Coral Reefs Baseline Study for Aruba

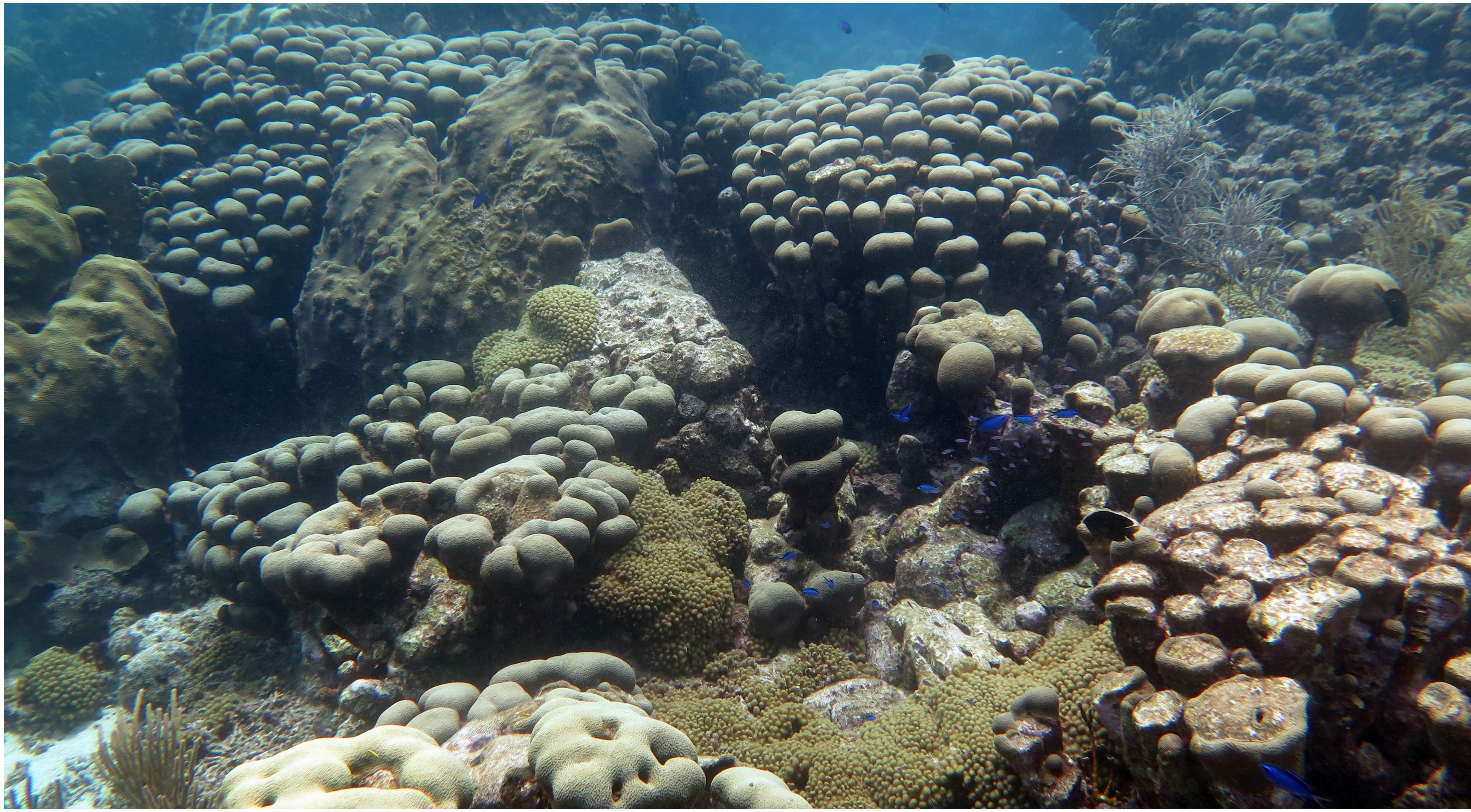
2019

Report prepared by: Dr. Mark Vermeij (CARMABI, Curaçao), Dr. Kristen Marhaver (CARMABI), Andrew Estep (GCRMN) and Dr. Stuart Sandin (Scripps Institution of Oceanography)

Commissioned by:

DIRECTIE NATUUR & MILIEU

GOBIERNO DI ARUBA



The contents of this report, including any errors or omissions, are solely the responsibility of CARMABI. This report does not provide for recommendations about future protection or management initiatives. Rather, the report provides an evidence-based assessment that identifies the status of Aruba's coral reefs along the Leeward side of the island at a depth of 10m, and if reliable information already exists, provides an expert opinion on trends, risks and threats of these systems to inform future protection and management initiatives. It provides a snapshot of the current condition of Aruba's leeward reef systems and examines, where possible depending on historic information, how its condition has changed through time or can be expected to change in the future.

Acknowledgments

CARMABI prepared this Marine Scientific Assessment with critical research, drafting, and editorial support provided by researchers from the Global Coral Reef Monitoring Network (GCRMN) and Scripps Institution of Oceanography. Zach Quinlan (San Diego State University, U.S.A.) and Irina Koester (Scripps Institution of Oceanography) are thanked for their help analyzing water samples. Dr. Jennifer Smith is thanked for her assistance with the isotope analyses. CARMABI especially thanks the Captain and crew of the Spicy Tuna for their support during the marine surveys in May 2019. CARMABI also expresses its gratitude to the Government of Aruba, especially Gisbert Boekhoudt and Robert Kock of the Directorate of Nature and Environment (DNM) for providing background information and suggestions to improve earlier versions of this report.

Contents

Background

There is almost no systematic information about the state of marine ecosystems in Aruba. A recent report commissioned by the United Nations Development Program (Pantin 2011) also noted an almost complete lack of information on Aruba's ecological resources, carrying capacity, limits of acceptable change and the existing level of environmental stress. The Government of Aruba therefore aims to create an assessment program to monitor the status and changes in the reef communities along its coastline. CARMABI, a Curaçaoan foundation specializing in tropical marine research, was selected to conduct the baseline assessment in collaboration with the Scripps Institution of Oceanography (U.S.A.) and the Global Coral Reef Monitoring Network (U.S.A.).

The geology and climate of Aruba

Aruba is the smallest and most western island of the Dutch Leeward Islands of the Lesser Antilles. Aruba is one of the most western islands of the Aruba-La Blanquila chain, consisting of little islands and atolls along the Venezuelan continental border. Aruba is situated just north of the Venezuelan peninsula of Paraguana. The island is generally flat and Mount Jamanota (189 m) is the highest point on the island. Aruba is, contrary to Bonaire and Curacao, not separated from the Venezuelan continent by the Bonaire Basin but is part of the Venezuelan continental flat (Van den Oever 2000). The distance between Aruba and the Venezuelan peninsula Paraguana is about 35 km and the maximum water depth in between is less than 190 m. The island is 31 km long and 9 km wide and its surface area is 178.91 km^2. The main axis of the island has a NW-SE direction.

Throughout its geological history, Aruba has undergone tectonic displacement, uplifting, sea level rises, and geological deformation that resulted in present day differences in morphology, mineral composition and physical-chemical characteristics of the rocks constituting the island. Aruba is currently comprised of a core of folded metamorphosed sedimentary and igneous rocks of Cretaceous age, unconformably overlain by (possibly) Eocene, Neogene and Quaternary limestone deposits (de Buisonjé 1974, Herweijer and Focke 1978). Its geological setting consists of three major lithological units: the Aruba Lava Formation in the central and northeastern part of the island, a tonalitegabbro batholite covering the main part of the island, and Neogene and Quaternary limestones (Van den Oever 2000). Sea level reached its current level about 3500 years ago and is rising at a rate of -4 mm per year at present (Parkinson et al. 1994, Hearty and Tormey 2017).

Aruba is situated in the Southern Caribbean Dry Zone characterized by a tropical steppe/semiarid hot climate (BSh) based on the Köppen Climate Classification (Kottek et al. 2006). Aruba lies on the southern fringes of the Hurricane belt. Only once every 100 years considerable damage is caused by tropical hurricanes passing just south of Aruba, though three Cat 2 hurricanes passed close to Aruba (< 20 km) in a relatively short time (1877, 1886 and 1892). Rough seas caused by tropical hurricanes or mid-latitude storm systems passing to the north can still cause some damages through beach erosion and coastal flooding (Departemento Meteorologico Aruba 2019).

Aruba has a dry and rainy season with sustained moderate to fresh Eastern trade winds and minor seasonal variations in wind direction and speed exist (mean wind velocity is about 7.7 $m\ s^{-1}$). Since 1970, a total of 19 tropical storms or cyclones has passed the 70°W meridian in the vicinity of Aruba. Daily average air temperatures vary minimally between 27°C (January and February) and 30°C (August and September). Variability in rainfall is greater than variation in temperature and greatly depends on the presence of tropical storms in the region. Large differences in total rainfall exist among years and the amount of rainfall appears to increase in recent decades. Average annual rainfall in recent years (2000 to 2011) was 588 mm, which is higher than the island's long-term average of 410 mm measured between 1953 and 1972 (Derix 2016). Rainfall decreases from the Southeast to the Northwest due to the direction of the trade winds and the island's topography (Finkel and Finkel 1975). Most (~90%) rainwater drains underground to the western coast especially in areas comprised of limestone or along fault lines and through smaller fractures and cracks in more impermeable rocks types (Finkel and Finkel 1975, ter Horst and Becker 2001, Derix 2016). Groundwater in Aruba is brackish, and increasingly so towards the coast due to subterraneous infiltration of the island by seawater (van Sambeek et al. 2000). Annual average seawater temperatures at the surface (SST) have increased over the last century and currently range between 27.0°C (1986) and 28.5°C (2010) (between 1985-2018; NOAA 2019). Highest SSTs occur in October.

Diurnal tidal differences are small around Aruba: the spring tidal range is 0.43 m and the neap range is 0.13 m. The wave climate is almost exclusively dominated by the trade winds with wind waves hitting the island from the east for 67% and from the north east for 18% of the time (Terwindt et al. 1984). From June until October the trade winds shift a little towards the southeast and during this period there is a vast increase in northward longshore currents that can be very strong at times. The average wave height is about 1.5 m and the average wave period is 7 s. Under normal conditions, wave refraction takes place around the north and south tips of the island whereby refracted waves meet near Manshebo resulting in unpredictable current speeds and directions at this site. A wave-generated longshore current is primarily responsible for alongshore sand transport, whereby sand is mainly derived from the erosion of skeletons produced by marine organisms, such as corals and certain algae. There is a net longshore current along the southern part of the island towards Manshebo (Terwindt et al. 1984) resulting in an accumulation of sediment at Aruba's most western side and beaches. A different pattern arises when refracted swell waves generated by hurricanes or storms tracking inside or tracking east or north of the Caribbean Island Arch hit the island. During such times, swell waves can produce high breakers that, when reaching shallow waters, are capable of causing damage to coastal infrastructure and sediment normally moving westward during wind wave conditions starts moving east (Kohsiek et al. 1987).

Historical context

Pre-ceramic people have visited Aruba incidentally since ~4,000 BP, especially the island's coastal areas where they depended on a hunting/fishing and gathering lifestyle (Versteeg and Ruiz 1995). Ceramic Indians arrived on Aruba around 900 A.D. and lived on the island lasted until 1499 when the island was colonized by the Spanish who deported the entire Indian community to Hispaniola. The Dutch occupied Aruba in 1636 While Curaçao was used as an administration and military outpost and Bonaire was used to produce salt, Aruba was foremost used to raise cattle to support Curaçao. These activities of the early colonizers impacted land and marine ecosystems on Aruba through deforestation, overharvesting and grazing resulting in heavy erosion (Hartog 1953). In the mid-17th century large numbers of goats and sheep roamed and grazed the land and severe overharvesting of trees (for e.g., ship repairs and charcoal production) occurred in the subsequent 3 three centuries (Hartog 1953).

Starting in the mid-18th century, when piracy declined in the region, Aruba was deemed "safe for inhabitation" by settlers from Europe and Curaçao that, like the Indians, sustained themselves through small-scale agriculture, fishing, herding of cattle and trading with the South American mainland. At the beginning of the 19th century, Aruba was described as "harsh, barren without much vegetation and with little or no topsoil", "devoid of forests" and characterized by "large open panoramas" (Teenstra 1837). Aloë vera was introduced to Aruba in 1840 and became the main product of export in the late 19th century.

Aloë was mostly farmed on the limestone terraces at the southwest side of the island and Aloë plantations covered approximately one third of the island at the beginning of the 20th century (Teenstra 1837). Around that same period phosphate was mined from guano at the island's southern coastal areas. The production and export of Aloë, phosphate, but also gold stopped at the beginning of World War I.

After the discovery of oil in Venezuela, refineries were built in the Dutch Caribbean after World War I: two on Aruba and one on Curaçao. The arrival of the oil industry on both islands improved their economies and welfare (Ridderstaat 2008). Many farmers started working in the new oil refineries so that the landscape that was till then characterized by small scale agricultural activities ("cunucu" landscape) wildered ("mondi" landscape) and barren areas became again occupied by plants. These were later cleared again to make space for new developments as the oil refineries attracted many workers and consequently the island's population grew rapidly through immigration. A growing population resulted in an increase in construction in the south-east of Aruba due to a demand for workers by the oil refinery. The development of the island's Leeward shore later moved to the north-west driven by the developing tourism industry.

After a period of economic prosperity, both refineries on Aruba eventually had to close, one in 1953 (Arend oil company) and the other in 1985 (Lago Oil and Transport Company) resulting in a 30% loss of all jobs on the Island. The latter was reopened for a short time afterwards but the new owner (Valero Oil Company) closed the refinery permanently in 2012, though a possible reopening is considered. In 1947, Aruba's government first explored the possibility of developing a tourism industry and already several years later cruise ships arrived at the island. The island's first luxury hotel was built in 1959. Tourism created new jobs on the island and boosted its economy as the contribution of the refineries decreased. The government produced the First Tourism Plan (first compiled in 1981) to generate new jobs by expanding the island's tourism sector and offset unemployment resulting from the refinery closure and to address the reduction in tourist arrivals due to uncertainties surrounding the island's independence ('status aparte") (Cole and Razak 2009). The economic decline rapidly reversed and between 1985 and 2000, another 10 hotels (i.e., ~4000 additional rooms) were constructed. Population numbers also almost doubled in nearly three decades (1987: 58873, 2015: 101080) and the island's countryside transformed into urban sprawl.

In a relatively short period, the Northwestern part of Aruba became a hot spot for tourism and associated businesses, whereas private housing projects occurred more inland. The intensity of tourism in Aruba is enormous and measured as hotel rooms per surface area, it is among the highest in the Caribbean (Cole and Razak 2004). There is concern that the Island is approaching its carrying capacity for tourism either because of the exhaustion of resources that can be used for recreation or through tourists' sense of overcrowding. Tourism accounts directly for ~30% of the island's GDP and when indirect contributions are included this value increases to ~90% and is expected to reach 97.4% by 2027 (Charles 2013, Polaszek et al. 2018). Currently, ambitions exist to diversify the economy in the areas of technology, finance, and communications.

Economic value of Aruba's natural ecosystems

Functioning ecosystems provide a range of services and benefits to humans, including supporting, provisioning, regulating and cultural services (Millennium Ecosystem Assessment 2005). Aruba's natural scenery is recognized as a prime asset by the tourism industry (Murphy 2011). The value of Aruba's ecosystems through tourism, culture, fishing and carbon sequestration exceeds US$ 287.3 million per year (Polaszek et al. 2018). Direct expenditures by tourists contribute by far the majority of this amount, i.e., US$ 269 million, making Aruba the second most dependent country on tourism in the world based on tourism's contribution to a nation's GDP (Polaszek et al. 2018).

Following concerns that Aruba is losing its tourist attractiveness and competitiveness with other islands in the region, the Forum for the Future of Tourism in Aruba concluded in 2011 that (amongst other factors) "the restoration of environmental forces and pristine natural Aruban settings is of major concern to be able to compete internationally for tourist visitation" (Murphy 2011). In 2018, the Aruban Government itself stated that further deterioration of the island's natural resources would come with negative impacts for the island's tourism industry (Ministerie van Ruimtelijke Ontwikkeling 2018). A recent survey confirmed that ~50% of present-day tourists, mostly from the U.S.A. (~60% of total) would not return to Aruba if the island's ecosystems, marine and terrestrial, would deteriorate compared to their present day's condition. This is especially worrisome as Aruba is well known for its high rate of repeat visitors (Gamarra 2018). In sum, the above clearly illustrates the importance of nature management to support the island's most important source of income, i.e., tourism (Polaszek et al. 2018).

Sensitive ecosystems: coral reefs

The dramatic future painted for coral reef is often dismissed and considered as "unrealistic" or "unlikely to occur". However, several Caribbean locations have now experienced the consequences of sudden reef degradation (i.e., "collapse") and found out three things. First, when reefs collapse, they often do so unexpectedly as factors till then believed to be unimportant, turn out to be crucially important to maintain the functioning of coral reef systems. A precautionary approach to reef protection is hence crucial. Secondly, once reefs degrade and one realizes what is lost, it is generally too late to reverse reef degradation and lastly, once services provided by reefs through e.g., tourism and coastal protection are lost, reef degradation turns out to be costly as such services need to somehow be replaced. For example, the Dominican Republic depends on its beaches to attract tourists and the island's coral reefs produce the sand to form beaches and prevent the shoreline from eroding. When the reefs in the Dominican Republic started to disappear, the beaches also disappeared which negatively impacted tourism. Researchers found that for each meter of beach a resort loses the average per-person hotel room rate drops by about $1.50 per night (Wielgus et al. 2010). If beaches continue to erode at the current rate, the Dominican tourism industry stands to lose $52-100 million in revenue over the next decade. Another example showing the economic impact of degrading natural resources: a 2003 study found that overfishing at landing sites on Jamaica's north coast led to a 13 percent decline in total fish catch volume and a 17.3 percent decline in fish catch value between 1968 and 2001 (Waite et al. 2011). Scaling this up to the national level suggests that Jamaica's failure to effectively manage its fisheries will cost the country US$1.6 billion in lost revenues over the period from 1975 to 2000.

The fact that healthy ecosystems provide more substantial tourism revenue than other "tourism branches" (e.g., mass tourisms, cruise tourism) is probably best illustrated by a recent study from Belize (Cooper et al. 2008). In 2007, reef- and mangrove-associated tourists spent an estimated US$176 to $265 million on accommodation, reef recreation (e.g., diving), and other expenses in Belize. This corresponds to approximately US$1M per kilometer of reef per year. Belize's cruise industry, by comparison, brings a high volume of tourists—620,000 in 2007—but has a very small economic impact (i.e., US$5.3 to $6.4M). The entire cruise tourism industry in Belize generates a similar amount of revenue as ~6 km of coastline with functional marine ecosystems, such as coral reefs or mangroves. Another example: Improvement in the collection and treatment of wastewater from coastal settlements benefits both reefs and people through improved water quality and reduced risk of bacterial infections, algal blooms, and toxic fish. Estimates show that for every US$1 invested in sanitation, the net benefit is US$3 to US$34 in economic, environmental, and social improvements for nearby communities (Jeftic et al. 2006).

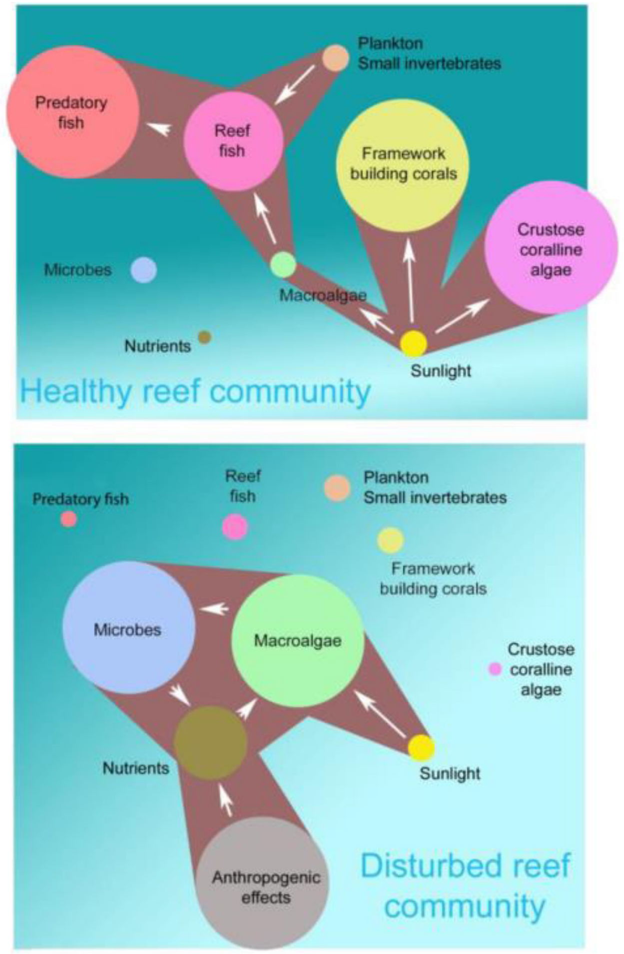


FIGURE 1: Collapse of trophodynamic relationships between functional groups that dominate(d) past and present-day reefs. The shaded area with white arrows indicates the dominant trophic relationships before human disturbance (top) and at present day (bottom).

There are many more examples of the associated costs and benefits that coral reef systems provide to small Caribbean islands. The ones above only show that what might happen once reefs degrade has become reality in localities where protection efforts were begun too late. It is also evident that a failure to protect one's marine resources comes with substantial economic losses.

Stressed reef systems

Despite the observation that reef decline is generally higher in areas close to coastal urbanization, not much is known about the dynamics that drive reef community decline on Caribbean reefs. Most studies have focused on quantifying resultant reductions in coral cover, but such approach is largely retrospective, does not provide early warning signs that decline is forthcoming and hardly generates insight in the dynamics that drive such decline to inform policy and management. Such surveys are often carried out once a year which complicates the direct quantification of episodic and short-lived events (e.g. storms, sewage spills, groundwater inputs). Components of the benthic community other than coral, often respond faster to such inputs and might thus be more suitable for the detection of undesirable land-sea interactions (e.g. (turf)algae and microbes). Increasing evidence (e.g., Dinsdale et al. 2008, Haas et al. 2016) strongly suggests that algal abundance and organic run-off fuel the growth of unnaturally abundant microbial communities in reef waters. "Microbialization" of reef communities could hence be part of their degradation trajectory with subsequent consequences for corals (increases in pathogens) and potentially humans that use the water for recreational purposes. Under increasing human disturbance, coral reef ecosystems start to "leak" energy to trophic levels dominated by opportunistic organisms (e.g. microbes and algae) as longer-lived organisms such as corals and fish are no longer capable of "holding on" to the energy available in a certain area. These predictions are visualized in **Figure 1**, where the size of each circle indicates the relative abundance of various functional groups in undisturbed (top) and disturbed (bottom) reef communities. While many studies primarily focus on the disappearance of key-stone species such as large fish and corals, this figure clearly illustrates that the appearance of less conspicuous functional groups such as microbes and (turf)algae should be taken as seriously.

Potential factors affecting the functioning of Aruba's marine ecosystem in general

Aruba's leeward coast comprises a range of habitats, nearshore reefs, seagrass beds, mangrove stands and other lagoonal systems. These systems (habitats, species and processes) are under increasing threat from human activities, including impacts through climate change.

Global change - Climate change due to increased CO_2 concentrations in the atmosphere result in a warming climate and ocean acidification (Pachauri and Reisinger 2007). Caribbean islands are extremely vulnerable to climate change due to (among others) their small size and a near-exclusive reliance on climate sensitive economic activities such as agriculture and tourism (Taylor et al. 2018). While Aruba's annual CO_2 emissions have increased over the last 3 decades, from 0.30 Mt CO_2 yr^{-1} in 1990, to 0.47 Mt CO_2 yr^{-1} in 2005 to 0.96 Mt CO_2 yr^{-1} in 2017, Aruba currently contributes <0.00% of global CO_2 emissions[1]. Minimizing CO_2 emissions will hence not contribute to meaningful reductions in atmospheric CO_2 concentrations and its consequences such as ocean acidification, increasing frequency and intensity of storms and droughts or rising (sea water) temperatures etc. (Stephenson et al. 2014, Taylor et al. 2018). Corals are particularly sensitive to small changes in temperature because of their narrow thermal tolerance range (Baker et al. 2008). Thermal stress of just one degree Celsius above the long-term summer maximum temperature for a few weeks can cause reef-building corals to eject the algae that live in their tissue, a process known as coral bleaching. While bleaching has (severely) impacted coral reefs on Aruba, its reef communities, like those at Bonaire and Curaçao, are less impacted by bleaching events in comparison to other island in the Caribbean region as coastal wind-driven upwelling in the southern Caribbean can buffer coral reefs from bleaching episodes.

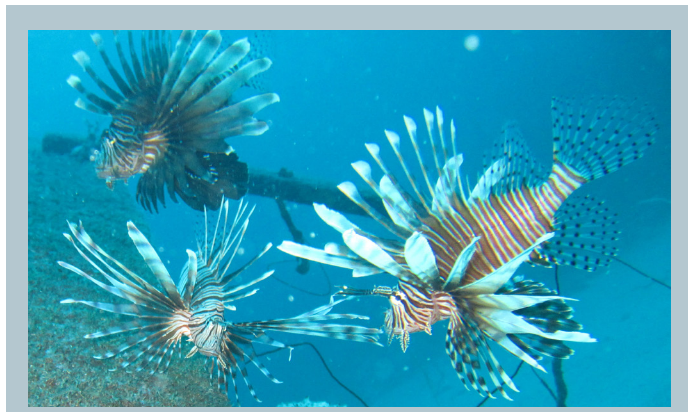
In 2005, high ocean temperatures in the tropical Atlantic and Caribbean resulted in the most severe bleaching event ever recorded in the basin. Another severe bleaching event occurred in 2010 when a second bout of extremely strong thermal stress struck the Caribbean, this time centered on the southern Caribbean (including Aruba) where little bleaching had been reported in the past. A regional average of thermal stress during the 2010 event exceeded any observed from the Caribbean in the prior 20 years of satellite records and 150 years of reanalyzed temperatures, including the record-setting 2005 bleaching event. The return of severe thermal stress just 5 years after the 2005 bleaching event suggests that we may now be moving into conditions predicted by climate models where severe bleaching in the Caribbean becomes a regular event. This does not bode well for tropical marine ecosystems under a warming climate. For example, on Curaçao 12% of the bottom covered by reef building coral "bleached" in 2010 (although in certain areas this value exceeded 30%) and of all affected corals 10% subsequently died.

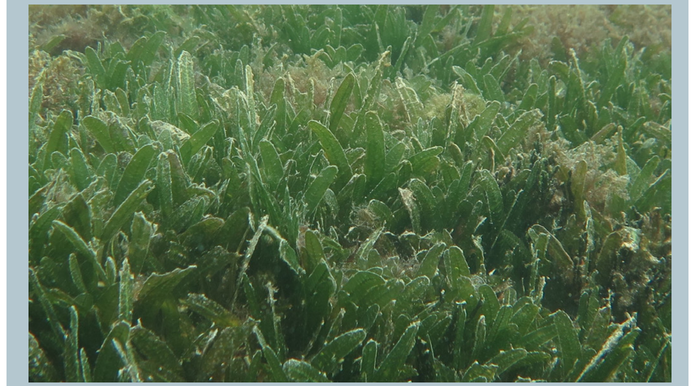
Fishing – An estimated 1700 fishers and 56 active (out of 3000 total) fishing boats exist on Aruba resulting in a total annual catch of approximately 390 tons of reef associated fishes through recreational and artisanal fishing and 359 tons through "industrial fishing". The value of fish caught each year is estimated at US$ 4.45 million, though illegal fishing (mostly in the island's Exclusive Economic Zone) accounts for US$ 2.1 million of this amount (Polaszek et al. 2018).

Most fishers (1492) occasionally take part if fishing activities and only 6 fishers consider themselves full time fishers, with the remainder (177) being "part time fishers". Snappers and jobfishes, wahoo's and "other marine fishes" each account for ~30% of the total catch (Polaszek et al. 2018). A quarter of all Arubans take part in fishing activities at least once a year. Because Aruba is located on the South American Continental shelf it is surrounded by extensive shallow waters so that demersal species like snappers and groupers are more prominent components of local fish catches than those on nearby oceanic island like Curacao (Weidner et al. 2001, Vermeij et al. 2019). The impact of fishing extends beyond fishes as ~20% of all dolphins and whales have been impacted by fishing gear or propeller hits from fishing (or recreational) boats (Luksenburg 2014). No specific studies were found to assess the degree of overfishing on Aruba, but it likely, together with habitat degradation, has contributed to a decline of the island's reef fish communities, similar to e.g., Curaçao (Vermeij et al. 2019). Especially the overharvesting of herbivorous fishes is of concern given their importance in controlling the abundance of benthic algae that would otherwise overgrow neighboring corals (e.g., Mumby 2006, Mumby et al. 2006, Edwards et al. 2011, Bozec et al. 2016).

Exotic species – Eradicating and controlling populations of marine invasive species has been shown to be a challenging task. In contrast to terrestrial invasions, experiences with and methods to deal with marine invasions are limited (Bax et al. 2003) and relatively few marine invaders have been fully removed from their non-native range (Bax et al. 2001). Full removal or control of marine invasives is complicated by the ability of marine invasives to disperse across large distances (e.g. through currents or in ballast water), limited financial and physical resources in areas where invasions have occurred and a persistent reservoir of invasives in remote or hard to access locations. Furthermore, given the large dispersal potential of marine invasives, management of such species often requires international collaboration to ensure effective control.

All aforementioned aspects are relevant to Aruba's management efforts aimed at minimizing the negative effects of the invasive Pacific lionfish (*Pterois volitans*) and the invasive seagrass *Halophila stipulacea*. Lionfish were first sighted in the Atlantic region near the southeast coast of North America in 1985, where they were likely released by aquarists (Semmens et al. 2004). From there, they first spread northward along the east coast of the USA and since 2004 also southward toward the Caribbean Sea (Frazer et al. 2012). In the Caribbean, lionfish have established themselves in a variety of marine habitats, including coral reefs, mangroves, sea grass beds, coastal estuaries and deep waters up to 300 m. They are generalist predators of small and juvenile fish (Albins and Hixon 2008) and characterized by higher predation rates than similarly sized native predators with similar life-history characteristics (Albins 2013). In most areas, natural control of lionfish is unlikely as overfishing has reduced the number of native predators potentially capable of consuming them, e.g. Atlantic grouper species (De León et al. 2013). The invasive seagrass *Halophila stipulacea* (Hydrocharitaceae) has been firstly reported on Aruba in 2013 (Willette et al. 2014). Native to the Red Sea and western Indian Ocean, *H. stipulacea* in the Caribbean has demonstrated exceptional ecological flexibility in salinity, depth and habitat in its invasive range and a high potential to establish itself in new locations.





Box 1: Both the lionfish (*Pterois volitans*) and seagrass *Halophila stipulacea* have become a common site in aruban waters. Worldwide, invasive species are considered one of the main threats to the persistence of native communities and vectors like aquaculture, the pet trade and ballast water are responsible for spreading a large number of marine invasives around the world.

---

[1] Google - public data (https://www.google.com/publicdata/directory)

Waste and pollution – With more than 100.000 inhabitants and approx. 1.7 million visitors per year, Aruba produces a variety of waste products (e.g., medical/ chemical waste, plastics, oil, ballast water, animal cadavers) that to large degree accumulate on the island (Ministerie van Ruimtelijke Ontwikkeling 2018). Dealing with this waste has proven problematic (Derix 2016). Litter and waste are generally discarded in one giant open dump directly bordering the sea, and smaller dump sites can be found across the island (Beroske and Timpen 2018). Landfills produce leachate that contains pollutants that often enter groundwater or surface waters (Kjeldsen et al. 2002). Increases in heavy metal concentrations (e.g., cupper, chromium) have indeed been identified around many dumpsites across Aruba (Beroske and Timpen 2018). While a gas plant is planned to solve the waste problem, the disposal of nutrients and contaminants (including those from coastal cesspools) that leak into soils and waters has proven more problematic and is currently not addressed.

There are 4 locations (Seroe Colorado, Savaneta Bayerlite, Pos Chiquito - Faradaystraat, WEB -dorp Balashi) where domestic sewage water is dumped directly (i.e., untreated) into the sea (Ministerie van Ruimtelijke Ontwikkeling 2018). There are also 3 sewage treatment facilities (Bubali, Parkietenbos, Zeewijk) where sewage water of nearby houses and hotels is partially treated (Ministerie van Ruimtelijke Ontwikkeling 2016)). Land-derived sediments, nutrients, pesticides, herbicides, and other pollutants enter the ocean through wind and rain, especially during the wet season. A fraction of most dissolved nutrients is rapidly taken up biologically or bound chemically, but excess dissolved inorganic nutrients will enter nearshore waterbodies. Nutrients that entered the marine environment can be transported across large distances and increase the susceptibility of corals to disease and thermal stress and promote fleshy macro- and turfalgal growth (McCook 1999, McCook et al. 2001, Vermeij et al. 2010, Vega Thurber et al. 2014). Excessive levels of nutrients like nitrogen and phosphorus in shallow coastal waters (i.e., eutrophication) can also encourage blooms of phytoplankton in the water, which block light from reaching the corals, or they can cause vigorous growth of algae and seaweeds on the sea bed that out-compete or overgrow corals. In severe cases (which have occurred on Curaçao in 2009 and 2011), eutrophication can lead to hypoxia, where decomposition of algae and other organisms consumes all the oxygen in the water, leading to "dead zones". In addition to nutrients, coral reefs change when carbon-based compounds ("sugars') enter the water (e.g., in sewage water). Addition of carbon compounds fuels local microbial communities that feed on these compounds. As a result, microbes increase in abundance and become increasingly more pathogenic. Therefore, in addition to nutrients, unnatural carbon sources (e.g., sewage, terrestrial run off) should be minimized in order to prevent the rise of pathogens (i.e., "microbialization") of Aruba's coral reefs.

Box 2: Examples of severe degradation whereby the abundance of historically abundant reef organisms has severely declined, and benthic habitats are now dominated by high abundance of (cyano)bacteria and various algal groups. The organic material produced by these groups is mineralized in reef sediments by microbes resulting in anoxia, muddy bottoms and rot.

Microbialization - Microbes are often the unseen drivers of many ecosystem processes (Kline et al. 2006, Smith et al. 2006, Rohwer et al. 2010, Haas et al. 2011, Barott et al. 2012, Kelly et al. 2012, Marhaver et al. 2013, Nelson et al. 2013). Microbes convert dissolved nutrients into plankton biomass, which supports the marine food web. Microbial communities influence the health of other organisms through (disruption of) important symbiotic relationships. Natural microbial communities often become altered due to eutrophication, increased algal abundance and introduction of foreign microbes through e.g., sewage water inflow (Haas et al. 2016). Harmful microbes can affect the health of corals, sponges, seagrasses and other organisms, including people, causing disease and mortality. Over-abundance of harmful microbes in the ecosystem arises from other stressors, such as overfishing, exposure to elevated nutrient concentrations and increased temperatures.

Sedimentation - Sedimentation into coastal waters can be extremely high after heavy rains, especially in areas with draining infrastructures that rapidly channel rainwater runoff to the ocean and in areas where land is 'cleared' for development (Derix 2016). In urbanized areas, sedimentation, ground- and rainwater run-off coincide with nutrient enrichment, influx of herbicides, pesticides, detergents and other discharges such as those resulting from inadequate sewage infrastructure such as cesspools. Combined, these processes negatively impact the quality of ground- and surface waters (Cable et al. 2002, Day 2010, Wear and Thurber 2015, Vermeij and Estep 2016). Sedimentation and mechanical damage associated with dredging for the construction and maintenance of harbor and refinery facilities also impacted marine life around Aruba. Dredging and blasting operations resulted in large quantities of sediment into reefal environments. Sediments often become resuspended by shipping activities, further impacting marine ecosystems that eventually no longer possess enough topographic complexity to baffle water flow at the sediment water interface and prevent sediment resuspension (Eakin et al. 1993).

The island's sand budget whereby sand produced by marine organisms moves northward where it supplies beaches and prevents shore erosion was also affected by land reclamation (e.g., the Renaissance Suites Hotel) and earlier dredging activities. For example, the dredging to create the harbor near Oranjestad between 1948 and 1952 severely impacted the island's natural sand budget (Kohsiek et al. 1987). This operation required dredging of 150.000m3 of fine sand. This sand is finer than normal reef sand and was dumped near shore at Pelican Beach from where it moved northward at $35m^3$ day^{-1}. The resulting "opening" in the harbor itself subsequently trapped natural sand moving northward thus reducing the inflow of sand to the island's northern beaches which as a result started to erode and hotels initially built far from shore are now near the waterline.

Oil industry – The development of an oil refinery and transshipment station and the many storage tanks negatively impacted the environment, though these effects remain poorly quantified (Derix 2016). The abundance of important reef building coral species corals has declined severely near and up to 10 km's downstream of the refinery and coral recruitment near the refinery had already approached zero in the mid-eighties (Bak 1987). Growth rates of corals on nearby reefs dropped when refinery operations started (Eakin et al. 1993). The refineries affected their surroundings through under- and aboveground leakage and the use of dump sites for rubble and oily waste, heavy metals, Sulphur, all kinds of toxic waste, and temporary storage of tar residuals (Ridderstaat 2008). The greatest negative impacts resulting from the oil industry on Aruba occurred in the form of leakages from oil holding tanks (into Sint Nicolaas Baai and Commandeurs Baai) and operational losses from the transshipping facilities (Eakin et al. 1993). There are also known indirect effects of the oil industry on Aruba's natural resources: dredging activities aimed to facilitate oil tankers' access to the oil terminals resulted in the complete destruction of reefs in such areas (e.g., San Nicolaas Baai) and the refineries' need for fresh water caused the island's groundwater to become more saline through seawater infusion.

Urban sprawl - Human activities far inland can impact coastal waters and coral reefs. At the coast, sediments, nutrients, and pollutants disperse into adjacent waters where they impact sensitive marine ecosystems such as coral reefs. Such impacts can be reduced where mangrove forests or sea grass beds lie between land and the reefs. Construction currently occurs in areas that formerly were undesirable for building, for example along the northeast coast where salt laden winds easily corrode building materials, or amidst large dioritic boulder formations in the more central regions in Aruba (Derix 2016). Only along the Northeast and Southeast coast remain relatively 'untouched' habitats though they are also used for recreation and tourism. Habitat fragmentation caused by this expanding infrastructure and neighborhoods into former semi-natural areas is considered one of the main causes of ecological degradation of natural habitats on Aruba (van der Perk et al. 2003). National Geographic travel guide recently scored Aruba close to the bottom of one hundred and eleven island destinations in terms of its ''integrity of place''. Instead, Aruba was described as a ''A vacation factory with fabulous beaches, overbuilt, gaudy, fast losing its culture.'' (Cole and Razak 2009).

Tourism - As the oil refinery automated its production after World War II, the Aruban Government initiated tourism development with a ''sun, sand, and sea'' theme (plus gambling) to offset layoffs. The tourism sector has since then rapidly expanded and grown over the last several decades. Construction continues to boom, with hotel capacity currently being ~5 times higher compared to 1985. In stark contrast to other islands, large-scale accommodations became the cornerstone of the Aruban style of tourism (Cole and Razak 2009). The island has developed a rather homogeneous tourism product ("luxury casino-hotel") oriented to a limited segment of the North American market, neglecting potential opportunities for ''destination branding'' based on authentic cultural experience, heritage, and other local attributes that could provide a counterpoint to international chain hotel branding (Cole and Razak 2009).

Lack of legislation and enforcement – Effective legislation to ensure the sustainable management and protection of the island's natural resources is largely lacking (Ministerie van Ruimtelijke Ontwikkeling 2018). In the same report the lack of enforcement is deemed suboptimal as inspectors tasked with enforcing environmental legislation lack a proper mandate. Only the Coast Guard and Maritime Police are mandated to enforce existing rules and regulations. DNM's Inspection department does not conduct enforcement at sea, whereas Parke Nacional Arikok (the management authority of the marine parks) does not have any authority to enforce legislation.

