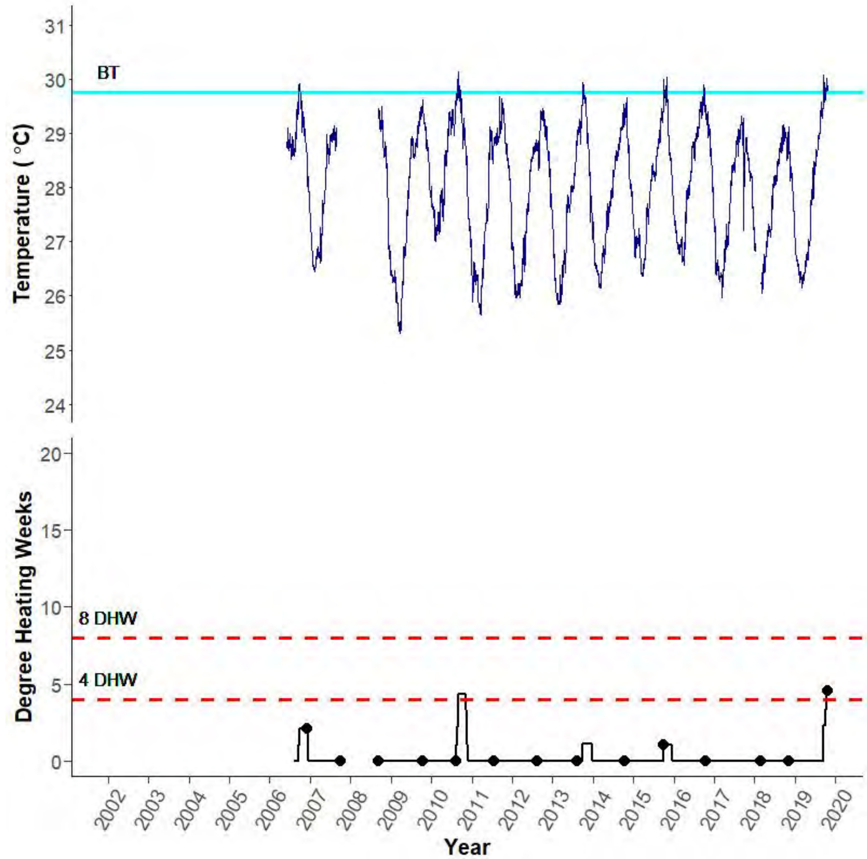


Figure 29. Cane Bay benthic temperatures (8 m depth)

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. Temperatures surpassed the bleaching threshold in 2010 and 2019.

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.

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.

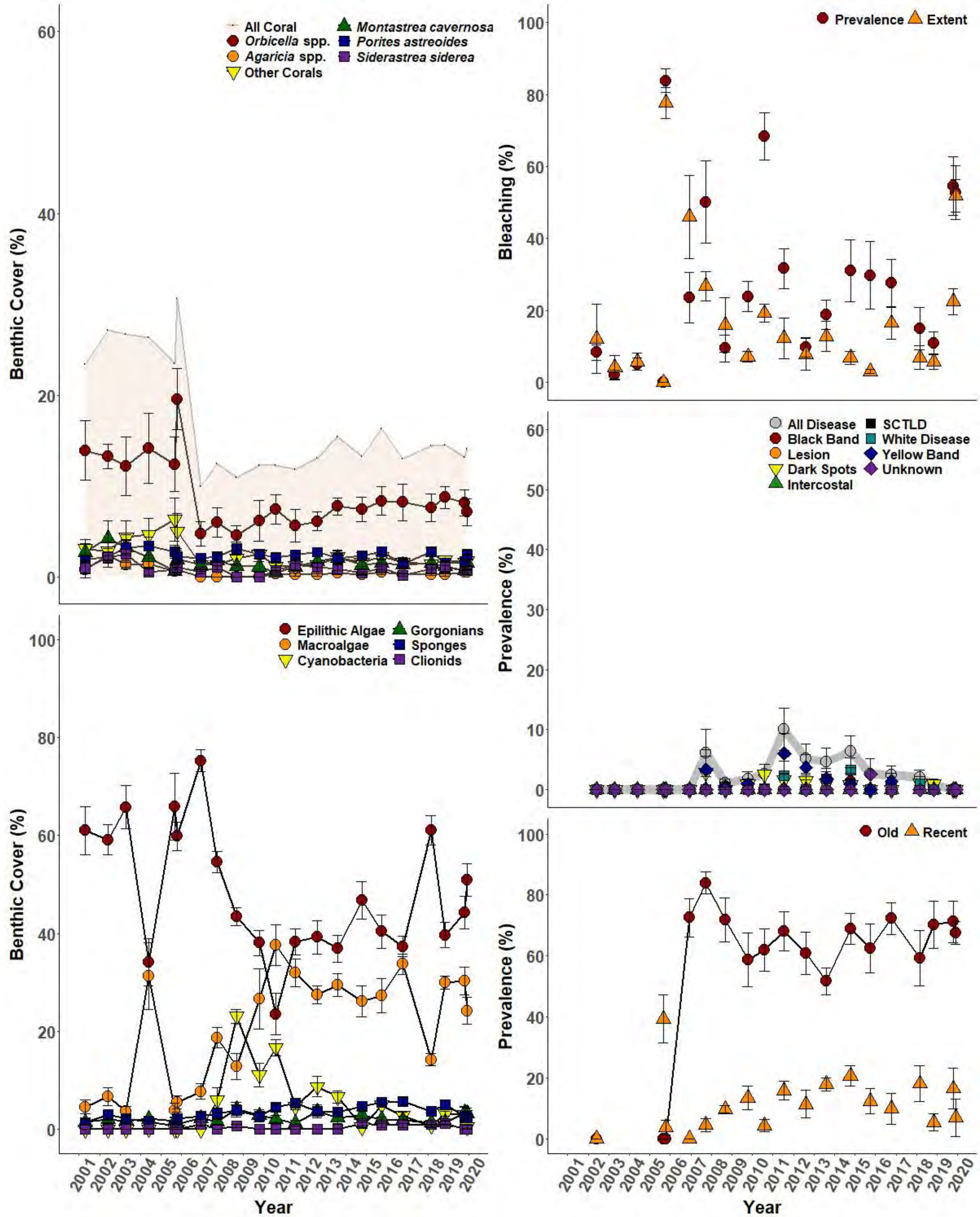


Figure 30. Cane Bay benthic cover and coral health through time (mean ± SE).

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 durgeon, 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, a tiger grouper and Nassau grouper (~30 cm total length each) were sited at the shelf break in 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.

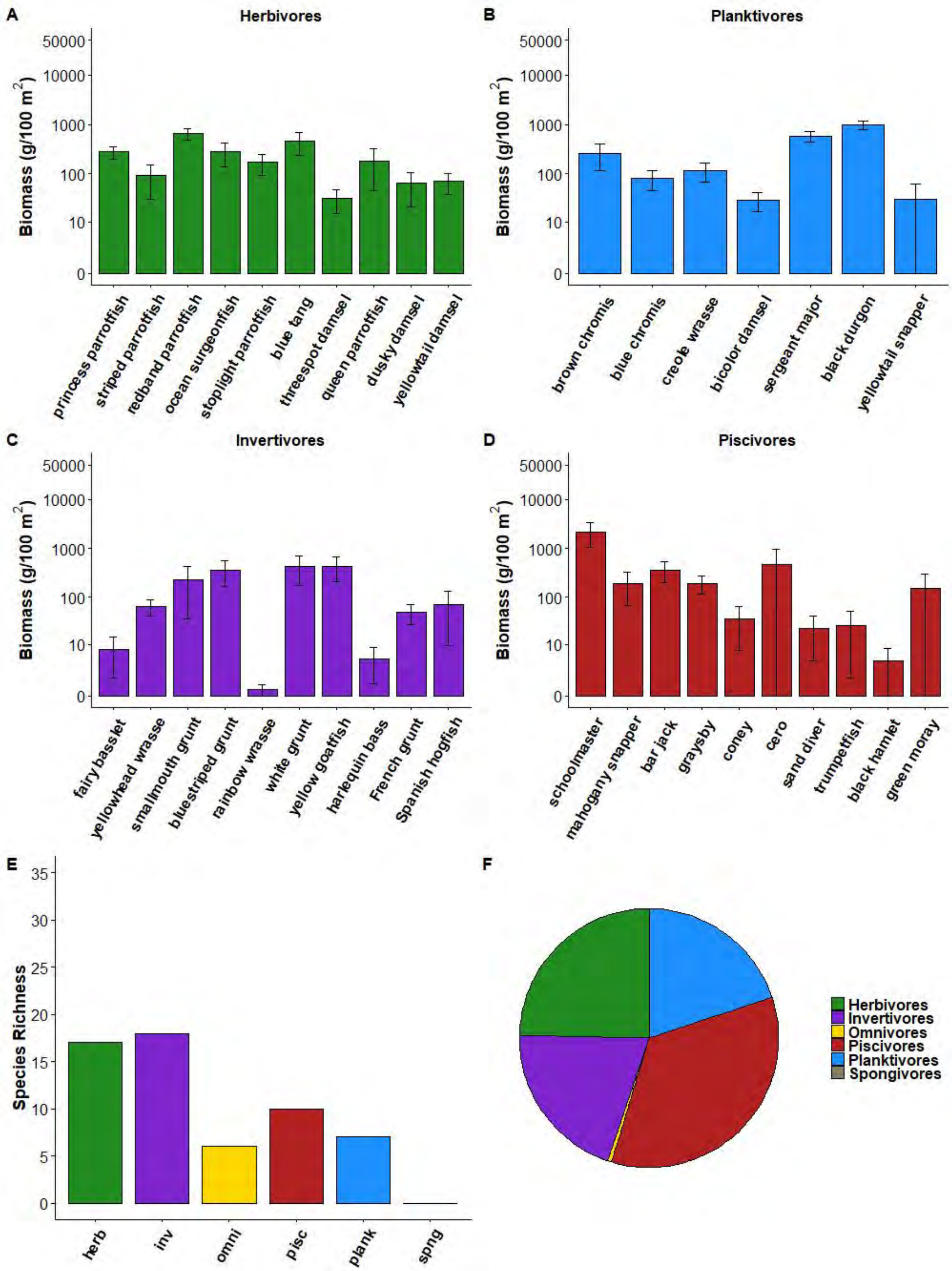
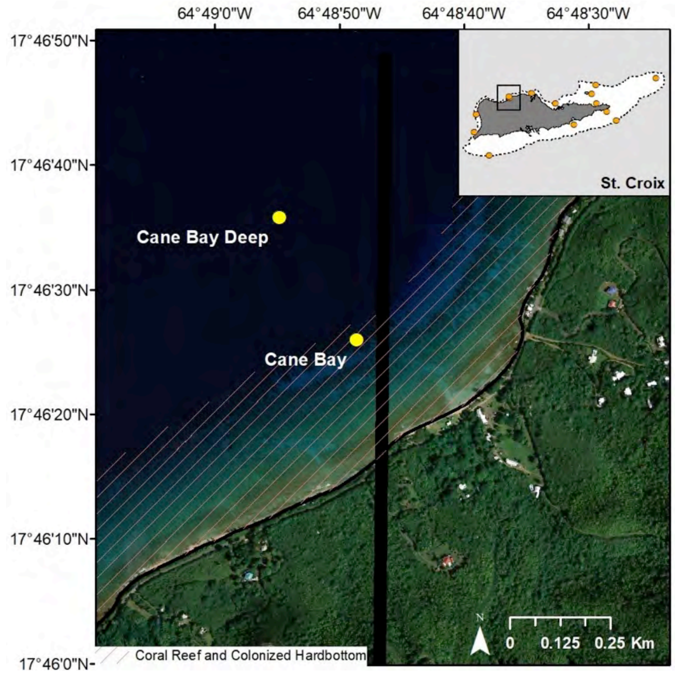


Figure 31. The Cane Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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).

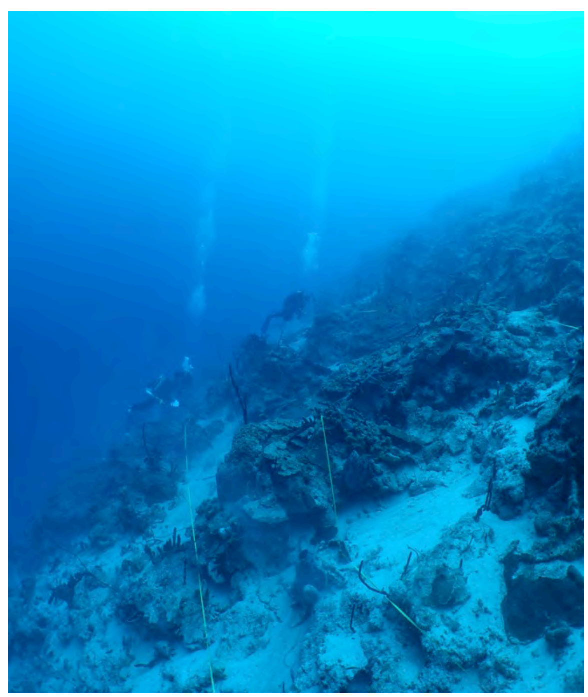
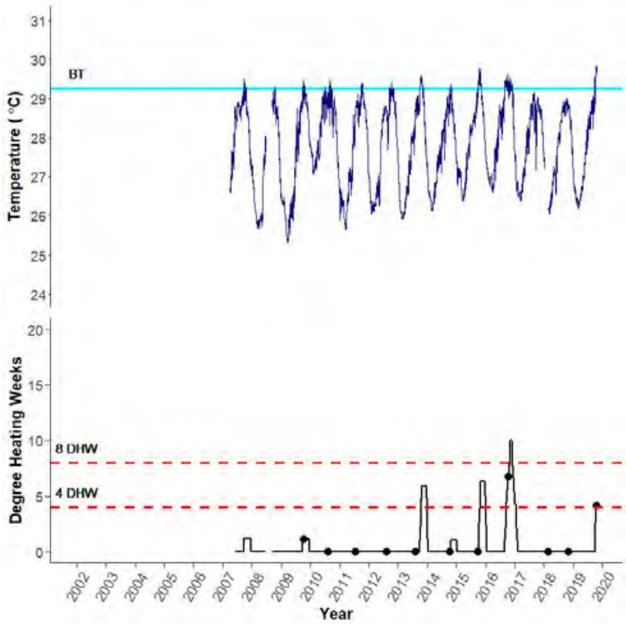
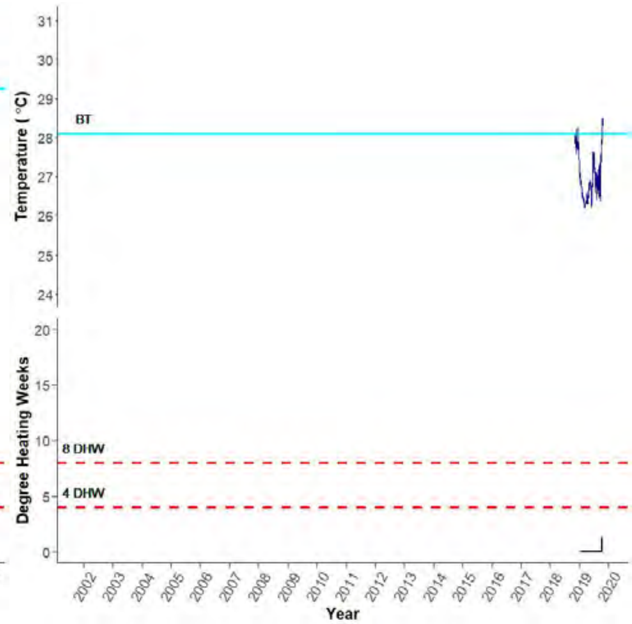


Figure 32. (top) Cane Bay Deep location. (right) A representative photo of the reef at the monitoring site (photo credit: J. Quetel).





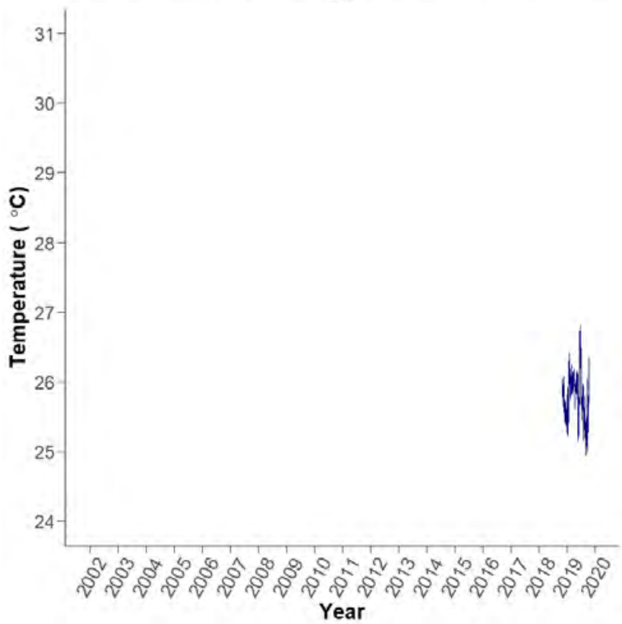


Figure 33. Cane Bay Deep temperature (Top left: 39 m depth, top right: 67m depth, bottom left: 100 m depth).

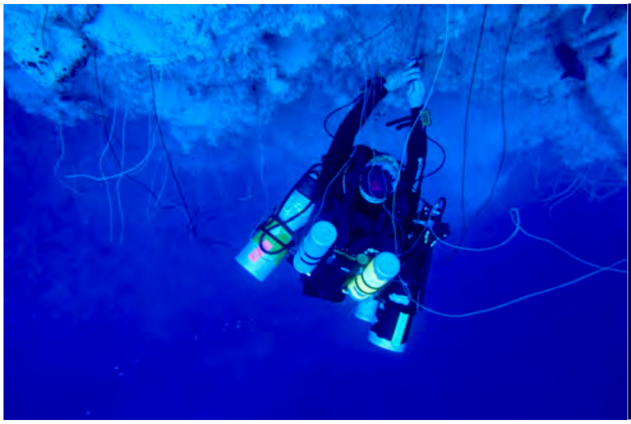


Figure 34. Installation of temperature monitoring stations at Cane Bay at 67 m (left) and 100 m (right) on the wall (credit: Viktor Brandtneris).

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.

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. 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.

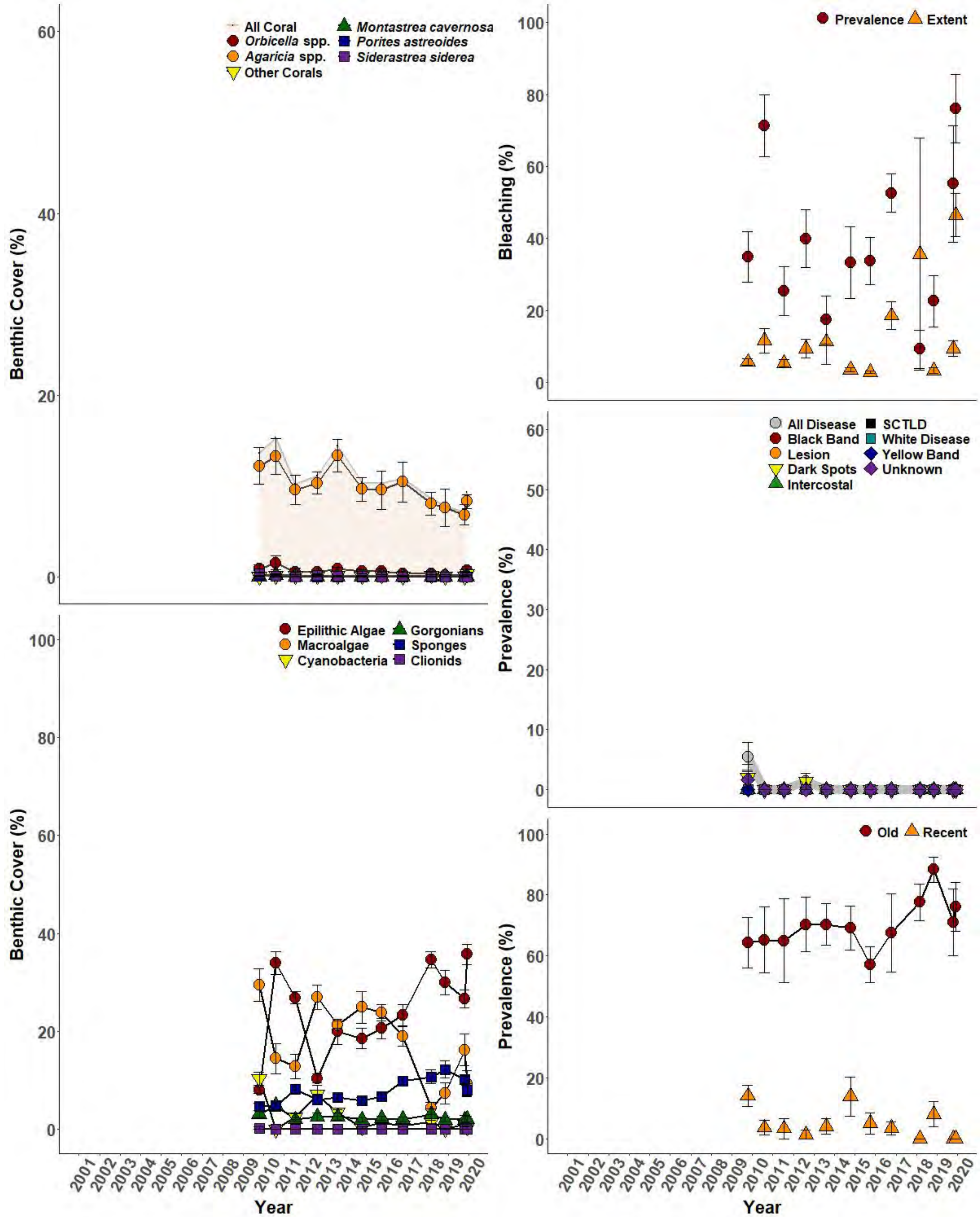


Figure 35. Cane Bay Deep benthic cover and coral health through time (mean ± SE).

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 dominated by planktivores: creole wrasse, blue chromis black durgeon and yellowtail snapper. This planktivorous community is depauperate compared to that of Salt River Deep however. 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 that has become common from local divers. They have become quite bold as a consequence of this generosity however lionfish are now absent from the site. 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.

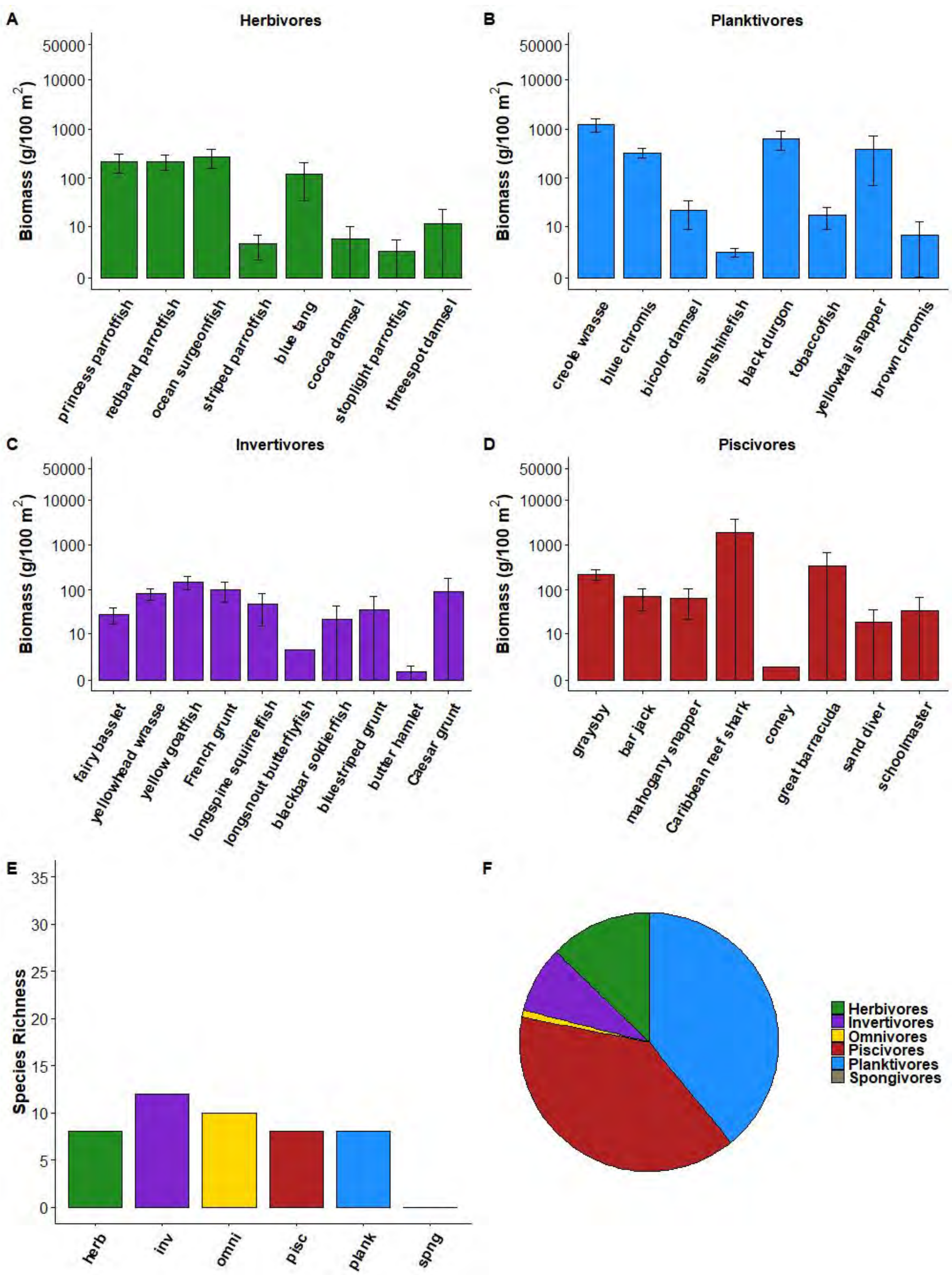
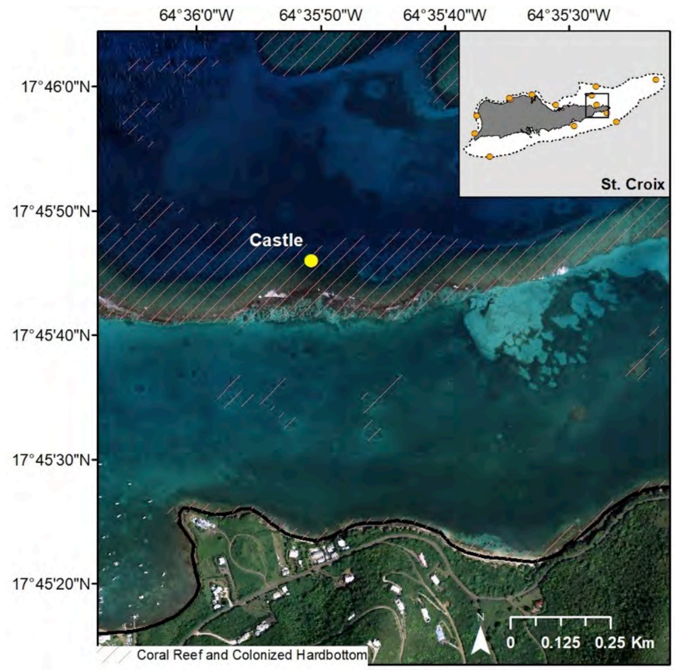


Figure 36. The Cane Bay Deep fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

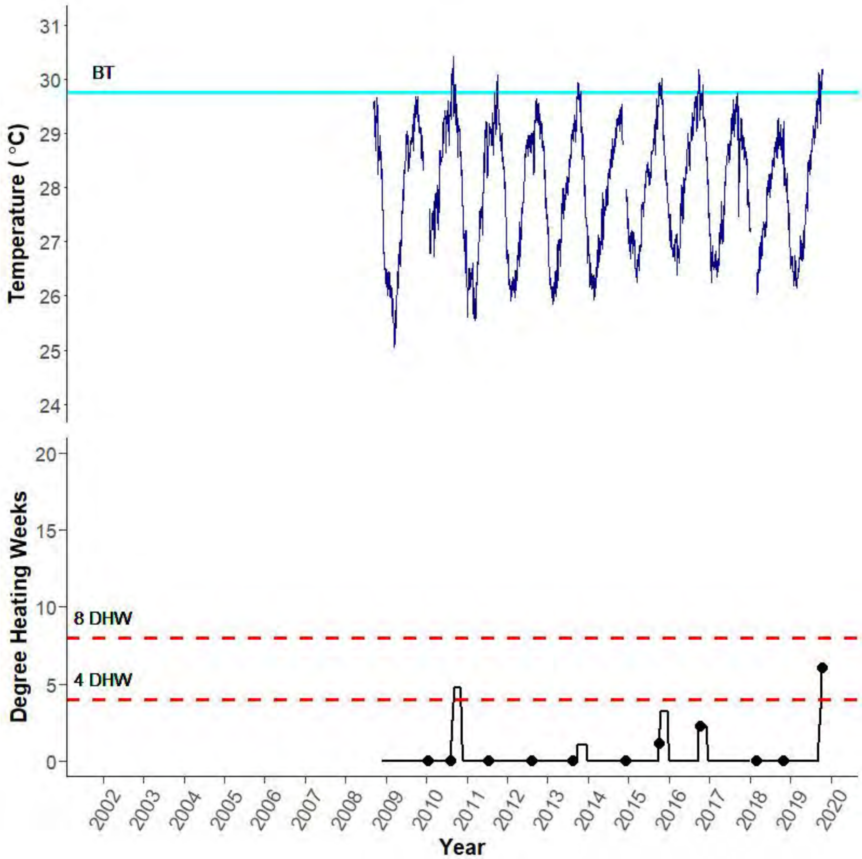


Figure 38. Castle benthic temperatures (9 m depth).

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 at least 6 DHW in 2019 when the sensor was retrieved.

SITE SUMMARIES

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.

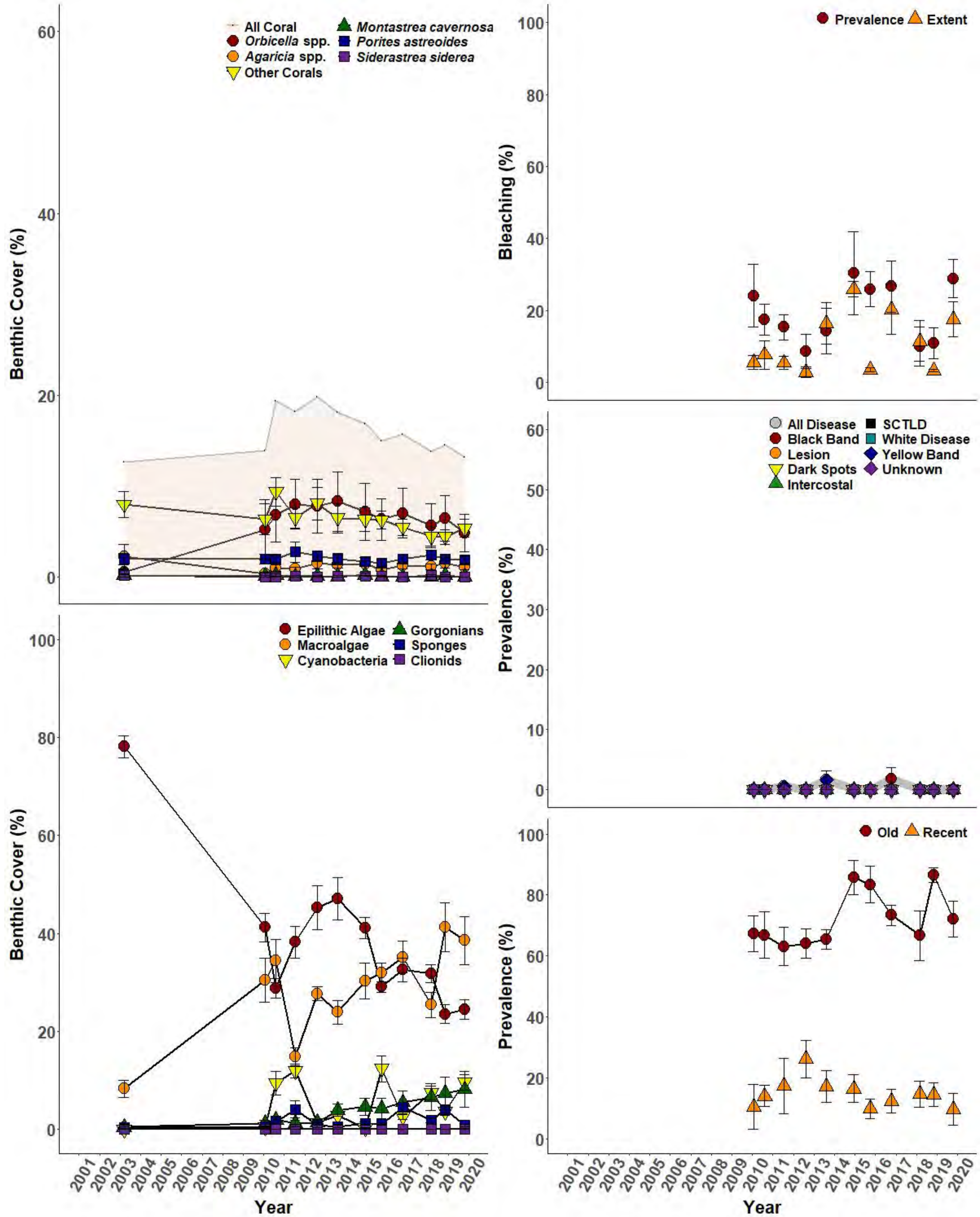


Figure 39. Castle benthic cover and coral health through time (mean ± SE).

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 there commonly over the past five years.

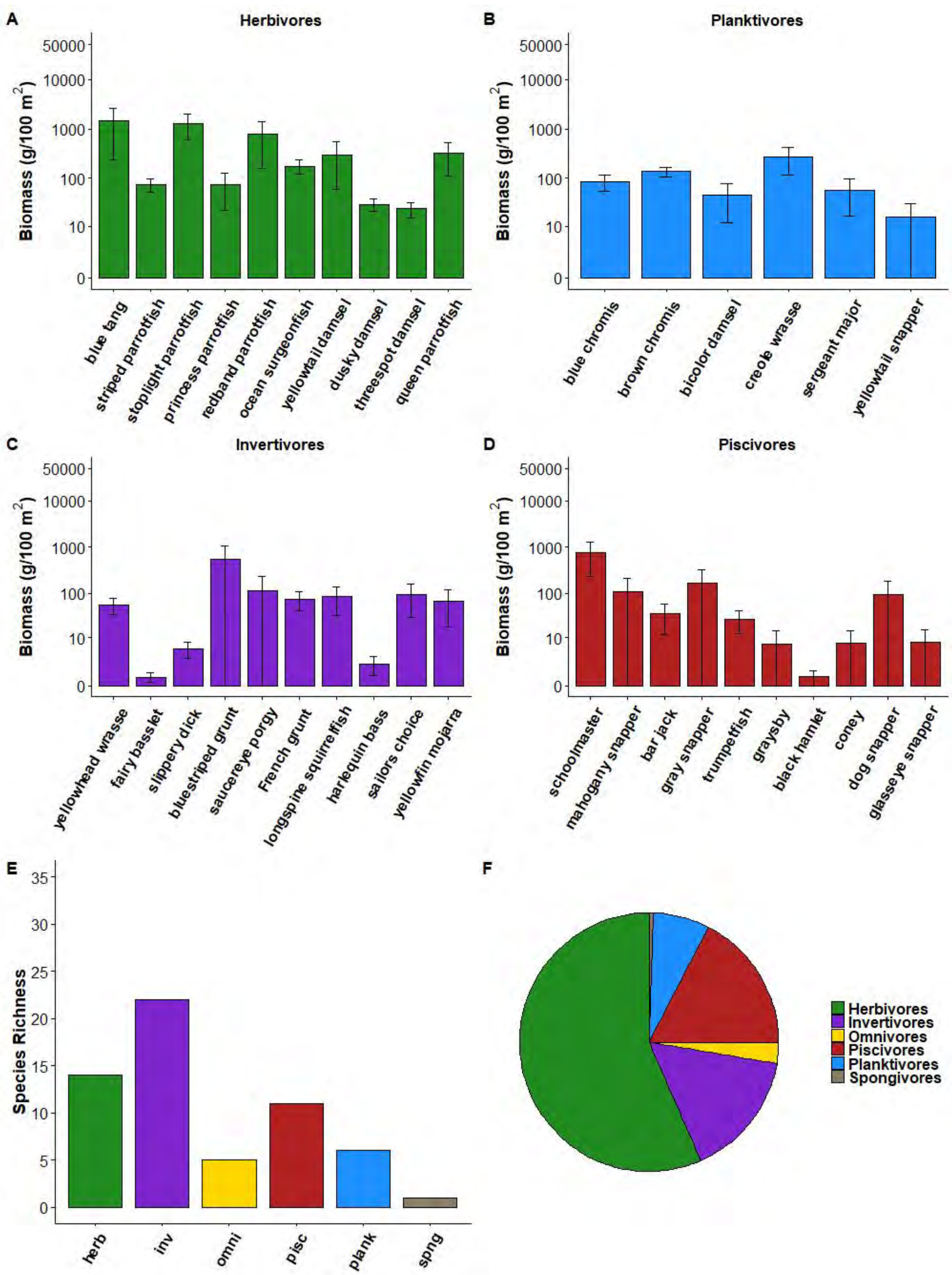


Figure 40. The Castle fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

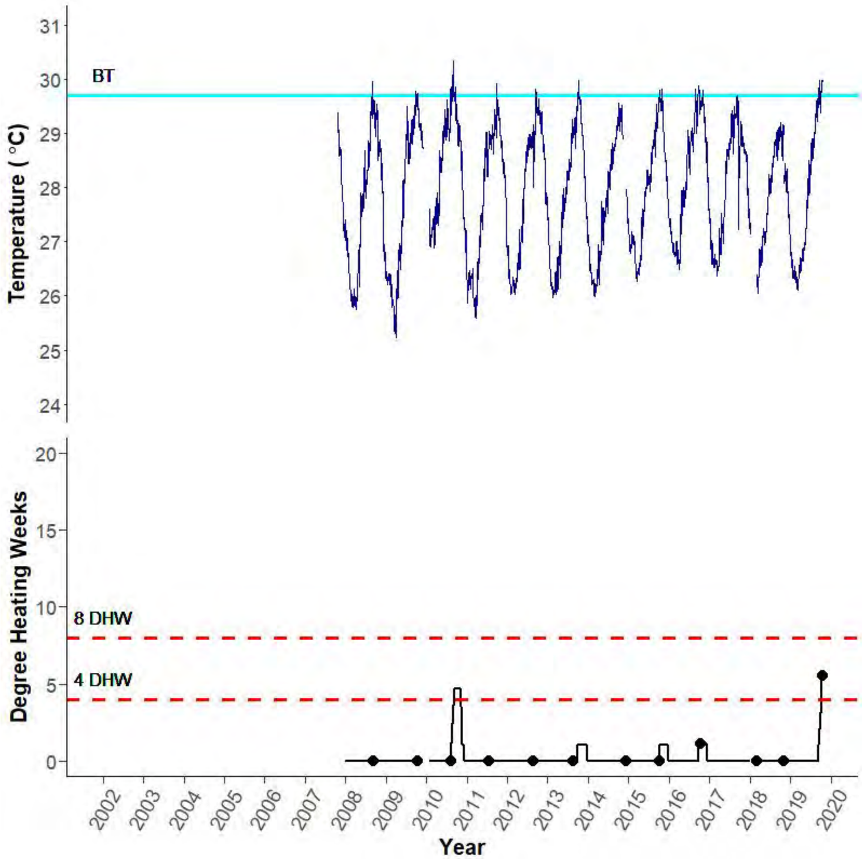


Figure 42. Eagle Ray benthic temperature at 9 m depth

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.

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 has come back and actually increased above pre-bleaching values. The limited response may be partly due to the high relative abundance of more thermally resistant coral species. 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.

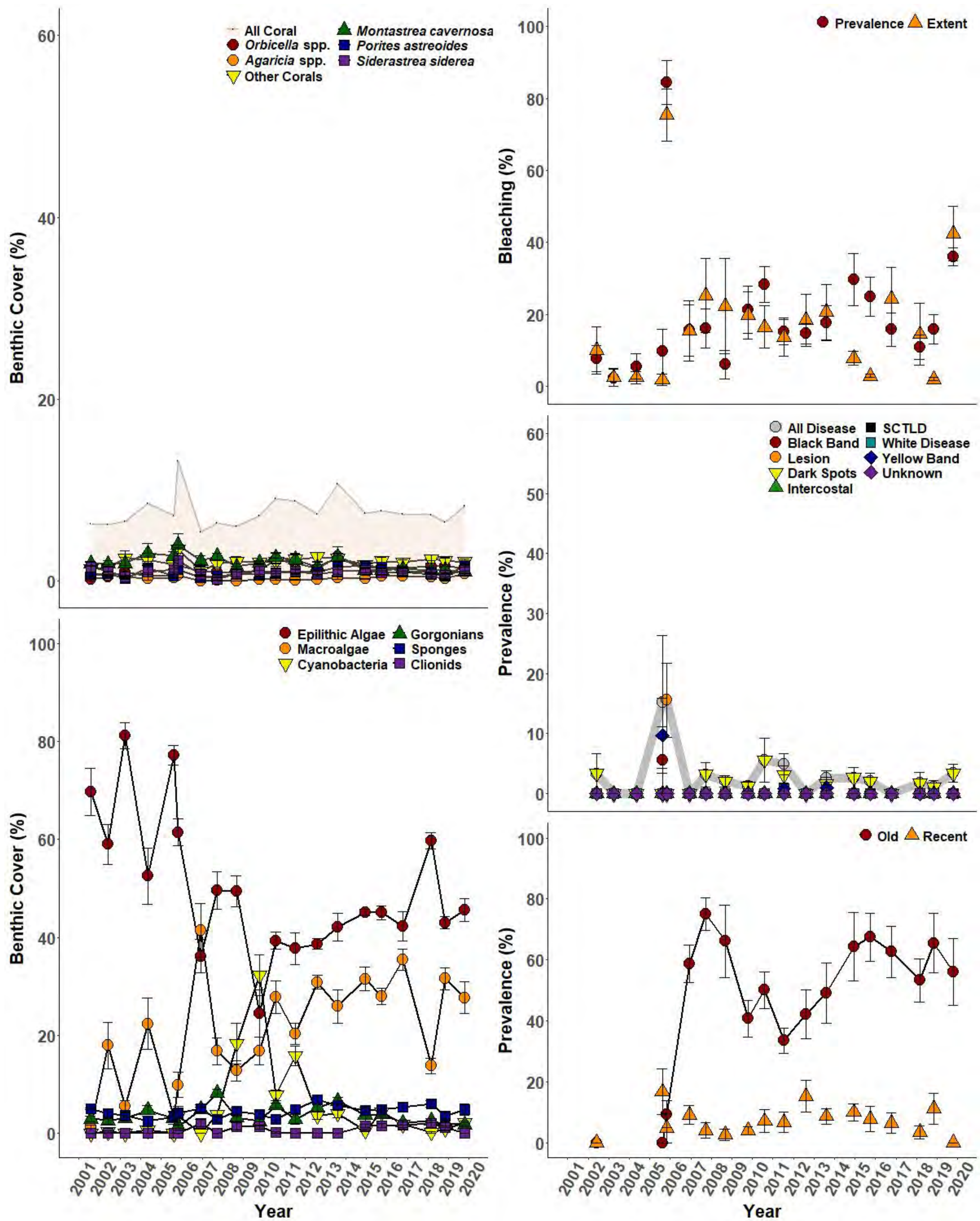


Figure 43. Eagle Ray benthic cover and coral health through time (mean ± SE).

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, and black durgeon and 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 overall the fish community remains high in overall biomass and species richness.

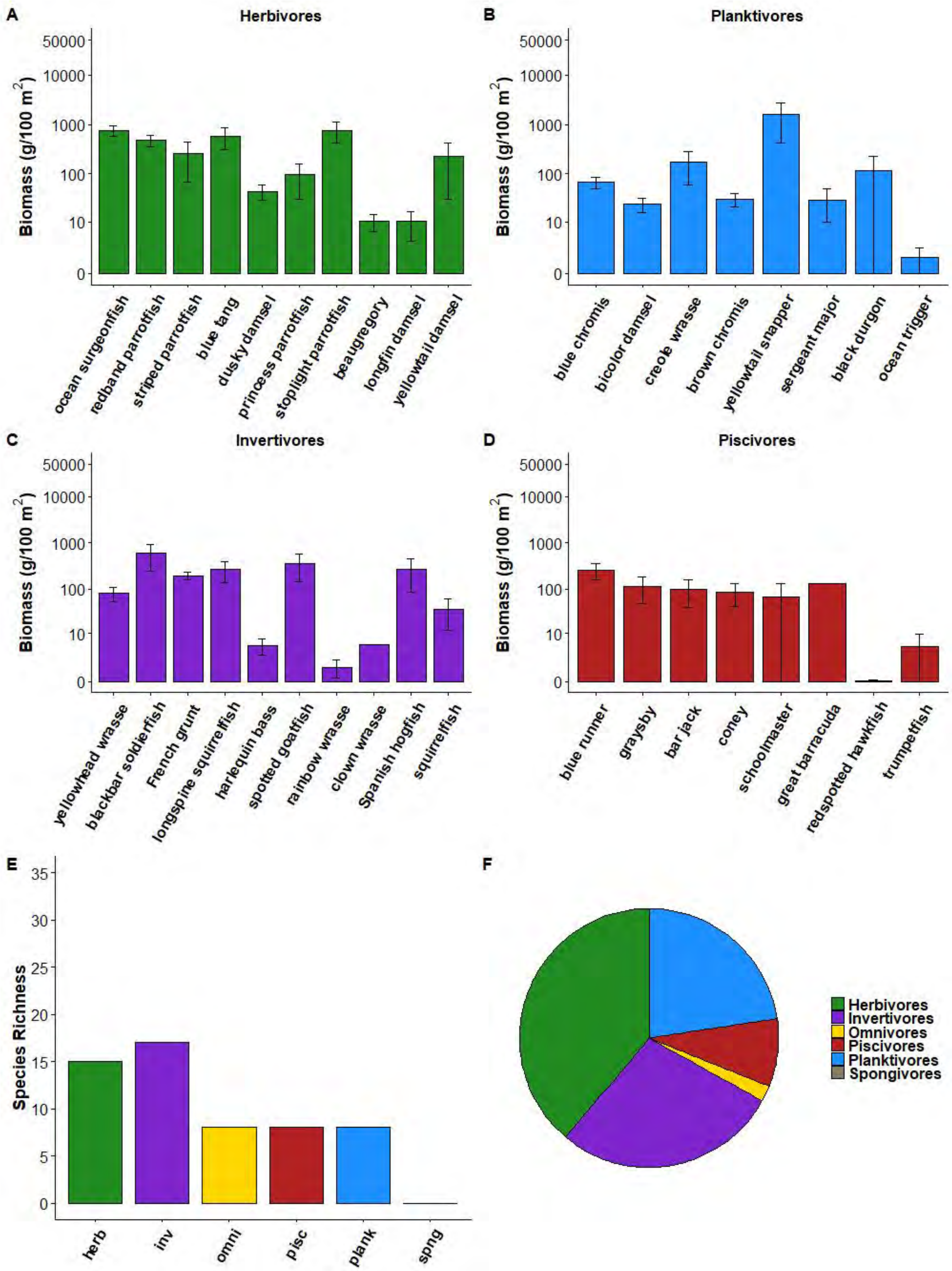
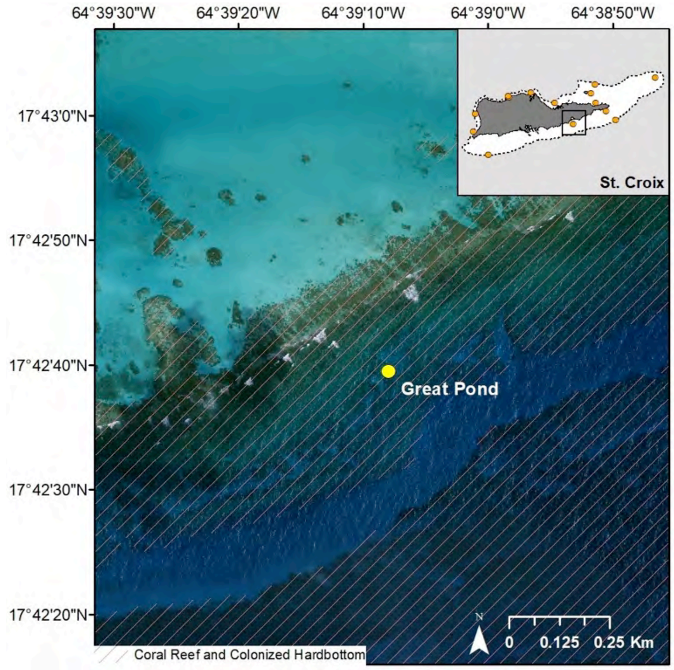


Figure 44. The Eagle Ray fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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

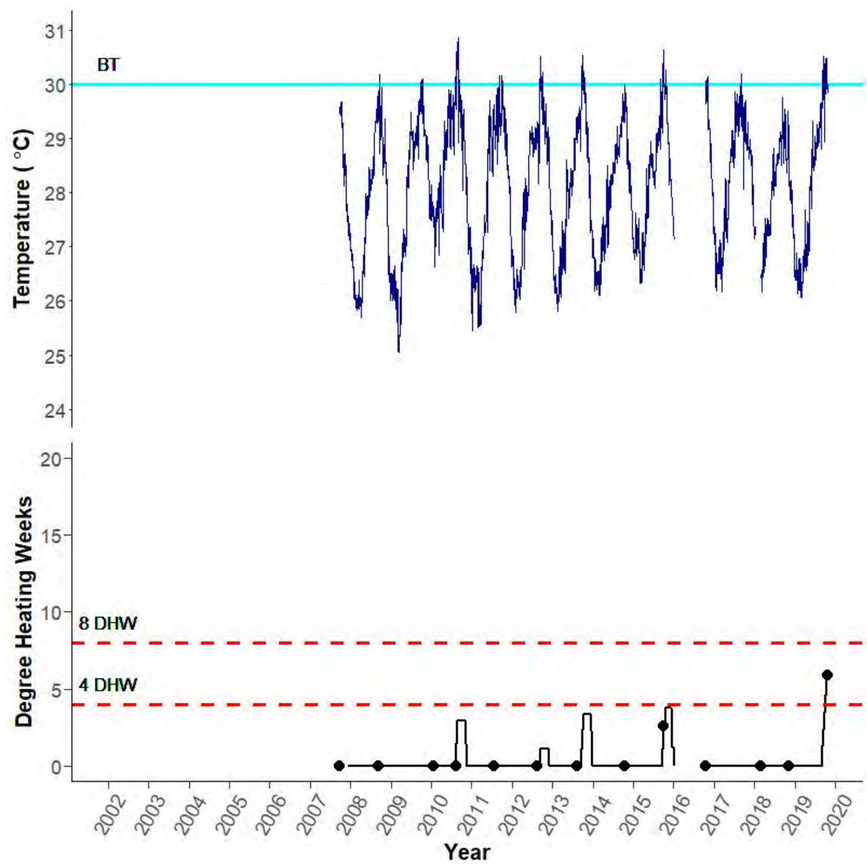


Figure 46. Great Pond benthic temperature (5 m depth).

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.

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 has regained about half as of 2011. 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 be a reflection of 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.

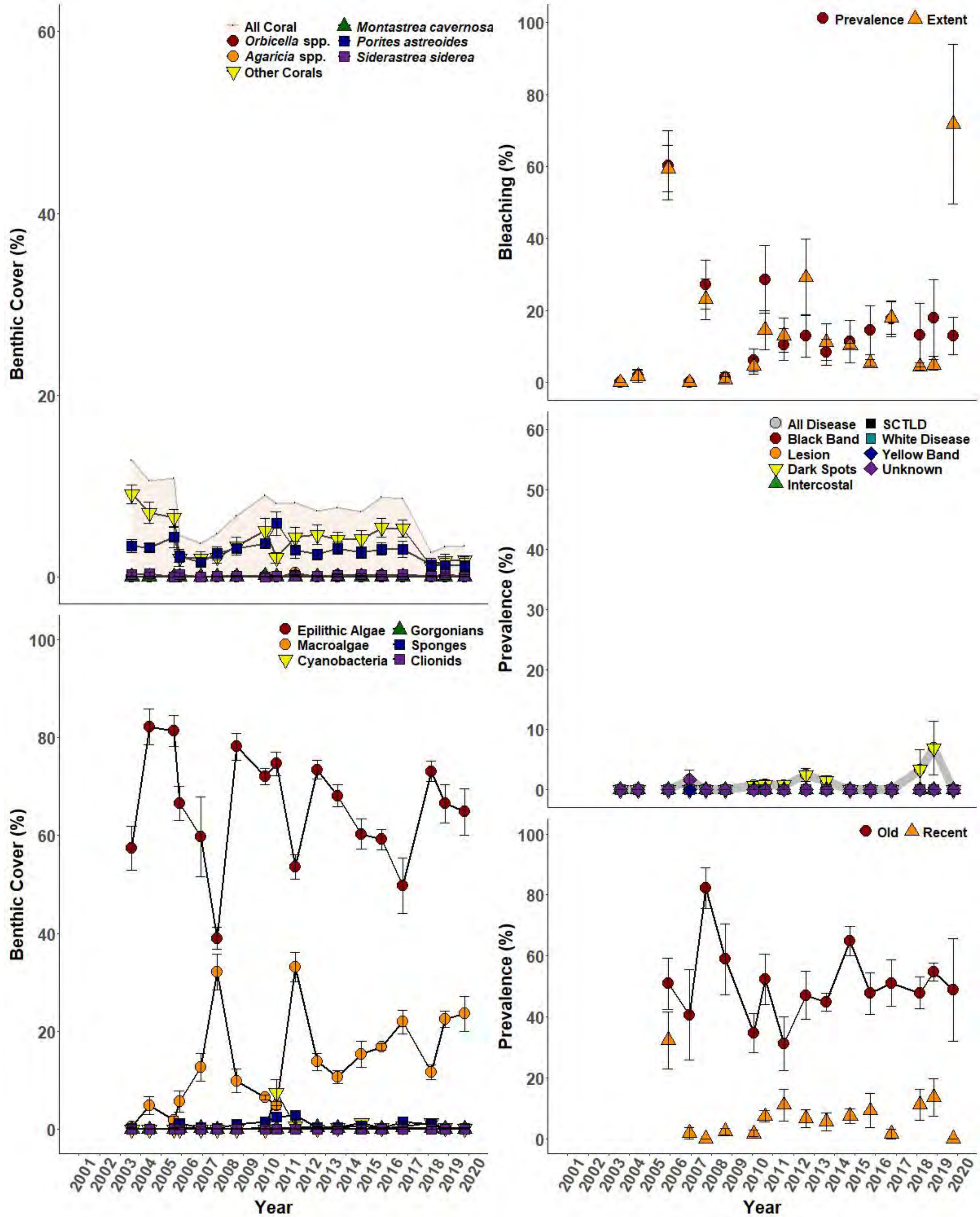


Figure 47. Great Pond benthic cover and coral health through time (mean ± SE).

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.

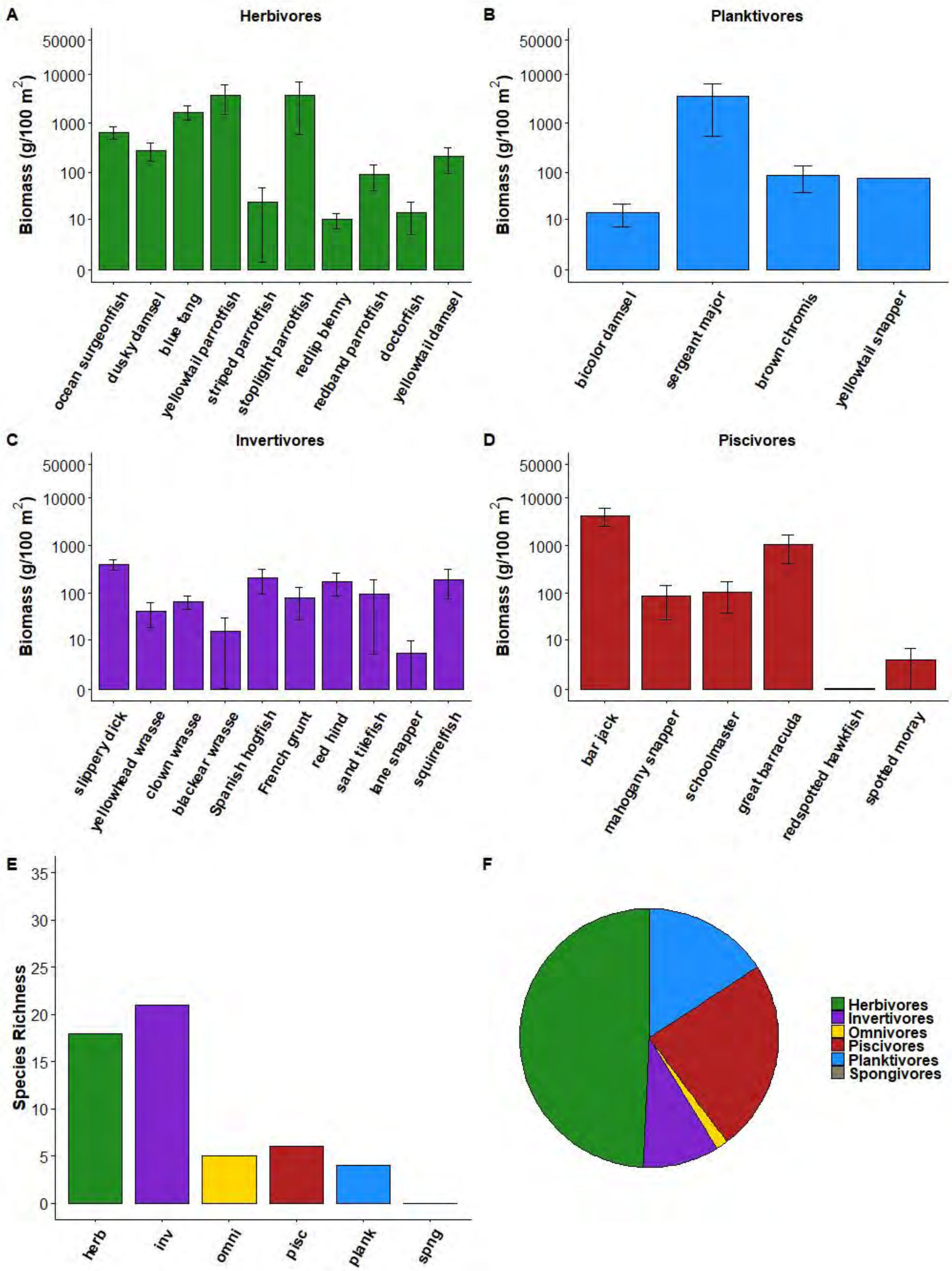
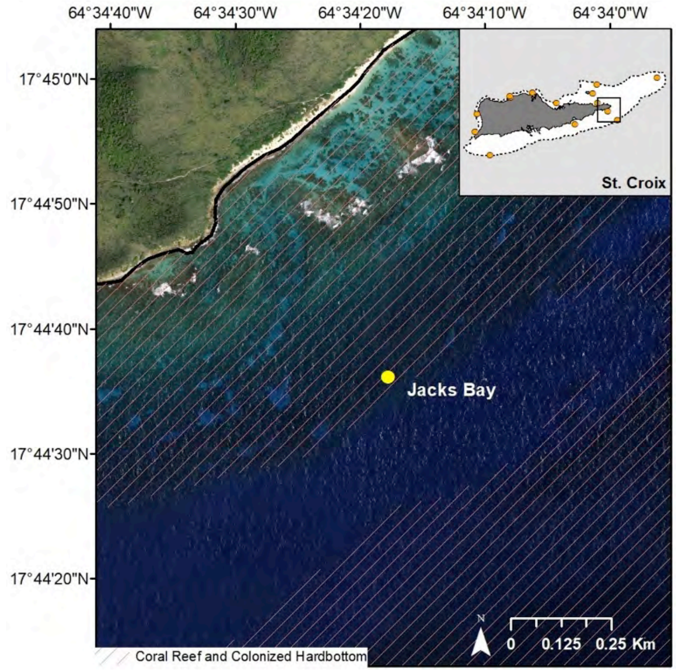


Figure 48. The Great Pond fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

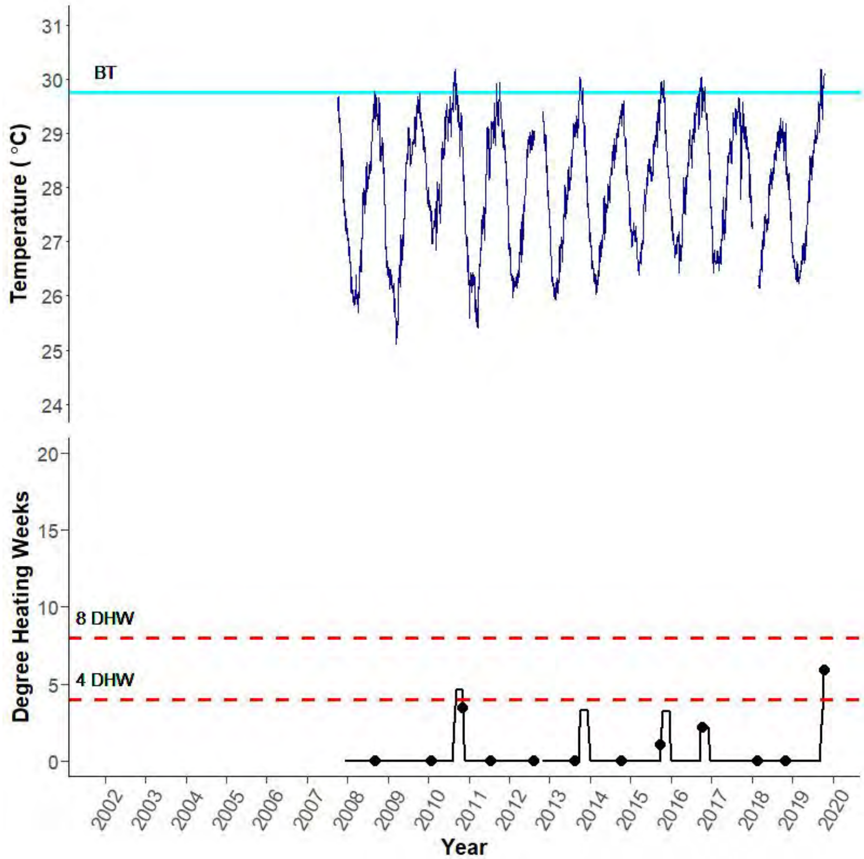


Figure 50. Jacks Bay benthic temperature at 12 m depth

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. 2010 and 2019 showed sufficient accumulation of heat stress to cause coral bleaching.

SITE SUMMARIES

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.

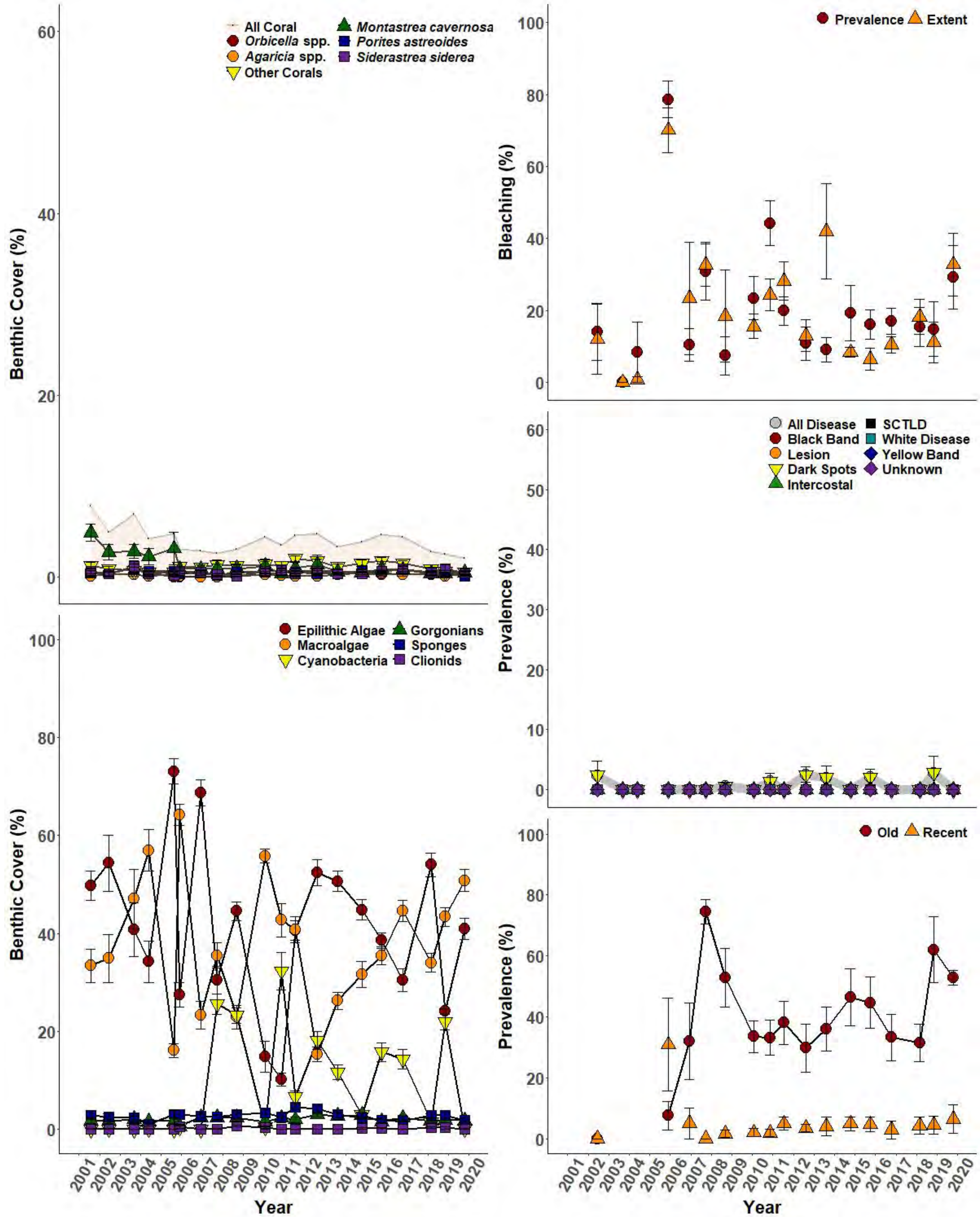


Figure 51. Jacks Bay benthic cover and coral health through time (mean ± SE).

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.

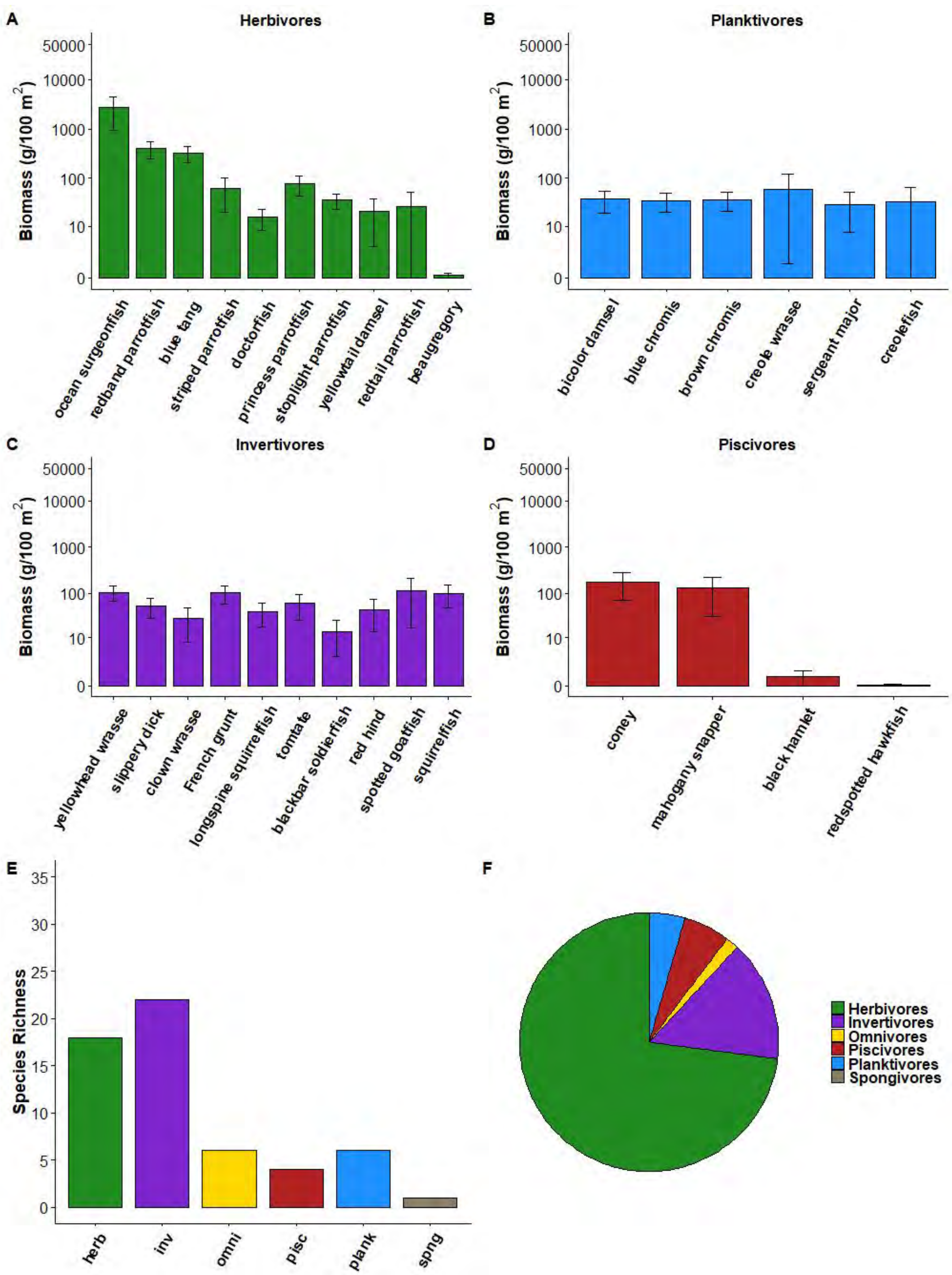
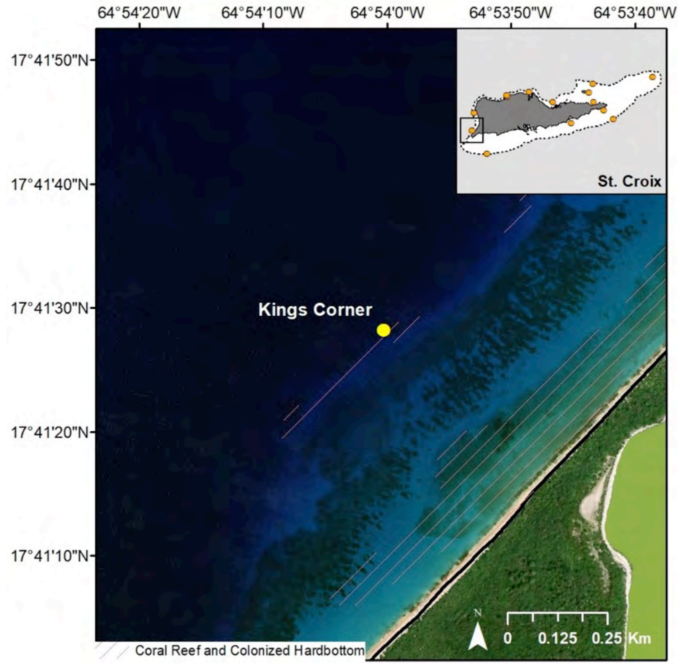


Figure 52. The Jacks Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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.

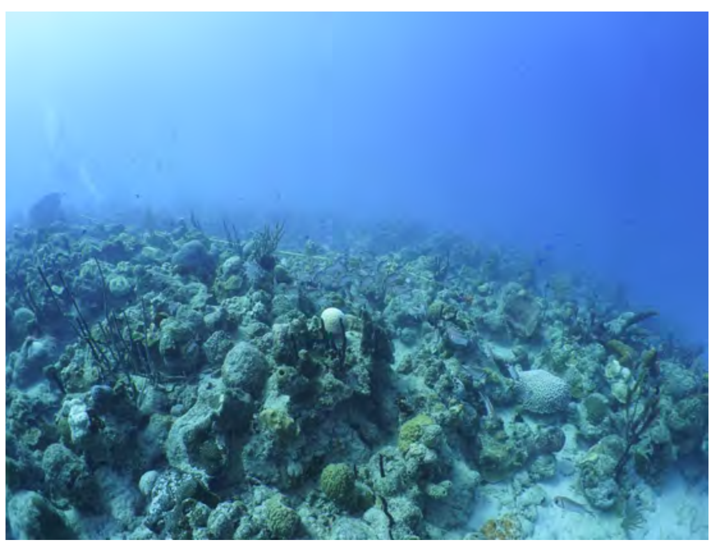


Figure 53. Kings Corner. (top) Location. (right) A representative photo of the reef (photo credit: L. M. Henderson).

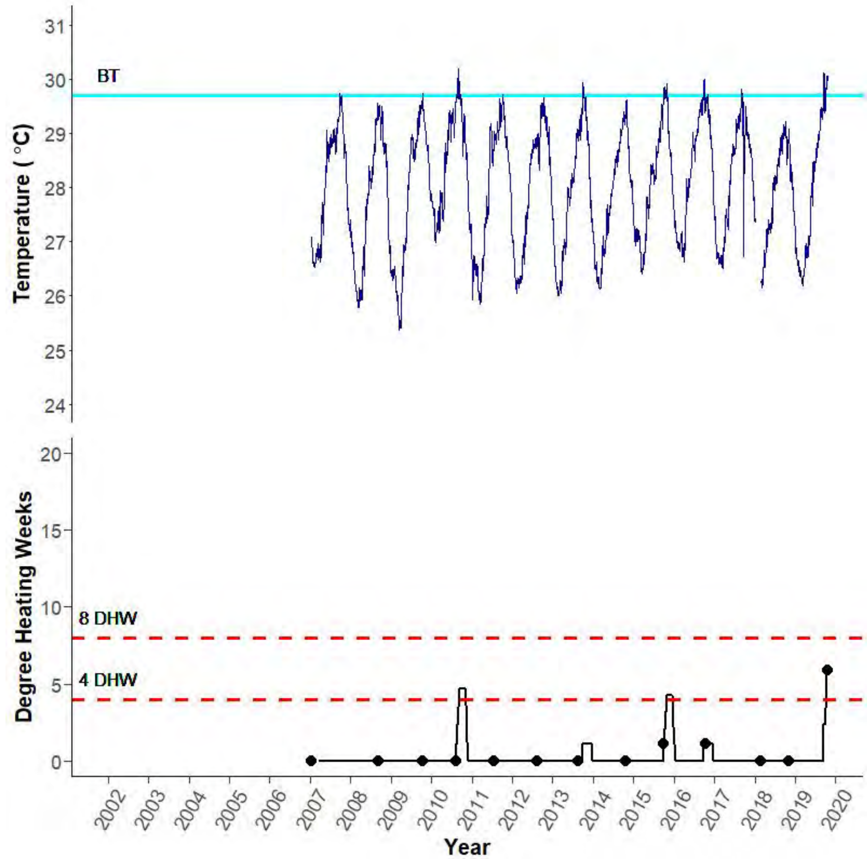


Figure 54. Kings Corner benthic temperature (17 m depth)

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

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. 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.

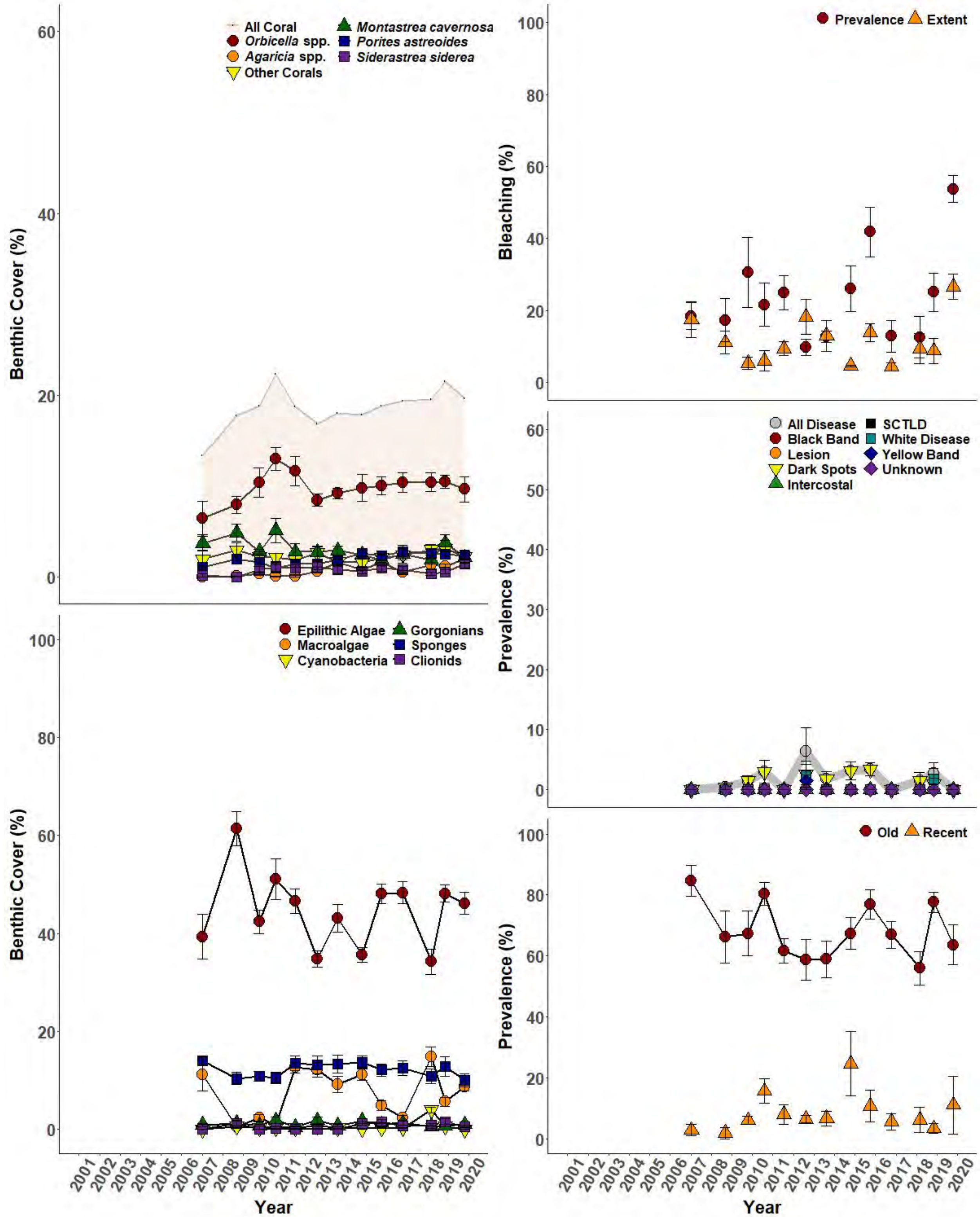


Figure 55. Kings Corner benthic cover and coral health through time (mean ± SE).

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 durgeon, and creole wrasse. 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 huge moray eels. Mutton snapper are occasional. 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). No large snappers or groupers have been observed on the site. It is not protected from any fishing pressure.

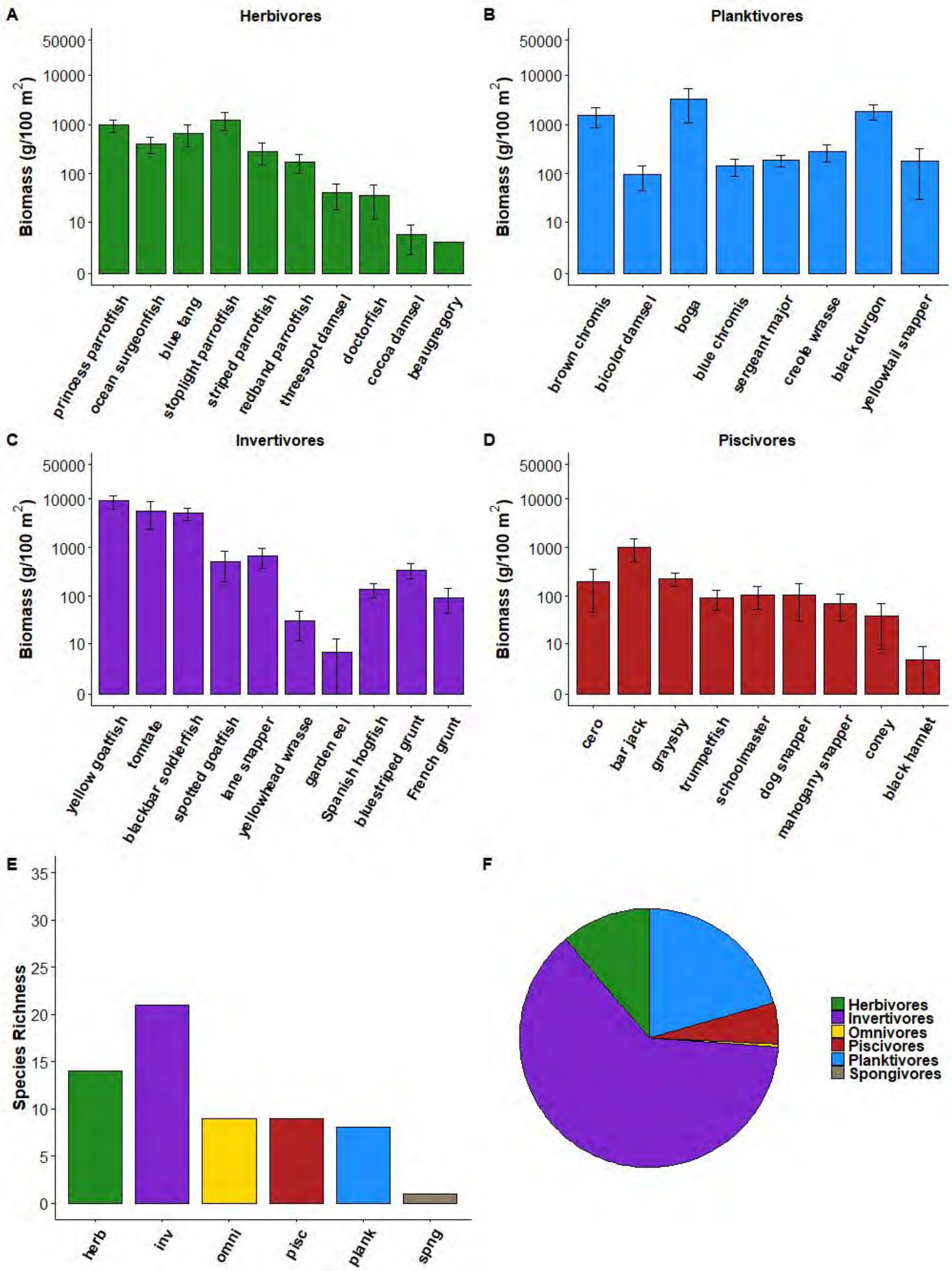
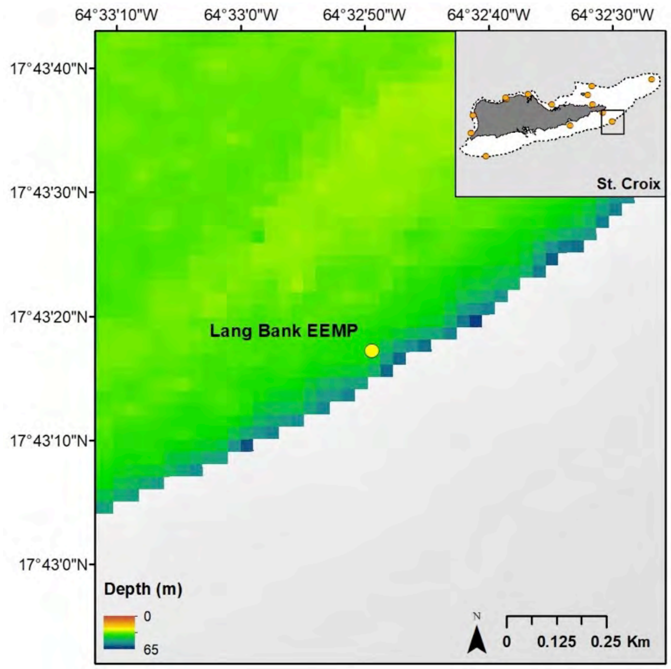


Figure 56. The Kings Corner fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

LANG BANK EAST END MARINE PARK

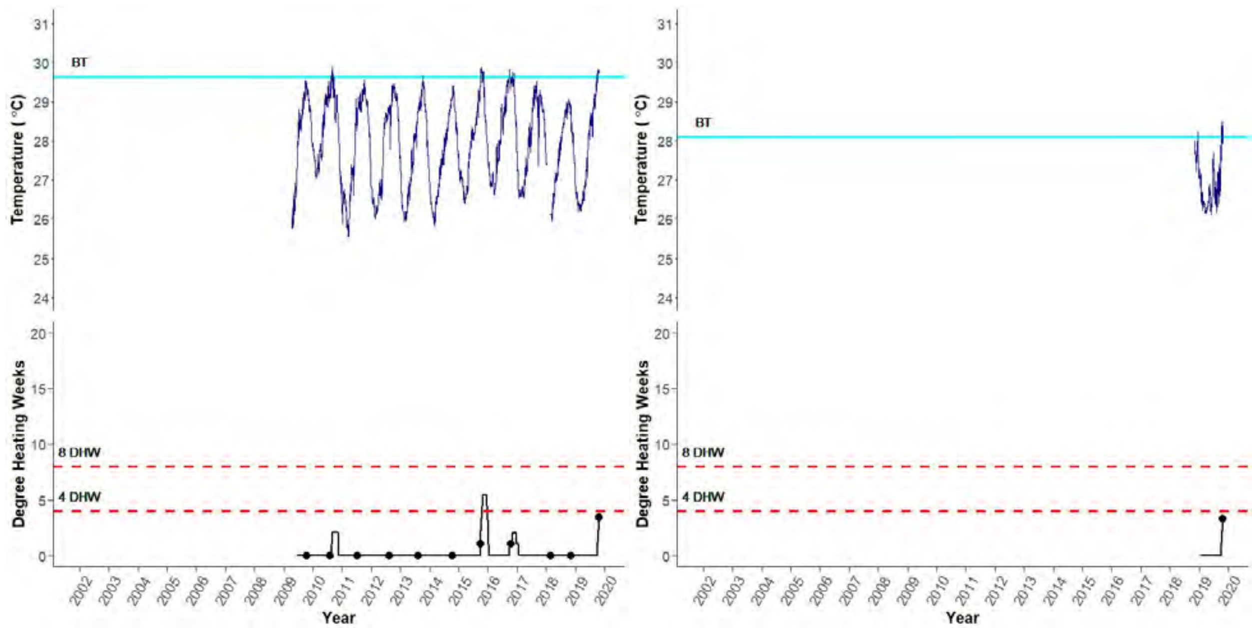
Description. The Lang Bank EEMP site is a shelf edge mesophotic coral reef located at a depth of 27 – 30 m. The monitoring site sits just above a steep shelf break and is composed of rolling coral knolls dominated by boulder star corals (*Orbicella* spp.). This site was established in 2009.



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



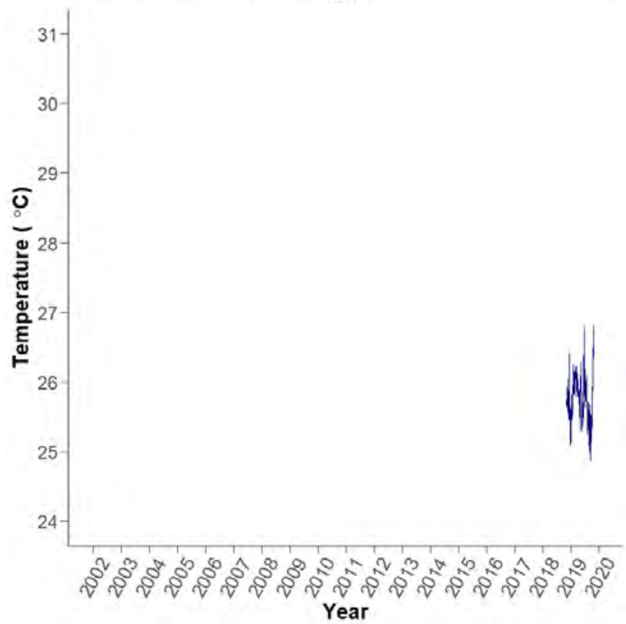


Figure 58. Lang Bank EEMP benthic temperature (Top left: 28 m depth, top right: 67m depth, bottom left: 100 m depth).

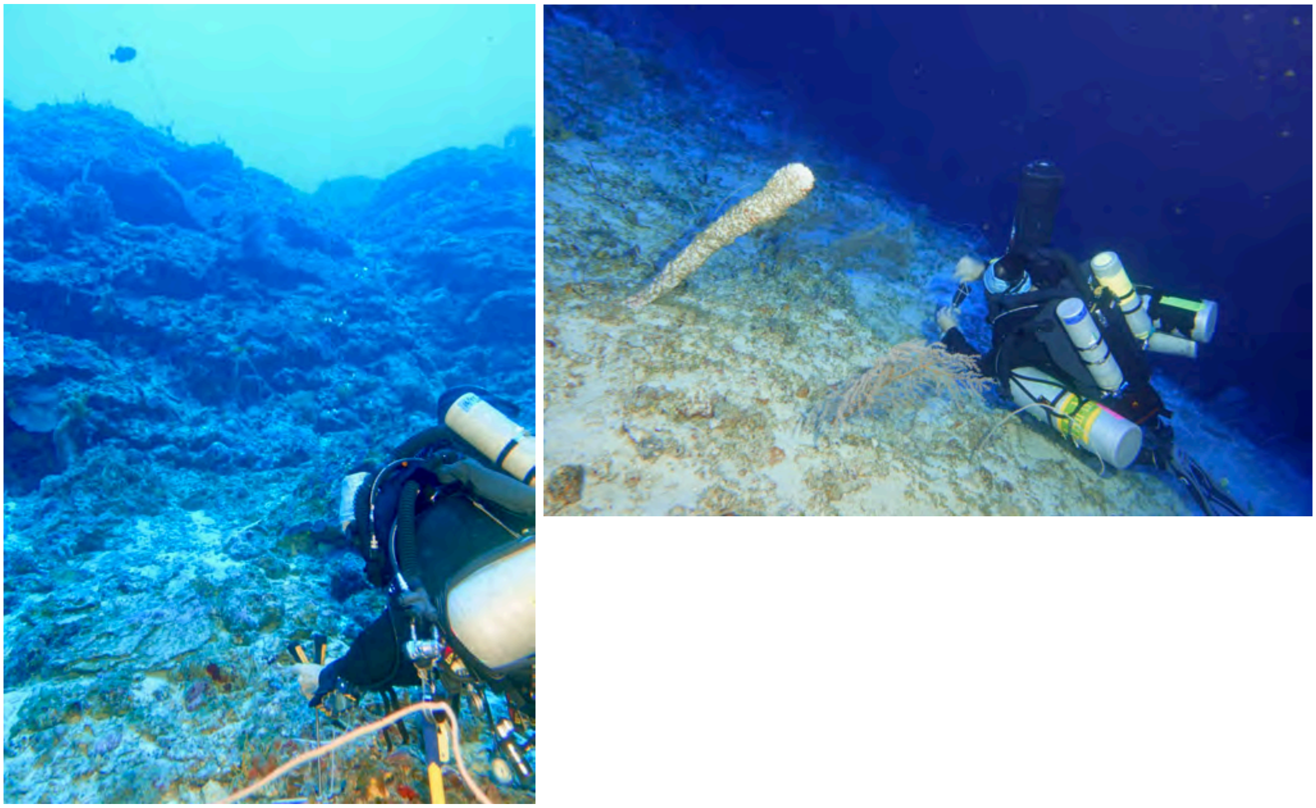


Figure 59. Installation of temperature monitoring stations at Lang Bank EEMP at 67 m (left) and 100 m (right) (credit: Viktor Brandtneris). There is a nice *Agaricia* spp. reef on the escarpment at 67 m.

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 (>10cm 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 °C was established.

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.

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.

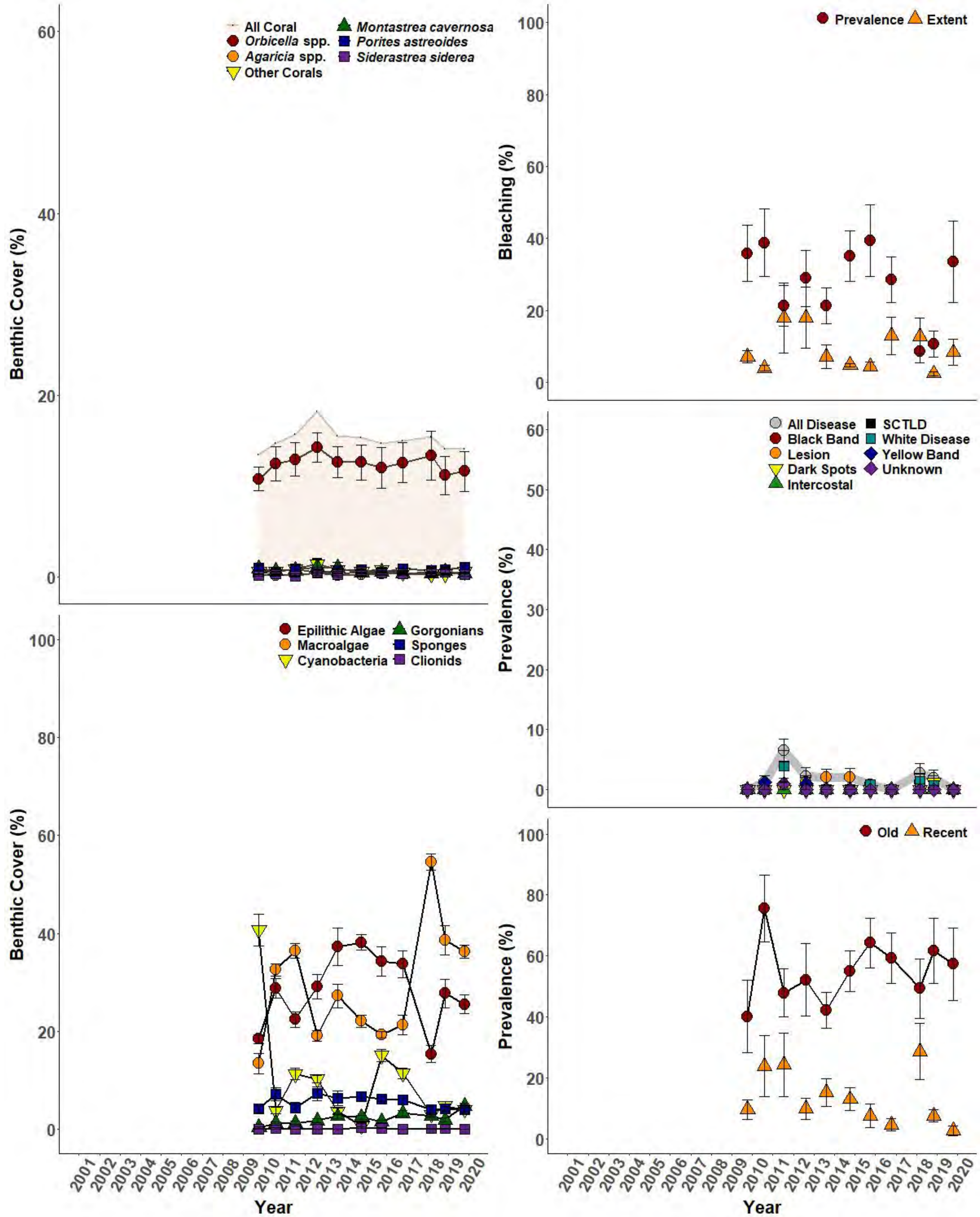


Figure 60. Lang Bank EEMP benthic cover and coral health through time (mean ± SE).

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 durgeon, 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. There have been no large snappers or groupers recorded there. The Lang Bank East End Marine Park is now protected from fishing, so there is hope that large snappers and groupers will return to this rich mesophotic community.

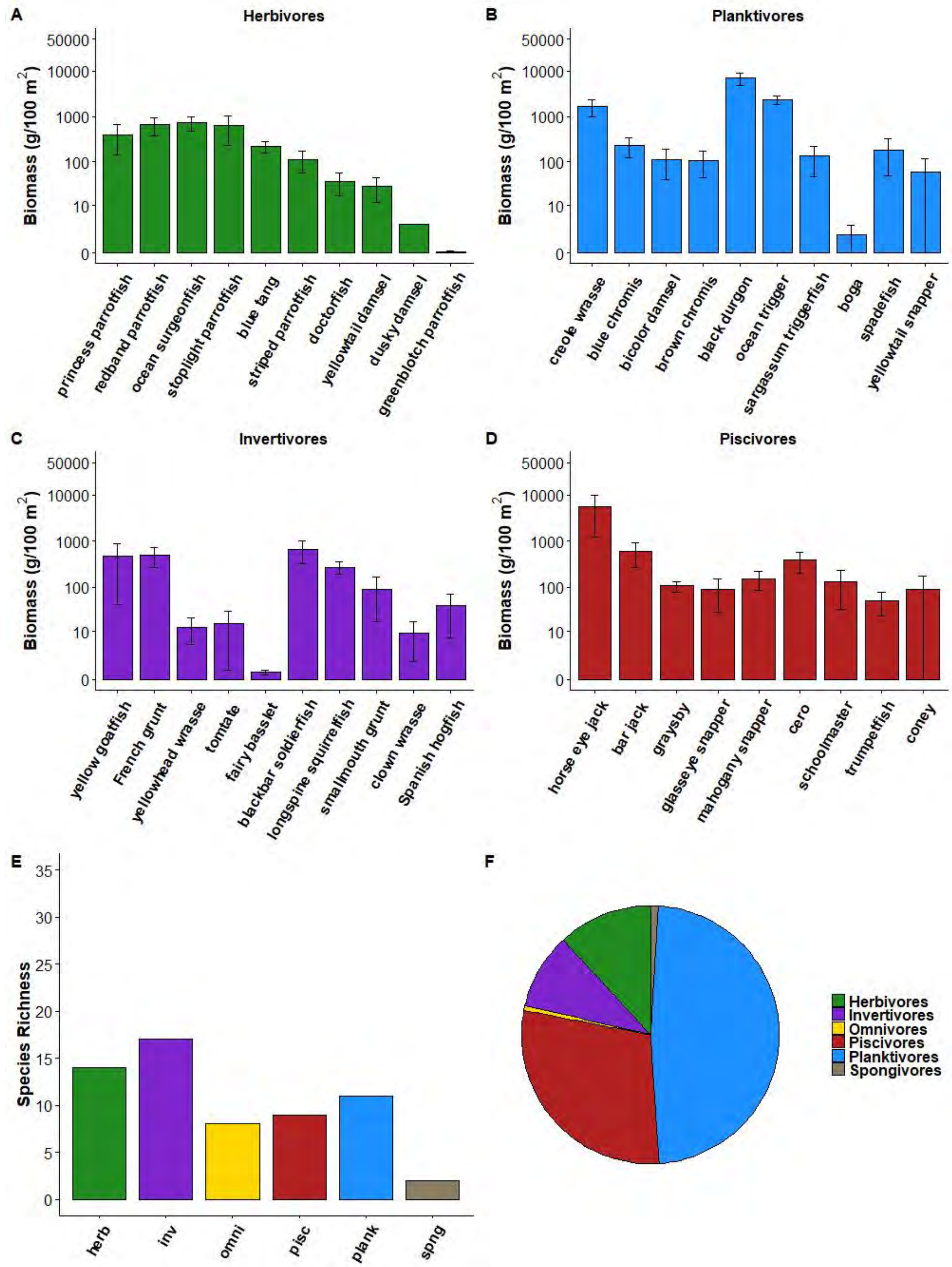
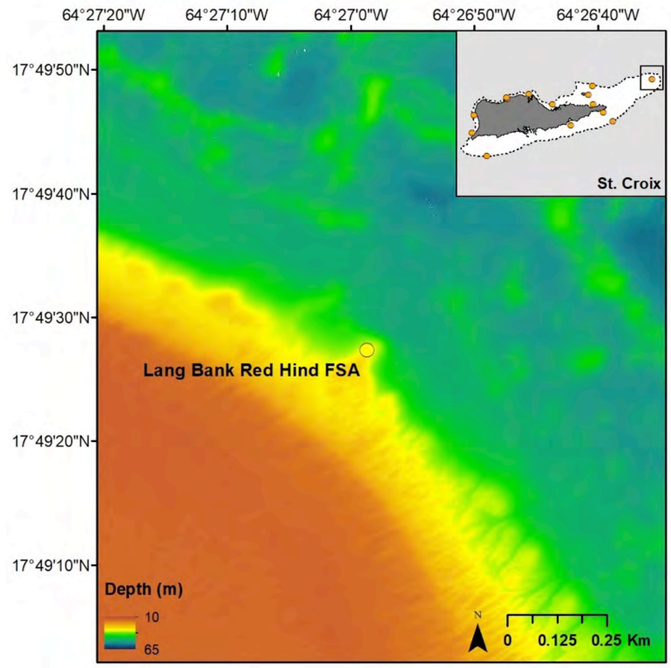


Figure 61. The Lang Bank EEMP fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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 62. Lang Bank Red Hind FSA. (top) Location. (right) A representative photo of the reef

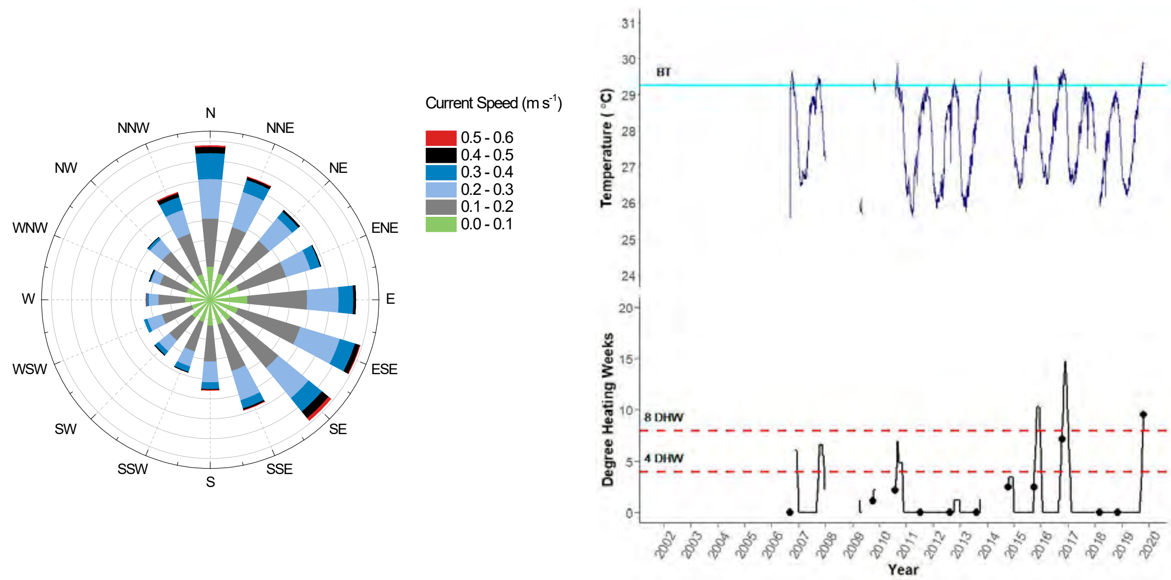


Figure 63. Lang Bank Hind current speed (left) and benthic temperature (right; 33 m depth).