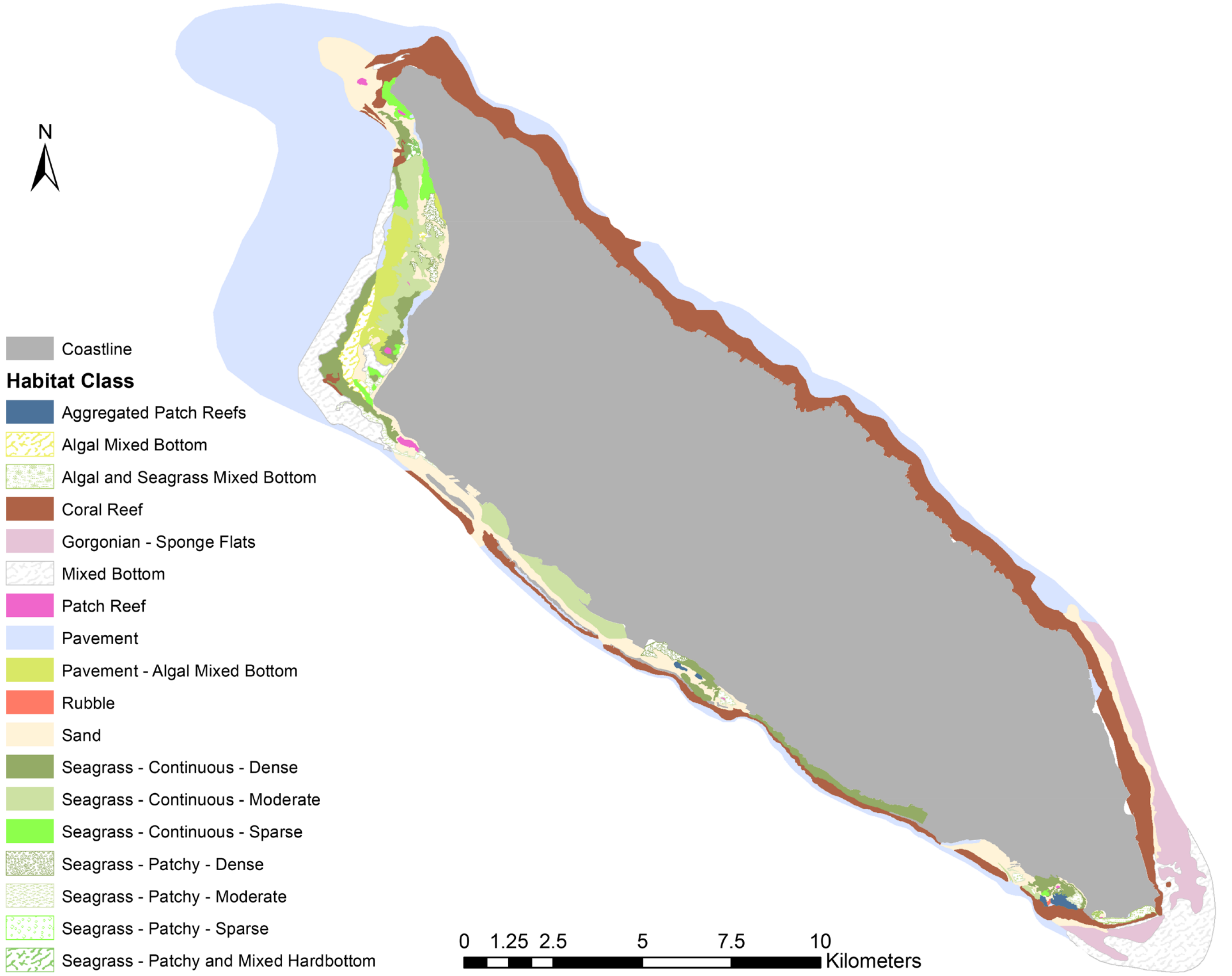


FIGURE 2: General abundance and occurence of main benthic habitat types up to depths of approximately 10 m around Aruba in 2019. Data from satellite imagery and groundtruthing in the field were combined to produce this map.

Aruba's marine ecosystems: general distribution and abundance

The spatial distribution of Aruba's main marine habitat types (up to a depth of approximately 10 meters) was derived from commercially available satellite images (LANDSAT, Quickbird) in combination with ground-truth data we collected in the field in 2019. The resulting habitat map is shown in **Figure 2** and the surface area of the most important habitat types is shown in **Table 1**.

This assessment shows that Aruba possesses a large diversity of habitat types. A continuous forereef extends along much of the Leeward and Windward coast. Along the Leeward coast it tends to only be interrupted by channels between barrier islands. Mixed bottom habitats vary from little hard bottom (<10%) to significant hardbottom (>50%). Surveys revealed these habitats are comprised of a marl matrix (unconsolidated sedimentary rock) more often than patches of hard bottom with patches

TABLE 1: The areal coverage of abundant marine communities and habitat types around Aruba.

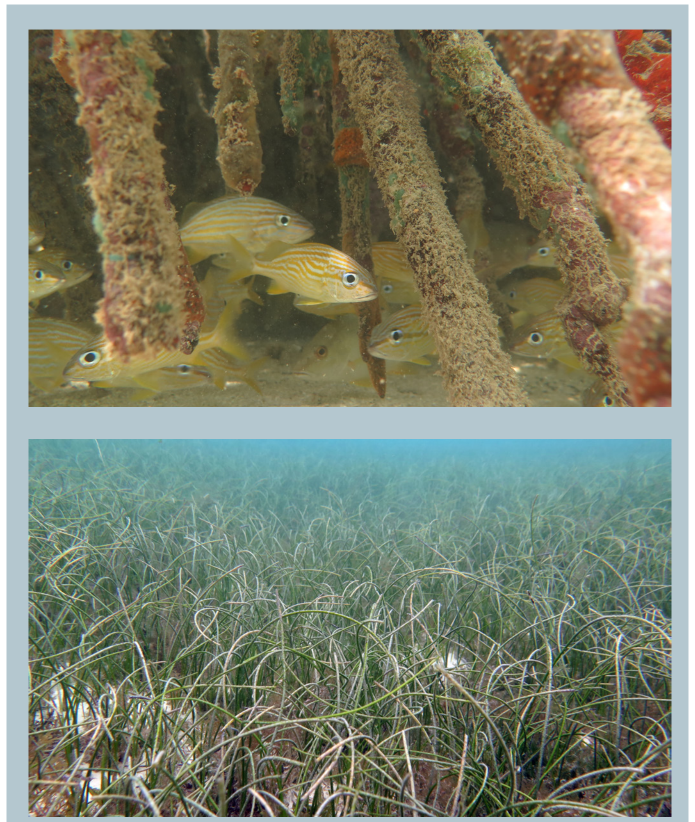
Habitat type	Surface (in km^2) up to a depth of ~10m
Aruba (land)	179
Coral reefs (all)	20.1
Coral reefs (leeward coast only)	4.4
Patch reefs	0.2
Continuous seagrass (dense to sparse)	11.1
Gorgonian-sponge flats	5.1
Sand	9.5
Pavement	48.9

of sand. These habitats are extensive, especially between the Western lighthouse and Surfside beach. Inside the barrier reef complex and along the flats extending along much of the entire leeward side of the island are complex soft bottom habitats. Here, all types of native seagrass beds are found which can be locally dominant around Aruba. These habitats can also be dominated by invasive seagrass (*Halophila stipulacea*), macroalgae and cyanobacteria. The coverage of submerged aquatic vegetation varies from dense canopies and patches to sparsely covered flats and patches. The methods used to produce this map are described on **page 23**.

Aruba's marine ecosystems: general description

In contrast to Curaçao and Bonaire sandy beaches are common on Aruba and present along the leeward coast, while smaller ones occur in boca's along the windward coast. On Aruba dunes can also be found. Part of the shallow sea bottom of the leeward beaches of Aruba is covered by seagrass. Along the Southcoast of Aruba a partly emerged reef is present, with several tiny islands, partly covered by mangroves and separated from the main islands by a long and narrow lagoon. At the seaside of the reef islands the bottom slopes down gradually, without the steep slopes that are common in Curaçao and Bonaire. As a consequence the reefs formed here are more uniform over greater distances in seaward direction than at the steep slopes along the leeward coasts of Curaçao and Bonaire (Roos 1971).

Mangroves - Mangroves grow in tropical and subtropical climates at the transition from land to sea, where they must cope with varying salt concentrations. Different mechanisms, including salt-excreting leaves or ultra-filtration at the root cell membranes, enable water uptake by mangrove trees under saline conditions (Parida and Jha 2010). Species differ in their ability to cope with high salt concentrations resulting in a clear species-specific zonation pattern in Caribbean mangrove forests. Mangrove forests were present already since approximately 7,000 BP on Aruba, but through time became displaced by more terrestrial tree species, either through natural changes in climate, human impacts and/ or extreme weather events (Derix 2016). At the beginning of the 19th century, many mangrove forests were logged to construct houses and to fuel stoves and lime kilns (Versteeg and Ruiz 1995) and uncontrolled logging of mangroves continues until today (Ministerie van Ruimtelijke Ontwikkeling 2018). Mangroves are presently foremost found in some inlets and on the islets along Aruba's southwest shore where they provide protection against waves and currents and serve as nursery habitats for fish and other organisms, but also contribute to pollution absorption, nutrient cycling, primary production and carbon storage (Pendleton et al. 2012, Lovelock et al. 2017). Mangroves in the Spanish Lagoon are designated as Aruba's only Ramsar site and an official management plan exists for this area (dated: November 2017). Presently an estimated total of only 171 hectares of mangrove remains on Aruba (Polaszek et al. 2018) and all mangrove species have been protected as of 2017 (AB 2017, no. 48).

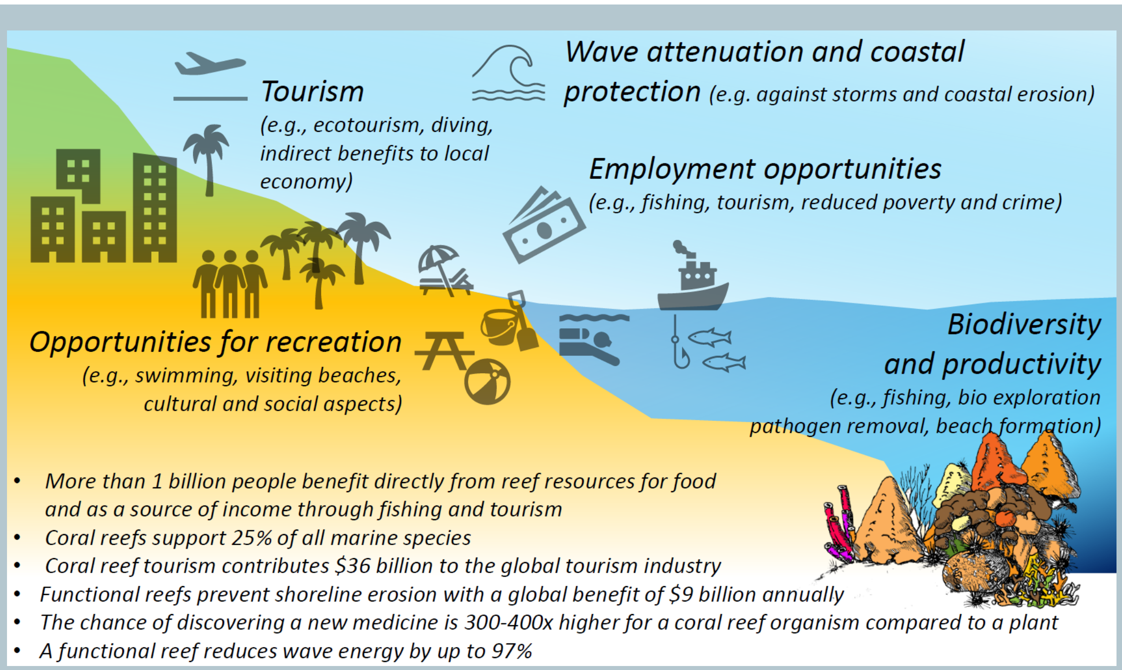


Box 3: Coral reefs are not the only marine ecosystems delivering "ecosystem services", i.e., a value provided to nearby communities in the form of generation of revenue (through e.g., tourism and fishing), coastal protection and by providing options for recreation. Mangroves and seagrasses are similarly valued for their ecosystem services in the form of acting as a natural filter against certain land-based pollutants, as a nursery to support reef fish communities (and consequently fishing) and as coastal protection.

Seagrass meadows - Seagrass meadows stabilize the seafloor, protect it from erosion and storms, and play an important role in nutrient cycling and carbon sequestration (Nagelkerken et al. 2000, Heck et al. 2008, Govers et al. 2014, York et al. 2018). Seagrass meadows even reduce exposure to bacterial pathogens of humans, fishes, and invertebrates (Lamb et al. 2017) and form highly productive habitats for fishes and invertebrates (Sierra 1994, Nagelkerken et al. 2000, Nagelkerken et al. 2002, Harborne et al. 2006) and are the primary food source for green turtles. Seagrass beds currently cover an estimated 1044 hectares on Aruba (Polaszek et al. 2018) and are under immense pressure due to a decrease in water quality and increase in negative human interactions (such as trampling, anchoring, and dredging). In addition, opportunistic invasive species, such as Halophila stipulacea, have started overgrowing native seagrass fields. Similar to mangroves, the economic value of seagrasses per hectare in terms of carbon sequestration (i.e., ~16K and ~4K US$ per hectare yr-1 for seagrass beds and mangroves, respectively) is low due to their low overall abundance (Polaszek et al. 2018). Specific seagrass species have been protected since 2017 (AB 2017, no. 48), i.e., *Halodule wrightii* (shoalweed or shoal grass), *Halophila baillonis* (clover grass), *Halophila decipiens* (Caribbean seagrass or paddle grass), *Halophila engelmannii* (star grass and Engelmann's seagrass), *Syringodium filiforme* (manatee grass),and *Thalassia testudinum* (turtle grass).

Coral reefs - The reefs of Aruba occur mostly along the leeward coast and harbor approximately 68 reef building coral species (Bak 1975,1977) which is relatively high compared to other Caribbean islands (Miloslavich et al. 2010). Reefs along the islands' windward shores are less well developed but are more common that on Aruba's neighboring islands Curaçao and Bonaire. Locally some very well-developed coral communities can be present. Relatively healthy reefs (characterized by e.g., more than 30% coral cover and/ or the presence of Acroporid and other threatened coral species) can still be found locally along Aruba's leeward coast. Acroporid corals were still fairly abundant around Aruba in 1986 (Bak 1987). Vertical zonation of coral species indicates that species' distributions are influenced primarily by depth and wave energy (Duyl 1985). Montastraea spp. (recently reclassified as *Orbicella* spp., i.e., *Montastraea faveolata*, *M. annularis*, and *M. franksi)* are stony, reef-building coral species and contributed predominantly to reef formation in the past thus providing the structural backbone for Aruba's shallow, fringing reefs. The Southwest coast of Aruba has historically been described as a sandy flat, populated with relatively few corals (Bak 1975). In some places (e.g. Arashi) the sandy flat slowly slopes in an offshore direction and changes into a shingle bottom at about 1km offshore around a depth of 20 m. On this loose sediment many small coral colonies occur. South of the Paardenbaai, a steeper slope is present. Dense *Montastraea annularis* communities have locally formed in relatively shallow water (Roos 1971). Down the slope, as sedimentation increases, coral growth decreases until the sandy flat is reached again at a depth of 20 to 30 m. Remarkable and inexplicable is the historic absence of *Agaricia* species at the deeper reef in certain areas that dominate deeper reef sections on Curaçao and Bonaire (Bak 1975). Towards the exposed S.E. point of Aruba coral growth increases and reef community's characteristic of the shallower zones of reefs occured deeper. In response to the strong water movement near the Southern tip of the island, *Millepora* species, *Agaricia agaricites* and gorgonians were very common at a depth of 10 m, where *Millepora* species locally formed large ridges extending seawards (Bak 1975). Coral reef formation on Aruba is largely restricted to shallower depths due to the beginning of a sandy plateau at 20-30m depth. In the recent past (mid 1970's), coral cover at the lower reef terrace and drop-off zone ranged between 30 and 40% (Bak 1977). Patch reefs occur offshore in the Northern part of the island. In the late eighties, *M. annularis* reefs in shallower reef sections had become replaced by a community of small (≤12 cm diameter) braincorals of the genus *Diploria* spp. (Bak 1987). All scleractinian coral species have been protected as of 2017 (AB 2017, no. 48).

Aruba appears to be unique in the sense that the island harbors well-developed coral communities along its Northshore in contrast to its neighboring islands Bonaire and Curaçao. Along the windward shore, coral cover is low between depths of 0 to 5 m where benthic communities consist of sandy and stony bottoms covered by turfalgae. *Siderastrea* spp. are the most common coral species in this zone. In deeper water (10 to 16 m) wave action is reduced and scattered coral communities are present dominated by *Diploria clivosa* and *Montastraea* spp. Macroalgae are abundant and sea fans (mainly *Gorgonia flabellum*) and sea rods (*Plexaurella flexuosa*) are present of in areas between hard bottom communities (Wouters 2018). Fish communities are dominated by grunts (Haemulidae), blue tangs (Acanthuridae), parrotfishes (Scaridae), while small groupers and snapper species were also abundant (Wouters 2018).



- *More than 1 billion people benefit directly from reef resources for food and as a source of income through fishing and tourism*
- *Coral reefs support 25% of all marine species*
- *Coral reef tourism contributes $36 billion to the global tourism industry*
- *Functional reefs prevent shoreline erosion with a global benefit of $9 billion annually*
- *The chance of discovering a new medicine is 300-400x higher for a coral reef organism compared to a plant*
- *A functional reef reduces wave energy by up to 97%*

Box 4: Coral reefs bolster island economies. Coral reefs are among the most biologically diverse and productive ecosystems on earth, providing tropical communities with wealth in the form of tourism, recreation, employment, fisheries production, shoreline protection, beach creation, and cultural heritage (Fig. 1). Some of the best reefs remaining in the entire Caribbean region are found around Dutch Caribbean islands, especially Bonaire and Curaçao. The economic revenue derived directly from coral reefs accounts for 21-63% of total gross domestic product across the six islands of the Dutch Caribbean (Aruba, Bonaire, Curaçao, Saba, St. Eustatius, and St. Maarten). However, as coral reef health continues to decline region-wide due to local and global stressors (especially wastewater, pollution, fertilizer, run-off, coastal development, overfishing, and global change), communities in the Dutch and wider Caribbean risk losing an increasing proportion of the economic, social, and cultural benefits provided by coral reefs.

General description of the 2019 survey of Aruba's shallow water coral reefs

In May 2019, CARMABI and colleagues conducted marine surveys at 53 sites, approximately 700 meters apart, along Aruba's Leeward coast (**Figure 3**). At each site, the health and condition of the reef communities were quantified based on the following reef characteristics: (1) the abundance of reef building organisms and their dominant competitors, (2) the abundance of coral recruits ("juvenile corals") and their competitors, (3) the diversity, abundance, and biomass of all reef associated fishes, (4) the abundance of mobile invertebrates such as lobsters and conch and (5) water quality based on stable isotopes measurements in benthic algae, indicative of the presence of sewage water. At each site, measurements were collected along five 30-meter transects at depths between 9 to 11 m following standardized methods most preferred by the Global Coral Reef Monitoring Network (GCRMN). Use of standardized methods enables comparisons with reef communities elsewhere in the Caribbean where reefs where quantified in a similar matter (e.g., Curacao, Jamaica, Saba, and St, Maarten). An ecosystem is considered healthy if it is able to maintain its structure and function in the face of external pressures (Costanza and Mageau 1999). The overall health of a reef system depends on several local physical, chemical and ecological processes, both natural and related to human activities. This report focusses foremost on the ecological components contributing to reef health.

Human activity has caused significant environmental change for centuries so that identifying the pristine state, or natural baseline, from which to measure environmental change can be problematic. To overcome this problem and to limit the variation associated with many parameters measured in this report, metrics were classified on a scale from "critical" to "very good". Reference values were derived from similar approaches to evaluate reef health in the Mesoamerican Barrier Reef (Mexico, Guatemala, Honduras and Belize) and are based on pre-set values for e.g., coral cover and fish biomass associated with differing levels of reef health (McField et al. 2018).

Marine survey design

Sites were labeled in with increasing numbers starting with ARU_02 in the North to ARU_54 in the South (**Figure 3**). At each site, five 30 m long transects were laid out parallel to shore (**Figure 4**). Along each transect, the number, size and identity of all fish as well as coral abundance were quantified (**Figure 4**). At 10 m intervals along each of the five transects, the abundance of juvenile corals ("recruits") and the height of turf algae (measure for herbivory) was assessed (**Figure 4**, red squares). After counting fish in one direction along the transect line, the number of mobile invertebrates (e.g., sea cucumbers, conch, lobsters) was counted. Lastly, the percentage of the bottom covered by all reef organisms was quantified (**Figure 4**, blue squares). All transect lines were placed at depths between 9 to 11 m.

Methods: assessing the abundance of reef building organisms and their dominant competitors

Percent cover is the percent of the seafloor that is covered by a given species or group of organisms with a similar ecological function. At each site, 75 photographs of the reef bottom (90 x 60 cm) were taken every 2 m (15 per transect) (blue squares in **Figure 4**) to estimate coverage for reef building species (corals and crustose coralline algae) and their dominant competitors (fleshy macroalgae and turf algae). For each photo, the percent cover of all organisms under 25 randomly placed points was determined using specialized software (Photogrid, v1.0) following benthic classifications recommended by the GCRMN (GCRMN 2016). Afterwards, values derived from all pictures taken at one site were averaged values to produce site-wide estimates of species' abundance and cover.

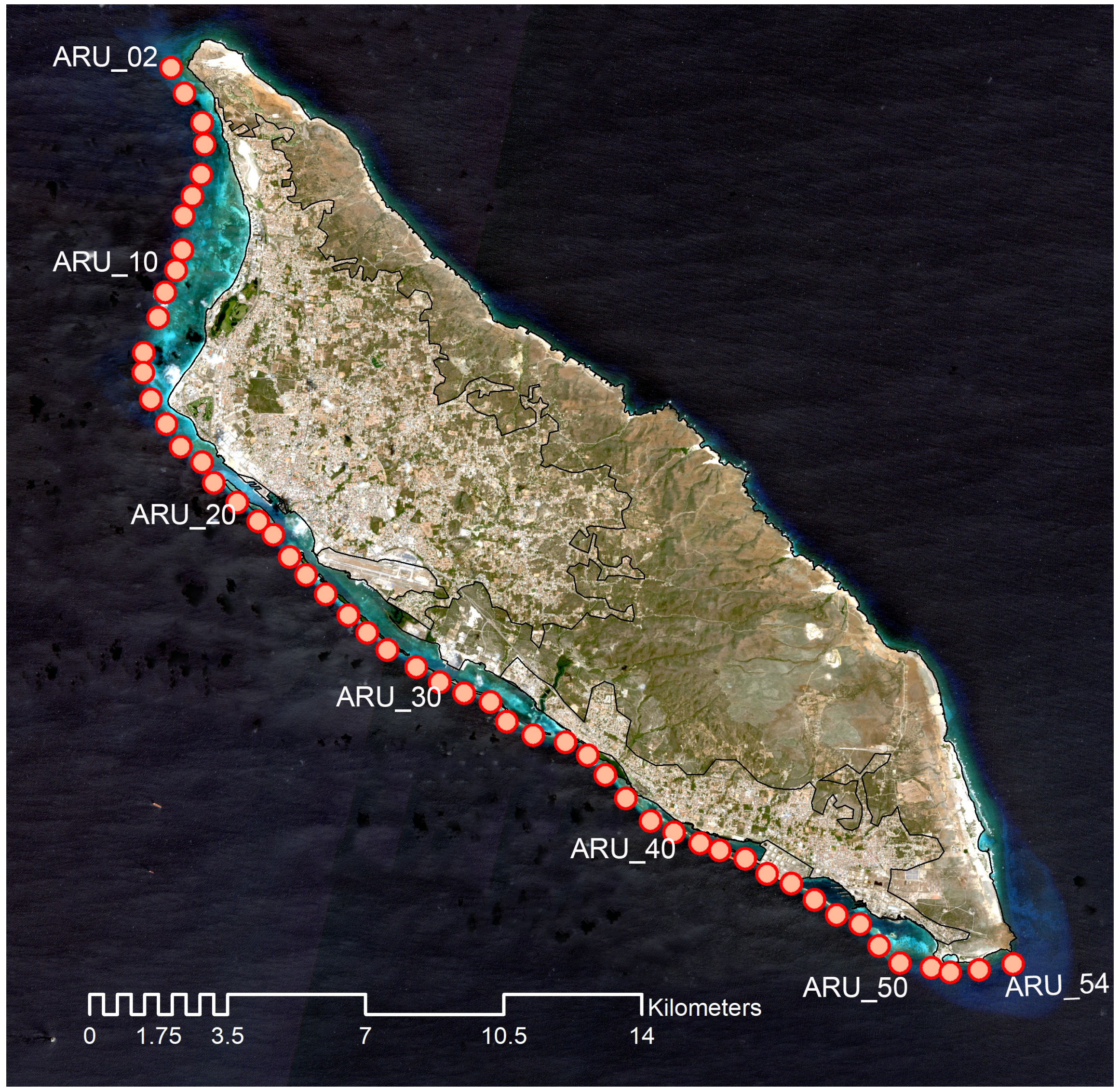


FIGURE 3: Overview of sites (red dots) were surveys were conducted in May 2019. Site names are indicated for some sites as increasing numbers from North to South.

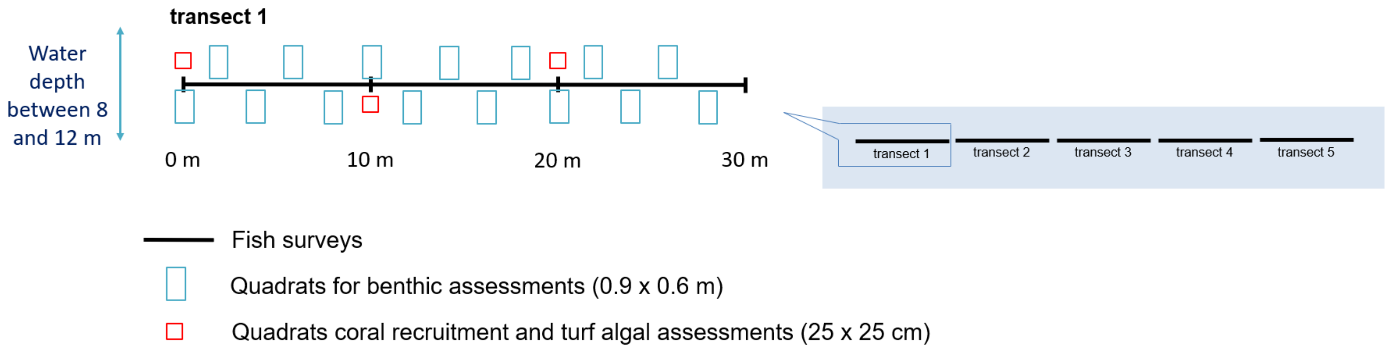


FIGURE 4: Marine survey design to quantify benthic and fish communities at each site.

Methods: determining the abundance of juvenile corals and local degree of herbivory

The goal of data collection for coral recruitment is to estimate the density of young ("juvenile") corals that are likely to contribute to the next generation of adult corals. For each transect, all juvenile coral colonies between 0.5 and 4 cm in diameter were counted and identified to species in three 25 x 25 cm (625 m^2) areas ("quadrats") at 10 m intervals along the transects used for benthic surveys. Because the survival of juvenile corals depends on herbivores removing turf algae that compete with corals for space, the height of turf algae at five random points in the quadrats were also measured to produce an average for each quadrat. "Shorter" turf algae are indicative of higher herbivory at a location and thus provide a measure of herbivory.

Methods: quantifying fish biodiversity, abundance, and biomass

To measure fish biomass, all fish were identified, counted, and sized in 5 cm bins (0-5 cm, 6-10 cm, etc.) along each transect line following a belt transect approach of 30 m length x 2 m width. Survey times per transect were limited to approximately 6 minutes per transect. This time limit is used to prevent a longer search that leads to inflated fish biomass and diversity estimates. At each site, data from all five transects were averaged to provide an average estimate of the density and size structure of all fish species.

Methods: determining the abundance of mobile invertebrates

Common mobile invertebrates on Caribbean coral reefs include sea urchin species, sea cucumbers, conch, and lobsters. Many species of sea urchin, especially the historically common long-spined sea urchin (*Diadema antillarum*), are important herbivores on Caribbean reefs with a capacity to control the overabundance of macroalgae (large fleshy algae that compete with coral for space). As such, sea urchins can play an important role comparable to that of seaweed-consuming herbivorous fishes. The abundance of mobile invertebrates following GCRMN's preferred methodology (GCRMN 2016) is not reported here because a preliminary review of the assessment data indicates that their abundance is so low that reliable estimates of their abundance would require a much higher statistical power than provided by GCRMN's methods. In other words, the abundance of these invertebrates is so low that they no longer provide an ecologically meaningful contribution to the dynamics of Aruba's reef systems within the context of this survey.

Methods: water quality

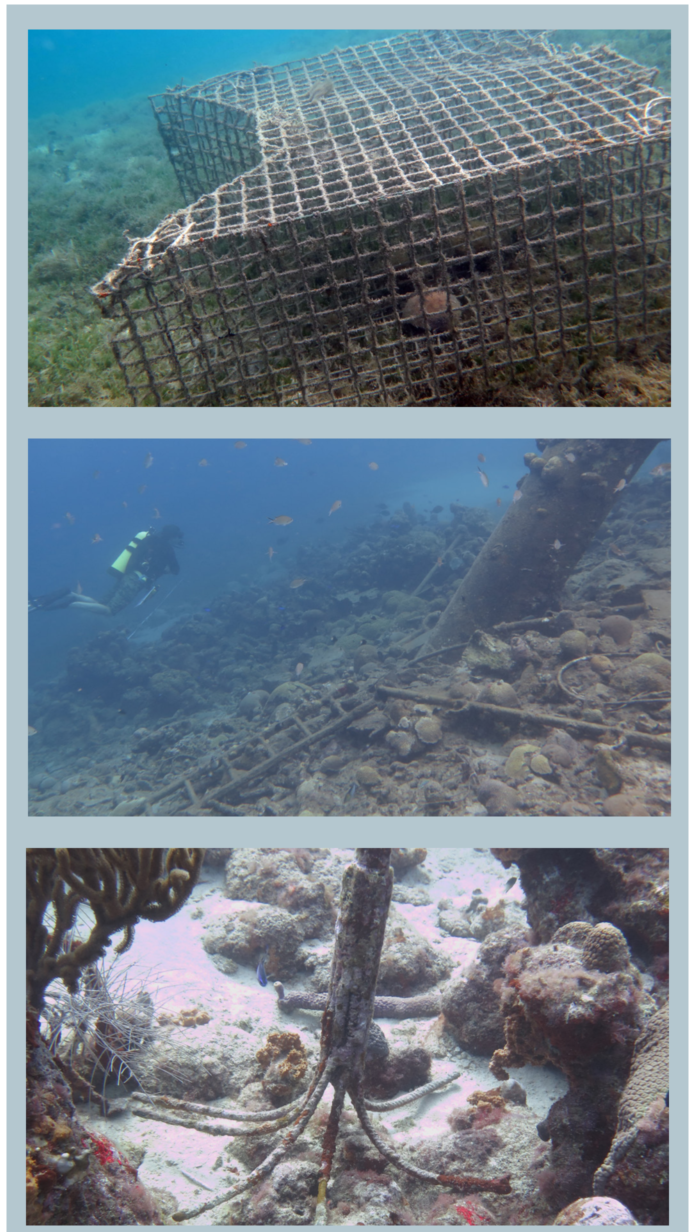
To measure water quality, five samples of the fleshy algae Dictyota were collected along each transect. Using stable isotope analysis (Risk et al. 2009) the ratio of nitrogen 15 (N^{15}) to nitrogen 14 (N^{14}) can be determined. N^{15} increases in relative abundance in higher trophic level organisms (i.e. organisms that consume things are the top of the food chain such as people). The waste from such organisms provides a distinct signal over lower trophic level waste and is therefore indicative of organic waste products, including sewage water (Kendall et al. 2007). Algae absorb both forms of nitrogen based on the availability of N^{14} and N^{15} in water column so that water polluted with sewage will have more N^{15} than waters without sewage, i.e., the ratio of N^{15} to N^{14} will be higher in algae that live in waters polluted with sewage. N^{14}:N^{15} ratios can consequently be used to generate a time-integrated measure of water quality.

Methods: trash

Additionally, all pieces of trash at each site were counted and categorized as follows: (1) trash smaller than 1 m in length (e.g., bottles, cups etc.), (2) trash larger than 1 m (e.g., construction materials etc., but in Aruba's case often lost anchors) and (3) fishing gear (e.g., lost lines and gill nets).

Methods: chemical pollution

At several sites, the chemical composition of seawater was assessed to determine the presence of molecules associated with specific human activities (e.g., tourism, oil industry, pesticides) using metabolome extractions, i.e., the extraction of all small-molecule chemicals found within each sample. Procedures are described in detail in: Quinn et al. (2016), Hartmann et al. (2017), and Petras et al. (2017).



Box 5: Aruba's industrial and fishing history are reflected in the large amounts of debris from lost anchors to industrial waste that can be found all around the island's Leeward shore.

Methods: habitat map

Data on benthic habitat types were collected from the high tide line to depths of approximately 10m at all sites sampled and an additional 137 sites that were not included in the reef surveys. Sample sites were chosen to equally represent different bottom types visible from satellite imagery around Aruba (LANDSAT 8 and QuickBird multispectral data). Some portions of the aerial imagery available for mapping provided excellent visibility through the water column while a significant portion of the images had glare or sedimentation that prohibited photointerpretation. In these cases, an attempt was made to gather context from prominent adjacent superstructures to make a generalized habitat classification. 18 different benthic habitat types could be distinguished (at ~90% accuracy) after combining satellite imagery with in-situ assessments following methods described in: (Mishra et al. 2006, Wabnitz et al. 2008, Roelfsema et al. 2009), i.e., (1) aggregated patch reefs, (2) algal mixed bottom, (3) algal and seagrass mixed bottom, (4) coral reef, (5) gorgonian-sponge flats, (6) mixed bottom, (7) patch reef, (8) pavement, (9) pavement-algal mixed bottom, (10) rubble, (11) sand, (12) seagrass-continuous-dense, (13) seagrass-continuous-moderate, (14) seagrass-continuous-sparse, (15) seagrass-patchy-dense, (16) seagrass-patchy-moderate, (17) seagrass-patchy-sparse and (18) seagrass-patchy and mixed hardbottom).

Methods: additional information

Where possible existing information (e.g., reports, policy documents) was used to contextualize our findings and identify potential drivers of changes in reef composition through time. Only data from peer reviewed scientific papers or reports produced by governments or large NGOs were used to ensure reliable data sources. Published peer-reviewed literature from technical experts was prioritized over other forms of evidence.

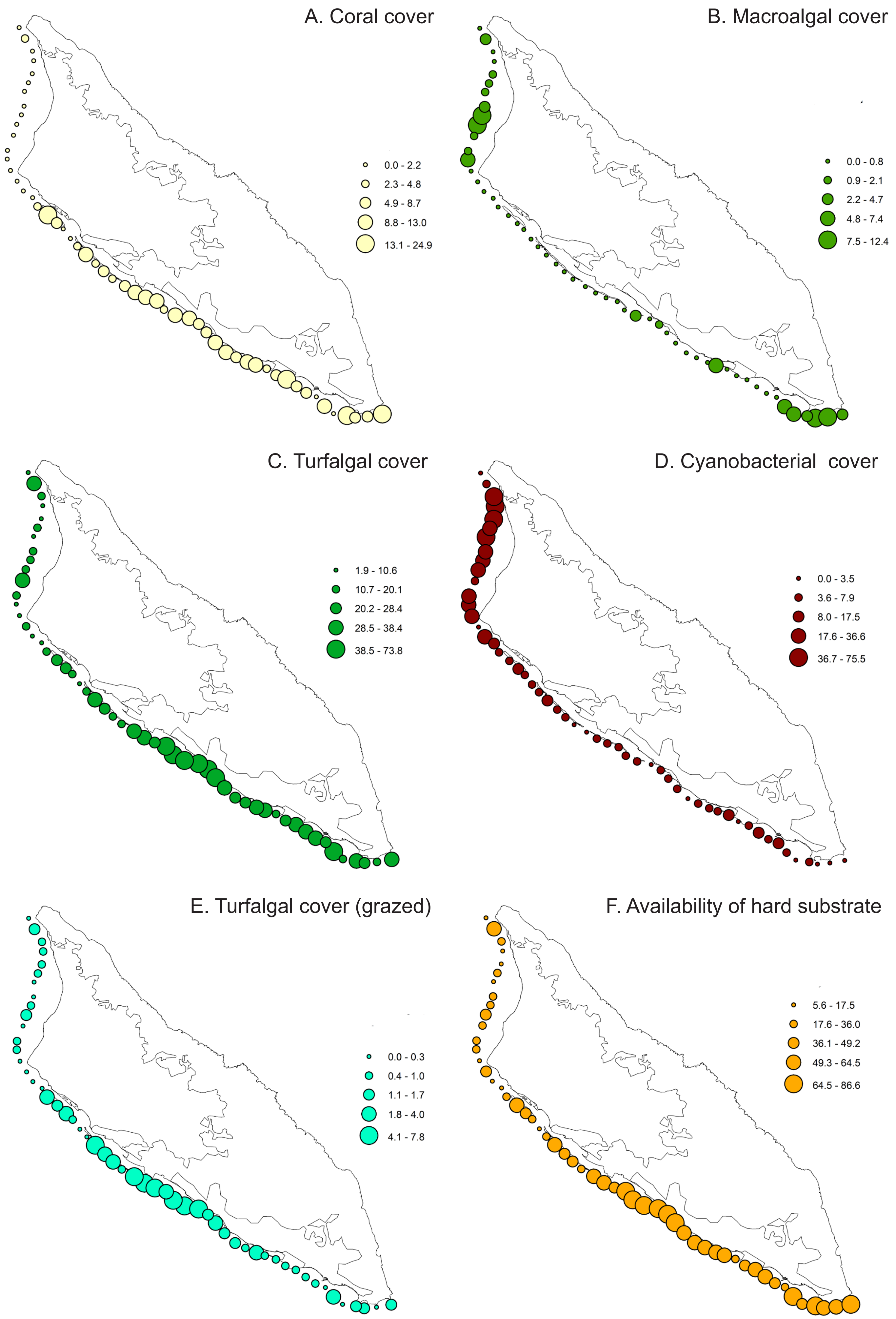


FIGURE 5: Distribution of main benthic groups at 10 m depth along Aruba's leeward shore in 2019.

Results – General distribution of corals

Reef building, or the growth of coral reefs, occurs when net accretion of calcium carbonate by calcifying organisms exceeds net erosion. Hard coral growth is the primary driver of reef building, contributing up to 75 per cent of the total calcium carbonate (Perry et al. 2012). Other calcifiers, such as the alga *Halimeda*, foraminifera and crustose coralline algae, also contribute a significant amount of carbonate sediments to inter-reefal areas and reef-building 'cement', consolidating the reef framework. Average coral cover along Aruba's leeward shore is low at 6.2% (**Figure 5a**). The overall low average abundance of corals is in large part due to the extreme level of degradation of reef systems in the area starting at the northern tip of the island (Arashi Beach, ARU_02) to Manchebo Beach (ARU_15) and further south to Renaissance Island (ARU_24). In this area, average coral cover is only 2.0% (range: 0.0 – 16.7%) and relatively high coral cover (16.7%) is only found at one site near Paardenbaai (ARU_20). From Renaissance Island southward, reef condition improves towards the southern tip of the island (Seroe Colorado Lighthouse, ARU_54). In this area, average coral cover is 9.4% (range: 1.1 – 24.9%) and small pockets of healthy-looking reefs are locally present near the southern tip of the island (ARU_54, and near Rodgers Beach ARU_51). In summary, coral cover on Aruba is currently extremely low and corals have all but disappeared in the area between Arashi Beach and Renaissance Island. Now dead reefs are still visible in this area indicating coral growth did take place in this area in the past. The health of reefs improves towards the South where locally a few healthy reefs are still present. Competition for space is evident among species comprising coral reef communities. Coral diseases were rarely encountered in 2019, and most were most frequently observed at sites near Oranjestad. The prevalence of diseases was also relatively low in 2018 (Wouters 2018).