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 0.4m 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.

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. 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.

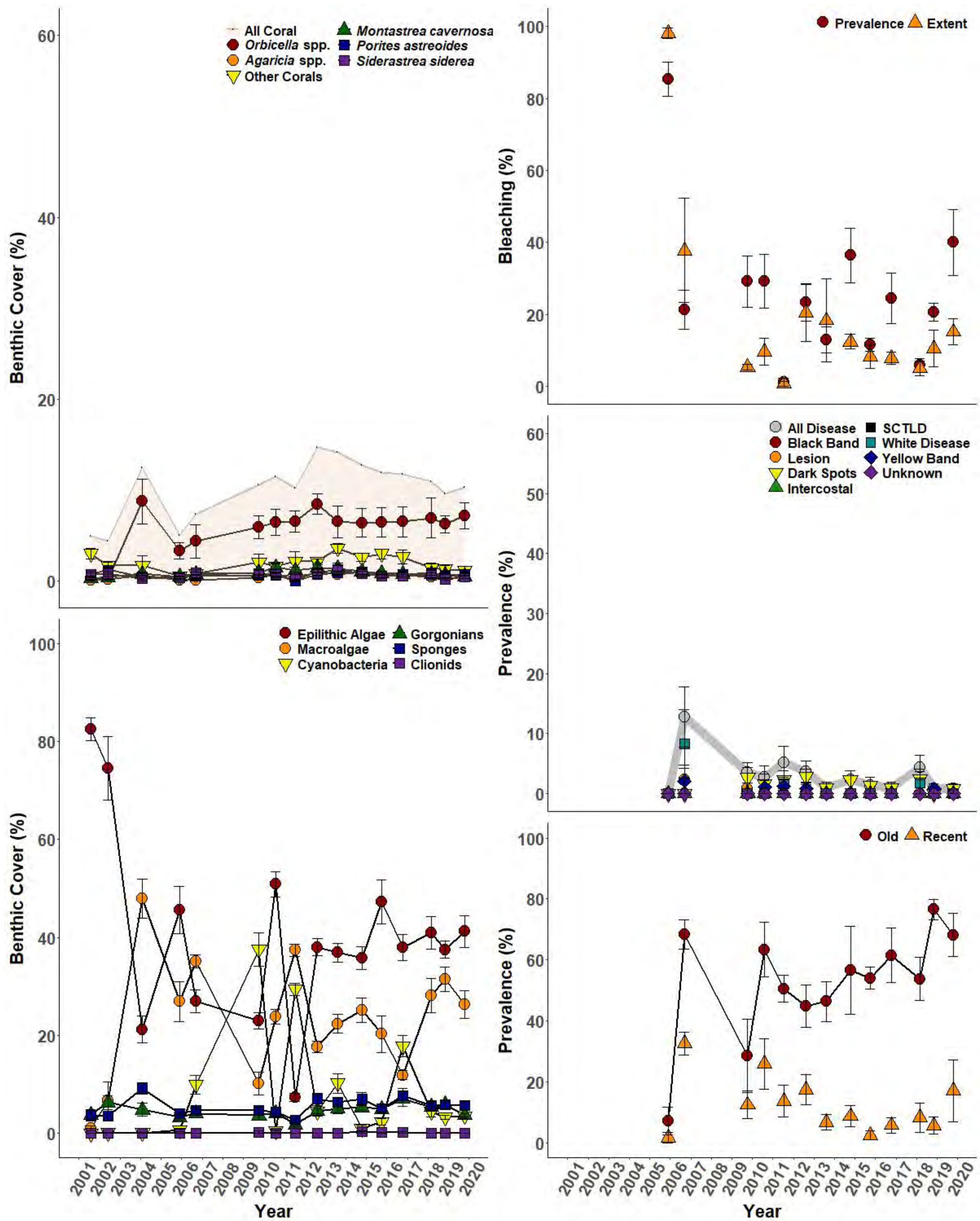


Figure 64. Lang Bank Red Hind FSA benthic cover and coral health through time (mean ± SE).

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 durgeon, 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 reportedly 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.

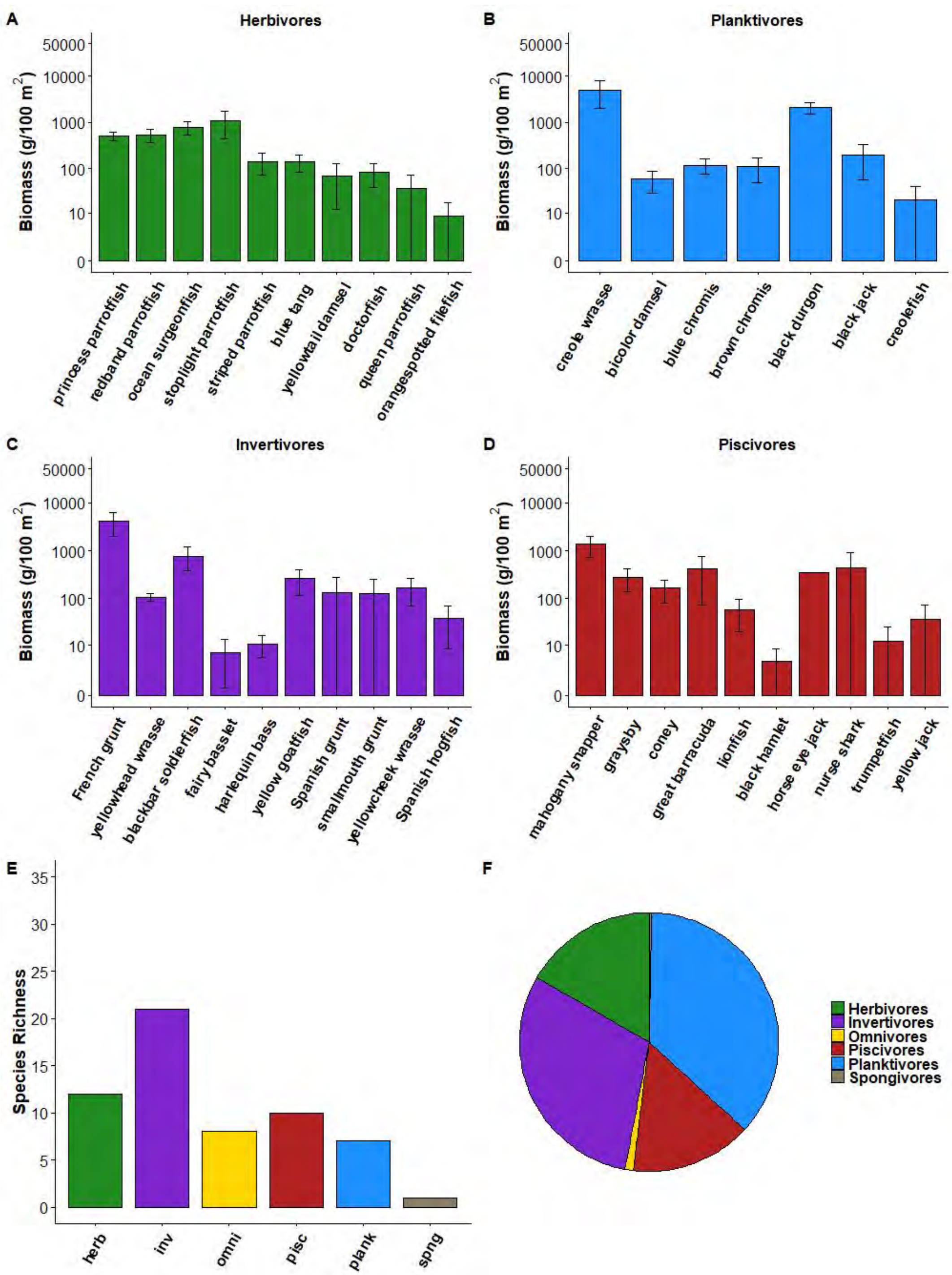
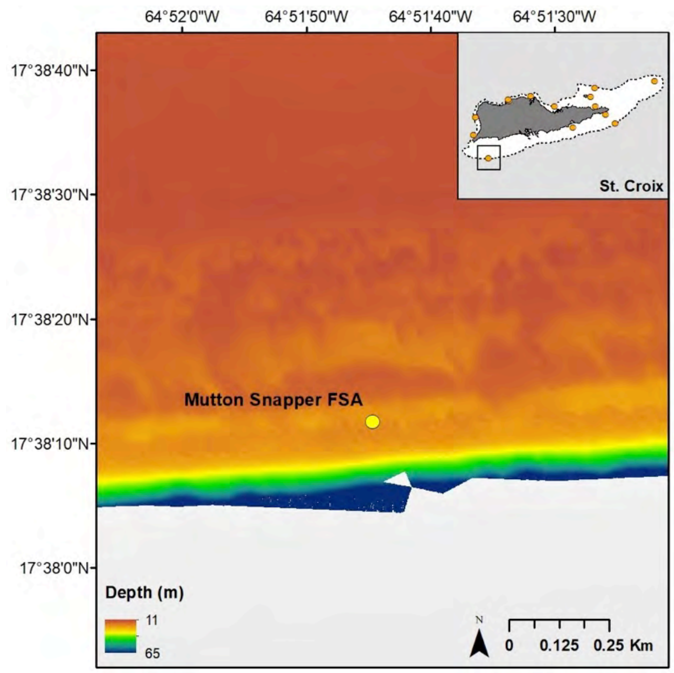


Figure 65. The Lang Bank Red Hind FSA fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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.

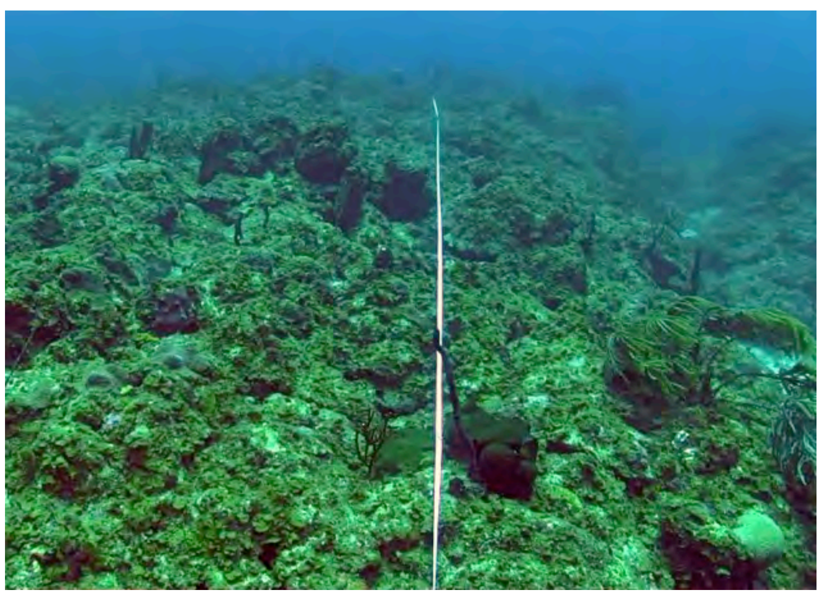


Figure 66. Mutton Snapper. (top) Location. (right) A representative photo of the reef taken in 2014.

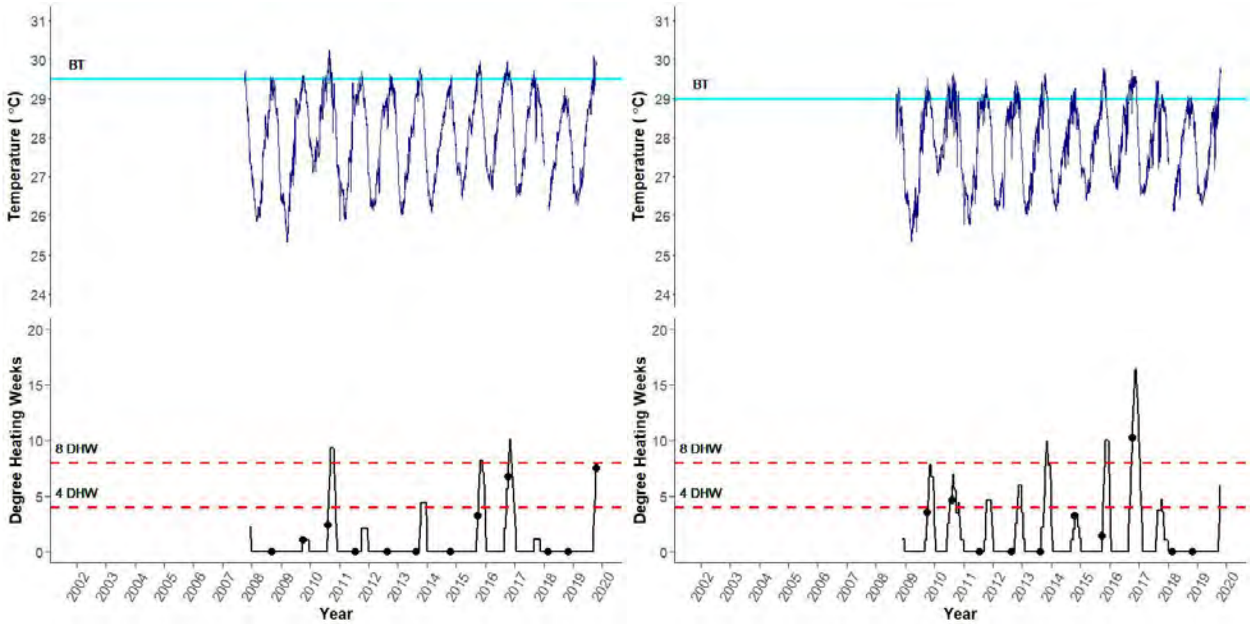


Figure 67. Mutton Snapper benthic temperature record at 24 m (left) and 40 m depth (right).

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

SITE SUMMARIES

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. *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.

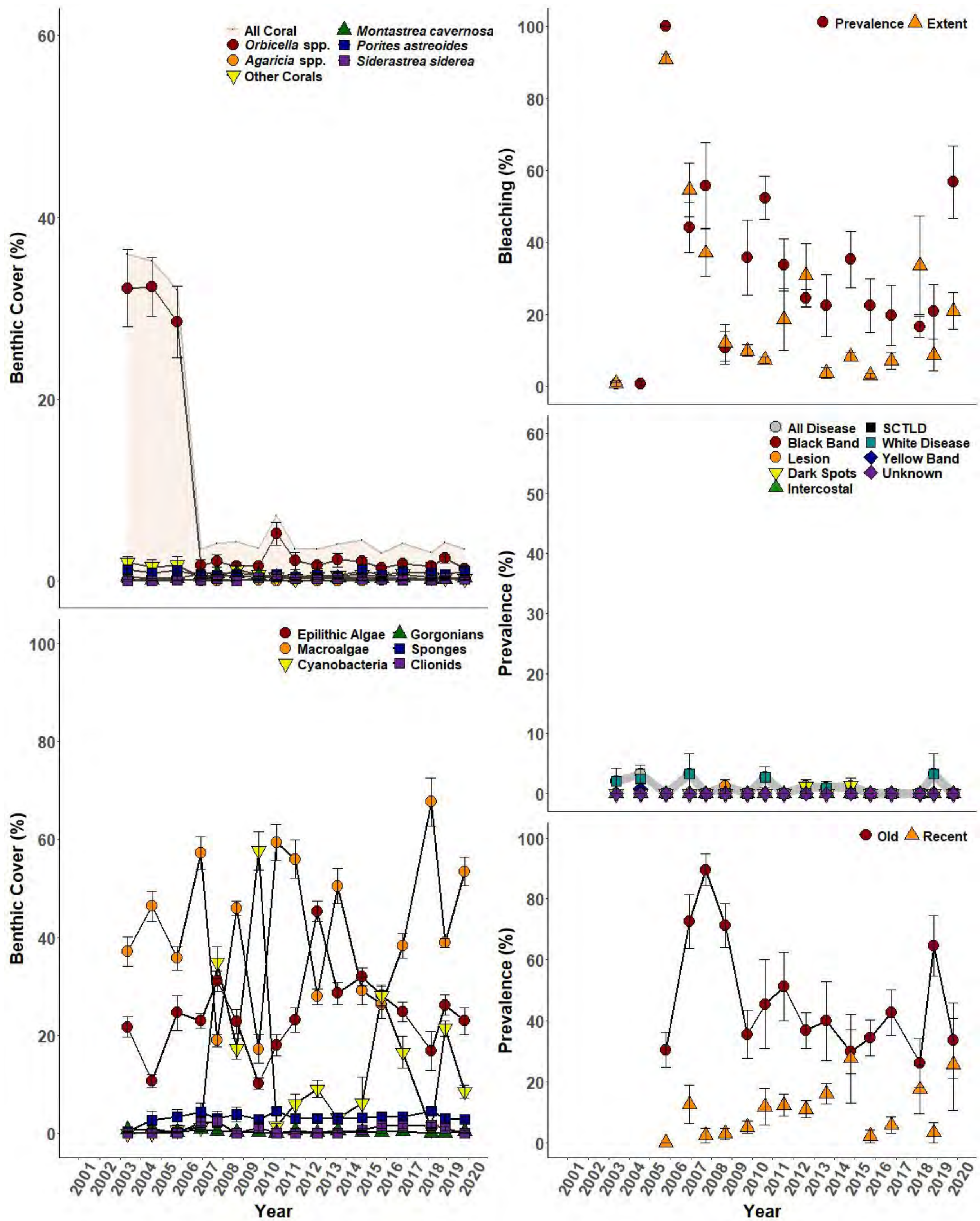


Figure 68. Mutton Snapper benthic cover and coral health through time (mean ± SE).

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 durgeon 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.

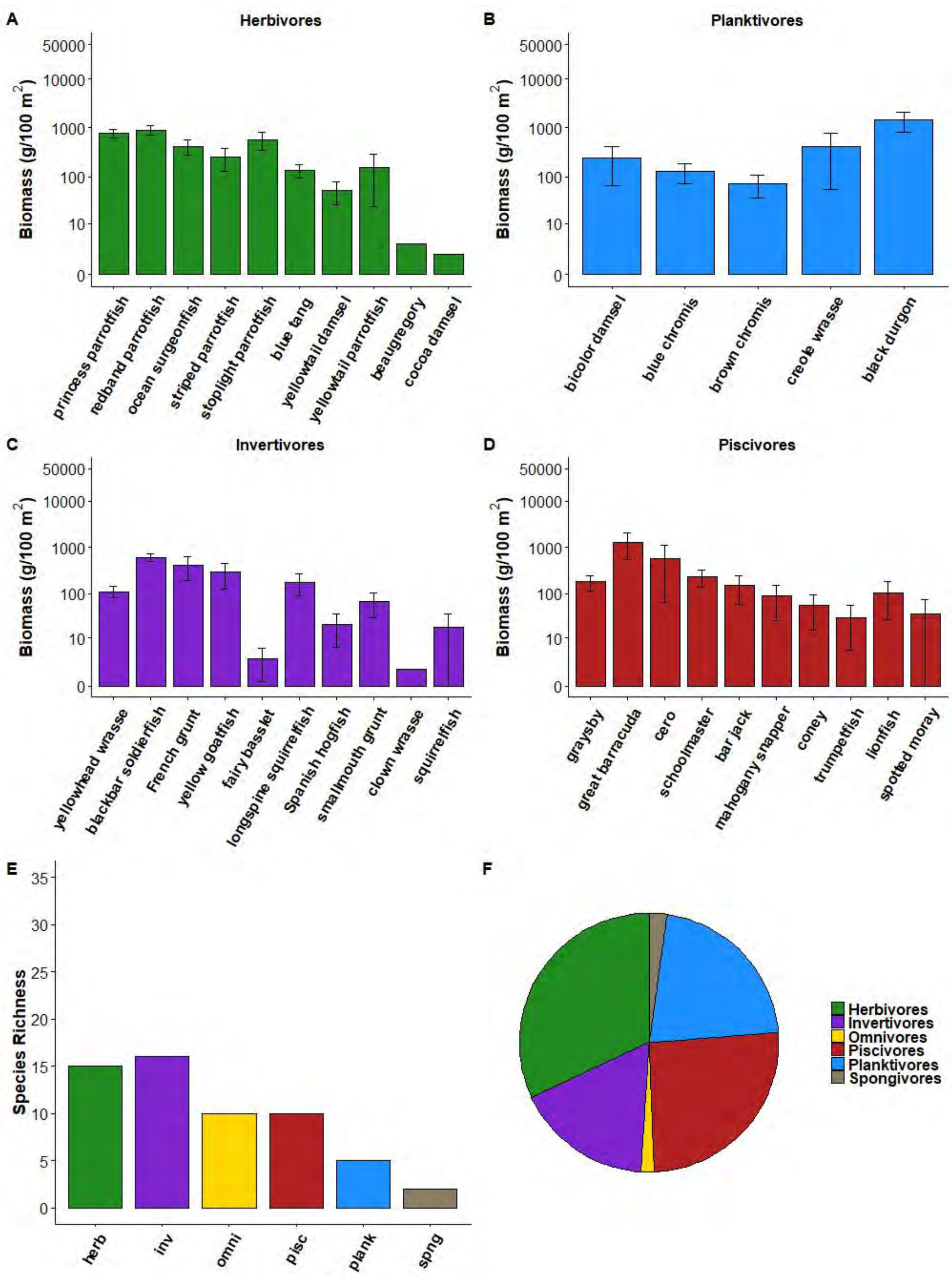
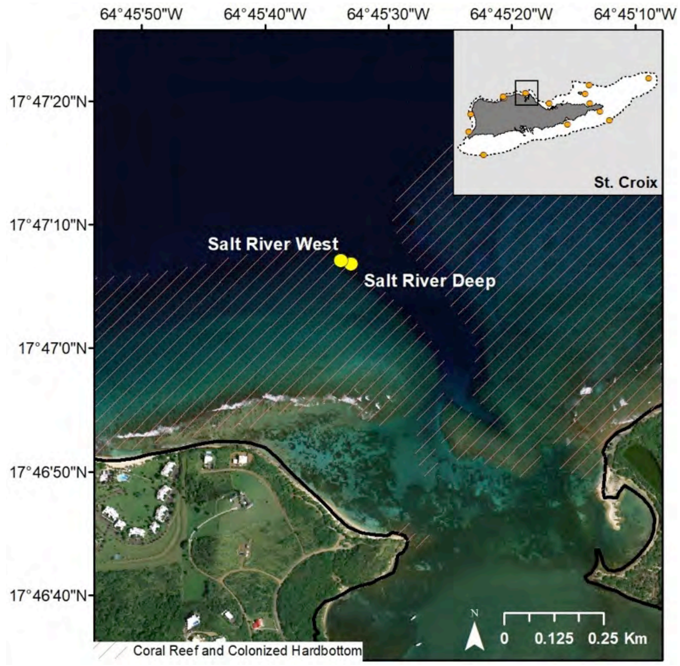


Figure 69. The Mutton Snapper fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

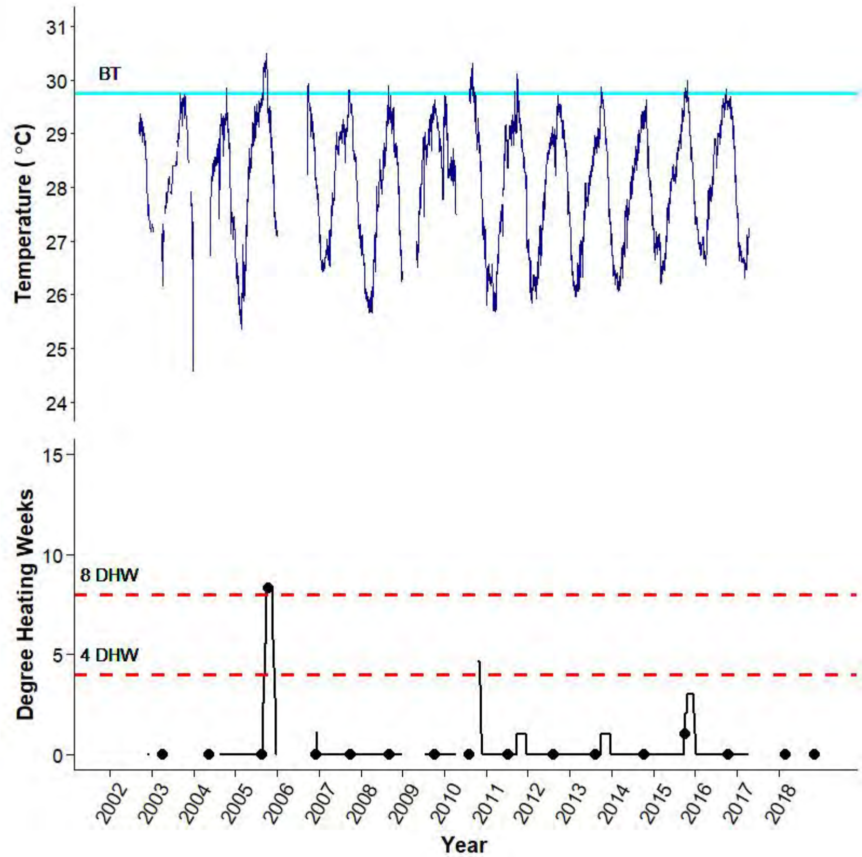


Figure 71. Salt River West surface-benthic temperature record 5m depths. Data provided by the NOAA ICON monitoring network.

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 (<15cm 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

Benthic Community. The Salt River West epibenthic sessile animal community has a diverse hard coral community of small massive head 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%). 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 between 2009 and 2018, 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).

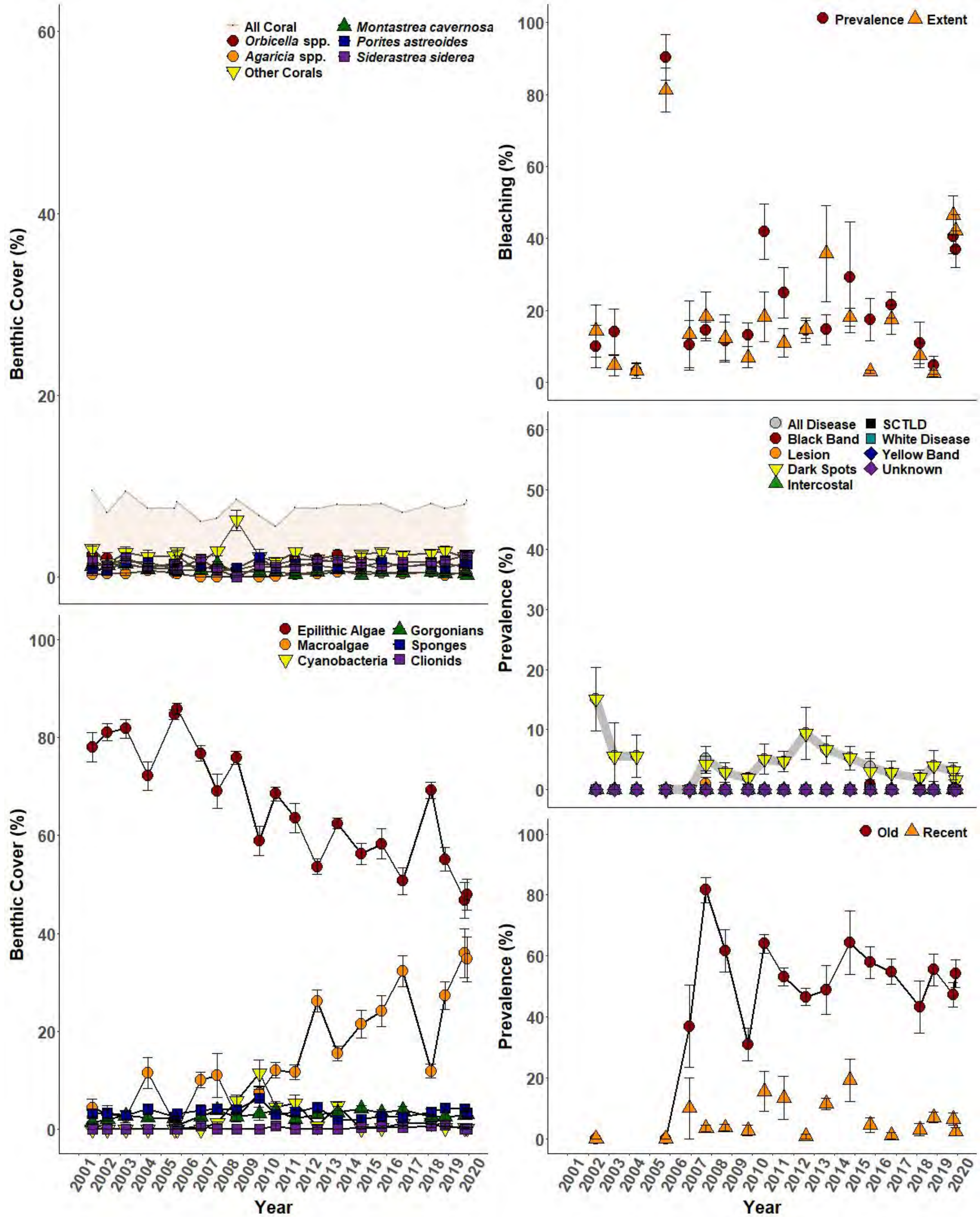


Figure 72. Salt River West benthic cover and coral health through time (mean ± SE).

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 durgeon, 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.

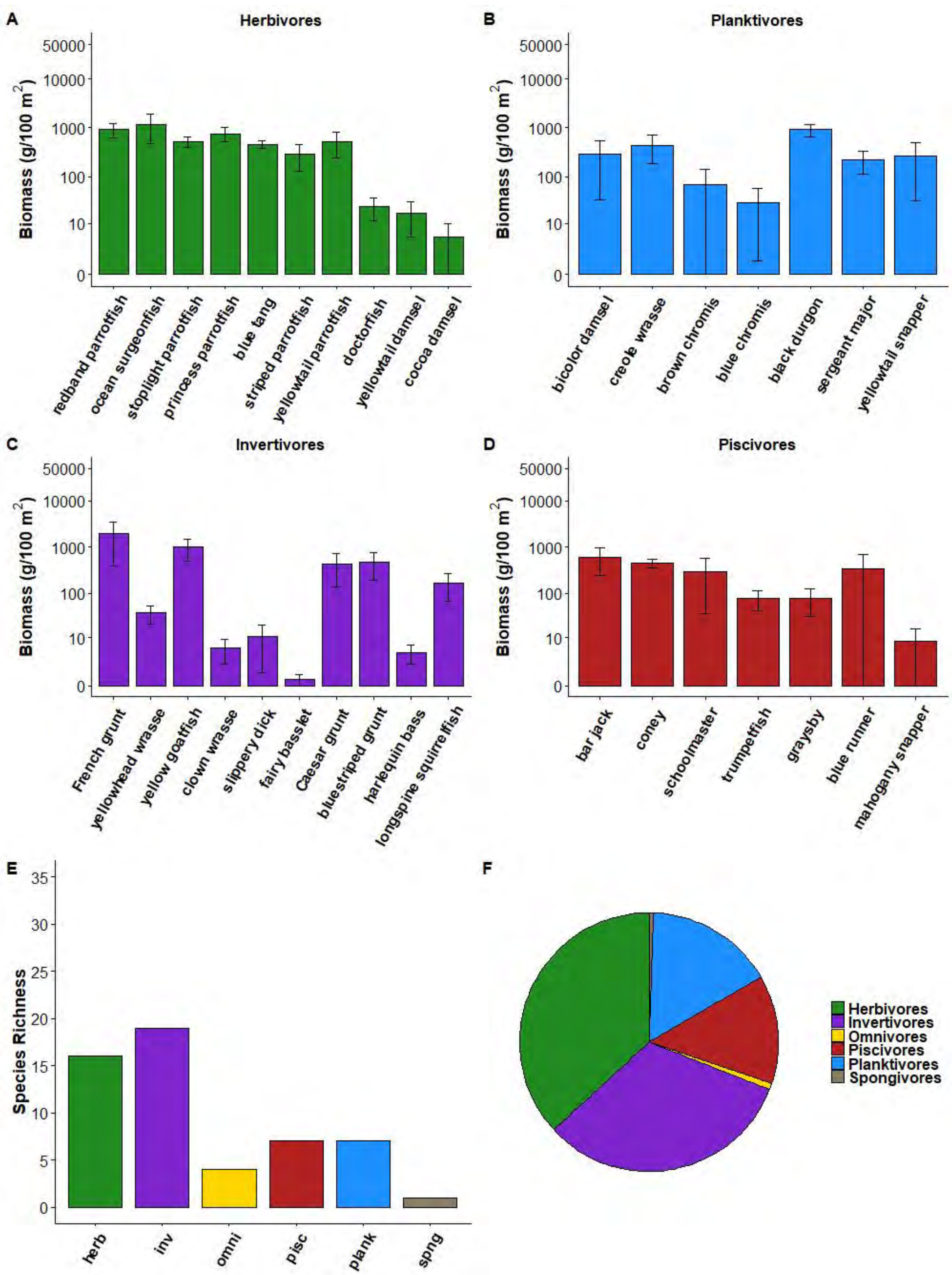
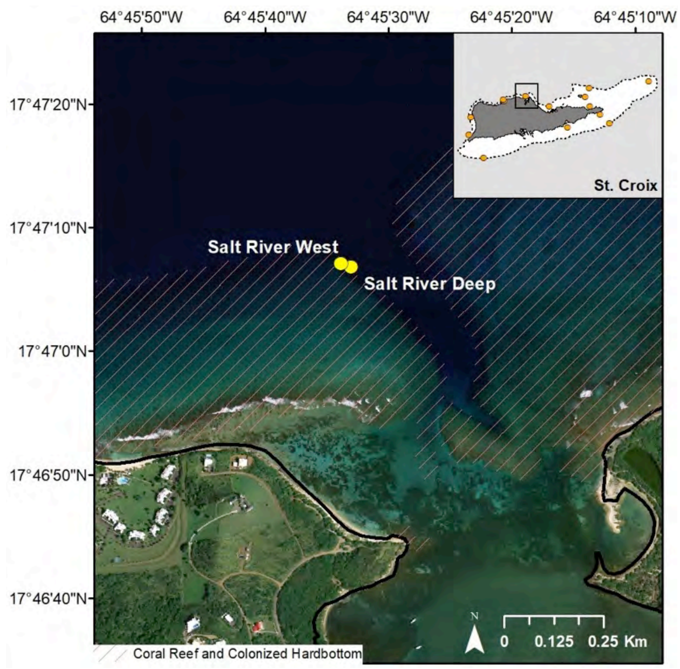


Figure 73. The Salt River West fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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.

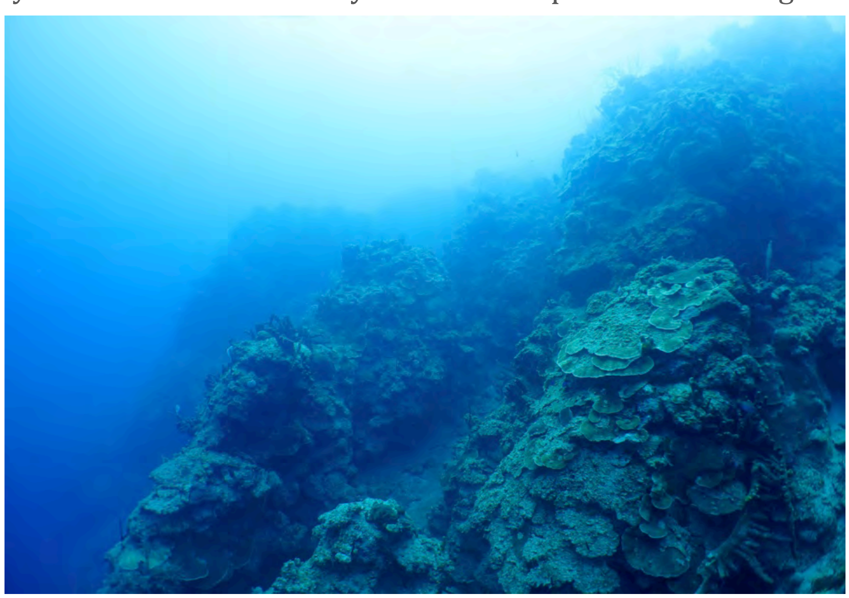


Figure 74. Salt River Deep. (top) Location. (right) A representative photo of the reef (photo credit: L. M. Henderson).

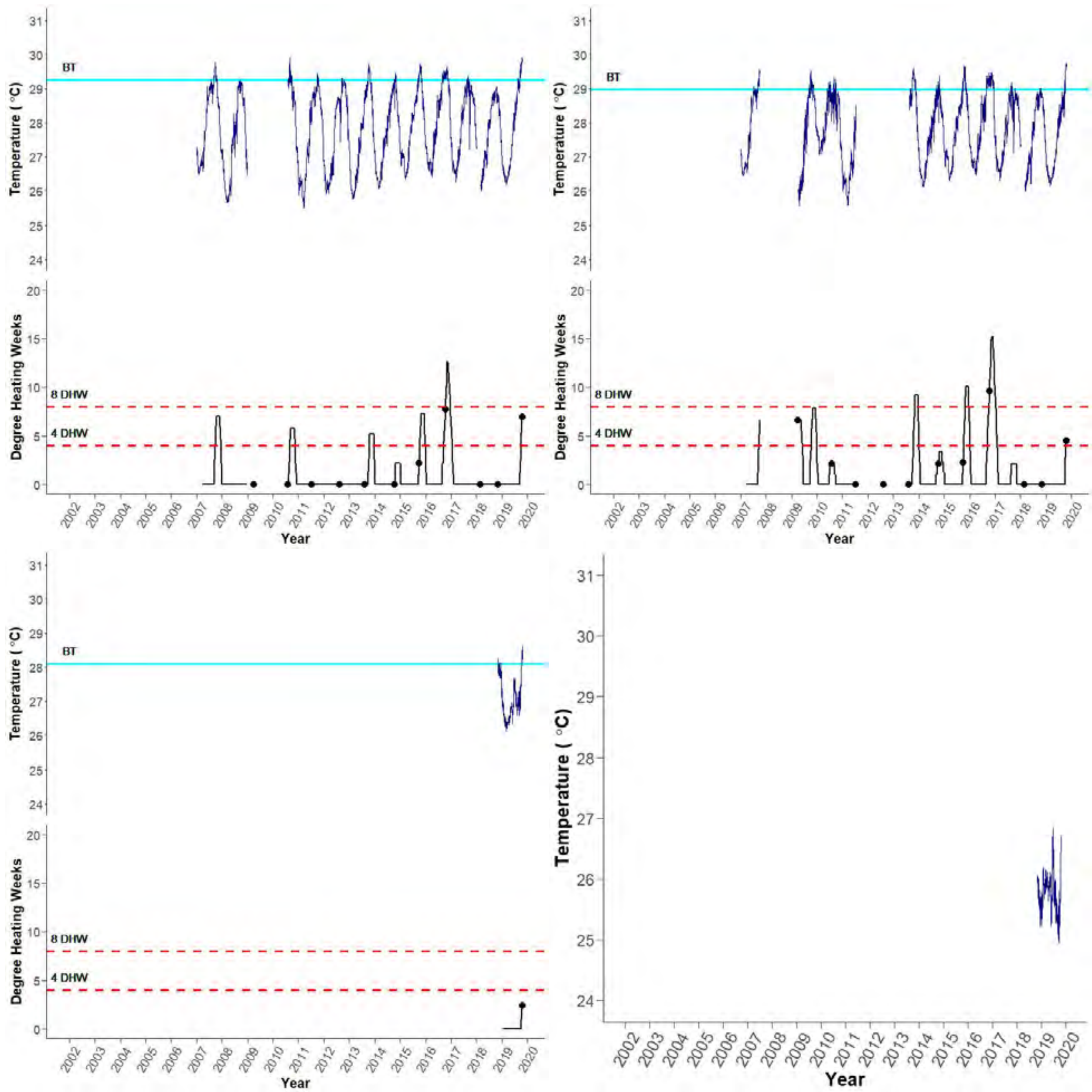


Figure 75. Salt River Deep benthic temperature (Top left: 30 m depth, top right: 41 m depth, bottom left: 67 m depth, bottom right: 100 m depth).

Figure 76. Installation of temperature monitoring stations at Salt River Deep at 67 m (left) and 100 m (right) 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).

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. Diseases have not been observed. 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.

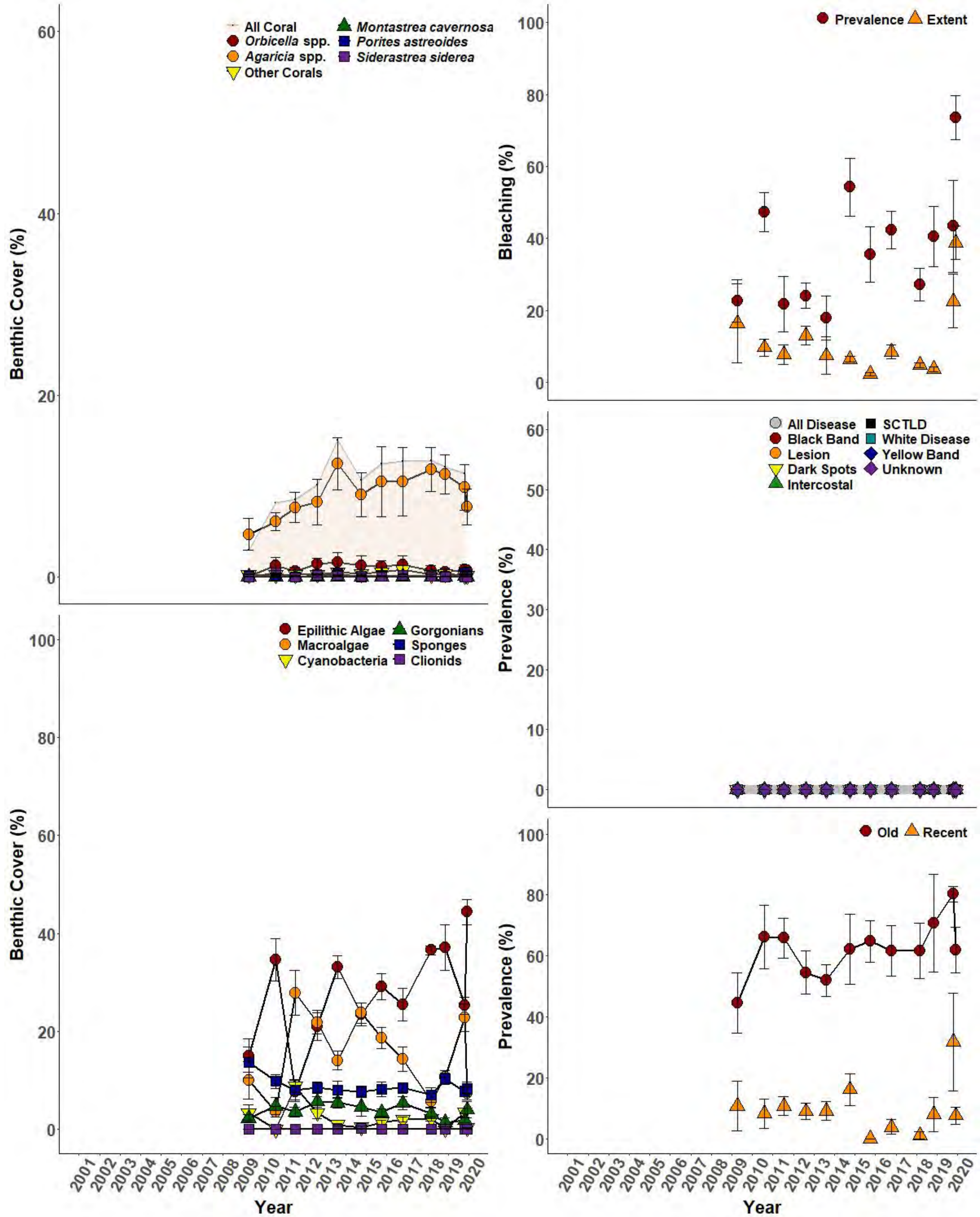


Figure 77. Salt River Deep benthic cover and coral health through time (mean ± SE).

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 perezi*) are present. Deeper in the canyon in the 50 – 70 m depth range, resting schools of black margate have been observed on every dive.

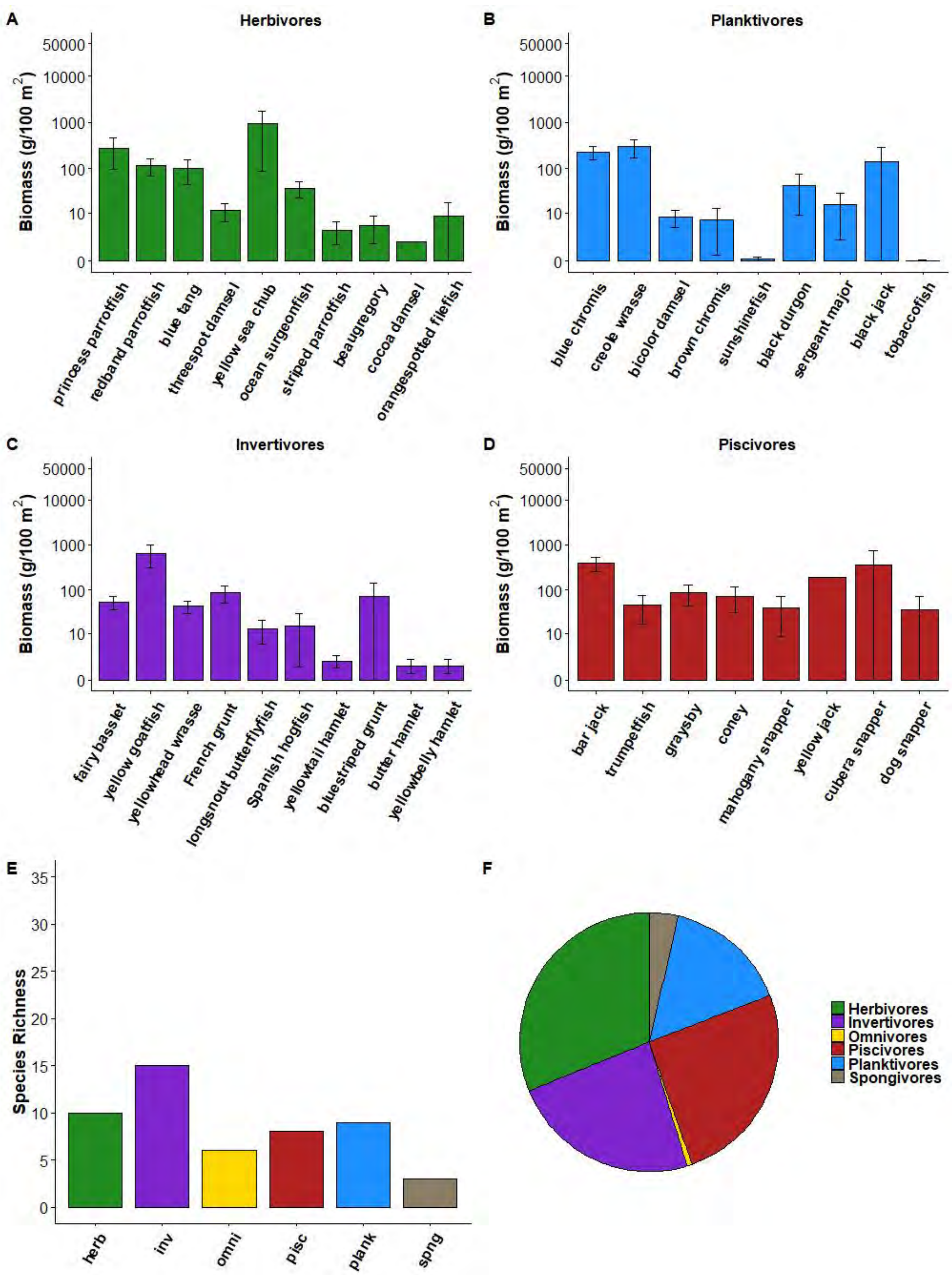
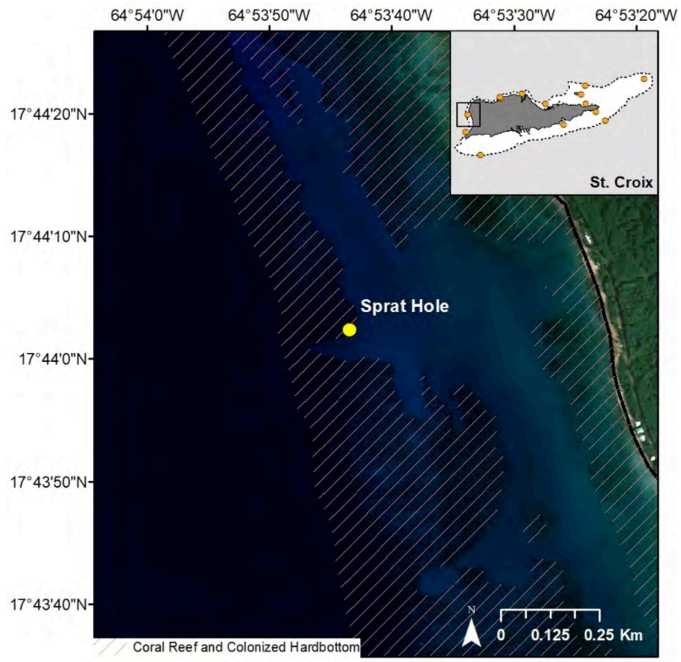


Figure 78. The Salt River Deep fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

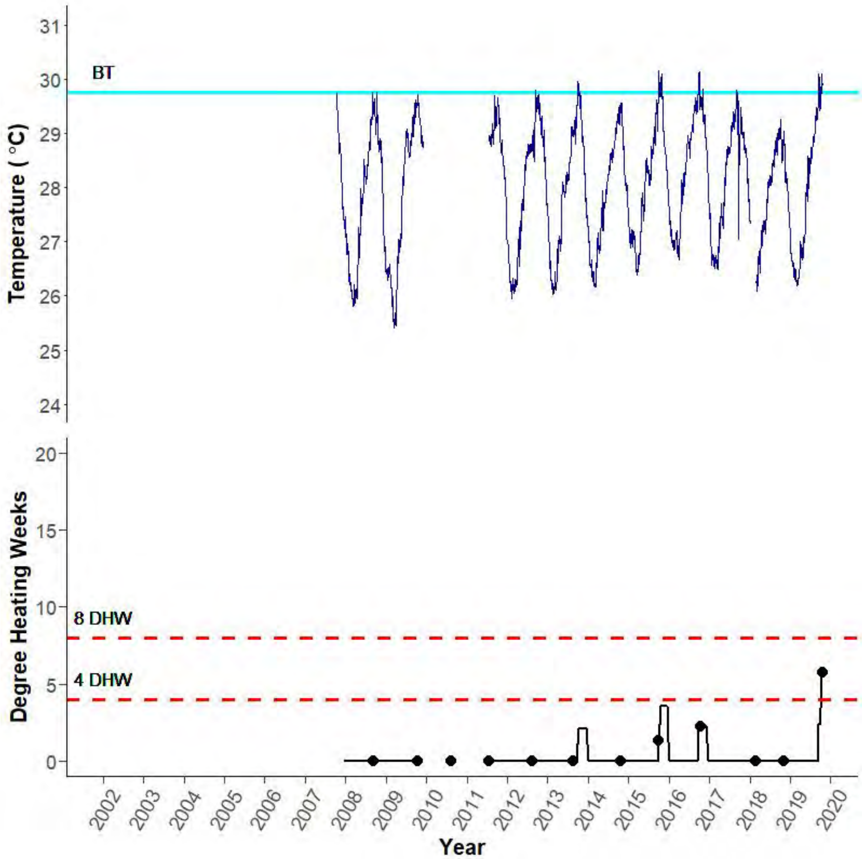


Figure 80. Sprat Hole benthic temperature (7 m depth).

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 (<10cm 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.

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.*

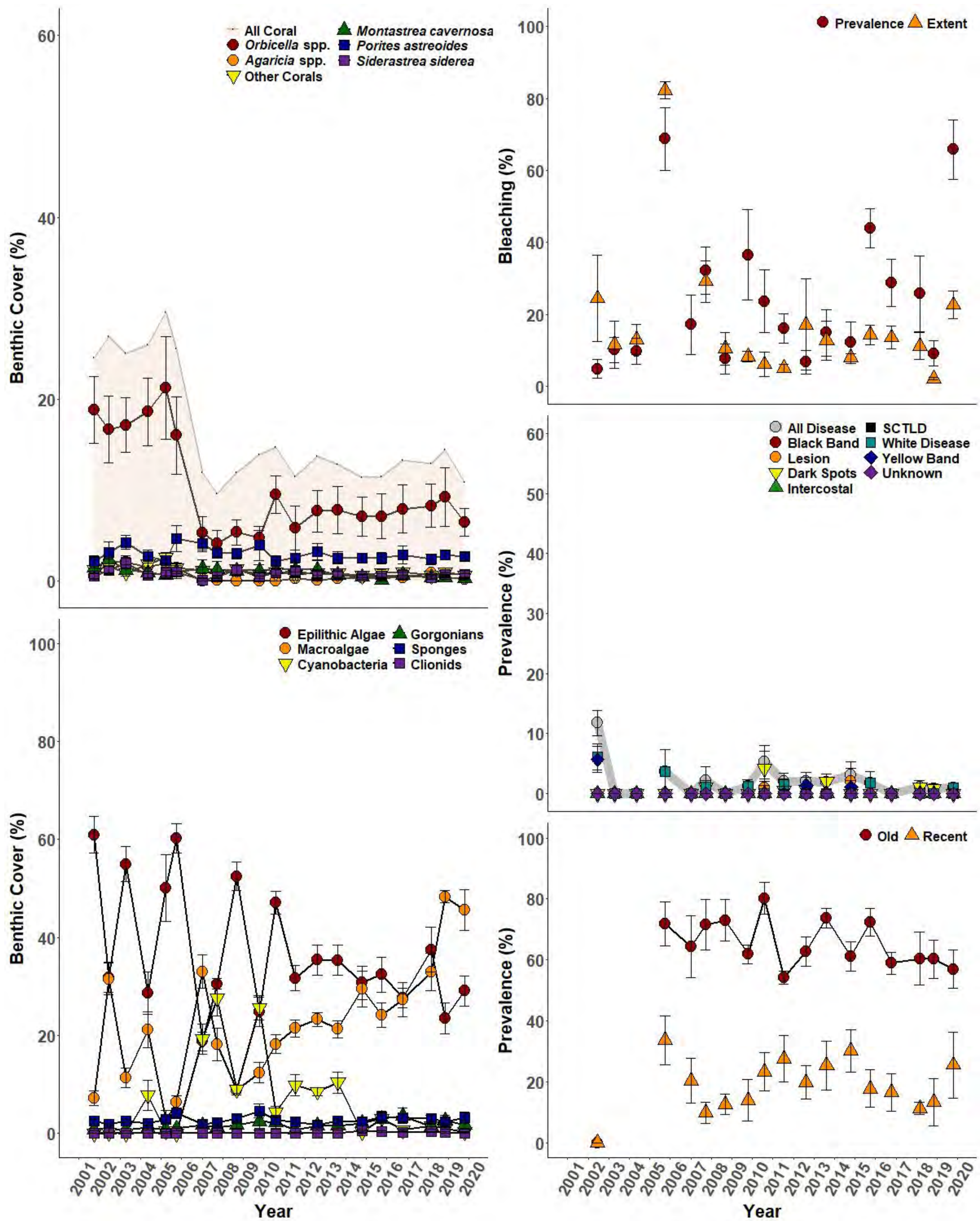


Figure 81. Sprat Hole benthic cover and coral health through time (mean ± SE).

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 every year since 2012. Bar jacks and cero mackerel, nearshore pelagic piscivores, round out the piscivore trophic guild.

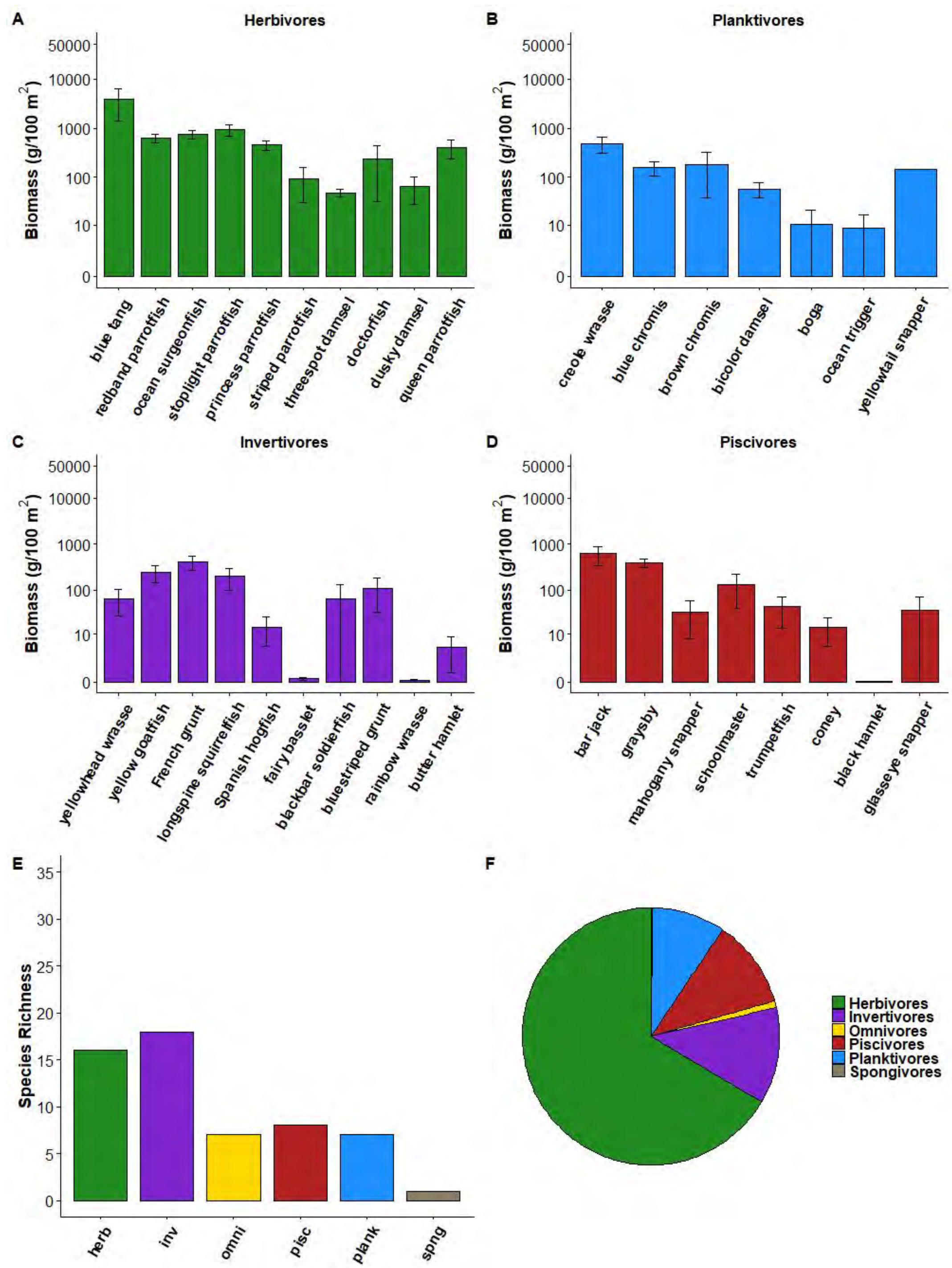


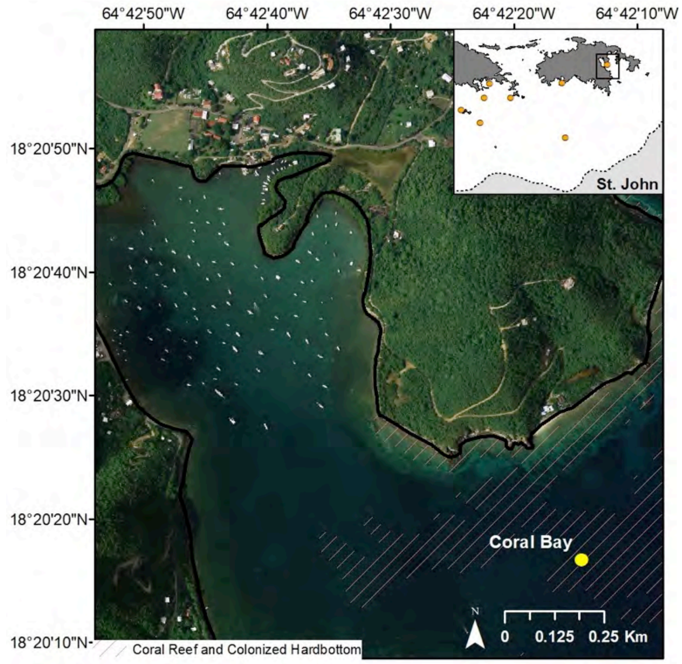
Figure 82. The Sprat Hole fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

St. John

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. Recent restoration activities in the watershed are expected to decrease the sediment influx. Coral Bay may also be threatened by maritime activities within Coral Harbor. Proximity to land makes this site in territorial waters potentially vulnerable to fishing.

Figure 83. Coral Bay. (top) Location. (right) A representative photo of the reef.

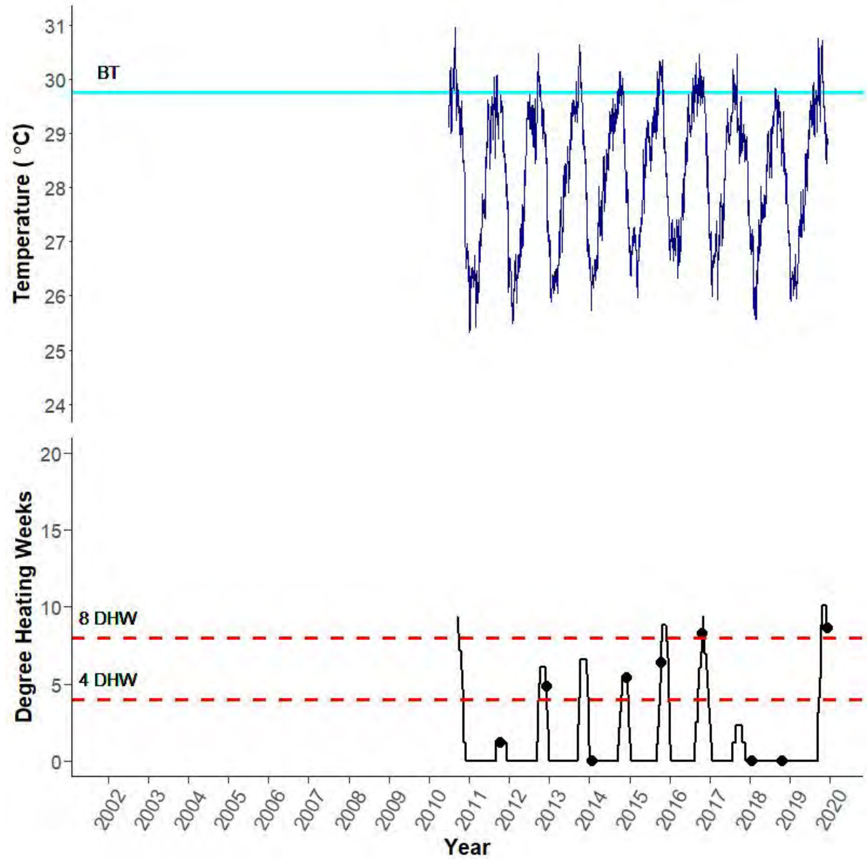


Figure 84. Coral Bay benthic temperature (9 m depth)

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).

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. In particular, 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. Diseases were not recorded in 2011. Old partial mortality prevalence was low in 2011, but this may partly be explained by the high abundance of small coral colonies that are less prone old partial mortality. Recent mortality had low prevalence in 2011.

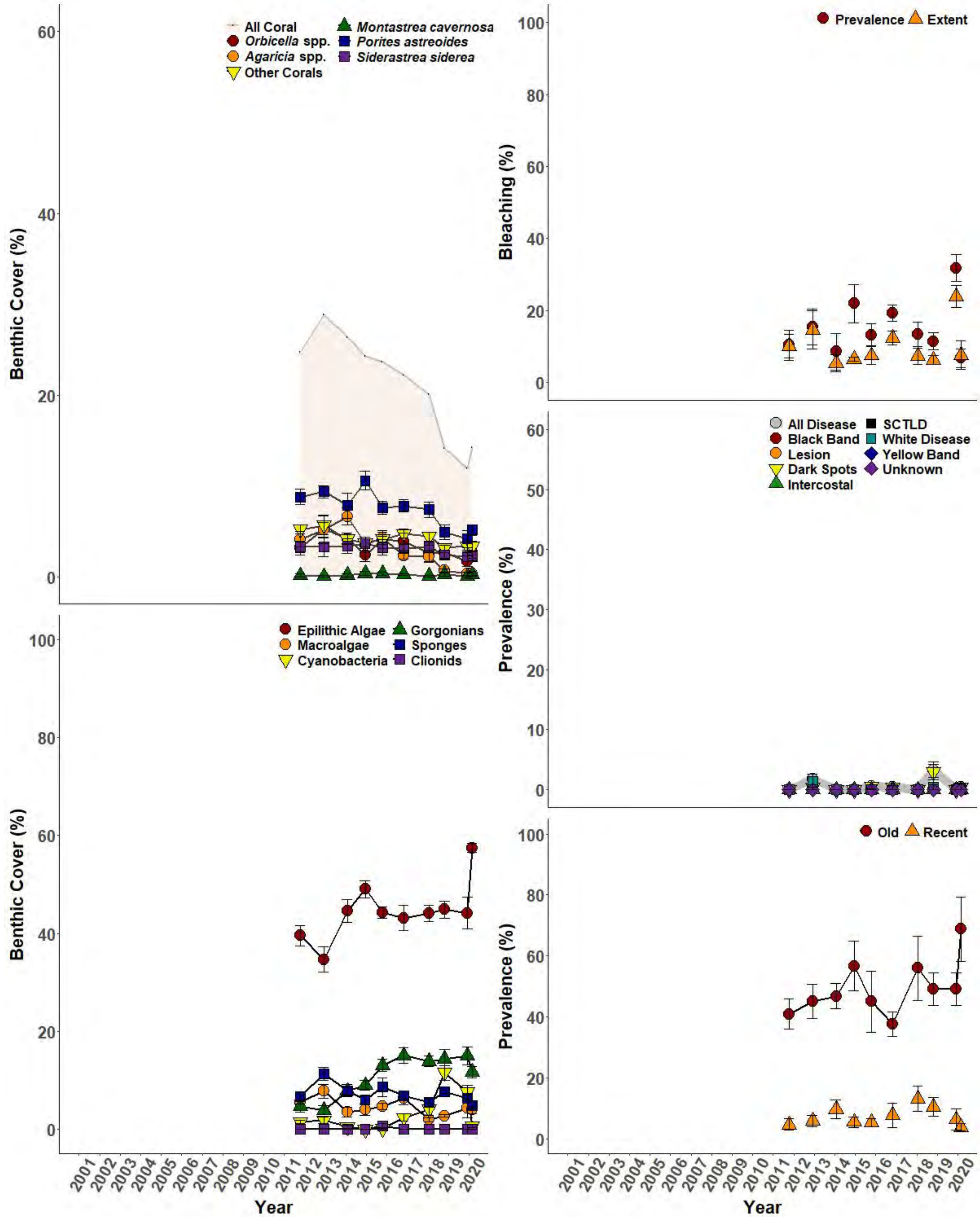


Figure 85. Coral Bay benthic cover and coral health through time (mean ± SE).

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 redbad 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.

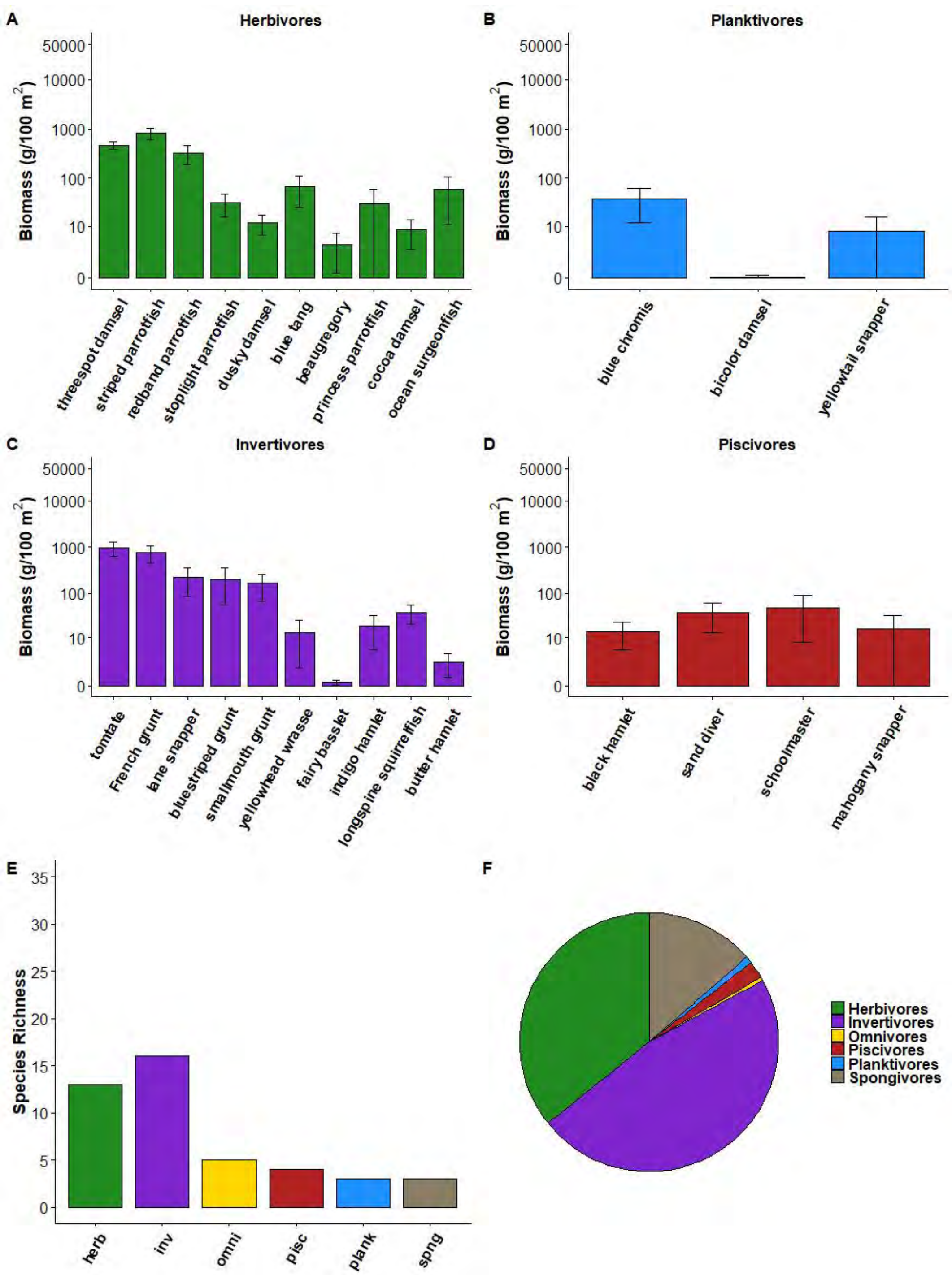
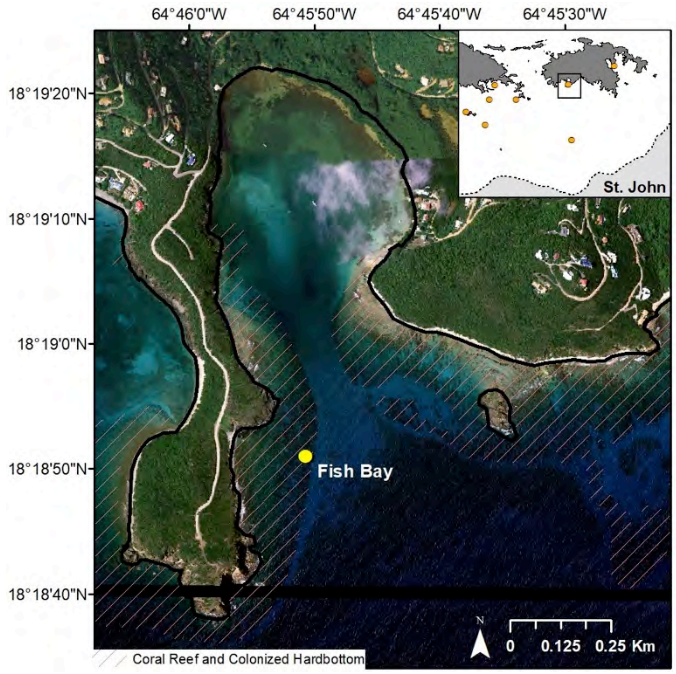


Figure 86. The Coral Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

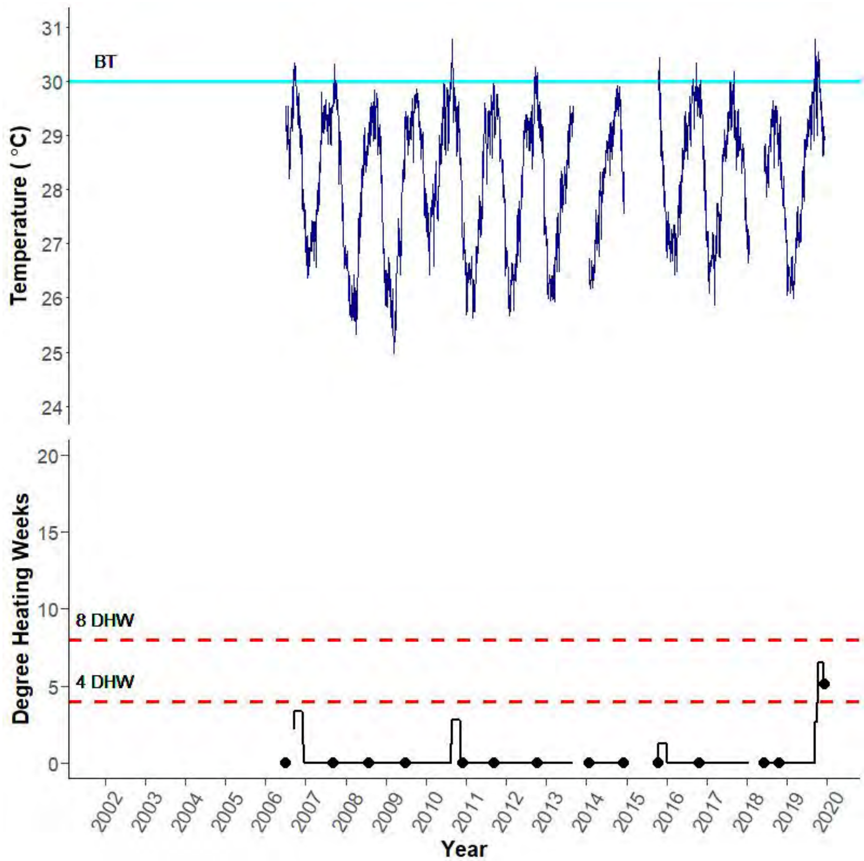


Figure 88. Fish Bay benthic temperature record (6 m depth).

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

Benthic Community. The coral community of Fish Bay is dominated by the boulder star coral *Orbicella* spp.. In particular, 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 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. 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.).

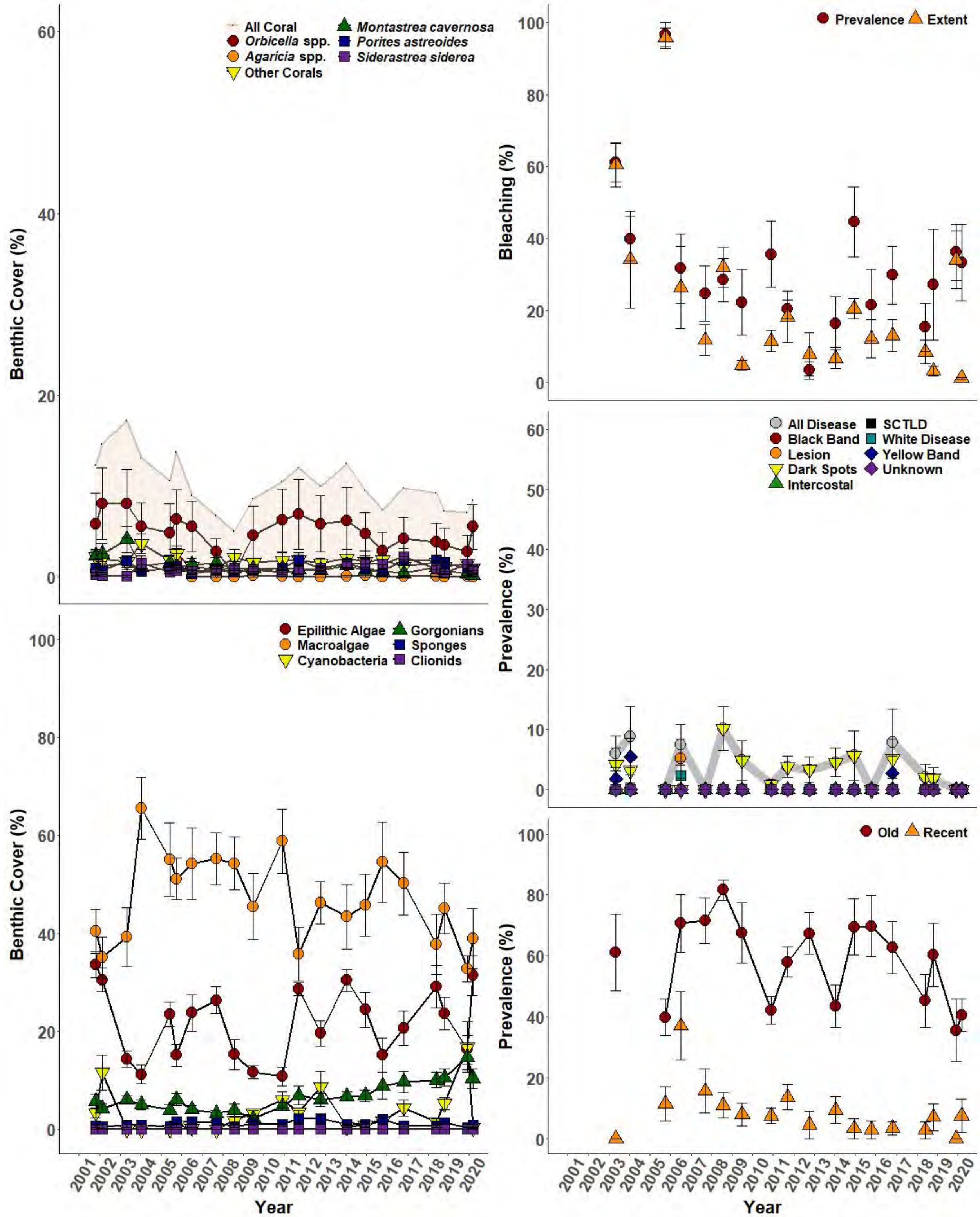


Figure 89. Fish Bay benthic cover and coral health through time (mean ± SE).

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 of 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. 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.

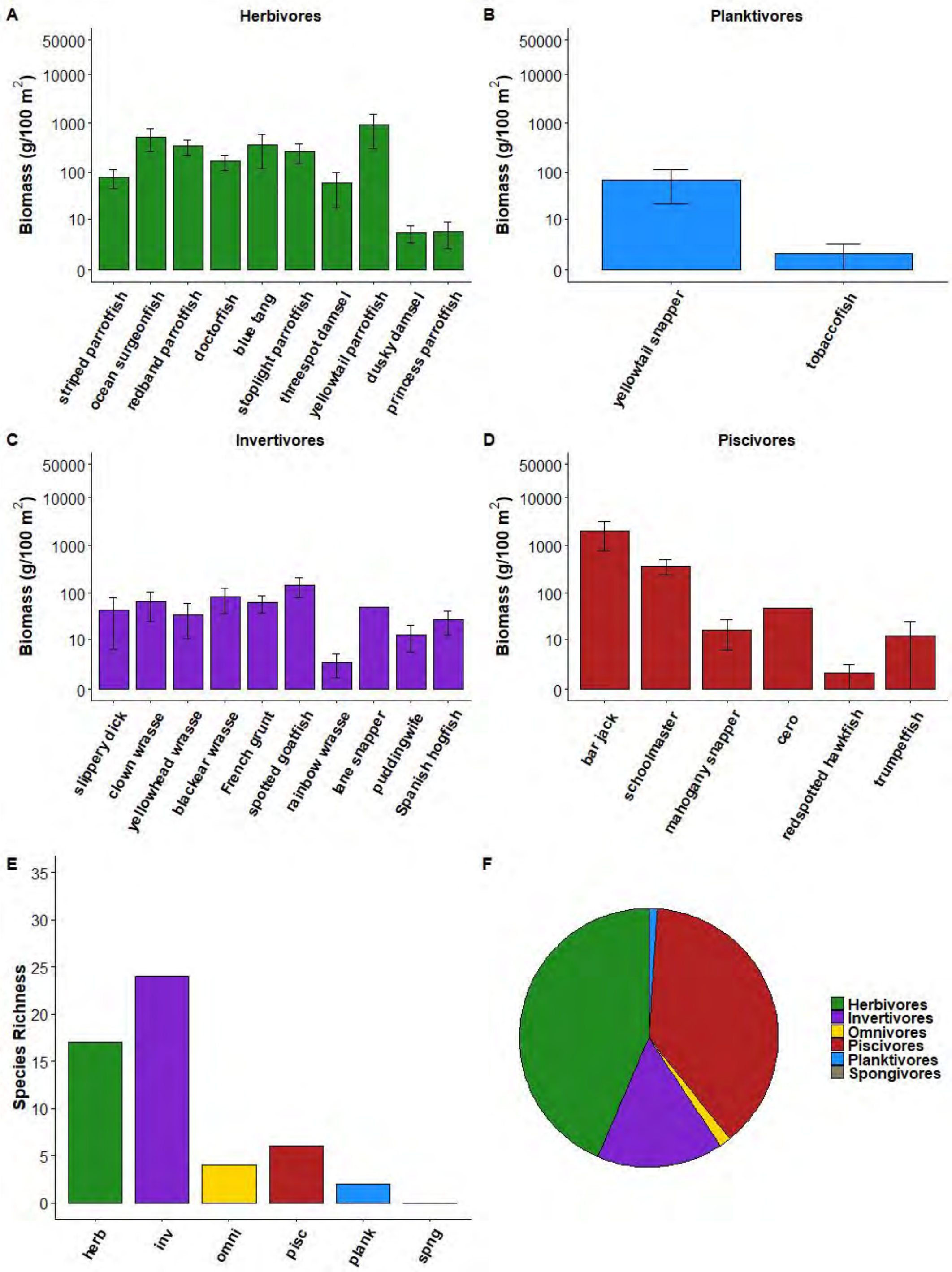
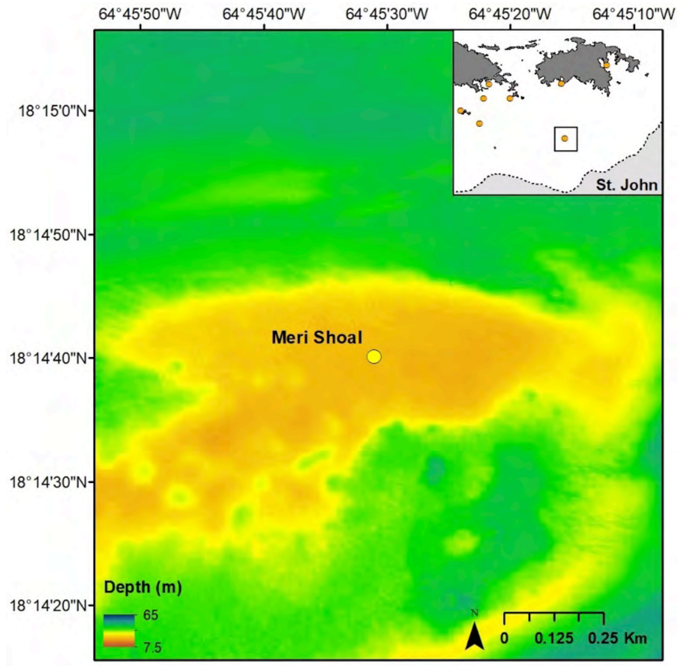


Figure 90. The Fish Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



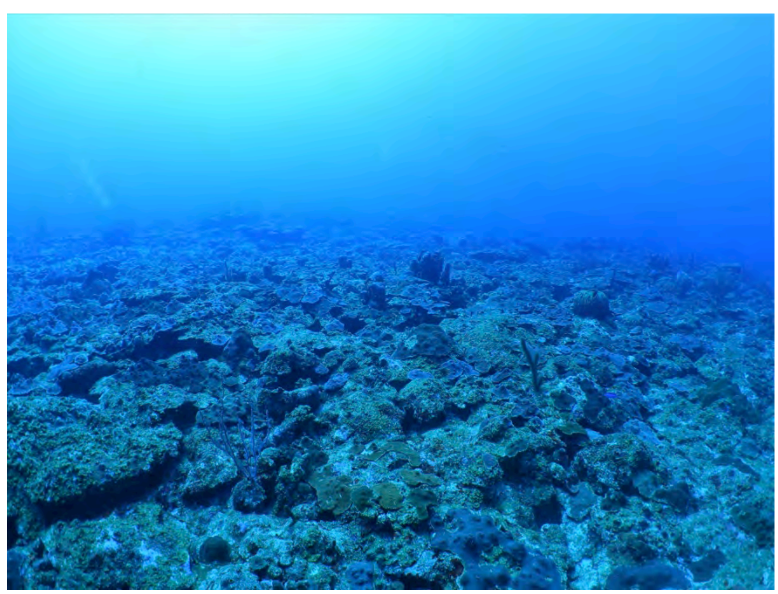
MERI SHOAL

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



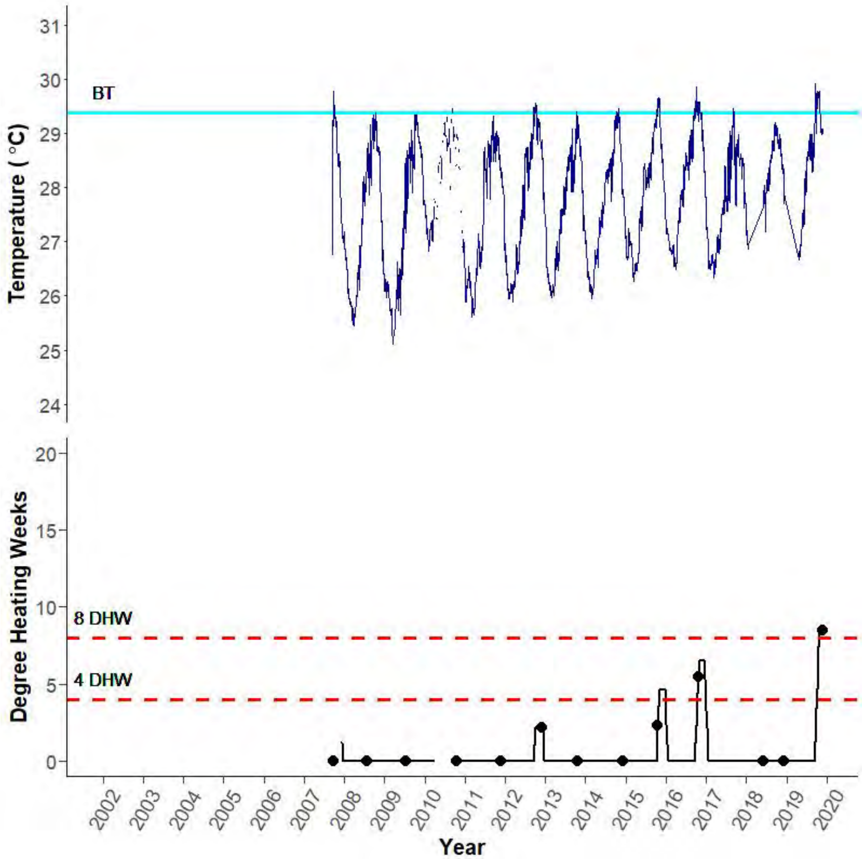


Figure 92. Meri Shoal benthic temperature record (30 m depth).

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

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%). 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. 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.

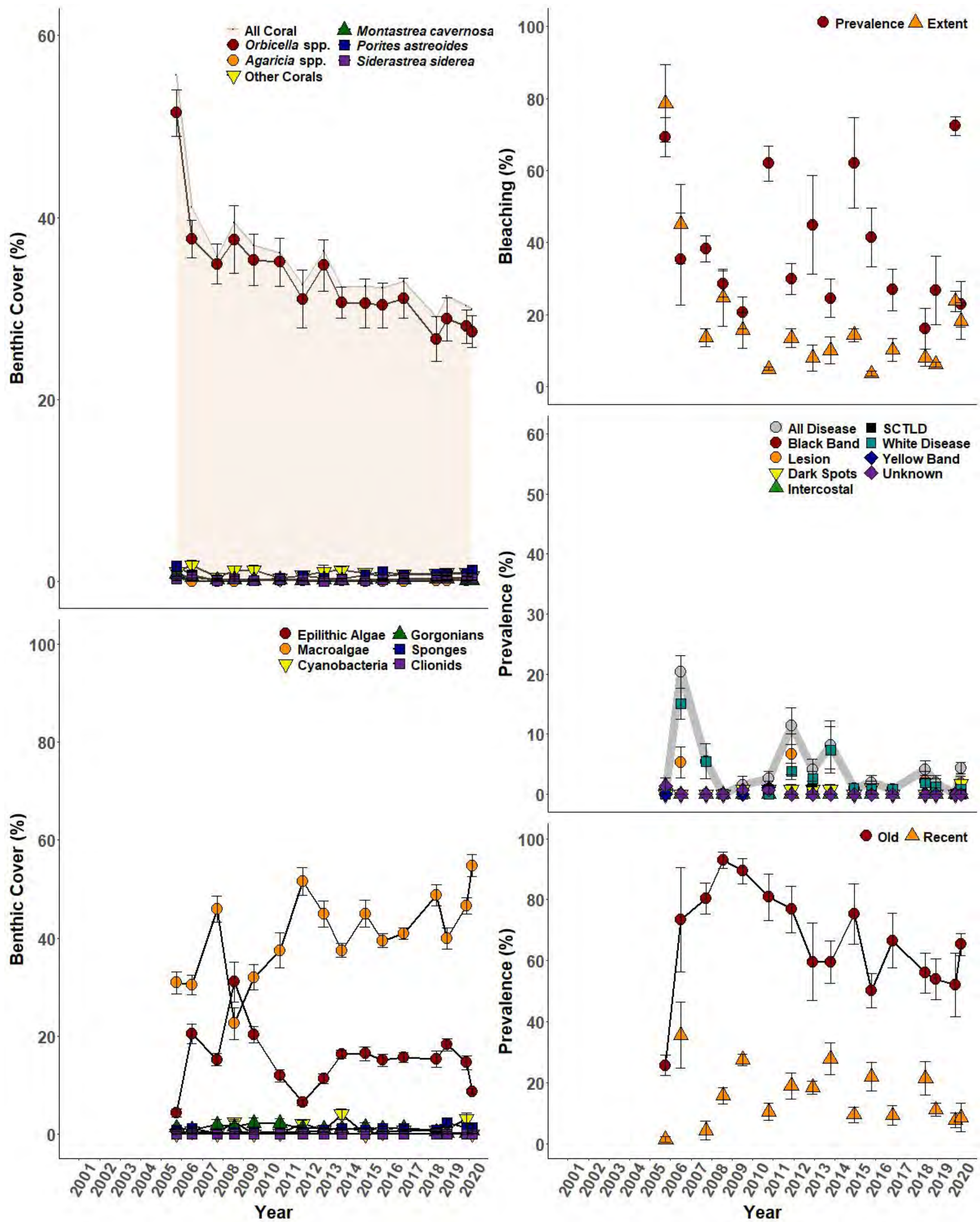


Figure 93. Meri Shoal benthic cover and coral health through time (mean ± SE).

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 durgeon, 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.

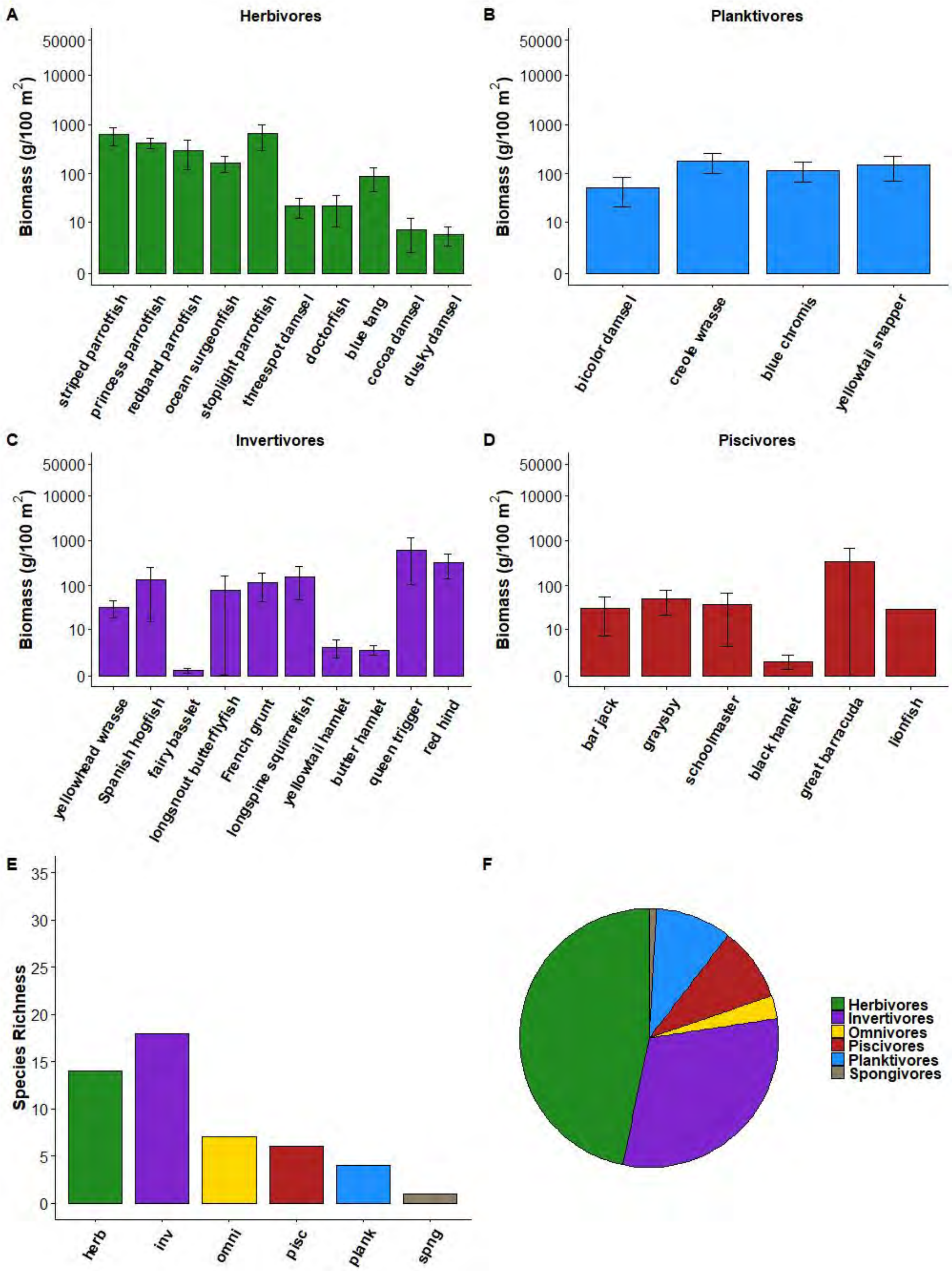
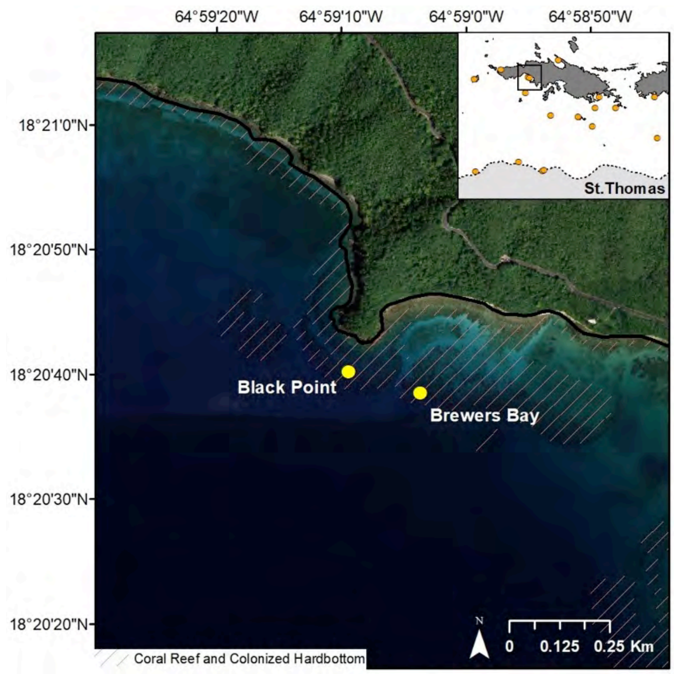


Figure 94. The Meri Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

St. Thomas

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

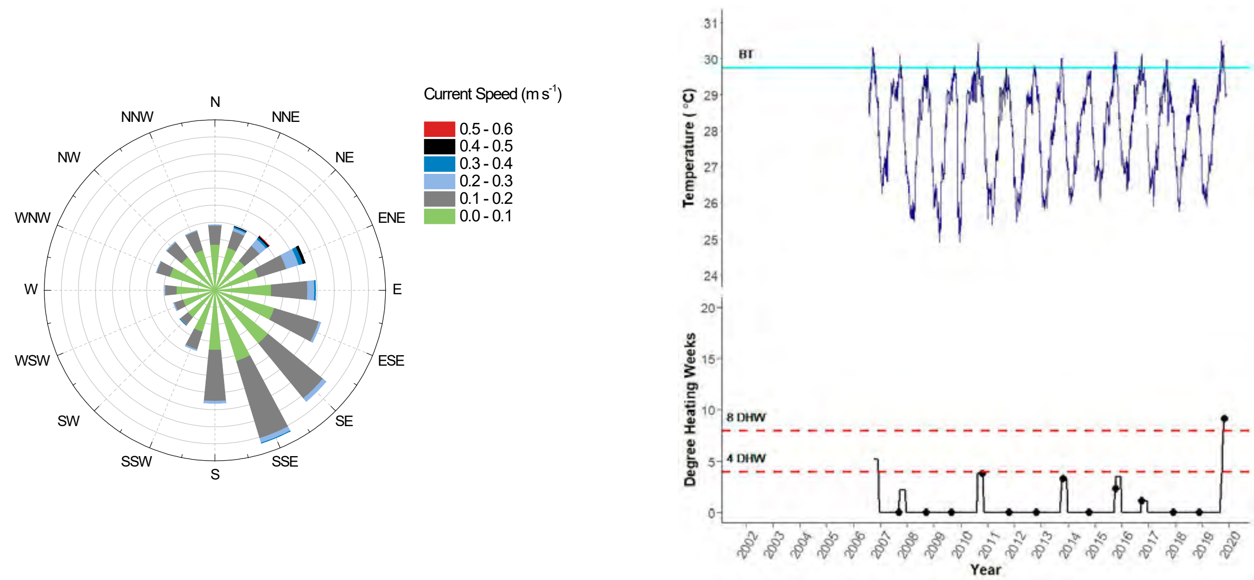


Figure 96. Black point current speed and benthic temperature record (8 m depth).