Results – General distribution of algae and cyanobacteria

Of importance is the interaction between corals and (macro)algae, whereby the balance can be tipped from coral to algal dominance through e.g., higher nutrient levels, coral bleaching events, declining coral recruitment and overfishing of herbivorous species (Mumby et al. 2014). The low abundance of corals cannot be directly linked to a large abundance of fleshy macroalgae that compete with corals for space. Mean macroalgal cover on Aruba was extremely low (1.9%, range: 0.0 – 12.5%) during the time of our surveys (**Figure 5b**). Highest macroalgal abundance was observed in approximately the same area where coral abundance was lowest, i.e., between Arashi Beach and Manchebo Beach, but also near Palm Island (ARU_32), Savaneta (ARU_42) and the southern tip of the island (ARU_48 to ARU_54). While macroalgal abundance is low, the average abundance of turfalgae and cyanobacteria is extremely high along the entire leeward shore (Figure 3c and 3d). Average turfalgal cover is 27.6% (range: 3.5 -73.0%) and 12.7% (range: 0.0 – 75.5%) for cyanobacteria. Cyanobacteria dominate benthic communities between Arashi Beach (ARU_02) to Manchebo Beach (ARU_15) and further south to Renaissance Island (ARU_24), i.e., the same area where corals are presently effectively absent. Due to the high abundance of cyanobacteria, average cover by turfalgae is relatively low in this area (19.4%; range: 3.5 - 45.7%) but increases in the area between Renaissance Island and Seroe Colorado Lighthouse (ARU_54), while cyanobacterial abundance in this area decreases. Though turfalgae are abundant, many of them were observed to be in a cropped state, i.e., their abundance was visibly controlled by herbivores (**Figure 5e**).

Results – Substrate availability

The spatial differences in the abundance of abovementioned groups is in large part related to spatial differences in the availability of hard substrate, i.e., the presence of former reefs created by calcifying organisms in the past. The abundance of sessile organisms (i.e., those attached to the bottom) such as corals and turfalgae overall increases when more habitat (i.e., limestone substrate) is available, whereas cyanobacteria (but also seagrasses) that in large part occur as mats covering sandy surfaces are dominant in areas where these sandy surfaces are abundant (i.e., the northwestern part of Aruba). In short, the present distribution of reef building organisms is driven by the distribution of reefs in the past that have built the surfaces on which these organisms can settle and grow today (**Figure 5f**). The areas where corals are most abundant at present (roughly between Barcadera (ARU_30) and Seroe Colorado Lighthouse (ARU_54)) also represent the areas with the highest availability of substrate in general (and greatest reef complexity) suggesting that coral growth has always been high in this area relative to other areas.

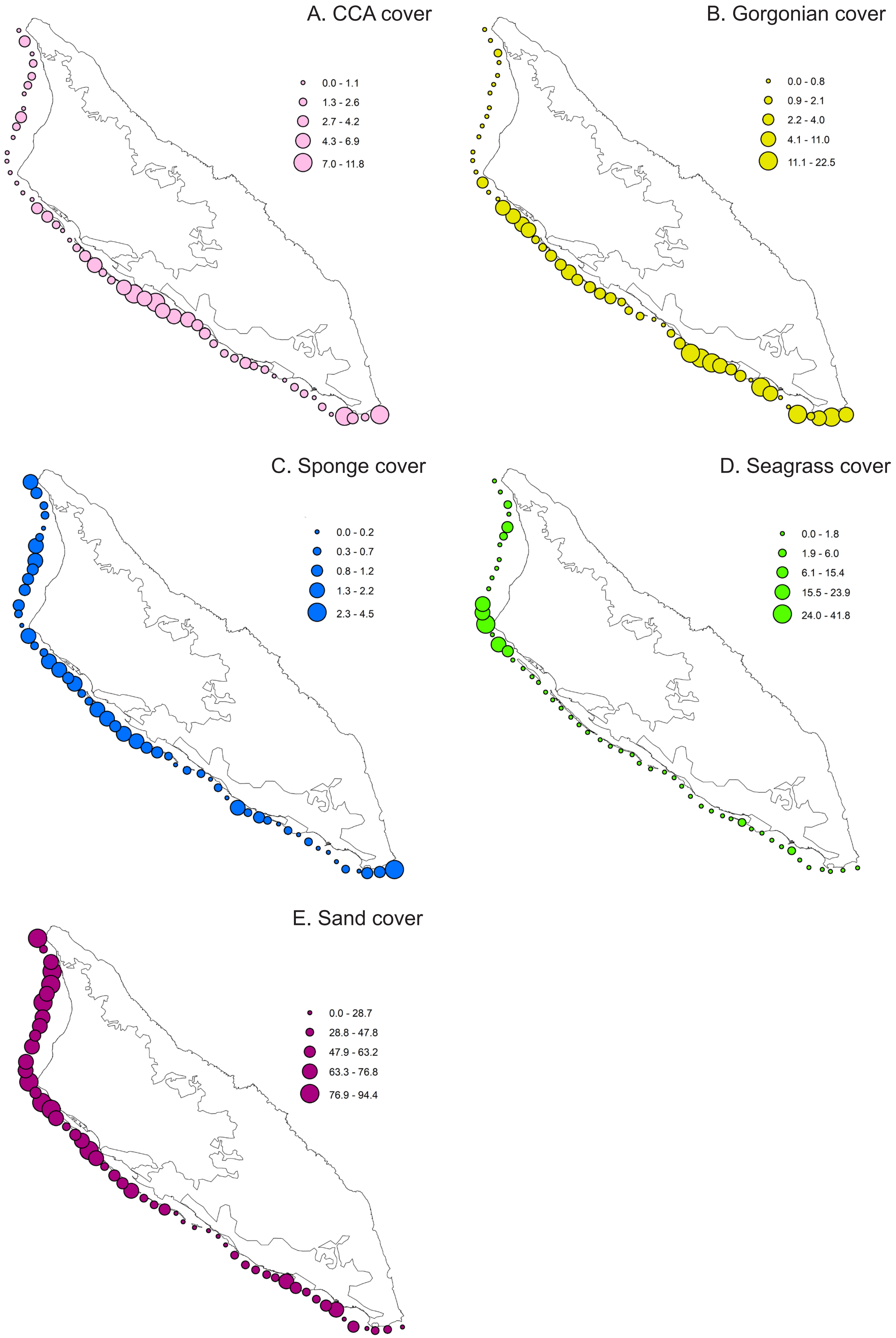


FIGURE 6: Distribution of main benthic groups at 10 m depth along Aruba's leeward shore in 2019 (continued).

The strength and statistical significance of relationships among benthic groups (but also fish groups) reported here are all shown in **Appendix I**.

Results – General distribution of other benthic groups

Crustose coralline algae (CCA) are calcifying algae that solidify reef frameworks and facilitate coral recruitment. Their distribution (**Figure 6a**) largely follows that of corals (between Barcadera (ARU_30) and Seroe Colorado Lighthouse (ARU_54)), though CCAs occur in low abundance in an area measuring ~ 3km around the refinery near San Nicolas. Gorgonians also (**Figure 6b**) follow such general distribution pattern but become rarer in areas in front of openings between the barrier islands or in areas where such barrier islands are missing altogether (e.g., near Barcadera and Baby Beach). Sponges are the only animals that are relatively abundant within benthic communities in the Northwestern part of the island where all other reef organisms (e.g., corals, gorgonians, CCA etc.) are found in extremely low abundances (**Figure 6c**). Seagrasses (at 10m) were foremost abundant in the area around Manchebo Beach (ARU_13 to 18) (**Figure 6d**). Aruban reef communities are extremely sandy (average bottom cover of 39.3%). The Northern part of the island is the sandiest (average cover: 43.1%) but remains high along the remainder of the coast (average cover: 36.4%). Coral communities often occur as large bommies and structures within large sandy flats. Only in the middle of the island is sand cover low (**Figure 6e**).

Results - Sand corrected values?

An approach sometimes used by researchers to express cover of benthic organisms is to subtract the area covered by soft sediments or the organisms that live on them (here: sand, seagrass, rubble, cyanobacteria growing on sand) and express the cover of group X (e.g., corals) as the percentage cover by group as its cover of only hard bottom, i.e., the area not covered by soft sediments or associated organisms. The (theoretical) problem with that approach is that a reef consisting of only sand with one healthy coral with a surface of 5 cm² would be assigned a coral cover value of 100% which suggests an extremely healthy reef whereas corals are pretty much absent altogether. Nonetheless, the benthic cover of all major benthic groups is given in **Appendix II** following this alternative approach whereby coverage calculations are only conducted for areas covered by hard substrates. As a rule of thumb, one could multiply all values reported here by 1.6 to get similar (i.e., sand-corrected) values.

Results – General distribution of reef fishes

The island-wide average total biomass of all reef fishes on Aruba was 139.7 g m^{-2} (range: 9.3 – 473.2) is relatively high for Caribbean standards. Their distribution (**Figure 7**) once again shows a pattern very similar to reef-building species: fishes are abundant in the area between Renaissance Island (ARU_24) and the southern tip of the island (Seroe Colorado Lighthouse, ARU_54), except in the entrance of the harbor of Oranjestad (ARU_17 and 18). Due to the large differences in fish abundance and composition, fish communities in the extremely degraded western part of the island (ARU_02 to 24) and the less degraded remainder of the island (ARU_25 to 54) were considered separately. In the Western zone, average total biomass of all reef fishes on Aruba was 75.3 g m^{-2} (range: 9.3 – 312.7), whereas the remainder of the island (ARU_25 to 54) the average total biomass of all reef fishes on Aruba was 189.3g m^{-2} (range: 56.4 – 473.2). Herbivores accounted for the majority of total fish biomass in both zones but were four times more abundant in terms of biomass outside the degraded Western zone (**Figure 8a**), as were carnivorous fish (**Figure 8b**). Only invertivorous (**Figure 8c**) fishes occurred in somewhat similar abundances in both zones. The distribution of all other fish groups (**Figure 8d-f**) is similar to that of herbivorous fishes, and the fish community at sites between Renaissance Island (ARU_24) and the southern tip of the island (Seroe Colorado Lighthouse, ARU_54) was very similar. Note that site specific estimates for fishes need cautious interpretation as fishes move around so that estimated abundances should be considered indicative of possible abundances within a larger general area.

Predation (the process of animals consuming other animals) influences the distribution, abundance, behavior, fitness, and evolution of prey species. Carnivorous fishes, such as sharks, groupers and snappers, characterize a healthy reef fish community (Sandin et al. 2008). However, these species were found at extremely low abundance across all sites. The depletion of carnivorous species is especially worrisome as they support local fishing economies and control the abundance of certain "nuisance" fish species (e.g., damsel- and lionfish) that, when no longer controlled through predation, inflict significant damage to corals (Vermeij et al. 2015).

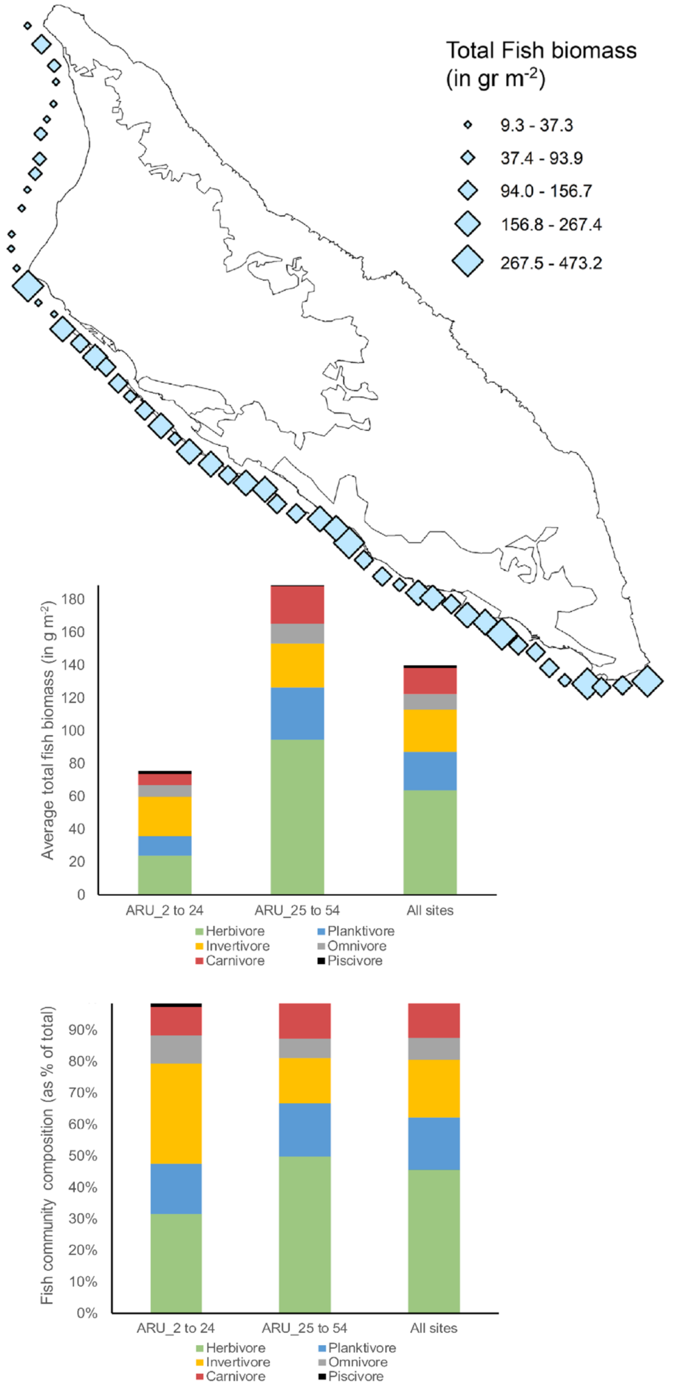


FIGURE 7: Distribution of total reef fish biomass around Aruba (top). Below is the biomass of reef fishes in the degraded Western part and the remainder of the island for the main trophic fish groups (middle) as well as their composition (bottom).

On Aruba, the island wide average abundance of herbivorous fish is 63.6 g m^{-2}. On healthy reefs, biomass of herbivorous fish should be around 70 g m^{-2}, but preferably above 100 g m^{-2} (Edwards et al. 2014). Herbivory is the removal and consumption of plant matter by large herbivores (e.g., green turtles, large parrotfishes) and cropping, grazing and excavation of algae, predominantly by herbivorous fishes and to a lesser extent by mollusks, echinoderms, and crustaceans. The contribution of the sea urchin *Diadema antillarum*, historically an important

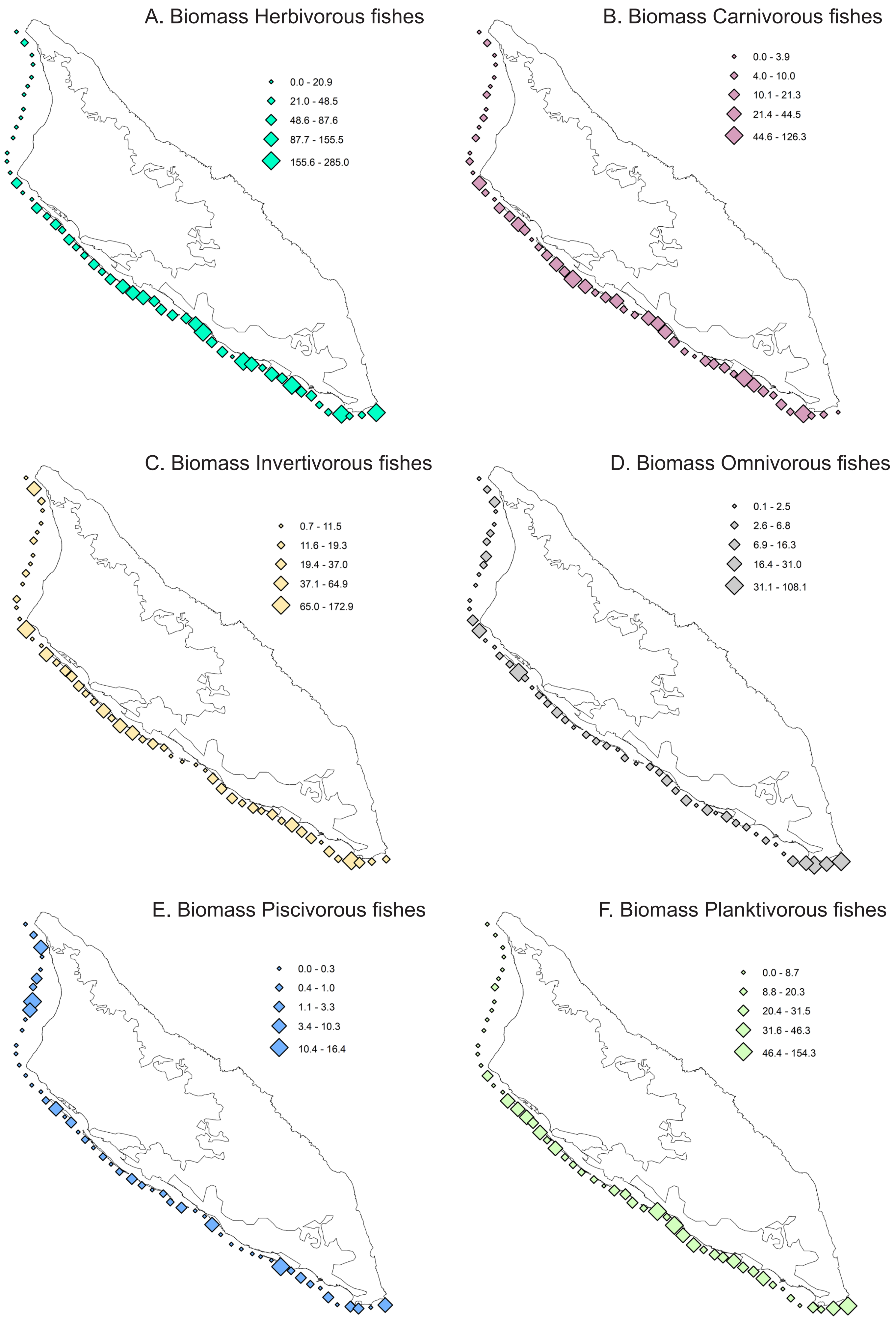


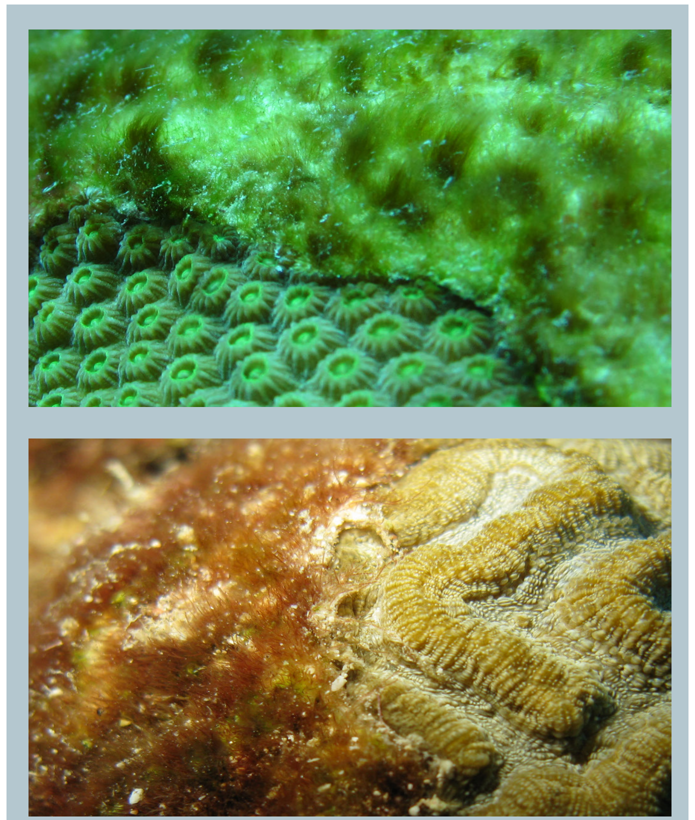
FIGURE 8: Distribution (based on average biomass; in grams m^{-2}) of main trophic fish groups around Aruba in 2019.

herbivore on Caribbean reefs, is minimal as this species has become extremely rare on Aruban reefs (Wouters 2018). When macroalgae get too dense and form underwater forests, herbivores are no longer capable of suppressing such algal proliferation resulting in a negative feedback loop whereby more and more coral die-off occurs resulting in even faster algal proliferation of newly available space. Herbivory thus plays an important role in reef functioning by keeping corals free of algal overgrowth, though species capable of such ecological task are not necessarily capable of removing algae once algae dominate a reef community (Williams et al. 2001, Bellwood et al. 2006).

Benthic turf algae are usually the first species to establish or regrow after a disturbance, and there is a diverse group of herbivores (both fish and invertebrates) that feed on this type of algae. In contrast, few fish species can effectively remove larger fleshy macroalgae so maintaining algal communities in an early successional stage is paramount for coral survival and growth. While herbivorous fishes on Aruba do not control the abundance of turfalgae, i.e., the most abundant algal group on the island, they do keep local turfalgal communities in a finely cropped state (**Appendix I**). Cropped turfalgal communities are required to allow settling coral larvae to find a spot on the reef, i.e., for local recruitment rates. On Aruba, a strong positive relationship between herbivory, algal height and recruitment was observed, i.e., the more turfalgae were cropped by herbivores, the more coral recruits were found (**Appendix I**).

Results – Coral recruitment

Recruitment is a process by which new individuals are added to an existing population. Successful recruitment relies on sufficient individuals surviving through various life history stages to become part of the reproductive population. The process of recruitment is one of the most important ways in which depleted coral populations are replenished. Average island wide coral recruitment rates on Aruba were decent (0.5 recruit per 0.043m²; range: 0 – 1.7) and coral recruitment was highest in the area located between the airport (ARU_24) and Savaneta (ARU_40) (**Figure 9**). Overall, coral recruitment approached zero at sites where turfalgal height exceeded 4 mm. Other than near the tips of the island, most coral recruits (92%) belonged to brooding species, i.e., coral species that release larvae rather than gametes (i.e., broadcast spawning species) (**Figure 9**). The species composition of small corals (< 4cm) was very similar to that observed in 1986 (Bak 1987).



Box 6: Turf algae are multispecies communities of small marine algae that are becoming a dominant component of coral reef communities around the world. Turf algae cause visible (overgrowth) and invisible negative effects (reduced fitness) on neighboring corals. Corals can overgrow neighboring turf algae, but when increased nutrients are present in the water turf algae rapidly overgrow corals. Herbivores can control turf algae during early successional stages (as is often the case on Aruba), but if algae reach larger sizes during e.g., nutrient pulses, parrotfishes are no longer capable of controlling the abundance of turf algae with subsequent negative effects for neighboring corals.

Results – Calcification

Reefs can erode in three ways: mechanical erosion due to waves and currents; bioerosion caused by reef animals, such as boring worms, sponges and crustaceans as well as dissolution caused by ocean acidification (Hoegh-Guldberg et al. 2007). For reef building to remain stable, calcification rates must be greater than the rate of erosion. In this case one could approximate whether a reef community is net calcifying by determining whether the total amount of reef builders (i.e., corals and CCA) exceeds that of non-reef- builders (i.e., macroalgae, turfalgae, sponges etc). Such ration would exceed 1 if the bottom is foremost covered by reef builders, whereas values

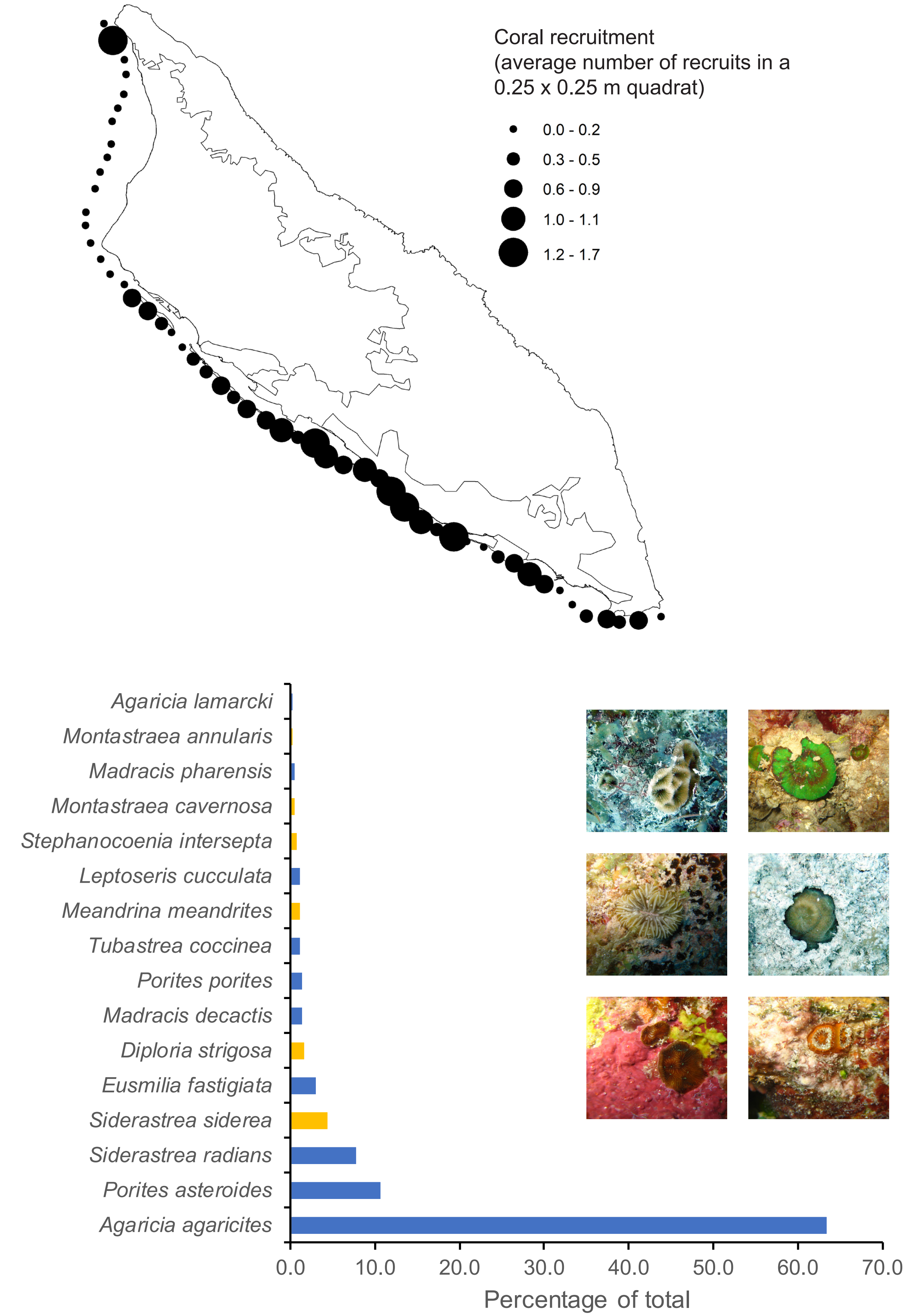


FIGURE 9: Distribution of coral recruits around Aruba (top) and species composition of all recruits observed (bottom). Some examples of caribbean coral juveniles smaller than 2 cm in diameter are also shown.

< 1 suggest low or no potential for reef growth). The average ratio for Aruba of calcifiers to non-calcifiers, i.e., N:NC and excluding sandy areas is 1:4 and not one site exceeded a 1:1 ratio. This strongly suggests that all of Aruba's reefs are currently eroding or at best contribute little to nothing to net reef building (**Figure 10**).

Results – Trash

Fishing lines as well as small (i.e., bottles, plastic, cans etc.) and large forms of debris (e.g., industrial waste near refineries, collapsed piers, lost anchors, construction materials) were found along the entire Leeward shore (**Figure 11**). Especially the large number of lost anchors was noteworthy.

Results - Sewage pollution of nearshore waters

Sewage water is released into Aruba's coastal waters along its entire leeward shore, i.e., at 3 RWZI's (see below) and through point discharge at Savaneta, Pos Chikito and Sero Colorado. There are three sewage treatment facilities that release effluent into the ocean, one does so directly (RWZI Zeewijk), whereas RWZI Bubali and RWZI Parkietenbos first release effluent in respectively a saliña and wetland first. Overflow into the neighboring sea is especially prominent during heavy rainfall (Naviel, pers. comm.), but might also occur through subterraneous groundwater flow. Several areas exist where untreated sewage water is released into the ocean (Savaneta Bayerlite, 2 sites near Pos Chikito and Colony). Nutrient concentrations in the effluent of RWZI's are extremely high. Data only exists for Bubali (Lue 2019a) but shows that effluent water from this plant that is (indirectly) released into the ocean, especially during periods of heavy rainfall, contains on average 2121 µmol N/L (SD: 877, n= 14, period: 2016-2019) and 102 µmol P/L (SD: 48, n= 14, period: 2016-2019). Assuming these reported values are correct, the values exceed natural concentrations of these nutrients associated with functional reefs (i.e., 1.0 to 2.0 for N and 0.02-0.10 for P) by nearly 3 orders of magnitude. Though high, these values appear realistic as similar values were measured in the Bubali pond in the late 1980's (Van Halewijn et al. 1992) and isotope levels observed in this study peaked in this area indicating the presence of sewage water (**Figure 12**). Along the heavily used northwestern shore of Aruba the combination of high nutrient levels and the high abundance of organic material in (partially treated) sewage water (Wear and Thurber 2015) will sometimes result in anoxia near the bottom at night (Van Halewijn et al. 1992). Consequently, benthic animals have become scarce and cyanobacteria and algae now dominate benthic communities (**Figure 13**). Cyanobacteria favor places enriched in dissolved carbons (Brocke et al. 2015) whereas algae proliferate in the abundance of nutrients. Anoxic sediments were frequently observed along the Northwestern part of the island (**Figure 13**), again indicating that reef communities in this area are extremely degraded ("microbialized") and animals have largely died during occasional moments of anoxia and partially treated sewage water in this area fuels communities of opportunistic species such as cyanobacteria and algae. The fact that such observations were foremost made near the Bubali RWZI is likely caused by the far lesser efficiency or capacity of this RWZI compared to those at Parkietenbos and Zeewijk based on the concentration of fecal bacteria are measured in their effluents (**Table 2**).

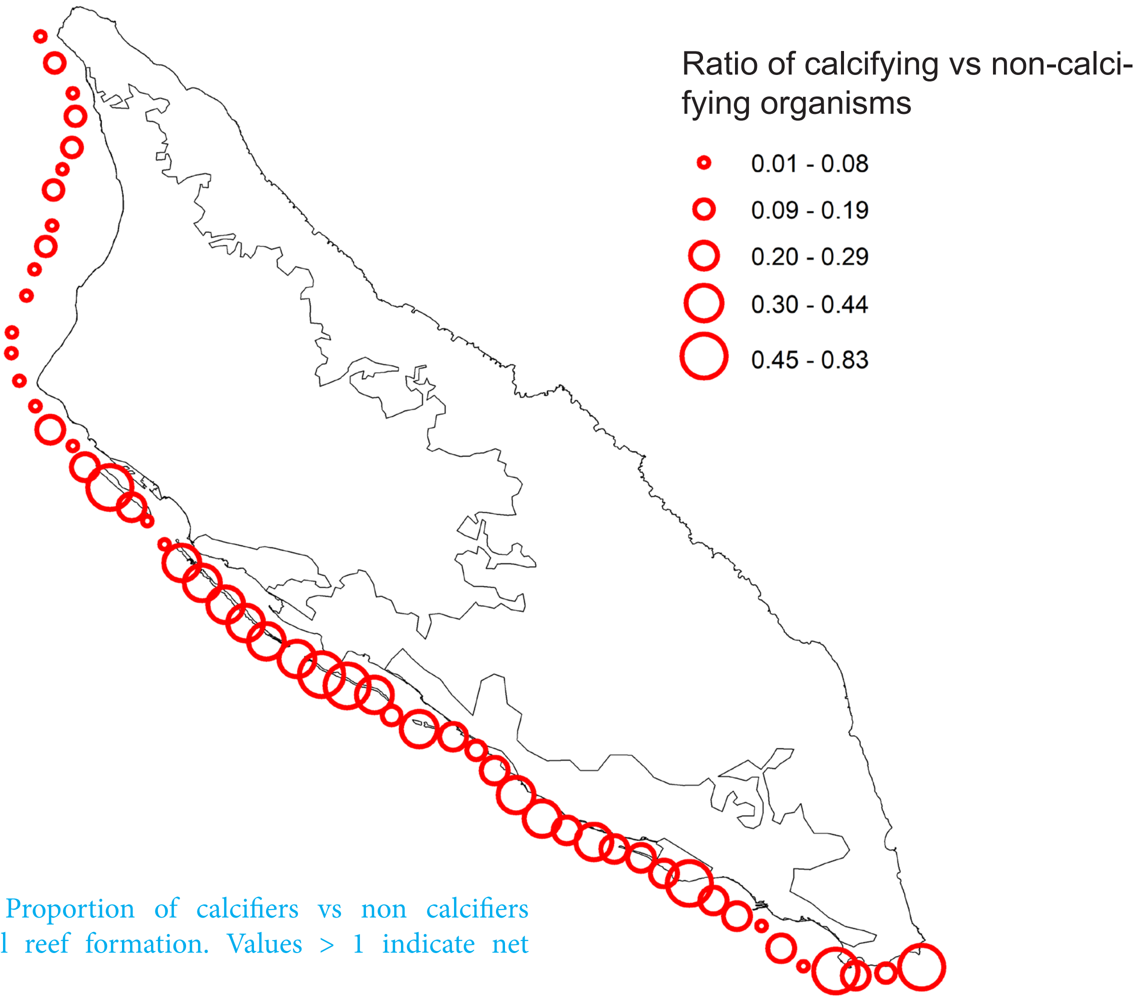


FIGURE 10: Proportion of calcifiers vs non calcifiers i.e., potential reef formation. Values > 1 indicate net calcification.

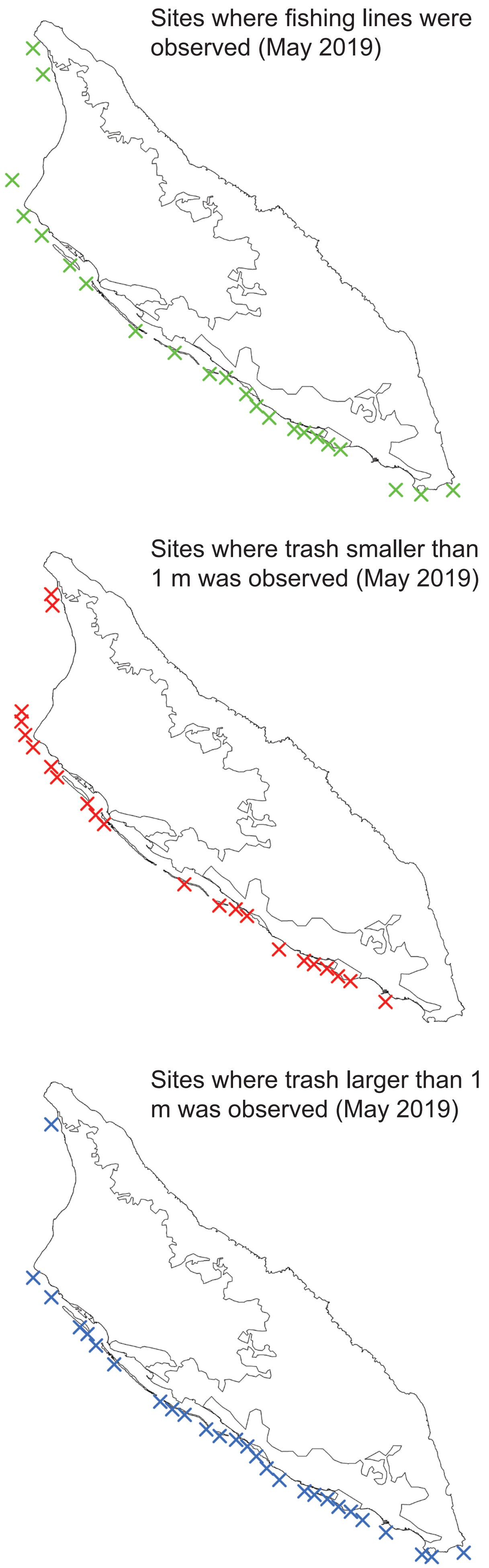


FIGURE 11: Distribution of trash around Aruba for different types of trash.

Beach water quality is generally determined through counts of fecal bacteria such as *Escherichia coli* and other enteric gram-negative species or coliform bacteria (e.g., *Enterococci*). Their abundance is expressed as the number of colony forming units (CFU, or kve in Dutch) per 100 ml. These metrics, indicative of fecal contamination, were determined in the released effluent of sewage treatment facilities (RWZI sites) or seawater (for all other sites). While variable (measurements were taken approximately monthly between 2010 and 2017), concentrations of both sewage water indicators are extremely high (**Table 2**) and have remained stable or increased through time between 2010 and 2017 (Lue 2019b) indicating that water quality has decreased in recent years along the island's leeward coast. The mean abundance of *E. coli* and *Enterococci* in coastal waters across all sites between 2010 and 2017 is 24 (max: 8000) and 25 (max: 3000) kve per 100 mL (CFU/100ml), respectively (**Figure 14**).While aforementioned values might not strike one has "high values", they exceed measurements on Curaçao >10-fold (Vermeij and Jonkers 2013), where direct dumping of (untreated) sewage mostly takes part along the island's North shore, where, in contrast to Aruba, corals historically occurred in extremely low abundances.

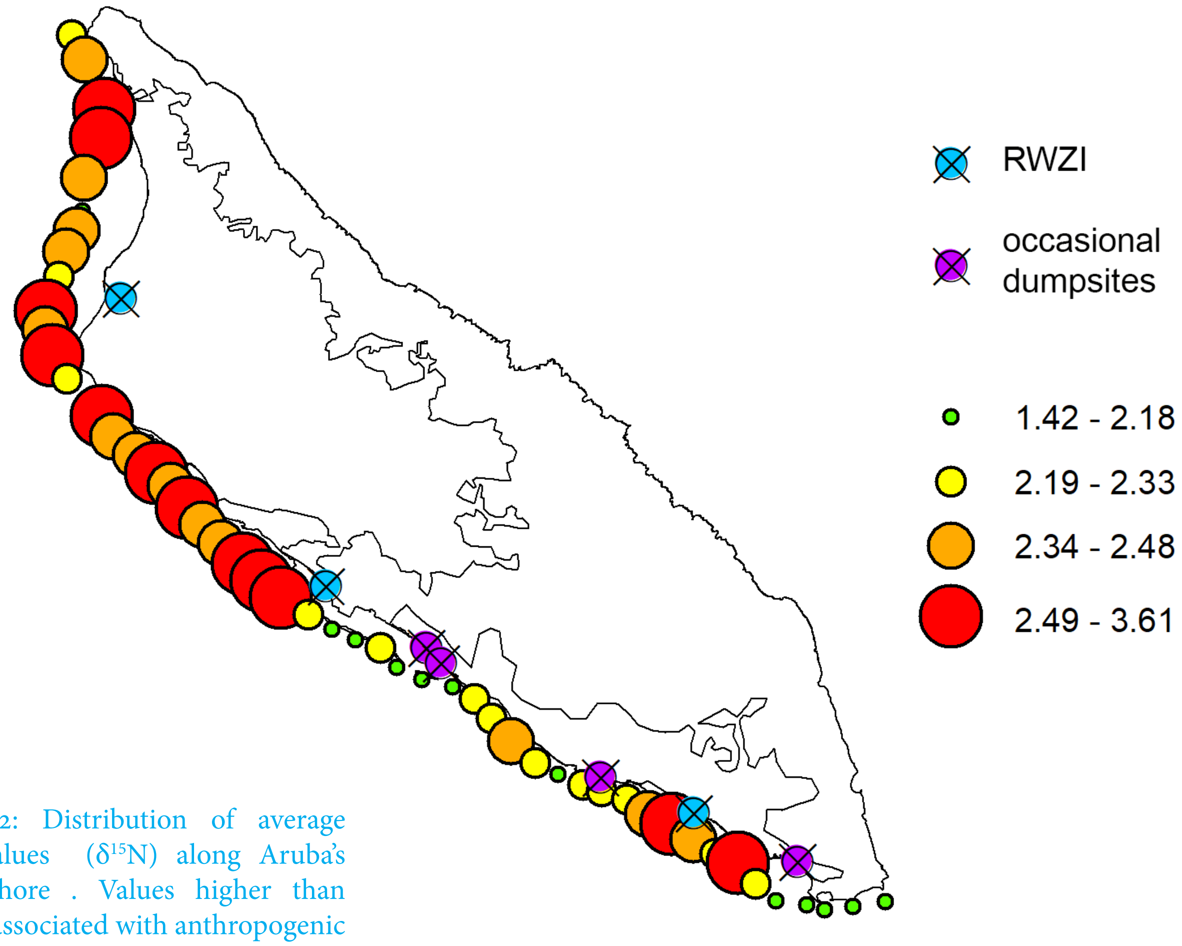


FIGURE 12: Distribution of average isotope values ($\delta^{15}N$) along Aruba's leeward shore . Values higher than 2.0‰ are associated with anthropogenic nutrient contributions (through e.g., sewage, fertilizer, animal waste etc.).