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.

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

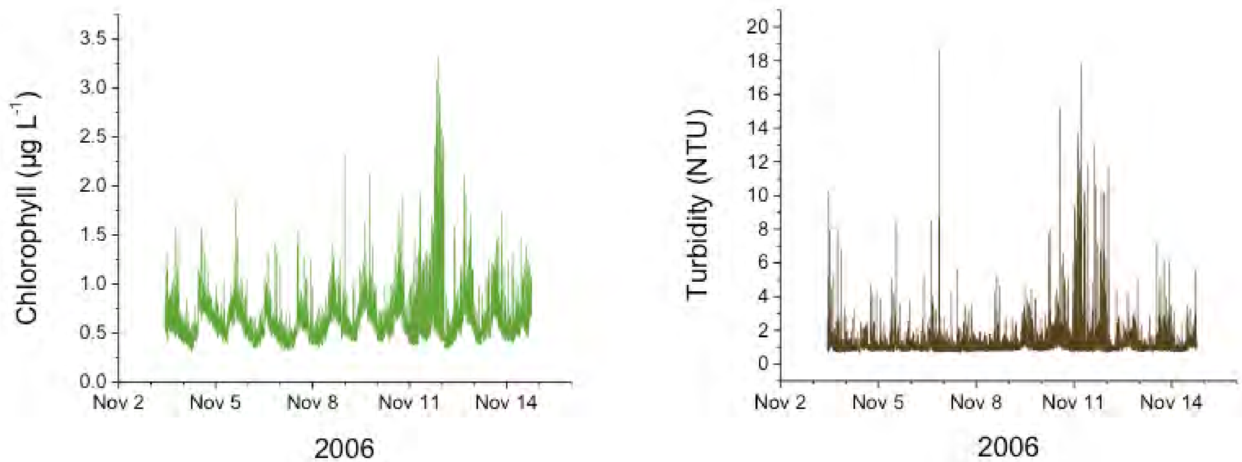


Figure 97. Black Point chlorophyll (left) and turbidity (right) record (16 m depth).

SITE SUMMARIES

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 had already caused about a 30% decline in coral cover. 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.

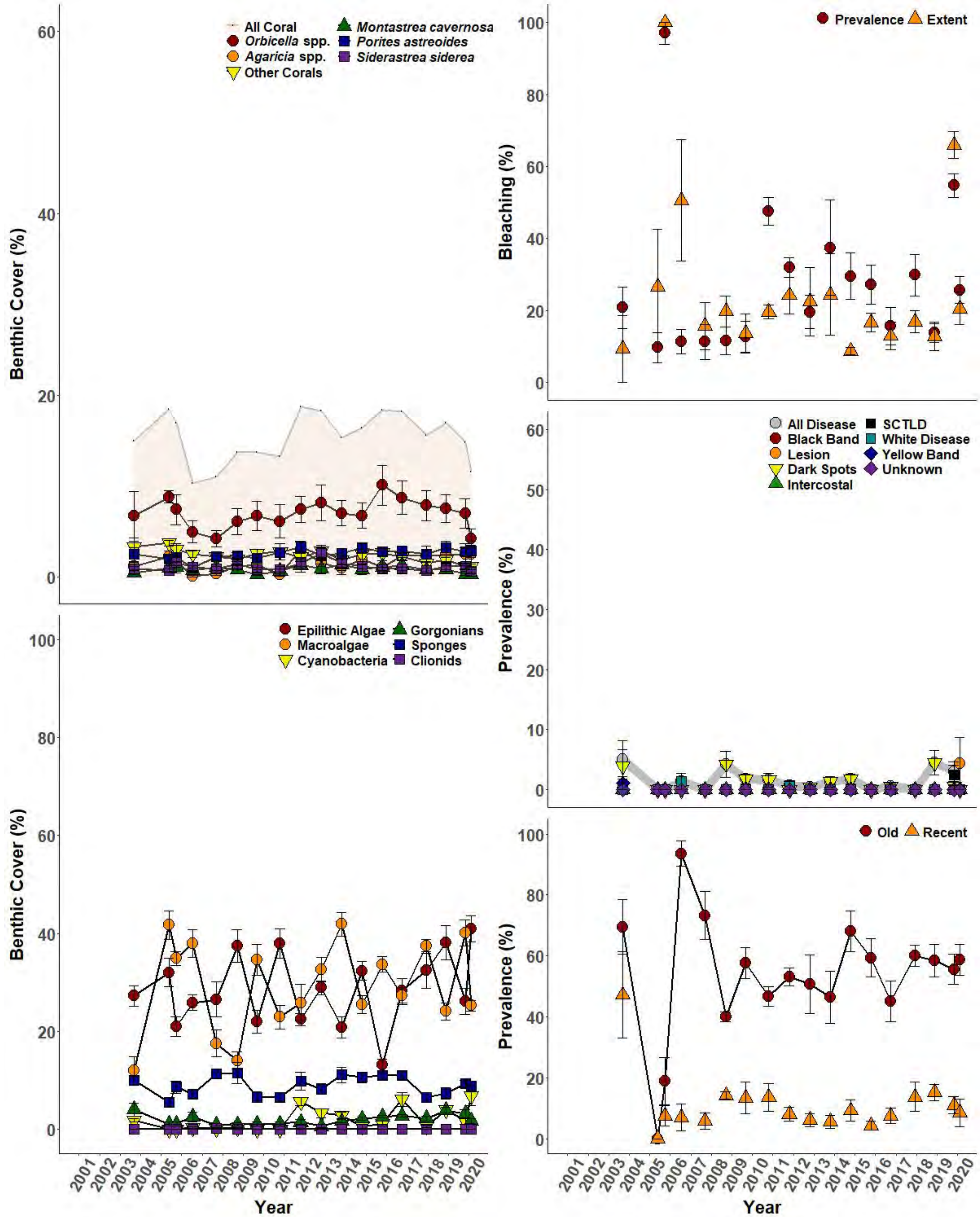


Figure 98. Black Point benthic cover and coral health through time (mean ± SE).

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 in to 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.

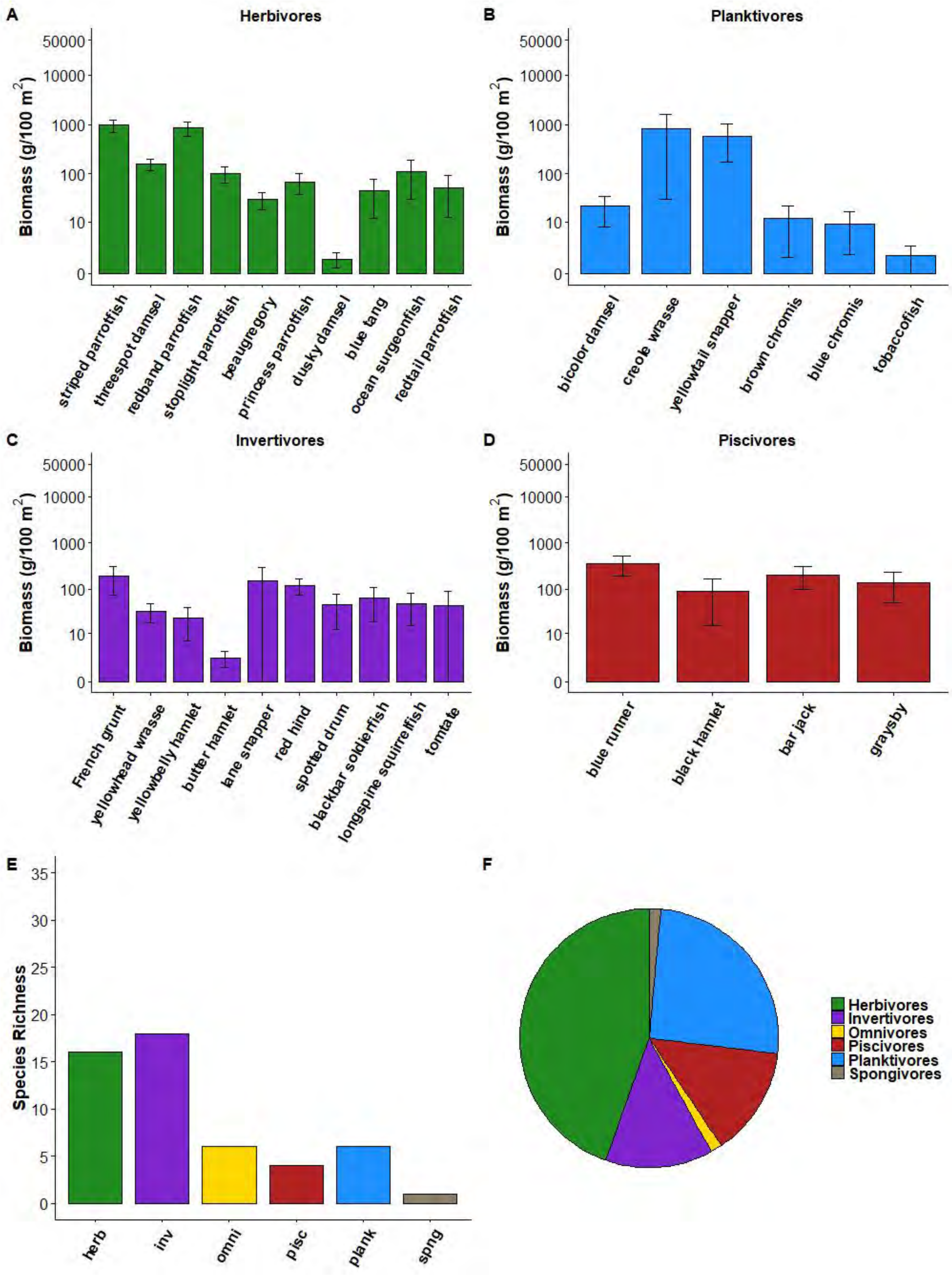
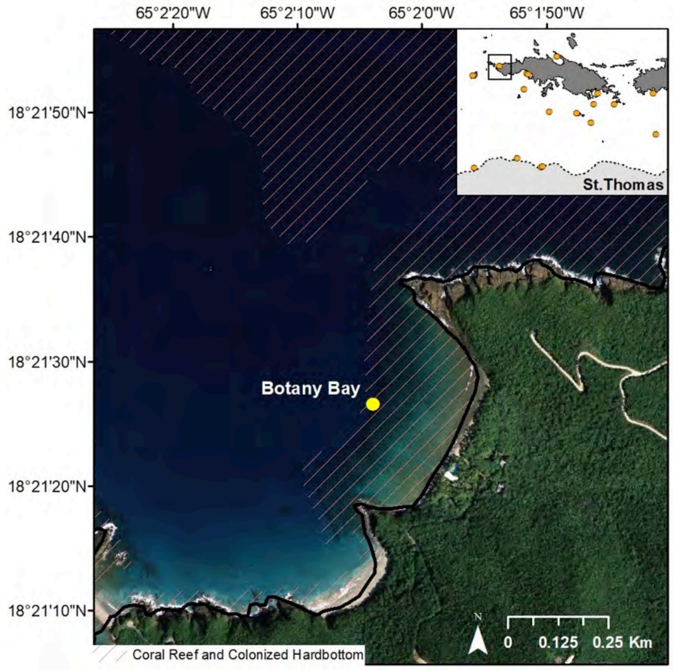


Figure 99. The Black Point fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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.

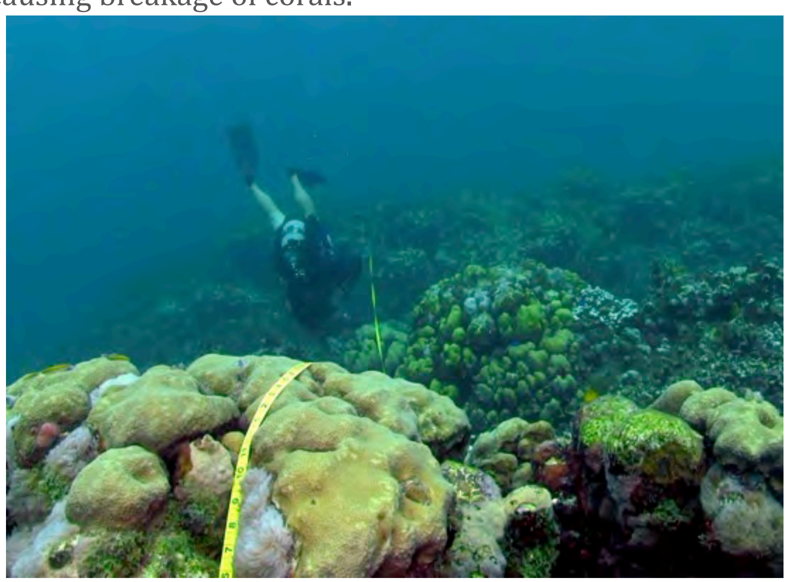


Figure 100. Botany Bay. (top) Location. (right) A representative photo of the reef.

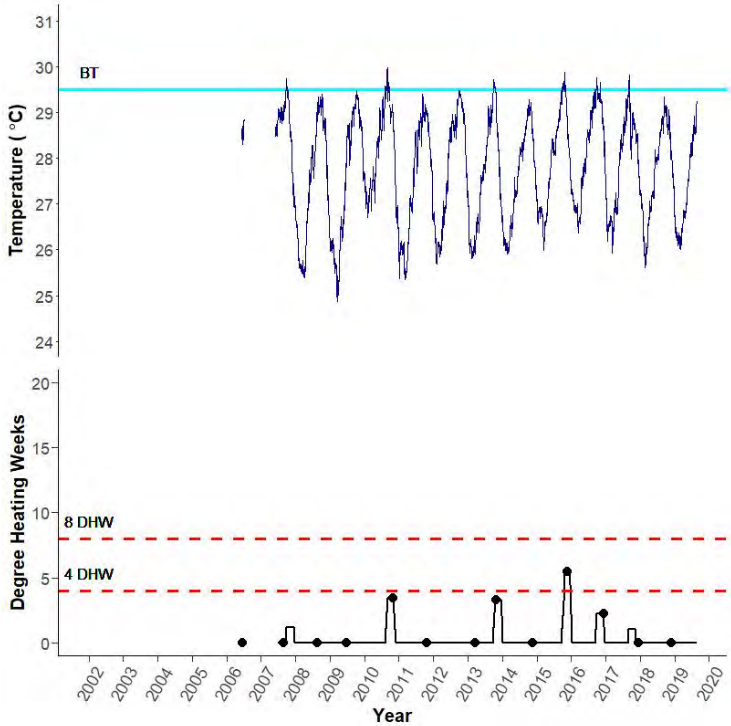


Figure 101. Botany Bay benthic temperature record (11 m depth).

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.

Figure 102. A large colony of pillar coral (*Dendrogyra cylindricus*) dislodge, toppled, and diseased after the 2009 swell event (Botany Bay, June 25, 2009).

SITE SUMMARIES

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, 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. 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 and in 2010 at a low extent. Even though not indicated by records of thermal stress, the site showed 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. 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).

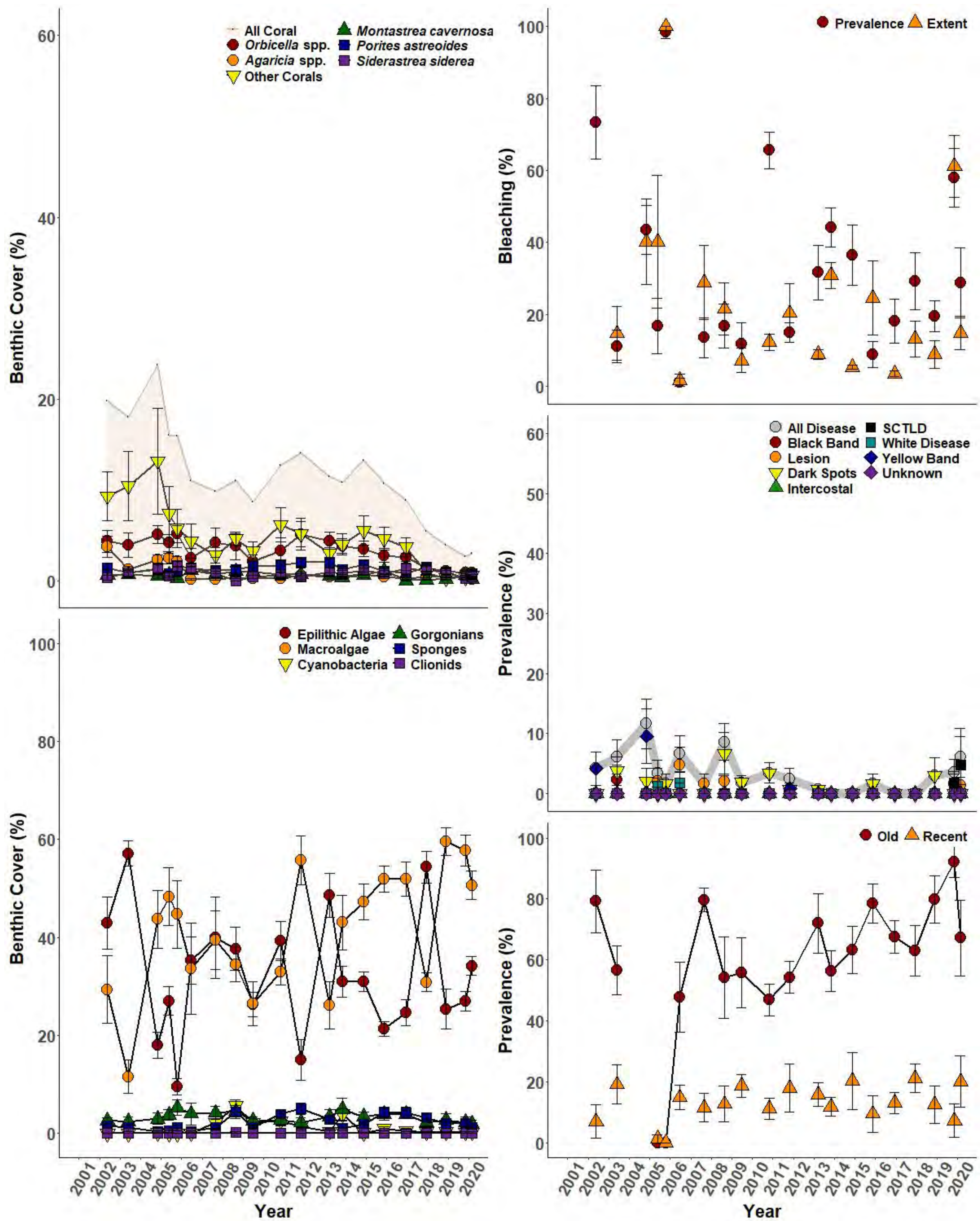


Figure 103. Botany Bay benthic cover and coral health through time (mean ± SE).

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, a 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. Similar to most of the nearshore reefs in the northern USVI's, large jacks and mackerels are nearly absent from the site.

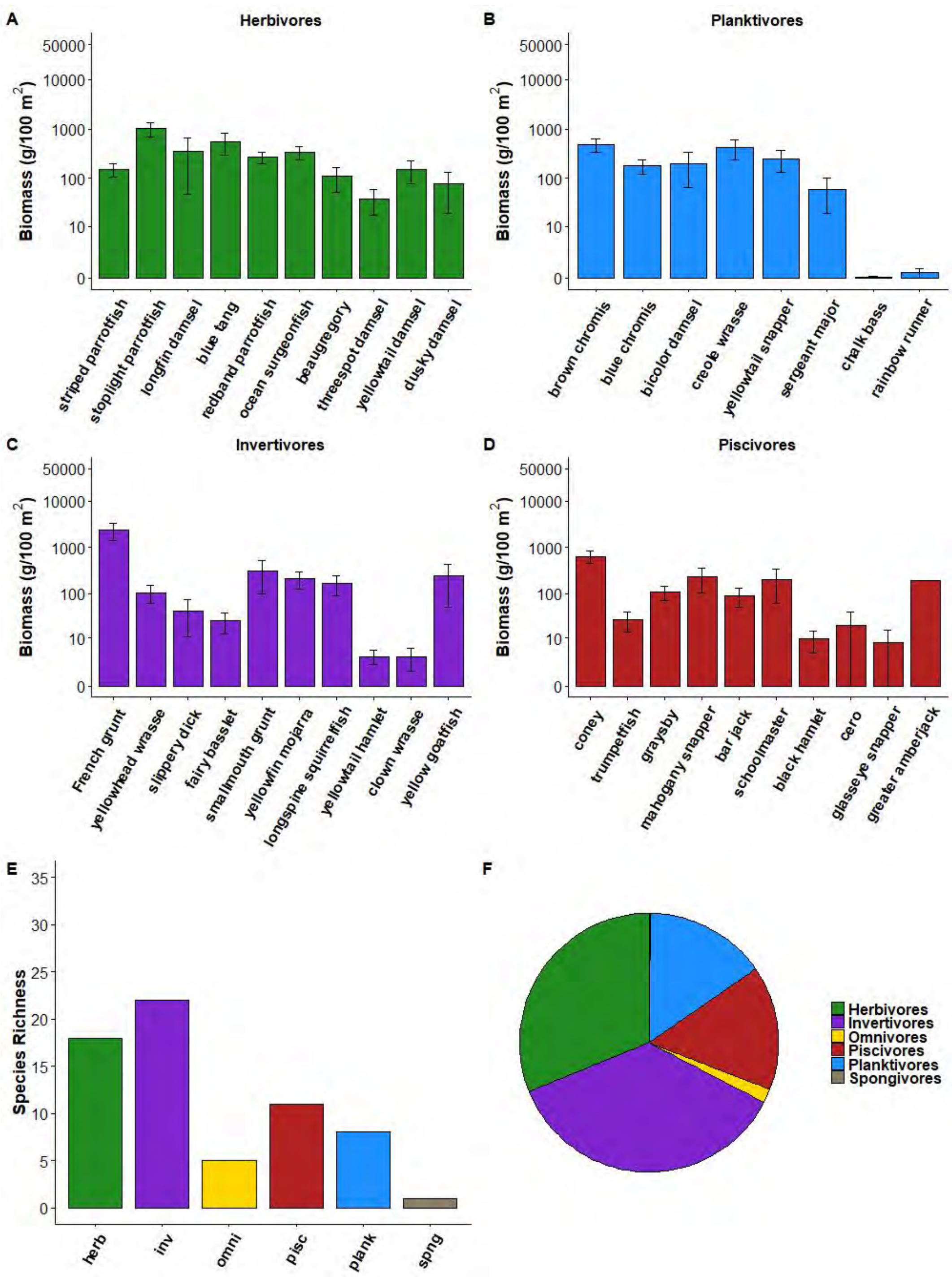
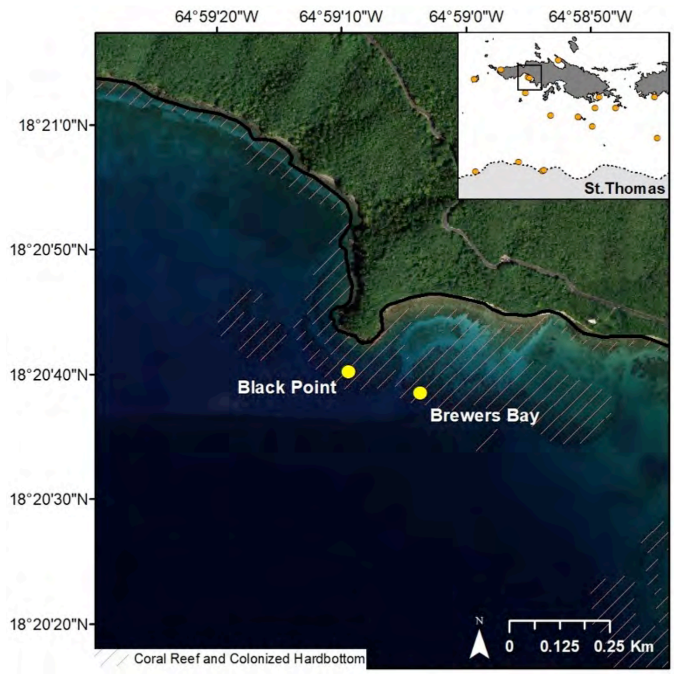


Figure 104. The Botany Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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 and overgrowth by heterotrophic organisms, such as sponges. 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.

Figure 105. Brewers Bay. (top) Location. (right) A representative photo of the reef.

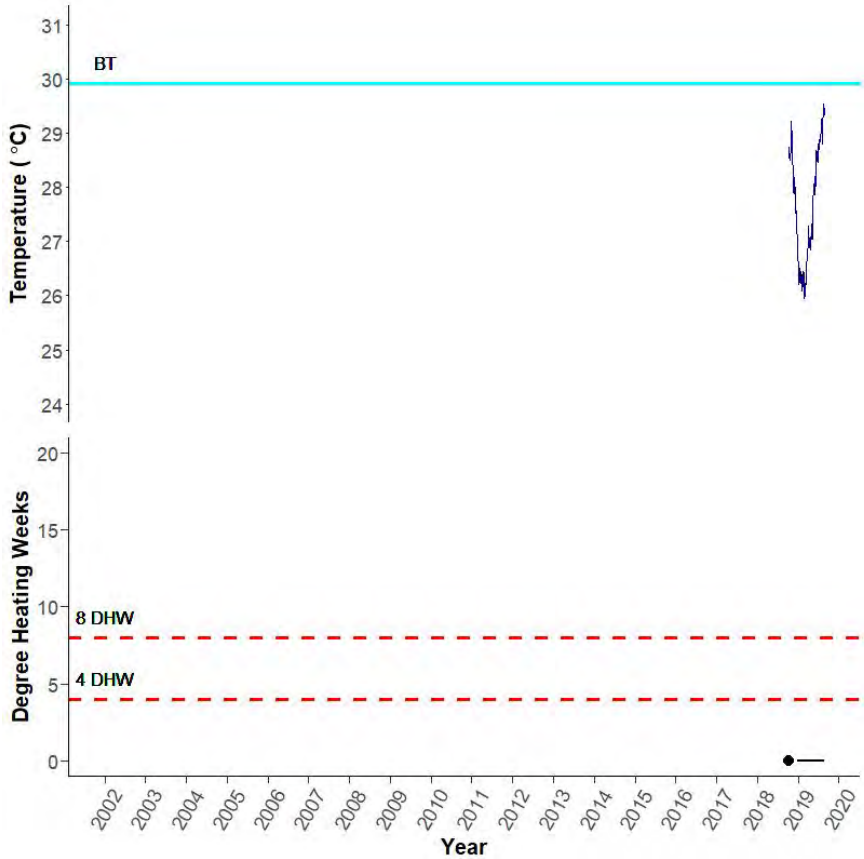


Figure 106. Brewers Bay benthic temperature record (8 m depth).

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 have not been recorded directly, but see the Black Point temperature data from less than 300 m horizontal distance. The site has restricted flow and should develop high warm season temperatures.

SITE SUMMARIES

Benthic Community. The Brewers Bay site is highly dominated by the boulder coral *Orbicella annularis* and exhibits 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. SCTLD arrived at Brewers in 2019 and has already caused a catastrophic decline in coral cover from 30% in 2018 to 9.8% by February 2020. 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 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).

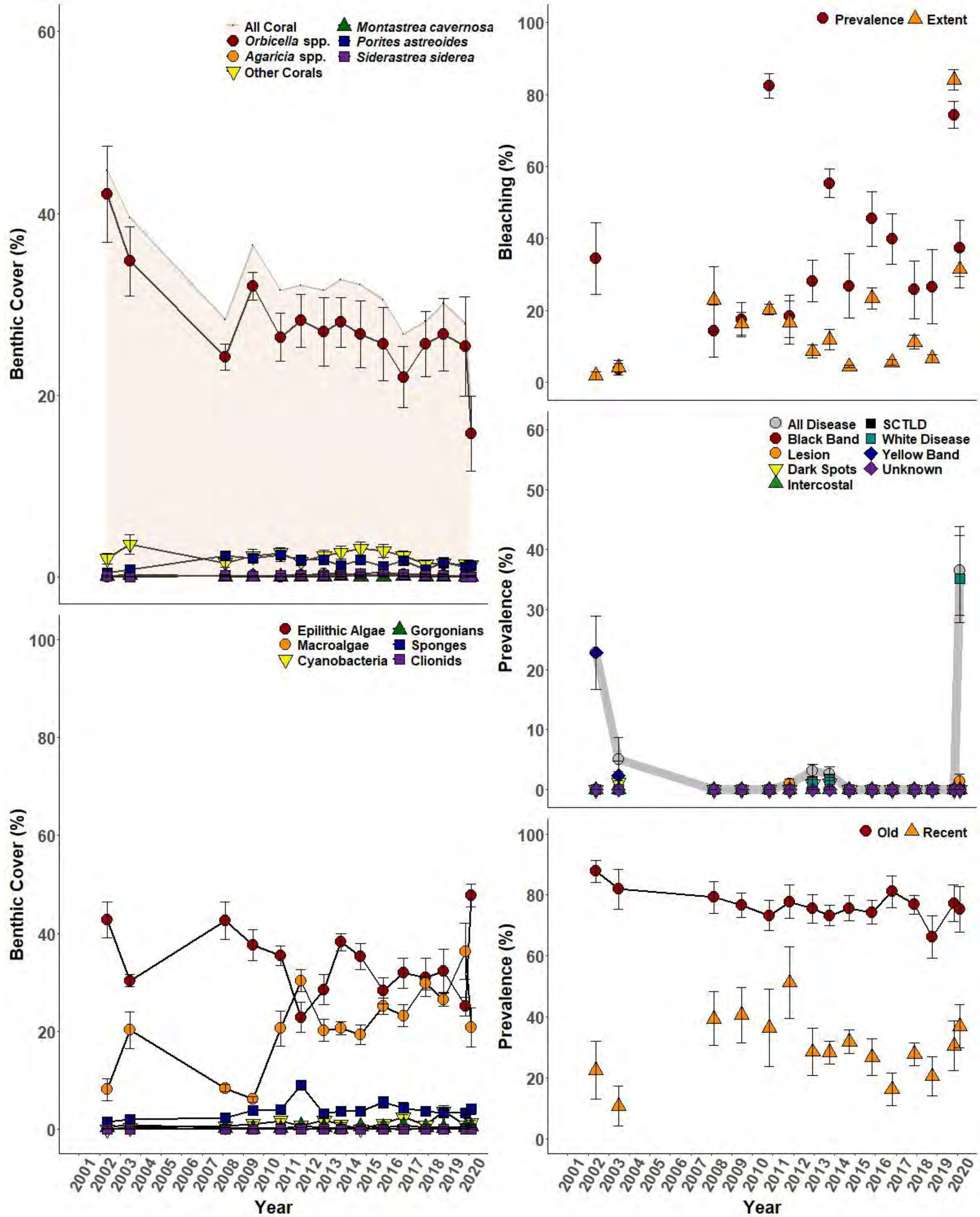


Figure 107. Brewers Bay benthic cover and coral health through time (mean ± SE).

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.

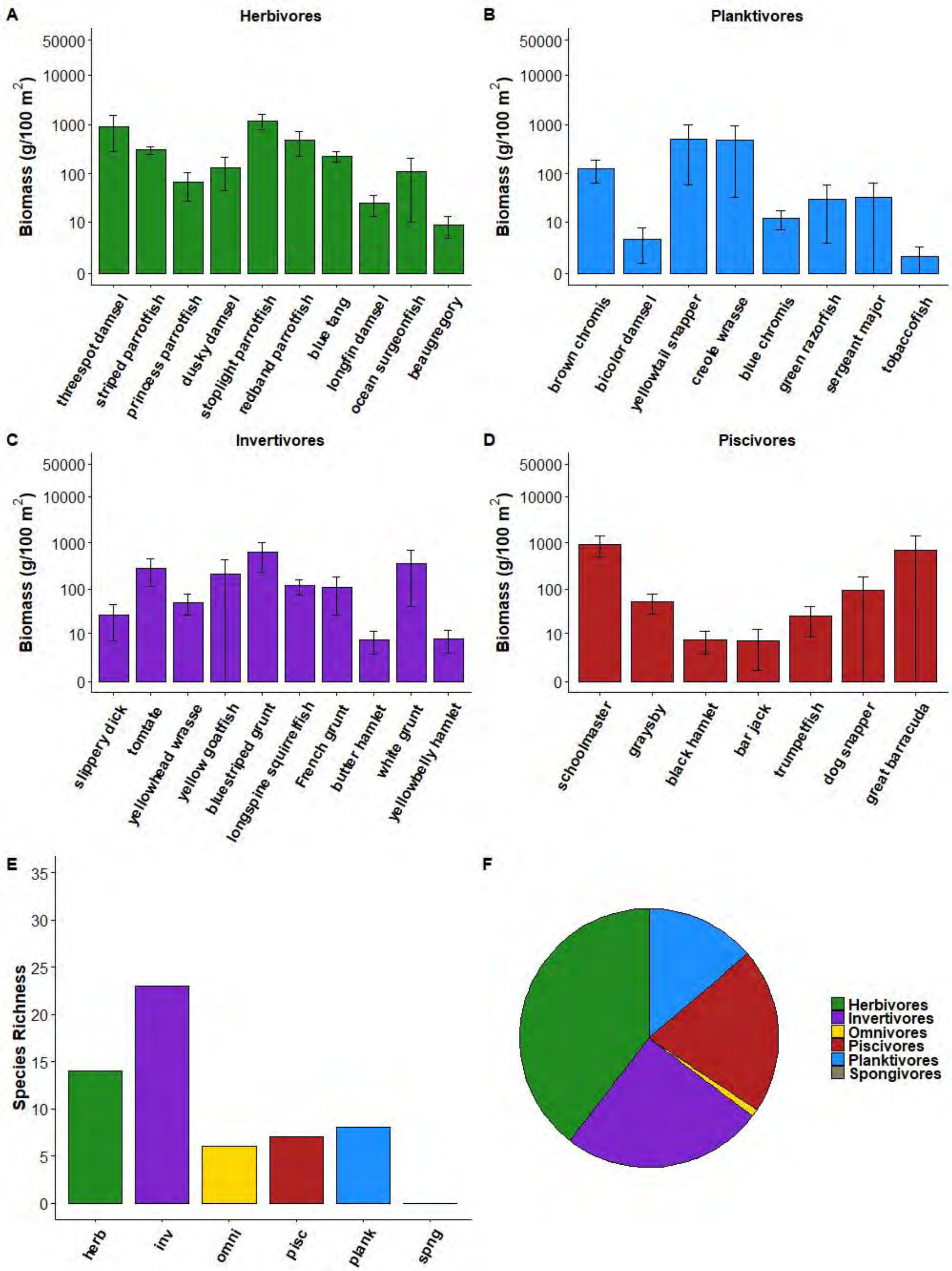
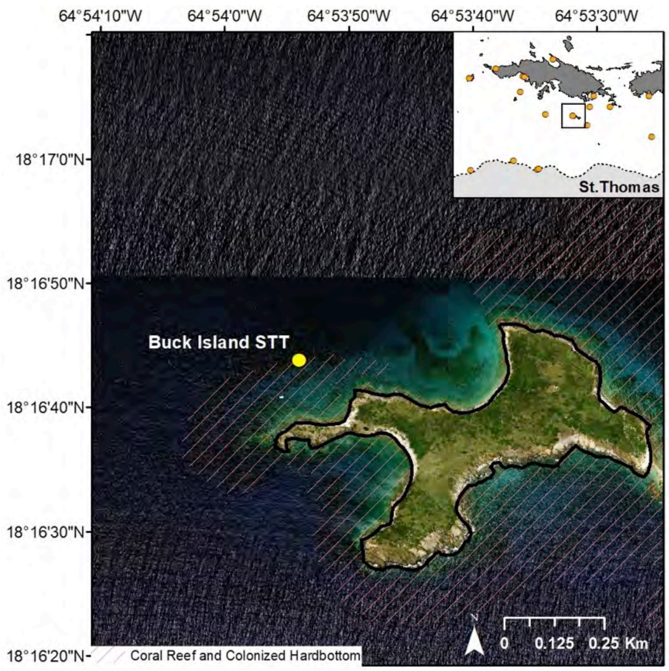


Figure 108. The Brewers Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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

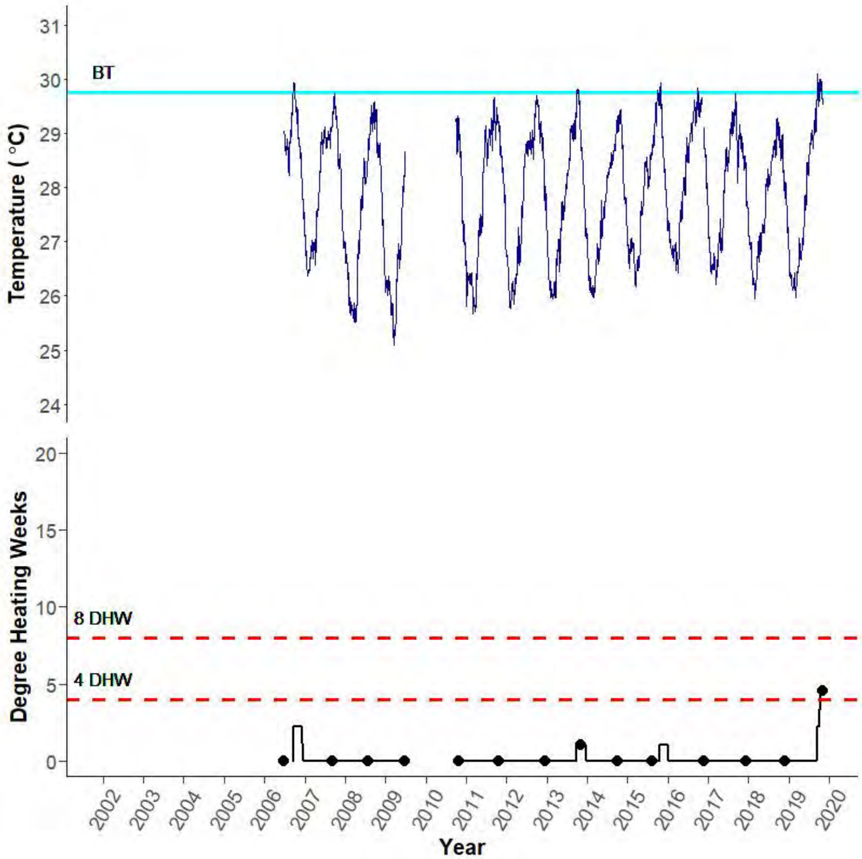


Figure 110. Buck Island, St. Thomas benthic temperature record (12 m depth).

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.

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 SCTLD 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 and largely the result of increases in *Dictyota*. *Ramicrusta* spp. is also a very significant space occupier on the upper slope just south of the site, but is largely absent from the TCRMP transects. 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. In 2019 SCTLD reached the monitoring site. Old partial mortality increased rapidly after the 2005 bleaching event and then declined steadily in following years.

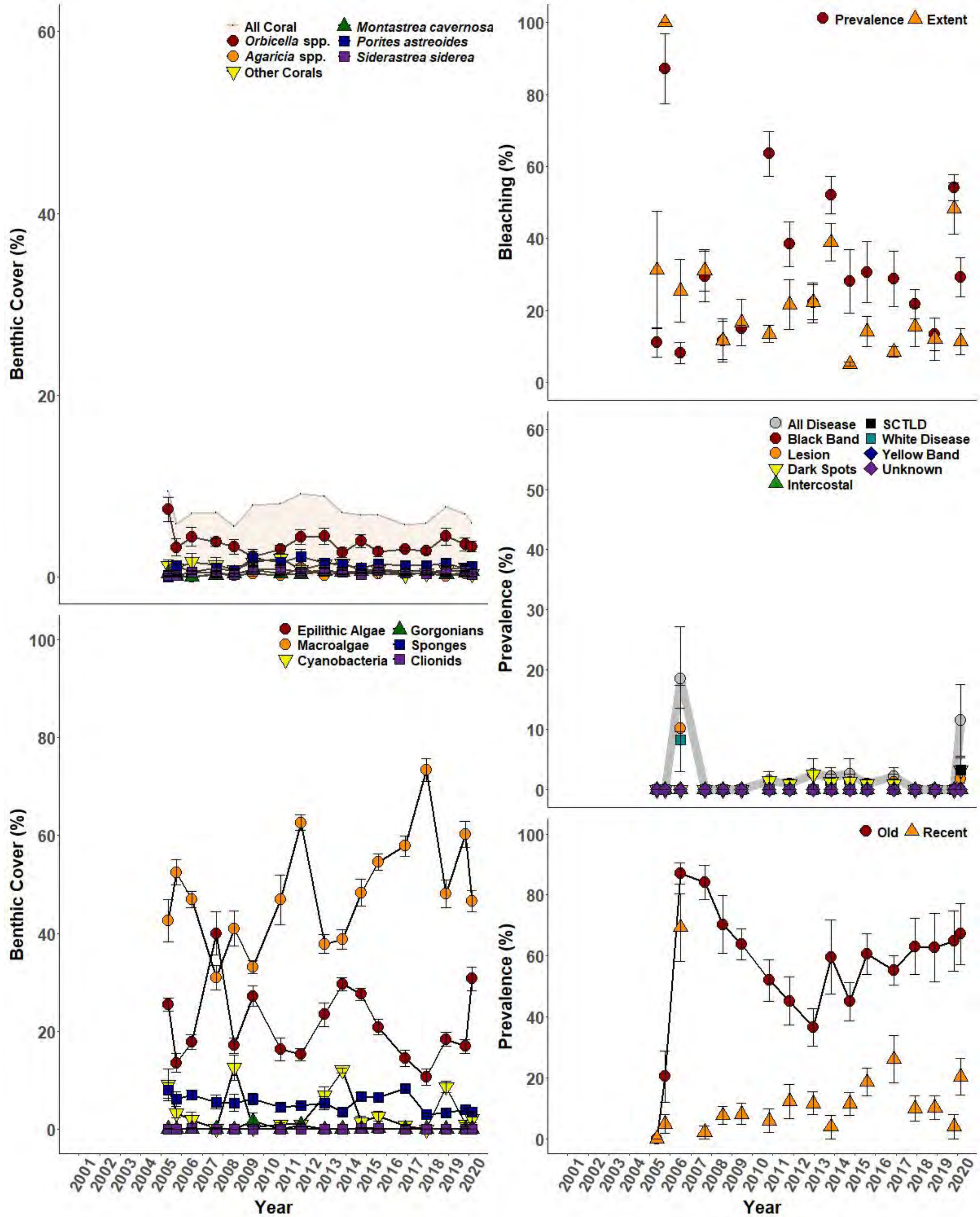


Figure 111. Buck Island, St. Thomas benthic cover and coral health through time (mean ± SE).

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. It is also a very heavily dove SCUBA and snorkel site.

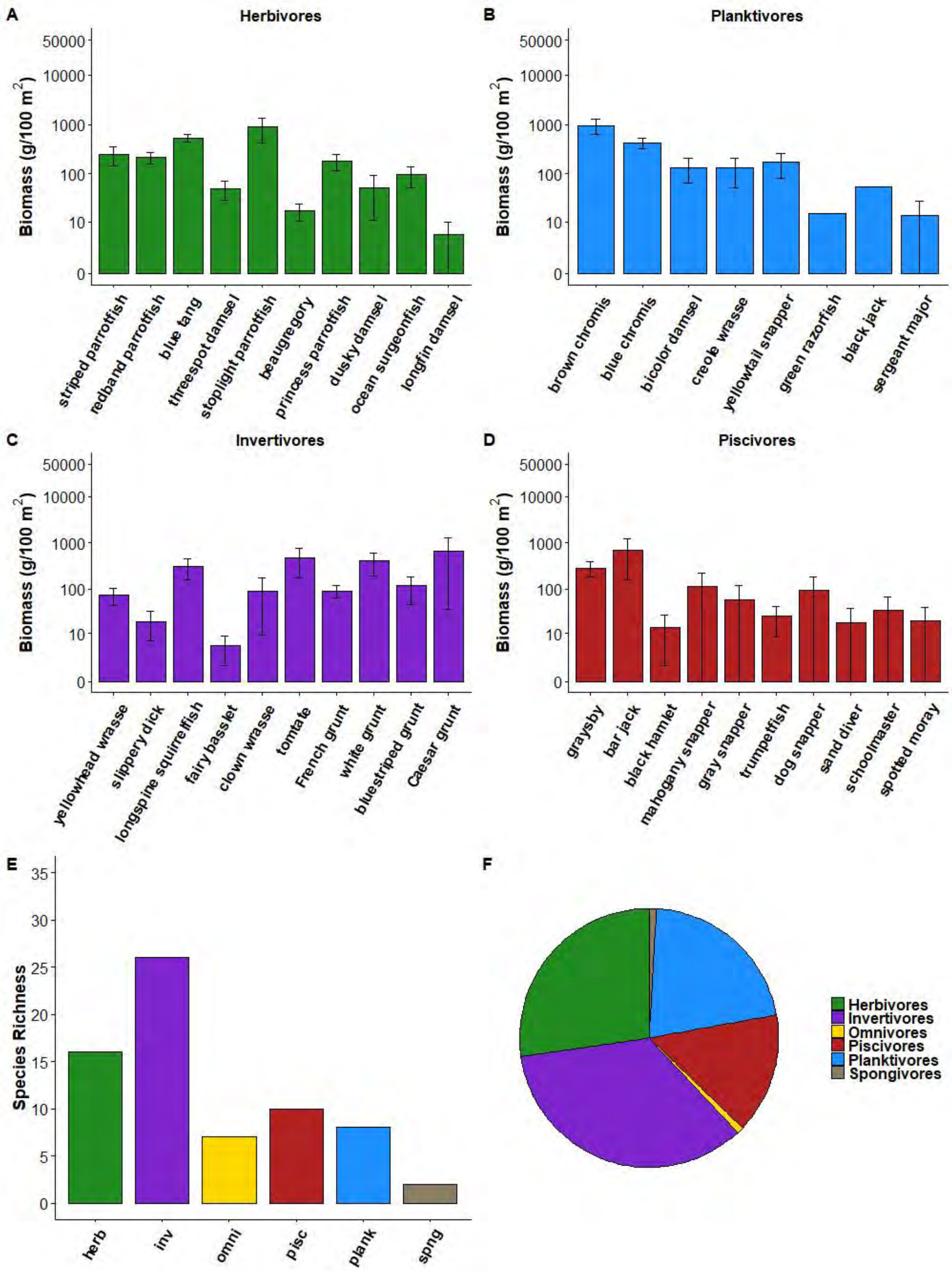
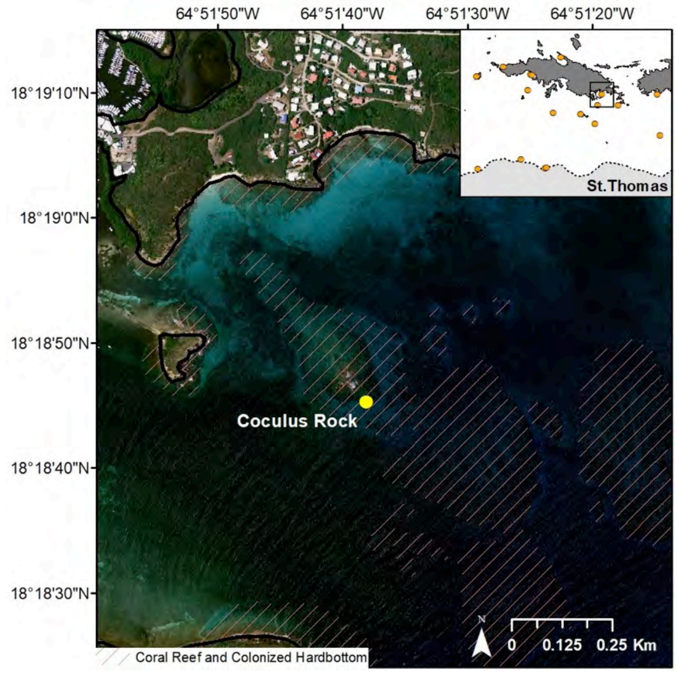


Figure 112. The Buck Island, St. Thomas fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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 located in the St. Thomas East End Reserve and is closed to taking of reef fishes. The site supports a fish spawning aggregation of redfin parrotfish (*Sparisoma rubripinne*). These 100+ fish engage in daily afternoon mating at southeast reef corner. A ciguatera study with monthly sampling has been ongoing since 2009.

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 113. Coculus Rock. (top) Location. (right) A representative photo of the reef showing the aggregation of redfin parrotfish.

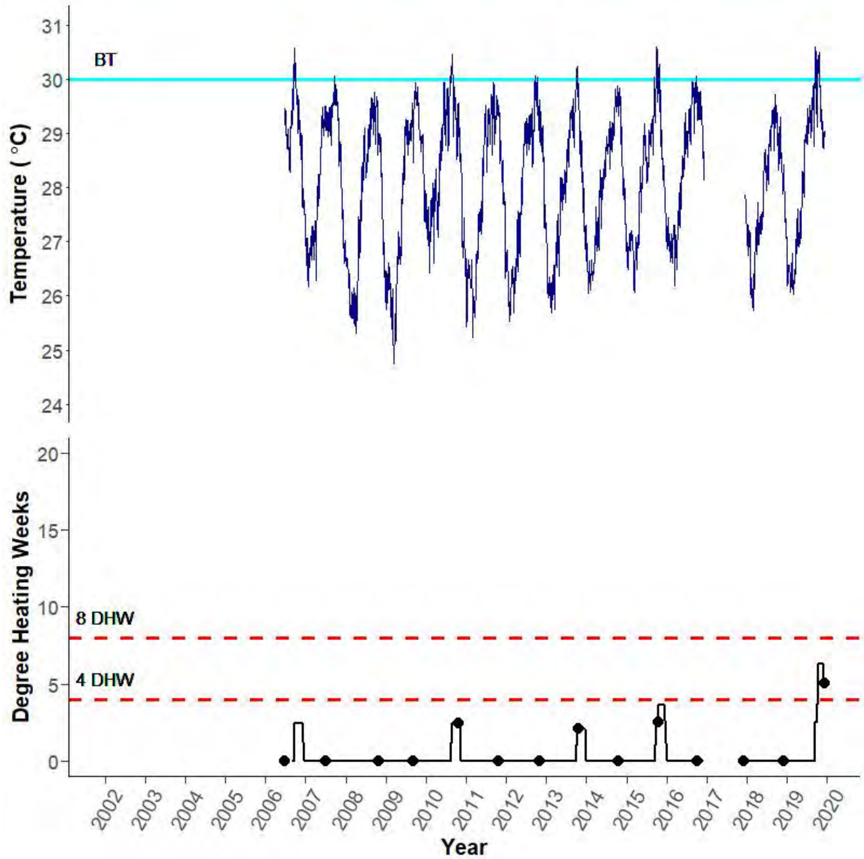


Figure 114. Coculus Rock benthic temperature record (7 m depth).