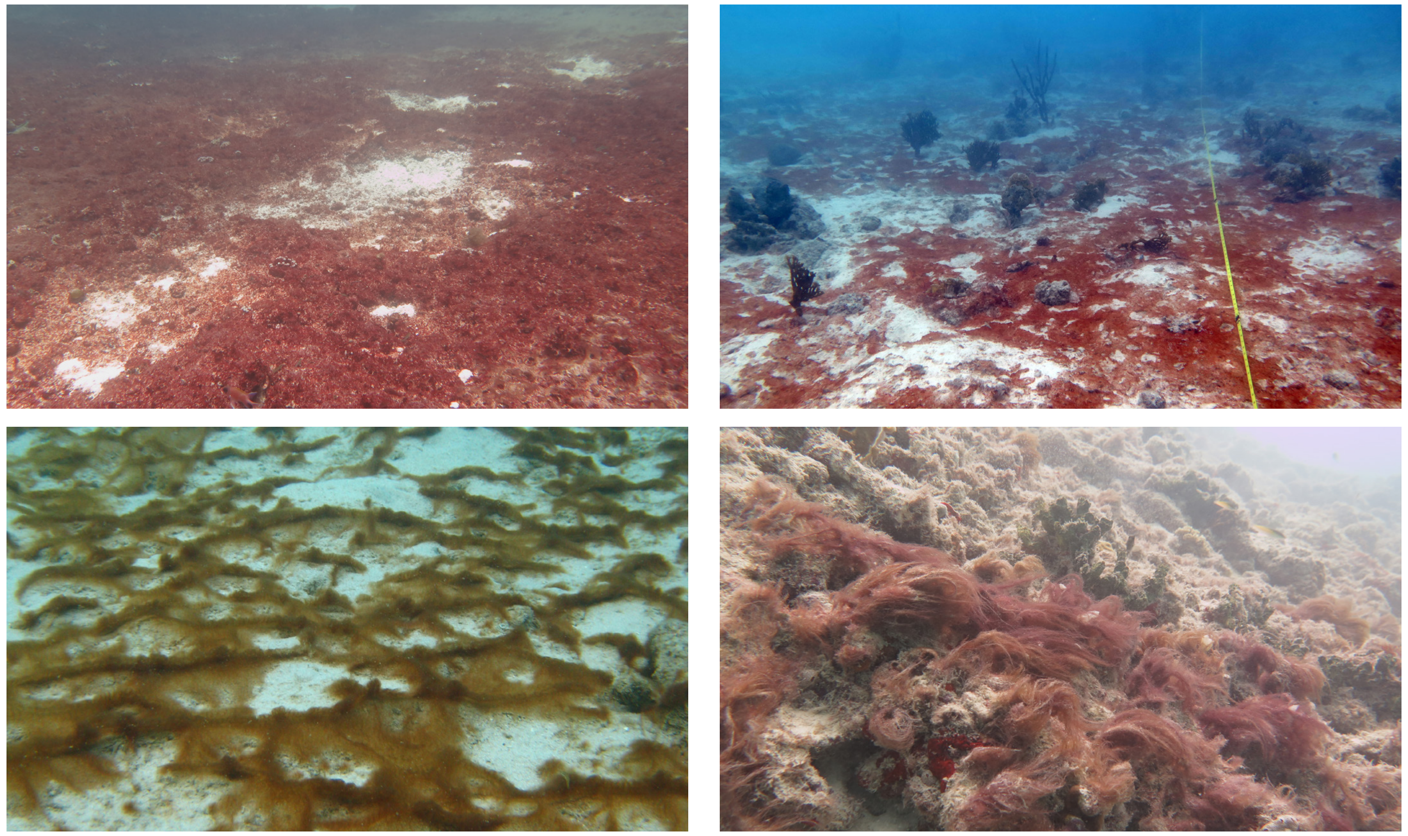


FIGURE 13: Examples of benthic communities dominated by cyanobacteria and turfalgae. The high production of organic material by such communities in combination with land-based factors (e.g., sewage, nutrients) creates "microbialized" landscapes with high oxygen demands which can lead to the formation of anoxic environments in which organisms like corals and fishes cannot survive.

TABLE 2: Faecal indicators of Aruba's three sewage treatment plants through time (measured in effluent).

			Faecal indicators			
			E. coli		*Enterococci*	
Site	Year	Number of measurements	Average	Maximum	Average	Maximum
RWZI Bubali	2010	10	11750	40000	500	1700
	2011	18	7499	65000	1392	17000
	2012	13	1857	7000	467	2000
	2013	17	55950	840000	9991	152000
	2014	11	8850	70000	1347	3720
	2015	2	134375	250000	2100	2400
	2016	5	88250	176000	3040	6000
	2017	11	63364	240000	2130	4800
RWZI Parkietenbos	2010	11	785	3000	172	1200
	2011	12	3342	20000	472	2160
	2012	12	3423	27000	178	960
	2013	19	2571	12750	1400	16000
	2014	22	11883	150000	764	4900
	2015	7	1030	4500	70	400
	2016	5	1345	3750	406	1000
	2017	9	967	4000	111	400
RWZI Zeewijk	2010	8	4829	13000	159	510
	2011	8	1358	8000	32	148
	2012	4	2525	8000	219	600
	2013	5	810	1850	400	730
	2014	2	100	100	16	30
	2016	2	51	100	6	10
	2017	6	933	3000	163	330

Water quality standards depend on climate and location and therefore "universal water quality standards" do not exist. However, values measured at all sampling sites for seawater frequently exceed water quality standards according to the U.S. Environmental Protection Agency (EPA 2017) which define upper limits for *E.coli* abundance at 100 CFU/100ml and at 30 CFU/100ml for *Enterococci*. Sewage effluent guidelines as stipulated in Annex III of the LBS Protocol (the Protocol concerning pollution from land-based sources and activities in the wider Caribbean region) are very similar (for *E.coli*:126 CFU/100ml and 34 CFU/100ml for *Enterococci*).

While *E. coli* abundance exceeds these limits in ~ 2% of all measurements, the abundance of *Enterococci,* a more reliable measure than *E. coli* of fecal contamination in marine waters, exceeds safe limits ~ 11% of all measurements. Exceeding upper limits implies that 32 out of 1000 people using such water for recreation etc. will get ill from sewage associated bacterial diseases (EPA 2012). If abundances of *Enterococci* exceed 70 CFU/100ml the use of such waters in Florida, with roughly a similar Caribbean climate, is immediately discouraged. In short, based on the abundances of *E.coli* and especially *Enterococci*, the amount of sewage waters entering Aruba's coastal waters appears significant and locally exceeds limits for safe use by humans. Locations with increased concentrations of fecal indicators are foremost associated with the locations of RWZIs (sewage treatment plants) and to lesser agree Oranjestad (**Figures 12 and 14**).

Note that sewage water also carries other problematic components in the forms of e.g., antibiotic resistant bacteria and nutrients that could worsen aforementioned negative consequences.

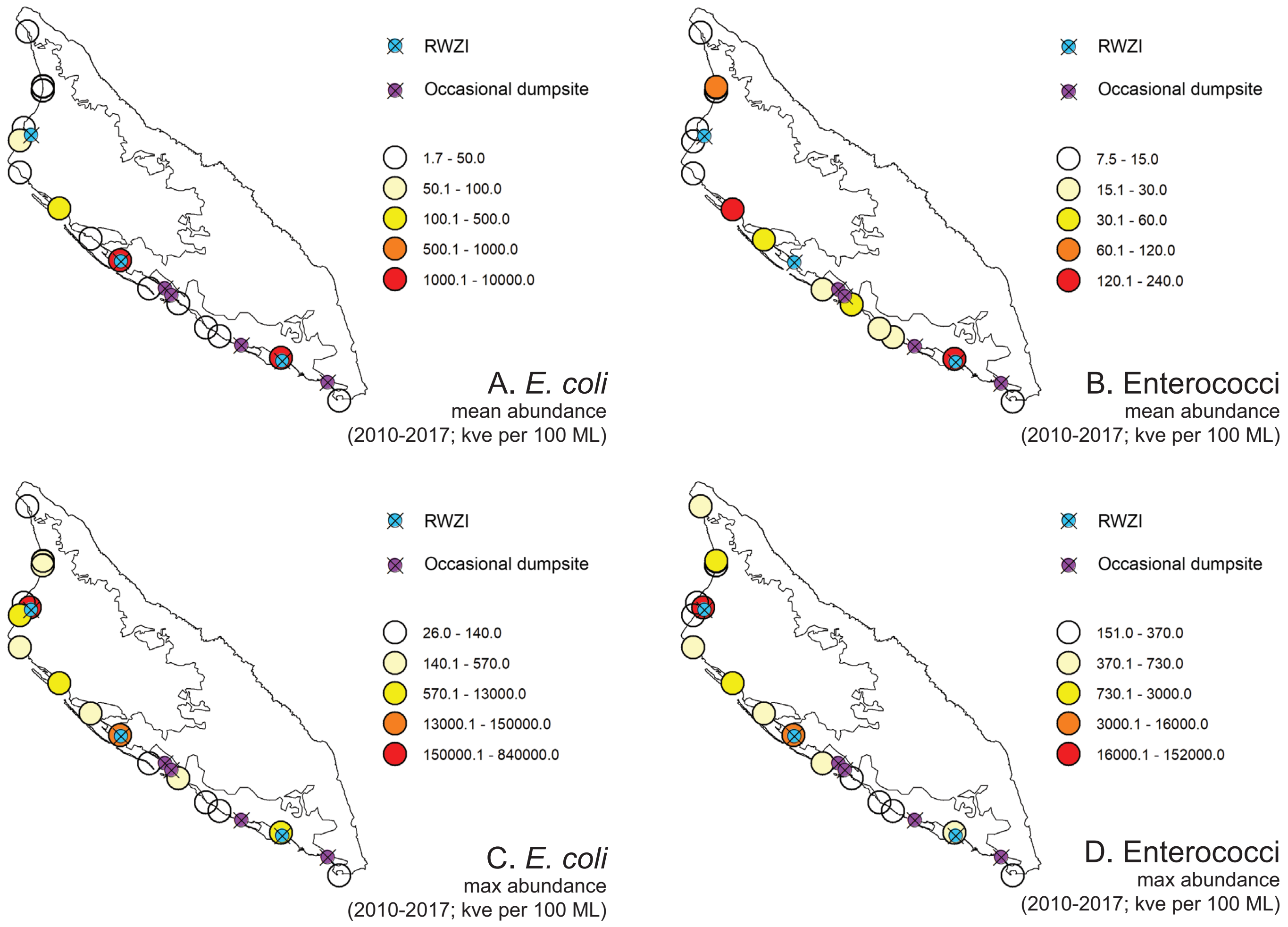


FIGURE 14: Distribution and abundance of fecal indicator bacteria indicative of sewage water influx in costal waters. Secondly, when such organisms are present in high abundance, they pose a human health risk. values measured at all sampling sites for seawater frequently exceed water quality standards according to the U.S. Environmental Protection Agency (EPA 2017) which define upper limits for E.coli abundance at 100 CFU/100ml and at 30 CFU/100ml for Enterococci. Sewage effluent guidelines as stipulated in Annex III of the LBS Protocol (the Protocol concerning pollution from land-based sources and activities in the wider Caribbean region) are very similar (for E.coli:126 CFU/100ml and 34 CFU/100ml for Enterococci).

The distribution and amount of excess nutrients that enter coastal waters in sewage water was assessed based on stable isotope signatures collected from algal tissues (**Figure 12**). Average isotope values (δ^{15}N) along Aruba's leeward shore were 2.4‰ (SD: 0.4, n= 51, range: 1.4-3.6) which are slightly higher than those on Curaçao (average: 2.2‰, 1.7, n= 140, range: 0.7-12.0). The distribution of excess (sewage associated) nutrients is similar to that of sewage associated bacteria and highly associated with the location of RWZIs and Oranjestad, but also the saliña near Malmok (**Figure 12**). Natural δ^{15}N values for Southern Caribbean waters are smaller than ~1.7‰, and values higher than 2.0‰ are associated with anthropogenic nutrient contributions (through e.g., sewage, fertilizer, animal waste etc.). While higher on average than on Bonaire and Curaçao, offshore nutrient values measured in 2018 between depths of 0 and 40m show natural concentrations for DIN (dissolved inorganic nitrogen), i.e., between 0.27 and 0.82 µmol.L^{-1} and PO_4 concentrations, i.e., between 0.014 and 0.059 µmol.L^{-1} (Visser et al. 2018). DIN values greater than 1.0-2.0 µmol.L^{-1} and PO_4 concentrations exceeding 0.02-1.0 µmol.L^{-1} are indicative of excess nutrient influxes due to e.g., sewage or fertilizers (DeGoeij, pers. comm.). Combined, these observations suggest that the excess nutrients detected by isotope analyses are almost certainly derived from land-based sources.

Nearshore geographic features (e.g., lagoon and barrier islands) as well as lacking information on fine-scale coastal currents preclude predictions as to where sewage effluent encounters the reef communities surveyed in this report. Based on our isotope analyses (**Figure 12**) it appears that the entire leeward shore of Aruba, with maybe the exception of a small area westerward of Parkietenbos to Savaneta Bayerlite remains spared from direct impacts by sewage pollution although our measurements were taken in May 2019 only and in a period with little to no rain when terrestrial influxes are smaller compared to rainier periods.

Nonetheless, comparing the locations of the sewage release sites and the composition of nearby reef communities suggests the following (1) The release of effluent near Bubali, where extremely polluted sewage water is released indirectly into the ocean is associated with enormous abundances of benthic cyanobacteria and macroalgae and a near absence of corals and fishes (**Figures 5 and 7**), (2) coral cover decreases and the abundance of cyanobacteria and turf algae increases in other areas where release of effluent takes place, though not as extreme as near Bubali, (3) nearly the entire leeward coast of Aruba is influenced, to some degree, by sewage pollution.

Results – Chemical pollution

Similar to δ^{15}N values indicating widespread occurrence of (untreated) sewage water in coastal waters, metabolomic analyses of seawater samples indicate widespread abundance of non-natural substances derived from land in Aruba's coastal waters (**Figure 15**). The abundance of some of these substances can be related to coastal usages and infrastructure: near hotels along the Western part of Aruba the abundance of anthropogenic substances is highest. The relative abundance of chemicals related to tourism (e.g., coffee-derived chemicals, sunscreen, detergents) is highest in this area. The occurrence of chemicals related to industry and illicit drug use are highest in coastal waters near Oranjestad. The abundance of other indicators of human waste streams entering Aruba's coastal waters (e.g., medical waste) are largely similar along Aruba's entire southwestern shore. The general high abundance of chemicals reflecting and related to anthropogenic activities on land suggest a strong influence of land-based activities on Aruba's coastal ecosystems. Such interpretation is further supported by the observation that many land-based substances (e.g., coffee related substances, human and medical waste) decline, albeit slightly, in abundance as one moves offshore. Such differences appear larger in areas where a lagoon separates the ocean from land confirming the often-proposed role as natural filters of vegetation that is found within these lagoons (e.g., seagrass and mangroves) (e.g., Du et al. 2020, Gaylard et al. 2020).

Results – Simplified reef status maps of Aruba

Overall, Aruban reefs other than those in the Western part of the island (ARU_02 to 24) are in "fair" condition based commonly used standards to define "reef health" (McField and Kramer 2017, McField et al. 2018). Given the large amount of sandy areas around the island, sand-corrected abundance estimates (see **page 27 and Appendix 2**) were used to calculate all health indexes. Of all 53 surveyed sites, 16 (30%) were sites were in critical condition (mostly in the Western part of the island), 7 (13%) were in poor condition, 23 (43%) were in fair condition, and 7 (13%) were in good condition. Not one of the sites could be classified as "very good" based on abovementioned standards (**Figure 16**). While the abundance of macroalgae is low (a characteristic that could qualify Aruba's reefs as "very good"), the abundance of turfalgae and cyanobacteria is extremely high. Based on this high abundance, one would have to qualify the state of Aruba's reefs as "critical" along the island's entire Western coastline. Fortunately, turfalgae are often cropped (i.e., they are low in height), which is likely attributable to the island's relatively healthy community of herbivorous fishes. Based on their average abundance (63.6 g m^{-2}) communities of herbivorous fishes can indeed be qualified as "very good", while the abundance of commercially interesting species (i.e., piscivorous fishes) is extremely low and should be classified as "critical". Combined, a mixed image emerges where Aruba's shallow reef communities are compromised in terms of high turfalgal and cyanobacterial abundance, low biomass of piscivorous fishes, whereas herbivorous fish communities can be qualified as "fair" to "very good. Coral abundance is fair to poor on average (**Figure 16**).

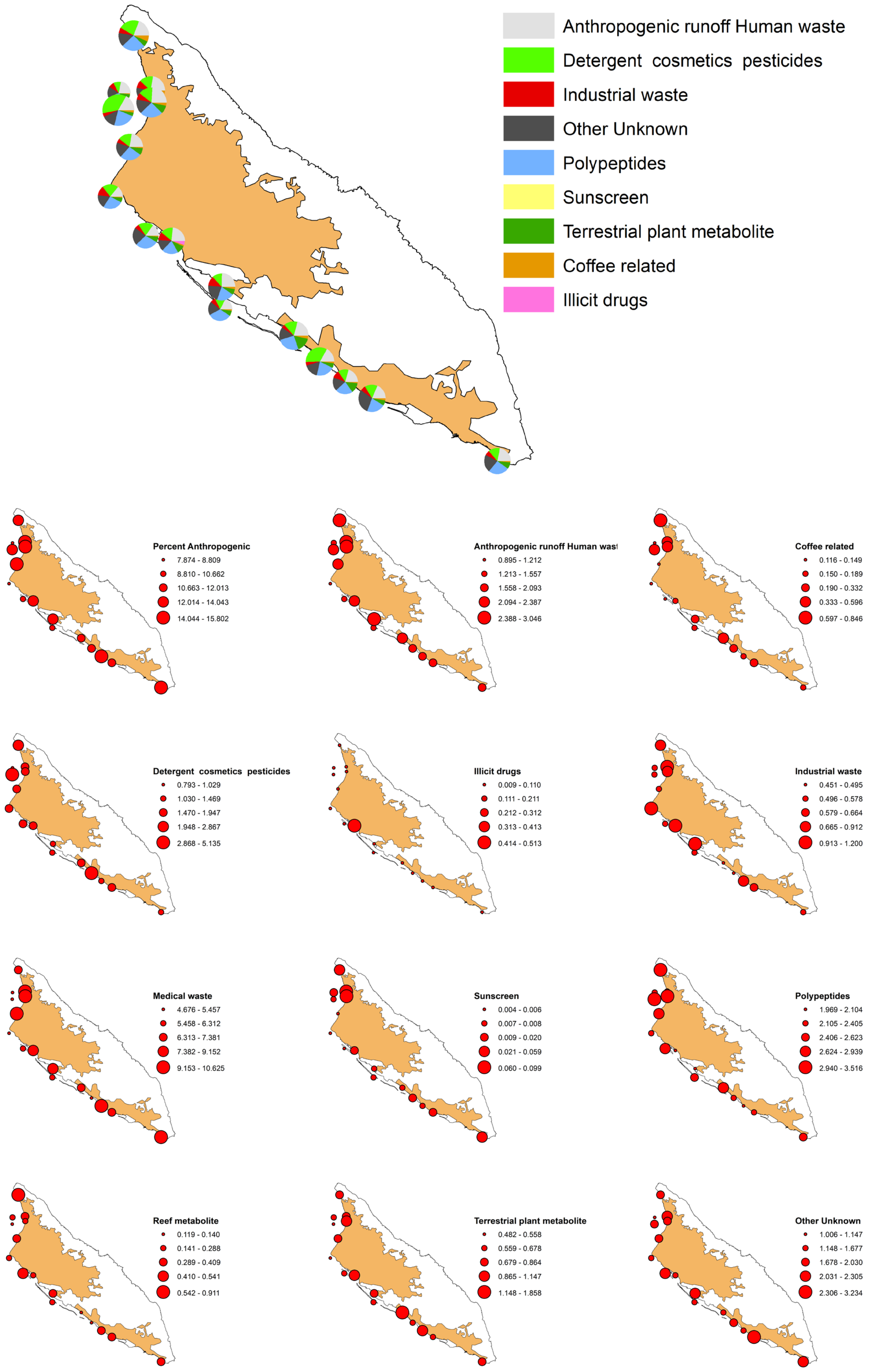
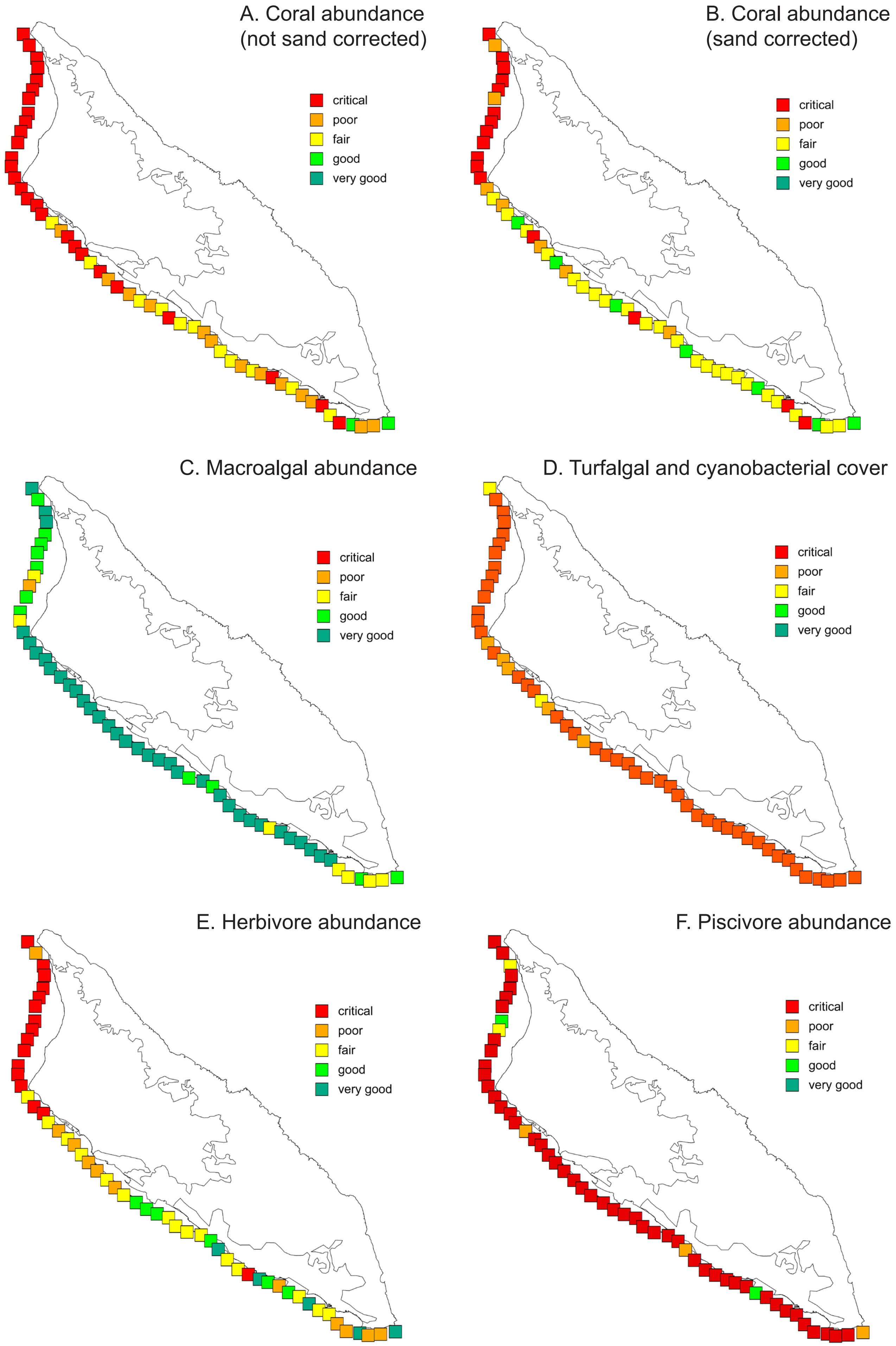


FIGURE 15: The relative abundance of land-based natural and human substances in Aruba's coastal waters. All substances are shown as relative abundances in comparison to other sites. Values reflect these relative abundances, i.e., they do not indicate concentrations.



Fish group	Average biomass (in g m^{-2})	Percentage of total herbivore community:
chubs	7.3	11.4
damselfishes	6.8	10.6
parrotfish	27.5	43.3
surgeonfishes	22.1	34.7

FIGURE 16: Simplified visualizations of the differences in reef health around Aruba.

Changes in coral abundance through time

The results of this assessment represent one point in time and because long-term monitoring programs do not exist on Aruba, it is difficult to assess whether reef are declining on Aruba or whether reefs are improving relative to historical baselines. Only two studies exist that surveyed reefs reliably in the past. A total 17 reef sites along the Southwestern shore of Aruba were surveyed in 1986 (Bak 1987) and 1988 (Eakin et al. 1993). Comparing our data for the locations closed to the original survey locations in 1986 and 1988 (**Figure 17**), an average decrease in coral cover from 22.2% in 1986/8 to 8.8% in 2019 was observed, i.e., a decline of 60% over the last 3 decades. Interestingly, sites with low coral cover (<~4%) in 1986 have seen increases in coral cover (~ 2-fold) showing that reef recovery, albeit moderate, occurs at certain sites. Nevertheless, the abundance of corals appears to be in strong decline on average.

Aruba in comparison

Coral cover, the most commonly used metric to indicate "reef health", is approximately half that of neighboring islands Bonaire and Curaçao (**Figure 18, Table 3**) (De Bakker et al. 2016, WaittInstitute 2017, de Bakker et al. 2019). There is however no reason to assume that current degrees of coral cover represent island-specific deviations from a similar (historic) baseline value for reefs of all three islands and that the current abundance of corals reflects island specific deviations from such historic baseline as a result of differing approaches to marine resource management. Such might be true for Bonaire and Curacao that are both oceanic islands sharing similar biogeographic and geological characteristics. Aruba, however, is a continental island and therefore fundamentally different from Bonaire and Curaçao. This has for example resulted in a greater abundance of sandy areas due to the vicinity of large sandy areas nearby (i.e., the shallow waters and strong currents separating Aruba from the South American mainland). In addition, high sand production in Aruba's lagoonal systems further contributes to the high abundance of sandy areas in within Aruba's reef communities at 10 m. In short, geological differences between Aruba and Bonaire/ Curaçao preclude straightforward comparisons among (the state of) these islands' reef communities.

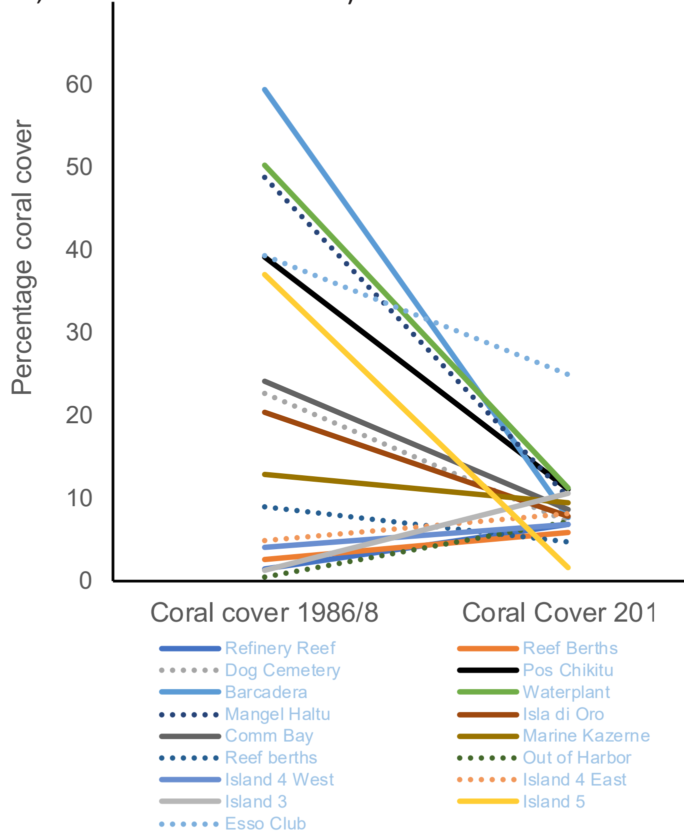


FIGURE 17: Changes in coral cover for 17 sites along Aruba's southwestern shore between 1986/88 and 2019.

TABLE 3: Comparison of island wide coral abundance for Aruba, Bonaire and Curacao. Non sand corrected values were used to compare islands.

	average coral cover	SD	CV (SD/ mean)	sites
Aruba	6.19	5.96	0.96	53
Bonaire	13.25	13.64	1.03	230
Curacao	13.50	10.51	0.78	147

The observed differences among the three Leeward islands should thus be carefully interpreted considering local factors (including different forms of management regimes, land use, fishing intensity and waste (water) treatment), but also inherent biogeographic differences among the three islands.

Species specific distributions: coral

A total of 25 coral species, including the hydrocorals *Millepora* spp. (fire corals), were frequently encountered during the surveys (at depths around 10m) in 2019 and their island-wide average abundance is shown in **Table 4**. The total number of reef building corals on Aruba is expected to lie around ~70 assuming a similar number of species as Curaçao (Bak 1975).

The average coral community composition of Aruba's leeward reefs is largely typical for the region. Some species appear relatively overrepresented compared to reefs around Curaçao and Bonaire (*M. cavernosa*, *Millepora* spp., *D. strigosa* and *M. meandrites*), whereas the abundance of others appears underrepresented (*M. mirabilis* and *A. agaricites*). Species that were overrepresented often cooccur in areas characterized by strong water movement. The distribution of the 6 most common coral species is shown in **Figure 19** and clearly shows two main coral community types around Aruba: between roughly ARU_19 and 37 coral communities represent typical Southern Caribbean coral communities frequently seen on Curaçao and Bonaire that are dominated by *Orbicella* spp., *M. mirabilis* and *A. agaricites*. From approximately ARU_38 to the southern tip of the island coral communities are typical of coral communities experiencing strong water movement and/ or recent regrowth after earlier declines (e.g., near the refinery, see: "Changes in coral abundance through time" above) that are dominated by *M. cavernosa*, *D. strigosa* and *Millepora* spp. ("fire corals"). The area north of Manchebo no longer harbors any coral communities of ecological significance.

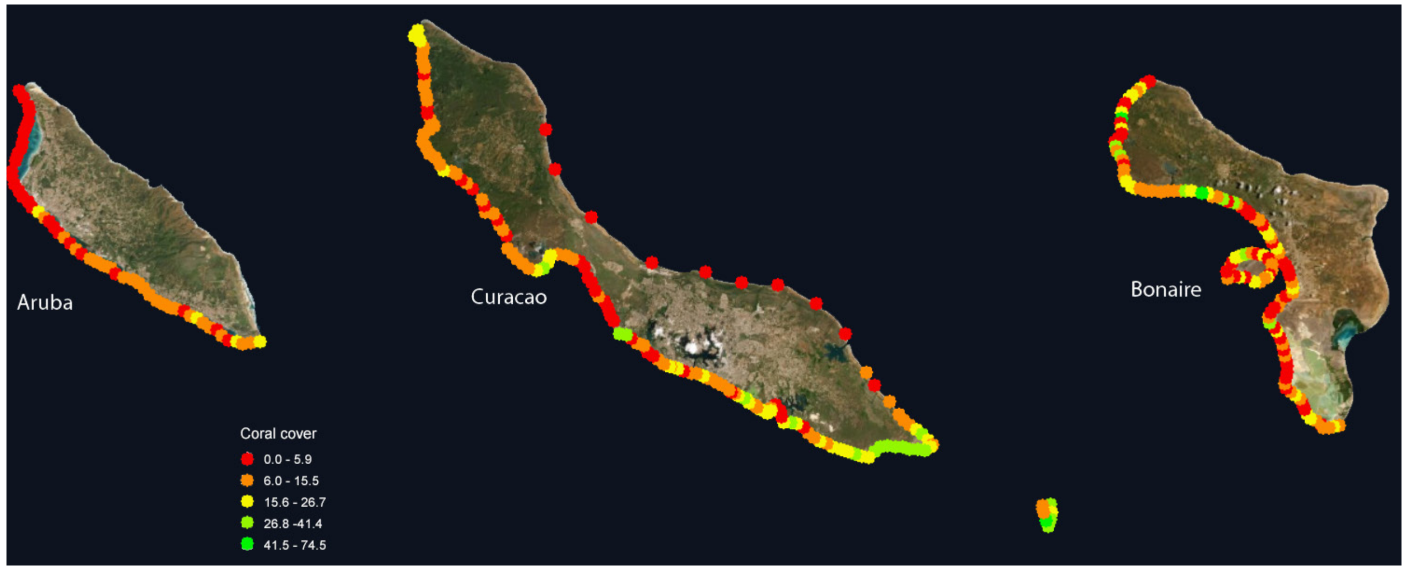


FIGURE 18: Comparison of reef health (in terms of coral cover) of Aruba to its neighboring islands Curacao and Bonaire.

TABLE 4: Overview of the relative abundance of the most common coral species encountered during the reef surveys at a depth of 10m in May 2019.

	average coral cover	percentage of total
Orbicella annularis	0.829	15.472
Montastraea cavernosa	0.796	14.844
Madracis mirabilis	0.753	14.057
Orbicella faveolata	0.623	11.632
Millepora spp.	0.619	11.553
Diploria strigosa	0.558	10.415
Agaricia agaricites	0.512	9.550
Meandrina meandrites	0.332	6.194
Siderastrea siderea	0.319	5.951
Colpophyllia natans	0.295	5.498
Porites astreoides	0.249	4.637
Stephanocoenia michelinii	0.068	1.269
Madracis decactis	0.065	1.218
Orbicella franksi	0.041	0.769
Porites porites	0.035	0.647
Eusmilia fastigiata	0.022	0.417
Dendrogyra cylindrus	0.021	0.387
Diploria labyrinthiformis	0.017	0.309
Dichocoenia stokesi	0.011	0.214
Agaricia lamarcki	0.007	0.128
Madracis pharensis	0.007	0.124
Siderastrea radians	0.005	0.089
Acropora spp.	0.003	0.053
Madracis carmabi	0.002	0.035
Favia fragum	0.001	0.018

Species specific distributions: fishes

A total of 135 fish species were frequently encountered during the surveys in 2019 and their (relative abundance) is shown in **Table 4**. The total number of fish species on Aruba is expected to lie around ~360 assuming a similar number of species as Curaçao (Sandin et al. 2008). The average fish community composition of Aruba's leeward reefs is largely typical for the region. Some species, especially herbivores (e.g., *Sparisoma viride*, *Acanthurus*

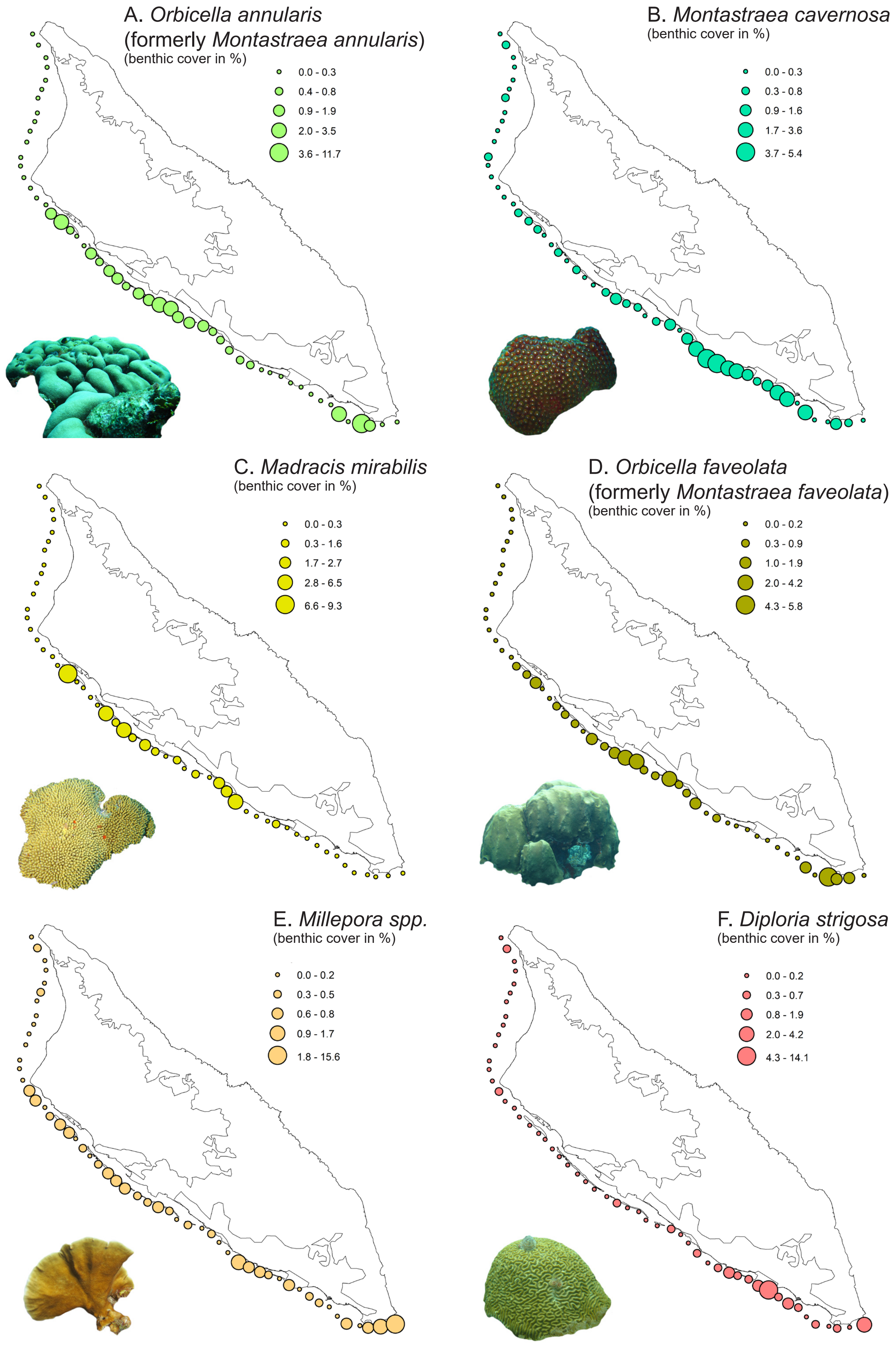


FIGURE 19: Distribution of the six most abundant coral species around Aruba. Millepora is a fire coral, but often included in standard assessments of Caribbean reef communities as a "coral" as it can significantly contributes to reef calcification.