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.

SITE SUMMARIES

Benthic Community. The Coculus 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. 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 Coculus 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 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 had not reached the site by 2019. 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.

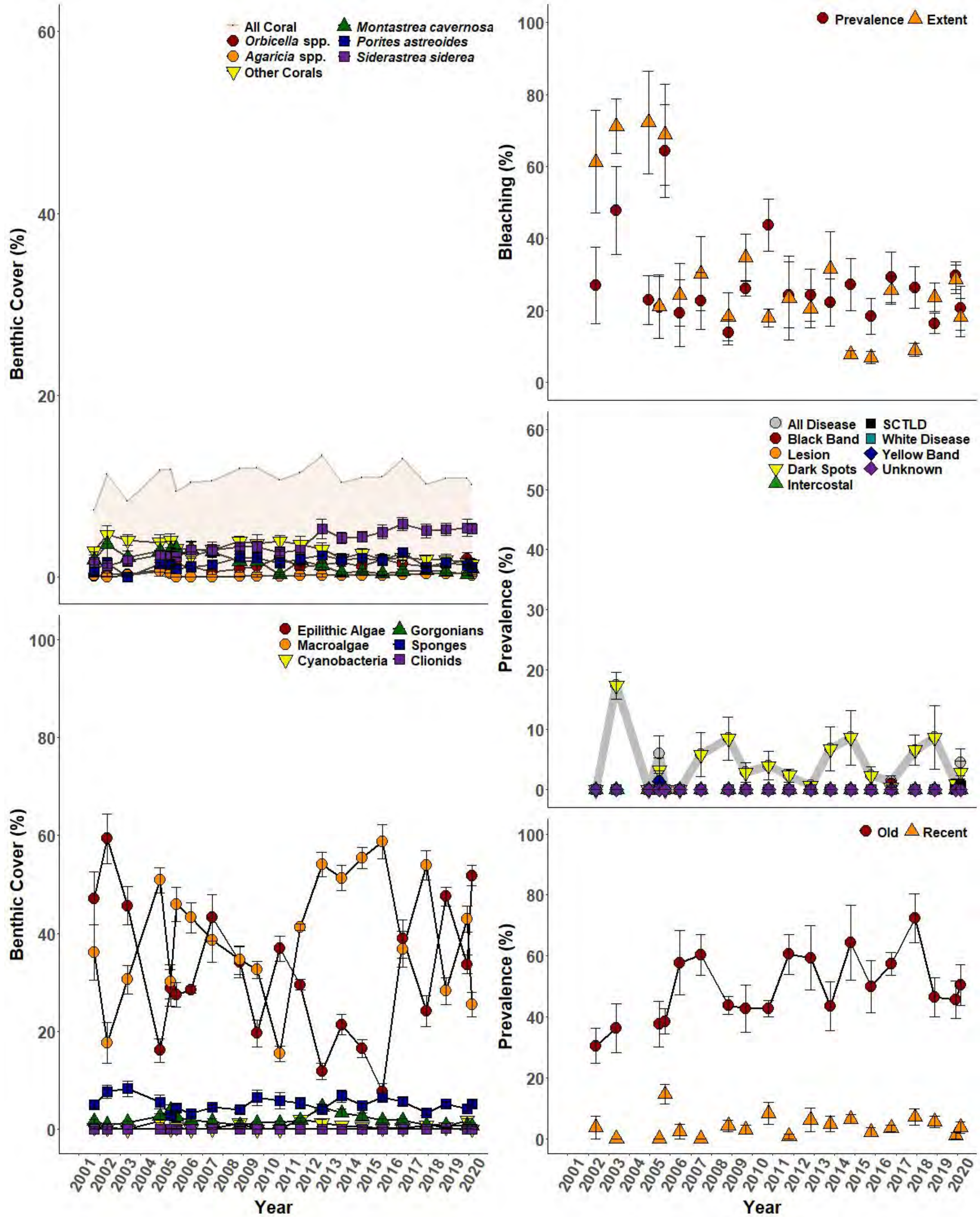


Figure 115. Coculus Rock benthic cover and coral health through time (mean ± SE).

Fish Community. The Coculus 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 Coculus 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 are made up of juvenile grunts and a variety of small wrasses. Coculus Rock is part of the territorial Saint Thomas East End Reserve (STEER) and fishes are protected from all harvest year-round.

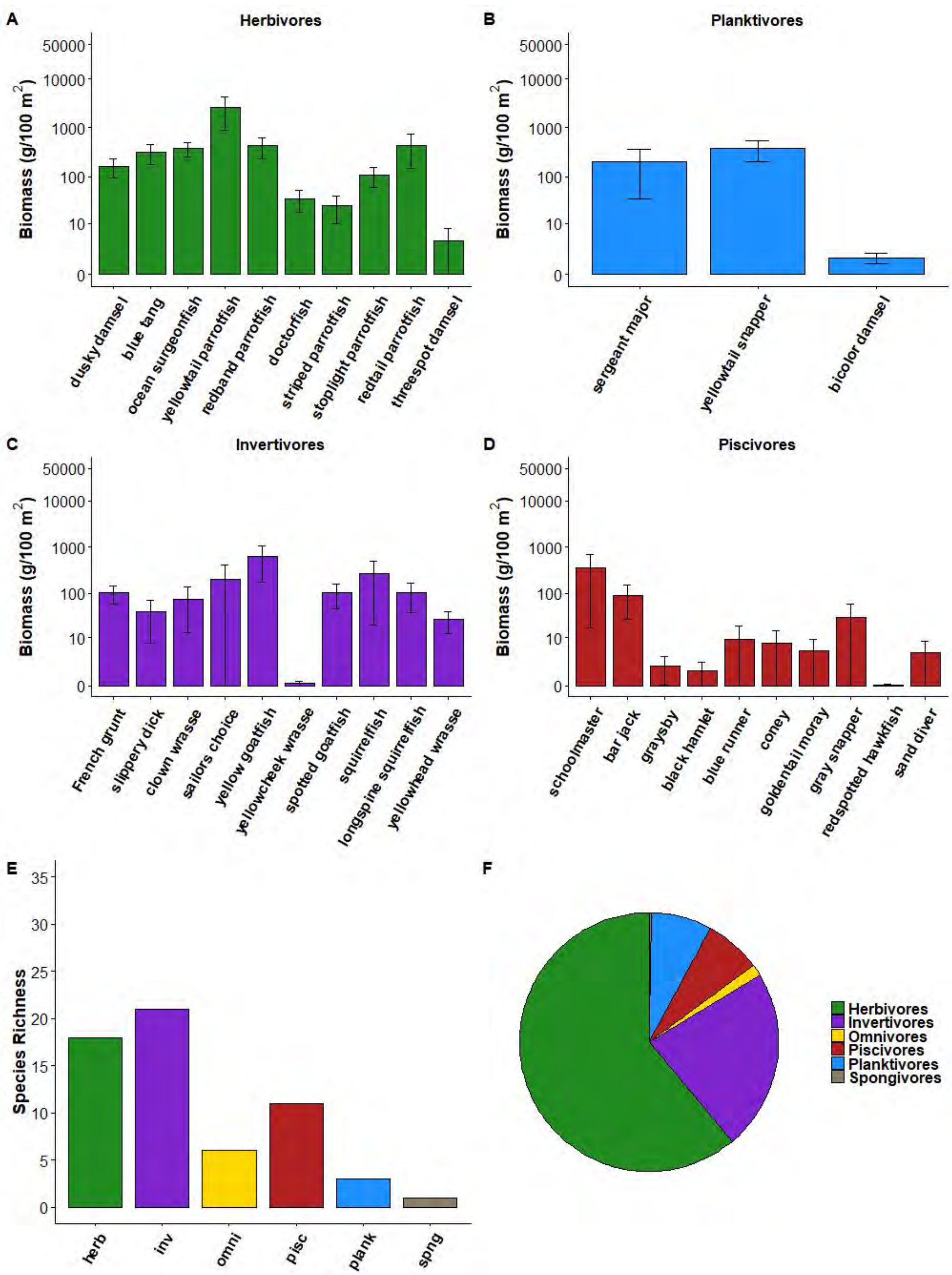
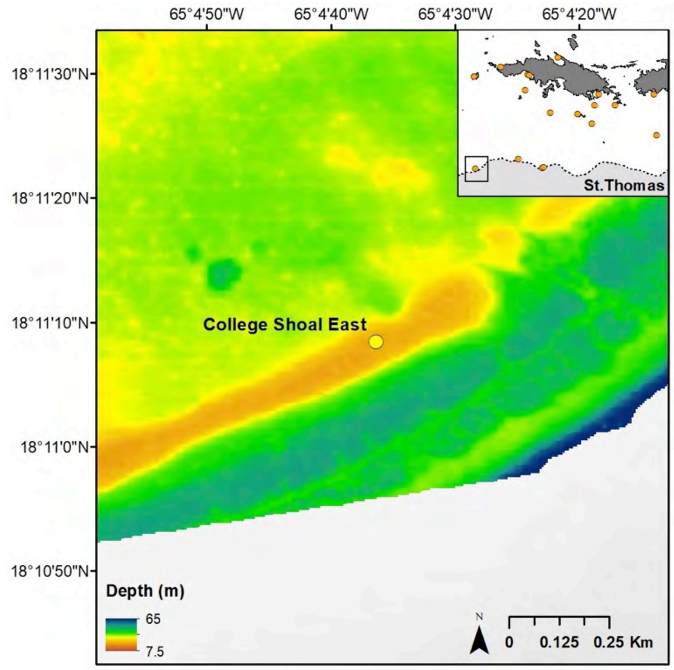


Figure 116. The Coculus Rock fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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), 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 relatively pristine condition, 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 117. College Shoal. (top) Location. (right) A representative photo of the reef (photo credit: V. W. Brandtneris).

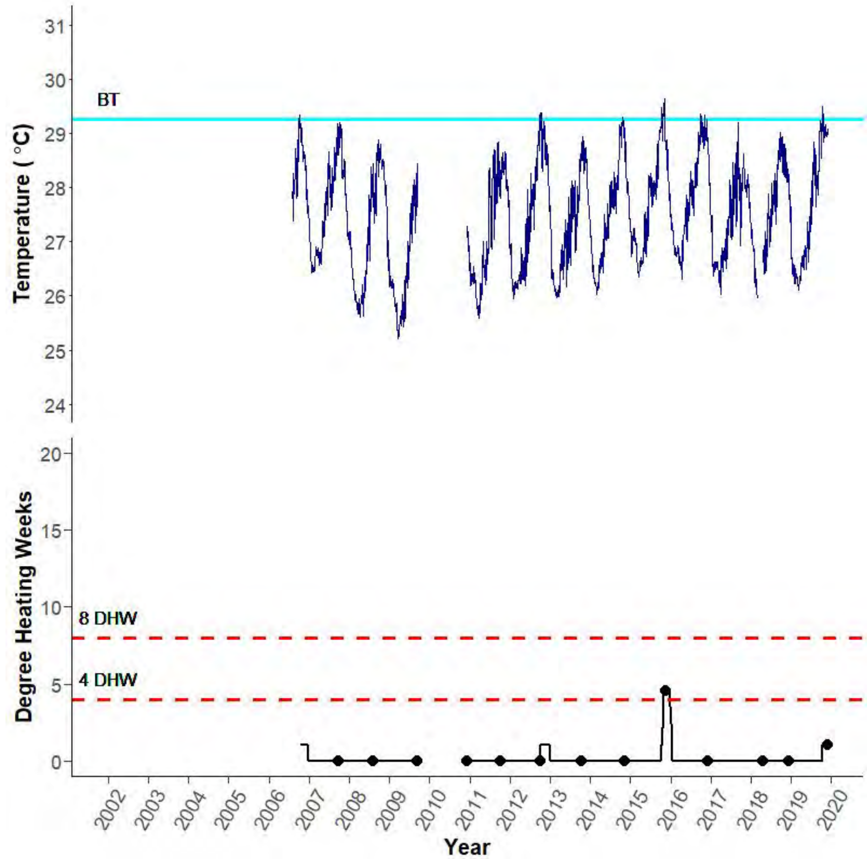


Figure 118. College Shoal benthic temperature record (29 m depth).

Physical Characteristics.

Currents. Although not measured directly, 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 where missed at this site.

SITE SUMMARIES

Benthic Community. College Shoal is among the TCRMP sites with the highest coral cover (38.2% in 2011) and, similar to 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 (-1.3%); however, these estimates have some additional error since transects were not made permanent until 2007. SCTLD arrived at this site in 2019 and has already contributed to a decline in coral cover from 33% to 27%. 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 SCTLD were very severe in 2019, with about 25% of colonies displaying disease signs that were likely related. 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.

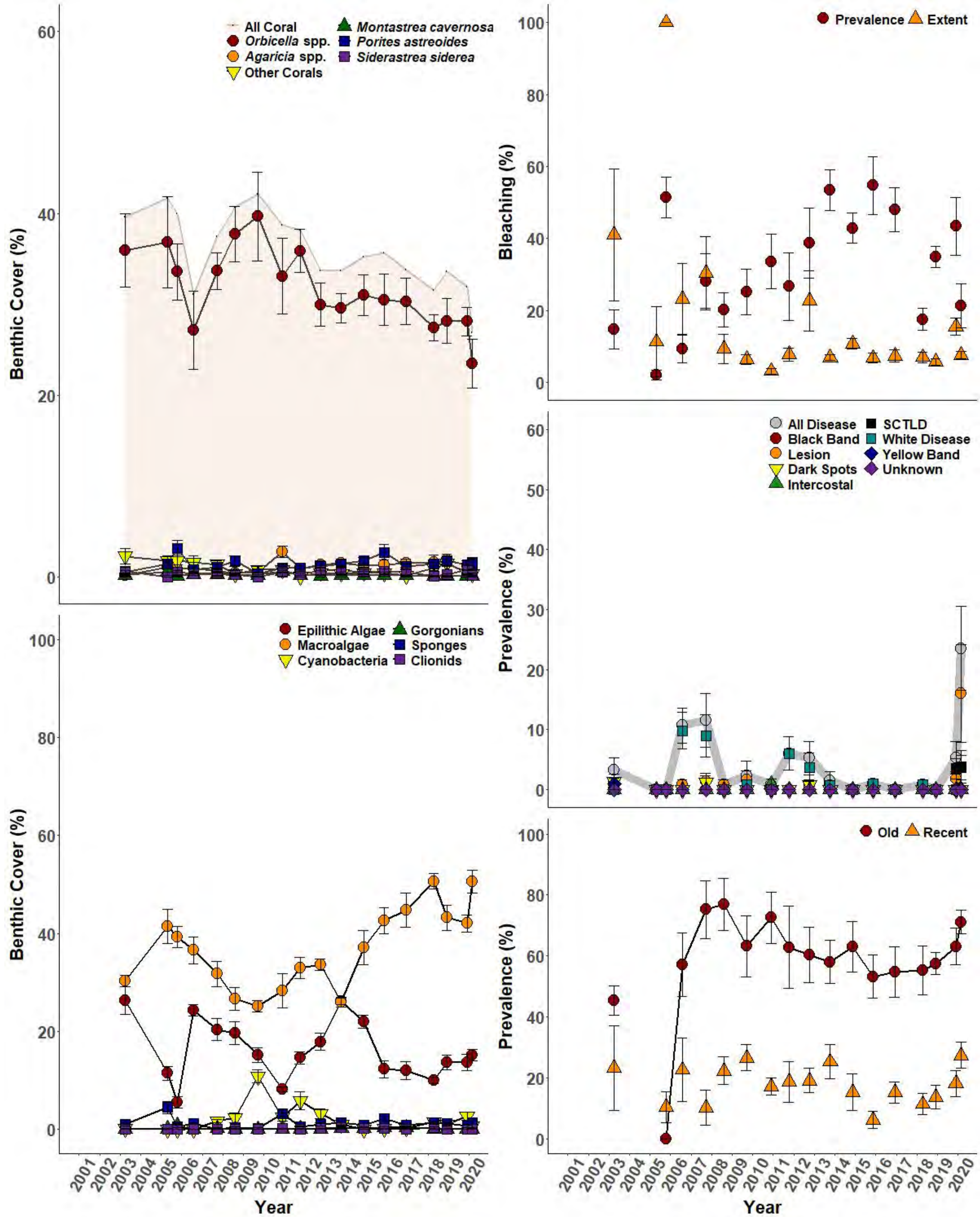


Figure 119. College Shoal benthic cover and coral health through time (mean ±SE).

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.

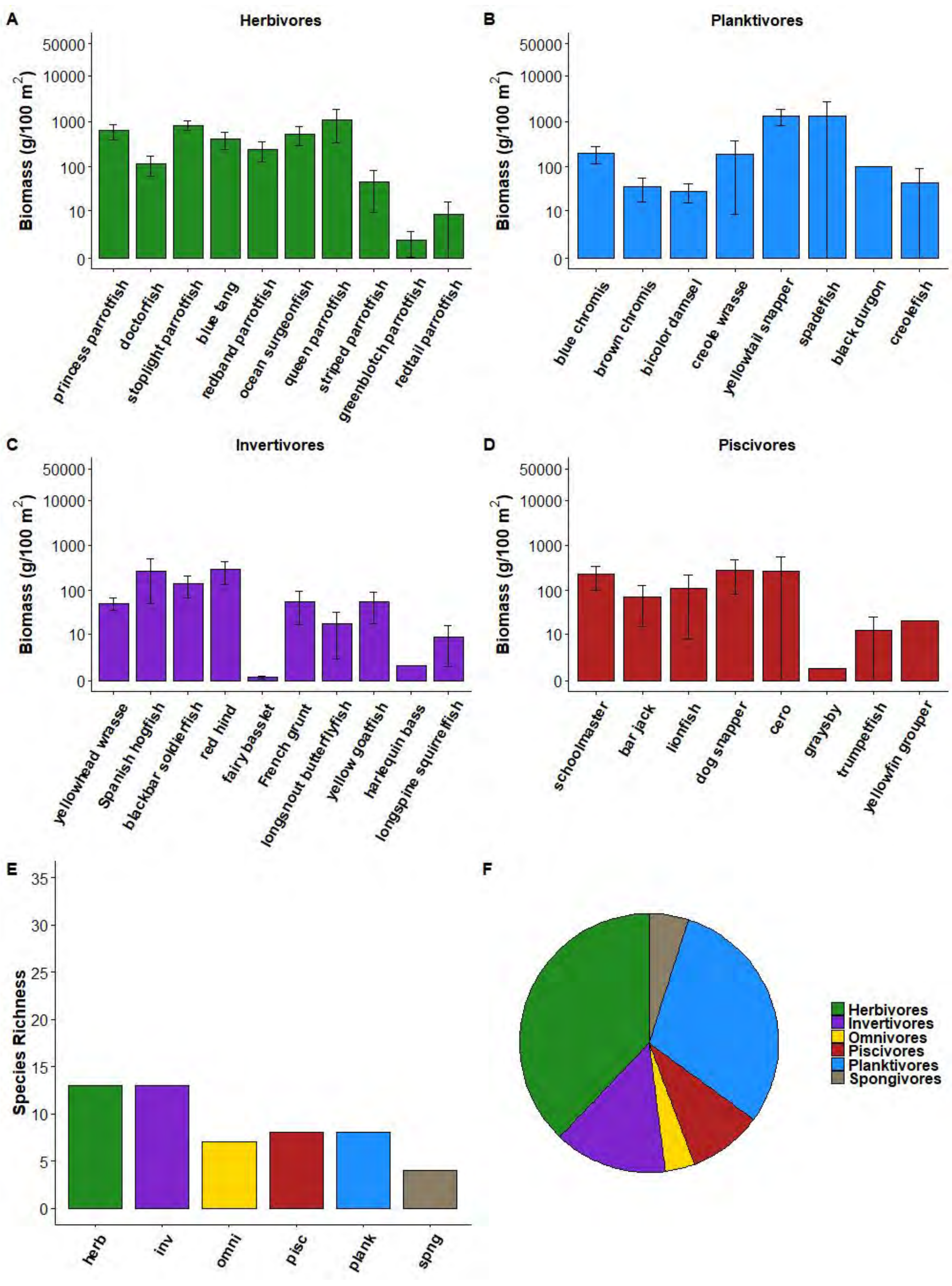
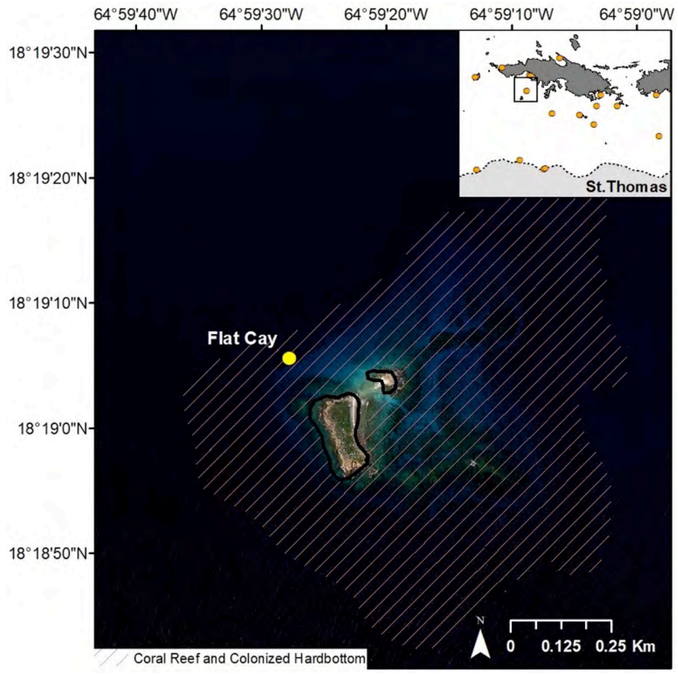


Figure 120. The College Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

FLAT CAY



Description. This monitoring site wraps around the northwest corner depths 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 sampling has been ongoing since 2009.

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.

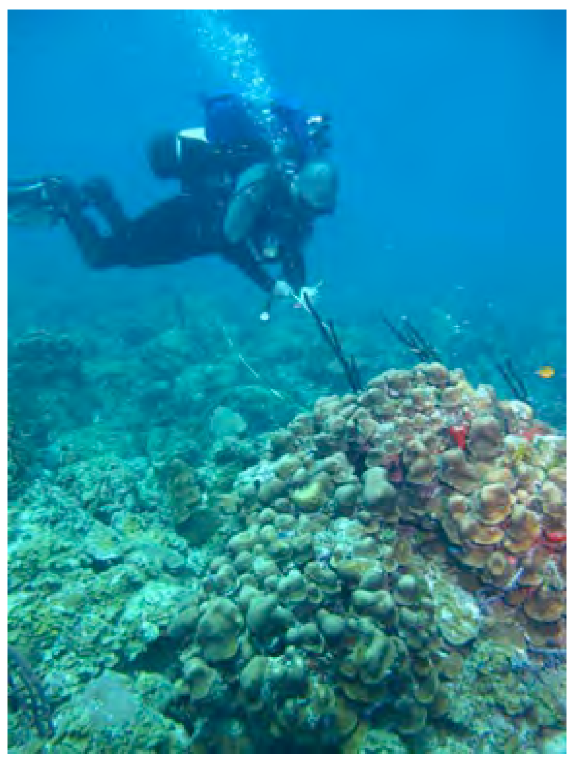


Figure 121. Flat Cay. (top) Location. (right) A representative photo of the reef.

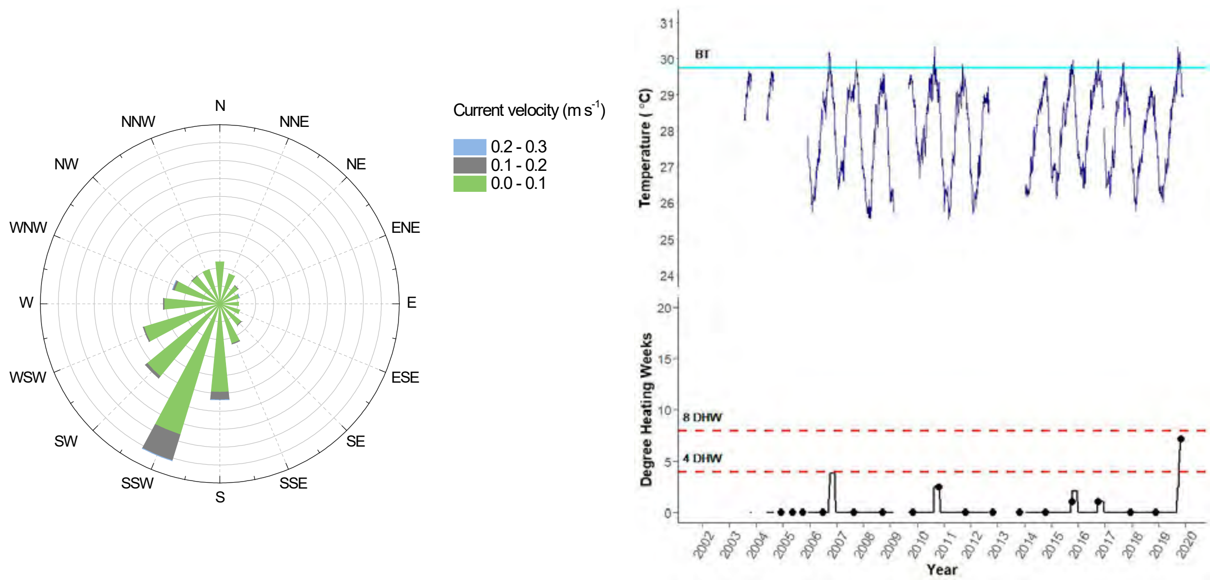


Figure 122. Flat Cay benthic current speed (left) and temperature record (right) (14 m depth).

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

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 SCTLD were catastrophic, with a decline in coral cover from 23% in 2018 to 7% in February 2020. 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 SCTLD 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. SCTLD 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.

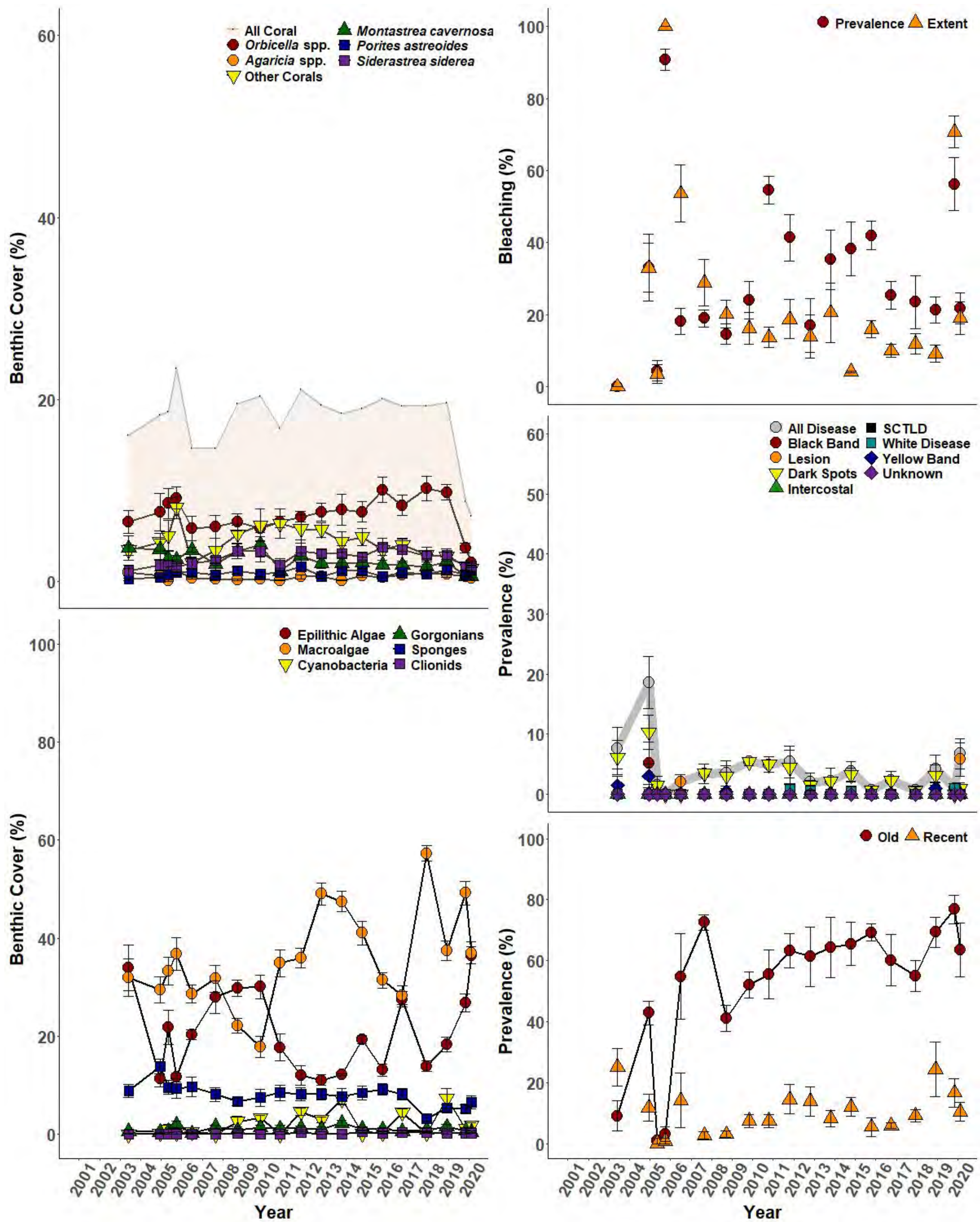


Figure 123. Flat Cay benthic cover and coral health through time (mean ± SE).

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. In 2018 a king mackerel was observed on as transect. Very occasional large groupers (Nassau, yellowfin, black) have been observed on Flat Cay over the past eight 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 sand seaward, 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.

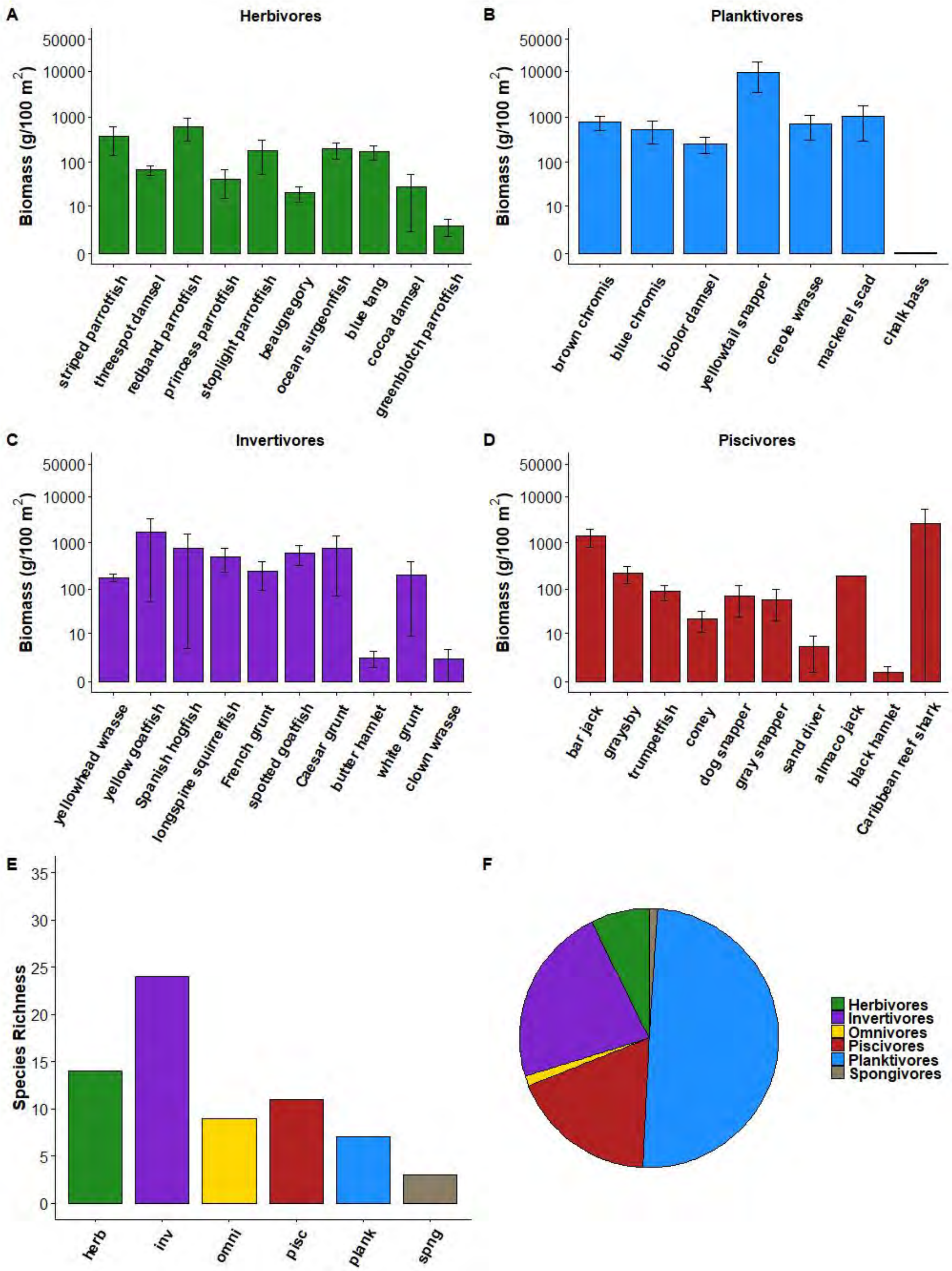
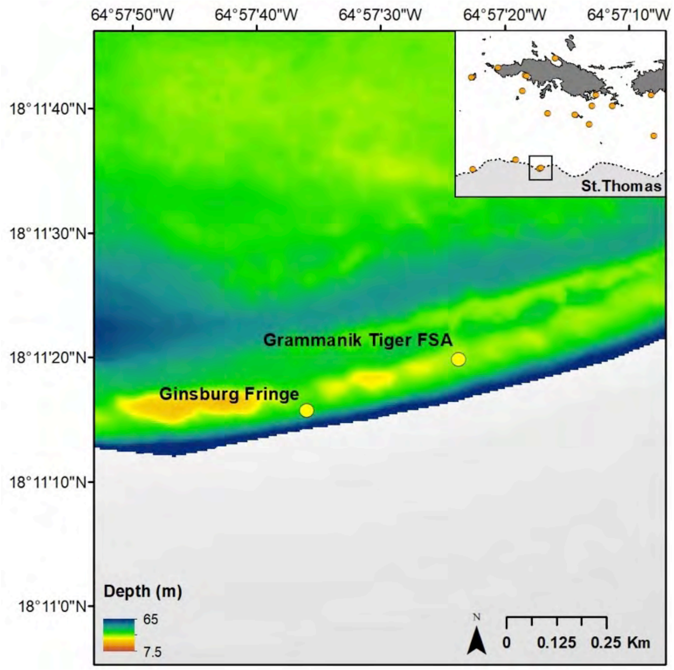


Figure 124. The Flat Cay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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. 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 125. Ginsburgs Fringe. (top) Location. (right) A representative photo of the reef showing whorled lettuce coral colonies up to 7m in width and research diver filming permanent transect in background (Nov. 13, 2015).

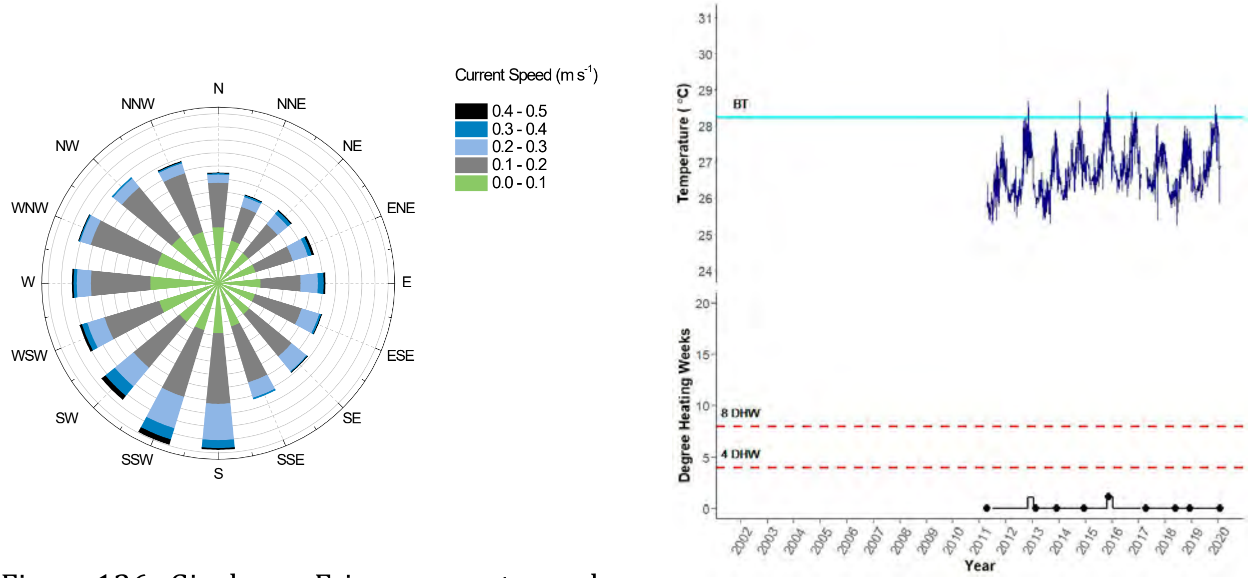


Figure 126. Ginsburgs Fringe current speed (50 m depth) and benthic temperature (63 m depth). BT = bleaching threshold ; DHW = degree heating weeks.

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.

Benthic Community. The coral community at Ginsburgs Fringe is almost exclusively lettuce corals of the genus *Agaricia*. Among the agariciid genus, the rank abundance of species is *A. undata* (30.8% absolute cover), *A. grahamae* (8.2%), and *A. lamarcki* (2.3%), with no colonies of *A. agaricites* and *A. fragilis* occurring in transects. These species identifications are tentative 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 coral cover (65%), likely due to anchoring (Smith et al. 2019b). 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.

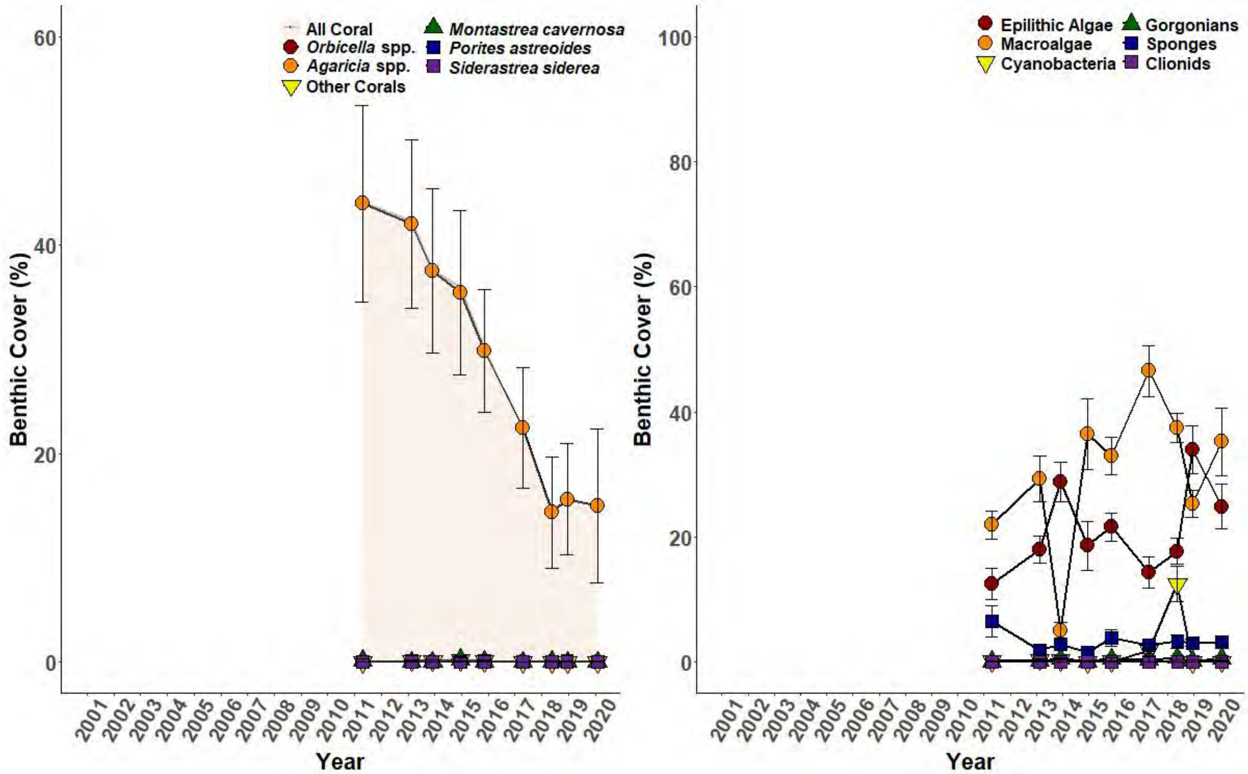


Figure 127. Ginsburgs Fringe benthic cover through time (mean ± SE).

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. 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).

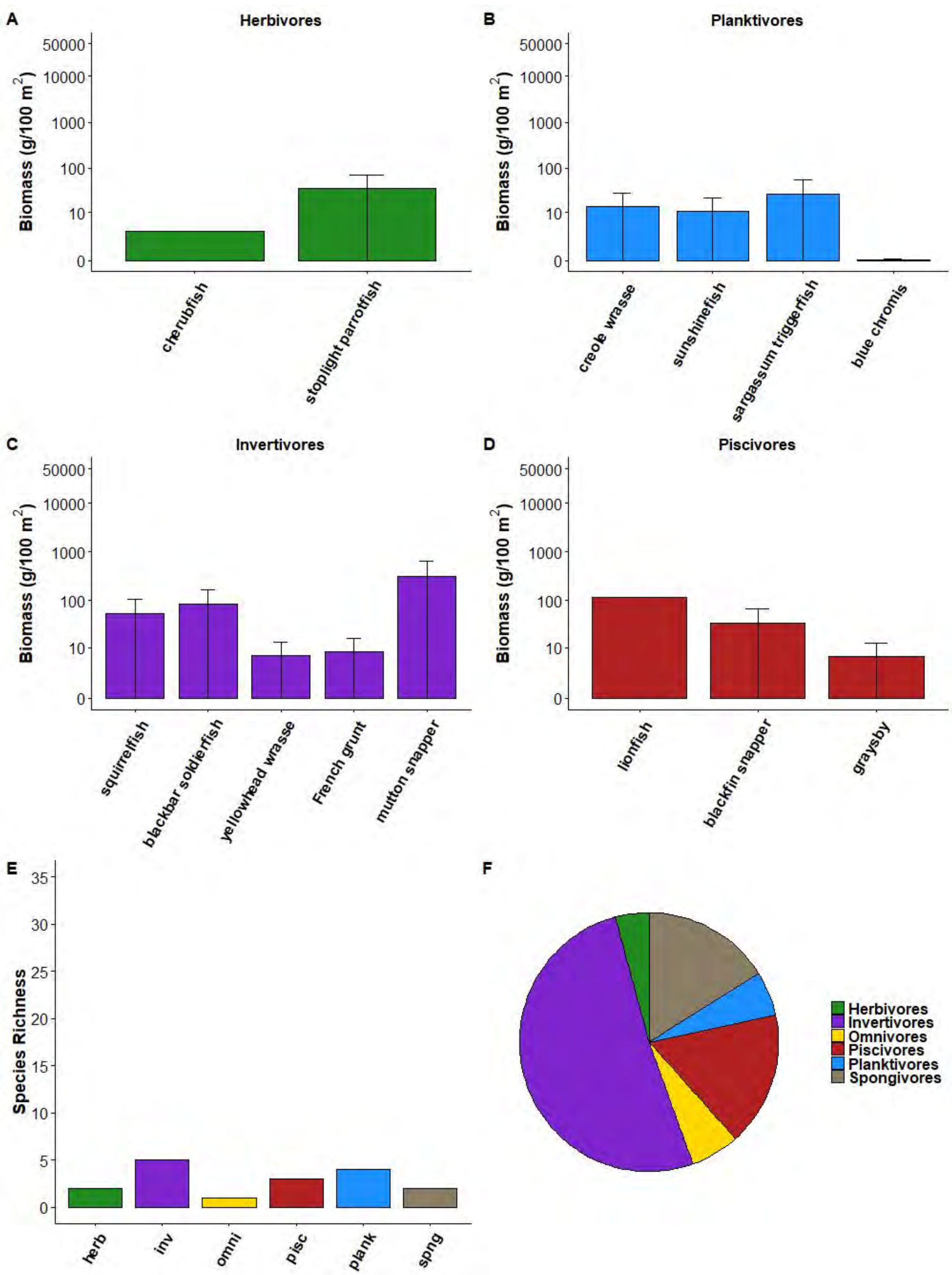
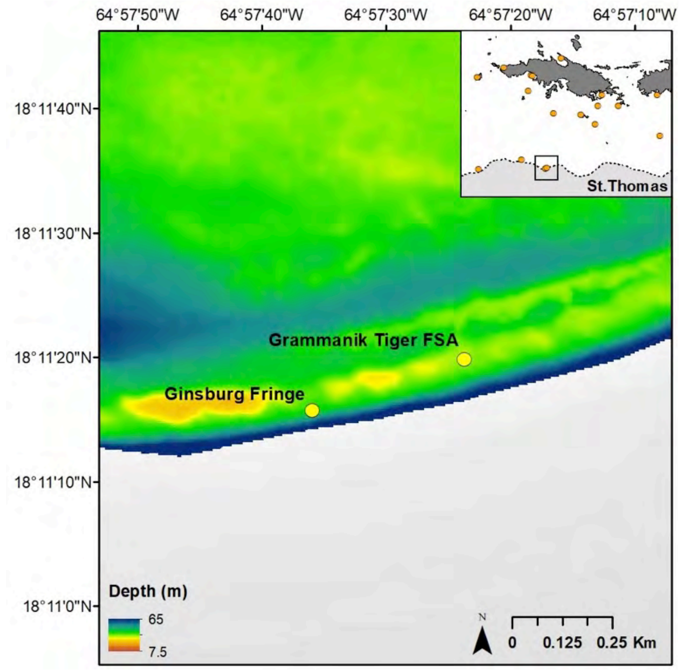


Figure 128. The Ginsburgs Fringe fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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.

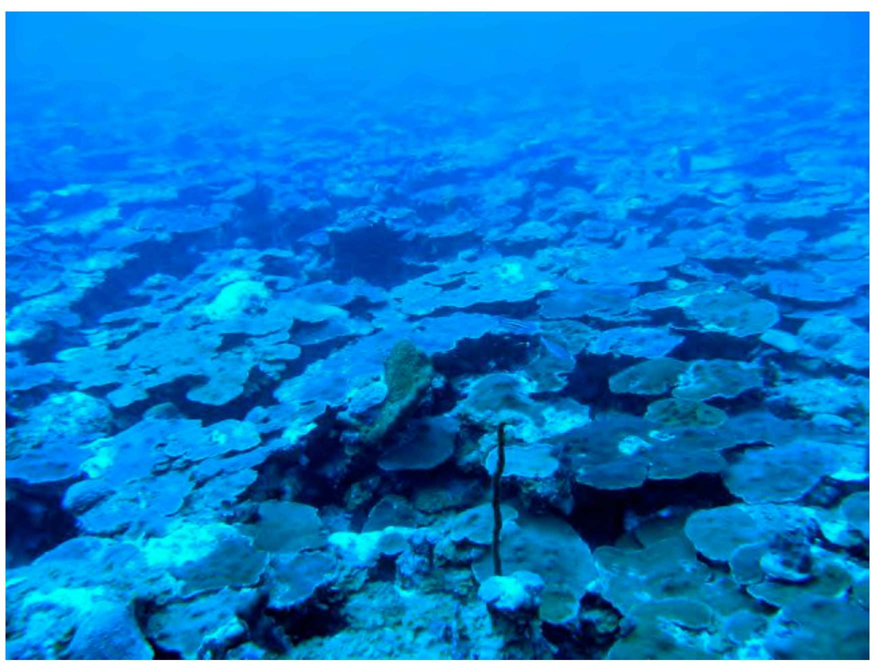
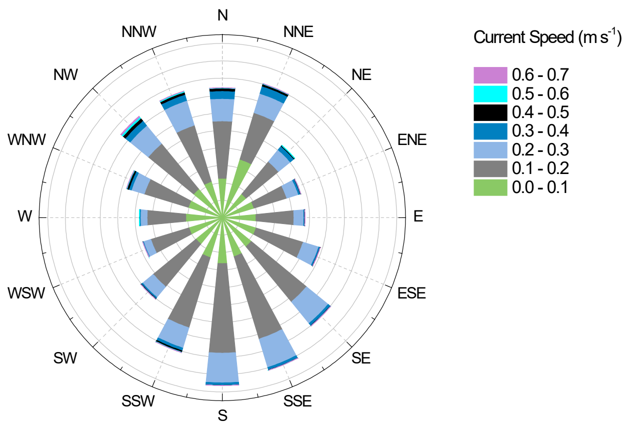


Figure 129. Grammanik Tiger (top) Location. (right) A representative photo of the reef.



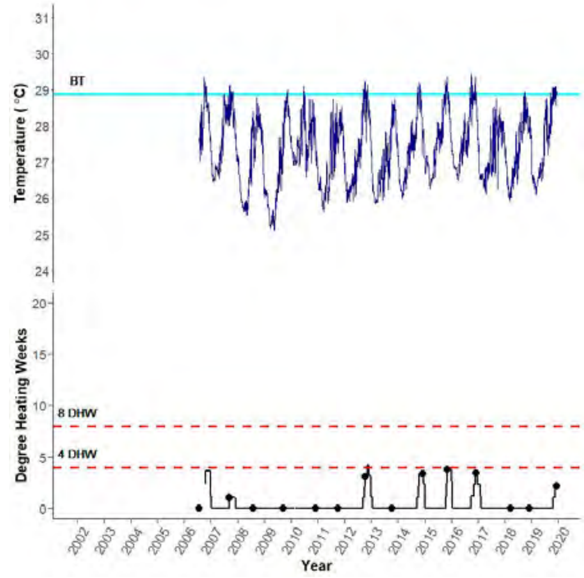


Figure 130. Grammanik Tiger benthic currents speed and temperature record (38 m depth).

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. Oscillatory currents are nil at this depth, with the possible exception of long period swells generated by tropical storms, although this has not been measured.

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).

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. 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 appeared at the site by February 2020 but had not yet had a significant impact on coral cover. Old partial mortality was low, but increased rapidly after the 2005 coral bleaching event. Recent partial mortality is very high and is caused by disease lesions, predations, and fish bites.

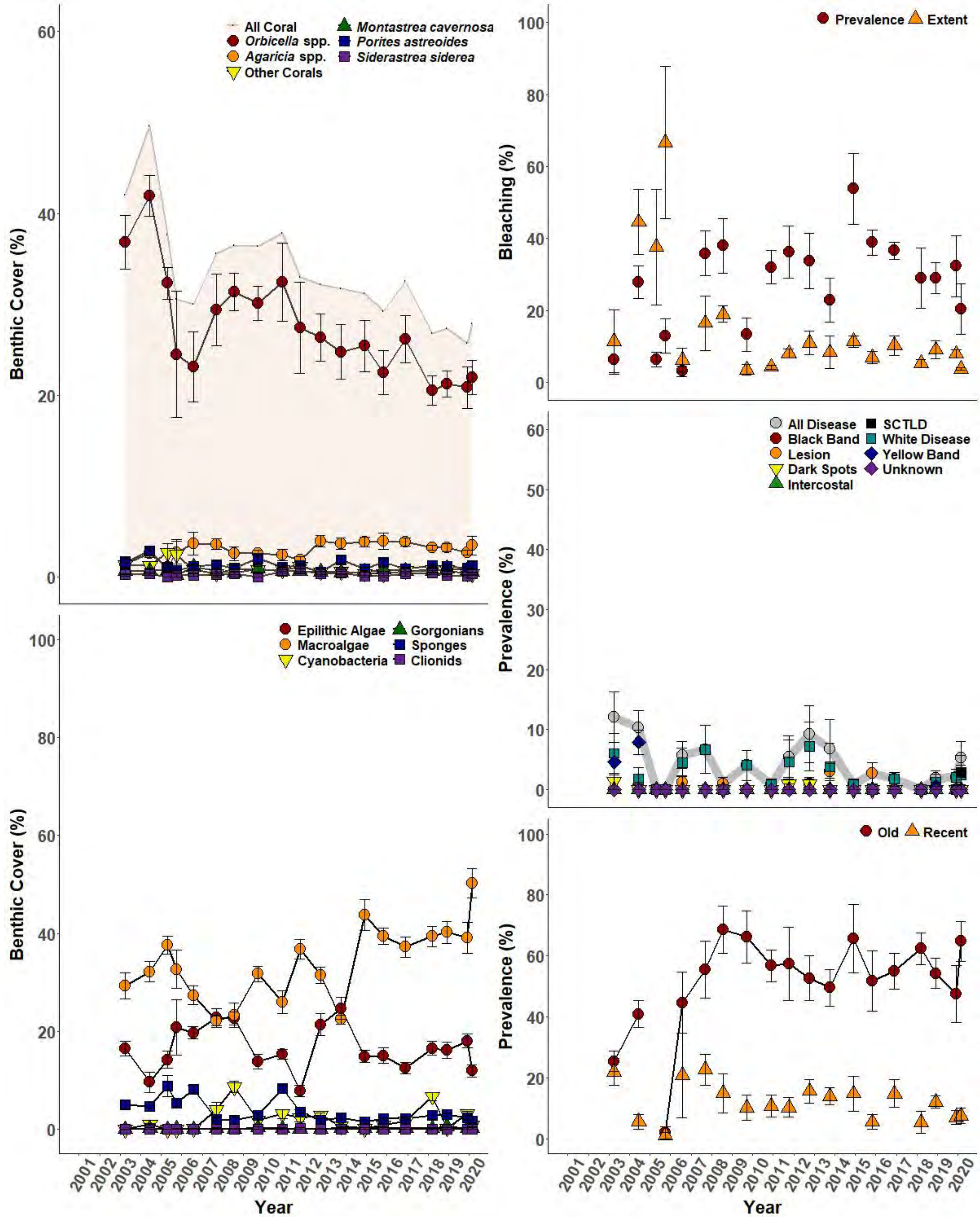


Figure 131. Grammanik Tiger benthic cover and coral health through time (mean ± SE).

Fish Community. The Grammanik Tiger site supports less herbivores and a greater number of piscivores than the more shallow 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 durgeon 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 greater than ten 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.

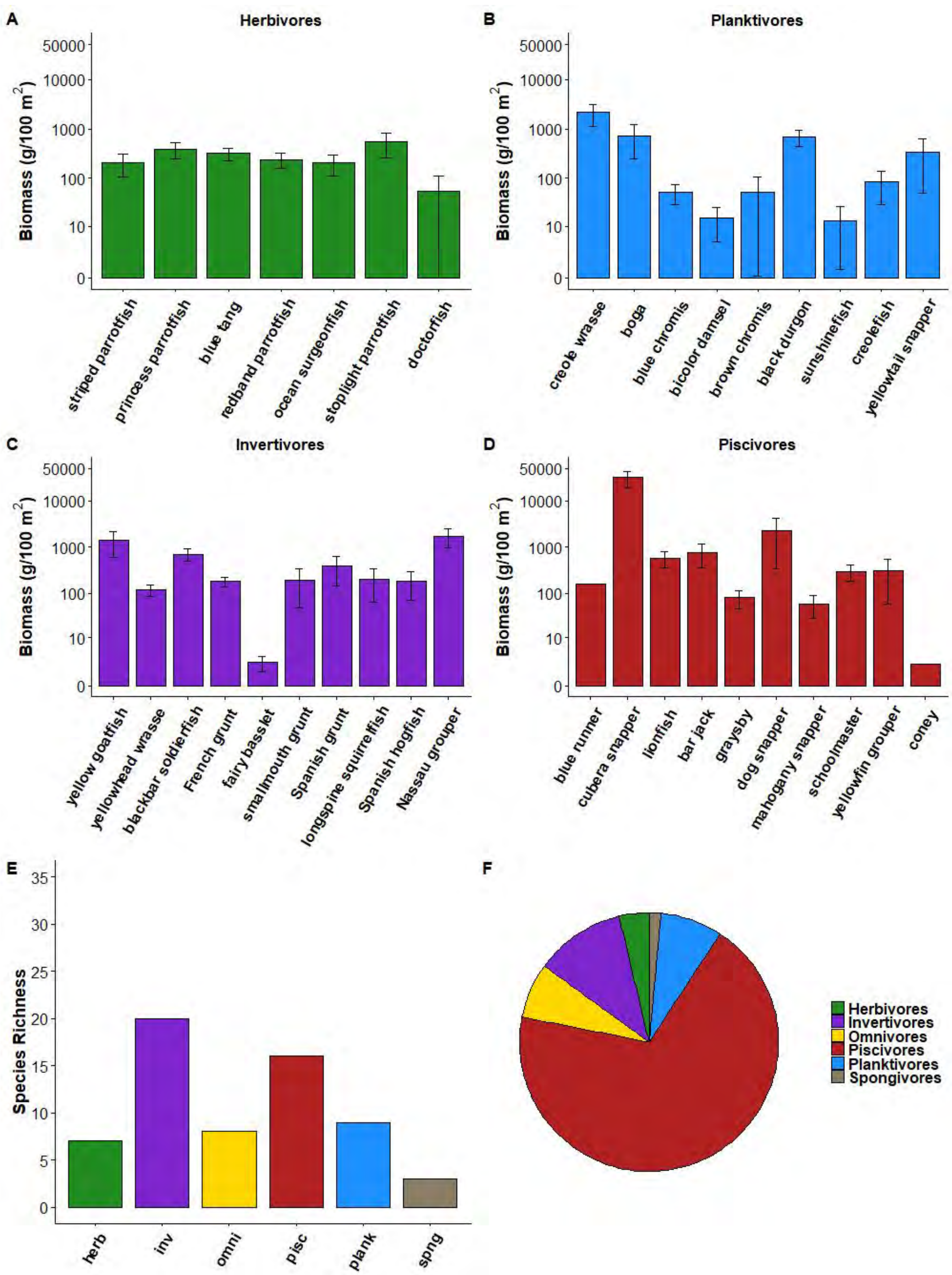
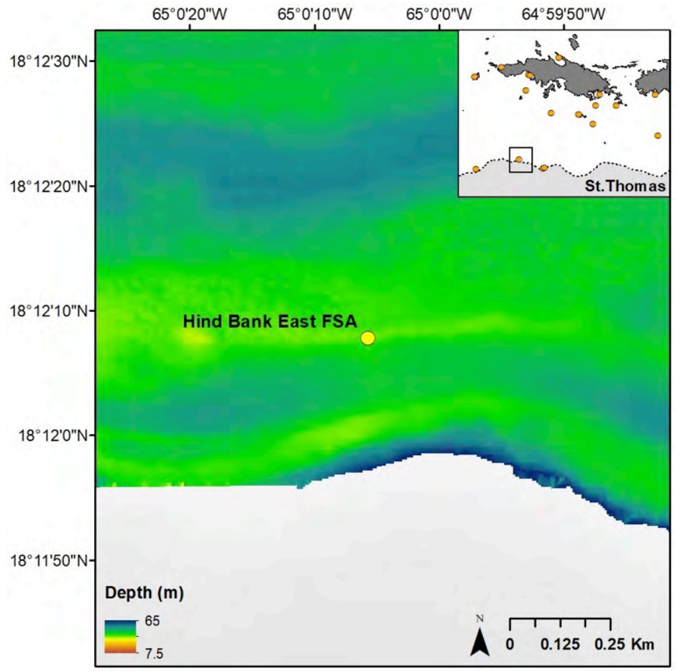


Figure 132. The Grammanik Tiger fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

HIND BANK

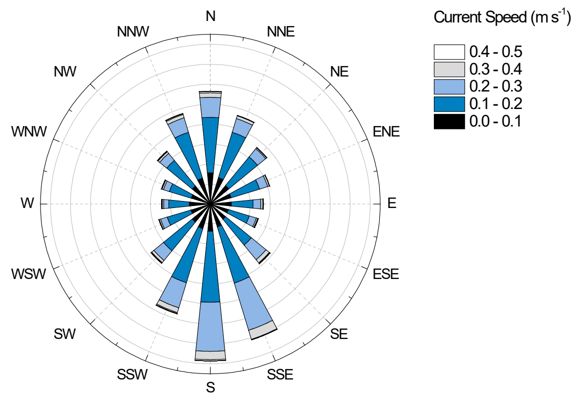


Description. The Hind Bank is a mesophotic tertiary bank in depths of 38 – 42 m. The reef is part of a patchy complex of star coral (*Orbicella* spp.) dominated reefs that stretch across the eastern Red Hind Marine Conservation District. The Hind Bank has been monitored since 2003, with permanent benthic 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 133. Hind Bank (top) Location. (right) A representative photo of the reef.



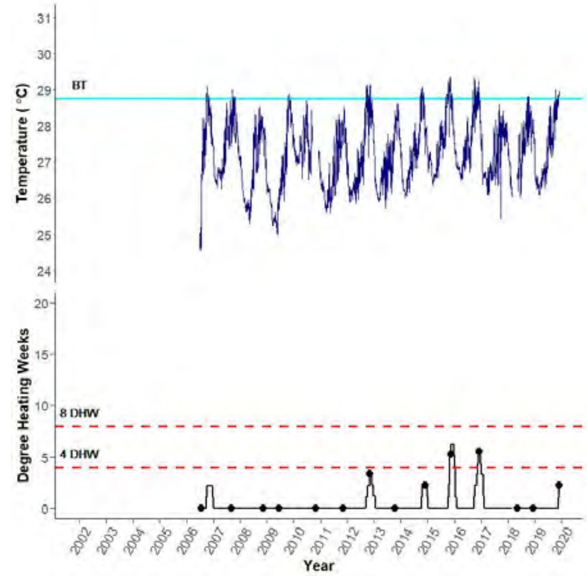


Figure 134. (top) Hind Bank benthic current speed (40m depth). (bottom) Benthic temperature record at 40 m depth.

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 (>20cm 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.

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 recent arrival of SCTLD in 2019 seems to be causing a decline in coral cover. 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 or 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 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.

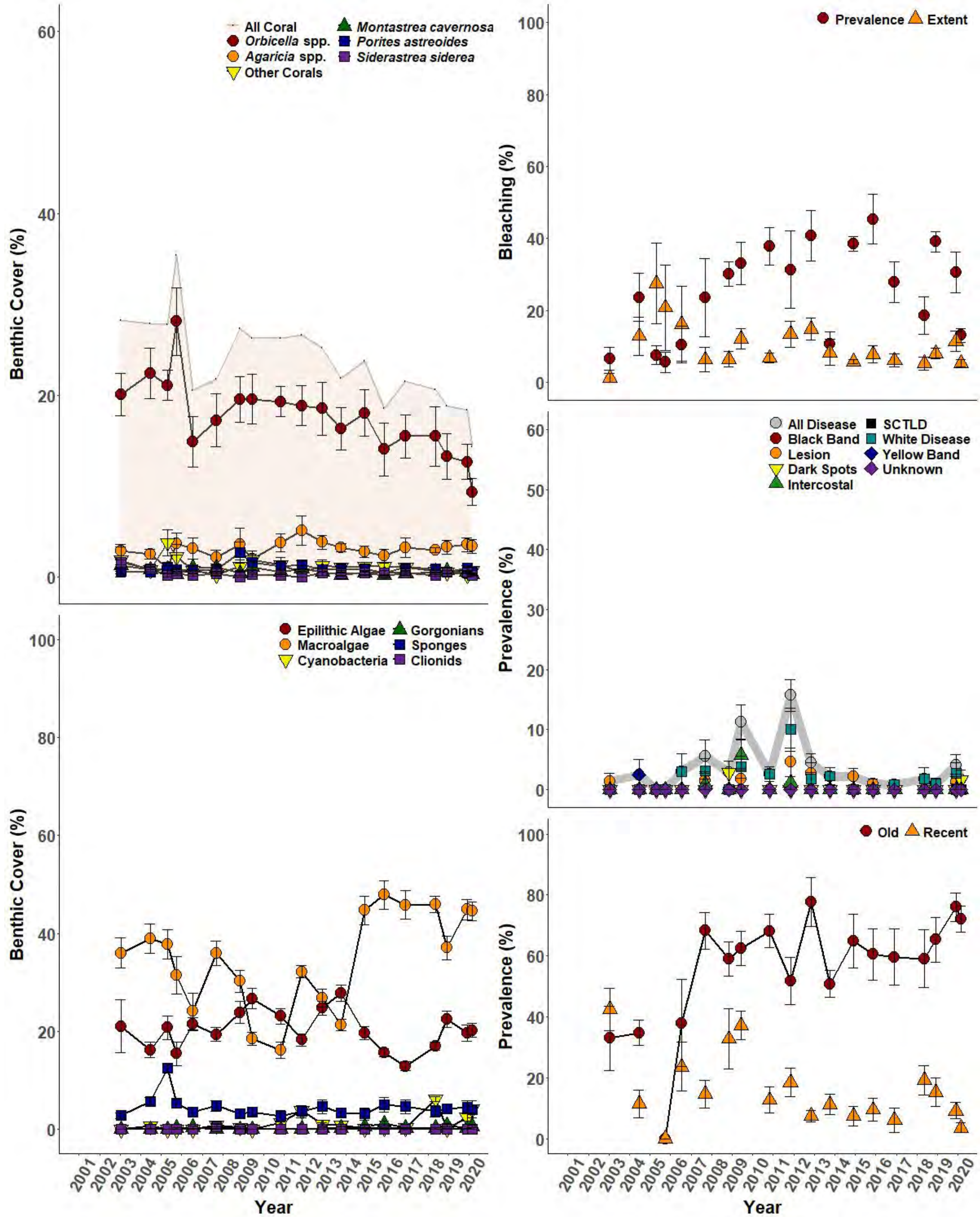


Figure 135. Hind Bank benthic cover and coral health through time (mean ± SE).

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. Plantivores 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 durgeon, 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.

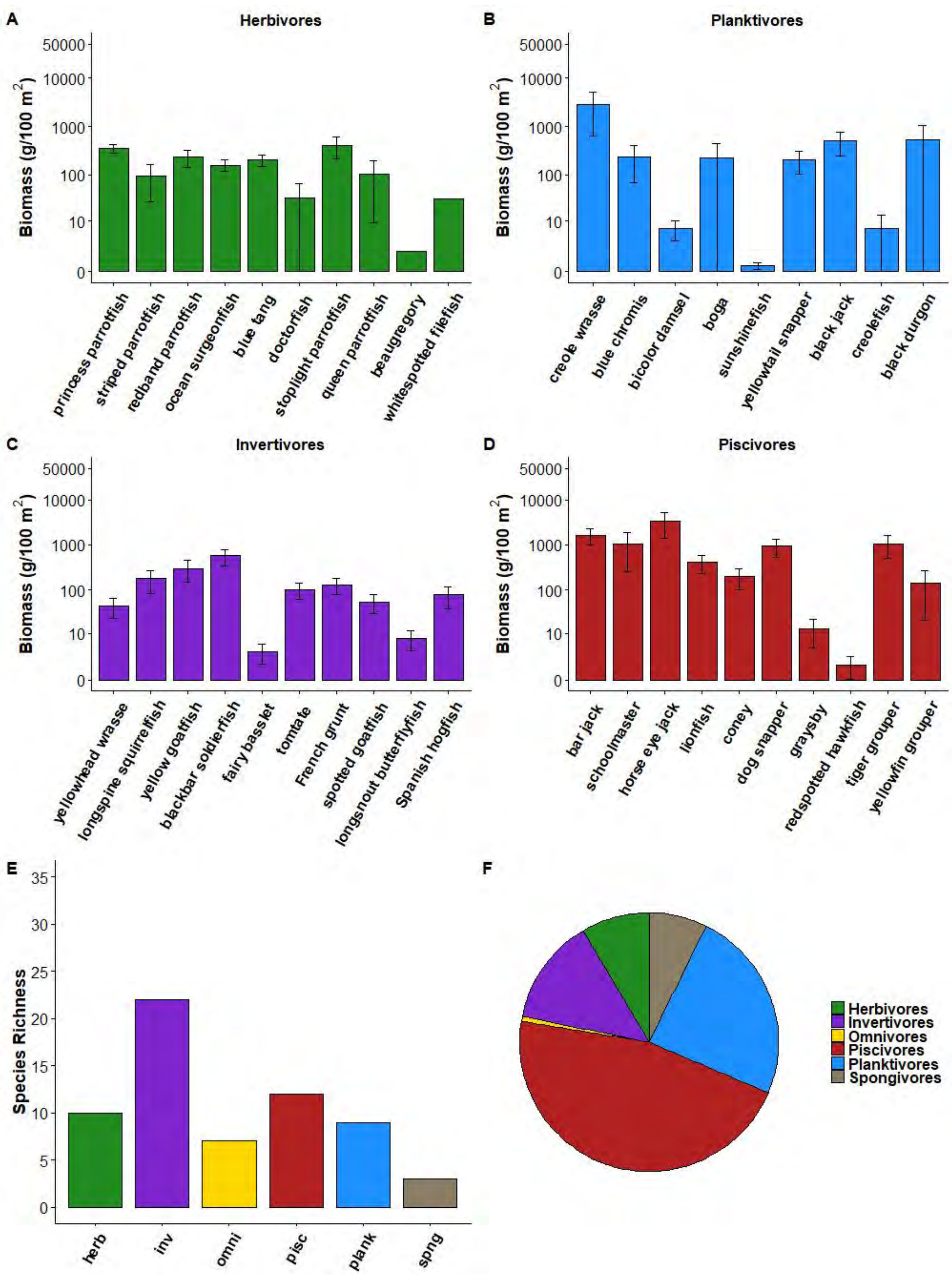
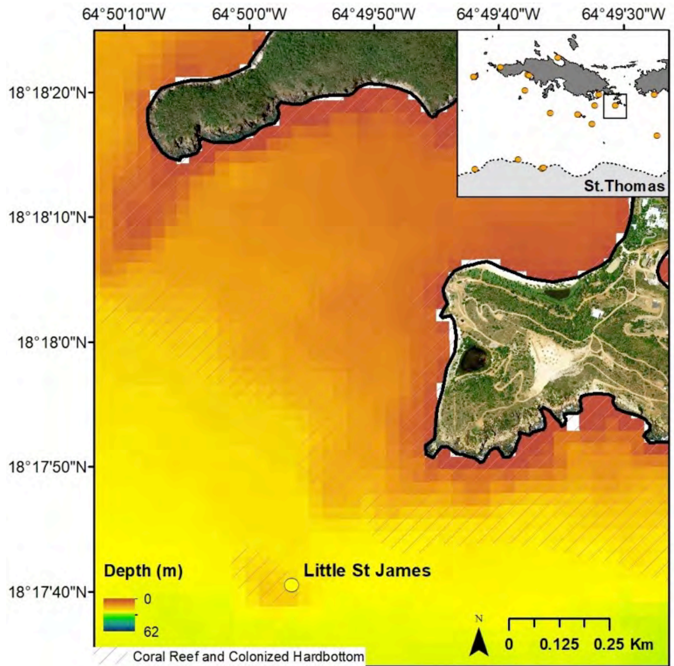


Figure 136. The Hind Bank East fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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

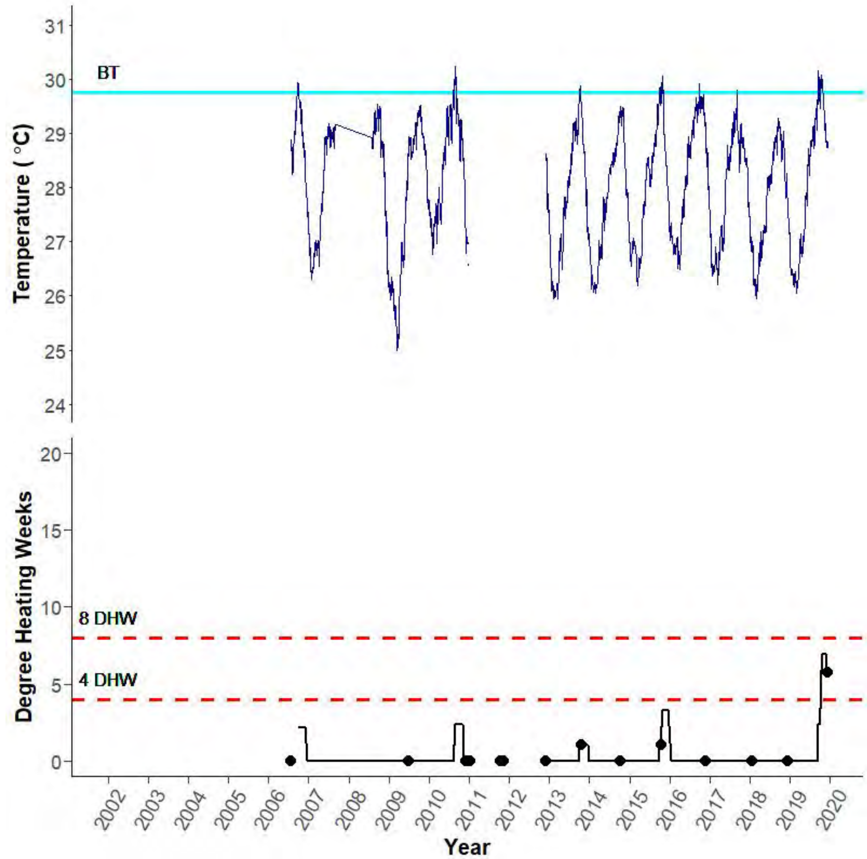


Figure 138. Little St. James benthic temperature record (19 m depth).

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 2010 and 2019.

SITE SUMMARIES

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, but had not cause large coral cover loss. 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. Diseases are less common, with the exception of a white disease outbreak that preceded the coral bleaching event in June 2005. Dark spots disease can also be common. Old partial mortality increased rapidly after the 2005 bleaching event. Recent partial mortality is not very prominent.

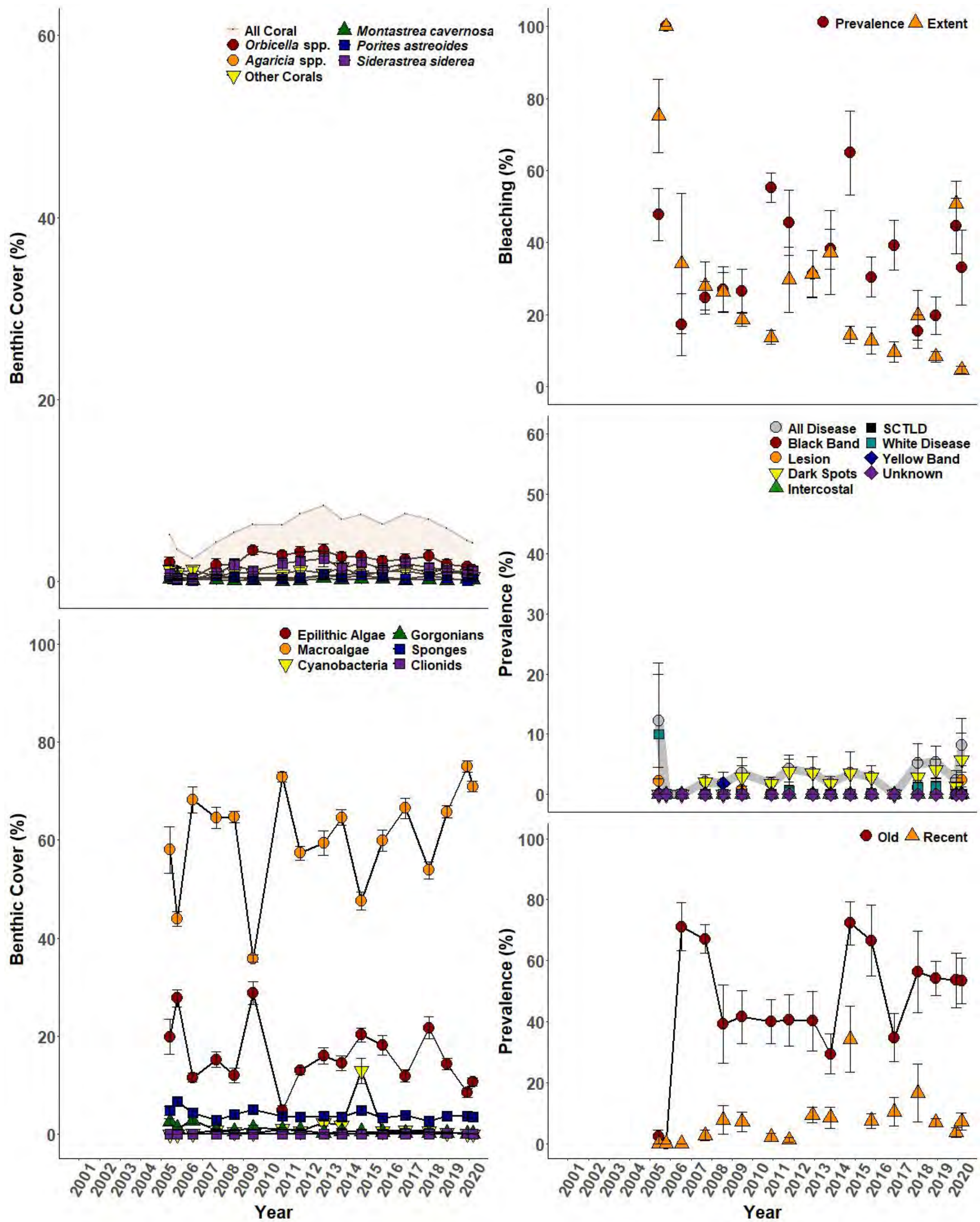


Figure 139. Little St. James benthic cover and coral health through time (mean ± SE).

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 queen triggerfish population, which holds both large numbers and variable sizes of fish at Little St. James. Lobster are also relatively dense and generally observed on both transects and roving dives 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, presumably fishing for lobster and queen triggerfish.

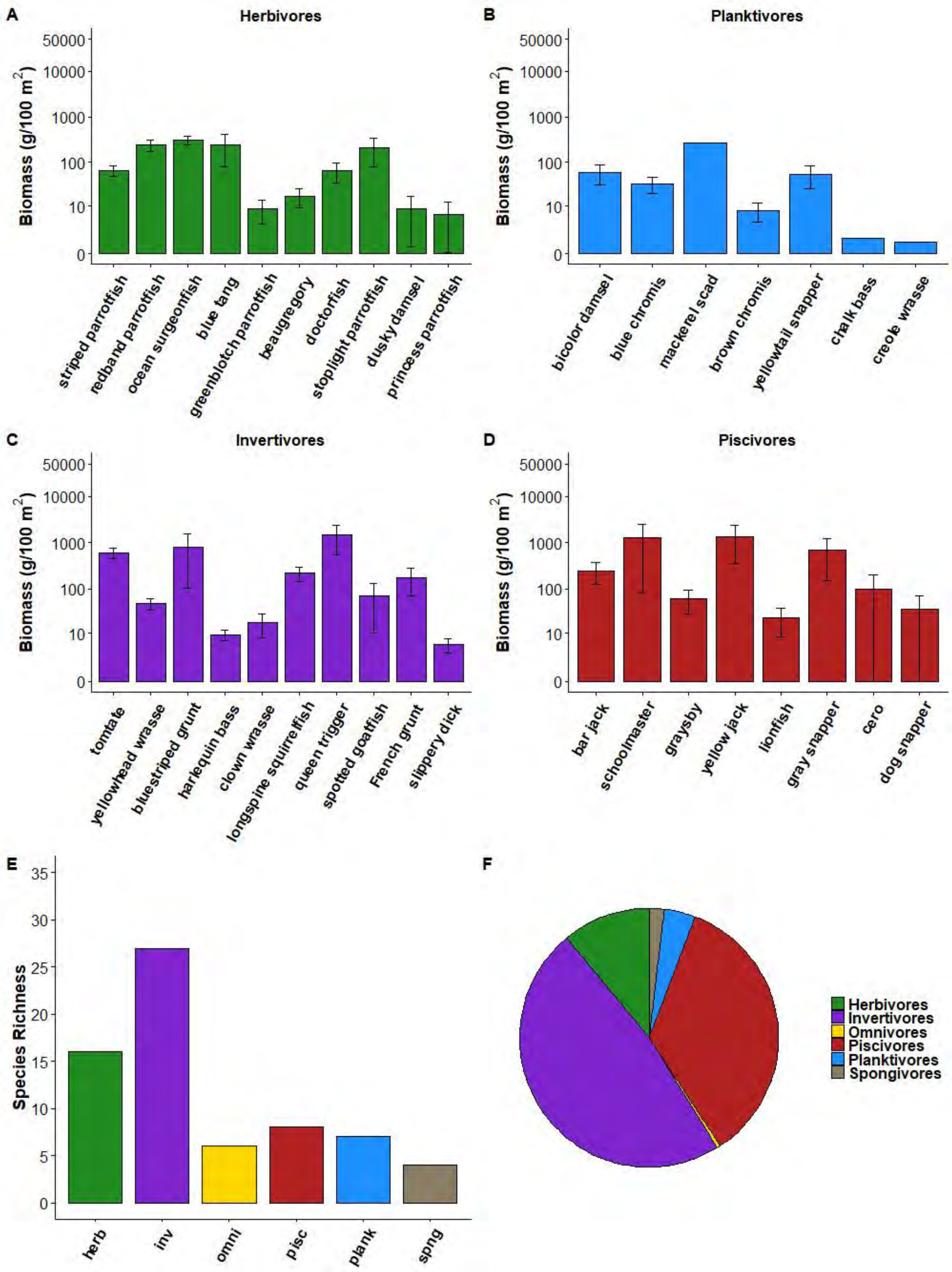
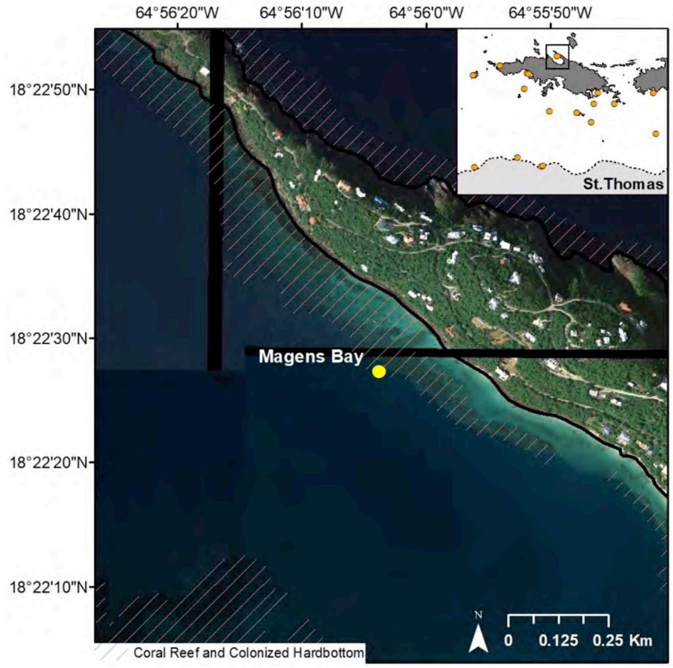


Figure 140. The Little St. James fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.



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

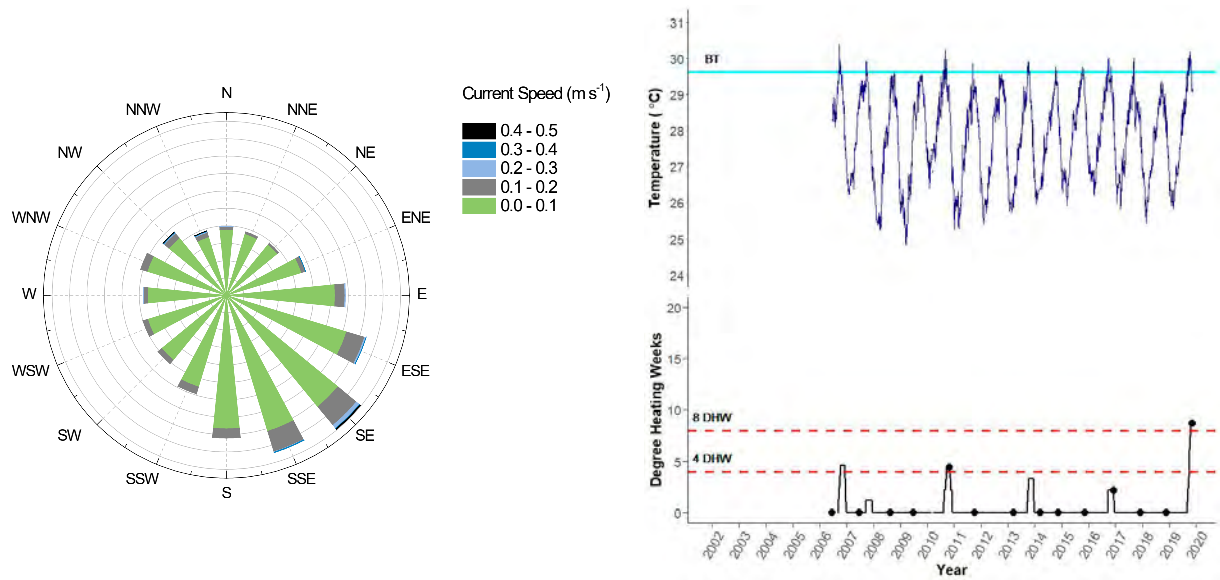


Figure 142. Magens Bay current speed and benthic temperature record (9 m depth).

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.

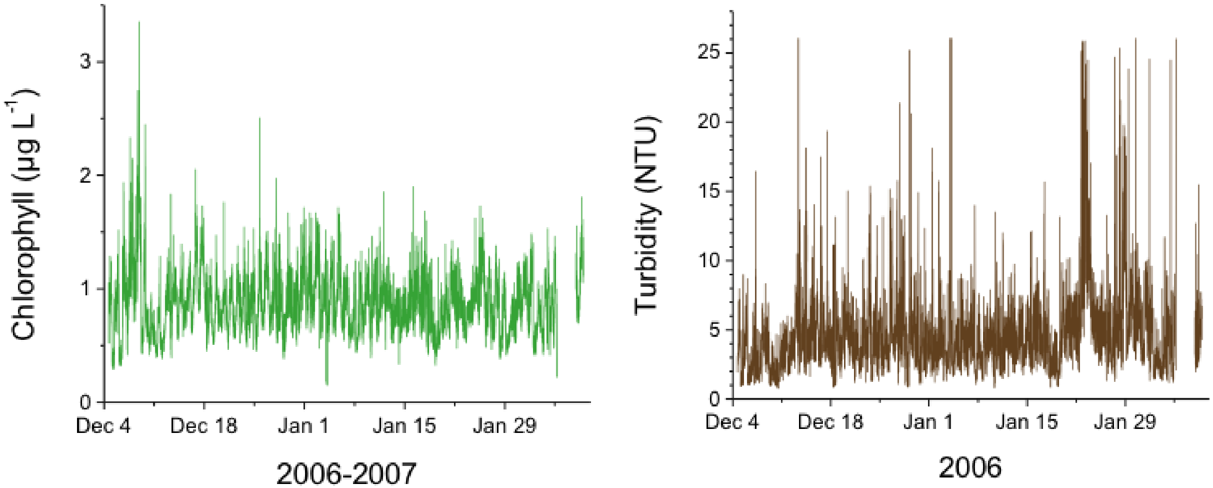


Figure 143. Magens Bay chlorophyll (left) and turbidity (right) record (16 m depth).

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

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 2019. 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).

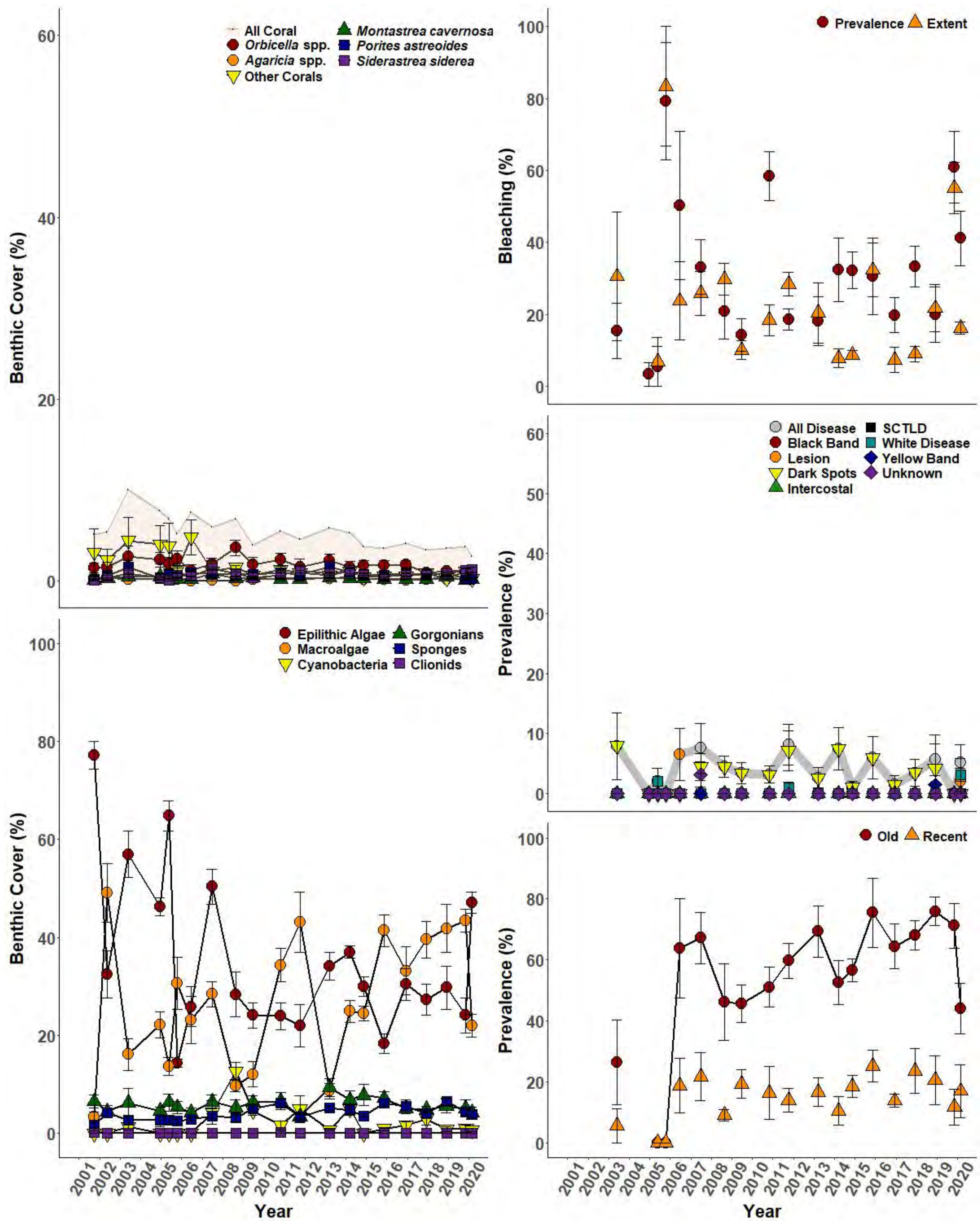


Figure 144. Magens Bay benthic cover and coral health through time (mean ± SE).

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. Anecdotally, 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.

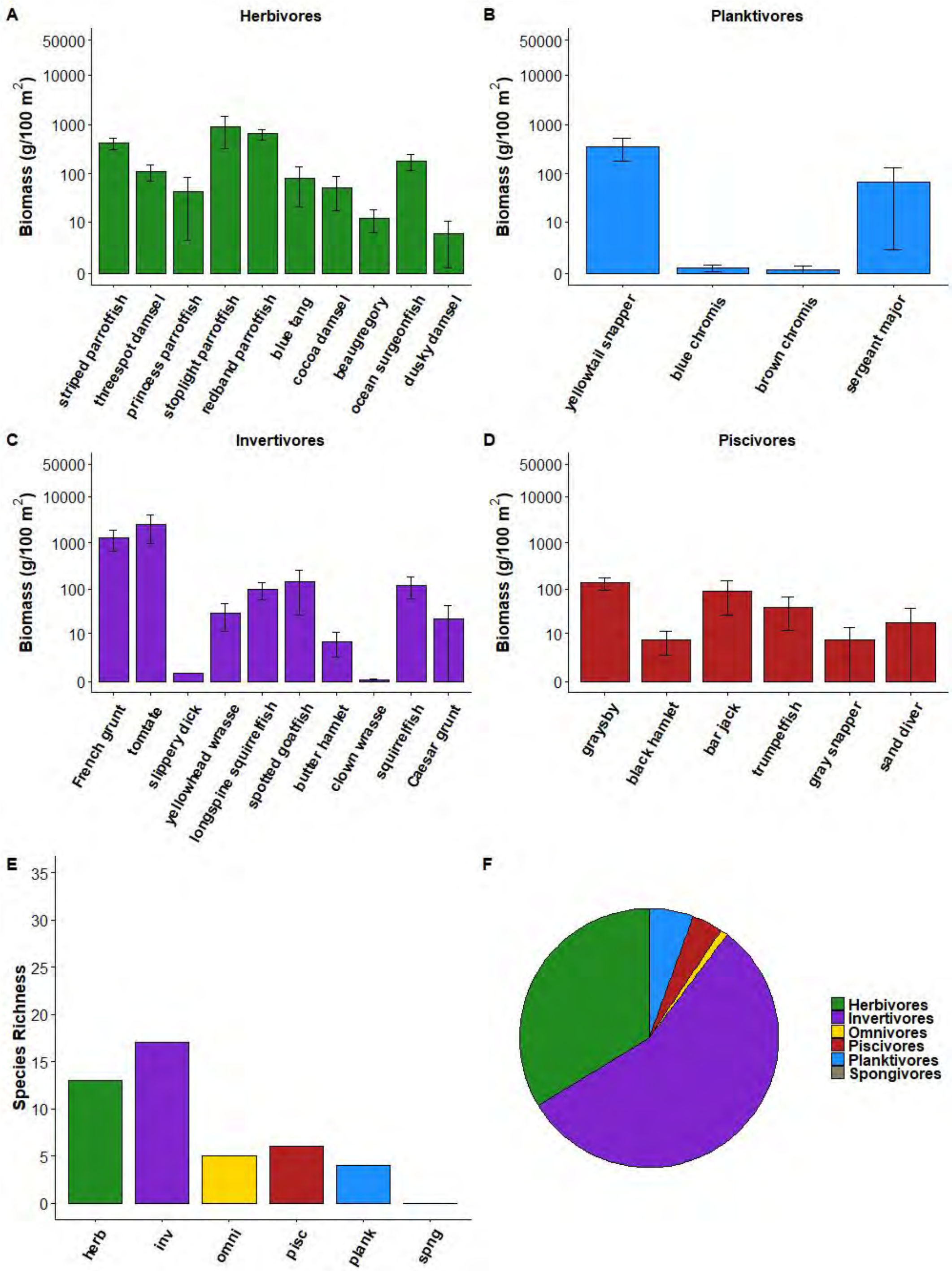
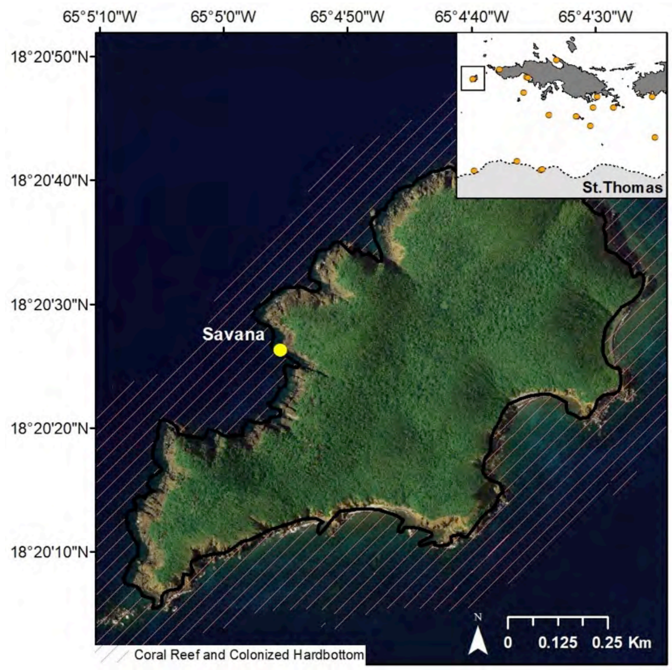


Figure 145. The Magens Bay fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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 behemoth colonies of boulder star coral (*Orbicella faveolata*) and a diverse and abundant fish community.

Threats. Savana is threatened the invasive algae *Ramicrusta* sp. (identification provisional) 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.

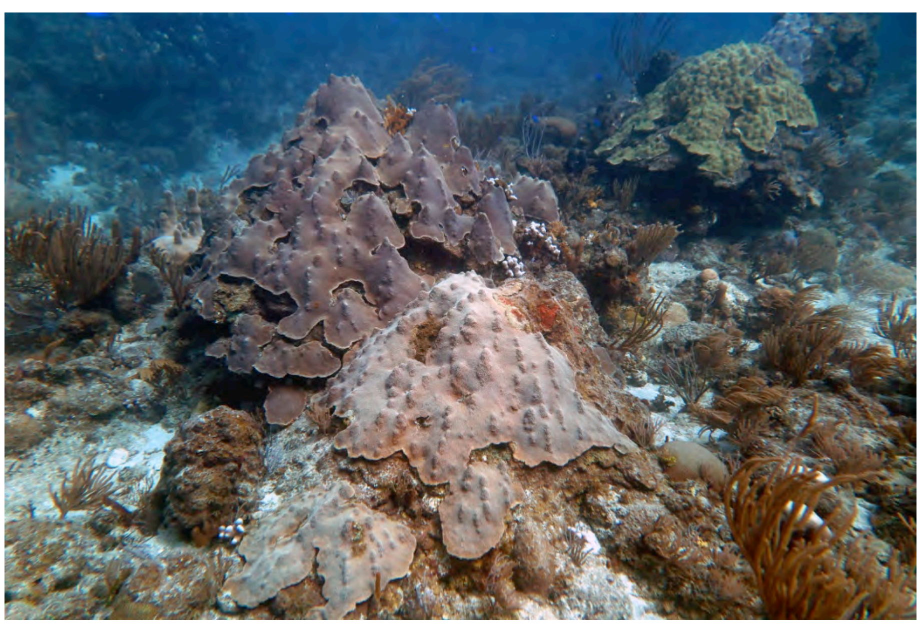


Figure 146. Savana. (top) Location. (right) A representative photo of the reef showing large colonies of *Orbicella faveolata* (Nov. 17, 2015).

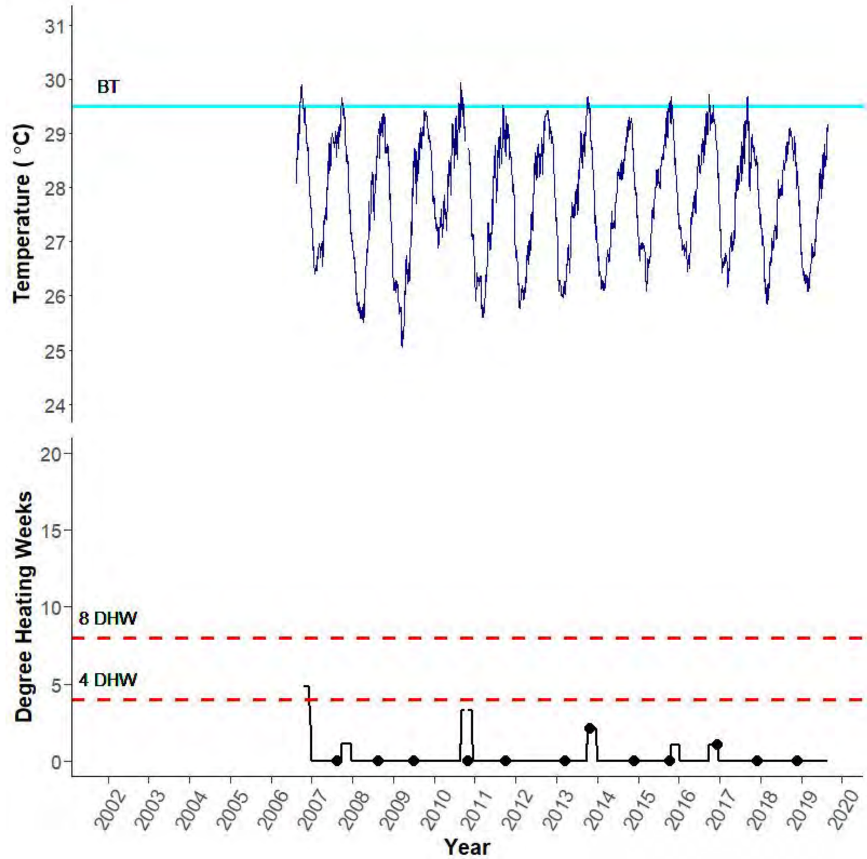


Figure 147. Savana benthic temperature record (10 m depth).