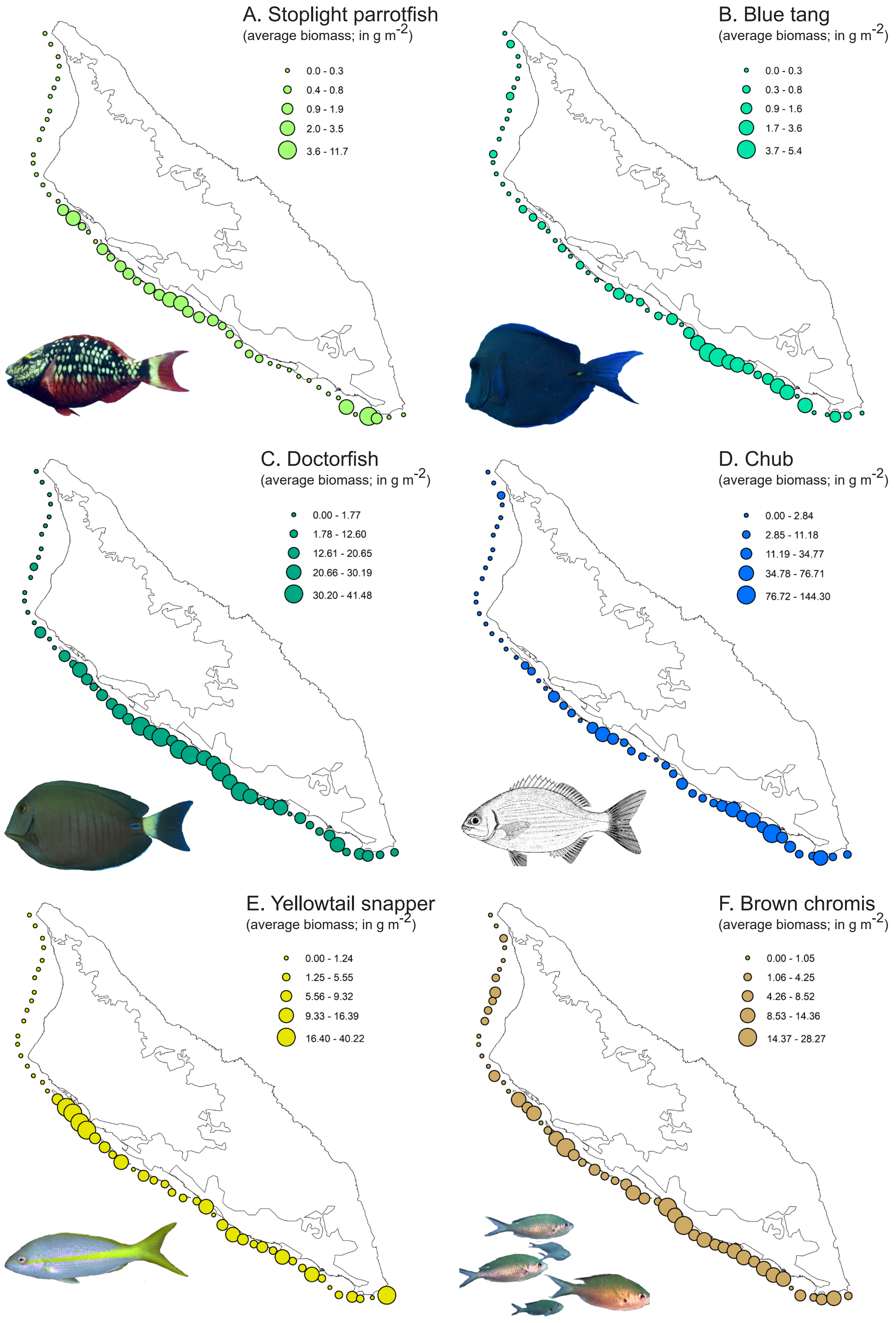


FIGURE 20: Distribution of tthe 12 most abundant fish species around Aruba (continued on next page).

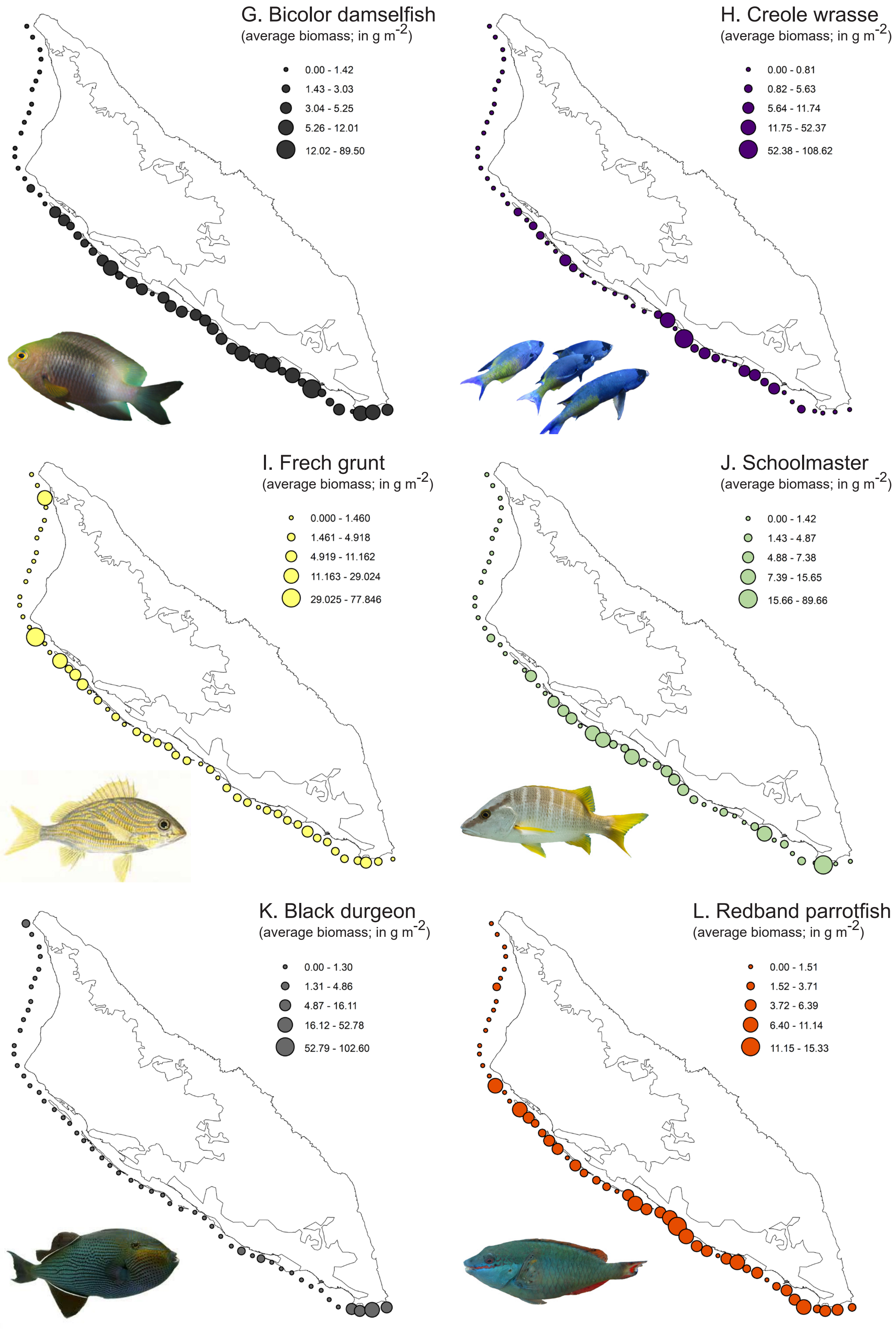


FIGURE 20: Distribution of tthe 12 most abundant fish species around Aruba (continued from previous page).

coeruleus, Acanthurus chirurgus) and intermediately sized roving omnivores (e.g., *Kyphosus spectator*) and snappers (e.g., *Ocyurus chrysurus*) appear relatively overrepresented compared to reefs around Curaçao and Bonaire, whereas the abundance of certain planktivores (e.g., *Clepticus parrae*, *Paranthias furcifer*), piscivores (e.g., *Carangoides ruber*, *Sphyraena barracuda*), soldier- (e.g., *Myripristis jacobus*) and goatfish (e.g., *Mulloidichthys martinicus*) appear underrepresented. The distribution of the 12 most common fish species is shown in **Figure 20**.

The overrepresentation of certain species could well relate to lagoon serving as a nursery area for certain reef fish species such as *Acanthurus chirurgus* (doctorfish), *Chaetodon capistratus* (foureye butterflyfish), *Gerres cinereus* (yellowfin mojarra), *Haemulon flavolineatum* (French grunt), *Haemulon parra* (sailors choice), *Haemulon plumieri* (white grunt), *Haemulon sciurus* (bluestriped grunt), *Lutjanus analis* (mutton snapper), *Lutjanus apodus* (schoolmaster), *Lutjanus griseus* (gray snapper), *Lutjanus mahogoni* (mahogany snapper), *Ocyurus chrysurus* (yellowtail snapper), *Scarus coeruleus* (blue parrotfish), *Scarus guacamaia* (rainbow parrotfish), *Scarus iserti* (striped parrotfish), *Sparisoma chrysopterum* (redtail parrotfish) and *Sphyraena barracuda* (great barracuda) (Nagelkerken et al. 2002). Due to the relative scarcity of steep reef walls, species preferring open or deep water near reefs for hunting (e.g., jacks) appear underrepresented.

While most fishes prefer areas with high coral cover, differences in the distribution of certain species exist that reflect the occurrence of the two main coral community types, i.e., (1) typical Southern Caribbean fish communities occur in areas dominated by *Orbicella* spp., *M. mirabilis* and *A. agaricites* (roughly between ARU_19 and 37) and (2) a second fish community is found in coral communities experiencing strong water movement (between approximately ARU_38 to the southern tip of the island). Species like the Blue tang and chubs prefer the latter habitat whereas e.g., stoplight parrotfishes and schoolmasters prefer the former (**Figure 20**). Based on each species' size frequency data, a clear "lagoonal signal" exists, i.e., there is a high abundance of small (< 5cm) individuals of species that use mangrove and seagrass beds in the lagoon as a nursery (see overview above), but large fish are relatively rare, i.e., less than 3% of all fish observed (n= 70037) is larger than 30cm (**Figure 21**). Fishes in larger size classes (>100cm) were mostly green morays (*Gymnothorax funebris*). In **Figure 21** the size frequency of the entire fish community is shown for Aruba's leeward reefs and compared to that of Curaçao where we know intense overfishing of reef associated has taken place, as early as the 1960's (Vermeij et al. 2019). While midsized fishes are still common on Aruba, the relative low number of larger fishes (> 25cm) suggests that both islands have to some degree experienced the effects of intense (historic) overfishing. Ecologically and commercially important larger reef species (e.g., snappers, grunts, parrotfishes) become reproductively active at sizes between 15 to 20 cm (Froese and Pauly 2016) suggesting that the low number of larger individuals in Aruba's fish communities will eventually result in a reduced influx of new individuals, which could worsen the effects of overfishing. These findings confirm earlier concerns about overfishing in Aruba's waters (Pauly et al. 2015, FAO 2015-2020, Polaszek et al. 2018) and as a consequence total artisanal catches (around 150 ton per year in 2010) are ~3 times lower compared to the 1970's to 1990's ago when they were estimated at ~500 ton per year (Pauly et al. 2015).

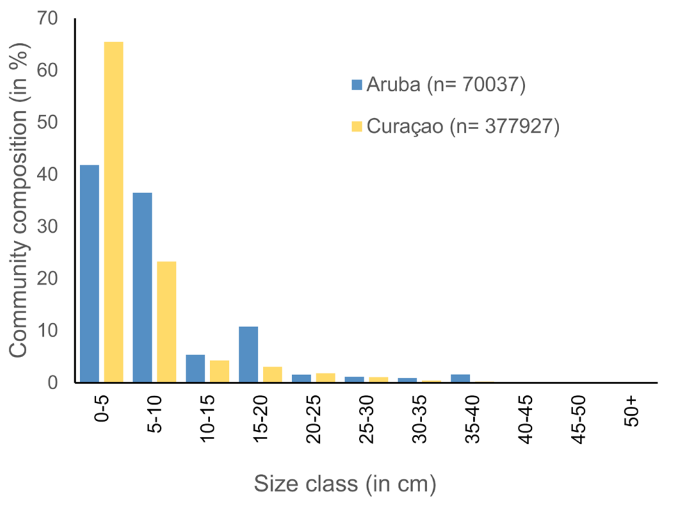


FIGURE 21: Comparison of the size distributions of all fishes surveyed around Aruba in comparison to Curacaoan fish communities that are known to be generally (i.e., for nearly all fish species) overfished. On both islands, an absence of large fish that are important to fisheries, population renewal and to diving tourism is obvious.

Table 4: Overview of the relative abundance of the most common fish species encountered during the reef surveys at a depth of 10m in May 2019.

Taxonomic name	Common name	Average biomass (per site; in g m^{-2})	Percentage of total fish community
Sparisoma viride	stoplight parrotfish	14.159	10.32
Acanthurus coeruleus	blue tang	12.036	8.77
Acanthurus chirurgus	doctorfish	7.987	5.82
Kyphosus sectator	chub (bermuda/yellow)	7.123	5.19
Ocyurus chrysurus	yellowtail snapper	6.496	4.73
Chromis multilineata	brown chromis	6.481	4.72
Stegastes partitus	bicolor damselfish	5.215	3.80
Clepticus parrae	creole wrasse	4.875	3.55
Haemulon flavolineatum	French grunt	4.422	3.22
Lutjanus apodus	schoolmaster	4.146	3.02
Melichthys niger	black durgeon	3.803	2.77
Sparisoma aurofrenatum	redband parrotfish	3.543	2.58
Cephalopholis cruentata	graysby	3.343	2.44
Haemulon chrysargyreum	smallmouth grunt	3.024	2.20
Mulloidichthys martinicus	yellow goatfish	2.883	2.10
Scarus vetula	queen parrotfish	2.372	1.73
Scarus taeniopterus	princess parrotfish	2.120	1.55
Pomacanthus paru	French angelfish	1.996	1.46
Chromis cyanea	blue chromis	1.975	1.44
Acanthurus bahianus	ocean surgeonfish	1.635	1.19
Cephalopholis fulva	coney	1.577	1.15
Scarus guacamaia	rainbow parrotfish	1.518	1.11
Scarus iseri	striped parrotfish	1.463	1.07
Myripristis jacobus	blackbar soldierfish	1.383	1.01
Holocentrus rufus	longspine squirrelfish	1.370	1.00
Haemulon sciurus	bluestriped grunt	1.308	0.95
Abudefduf saxatilis	sergeant major	1.289	0.94
Sphyraena picudilla	southern sennet	1.256	0.92
Pseudupeneus maculatus	spotted goatfish	1.252	0.91
Haemulon carbonarium	caesar grunt	1.228	0.89
Gymnothorax funebris	green moray	1.185	0.86
Lutjanus griseus	gray snapper	1.170	0.85
Thalassoma bifasciatum	bluehead	1.100	0.80
Bodianus rufus	Spanish hogfish	1.098	0.80
Sparisoma chrysopterum	redtail parrotfish	1.083	0.79
Aulostomus maculatus	trumpetfish	0.979	0.71
Lutjanus analis	mutton snapper	0.938	0.68
Holocentrus adscensionis	squirrelfish	0.895	0.65
Halichoeres bivittatus	slippery dick	0.891	0.65
Lutjanus mahogoni	mahogany snapper	0.858	0.63

Table 4 (continued): Overview of the relative abundance of the most common fish species encountered during the reef surveys at a depth of 10m in May 2019.

Taxonomic name	Common name	Average biomass (per site; in g m^{-2})	Percentage of total fish community
Microspathodon chrysurus	yellowtail damselfish	0.828	0.60
Anisotremus surinamensis	black margate	0.676	0.49
Halichoeres garnoti	yellowhead wrasse	0.663	0.48
Diodon hystrix	porcupinefish	0.658	0.48
Chaetodon capistratus	foureye butterflyfish	0.648	0.47
Lactophrys triqueter	smooth trunkfish	0.610	0.44
Stegastes planifrons	threespot damselfish	0.528	0.39
Balistes vetula	queen triggerfish	0.498	0.36
Scomberomorus regalis	cero	0.493	0.36
Sparisoma rubripinne	yellowtail parrotfish	0.433	0.32
Pterois volitans	red lionfish	0.417	0.30
Haemulon plumierii	white grunt	0.409	0.30
Cantherhines macrocerus	American whitespotted filefish	0.396	0.29
Chaetodon striatus	banded butterflyfish	0.352	0.26
Haemulon parra	Sailor’s choice	0.344	0.25
Haemulon macrostomum	Spanish grunt	0.314	0.23
Holacanthus ciliaris	queen angelfish	0.294	0.21
Acanthostracion polygonius	honeycomb cowfish	0.279	0.20
Canthigaster rostrata	sharpnose puffer	0.253	0.18
Priacanthus arenatus	bigeye	0.251	0.18
Mycteroperca bonaci	black grouper	0.244	0.18
Inermia vittata	boga	0.243	0.18
Holacanthus tricolor	rock beauty	0.234	0.17
Haemulon melanurum	cottonwick	0.191	0.14
Aetobatus narinari	spotted eagle ray	0.189	0.14
Sphyraena barracuda	great barracuda	0.176	0.13
Malacanthus plumieri	sand tilefish	0.163	0.12
Lachnolaimus maximus	hogfish	0.159	0.12
Carangoides ruber	bar jack	0.148	0.11
Aluterus scriptus	scrawled filefish	0.139	0.10
Scarus coeruleus	blue parrotfish	0.116	0.08
Chaetodon ocellatus	spotfin butterflyfish	0.114	0.08
Stegastes adustus	dusky damselfish	0.110	0.08
Cantherhines pullus	orangespotted filefish	0.107	0.08
Sparisoma atomarium	greenblotch parrotfish	0.101	0.07
Cryptotomus roseus	bluelip parrotfish	0.100	0.07
Lactophrys trigonus	trunkfish	0.096	0.07
Paranthias furcifer	atlantic creolefish	0.091	0.07
Mycteroperca venenosa	yellowfin grouper	0.091	0.07
Serranus tigrinus	harlequin bass	0.089	0.06

Table 4 (continued): Overview of the relative abundance of the most common fish species encountered during the reef surveys at a depth of 10m in May 2019.

Taxonomic name	Common name	Average biomass (per site; in g m^{-2})	Percentage of total fish community
Calamus bajonado	jolthead porgy	0.087	0.06
Heteroconger longissimus	brown garden eel	0.086	0.06
Haemulon aurolineatum	tomtate	0.083	0.06
Lactophrys bicaudalis	spotted trunkfish	0.078	0.06
Chaetodon sedentarius	reef butterflyfish	0.076	0.06
Epinephelus guttatus	red hind	0.073	0.05
Halichoeres maculipinna	clown wrasse	0.070	0.05
Mycteroperca interstitialis	yellowmouth grouper	0.066	0.05
Scorpaena plumieri	spotted scorpionfish	0.066	0.05
Mycteroperca tigris	tiger grouper	0.062	0.05
Synodus intermedius	sand diver	0.058	0.04
Synodus saurus	bluestriped lizardfish	0.055	0.04
Coryphopterus glaucofraenum	bridled goby	0.051	0.04
Stegastes diencaeus	longfin damselfish	0.051	0.04
Haemulon album	margate (white)	0.046	0.03
Calamus calamus	saucereye porgy	0.043	0.03
Anisotremus virginicus	porkfish	0.042	0.03
Heteropriacanthus cruentatus	glasseye snapper	0.037	0.03
Opistognathus aurifrons	yellowhead jawfish	0.035	0.03
Halichoeres radiatus	puddingwife	0.033	0.02
Sargocentron coruscum	reef squirrelfish	0.029	0.02
Gymnothorax moringa	spotted moray	0.023	0.02
Halichoeres poeyi	blackear wrasse	0.022	0.02
Rypticus saponaceus	greater soapfish	0.021	0.02
Equetus punctatus	spotted drum	0.018	0.01
Lutjanus jocu	dog snapper	0.017	0.01
Stegastes variabilis	cocoa damselfish	0.016	0.01
Equetus lanceolatus	jackknife fish	0.014	0.01
Echidna catenata	chain moray	0.012	0.01
Hypoplectrus unicolor	butter hamlet	0.011	0.01
Hypoplectrus chlorurus	yellowtail hamlet	0.009	0.01
Gnatholepis thompsoni	goldspot goby	0.009	0.01
Serranus tabacarius	tobaccofish	0.008	0.01
Prognathodes aculeatus	longsnout butterflyfish	0.007	0.01
Coryphopterus personatus/hyalinus	masked/glass goby	0.007	0.01
Ptereleotris helenae	hovering goby	0.006	0.00
Nicholsina usta	emerald parrotfish	0.006	0.00
Elacantinus randalli	Yellownose goby	0.004	0.00
Halichoeres pictus	rainbow wrasse	0.004	0.00
Ophichthus ophis	spotted snake eel	0.004	0.00

Table 4 (continued): Overview of the relative abundance of the most common fish species encountered during the reef surveys at a depth of 10m in May 2019.

Taxonomic name	Common name	Average biomass (per site; in g m^{-2})	Percentage of total fish community
Gymnothorax miliaris	goldentail moray	0.004	0.00
Xyrichtys splendens	green razorfish	0.003	0.00
Stegastes leucostictus	beaugregory	0.003	0.00
Xyrichtys martinicensis	rosy razorfish	0.003	0.00
Sparisoma radians	bucktooth parrotfish	0.002	0.00
Sphoeroides spengleri	bandtail puffer	0.002	0.00
Neoniphon marianus	longjaw squirrelfish	0.002	0.00
Hypoplectrus puella	barred hamlet	0.001	0.00
Amblycirrhitus pinos	redspotted hawkfish	0.001	0.00
Opistognathus whitehursti	duskyjawfish	0.001	0.00
Ctenogobius saepepallens	dash goby	0.001	0.00
Serranus baldwini	lantern bass	0.001	0.00
Hypoplectrus guttavarius	shy hamlet	0.001	0.00
Hypoplectrus nigricans	black hamlet	0.001	0.00
Serranus tortugarum	chalk bass	0.001	0.00

Locally healthy coral communities can still be found along Aruba's southern coast. In combination with healthy herbivore populations such coral communities have a fair chance to grow in the future assuming global factors such as coral bleaching and disease outbreaks do not interfere.

In conclusion

Aruba harbors a large variety of benthic community types

In summary, Aruba has a large variety of benthic habitat types (e.g., due its lagoon and relatively shallow, sandy bottoms around the island) that as a consequence harbor a large variety of benthic community types of significant abundance (e.g., seagrass beds, coral reefs, gorgonian-sponge flats). Together with the presence of a relatively well-developed reef along its entire windward shore, the distribution and composition of Aruba's shallow water communities are different from those on neighboring islands Bonaire and Curaçao.

Coral abundance on Aruba is naturally low due the high abundance of sand

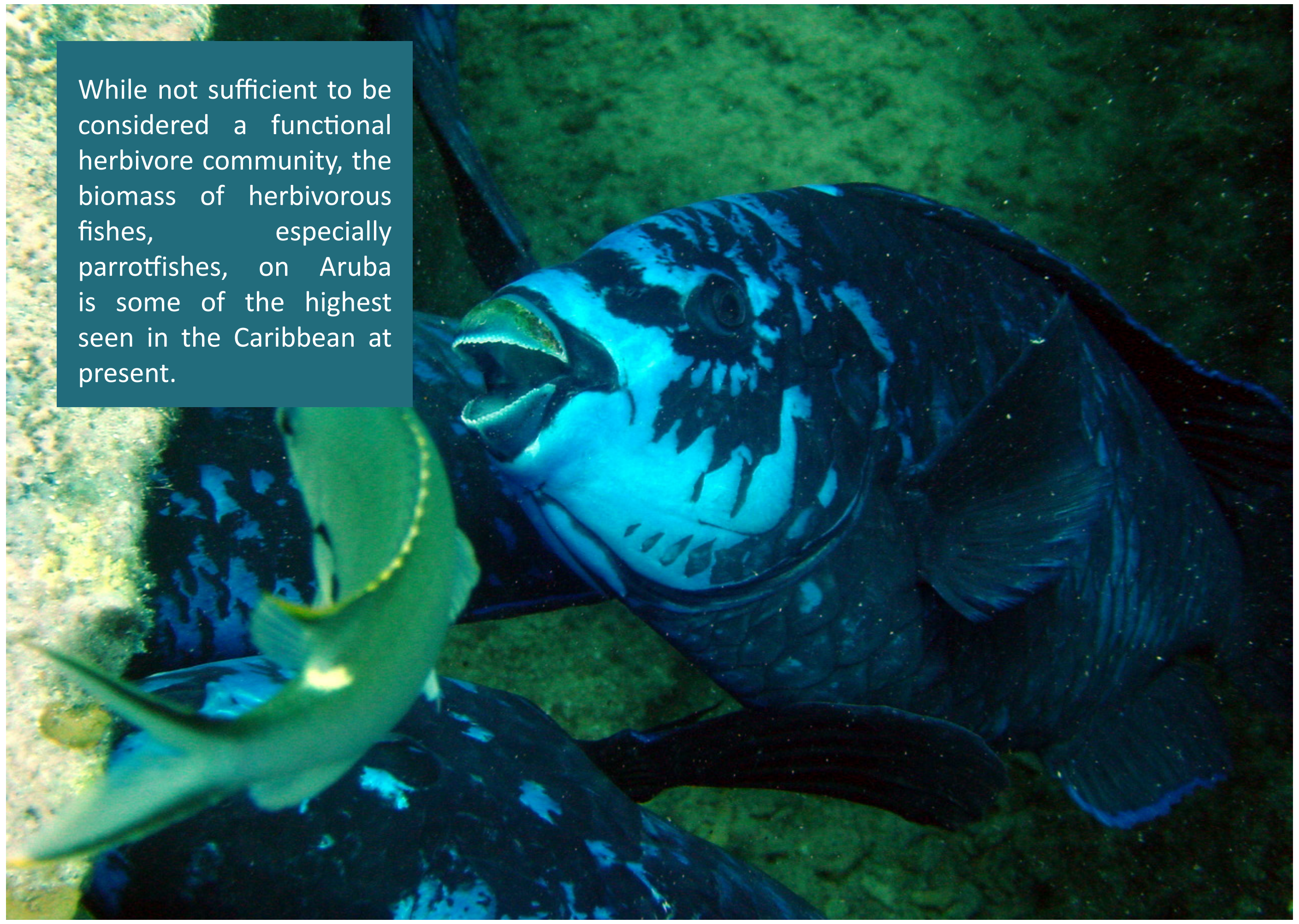
Sandy, shallow seas around Aruba complicate regionwide comparisons of reef health. Due to its location on the Venezuelan continental flat, Aruba's reef communities are dominated by sandy bottoms. This reduces the percentage of bottom available to coral growth and consequently, coral cover on Aruba is to certain degree naturally low (i.e., 6.2%) compared to nearby islands.

Decline of Aruba's nearshore marine communities is evident and ongoing

A large number of indicators strongly suggest widespread, ongoing degradation of Aruba's reef communities, whereby reef communities have all but disappeared in certain areas (e.g., the northwestern part of the island). The disappearance of reef building organisms, strong signal of overfishing, the widespread presence of land-based forms of pollution, and the appearance of organismal groups known to negatively impact reef growth (e.g., macro- and turfalgae and cyanobacteria) independently and jointly indicate that Aruba's reefs are experiencing an overall decline in reef abundance and health. The fact that calcification is never positive, i.e., not one reef that was surveyed is "growing", seems extremely worrisome in this regard and indicative of widespread net erosion.

Aruba's unique characterizes slow down reef degradation to some degree

While decline is evident, the presence of a relatively healthy parrotfish community preventing uncontrolled algal growth, strong currents ensuring dilution of land-based forms of pollution and the presence of the lagoon acting as a natural filter to certain land-based pollutants, all contribute to a more conducive environment for reef growth and should, where possible, be prioritized in management interventions.



While not sufficient to be considered a functional herbivore community, the biomass of herbivorous fishes, especially parrotfishes, on Aruba is some of the highest seen in the Caribbean at present.

Catastrophic declines have already occurred in certain areas

The replacement of reef building organisms by cyanobacteria and macroalgae represents a unique example of complete and utter reef decline in the Caribbean. Not only has the abundance of reef building organisms and fishes declined to extremely low abundance, the high abundance of cyanobacteria and turfalgae indicate a severely disrupted ecosystem. The influx of nutrients, general land-based forms of pollution and organic contributions from land, through the Bubali pond, subterreneaously, as run-off or through failing (sewage) infrastructure, all represent likely candidates that could drive the "microbialization" of Aruba's Northwestern reef sections and are in urgent need of attention given the high abundance of (pathogenic) microbes and widespread occurrence of anoxic sediments.

Reef decline on Aruba is a double-edged sword

While the ongoing decline of Aruba's reef systems will undoubtedly have negative consequences for dependent economies such as fishing and (eco) tourism, the rise of algae, cyanobacteria and microbes, especially along the island's northwestern shore, will complicate the recovery of reef communities in such areas, further reduce the attractiveness of such areas for visiting tourists and result in increasingly larger public health consequences. The island thus stands to lose valuable natural resources provided by coral and fish communities that support its economy but face increasingly larger challenges caused by the organism that take their place.

Aruba's coastal waters experience strong influxes of a large variety of land-based pollutants

Whereas strong currents will dilute some of the land-based forms of pollution that enter the island's coastal waters (e.g., sewage associated microbes, sewage, pollutants from industry and tourism industry), these substances are found along the entire leeward shore of the island whereby their abundance strongly reflects activities on shore. These substances compromise and interfere with the natural dynamics

The relatively high abundance of parrotfishes has a notable effect on the benthos along Aruba’s southern shore. While the proportion of reef substrate covered by turfalgae is high, turf algae are short due to grazing fishes and as a consequence neighboring corals suffer less from the presence of turf algae.

of reef communities resulting in reef decline. Their widespread occurrence (based on water analyses and isotope data etc.) requires urgent attention if Aruba intends to halt or reverse the decline of it nearshore reef communities. The presence of a lagoon appears to minimize these effects to some degree, but only for certain substances (e.g., coffee related substances, human and medical waste).

Coral reefs are not the only marine communities that are in decline

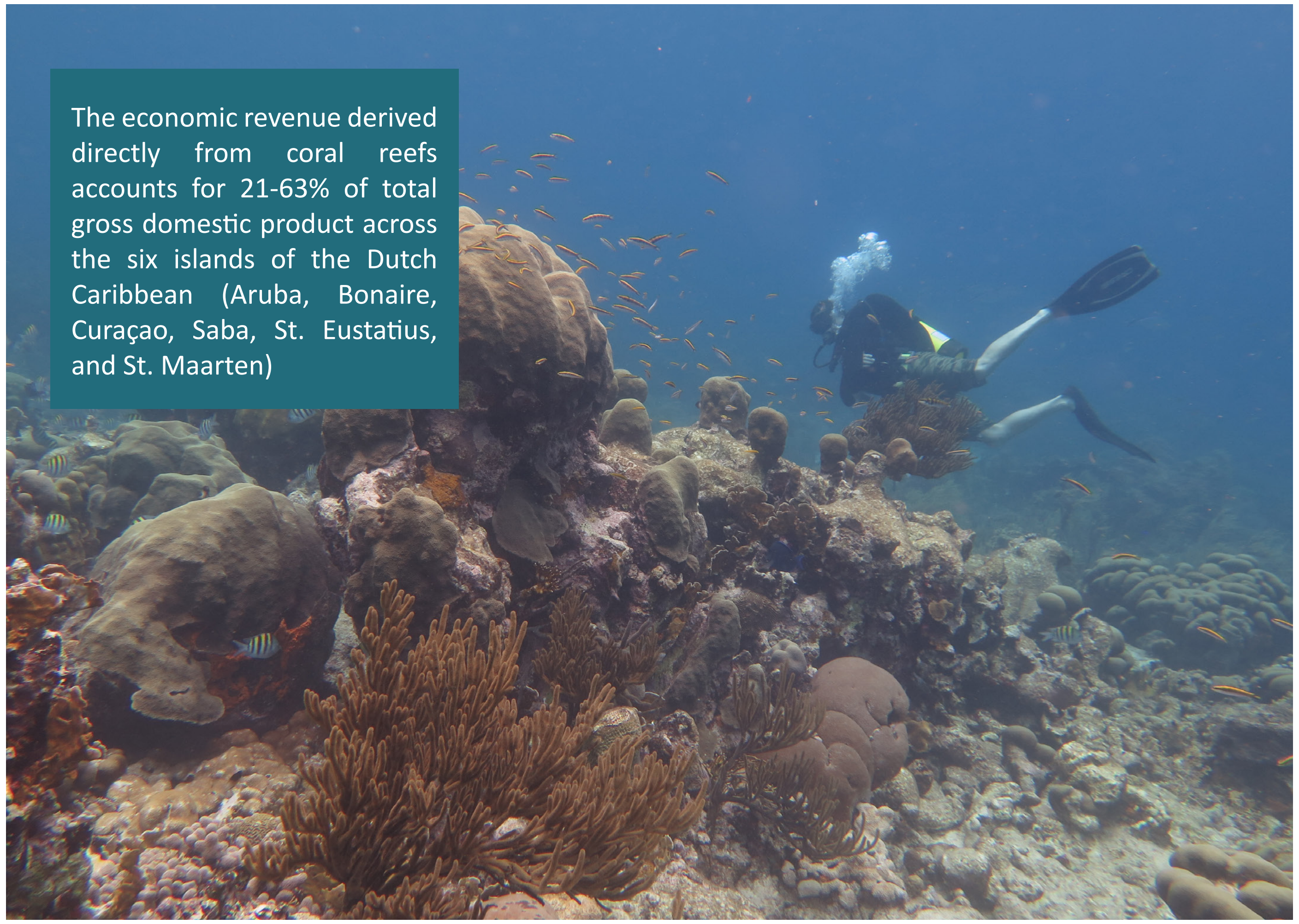
Native seagrass communities are being overgrown by the invasive seagrass Halophila stipulacea. Overgrowth is often observed in areas where native seagrass beds are damaged through human trampling, propeller scarring or the alteration of natural sediment flows. To secure the benefits of such communities (e.g., nursery function for reef fishes, natural filter reducing the abundance of certain land-based pollutants), the management of Aruba’s near shore communities requires a broader context than that on coral reefs alone.

Aruba locally harbors small but extremely healthy reef communities

Despite widespread decline, well-functioning reef communities, characterized by high coral cover, high abundance of parrotfish and low abundance of algae are found along the island’s middle section, especially in shallow waters (<10m). These reefs illustrate that reef growth is locally possible (e.g., as parrotfish occur in high enough abundance to control algal proliferation, even under elevated nutrient concentrations that normally promote algal abundance). Such areas deserve management attention to prevent decline of such last remaining functional reef communities rather, a strategy that should be preferred over assisted recovery approaches after reefs severely declined first.

Aruba’s reef communities lack access to abundant plankton as a source of food

While reef waters always contain zooplankton, species that specifically depend on this resource (e.g., the coral species *Madracis mirabilis*, *Agaricia agaricites* and fishes of the Chromis family) are relatively rare on Aruba (compared to Bonaire and Curaçao). Only in areas with strong water flow are planktivores



The economic revenue derived directly from coral reefs accounts for 21-63% of total gross domestic product across the six islands of the Dutch Caribbean (Aruba, Bonaire, Curaçao, Saba, St. Eustatius, and St. Maarten)

(e.g., gorgonians) found in high abundance. The relatively low abundance of zooplankton could have implications for corals during coral bleaching and disease outbreak events as zooplankton can serves as an additional energy resource to improve survival under such conditions.

Aruban fish communities are overfished, legalizing spearfishing would worsen this

Nearly all reef fish species appear overfished and large fishes (> 25cm) are uncommon in Aruba’s coastal waters. Ecologically and commercially important larger reef species (e.g., snappers, grunts, parrotfishes) become reproductively active at sizes between 15 to 20 cm (Froese and Pauly 2016) suggesting that the low number of larger individuals in Aruba’s fish communities will eventually result in a reduced influx of new individuals, which could worsen the effects of overfishing. In addition to such direct effect of fishing, the destruction of nearshore reef communities to anchor loss are substantial compounding the negative effects of fishing. Based on Aruba’s Fisheries Ordinance (Visserijverordening, AB 1992 no. 116) legal fishing practices are only allowed as long as the survival and natural development of fish stocks are not impacted to unsustainable levels. The consideration to allow spearfishing seems therefore premature given the strong signals for current and widespread overfishing. Aruba has had the foresight in the past to be among the first to protect parrotfishes on the island which noticeably improved the health of its nearshore reef communities. It would be advisable that Aruba continuous in this tradition and takes progressive action to protect, rather than harvest, what is left of its reef fish communities. Stock assessments and catch analyses are required to identify (offshore) fish populations that can be harvested sustainably and to determine when harvesting should be eased to avoid population collapse.

The abundance of commercially important invertebrates is low, confirming overharvesting has occurred

Evidence from widespread overharvesting does not only come from assessments of the fish community along Aruba’s leeward coast. The abundance of conch and lobsters was so low that reliable information on their abundance could not be gathered. The extremely low abundance of these species further supports the fact that Aruba’s reef communities are currently heavily overexploited for all species of


Benthic communities in most southern part of Aruba face strong currents and are dominated by planktivorous organisms such as gorgonians that can locally be very abundant.

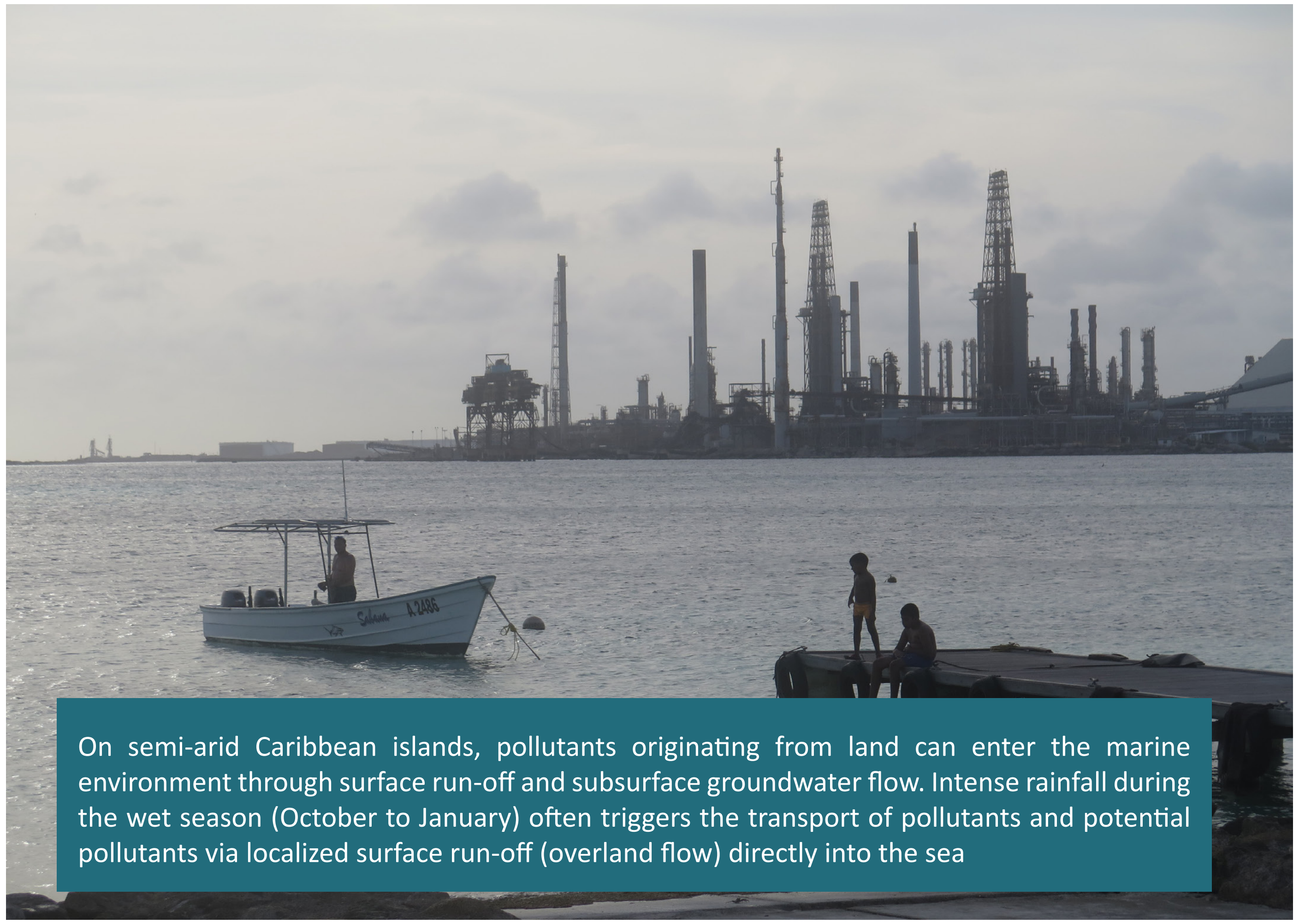
commercial interest.

Major issues affecting Aruba's reefs ask for similarly large management interventions

Given the severity and multitude of factors contributing to reef decline on Aruba (e.g., land-based forms of pollution, overfishing , widespread sewage influxes), conservation and management targets should be defined to reflect the scale of such factors to design meaningful management interventions to reverse the widespread decline of Aruba's reefs. Interventions such as bans on sunscreen or drinking straws could be useful to generate awareness but will never reverse the decline of Aruba's reefs. With ongoing warming of seas worldwide, the danger of coral bleaching events resulting in even higher mortality in the near future looms. Local management action aimed at creating the conditions that promote reef growth (e.g., high abundance of parrotfish) and the disappearance of nuisance species (e.g., cyanobacteria, turfalgae) will not only make reef recovery more likely, but will also improve the chances of corals' survival during coral bleaching events. Limiting the influx of pollutants from land (e.g., through improved rainwater infrastructure), limiting the influx of (partially treated) sewage waters into coastal waters by modernizing and expanding the capacity of the island's waste water treatment facilities, more effective enforcement of existing laws, large no-fishing areas to allow recovery of the island's fish communities.

Beware of spurious relationships to identify drivers of reef decline

When measuring many parameters that could drive reef decline and the abundance of multiple organisms that could undergo such decline, relationships between the two might appear by coincidence. One should be very cautions interpreting such apparent relationships as causal relationships to design management interventions. For example, one could link the abundance of sunscreen in the northwestern part of the island to the near-complete disappearance of reef communities in the same area. However, both sunscreen and catastrophic reef decline more likely follow from the unsustainable use of nearby coasts (e.g., tourism related infrastructure and usages, pesticide use, inefficient treatment and disposing of sewage water). Such more mechanistic explanations incorporating well known drivers of reef decline (e.g., overfishing (especially) of herbivores, land-based pollution (especially the release of sewage water and other forms of microbial and nutrient enrichment) need to be considered, rather than hyped or presumed drivers of reef decline (e.g., sunscreen, plastic straws, fish feeding) to inform management interventions to halt or reverse the decline of Aruba's shallow water reef systems.


On semi-arid Caribbean islands, pollutants originating from land can enter the marine environment through surface run-off and subsurface groundwater flow. Intense rainfall during the wet season (October to January) often triggers the transport of pollutants and potential pollutants via localized surface run-off (overland flow) directly into the sea

Not all forms of management should occur "at sea"

Because Aruba's coastal waters experience strong influxes of a large variety of land-based pollutants their sources and pathways that transport them to the island's coastal zones require attention. By limiting their influx through modifications on land, their effect of Aruba's reef communities can be minimized. Aruba should hence strongly consider an integrated coastal zone management framework (or a "ridge-to-reef approach") to improve its marine resources. The possibility that subterraneous groundwater flow plays an important role as a mechanism transporting substances from land to sea should hereby be strongly considered.

Beware of "doom and gloom", Aruba's reefs are not gone yet

The lack of upwelling (as suggested by the low relative abundance of planktivores) likely also reduces the natural influx of nutrients which limits algal proliferation. Algae, both turf and macroalgae overgrow corals and promote microbial growth and coral disease (through the release of organic carbon). Uncontrolled algal growth is therefore an undesirable element of reef community dynamics. The abundance of sandy surfaces and the relatively high abundance of herbivorous fishes (especially parrotfish) also reduce the risk of uncontrolled algal proliferation. Herbivores and limited natural influx of nutrients do however prevent algal proliferation, but do not reverse it once it has occurred. Algal abundance on Aruba is relatively low: turfalgae are often well-grazed which reduces their negative effects on neighboring corals and the abundance of macroalgae is extremely low along its southern coast. Coral diseases are also relatively rare and Aruba's lagoon buffers reefs to land-based pollutants to some degree. Combined such observations suggest that the decline in coral abundance can either be related to global factors such as climate change resulting in e.g., coral bleaching or local factors that can be managed. In a recent IUCN study overviewing the status and changes of all reefs around the Caribbean (Jackson et al. 2013) a clear pattern emerged indicating that local management

Both above and below water, biodiversity and pristine views are essential to an island's reputation as a tourist destination.

interventions foremost drive reef health at present and that global factors are (currently) still play a relatively minor role in determining what one's reefs look like. Combining the somewhat favorable conditions for coral growth described above with the fact that anthropogenic factors (e.g., overfishing, land-based forms of pollution) can be managed and that such local management interventions have resulted in desired effects (i.e., mostly the prevention of decline) elsewhere, one could argue that when Aruba takes management of its marine resources serious in the near future, a positive outcome is more likely than for most Caribbean islands facing similar issues. Based on experiences elsewhere in the Caribbean, the presence of healthy reefs foremost reflects timely and effective local management action.

Marine parks are largely, but not always, positioned in areas with high natural values

The recently assigned marine parks generally include some of the reefs of highest natural values on Aruba. The parks along the island's windward side are not considered in this context. However, the MPA Oranjestad, especially its northern section, does not harbor reef communities of significant value. In contrast, reef sections in between MPA Seroe Colorado and MPA Mangel Halto, but especially the area between MPA Magel Halto and MPA Oranjestad harbor some of the best remaining reefs along Aruba's leeward shore. For the purposes of reef conservation, assigning such areas a similar protected status similar to existing, and sometimes less important MPAs deserves critical attention.

Literature Cited

Albins, M. A. 2013. Effects of invasive Pacific red lionfish Pterois volitans versus a native predator on Bahamian coral-reef fish communities. Biological Invasions 15:29-43.

Albins, M. A., and M. A. Hixon. 2008. Invasive Indo-Pacific lionfish Pterois volitans reduce recruitment of Atlantic coral-reef fishes. Marine Ecology Progress Series 367:233-238.

Bak, R. 1987. Effects of chronic oil pollution on a Caribbean coral reef. Marine Pollution Bulletin 18:534-539.

Bak, R. P. 1975. Ecological aspects of the distribution of reef corals in the Netherlands Antilles. Bijdragen tot de Dierkunde 45:181-190.

Bak, R. P. 1977. Coral reefs and their zonation in Netherlands Antilles: modern and ancient reefs.

Baker, A. C., P. W. Glynn, and B. Riegl. 2008. Climate change and coral reef bleaching: An ecological assessment of long-term impacts, recovery trends and future outlook. Estuarine, coastal and shelf science 80:435-471.

Barott, K. L., B. Rodriguez-Mueller, M. Youle, K. L. Marhaver, M. J. Vermeij, J. E. Smith, and F. L. Rohwer. 2012. Microbial to reef scale interactions between the reef-building coral Montastraea annularis and benthic algae. Proceedings of the Royal Society B: Biological Sciences 279:1655-1664.

Bax, N., J. Carlton, A. Mathews-Amos, R. Haedrich, F. Howarth, J. Purcell, A. Rieser, and A. Gray. 2001. The control of biological invasions in the world's oceans. Conservation Biology 15:1234-1246.

Bax, N., A. Williamson, M. Aguero, E. Gonzalez, and W. Geeves. 2003. Marine invasive alien species: a threat to global biodiversity. Marine Policy 27:313-323.

Bellwood, D. R., T. P. Hughes, and A. S. Hoey. 2006. Sleeping functional group drives coral-reef recovery. Current Biology 16:2434-2439.

Beroske, E., and F. Timpen. 2018. The impact of illegal dumpsites on the environment. UAUCU Student Research Exchange Collected Papers 2018:142-168.

Bozec, Y.-M., S. O'Farrell, J. H. Bruggemann, B. E. Luckhurst, and P. J. Mumby. 2016. Tradeoffs between fisheries harvest and the resilience of coral reefs. Proceedings of the National Academy of Sciences 113:4536-4541.

Brocke, H. J., L. Polerecky, D. De Beer, M. Weber, J. Claudet, and M. M. Nugues. 2015. Organic matter degradation drives benthic cyanobacterial mat abundance on Caribbean coral reefs. PloS one 10:e0125445.

Cable, J. E., D. R. Corbett, and M. M. Walsh. 2002. Phosphate uptake in coastal limestone aquifers: a fresh look at wastewater management. Limnology and Oceanography Bulletin 11:29-32.

Charles, D. 2013. Sustainable tourism in the Caribbean: the role of the accommodations sector. International Journal of Green Economics 7:148-161.

Cole, S., and V. Razak. 2004. A framework for sustainable tourism in Aruba. Prepared for The National Tourism Council of Aruba and The Minister of Tourism and Transportation, December.

Cole, S., and V. Razak. 2009. How far, and how fast? Population, culture, and carrying capacity in Aruba. Futures 41:414-425.

Cooper, E., L. Burke, and N. Bood. 2008. Coastal capital: economic contribution of coral reefs and mangroves to Belize. Washington DC: World Resources Institute.

Costanza, R., and M. Mageau. 1999. What is a healthy ecosystem? Aquatic ecology 33:105-115.

Day, M. 2010. Human interaction with Caribbean karst landscapes: past, present and future. Acta Carsologica 39.

De Bakker, D. M., E. H. Meesters, R. P. Bak, G. Nieuwland, and F. C. Van Duyl. 2016. Long-term shifts in coral communities on shallow to deep reef slopes of Curaçao and Bonaire: are there any winners? Frontiers in Marine Science 3:247.

de Bakker, D. M., F. C. van Duyl, C. T. Perry, and E. H. Meesters. 2019. Extreme spatial heterogeneity in carbonate accretion potential on a Caribbean fringing reef linked to local human disturbance gradients. Global change biology 25:4092-4104.

de Buisonjé, P. H. 1974. Neogene and quaternary geology of Aruba, Curaçao and Bonaire. PhD thesis, Universiteit van Amsterdam.

De León, R., K. Vane, P. Bertuol, V. C. Chamberland, F. Simal, E. Imms, and M. J. Vermeij. 2013. Effectiveness of lionfish removal efforts in the southern Caribbean. Endangered Species Research 22:175-182.

Departemento Meteorologico Aruba. 2019. Climate Data Aruba.

Derix, R. R. W. M. 2016. Spatial Developments in the Aruban Landscape: A multidisciplinary GIS-oriented approach. Central Bureau of Statistics, Oranjestad.

Dinsdale, E. A., O. Pantos, S. Smriga, R. A. Edwards, F. Angly, L. Wegley, M. Hatay, D. Hall, E. Brown, and M. Haynes. 2008. Microbial ecology of four coral atolls in the Northern Line Islands. PloS one 3:e1584.

Du, J., W. Hu, I. Nagelkerken, L. Sangsawang, K. H. Loh, J. L.-S. Ooi, J. Liao, X. Zheng, S. Qiu, and B. Chen. 2020. Seagrass meadows provide multiple benefits to adjacent coral reefs through various microhabitat functions. Ecosystem Health and Sustainability 6:1812433.

Duyl, F. C. 1985. Atlas of the living reefs of Curacao and Bonaire (Netherlands Antilles). Vrije Universiteit, Amsterdam.

Eakin, C. M., J. S. Feingold, and P. W. Glynn. 1993. Oil refinery impacts on coral reef communities in Aruba. Pages 139-145 in Proceedings of the Colloquium on Global Aspects of Coral Reefs, Health, Hazards and History.

Edwards, C. B., A. Friedlander, A. Green, M. Hardt, E. Sala, H. Sweatman, I. Williams, B. Zgliczynski, S. Sandin, and J. Smith. 2014. Global assessment of the status of coral reef herbivorous fishes: evidence for fishing effects. Proceedings of the Royal Society of London B: Biological Sciences 281:20131835.

Edwards, H. J., I. A. Elliott, C. M. Eakin, A. Irikawa, J. S. Madin, M. McField, J. A. Morgan, R. van Woesik, and P. J. Mumby. 2011. How much time can herbivore protection buy for coral reefs under realistic regimes of hurricanes and coral bleaching? Global change biology 17:2033-2048.

EPA. 2012. 2012 Recreational Water Quality Criteria.

EPA. 2017. Water Quality Standards Handbook: Chapter 3: Water Quality Criteria. Washington, DC.

FAO. 2015-2020. Fishery and Aquaculture Country Profiles. Aruba (2018). Country Profile Fact Sheets.

Finkel, and Finkel. 1975. Water resources development program., Haifa, Israel.

Frazer, T. K., C. A. Jacoby, M. A. Edwards, S. C. Barry, and C. M. Manfrino. 2012. Coping with the Lionfish Invasion: Can targeted removals yield beneficial effects? Reviews in Fisheries Science 20:185-191.

Froese, R., and D. Pauly. 2016. FishBase.(2016). World wide web electronic publication. Available from:< http://www. fishbase. org>. Access on: Jun 13.

Gamarra, J. M. 2018. Perceived economic impact of tourism. UAUCU Student Research Exchange Collected Papers 2018:62-79.

Gaylard, S., M. Waycott, and P. Lavery. 2020. Review of Coast and Marine Ecosystems in Temperate Australia Demonstrates a Wealth of Ecosystem Services. Frontiers in Marine Science 7:453.

GCRMN. 2016. The GCRMN-Caribbean guidelines.in U. Environment, editor.

Govers, L. L., L. P. Lamers, T. J. Bouma, J. H. de Brouwer, and M. M. van Katwijk. 2014. Eutrophication threatens Caribbean seagrasses–An example from Curaçao and Bonaire. Marine Pollution Bulletin 89:481-486.

Haas, A. F., M. F. Fairoz, L. W. Kelly, C. E. Nelson, E. A. Dinsdale, R. A. Edwards, S. Giles, M. Hatay, N. Hisakawa, and B. Knowles. 2016. Global microbialization of coral reefs. Nature Microbiology 1:16042.

Haas, A. F., C. E. Nelson, L. W. Kelly, C. A. Carlson, F. Rohwer, J. J. Leichter, A. Wyatt, and J. E. Smith. 2011. Effects of coral reef benthic primary producers on dissolved organic carbon and microbial activity. PloS one 6:e27973.

Harborne, A. R., P. J. Mumby, F. Micheli, C. T. Perry, C. P. Dahlgren, K. E. Holmes, and D. R. Brumbaugh. 2006. The functional value of Caribbean coral reef, seagrass and mangrove habitats to ecosystem processes. Pages 57-189 in A. J. Southward, C. M. Young, and L. A. Fuiman, editors. Advances in Marine Biology, Vol 50.

Hartmann, A. C., D. Petras, R. A. Quinn, I. Protsyuk, F. I. Archer, E. J. Ransome, G. J. Williams, B. Bailey, M. J. Vermeij, T. Alexandrov, P. C. Dorrestein, and F. Rohwer. 2017. Meta-Mass Shift Chemical (MeMSChem) profiling of metabolomes from coral reefs. Proceedings of the National Academy of Sciences 114:11685-11690.

Hartog, J. 1953. Aruba. Zoals het was, zoals het werd. Van de tijd der Indianen tot heden., Aruba.

Hearty, P., and B. Tormey. 2017. Sea-level change and superstorms; geologic evidence from the last interglacial (MIS 5e) in the Bahamas and Bermuda offers ominous prospects for a warming Earth. Marine geology 390:347-365.

Heck, K. L., T. J. B. Carruthers, C. M. Duarte, A. R. Hughes, G. Kendrick, R. J. Orth, and S. W. Williams. 2008. Trophic Transfers from Seagrass Meadows Subsidize Diverse Marine and Terrestrial Consumers. Ecosystems 11:1198-1210.

Herweijer, J., and J. Focke. 1978. On the Pleistocene sea level history of the Netherlands Antilles. Geol. Mijnbouw.

Hoegh-Guldberg, O., P. Mumby, A. Hooten, R. Steneck, P. Greenfield, E. Gomez, C. Harvell, P. Sale, A. Edwards, and K. Caldeira. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318:1737-1742.

Jackson, J., M. K. Donovan, K. Cramer, and Y. Lam. 2013. Status and Trends of Caribbean Coral Reefs: 1970-2012.

Jeftic, L., J. Laughlin, P. Vanrompay, A. Matte-Baker, and M. Schomaker. 2006. the Protection of the Marine Environment from Land-based Activities (gpa) of the United Nations Environment Programme (unep).

Kelly, L. W., K. L. Barott, E. Dinsdale, A. M. Friedlander, B. Nosrat, D. Obura, E. Sala, S. A. Sandin, J. E. Smith, M. J. A. Vermeij, G. J. Williams, D. Willner, and F. Rohwer. 2012. Black reefs: iron-induced phase shifts on coral reefs. Isme Journal 6:638-649.

Kendall, C., E. M. Elliott, and S. D. Wankel. 2007. Tracing anthropogenic inputs of nitrogen to ecosystems. Stable isotopes in ecology and environmental science 2:375-449.

Kjeldsen, P., M. A. Barlaz, A. P. Rooker, A. Baun, A. Ledin, and T. H. Christensen. 2002. Present and long-term composition of MSW landfill leachate: a review. Critical reviews in environmental science and technology 32:297-336.

Kline, D. I., N. M. Kuntz, M. Breitbart, N. Knowlton, and F. Rohwer. 2006. Role of elevated organic carbon levels and microbial activity in coral mortality. Marine Ecology Progress Series 314:119-125.

Kohsiek, L., C. Hulsbergen, and J. Terwindt. 1987. Beach erosion along the west coast of Aruba, Netherlands Antilles. Journal of coastal research:37-53.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006. World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15:259-263.

Lamb, J. B., J. A. Van De Water, D. G. Bourne, C. Altier, M. Y. Hein, E. A. Fiorenza, N. Abu, J. Jompa, and C. D. Harvell. 2017. Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates. Science 355:731-733.

Lovelock, C. E., I. C. Feller, R. Reef, S. Hickey, and M. C. Ball. 2017. Mangrove dieback during fluctuating sea levels. Scientific Reports 7:1680.

Lue, D. 2019a. Overzicht RWZI Bubali Rendement 2006 tot 2019.xlsx.in D. O. W. A. afdeling Beheer Waterschappen, editor., Oranjestad.

Lue, N. 2019b. Watermonitoring analyseresultaten 2010-2017.

Luksenburg, J. A. 2014. Prevalence of external injuries in small cetaceans in Aruban waters, Southern Caribbean. PloS one 9:e88988.

Marhaver, K. L., M. J. A. Vermeij, F. Rohwer, and S. A. Sandin. 2013. Janzen-Connell effects in a broadcast-spawning Caribbean coral: distance-dependent survival of larvae and settlers. Ecology 94:146-160.

McCook, L. 1999. Macroalgae, nutrients and phase shifts on coral reefs: scientific issues and management consequences for the Great Barrier Reef. Coral Reefs 18:357-367.

McCook, L., J. Jompa, and G. Diaz-Pulido. 2001. Competition between corals and algae on coral reefs: a review of evidence and mechanisms. Coral Reefs 19:400-417.

McField, M., and P. Kramer. 2017. Healthy Reefs for Healthy People: A Guide to Indicators of Reef Health and Social Well-being in the Mesoamerican Reef Region. With contributions by M. Gorrez and M. McPherson.

McField, M., P. Kramer, L. Alvarez Filip, D. I, M. Rueda Flores, A. Petersen, and M. Soto. 2018. 2018 Report card for the Mesoamerican Reef.

Millennium Ecosystem Assessment, M. 2005. Ecosystems and human well-being. Synthesis.

Miloslavich, P., J. M. Diaz, E. Klein, J. Jose Alvarado, C. Diaz, J. Gobin, E. Escobar-Briones, J. J. Cruz-Motta, E. Weil, J. Cortes, A. C. Bastidas, R. Robertson, F. Zapata, A. Martin, J. Castillo, A. Kazandjian, and M. Ortiz. 2010. Marine Biodiversity in the Caribbean: Regional Estimates and Distribution Patterns. PloS one 5.

Ministerie van Ruimtelijke Ontwikkeling, I. e. I. 2016. SEWAGE TREATMENT PLANTS BUBALI PARKIETENBOS ZEEWIJK.

Ministerie van Ruimtelijke Ontwikkeling, I. e. M. 2018. Onze Natuur & Ons Milieu, op weg naar een evenwichtige toekomst. Natuur- en Milieubeleidsnota 2018-2021. Ministerie van Ruimtelijke Ontwikkeling, Infrastructuur en Milieu, Oranjestad.

Mishra, D., S. Narumalani, D. Rundquist, and M. Lawson. 2006. Benthic habitat mapping in tropical marine environments using QuickBird multispectral data. Photogrammetric Engineering & Remote Sensing 72:1037-1048.

Mumby, P., J. Flower, I. Chollett, S. Box, Y. Bozec, C. Fitzsimmons, J. Forster, D. Gill, R. Griffith-Mumby, and H. Oxenford. 2014. Towards Reef Resilience and Sustainable Livelihoods. A Handbook for Caribbean Coral Reef Managers.

Mumby, P. J. 2006. The impact of exploiting grazers (scaridae) on the dynamics of Caribbean coral reefs. Ecological Applications 16:747-769.

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

Murphy, K. S. 2011. An exploratory study of global issues impacting the future of tourism in Aruba. ARA Journal of Tourism Research 5:5-18.

Nagelkerken, I., C. Roberts, G. Van Der Velde, M. Dorenbosch, M. Van Riel, E. C. De La Moriniere, and P. Nienhuis. 2002. How important are mangroves and seagrass beds for coral-reef fish? The nursery hypothesis tested on an island scale. Marine Ecology Progress Series 244:299-305.

Nagelkerken, I., G. Van der Velde, M. Gorissen, G. Meijer, T. Van't Hof, and C. Den Hartog. 2000. Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. Estuarine, coastal and shelf science 51:31-44.

Nelson, C. E., S. J. Goldberg, L. W. Kelly, A. F. Haas, J. E. Smith, F. Rohwer, and C. A. Carlson. 2013. Coral and macroalgal exudates vary in neutral sugar composition and differentially enrich reef bacterioplankton lineages. The ISME journal.

NOAA. 2019. Caribbean 5-km Coral Bleaching Data Products: Aruba, Curacao and Bonaire v 3.1. Coral Reef Watch, Maryland.

Pachauri, R., and A. Reisinger. 2007. IPCC fourth assessment report. IPCC, Geneva:2007.

Pantin, D. A. 2011. Lessons of Tourism Development in Aruba for Sustainable Tourism Development in Tobago-Study Commissioned by the UNDP.

Parida, A. K., and B. Jha. 2010. Salt tolerance mechanisms in mangroves: a review. Trees 24:199-217.

Parkinson, R. W., R. D. DeLaune, and J. R. White. 1994. Holocene sea-level rise and the fate of mangrove forests within the wider Caribbean region. Journal of coastal research:1077-1086.

Pauly, D., S. Ramdeen, and A. Ulman. 2015. Reconstruction of total marine catches for Aruba, southern Caribbean, 1950-2010. Fisheries Centre The University of British Columbia Working Paper Series 10:1-9.

Pendleton, L., D. C. Donato, B. C. Murray, S. Crooks, W. A. Jenkins, S. Sifleet, C. Craft, J. W. Fourqurean, J. B. Kauffman, and N. Marbà. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PloS one 7:e43542.

Perry, C. T., E. N. Edinger, P. S. Kench, G. N. Murphy, S. G. Smithers, R. S. Steneck, and P. J. Mumby. 2012. Estimating rates of biologically driven coral reef framework production and erosion: a new census-based carbonate budget methodology and applications to the reefs of Bonaire. Coral Reefs 31:853-868.

Petras, D., I. Koester, R. Da Silva, B. M. Stephens, A. F. Haas, C. E. Nelson, L. W. Kelly, L. I. Aluwihare, and P. C. Dorrestein. 2017. High-resolution liquid chromatography tandem mass spectrometry enables large scale molecular characterization of dissolved organic matter. Frontiers in Marine Science 4:405.

Polaszek, T., F. Lacle, P. van Beukering, and E. Wolfs. 2018. The Economics of Ecosystems and Biodiversity, Aruba (Updated version). Amsterdam.

Quinn, R. A., M. J. Vermeij, A. C. Hartmann, I. G. d'Auriac, S. Benler, A. Haas, S. D. Quistad, Y. W. Lim, M. Little, and S. Sandin. 2016. Metabolomics of reef benthic interactions reveals a bioactive lipid involved in coral defence. Proc. R. Soc. B 283:20160469.

Ridderstaat, J. R. 2008. The lago story: the compelling story of an oil company on the island of Aruba. Editorial Charuba.

Risk, M. J., B. E. Lapointe, O. A. Sherwood, and B. J. Bedford. 2009. The use of δ15N in assessing sewage stress on coral reefs. Marine Pollution Bulletin 58:793-802.

Roelfsema, C., S. Phinn, N. Udy, and P. Maxwell. 2009. An integrated field and remote sensing approach for mapping seagrass cover, Moreton Bay, Australia. Journal of Spatial Science 54:45-62.

Rohwer, F., M. Youle, and D. Vosten. 2010. Coral reefs in the microbial seas. Plaid Press.

Roos, P. J. 1971. The shallow-water stony corals of the Netherlands Antilles. Studies on the Fauna of Curacao and other Caribbean Islands 37:1-108.

Sandin, S. A., M. J. A. Vermeij, and A. H. Hurlbert. 2008. Island biogeography of Caribbean coral reef fish. Global Ecology and Biogeography 17:770-777.

Semmens, B. X., E. R. Buhle, A. K. Salomon, and C. V. Pattengill-Semmens. 2004. A hotspot of non-native marine fishes: evidence for the aquarium trade as an invasion pathway. Marine Ecology Progress Series 266:239-244.

Sierra, E. E. B. 1994. Size Distribution Patterns of Some Selected Fish Species, in Mangrove, Seagrass, Algal-bed and Coral Reef Habitats at Spaanse Water Bay-Curaçao. Katholieke Universiteit Nijmegen.

Smith, J. E., M. Shaw, R. A. Edwards, D. Obura, O. Pantos, E. Sala, S. A. Sandin, S. Smriga, M. Hatay, and F. L. Rohwer. 2006. Indirect effects of algae on coral: algae-mediated, microbe-induced coral mortality. Ecology letters 9:835-845.

Stephenson, T. S., L. A. Vincent, T. Allen, C. J. Van Meerbeeck, N. McLean, T. C. Peterson, M. A. Taylor, A. P. Aaron-Morrison, T. Auguste, and D. Bernard. 2014. Changes in extreme temperature and precipitation in the Caribbean region, 1961–2010. International Journal of Climatology 34:2957-2971.

Taylor, M. A., L. A. Clarke, A. Centella, A. Bezanilla, T. S. Stephenson, J. J. Jones, J. D. Campbell, A. Vichot, and J. Charlery. 2018. Future Caribbean climates in a world of rising temperatures: the 1.5 vs 2.0 dilemma. Journal of Climate 31:2907-2926.

Teenstra, M. D. 1837. De Nederlandsche West-Indische Eilanden. Sulpke.

ter Horst, E., and T. Becker. 2001. The current status of mangrove forests in Spanish Lagoon (Aruba) evaluated from a hydrological point of view.

Terwindt, J., C. Hulsbergen, and L. Kohsiek. 1984. Structures in deposits from beach recovery, after erosion by swell waves around the southwestern coast of Aruba (Netherlands Antilles). Marine geology 60:283-311.

Van den Oever, F. 2000. Aruba-a geochemical baseline study. Netherlands Journal of Geosciences 79:467-477.

van der Perk, J. P., A. J. Schilstra, D. Strijker, and K. Bettels. 2003. Towards sustainable development of Aruba: Indicators for Ecological Quality. Second Volume C and D.

Van Halewijn, R., L. W. G. Higler, and A. L. Spaans. 1992. Ecologisch onderzoek Bubali-plas, Aruba. IBN-DLO.

van Sambeek, M. H., H. G. M. Eggenkamp, and M. Vissers. 2000. The groundwater quality of Aruba, Bonaire and Curaçao: a hydrogeochemical study. Geologie en Mijnbouw 79:459-466.

Vega Thurber, R. L., D. E. Burkepile, C. Fuchs, A. A. Shantz, R. McMinds, and J. R. Zaneveld. 2014. Chronic nutrient enrichment increases prevalence and severity of coral disease and bleaching. Global change biology 20:544-554.

Vermeij, M., H. DeBey, G. Grimsditch, J. Brown, D. Obura, R. DeLeon, and S. Sandin. 2015. Negative effects of gardening damselfish Stegastes planifrons on coral health depend on predator abundance. Marine Ecology Progress Series 528:289-296.

Vermeij, M., and A. Estep. 2016. 2015 Marine Scientific Assessment of the state of Curaçao's coral reefs. San Diego.

Vermeij, M. J., K. R. Latijnhouwers, F. Dilrosun, V. F. Chamberland, C. E. Dubé, G. Van Buurt, and A. O. Debrot. 2019. Historical changes (1905-present) in catch size and composition reflect altering fisheries practices on a small Caribbean island. PloS one 14:e0217589.

Vermeij, M. J. A., and T. Jonkers. 2013. Bacteriological quality of seawater along the south coast of Curacao. Carmabi unpubl. report:46.

Vermeij, M. J. A., I. van Moorselaar, S. Engelhard, C. Hornlein, S. M. Vonk, and P. M. Visser. 2010. The effects of nutrient enrichment and herbivore abundance on the ability of turf algae to overgrow coral in the Caribbean. PloS one 5.

Versteeg, A. H., and A. C. Ruiz. 1995. Reconstructing brasilwood island: the archaeology and landscape of Indian Aruba. Archaeological Museum Aruba.

Visser, P. M., E. Meesters, and F. C. Van Duyl. 2018. Cruise report RV Pelagia 64PE430 Bottom topography, groundwater discharge and cyanobacterial mats of mesophotic reefs.

Wabnitz, C. C., S. Andréfouët, D. Torres-Pulliza, F. E. Müller-Karger, and P. A. Kramer. 2008. Regional-scale seagrass habitat mapping in the Wider Caribbean region using Landsat sensors: Applications to conservation and ecology. Remote Sensing of Environment 112:3455-3467.

Waite, R., E. Cooper, N. Zenny, and L. Burke. 2011. Coastal Capital: Jamaica. The economic value of Jamaica's coral reef-related fisheries. Washington, DC.

WaittInstitute. 2017. Marine Science Assessment: The State of Curacao's coral reefs. San Diego.

Wear, S. L., and R. V. Thurber. 2015. Sewage pollution: mitigation is key for coral reef stewardship. Annals of the New York Academy of Sciences 1355:15-30.

Weidner, D., G. Laya, and J. Serano. 2001. World swordfish fisheries: an analysis of swordfish fisheries, market trends and trade patterns, past-present-future. Vol. IV. Latin America, Part B. Caribbean, Section 4:1053-1145.

Wielgus, J., E. Cooper, R. Torres, and L. Burke. 2010. Coastal Capital: Economic Valuation of Coral Reefs in the Dominican Republic. World Resource Institute (2010). Working Paper available on: http://www. wri. org/publication/coastal-capital-dominican-republic. Accessed 10:2010.

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

Williams, I. D., N. V. Polunin, and V. J. Hendrick. 2001. Limits to grazing by herbivorous fishes and the impact of low coral cover on macroalgal abundance on a coral reef in Belize. Marine Ecology Progress Series 222:187-196.

Wouters, O. 2018. Biodiversity Preliminary Study: Aruba Marine Park.

York, P. H., P. I. Macreadie, and M. A. Rasheed. 2018. Blue Carbon stocks of Great Barrier Reef deep-water seagrasses. Biology letters 14:20180529.

Appendix 1: The strength and statistical significance of relationships among benthic groups (but also fish groups) reported here

	Benthic groups and benthic characteristics																Biomass of fish groups				
Correlations (Kendall's Tau)	Coral recruits	Turfalgal height	Highest relief	Coral	Turfalgae	CCA	Cyanobacteria	Macroalgae	Sponges	Other invertebrates	Gorgonians	Seagrass	Grazed surface	Sand	Pavement	Hard substrate	Herbivore	Planktivore	Invertivore	Omnivore	Carnivore
Turfalgal height	-0.58 ***	—																			
Highest relief	0.60 ***	-0.62 ***	—																		
Coral	0.48 ***	-0.61 ***	0.61 ***	—																	
Turfalgae	0.44 ***	-0.38 ***	0.55 ***	0.40 ***	—																
CCA	0.47 ***	-0.49 ***	0.60 ***	0.46 ***	0.32 ***	—															
Cyanobacteria	-0.38 ***	0.42 ***	-0.29 **	-0.35 ***	-0.22 *	-0.14	—														
Macroalgae	-0.12	0.12	-0.05	-0.12	0.06	0.07	0.02	—													
Sponges	-0.03	0.02	-0.08	0.01	-0.15	0.09	-0.16	-0.05	—												
Other invertebrates	0.02	-0.18	0.10	0.23 *	-0.20	0.11	-0.21 *	-0.10	0.35 ***	—											
Gorgonians	0.33 ***	-0.36 ***	0.29 **	0.42 ***	0.09	0.20 *	-0.46 ***	-0.17	0.21 *	0.34 **	—										
Seagrass	-0.50 ***	0.38 ***	-0.50 ***	-0.48 ***	-0.39 ***	-0.38 ***	0.50 ***	-0.02	-0.24 *	-0.25 *	-0.42 ***	—									
Grazed surface	0.43 ***	-0.36 ***	0.49 ***	0.38 ***	0.40 ***	0.60 ***	-0.14	-0.08	0.11	0.04	0.19 *	-0.31 **	—								
Sand	-0.09	0.17	-0.26 **	-0.13	-0.36 ***	-0.33 ***	-0.21 *	-0.21 *	0.26 **	0.17	0.15	-0.12	-0.26 **	—							
Pavement	-0.28 *	0.42 ***	-0.31 **	-0.40 ***	-0.09	-0.08	0.40 ***	0.33 **	0.04	-0.25 *	-0.33 **	0.35 **	-0.07	-0.21	—						
Hard substrate	0.55 ***	-0.57 ***	0.68 ***	0.59 ***	0.70 ***	0.55 ***	-0.34 ***	0.11	-0.06	0.04	0.30 **	-0.50 ***	0.48 ***	-0.43 ***	-0.20	—					
Herbivore biomass	0.48 ***	-0.54 ***	0.57 ***	0.50 ***	0.46 ***	0.37 ***	-0.34 ***	-0.18	-0.03	0.06	0.32 ***	-0.46 ***	0.31 **	-0.03	-0.34 **	0.49 ***	—				
Planktivore biomass	0.40 ***	-0.45 ***	0.45 ***	0.51 ***	0.27 **	0.29 **	-0.33 ***	-0.13	0.10	0.29 **	0.47 ***	-0.48 ***	0.27 **	0.04	-0.36 **	0.42 ***	0.46 ***	—			
Invertivore biomass	0.28 **	-0.23 *	0.27 **	0.33 ***	0.19 *	0.18	-0.24 *	-0.09	0.15	0.17	0.35 ***	-0.37 ***	0.19 *	0.19 *	-0.15	0.20 *	0.38 ***	0.36 ***	—		
Omnivore biomass	0.19 *	-0.22 *	0.20 *	0.25 **	0.16	0.24 *	-0.14	0.13	0.16	0.12	0.32 ***	-0.24 *	0.12	-0.11	-0.12	0.28 **	0.17	0.29 **	0.22 *	—	
Carnivore biomass	0.45 ***	-0.45 ***	0.51 ***	0.43 ***	0.34 ***	0.32 ***	-0.22 *	-0.10	-0.05	0.00	0.26 **	-0.39 ***	0.31 **	0.00	-0.36 **	0.38 ***	0.47 ***	0.41 ***	0.44 ***	0.17	—
Piscivore biomass	0.08	-0.07	0.17	0.08	0.15	0.23 *	0.12	0.13	0.02	-0.06	-0.03	-0.09	0.10	-0.13	0.20	0.12	0.09	0.01	0.07	0.13	0.06

* p < .05, ** p < .01, *** p < .001

Appendix 2: Mean percentage benthic cover of main benthic groups (non sand corrected values) and the abundances of the same groups expressed as the percentage of bottom covered by them excluding sandy areas (sand-corrected values).