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. Temperatures over the 2019 bleaching event are not displayed and will be included once the data is extracted from the loggers.

SITE SUMMARIES

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 *Ramicrusta* sp. to over 60% cover (this is responsible for the spike in "macroalgae" in benthic cover after 2005). This algae overtops coral edges leading a slow, creeping mortality. In addition, SCTLD appeared in 2019 and has also contributed to a decline in coral cover. dGorgonians 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.

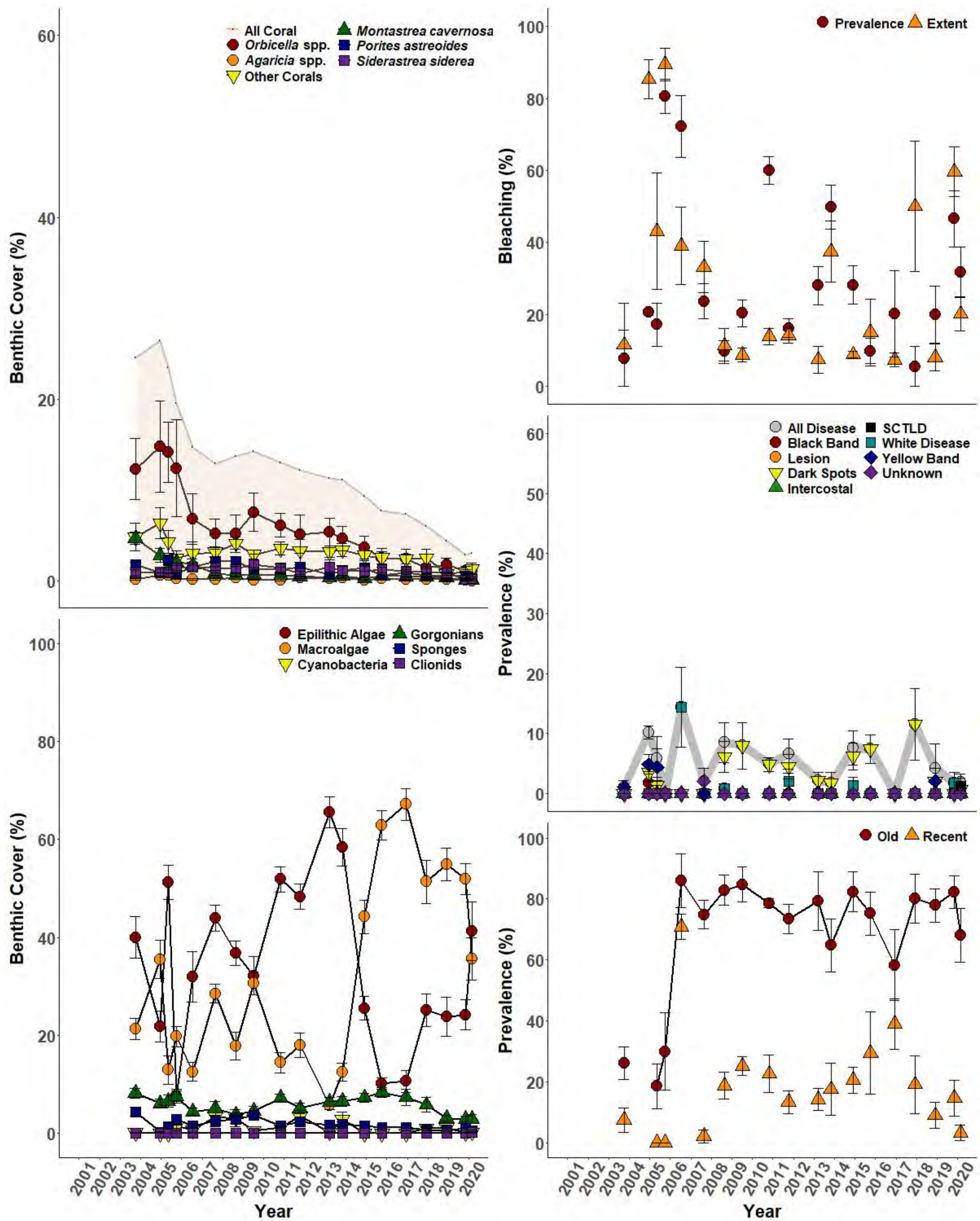


Figure 148. Savana Island benthic cover and coral health through time (mean ± SE).

Fish Community. The Savana Island fish community is fairly small 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 nearshore site. Otherwise no large snappers and groupers have been seen in the bay. The area is highly fished with fish traps.

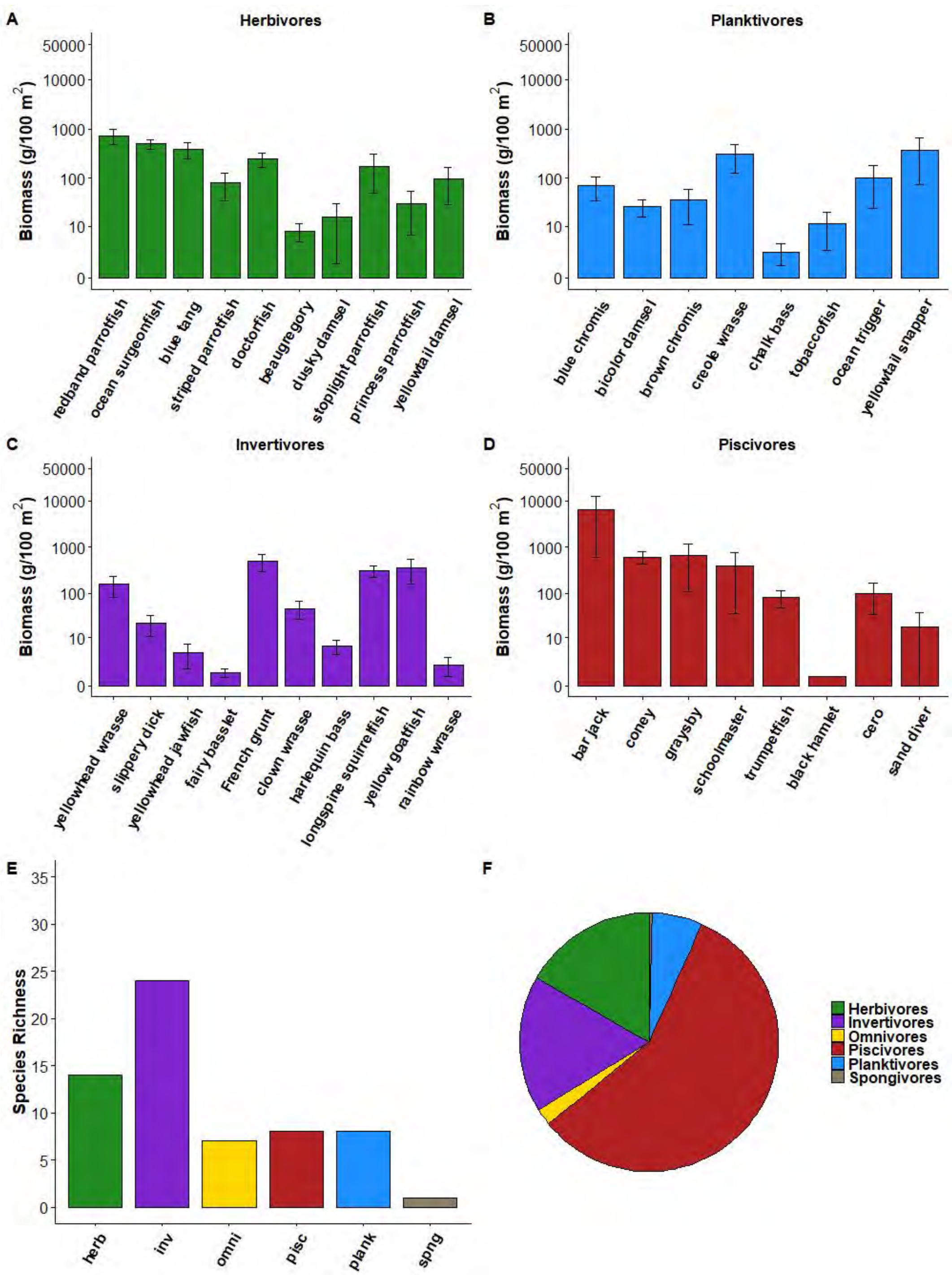
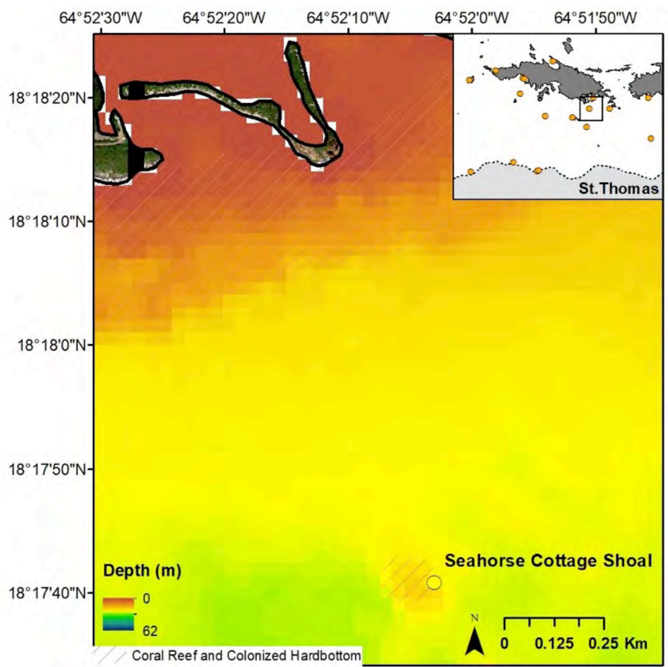


Figure 149. The Savana Island fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SEAHORSE COTTAGE SHOAL

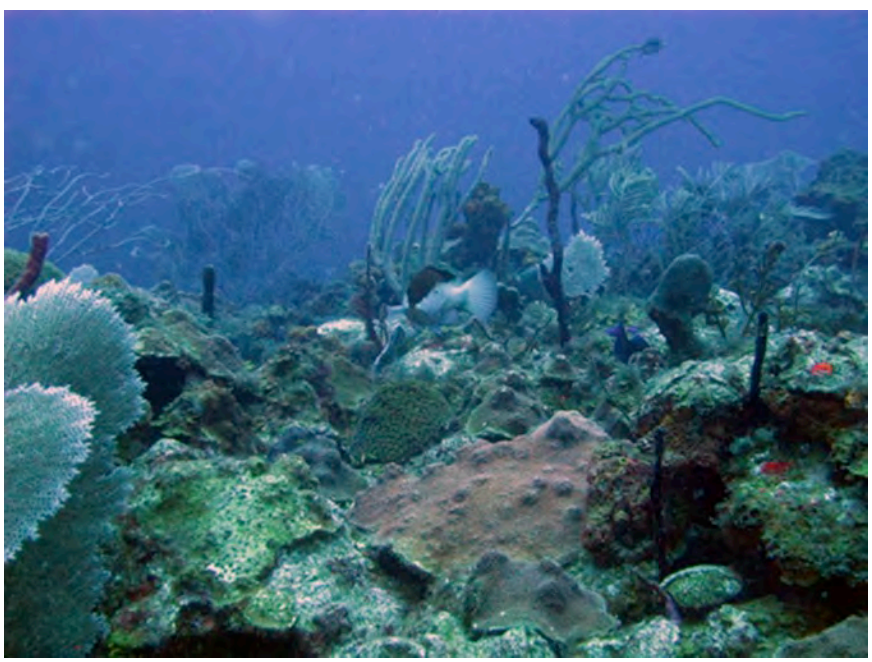
Description. The Seahorse Cottage Shoal site is a large patch reef surrounded by sand and rhodolith in depths of 17 – 23m. The isolated reef is flat topped and dominated by *Orbicella* spp.. Seahorse has been monitored since 2003, with permanent benthic transects installed in 2007. A ciguatera study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



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



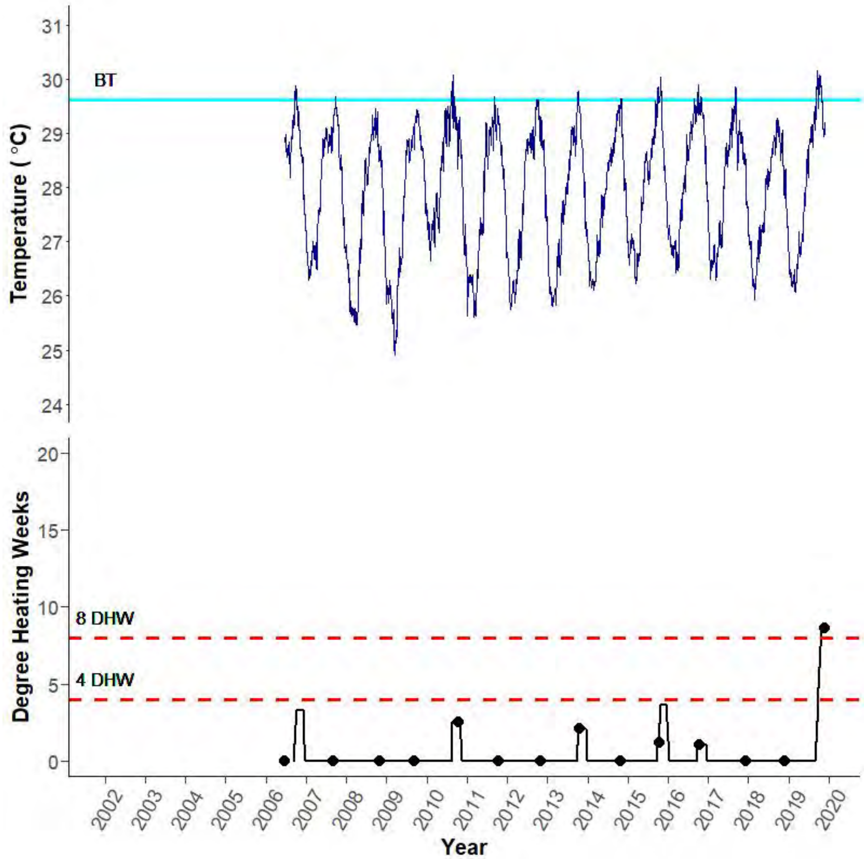


Figure 151. Seahorse benthic temperature record (21 m depth).

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.

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. SCTLD appeared in 2019 and caused a decline in coral cover from 16% in October 2018 to 9% in February 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. SCTLD appeared in 2019 and reached very high prevalenced. 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.

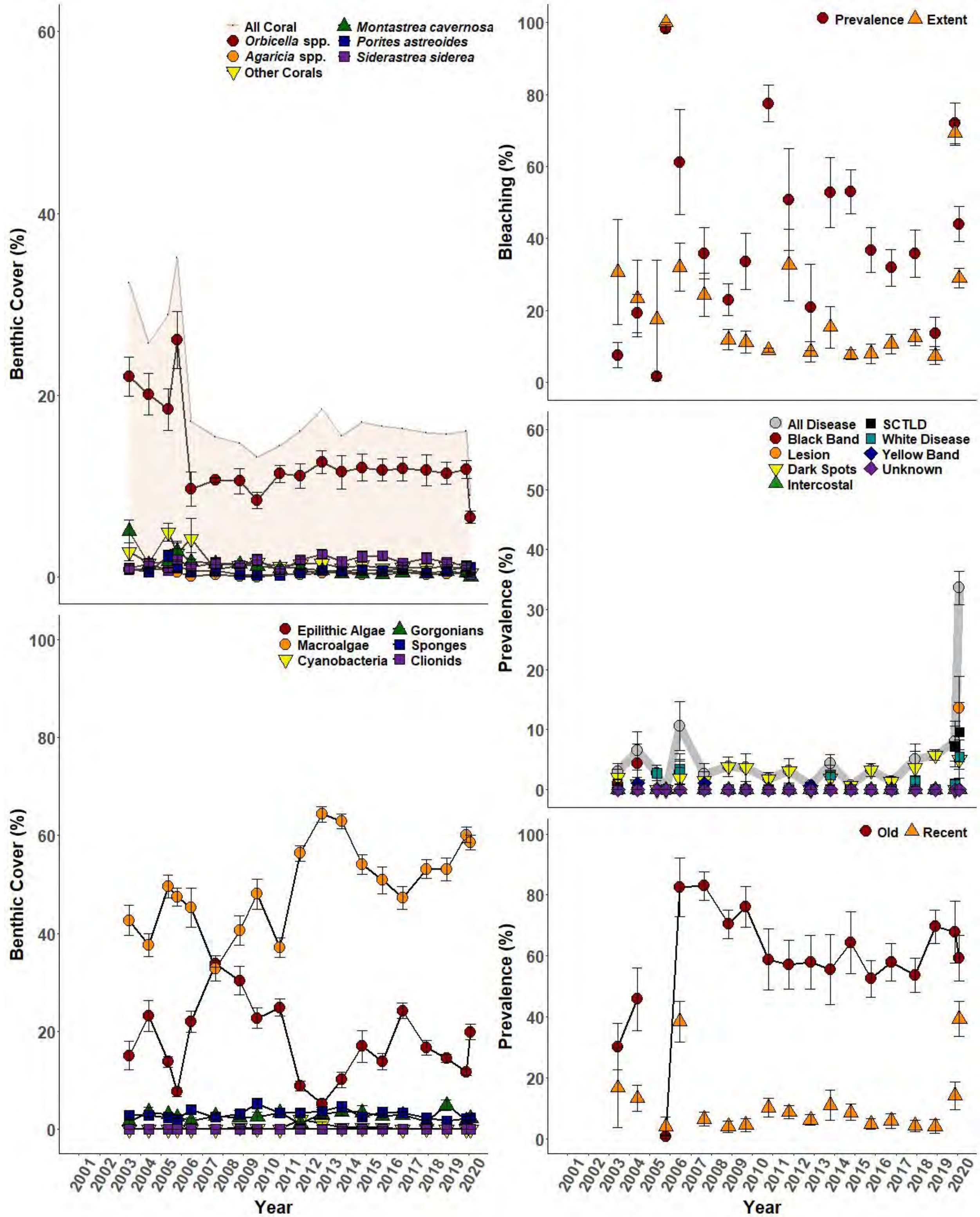


Figure 152. Seahorse Cottage Shoal benthic cover and coral health through time (mean ± SE).

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. Except for one sub-adult goliath grouper observed there in 2012, large groupers have never been seen on the reef. 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.

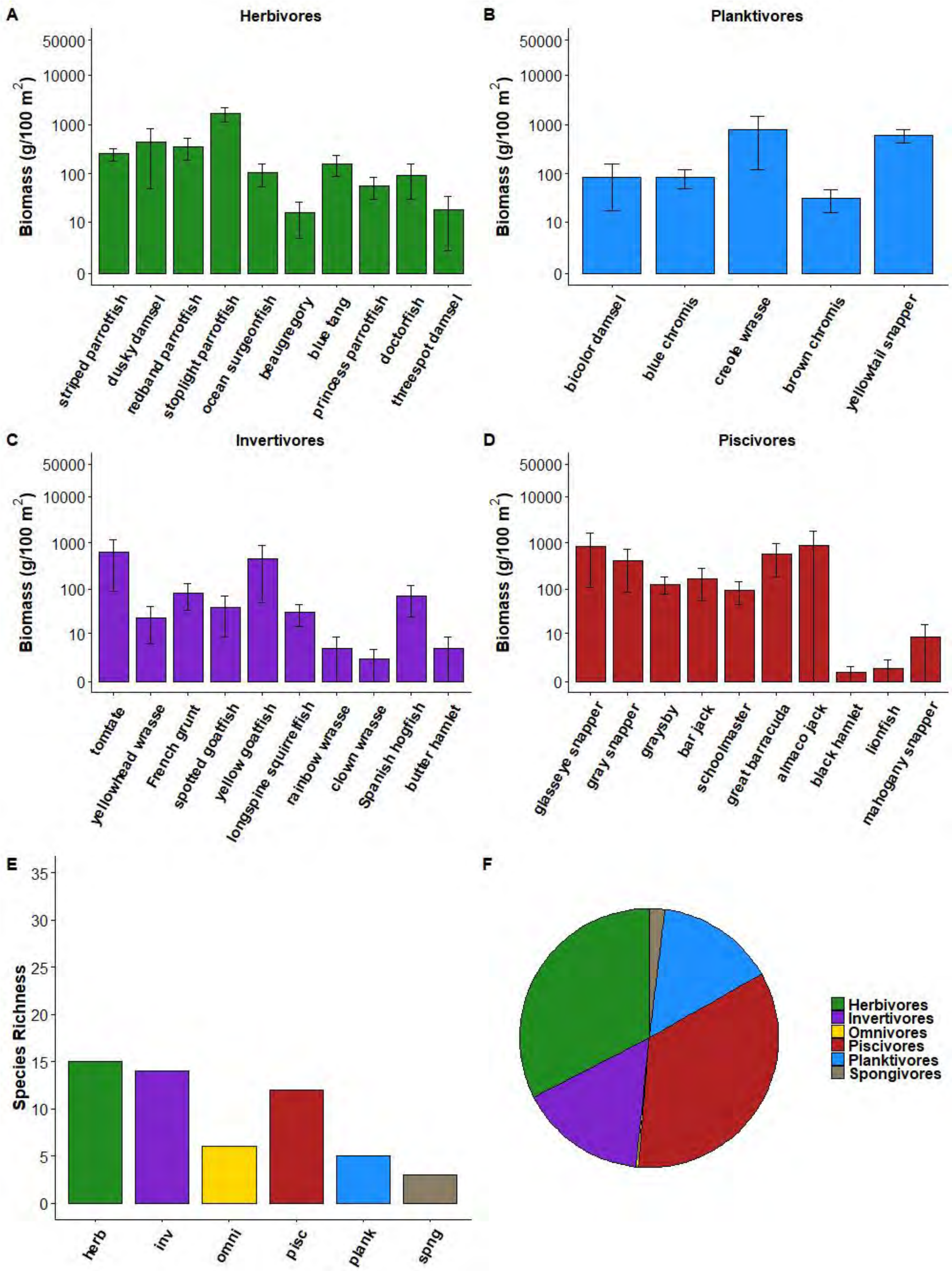
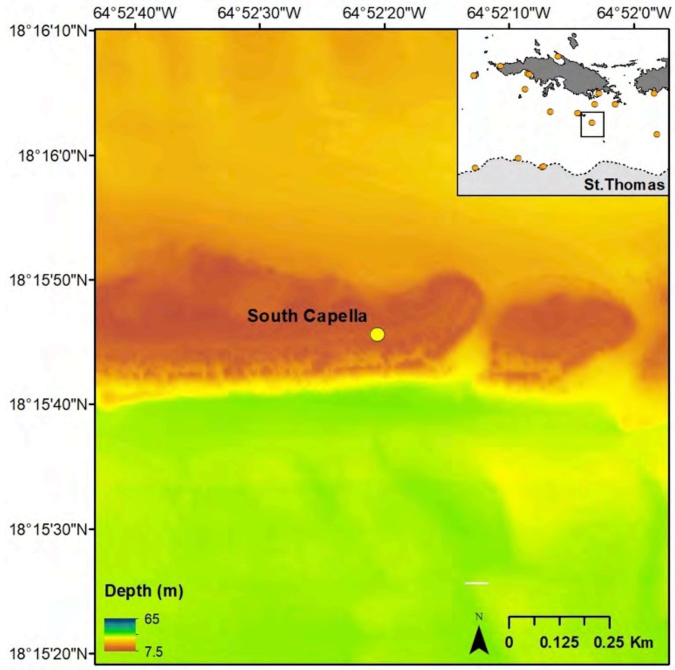


Figure 153. The Seahorse Cottage Shoal fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SOUTH CAPELLA

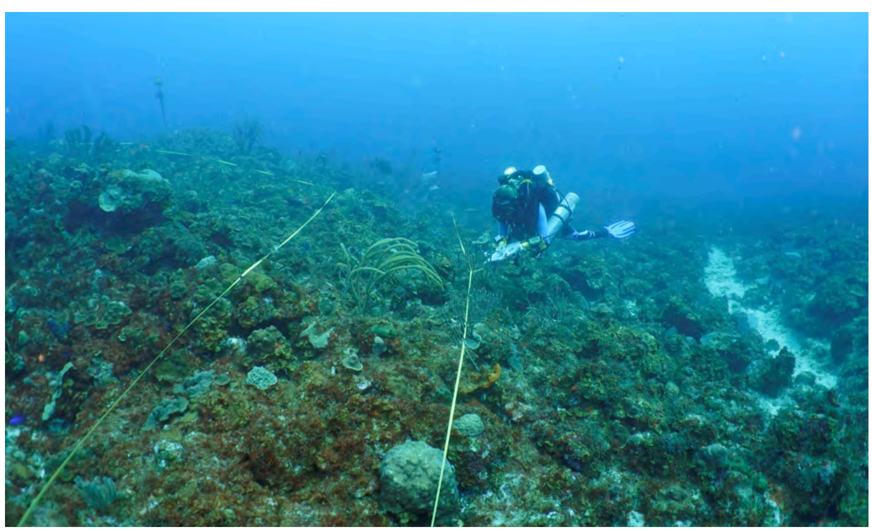


Description. The South Capella site is located on a rise of the St. Thomas-St. John midshelf reef complex in depths of 16 - 25 m. The reef is made of rolling ridges of coral and pavement interspersed with sand grooves. South Capella has been monitored since 2003, with permanent benthic transects installed 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 154. South Capella. (top) Location. (right) Representative photo of the reef (photo credit: V. W. Brandtneris).



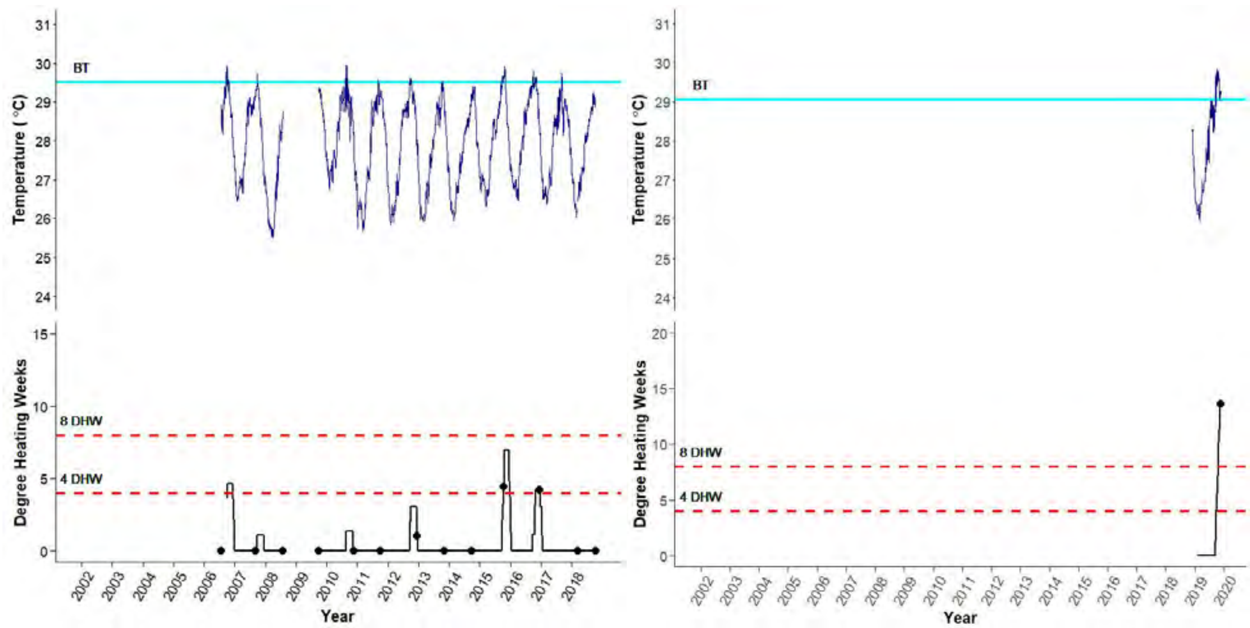


Figure 155. South Capella benthic temperature record (Top right: 24 m depth, top left: 35 m depth).

Physical Characteristics.

Current. Currents were directly measured at South Capella and this data will be included in a future report. 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.

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

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. The site lost 56.4% of its cover and had not regained any cover by 2011 (-3.7% recovery). 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.).

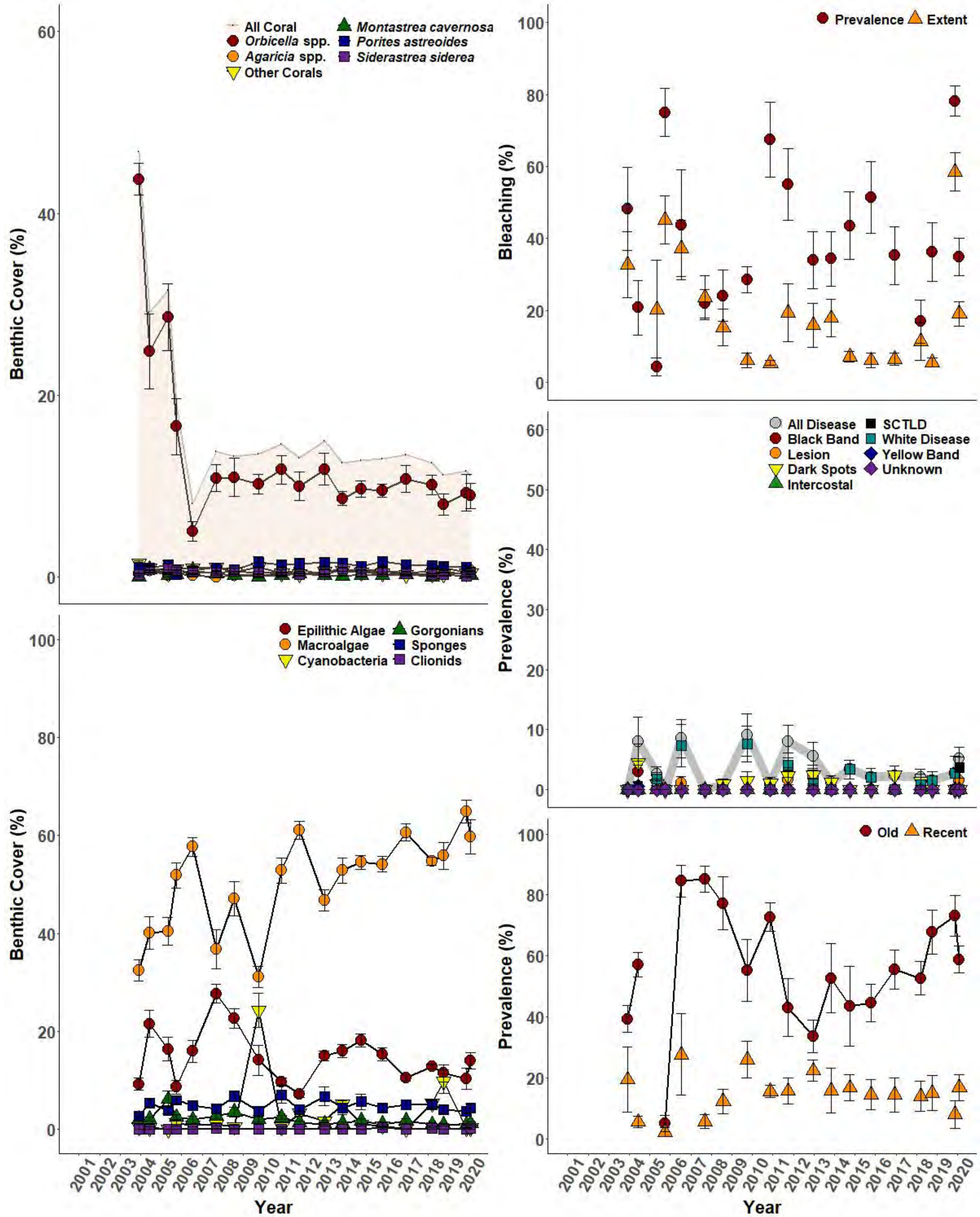


Figure 156. South Capella benthic cover and coral health through time (mean ± SE).

SITE SUMMARIES

Fish Community. South Capella is characterized by a diverse fish community that is fairly 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 durgeon, 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 offshore site.

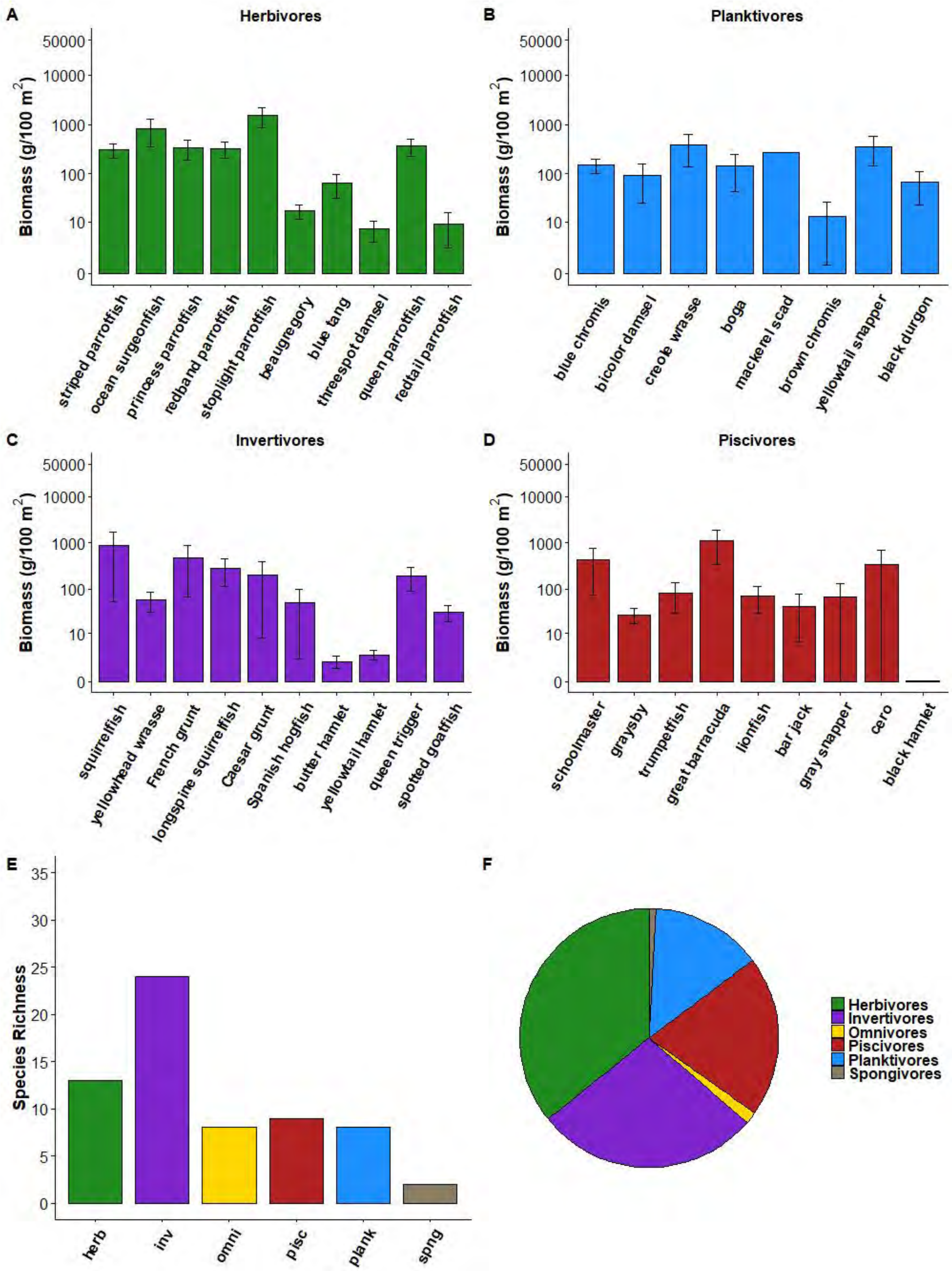
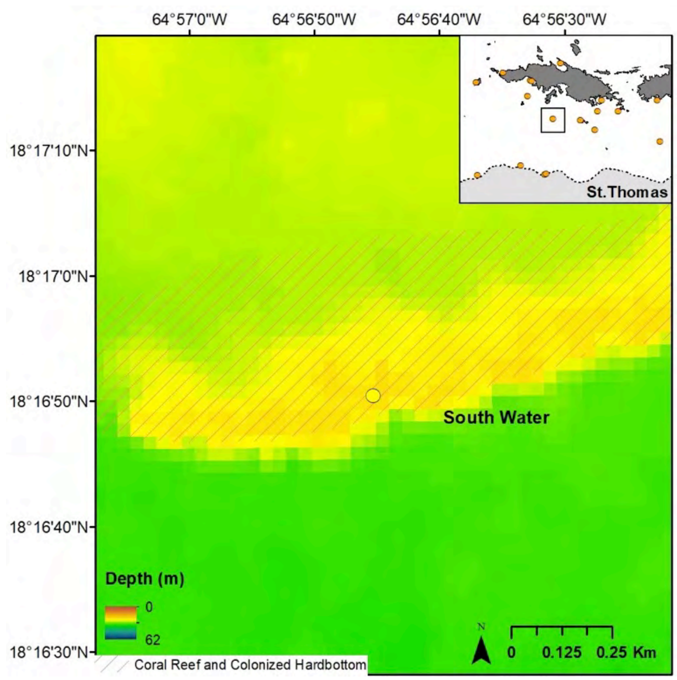


Figure 157. The South Capella fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

SOUTH WATER

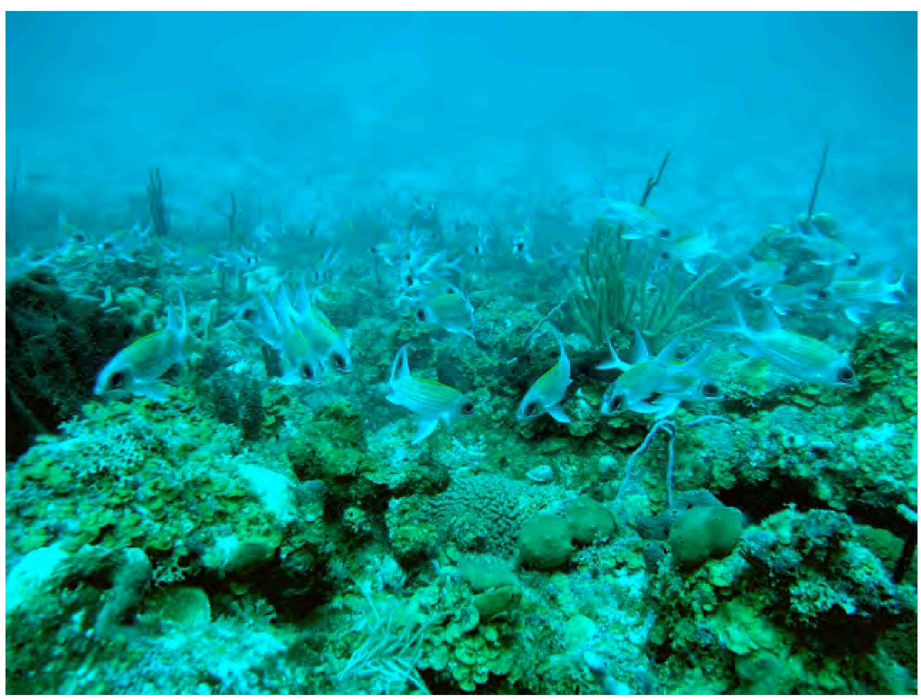
Description. South Water is a hardbottom coral community along the sharp break of a midshelf reef complex in depths of 17 – 28 m. The reef has a sharp break in slope leading to a steep escarpment that terminates in a sand/sediment plain at the reef base. South Water has been monitored since 2005, with 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 158.South Water. (top) Location. (right) A representative photo of the reef.



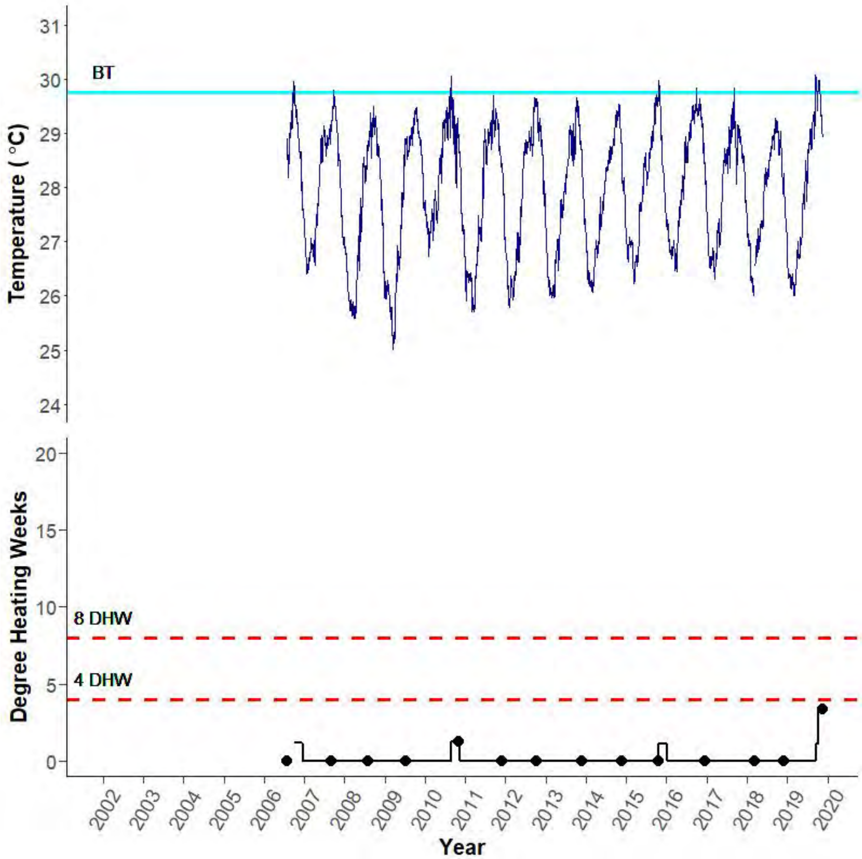


Figure 159. South Water benthic temperature record (24 m depth).

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.

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.

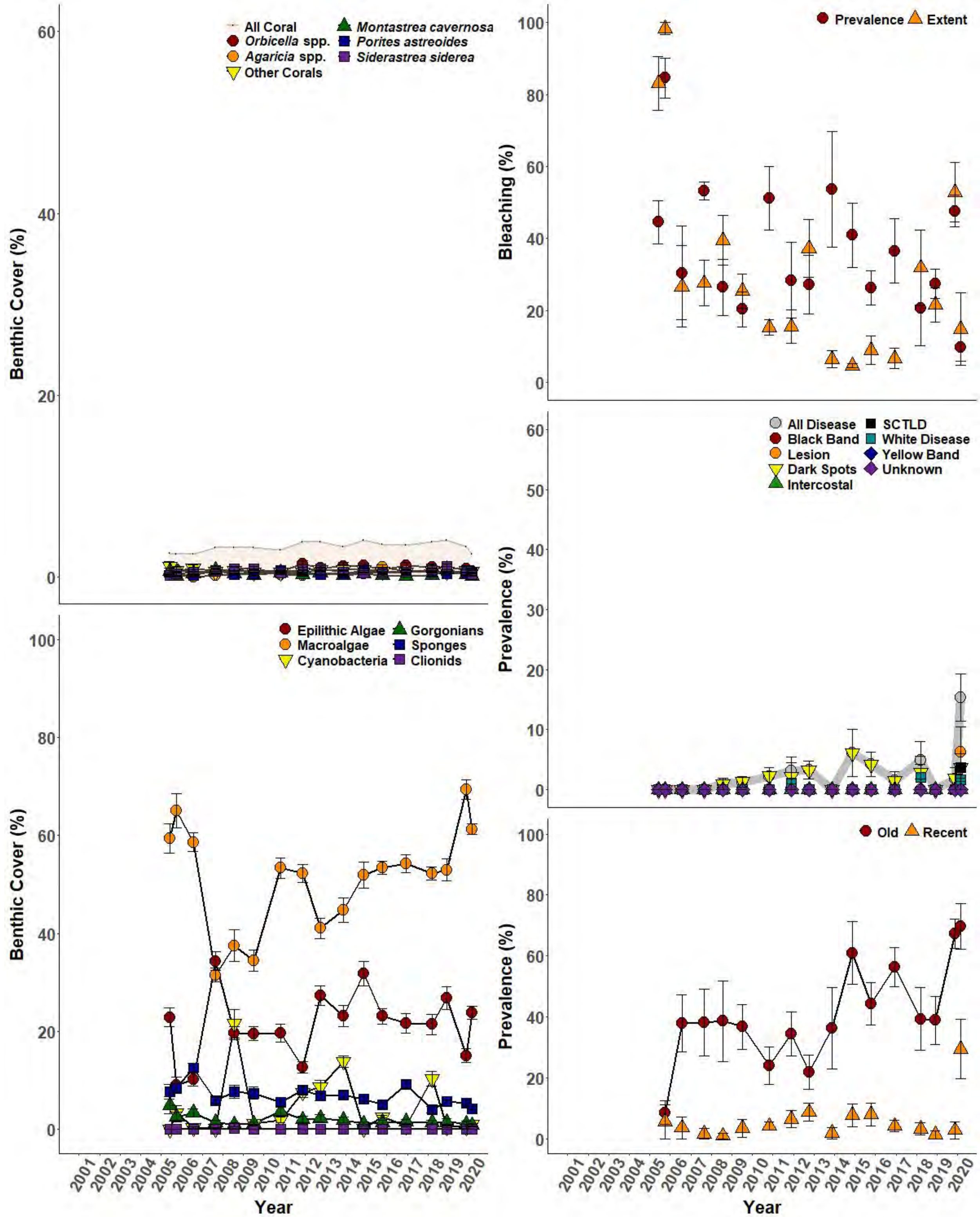


Figure 160. South Water benthic cover and coral health through time (mean ± SE).

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. With the exception of mutton snapper, the reef is bare of large snappers and groupers.

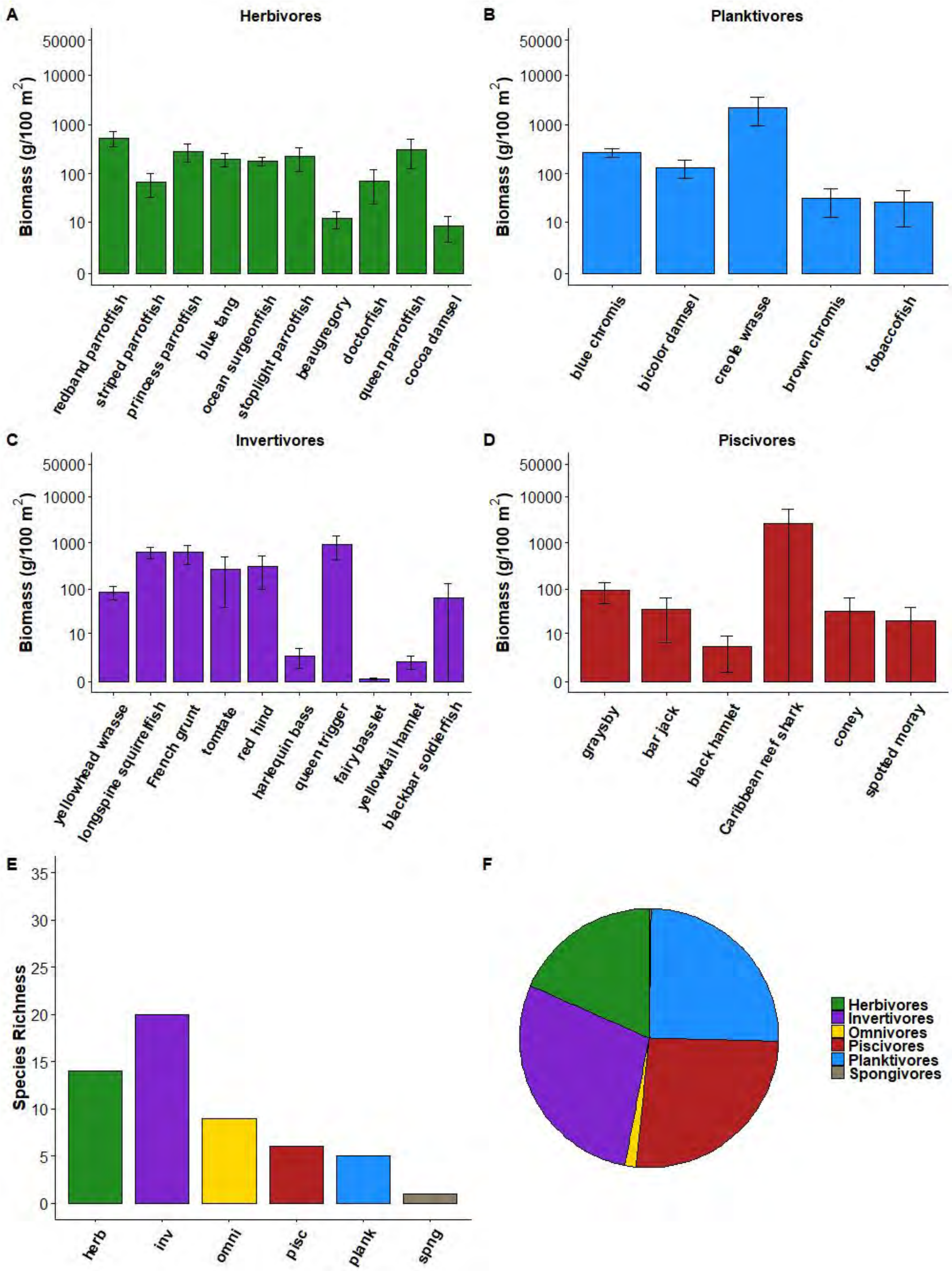


Figure 161. The South Water fish community as (A-D) average biomass per trophic group with the most common species shown in order on the x-axis, (E) species richness, and (F) relative community composition by total biomass. Note that biomass is a log scale.

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