			Average percentage bottom cover (non sand corrected values												Average percentage bottom cover (sand corrected values										
LAT	LONG	Site	Coral	Turfalgae	CCA	Cyanobacteria	Macroalgae	Sponges	Other invertebrates	Gorgonians	Seagrass	Grazed surface	Sand	Pavement	Coral	Turfalgae	CCA	Cyanobacteria	Macroalgae	Sponges	Other invertebrates	Gorgonians	Seagrass	Grazed surface	Pavement
12.6	-70.1	ARU_02	0.5	10.1	0.0	0.0	0.4	1.4	0.0	0.8	0.0	0.3	86.6	0.0	3.6	74.9	0.0	0.0	2.9	10.6	0.0	5.9	0.0	2.1	0.0
12.6	-70.1	ARU_03	3.7	45.7	3.0	5.5	3.2	1.1	0.0	0.3	0.0	1.4	35.7	0.4	5.8	71.0	4.6	8.6	5.0	1.7	0.0	0.5	0.0	2.2	0.5
12.6	-70.1	ARU_04	0.7	28.8	1.0	47.3	0.1	0.3	0.0	1.0	4.6	0.7	15.1	0.6	0.8	33.9	1.1	55.7	0.1	0.4	0.0	1.2	5.4	0.8	0.7
12.6	-70.1	ARU_05	0.0	9.4	1.8	75.5	0.1	0.6	0.0	0.0	1.8	0.7	10.1	0.0	0.0	10.4	2.0	83.9	0.1	0.7	0.0	0.0	2.0	0.8	0.0
12.6	-70.1	ARU_06	0.0	12.2	1.7	48.8	1.3	0.1	0.0	0.0	11.4	0.6	23.9	0.2	0.0	16.0	2.2	64.1	1.6	0.1	0.0	0.0	15.0	0.8	0.2
12.6	-70.1	ARU_07	0.7	26.6	1.3	35.5	1.4	0.5	0.0	0.0	4.4	0.5	28.8	0.5	1.0	37.4	1.9	49.9	1.9	0.6	0.0	0.0	6.1	0.6	0.6
12.6	-70.1	ARU_08	1.3	9.8	1.2	45.0	1.7	1.3	0.2	0.0	0.0	0.0	39.6	0.0	2.2	16.2	1.9	74.4	2.7	2.2	0.3	0.0	0.0	0.0	0.0
12.6	-70.1	ARU_09	0.2	23.4	1.1	31.4	4.1	1.4	0.0	0.1	0.0	0.2	38.2	0.2	0.2	37.8	1.8	50.7	6.6	2.3	0.0	0.1	0.0	0.3	0.2
12.6	-70.1	ARU_10	0.4	19.0	4.2	36.6	10.1	0.9	0.0	0.6	0.2	0.7	26.8	0.7	0.5	26.0	5.7	50.0	13.8	1.2	0.0	0.8	0.2	0.9	1.0
12.6	-70.1	ARU_11	0.6	26.5	1.9	26.4	12.5	0.7	0.0	0.3	0.0	1.2	29.9	0.3	0.8	37.7	2.6	37.6	17.7	1.0	0.0	0.4	0.0	1.7	0.4
12.6	-70.1	ARU_12	0.2	31.3	0.5	5.3	2.1	1.1	0.0	0.0	0.0	0.1	59.5	0.0	0.5	77.2	1.3	13.1	5.1	2.6	0.0	0.0	0.0	0.1	0.0
12.6	-70.1	ARU_13	0.9	21.7	1.0	22.9	1.6	0.7	0.0	0.1	18.6	1.0	31.5	0.1	1.2	31.7	1.4	33.4	2.3	1.1	0.0	0.1	27.2	1.5	0.1
12.5	-70.1	ARU_14	0.1	18.3	0.1	25.4	5.6	0.3	0.0	0.0	23.9	0.8	25.6	0.1	0.1	24.6	0.1	34.2	7.5	0.3	0.0	0.0	32.1	1.0	0.1
12.5	-70.1	ARU_15	0.0	17.2	0.2	24.8	0.1	0.0	0.0	0.0	41.9	0.0	15.7	0.0	0.0	20.5	0.2	29.5	0.1	0.0	0.0	0.0	49.8	0.0	0.0
12.5	-70.1	ARU_16	2.2	27.6	0.5	1.2	0.6	1.9	0.0	4.0	0.0	0.1	61.9	0.0	5.7	72.5	1.3	3.2	1.6	5.0	0.0	10.4	0.0	0.3	0.0
12.5	-70.1	ARU_17	1.0	3.5	0.1	26.0	0.0	0.6	0.1	0.4	19.7	0.0	48.7	0.0	1.9	6.8	0.2	50.7	0.0	1.1	0.1	0.7	38.4	0.0	0.0
12.5	-70.1	ARU_18	0.6	7.1	0.0	17.5	0.1	0.5	0.1	0.0	15.4	0.0	58.6	0.0	1.4	17.3	0.0	42.3	0.2	1.1	0.1	0.1	37.3	0.1	0.0
12.5	-70.1	ARU_19	4.2	17.6	3.4	3.9	0.4	2.2	0.2	5.7	0.0	2.3	60.1	0.1	10.4	44.2	8.4	9.7	1.1	5.6	0.4	14.4	0.0	5.7	0.1
12.5	-70.0	ARU_20	16.9	21.4	4.1	4.9	0.1	1.3	0.1	6.9	0.0	1.7	42.7	0.0	29.5	37.4	7.1	8.6	0.1	2.3	0.1	12.0	0.0	3.0	0.0
12.5	-70.0	ARU_21	6.3	24.4	1.7	17.0	0.4	1.2	0.1	8.1	0.0	2.5	38.4	0.0	10.3	39.5	2.7	27.5	0.7	1.9	0.2	13.1	0.0	4.1	0.0
12.5	-70.0	ARU_22	0.9	21.8	0.7	7.8	0.0	1.4	0.0	7.1	0.2	0.9	59.3	0.0	2.3	53.6	1.6	19.1	0.0	3.3	0.0	17.4	0.4	2.3	0.0
12.5	-70.0	ARU_23	0.8	7.3	0.0	5.1	0.0	0.7	0.2	2.0	0.0	0.1	84.0	0.0	5.0	45.6	0.0	31.6	0.0	4.1	0.9	12.5	0.0	0.3	0.0
12.5	-70.0	ARU_24	3.5	14.6	2.1	6.0	0.1	0.5	0.1	2.1	0.0	0.3	70.9	0.0	12.0	50.0	7.2	20.4	0.3	1.5	0.2	7.2	0.0	1.0	0.0
12.5	-70.0	ARU_25	13.0	30.9	3.0	10.4	0.0	2.0	0.1	3.7	0.0	5.5	31.4	0.0	18.9	45.1	4.4	15.1	0.0	2.9	0.1	5.4	0.0	8.0	0.0
12.5	-70.0	ARU_26	4.2	26.0	5.9	4.5	0.1	1.4	0.0	2.5	0.0	4.0	51.3	0.0	8.6	53.4	12.2	9.3	0.3	2.9	0.0	5.1	0.0	8.2	0.0
12.5	-70.0	ARU_27	7.1	19.7	1.8	6.2	0.0	0.8	0.1	6.0	0.0	3.0	55.5	0.0	15.8	44.2	4.0	13.9	0.0	1.7	0.2	13.4	0.0	6.7	0.0
12.5	-70.0	ARU_28	4.8	14.1	1.7	2.7	0.0	1.3	0.1	4.0	0.0	0.6	70.8	0.0	16.4	48.1	5.7	9.2	0.0	4.5	0.3	13.7	0.0	2.1	0.0
12.5	-70.0	ARU_29	7.7	28.2	5.4	3.5	0.1	1.4	0.1	3.6	0.0	5.8	44.4	0.0	13.8	50.6	9.6	6.2	0.1	2.6	0.1	6.5	0.0	10.5	0.0
12.5	-70.0	ARU_30	10.7	30.0	9.3	5.5	0.0	1.1	0.0	2.8	0.0	7.8	33.1	0.0	15.9	44.8	13.8	8.1	0.0	1.6	0.0	4.2	0.0	11.6	0.0
12.5	-70.0	ARU_31	9.9	23.5	6.9	4.2	0.0	0.9	0.1	2.9	0.0	5.0	46.6	0.0	18.5	43.9	12.9	7.8	0.0	1.7	0.2	5.5	0.0	9.4	0.0
12.5	-70.0	ARU_32	11.3	53.4	10.3	5.2	0.2	0.4	0.0	1.1	0.0	2.3	15.9	0.0	13.4	63.5	12.2	6.2	0.2	0.4	0.0	1.3	0.0	2.7	0.0
12.5	-70.0	ARU_33	3.5	54.3	5.1	4.7	0.8	0.1	0.0	1.0	0.0	6.4	24.0	0.0	4.6	71.4	6.7	6.2	1.1	0.1	0.0	1.4	0.0	8.4	0.0
12.5	-70.0	ARU_34	11.1	46.1	6.0	3.8	2.8	0.3	0.0	2.1	0.0	7.4	20.5	0.0	14.0	58.0	7.5	4.7	3.5	0.3	0.0	2.7	0.0	9.3	0.0
12.5	-70.0	ARU_35	10.1	58.0	5.4	2.5	0.0	0.3	0.0	0.8	0.0	6.1	16.9	0.0	12.2	69.7	6.5	2.9	0.0	0.4	0.0	1.0	0.0	7.3	0.0
12.5	-70.0	ARU_36	6.1	73.0	3.2	4.2	2.1	0.0	0.0	0.6	0.0	1.7	9.2	0.0	6.7	80.4	3.5	4.6	2.3	0.0	0.0	0.6	0.0	1.9	0.0
12.5	-70.0	ARU_37	7.9	56.2	3.9	5.8	0.1	0.3	0.1	1.5	0.0	2.3	22.0	0.0	10.1	72.1	4.9	7.4	0.1	0.3	0.1	1.9	0.0	3.0	0.0
12.4	-70.0	ARU_38	12.8	37.6	2.2	4.1	0.1	0.0	0.0	3.6	0.0	1.4	38.2	0.0	20.6	60.8	3.6	6.7	0.2	0.0	0.0	5.8	0.0	2.3	0.0
12.4	-70.0	ARU_39	10.7	28.0	2.5	2.9	0.0	1.9	0.4	13.9	0.0	1.3	38.5	0.0	17.5	45.4	4.1	4.7	0.0	3.2	0.6	22.6	0.0	2.1	0.0
12.4	-69.9	ARU_40	8.7	25.0	2.1	3.8	0.0	0.6	0.1	17.8	0.0	0.6	41.5	0.0	14.8	42.7	3.5	6.4	0.0	1.0	0.1	30.4	0.0	1.0	0.0
12.4	-69.9	ARU_41	10.9	31.8	3.2	4.1	0.1	0.9	0.0	12.7	0.0	2.4	33.9	0.0	16.4	48.1	4.8	6.2	0.2	1.4	0.0	19.3	0.0	3.6	0.0
12.4	-69.9	ARU_42	9.4	36.3	1.8	3.0	6.7	0.6	0.2	8.9	0.0	0.7	32.5	0.0	13.9	53.7	2.6	4.5	10.0	0.8	0.2	13.2	0.0	1.0	0.0
12.4	-69.9	ARU_43	4.7	19.3	1.5	11.6	0.3	0.2	0.0	2.8	6.1	0.5	53.1	0.0	10.0	41.1	3.3	24.8	0.6	0.3	0.0	6.1	12.9	1.0	0.0
12.4	-69.9	ARU_44	7.1	28.3	0.7	3.5	0.4	0.4	0.0	3.3	0.0	0.5	55.8	0.0	16.1	64.1	1.6	7.9	0.8	0.8	0.0	7.5	0.0	1.1	0.0
12.4	-69.9	ARU_45	19.1	35.3	0.7	4.2	0.3	0.0	0.0	0.4	0.0	0.6	39.4	0.0	31.5	58.3	1.2	6.9	0.4	0.0	0.0	0.7	0.0	1.0	0.0
12.4	-69.9	ARU_46	6.9	32.0	2.1	10.4	0.0	0.2	0.0	11.7	0.0	0.8	35.9	0.0	10.8	49.9	3.3	16.2	0.0	0.4	0.0	18.2	0.0	1.2	0.0
12.4	-69.9	ARU_47	8.2	29.5	1.3	7.1	0.0	0.1	0.0	8.3	0.0	0.4	45.1	0.0	14.9	53.8	2.3	13.0	0.0	0.2	0.0	15.1	0.0	0.7	0.0
12.4	-69.9	ARU_48	1.1	23.2	0.2	14.6	0.0	0.0	0.0	0.1	2.8	0.0	58.1	0.0	2.6	55.3	0.5	34.9	0.0	0.0	0.0	0.1	6.6	0.0	0.0
12.4	-69.9	ARU_49	10.6	50.1	2.6	7.9	7.4	0.1	0.1	0.7	0.0	2.3	18.3	0.0	13.0	61.4	3.2	9.7	9.1	0.1	0.1	0.8	0.0	2.8	0.0
12.4	-69.9	ARU_50	1.7	20.0	0.9	0.5	6.4	0.3	0.0	12.0	0.0	0.0	58.2	0.0	4.0	47.9	2.1	1.2	15.4	0.7	0.0	28.7	0.0	0.0	0.0
12.4	-69.9	ARU_51	24.9	37.8	11.8	6.8	4.7	0.1	0.0	1.4	0.0	1.2	11.5	0.0	28.1	42.7	13.3	7.6	5.3	0.1	0.0	1.6	0.0	1.3	0.0
12.4	-69.9	ARU_52	8.7	22.0	4.1	2.9	9.4	1.0	0.7	11.0	0.0	1.5	38.8	0.0	14.2	35.9	6.8	4.7	15.3	1.6	1.1	17.9	0.0	2.4	0.0
12.4	-69.9	ARU_53	7.1	19.5	2.1	1.8	8.3	0.9	0.3	22.5	0.0	0.2	37.4	0.0	11.3	31.1	3.4	2.9	13.2	1.4	0.5	36.0	0.0	0.3	0.0
12.4	-69.9	ARU_54	23.0	30.3	10.0	3.1	3.2	4.5	3.4	6.3	0.0	1.7	14.5	0.0	26.9	35.4	11.7	3.6	3.7	5.3	4.0	7.4	0.0	1.9	0.0

Data sets and metadata

The following pages overview the data collected at all sites including the average abundance of all measured benthic groups and fishes.

Data sets and metadata: site locations and description of surveys per site

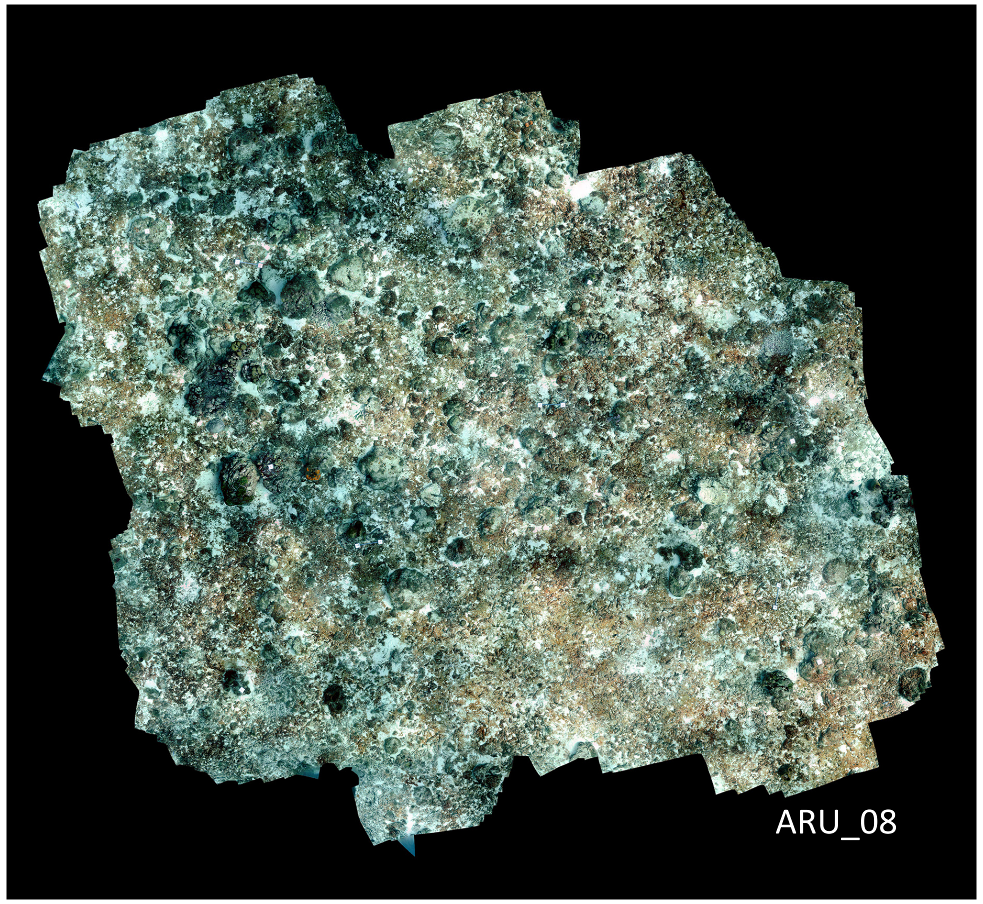
Survey date	Survey time	SITE_ID	Latitude	Longitude	Survey depth (in m)	Fish surveys?	Benthic surveys?	Photomosaics?
13-May-19	9:00 AM	ARU_01	12.62368	70.05963	11	NO	NO	NO
15-May-19	1:00 PM	ARU_02	12.616786	70.06471	12.8	YES	YES	NO
13-May-19	9:45 AM	ARU_03	12.51074	70.0603	10.8	YES	YES	NO
15-May-19	11:30 AM	ARU_03	12.61096	70.06029	9.6	NO	NO	YES
13-May-19	10:45 AM	ARU_04	12.60426	70.05621	11	YES	YES	NO
13-May-19	11:45 AM	ARU_05	12.59921	70.05559	11	YES	YES	NO
13-May-19	1:00 PM	ARU_06	12.5923	70.05633	11.5	YES	YES	NO
13-May-19	2:00 PM	ARU_07	12.58746	70.05841	11	YES	YES	NO
15-May-19	10:00 AM	ARU_08	12.58288	70.06043	12	YES	YES	YES
15-May-19	8:45 AM	ARU_09	12.57501	70.06068	12.1	YES	YES	NO
14-May-19	9:00 AM	ARU_10	12.57041	70.0621	13	YES	YES	NO
14-May-19	10:00 AM	ARU_11	12.56533	70.06459	11.5	YES	YES	NO
14-May-19	11:00 AM	ARU_12	12.55954	70.06632	10	YES	YES	YES
14-May-19	12:00 PM	ARU_13	12.55142	70.06954	10	YES	YES	NO
14-May-19	1:00 PM	ARU_14	12.54687	70.06966	10.5	YES	YES	NO
17-May-19	10:00 AM	ARU_15	12.54076	70.06787	11	YES	YES	NO
17-May-19	11:00 AM	ARU_16	12.53514	70.06426	10	YES	YES	NO
17-May-19	12:00 PM	ARU_17	12.52996	70.06091	12.5	YES	YES	NO
7-May-19	1:00 PM	ARU_18	12.52638	70.05586	11.1	YES	YES	NO
7-May-19	11:45 AM	ARU_19	12.52171	70.05315	12.2	YES	YES	NO
17-May-19	1:00 PM	ARU_20	12.51725	70.04758	11	YES	YES	YES
7-May-19	10:45 AM	ARU_21	12.51294	70.04272	12.1	YES	YES	NO
7-May-19	9:45 AM	ARU_22	12.50986	70.03922	13.2	YES	YES	NO
7-May-19	8:50 AM	ARU_23	12.50475	70.0353	13.5	YES	YES	NO
18-May-19	1:40 PM	ARU_24	12.50068	70.0315	13.6	YES	YES	YES
6-May-19	2:30 PM	ARU_25	12.49627	70.02692	13	YES	YES	NO
6-May-19	12:00 PM	ARU_26	12.4915	70.02161	12	YES	YES	NO
6-May-19	11:30 AM	ARU_27	12.48746	70.0172	13.2	YES	YES	NO
16-May-19	12:15 PM	ARU_28	12.48348	70.01251	15	YES	YES	YES
6-May-19	10:20 AM	ARU_29	12.4796	70.00573	11.5	YES	YES	NO
6-May-19	9:10 AM	ARU_30	12.47615	70.00018	12.1	YES	YES	NO
8-May-19	1:10 PM	ARU_31	12.47367	69.99449	11.5	YES	YES	NO
16-May-19	10:45 AM	ARU_32	12.47168	69.98839	13.8	YES	YES	YES
8-May-19	12:20 PM	ARU_33	12.46719	69.98452	10.6	YES	YES	NO
8-May-19	11:00 AM	ARU_34	12.46418	69.97838	12.6	YES	YES	NO
8-May-19	9:50 AM	ARU_35	12.46256	69.97082	13.6	YES	YES	NO
16-May-19	9:00 AM	ARU_36	12.45957	69.96564	14.2	YES	YES	YES
8-May-19	9:00 AM	ARU_37	12.45509	69.96154	12.8	YES	YES	NO
9-May-19	1:00 PM	ARU_38	12.44968	69.95673	11	YES	YES	NO
9-May-19	12:00 PM	ARU_39	12.44454	69.9509	11.6	YES	YES	NO
18-May-19	9:30 AM	ARU_40	12.44194	69.94539	13	YES	YES	YES
9-May-19	11:00 AM	ARU_41	12.43944	69.93937	11.8	YES	YES	NO
9-May-19	9:50 AM	ARU_42	12.43788	69.93478	11.3	YES	YES	NO
9-May-19	9:00 AM	ARU_43	12.43594	69.92882	11	YES	YES	NO
18-May-19	11:50 AM	ARU_44	12.43251	69.9237	10.2	YES	YES	NO

Survey date	Survey time	SITE_ID	Latitude	Longitude	Survey depth (in m)	Fish surveys?	Benthic surveys?	Photomosaics?
18-May-19	11:00 AM	ARU_45	12.43031	69.91801	19.2	YES	YES	NO
11-May-19	1:20 PM	ARU_46	12.42657	69.91264	11.2	YES	YES	YES
18-May-19	11:20 AM	ARU_46	N/A	N/A	9.5	NO	NO	NO
11-May-19	12:15 PM	ARU_47	12.42315	69.90741	13	YES	YES	NO
11-May-19	11:10 AM	ARU_48	12.42103	69.9019	12.2	YES	YES	NO
11-May-19	10:30 AM	ARU_49	12.41607	69.89755	11	YES	YES	NO
11-May-19	9:00 AM	ARU_50	12.41212	69.89258	10	YES	YES	NO
10-May-19	1:20 PM	ARU_51	12.41114	69.88532	14.1	YES	YES	YES
10-May-19	11:30 AM	ARU_52	12.41006	69.88088	12.5	YES	YES	NO
10-May-19	10:30 AM	ARU_53	12.41067	69.87417	11.1	YES	YES	NO
10-May-19	9:00 AM	ARU_54	12.41203	69.8662	10	YES	YES	NO

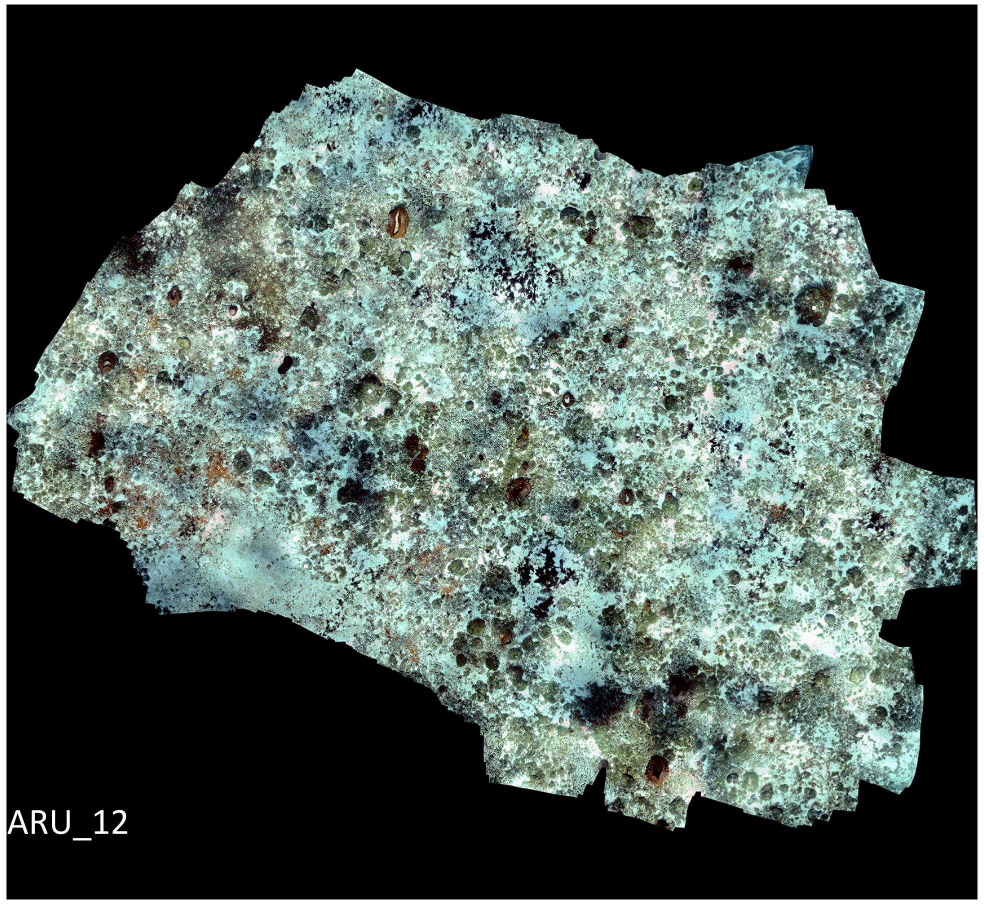
Data sets and metadata: watersampling locations

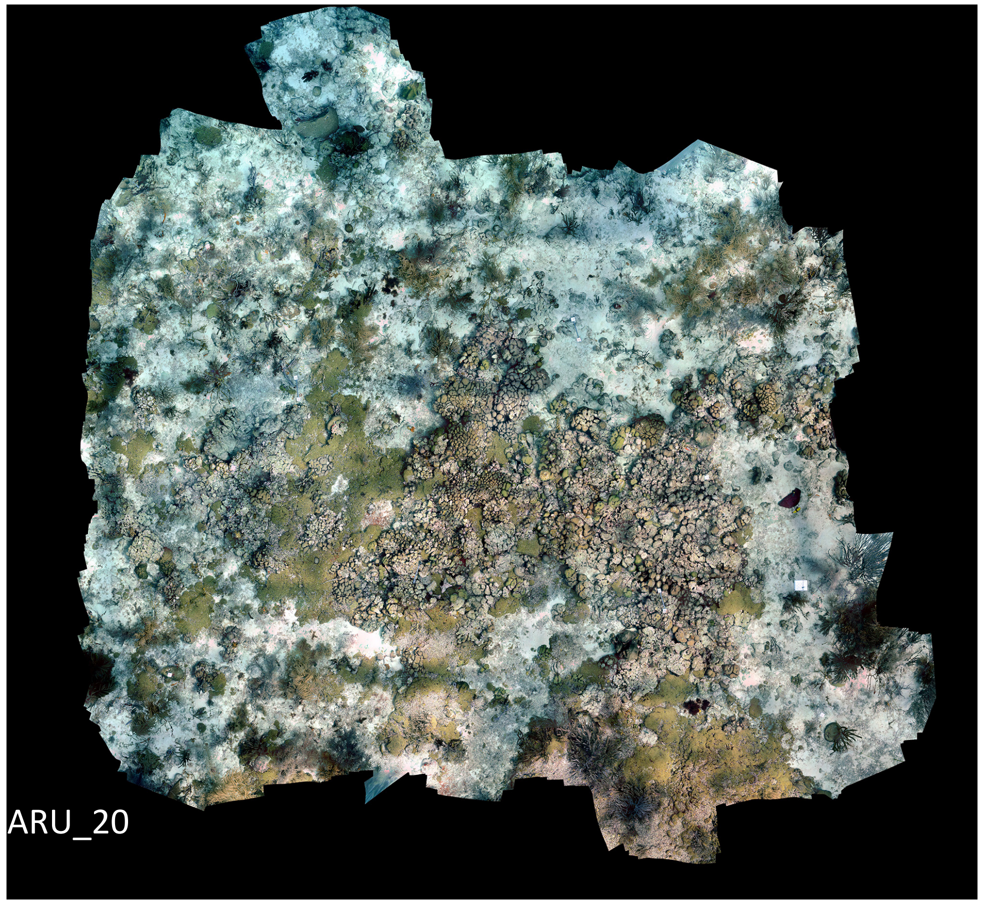
Date taken	Time taken	Sampling location	Location	Latitude	Longitude
20-May-19	2:20 PM	nearshore	Arashi Beach	12.609383	-70.053598
20-May-19	3:38 PM	nearshore	Surfschool	12.584118	-70.045519
20-May-19	4:00 PM	nearshore	Swim area north of Haricurari	12.578563	-70.045097
20-May-19	4:45 PM	nearshore	Exit to sea Bubali Pond	12.558064	-70.055262
20-May-19	5:30 PM	nearshore	Exit bridge	12.514938	-70.035411
20-May-19	6:17 PM	nearshore	South of yaght harbor near diveshop	12.493767	-70.011828
23-May-19	2:09 PM	nearshore	Nautical club	12.471481	-69.977963
23-May-19	3:29 PM	nearshore	Public beach	12.450294	-69.953787
23-May-19	4:30 PM	nearshore	Deserted lands with fallen apart buildings	12.442754	-69.941221
23-May-19	5:15 PM	nearshore	Baby Beach (north side)	12.41400	-69.88242
15-May-19	10:00 AM	above reef	on reef at ARU_08	12.58288	-70.06043
15-May-19	8:45 AM	above reef	on reef at ARU_09	12.57501	-70.06068
17-May-19	11:00 AM	above reef	on reef at ARU_16	12.53514	-70.06426
17-May-19	1:00 PM	above reef	on reef at ARU_20	12.51725	-70.04758
16-May-19	12:15 PM	above reef	on reef at ARU_28	12.48348	-70.01251
16-May-19	9:00 AM	above reef	on reef at ARU_36	12.45957	-69.96564
11-May-19	1:20 PM	above reef	on reef at ARU_46	12.42657	-69.91264
15-May-19	11:30 AM	above reef	on reef at ARU_03	12.61096	70.06029
18-May-19	1:40 PM	above reef	on reef at ARU_24	12.50068	70.0315
18-May-19	11:50 AM	above reef	on reef at ARU_44	12.43251	69.9237
16-May-19	10:45 AM	above reef	on reef at ARU_32	12.47168	69.98839
18-May-19	11:00 AM	above reef	on reef at ARU_45	12.43031	69.91801
11-May-19	1:20 PM	above reef	on reef at ARU_46	12.42657	69.91264
18-May-19	11:20 AM	above reef	on reef at ARU_46	12.42657	69.91264
18-May-19	9:30 AM	above reef	on reef at ARU_40	12.44194	69.94539

Data sets: impressions of the large scale photomosaics (2019) for long term monitoring. Locations are shown as sample site numbers.

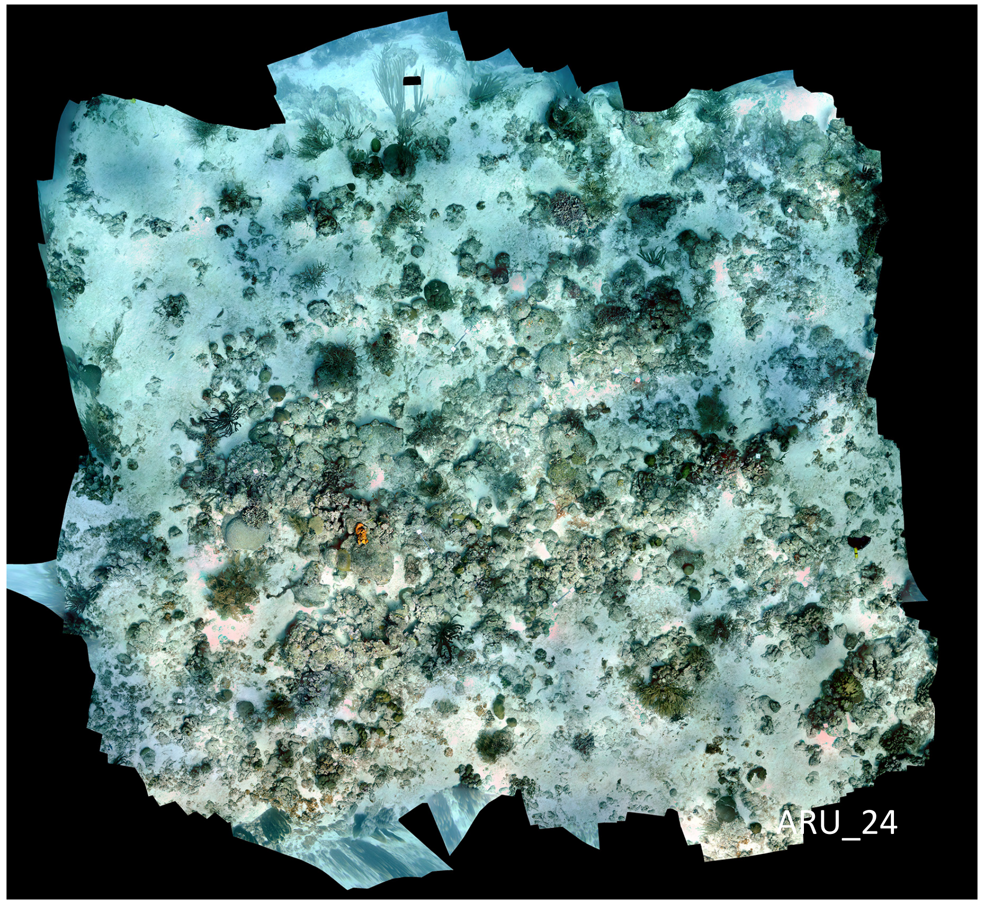


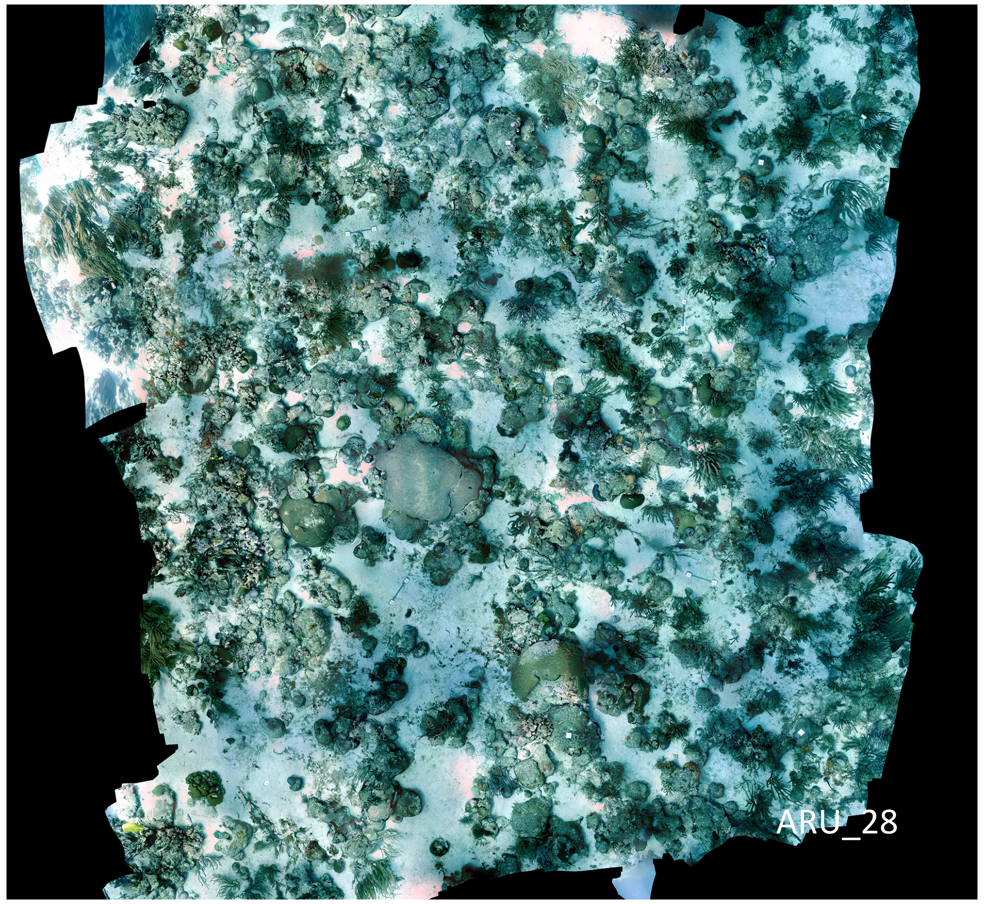
Data sets: impressions of the large scale photomosaics (2019) for long term monitoring (continued).



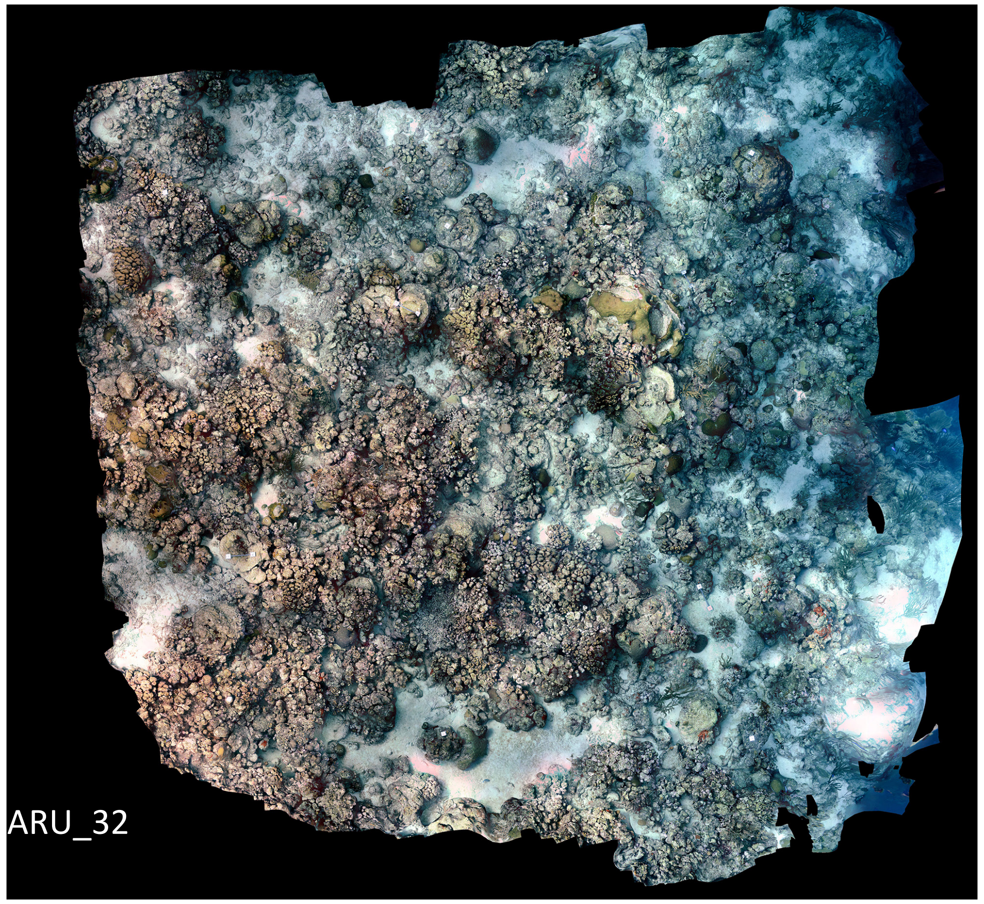


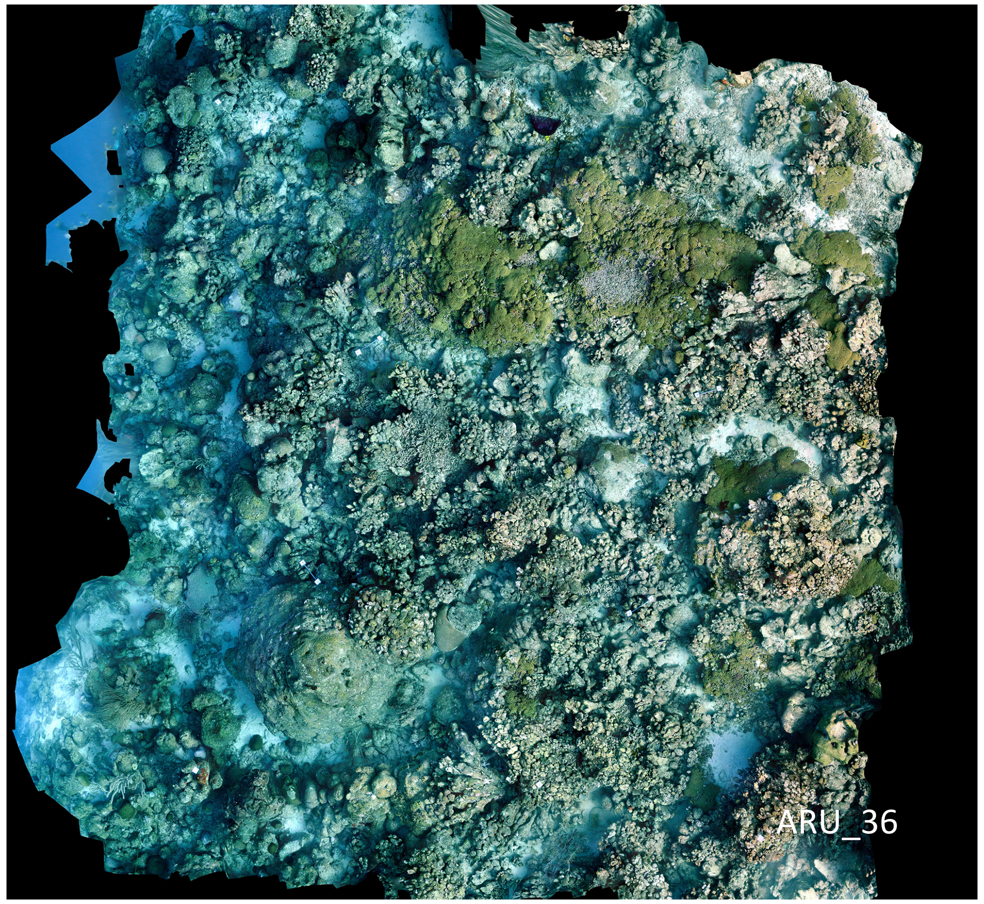
Data sets: impressions of the large scale photomosaics (2019) for long term monitoring (continued).



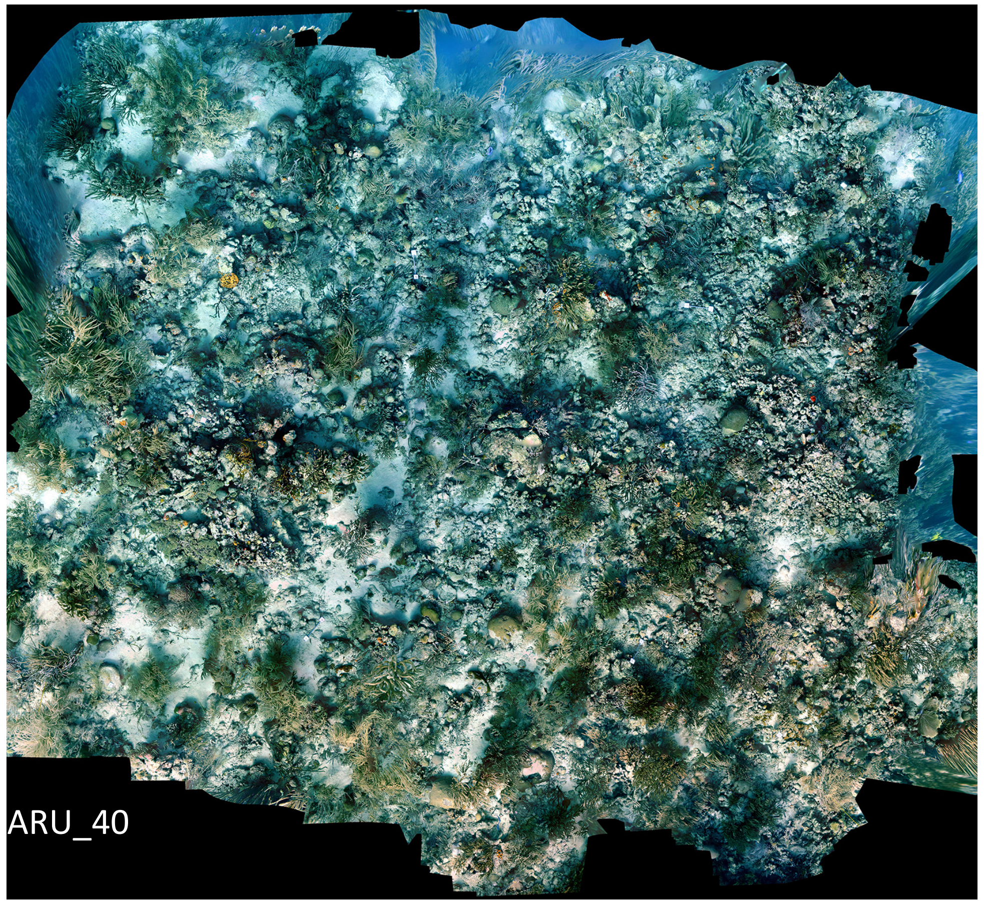


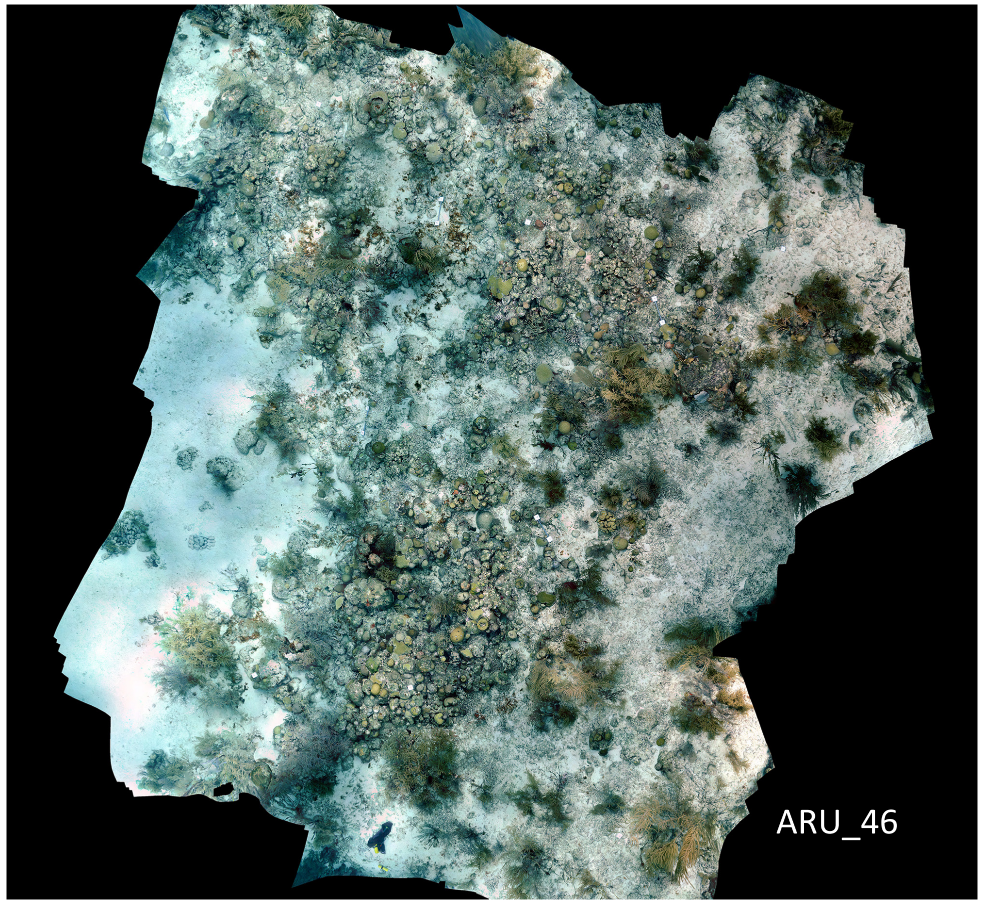
Data sets: impressions of the large scale photomosaics (2019) for long term monitoring (continued).



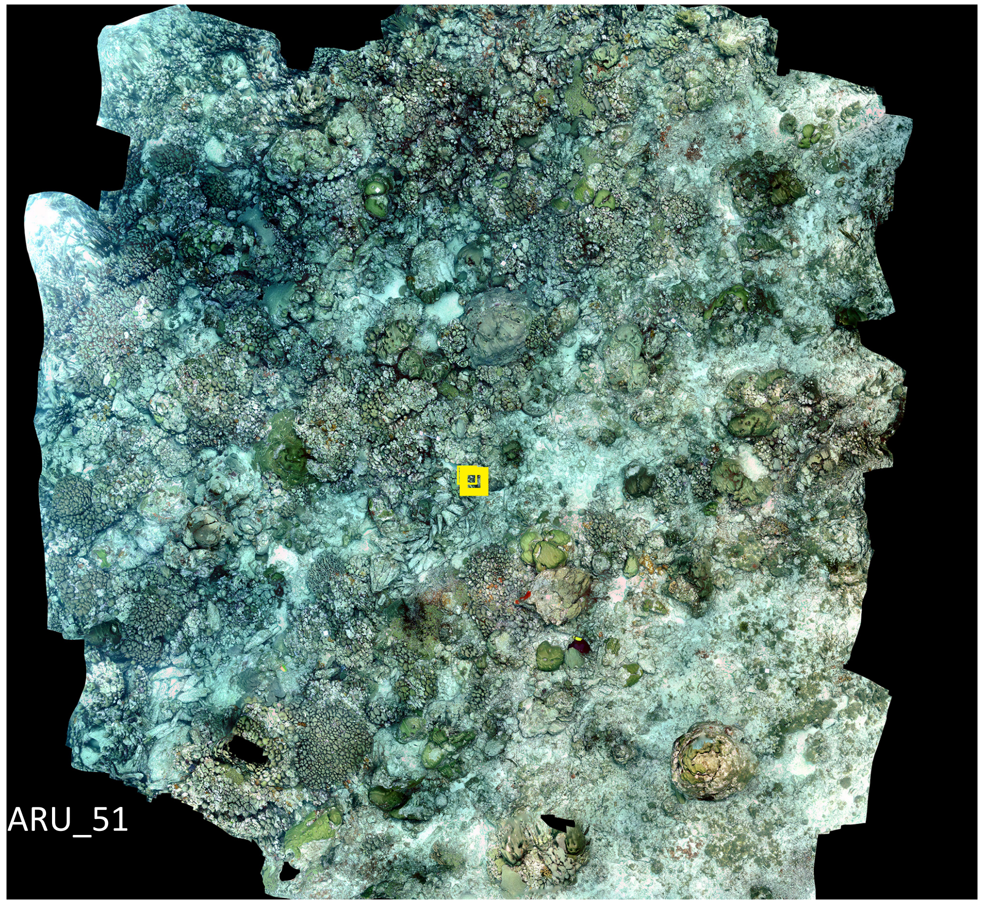


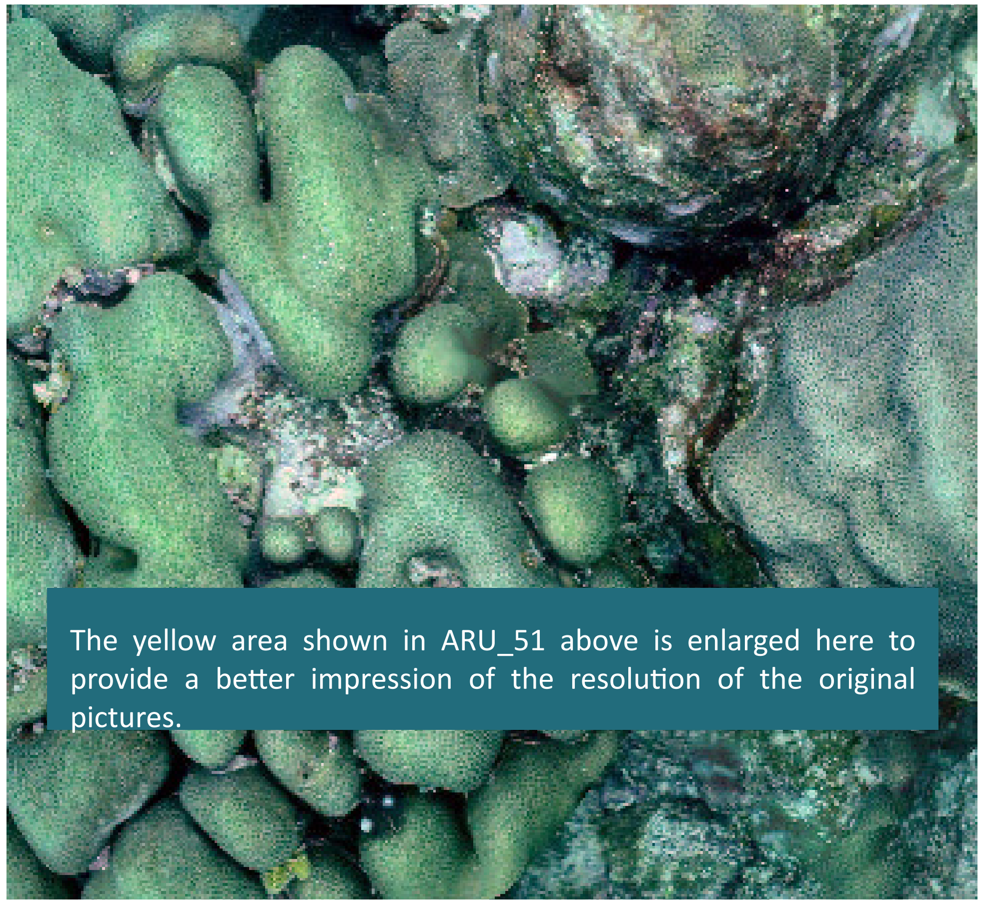
Data sets: impressions of the large scale photomosaics (2019) for long term monitoring (continued).





Data sets: impressions of the large scale photomosaics (2019) for long term monitoring (continued).





The yellow area shown in ARU_51 above is enlarged here to provide a better impression of the resolution of the original pictures.

Data sets: site averages for benthic groups and variables

SITE_ID	Coral	Turf	CCA	Cyanobacteria	Macroalgae	Sponges	Other invertebrates	Gorgonians	Seagrass	Grazed surface	Sand	Pavement	Isotopes (d15N)	Coral recruitment	Turfalgal height	Highest relief
ARU_02	0.49	10.08	0.00	0.00	0.38	1.43	0.00	0.79	0.00	0.28	86.55	0.00	2.20	0.07	11.81	0.07
ARU_03	3.73	45.67	2.97	5.54	3.22	1.10	0.00	0.32	0.00	1.41	35.69	0.35	2.42	1.73	8.25	0.36
ARU_04	0.66	28.75	0.95	47.34	0.10	0.32	0.00	0.98	4.56	0.69	15.09	0.56	1.84	0.00	18.50	0.18
ARU_05	0.00	9.36	1.84	75.46	0.10	0.61	0.00	0.00	1.81	0.71	10.10	0.00	2.49	0.00	39.06	0.05
ARU_06	0.00	12.16	1.70	48.77	1.25	0.05	0.00	0.00	11.43	0.60	23.89	0.15	3.19	0.07	5.64	0.10
ARU_07	0.70	26.63	1.32	35.52	1.35	0.45	0.00	0.00	4.36	0.45	28.75	0.46		0.00	7.45	0.28
ARU_08	1.32	9.81	1.15	44.96	1.66	1.34	0.16	0.00	0.00	0.00	39.61	0.00	2.43	0.00	4.33	0.26
ARU_09	0.15	23.35	1.10	31.35	4.05	1.40	0.00	0.05	0.00	0.20	38.20	0.15	2.15	0.00	10.73	0.22
ARU_10	0.40	19.00	4.15	36.60	10.10	0.90	0.00	0.55	0.15	0.65	26.80	0.70	2.44	0.07	5.33	0.33
ARU_11	0.55	26.45	1.85	26.40	12.45	0.70	0.00	0.25	0.00	1.20	29.85	0.30	2.37	0.07	10.24	0.33
ARU_12	0.20	31.29	0.54	5.32	2.08	1.05	0.00	0.00	0.00	0.05	59.46	0.00	2.25	0.13	4.30	0.24
ARU_13	0.85	21.73	0.96	22.86	1.60	0.75	0.00	0.10	18.63	1.01	31.47	0.05	2.75	0.00	4.90	0.20
ARU_14	0.05	18.27	0.10	25.44	5.55	0.25	0.00	0.00	23.88	0.75	25.61	0.10	2.41	0.07	4.15	0.08
ARU_15	0.00	17.24	0.17	24.81	0.11	0.00	0.00	0.00	41.92	0.00	15.74	0.00	3.61	0.00		0.00
ARU_16	2.17	27.58	0.50	1.22	0.61	1.91	0.00	3.97	0.00	0.10	61.94	0.00	2.29	0.07	2.95	0.18
ARU_17	0.98	3.50	0.10	26.04	0.00	0.56	0.05	0.36	19.73	0.00	48.67	0.00		0.00		0.26
ARU_18	0.59	7.14	0.00	17.49	0.10	0.47	0.05	0.05	15.44	0.05	58.63	0.00	2.85	0.13	5.06	0.09
ARU_19	4.16	17.65	3.37	3.89	0.42	2.22	0.15	5.74	0.00	2.29	60.06	0.05	2.47	0.67	1.61	0.47
ARU_20	16.88	21.39	4.07	4.92	0.06	1.29	0.06	6.89	0.00	1.71	42.75	0.00	2.43	0.67	1.21	0.58
ARU_21	6.33	24.37	1.67	16.96	0.41	1.18	0.10	8.10	0.00	2.51	38.38	0.00	2.59	0.27	3.40	0.54
ARU_22	0.93	21.80	0.65	7.78	0.00	1.36	0.00	7.06	0.15	0.93	59.34	0.00	2.48	0.13	3.29	0.28
ARU_23	0.80	7.30	0.00	5.05	0.00	0.65	0.15	2.00	0.00	0.05	84.00	0.00	2.58	0.00	8.88	0.20
ARU_24	3.50	14.55	2.10	5.95	0.10	0.45	0.05	2.10	0.00	0.30	70.90	0.00	2.36	0.47	3.25	0.47
ARU_25	12.96	30.95	3.04	10.36	0.00	2.02	0.05	3.70	0.00	5.49	31.44	0.00	2.35	0.33	2.96	0.59
ARU_26	4.21	25.97	5.93	4.53	0.14	1.40	0.00	2.48	0.00	4.00	51.34	0.00	2.70	0.87	1.85	0.73
ARU_27	7.05	19.70	1.80	6.20	0.00	0.75	0.10	5.95	0.00	3.00	55.45	0.00	2.83	0.53	3.74	0.36
ARU_28	4.80	14.05	1.65	2.70	0.00	1.30	0.10	4.00	0.00	0.60	70.80	0.00	2.67	0.67	2.01	0.56
ARU_29	7.67	28.16	5.35	3.47	0.05	1.44	0.05	3.63	0.00	5.82	44.36	0.00	2.25	0.60	1.56	0.68
ARU_30	10.65	29.95	9.25	5.45	0.00	1.05	0.00	2.80	0.00	7.75	33.10	0.00	2.18	1.13	2.41	0.94
ARU_31	9.88	23.46	6.87	4.17	0.00	0.93	0.11	2.93	0.00	5.03	46.62	0.00	2.16	0.47	1.73	0.75
ARU_32	11.28	53.40	10.28	5.22	0.15	0.37	0.00	1.06	0.00	2.29	15.94	0.00	2.24	1.73	1.10	1.38
ARU_33	3.53	54.30	5.10	4.72	0.82	0.10	0.00	1.03	0.00	6.41	24.00	0.00	1.87	1.13	1.52	1.27
ARU_34	11.10	46.12	6.00	3.78	2.75	0.28	0.00	2.12	0.00	7.39	20.47	0.00	1.88	0.80	1.32	1.39
ARU_35	10.13	57.95	5.37	2.45	0.00	0.31	0.00	0.82	0.00	6.09	16.88	0.00	2.01	1.13	1.27	1.61
ARU_36	6.07	72.98	3.17	4.16	2.10	0.00	0.00	0.58	0.00	1.70	9.24	0.00	2.19	0.80	1.40	1.77
ARU_37	7.90	56.22	3.85	5.79	0.10	0.26	0.05	1.51	0.00	2.33	22.00	0.00	2.24	1.47	1.88	1.40
ARU_38	12.75	37.58	2.22	4.12	0.11	0.00	0.00	3.57	0.00	1.44	38.22	0.00	2.35	1.67	2.00	0.95
ARU_39	10.75	27.97	2.51	2.87	0.00	1.94	0.37	13.88	0.00	1.27	38.45	0.00	2.33	1.00	1.31	0.63
ARU_40	8.65	24.97	2.07	3.76	0.00	0.61	0.05	17.82	0.00	0.60	41.47	0.00	2.15	0.40	1.42	0.51
ARU_41	10.86	31.76	3.20	4.10	0.10	0.94	0.00	12.73	0.00	2.38	33.92	0.00	2.19	1.53	1.12	0.78
ARU_42	9.38	36.25	1.79	3.02	6.74	0.57	0.15	8.88	0.00	0.69	32.53	0.00	2.22	0.13	1.71	0.64
ARU_43	4.70	19.29	1.54	11.62	0.26	0.15	0.00	2.84	6.05	0.47	53.06	0.00	2.26	0.13	2.73	0.37

Data sets: site averages for benthic groups and variables (continued)

SITE_ID	Coral	Turf	CCA	Cyanobacteria	Macroalgae	Sponges	Other invertebrates	Gorgonians	Seagrass	Grazed surface	Sand	Pavement	Isotopes (d15N)	Coral recruitment	Turfalgal height	Highest relief
ARU_44	7.12	28.31	0.71	3.50	0.35	0.35	0.00	3.31	0.00	0.51	55.83	0.00	2.34	0.40	2.47	0.52
ARU_45	19.09	35.34	0.70	4.16	0.25	0.00	0.00	0.42	0.00	0.62	39.42	0.00	3.47	0.60	2.42	0.45
ARU_46	6.90	32.00	2.10	10.36	0.00	0.25	0.00	11.69	0.00	0.79	35.91	0.00	2.38	1.07	1.42	1.04
ARU_47	8.18	29.54	1.27	7.12	0.00	0.11	0.00	8.30	0.00	0.41	45.07	0.00	2.27	0.73	2.17	0.63
ARU_48	1.08	23.19	0.21	14.63	0.00	0.00	0.00	0.05	2.78	0.00	58.06	0.00	2.73	0.07	3.97	0.19
ARU_49	10.62	50.15	2.58	7.89	7.41	0.05	0.05	0.68	0.00	2.29	18.28	0.00	2.25	0.20	2.70	1.31
ARU_50	1.66	20.05	0.87	0.52	6.42	0.31	0.00	11.99	0.00	0.00	58.19	0.00	1.88	0.40	4.23	0.24
ARU_51	24.90	37.80	11.75	6.75	4.70	0.05	0.00	1.40	0.00	1.15	11.50	0.00	2.11	0.60	1.13	1.50
ARU_52	8.70	21.98	4.13	2.89	9.36	0.98	0.70	10.97	0.00	1.46	38.83	0.00	1.42	0.53	2.07	0.62
ARU_53	7.06	19.49	2.10	1.80	8.29	0.89	0.30	22.51	0.00	0.16	37.40	0.00	2.07	0.80	1.89	0.57
ARU_54	23.00	30.25	10.05	3.11	3.20	4.51	3.44	6.32	0.00	1.67	14.45	0.00	1.61	0.20	0.41	0.61

Data sets: site averages for major fish groups

SITE_ID	Herbivores	Planktivores	Invertivores	Omnivores	Carnivores	Piscivores	Total fish biomass
ARU_02	1.97	3.59	8.58	0.29	0.47	0.00	14.90
ARU_03	45.89	6.62	48.95	4.34	6.07	1.03	112.91
ARU_04	16.27	0.85	17.51	11.03	0.04	8.06	53.77
ARU_05	0.97	0.43	4.17	0.12	3.53	0.07	9.30
ARU_06	12.16	0.20	10.20	0.06	0.63	0.01	23.26
ARU_07	19.55	2.86	8.24	3.68	1.22	1.75	37.30
ARU_08	12.51	11.52	19.34	6.33	7.75	0.65	58.10
ARU_09	6.08	3.23	10.03	9.38	1.21	16.37	46.30
ARU_10	13.58	3.02	5.71	6.09	6.20	10.33	44.93
ARU_11	5.84	4.84	11.73	0.50	2.54	0.01	25.46
ARU_12	16.14	1.89	4.51	0.66	5.60	0.19	29.00
ARU_13	6.95	1.88	15.78	0.24	0.33	0.01	25.19
ARU_14	1.34	1.12	7.73	0.05	8.99	0.00	19.24
ARU_15	0.03	0.00	0.75	14.33	0.00	0.00	15.11
ARU_16	74.63	21.34	172.89	20.69	23.11	0.00	312.67
ARU_17	1.41	0.25	7.66	0.38	4.86	0.03	14.59
ARU_18	2.13	2.10	5.60	0.15	0.30	0.16	10.45
ARU_19	55.76	36.14	64.93	4.14	11.69	0.61	173.27
ARU_20	40.10	38.85	11.75	6.68	15.23	4.92	117.53
ARU_21	60.71	41.25	30.63	60.11	25.49	0.00	218.19
ARU_22	40.45	31.47	36.99	4.18	21.32	2.67	137.09
ARU_23	63.65	42.21	30.81	0.06	2.18	0.00	138.92
ARU_24	48.46	20.32	12.89	5.13	6.28	0.84	93.93
ARU_25	40.22	45.19	16.69	6.79	12.87	0.00	121.76
ARU_26	57.92	18.62	59.39	9.50	37.34	1.00	183.77

Data sets: site averages for major fish groups (continued)

SITE_ID	Herbivores	Planktivores	Invertivores	Omnivores	Carnivores	Piscivores	Total fish biomass
ARU_27	32.79	14.91	12.41	4.39	12.42	0.00	76.93
ARU_28	76.18	15.41	46.02	0.35	76.49	0.87	215.32
ARU_29	123.13	13.74	43.25	5.82	23.99	1.59	211.51
ARU_30	102.99	7.62	17.84	4.28	9.82	0.53	143.08
ARU_31	98.77	22.11	27.64	3.27	16.86	0.01	168.66
ARU_32	79.30	24.30	18.69	2.54	44.50	0.41	169.75
ARU_33	78.48	23.92	11.47	4.84	10.01	0.76	129.49
ARU_34	60.70	17.34	9.42	1.86	7.76	1.51	98.60
ARU_35	80.61	92.61	9.18	4.28	23.16	0.00	209.83
ARU_36	103.64	17.95	10.75	4.87	31.03	0.28	168.51
ARU_37	198.85	154.33	24.76	10.80	24.61	4.86	418.21
ARU_38	68.43	33.67	27.17	5.96	14.37	0.13	149.73
ARU_39	61.16	43.99	33.37	12.84	5.30	0.00	156.68
ARU_40	20.91	15.73	16.18	0.49	2.81	0.30	56.42
ARU_41	185.43	21.62	30.74	16.31	13.31	0.00	267.41
ARU_42	155.45	24.35	17.95	2.01	12.22	0.00	211.98
ARU_43	37.99	34.54	26.86	8.52	12.57	0.00	120.49
ARU_44	97.40	26.42	17.38	3.47	6.90	13.16	164.73
ARU_45	61.64	27.83	60.60	2.86	63.69	0.49	217.11
ARU_46	284.98	42.85	26.58	0.95	30.09	3.11	388.58
ARU_47	77.82	17.71	23.25	5.51	13.66	1.01	138.95
ARU_48	87.62	3.07	10.02	0.11	7.08	0.00	107.90
ARU_49	36.51	18.75	31.30	0.70	16.63	1.51	105.40
ARU_50	36.99	8.70	15.52	12.98	7.91	0.00	82.10
ARU_51	178.03	20.77	121.51	23.26	126.31	3.28	473.16
ARU_52	35.40	18.72	26.03	56.13	8.70	1.98	146.96
ARU_53	24.12	46.28	11.82	30.98	9.01	0.00	122.20
ARU_54	241.70	80.01	13.76	108.09	3.89	7.33	454.78

Data sets: site averages for benthic species & groups

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
Benthic algae & cyanobacteria																		
Acetabularia calyculus	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Caulerpa serrulata	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustose coralline algae	0.0	3.0	1.0	1.8	1.7	1.3	1.2	1.1	4.2	1.9	0.5	1.0	0.1	0.2	0.5	0.1	0.0	3.4
Cyanobacteria	0.0	2.4	19.9	8.8	8.2	0.2	0.6	1.4	0.4	0.4	0.5	0.7	0.1	0.8	0.0	2.4	0.8	0.4
Cyanobacteria (sandy)	0.0	0.3	10.7	3.7	23.3	19.4	28.3	17.1	17.4	12.9	3.6	3.9	2.3	0.6	1.1	20.3	8.3	2.8
Cyanobacteria & turf (sandy)	0.0	0.0	0.8	9.3	10.1	12.3	0.2	7.8	10.1	6.8	0.0	8.9	11.8	11.0	0.1	0.3	2.4	0.4
Dictyota	0.4	3.2	0.0	0.1	1.1	1.4	1.6	4.1	10.1	12.4	2.1	1.5	5.3	0.0	0.6	0.0	0.1	0.4
Halimeda copiosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophora variegata	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mixed turf and cyanos	0.0	2.9	15.9	53.7	7.1	3.7	15.8	5.1	8.7	6.3	1.3	9.4	11.2	12.3	0.0	3.0	6.0	0.4
Mixed turf (sandy)	8.8	9.0	9.3	2.4	8.0	16.8	0.0	9.6	6.2	8.7	0.1	10.7	14.5	17.0	25.1	3.1	6.7	3.2
Mixed turf (thick)	0.8	25.8	13.8	2.1	2.2	3.4	0.2	4.6	6.1	7.6	0.2	4.1	1.6	0.1	0.2	0.1	0.5	0.0
Mixed turf (thin)	0.3	1.4	0.7	0.7	0.6	0.5	0.0	0.2	0.7	1.2	0.1	1.0	0.8	0.0	0.1	0.0	0.0	2.3
Turf (sandy)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sargassum	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Corals																		
Acropora spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agaricia agaricites	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Agaricia lamarcki	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colpophyllia sp	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Dendrogyra cylindrus	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dichocoenia stokesi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Diploria labyrinthiformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Diploria strigosa	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.1
Eusmilia fastigiata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Favia fragum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis carmabi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis decactis	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2
Madracis mirabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis pharensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Meandrina meandrites	0.0	0.5	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.1
Millepora spp.	0.1	0.3	0.1	0.0	0.0	0.4	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.6	0.6	0.0	0.5
Montastraea cavernosa	0.0	0.6	0.0	0.0	0.0	0.0	0.8	0.0	0.1	0.2	0.0	0.6	0.0	0.0	0.3	0.0	0.0	0.5
Orbicella annularis	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Orbicella faveolata	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Orbicella franksi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites astreoides	0.0	0.1	0.0	0.0	0.0	0.2	0.3	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.1
Porites porites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siderastrea radians	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siderastrea siderea	0.2	1.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2
Stephanocoenia michelinii	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.2
Other																		
Ascidians	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gorgonia sp	0.8	0.3	1.0	0.0	0.0	0.0	0.0	0.1	0.6	0.3	0.0	0.1	0.0	0.0	4.0	0.4	0.0	5.7
Lime pavement	0.0	0.4	0.6	0.0	0.2	0.5	0.0	0.2	0.7	0.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Other invert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Palythoa sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Sand rubble	87	36	15	10	24	29	40	38	27	30	59	31	26	16	62	49	59	60

Data sets: site averages for benthic species & groups (continued)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
Benthic algae & cyanobacteria																		
Acetabularia calyculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caulerpa serrulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustose coralline algae	4.1	1.7	0.7	0.0	2.1	3.0	5.9	1.8	1.7	5.4	9.3	6.9	10.3	5.1	6.0	5.4	3.2	3.9
Cyanobacteria	1.0	1.9	2.6	2.4	0.4	3.4	0.8	2.0	0.5	0.1	0.3	0.7	0.3	0.1	0.2	0.1	0.1	0.2
Cyanobacteria (sandy)	2.3	10.9	3.6	1.7	3.5	4.4	1.1	2.1	1.9	0.7	0.3	0.8	0.2	0.6	0.5	0.4	0.3	1.4
Cyanobacteria & turf (sandy)	0.0	1.7	0.3	0.5	0.1	0.7	0.0	0.7	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.4
Dictyota	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1
Halimeda copiosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophora variegata	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.8	2.7	0.0	2.1	0.1
Mixed turf and cyanos	1.6	2.4	1.4	0.5	2.0	1.9	2.6	1.6	0.4	2.6	4.9	2.6	4.7	4.0	3.0	2.0	3.8	3.8
Mixed turf (sandy)	0.2	4.2	6.8	1.9	0.1	9.1	2.0	2.3	0.0	2.7	2.6	1.3	0.2	1.3	1.9	1.1	0.0	1.5
Mixed turf (thick)	0.2	0.7	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.0	0.2	0.1	0.1	0.1	0.0
Mixed turf (thin)	1.7	2.5	0.9	0.1	0.3	5.5	4.0	3.0	0.6	5.8	7.8	5.0	2.3	6.4	7.4	6.1	1.7	2.3
Turf (sandy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sargassum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corals																		
Acropora spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agaricia agaricites	0.6	0.9	0.0	0.0	0.8	2.7	0.2	0.3	0.3	0.6	2.4	0.7	0.9	0.5	3.3	0.7	0.7	0.7
Agaricia lamarcki	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colpophyllia sp	0.0	0.2	0.0	0.1	0.0	0.7	0.0	0.0	0.2	0.2	0.1	0.1	0.8	0.2	1.8	0.6	0.3	0.9
Dendrogyra cylindrus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Dichocoenia stokesi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Diploria labyrinthiformis	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Diploria strigosa	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.3	0.1	0.1	0.1	0.0	0.5	0.1	0.1
Eusmilia fastigiata	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.1	0.0	0.1
Favia fragum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis carmabi	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis decactis	0.3	0.3	0.0	0.0	0.1	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.2	0.1	0.2	0.1	0.2	0.1
Madracis mirabilis	9.3	0.2	0.0	0.0	0.0	6.6	0.9	4.0	1.6	2.7	1.2	0.3	1.0	0.2	1.3	0.2	2.2	2.5
Madracis pharensis	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Meandrina meandrites	0.3	0.1	0.2	0.0	0.2	0.8	0.0	0.1	0.2	0.3	0.4	0.2	0.2	0.1	0.0	0.1	0.4	0.3
Millepora spp.	0.6	0.6	0.2	0.3	0.1	0.3	0.6	0.6	0.7	0.5	0.5	0.7	0.2	0.1	0.3	0.2	0.4	0.2
Montastraea cavernosa	0.7	0.4	0.0	0.0	0.4	0.0	0.4	0.1	0.1	0.6	1.0	0.3	0.5	0.0	0.4	1.1	0.1	0.9
Orbicella annularis	3.2	0.8	0.3	0.0	1.4	0.7	1.1	1.7	0.6	1.3	1.8	2.6	3.5	1.4	1.4	1.5	0.7	0.6
Orbicella faveolata	0.7	1.0	0.0	0.1	0.4	0.5	0.5	0.2	1.0	0.4	1.8	4.2	3.0	0.8	0.9	3.2	0.6	0.5
Orbicella franksi	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.1	0.2	0.1
Porites astreoides	0.1	0.4	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.4	0.7	0.2	0.2	0.2	1.2	0.8	0.4	0.3
Porites porites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.2	0.2	0.1
Siderastrea radians	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siderastrea siderea	0.4	0.6	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.2	0.3	0.1	0.1	0.4	0.0	0.2
Stephanocoenia michelinii	0.4	0.5	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.7
Other																		
Ascidians	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gorgonia sp	6.9	8.9	7.1	2.0	2.1	3.7	2.5	6.0	4.0	3.6	2.8	3.0	1.1	1.0	2.1	0.8	0.6	1.5
Lime pavement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invert	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Palythoa sp.	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sand rubble	43	38	59	84	71	31	51	55	71	44	33	47	16	24	20	17	9	22

Data sets: site averages for benthic species & groups (continued)

SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
Benthic algae & cyanobacteria																	
Acetabularia calyculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caulerpa serrulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustose coralline algae	2.2	2.5	2.1	3.2	1.8	1.5	0.7	0.7	2.1	1.3	0.2	2.6	0.9	11.8	4.2	2.1	10.0
Cyanobacteria	0.3	0.3	0.1	0.0	0.1	1.4	0.2	0.0	1.1	1.7	0.2	1.0	0.1	0.1	0.4	0.0	0.2
Cyanobacteria (sandy)	1.3	0.4	0.0	0.3	0.2	0.7	0.1	0.1	2.7	2.8	6.4	2.5	0.3	0.7	0.8	0.8	0.2
Cyanobacteria & turf (sandy)	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.5	0.0	0.0	0.0	0.0	0.1	0.0
Dictyota	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	6.4	4.6	9.3	8.2	3.2
Halimeda copiosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Lobophora variegata	0.0	0.0	0.0	0.1	6.6	0.3	0.4	0.2	0.0	0.0	0.0	7.3	0.0	0.1	0.0	0.1	0.0
Mixed turf and cyanos	2.6	2.1	3.7	3.8	3.9	9.5	3.2	4.1	6.3	2.6	7.6	4.3	0.2	6.0	1.7	1.0	2.7
Mixed turf (sandy)	1.1	0.3	0.0	0.7	0.4	1.0	1.3	2.6	0.1	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.2
Mixed turf (thick)	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.3	0.1	0.2	3.4	0.5	0.1	0.1	0.1	0.2
Mixed turf (thin)	1.4	1.3	0.6	2.4	0.7	0.5	0.5	0.6	0.8	0.4	0.0	2.3	0.0	1.2	1.5	0.2	1.7
Turf (sandy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sargassum	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Corals																	
Acropora spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Agaricia agaricites	0.3	0.4	0.2	0.3	0.1	0.0	0.1	0.1	0.0	0.2	0.1	0.3	0.0	5.4	1.9	1.2	0.2
Agaricia lamarcki	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Colpophyllia sp	0.8	0.1	0.7	0.5	0.2	0.3	0.9	0.5	0.9	0.8	0.2	1.9	0.0	0.9	0.1	0.0	0.4
Dendrogyra cylindrus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Dichocoenia stokesi	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploria labyrinthiformis	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Diploria strigosa	0.3	0.1	0.3	1.9	0.3	0.5	1.5	14.1	0.6	1.1	0.4	0.1	0.4	0.2	0.7	0.1	4.2
Eusmilia fastigiata	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Favia fragum	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis carmabi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madracis decactis	0.1	0.1	0.1	0.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Madracis mirabilis	4.6	0.0	0.2	0.0	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.1
Madracis pharensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meandrina meandrites	0.1	2.1	0.6	1.1	2.6	1.3	1.7	0.7	0.8	0.9	0.2	0.2	0.1	0.0	0.5	0.1	0.0
Millepora spp.	0.2	1.2	0.7	0.8	0.3	0.1	0.7	0.1	0.2	0.4	0.0	0.0	0.8	0.1	0.6	1.7	15.6
Montastraea cavernosa	3.3	5.4	4.1	3.6	3.1	1.2	0.6	1.6	2.5	2.2	0.2	2.9	0.2	0.1	0.8	0.4	0.2
Orbicella annularis	0.8	0.4	0.5	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.0	2.5	0.0	11.7	1.1	0.0	0.0
Orbicella faveolata	1.3	0.2	0.3	0.2	0.2	0.0	0.0	0.2	0.2	0.2	0.0	1.7	0.0	5.8	1.0	1.9	0.1
Orbicella franksi	0.8	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Porites astreoides	0.2	0.5	0.6	1.0	0.6	0.4	0.7	0.8	0.2	0.5	0.0	0.7	0.0	0.1	0.2	0.3	0.6
Porites porites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.2	0.1	0.1	0.0
Siderastrea radians	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siderastrea siderea	0.2	0.3	0.2	0.8	1.0	0.8	0.8	0.8	0.6	0.9	0.0	0.3	0.1	0.2	1.4	1.0	1.3
Stephanocoenia michelinii	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.4	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Other																	
Ascidians	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gorgonia sp	3.6	13.9	17.8	12.7	8.9	2.8	3.3	0.4	11.7	8.3	0.1	0.7	12.0	1.4	11.0	22.5	6.3
Lime pavement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invert	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Palythoa sp.	0.0	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.7	0.3	0.7
Sand rubble	38	38	41	34	33	53	56	39	36	45	58	18	58	12	39	37	14

Data sets: site averages for fish species (ARU_2 to 19)

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
American whitespotted filefish	0.0	1.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
atlantic creolefish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
balloonfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
banded butterflyfish	0.6	0.0	0.1	0.0	0.4	0.8	0.5	0.1	0.5	0.4	0.1	0.4	0.1	0.0	0.0	0.1	0.4	2.0
bandtail puffer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
bar jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
barred cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
barred hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beaugregory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
belted cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bicolor damselfish	0.0	0.1	0.0	0.0	0.4	1.2	1.0	0.6	0.7	1.4	0.2	0.5	0.7	0.0	2.2	0.8	0.5	5.2
bigeye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black durgon	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black margate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
blackbar soldierfish	0.0	2.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	11.7
blackear wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blackfin snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue chromis	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
blue parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue runner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue tang	0.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.3	1.2	0.0	0.0	0.0	1.9	0.0	0.0	1.3
bluehead	0.6	1.0	0.3	0.0	0.2	0.2	4.0	1.3	0.7	1.6	0.9	1.3	0.9	0.0	0.3	0.2	0.8	0.2
bluelip parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bluespotted cornetfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bluestriped grunt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bluestriped lizardfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
boga	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bonnetmouth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bridled goby	0.0	0.0	0.2	0.1	0.1	0.4	0.0	0.0	0.6	0.4	0.1	0.2	0.0	0.0	0.0	0.3	0.0	0.0
brown chromis	0.0	3.1	0.1	0.0	0.0	2.6	7.1	1.6	2.2	3.1	0.8	0.5	0.1	0.0	8.5	0.0	0.0	12.1
brown garden eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	1.2	0.0
bucktooth parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
butter hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
caesar grunt	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
caribbean reef shark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cero	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chain moray	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chalk bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cherubfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chub (bermuda/yellow)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0
clown wrasse	0.0	0.1	0.1	0.2	0.0	0.0	0.2	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cocoa damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
colon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
coney	0.5	3.0	0.0	0.0	0.6	1.2	2.5	0.3	0.7	0.8	5.2	0.3	1.1	0.0	15.5	0.0	0.3	0.0
cottonwick	0.0	0.0	0.3	0.6	2.6	0.0	6.3	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
creole wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
cubera snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_2 to 19)(continued)

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
dash goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
doctorfish	0.0	19.2	16.0	0.5	10.9	15.5	11.1	4.6	4.3	2.8	14.1	5.4	0.0	0.0	8.4	0.6	0.0	2.2
dog snapper	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dusky damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dusky squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
duskyjawfish	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
elacatinus species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
emerald parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
fairy basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flagfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flamefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flat needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
foureye butterflyfish	0.1	1.8	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.0	0.0	1.4	0.0	0.0	0.8
French angelfish	0.0	0.5	10.8	0.0	0.0	3.2	5.9	4.0	5.4	0.0	0.5	0.0	0.0	14.3	0.0	0.0	0.0	0.0
French grunt	0.5	21.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.8	0.0	0.6	29.0
fringed filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
giant manta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
glasseye snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
glassy sweeper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
goldentail moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
goldspot goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
gray angelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gray snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
graysby	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	7.3
great barracuda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greater soapfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
green moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.8
green razorfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
greenbanded goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greenblotch parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0
hairy blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hamlet species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harlequin bass	0.0	0.0	0.0	0.1	0.0	0.0	2.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
highhat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hogfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
honeycomb cowfish	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
horse-eye jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hovering goby	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
indigo hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
inshore lizardfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
jackknife fish	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
jolthead porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lane snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lantern bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longfin damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
longjaw squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longsnout butterflyfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_2 to 19)(continued)

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
longspine squirrelfish	0.0	4.9	2.3	0.8	0.3	2.2	0.7	0.1	0.0	0.6	0.0	1.0	0.0	0.0	2.3	0.0	0.0	19.3
mackerel scad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mahogany snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
margate (white)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
masked/glass goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
midnight parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
molly miller	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0
neon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ocean surgeonfish	2.0	4.8	0.0	0.0	0.4	0.0	0.0	0.6	0.1	0.9	0.0	0.3	0.3	0.0	1.6	0.0	1.6	0.6
ocean triggerfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
orangespotted filefish	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
painted wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pallid goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peacock flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peppermint basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peppermint goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
permit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pluma porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
porcupinefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
porkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
princess parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	3.2
puddingwife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
queen angelfish	0.0	0.9	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.6
queen parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
queen triggerfish	0.0	0.8	1.7	0.2	3.1	0.4	2.8	0.0	0.0	0.4	0.0	7.6	2.1	0.0	0.0	0.0	0.0	0.0
rainbow parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rainbow wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
red hind	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
red lionfish	0.0	0.0	8.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
redband parrotfish	0.0	1.5	0.2	0.2	0.4	2.7	0.4	0.3	0.7	0.3	0.6	0.2	0.0	0.0	8.4	0.0	0.0	7.2
redlip blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redspotted hawkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redtail parrotfish	0.0	1.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	0.0	0.0
reef butterflyfish	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0
reef squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rock beauty	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rock hind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rosy razorfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
saddled blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailfin blenny 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailors choice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sand diver	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sand tilefish	0.0	0.0	0.0	3.4	0.0	0.0	1.3	0.9	0.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
saucereye porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sawcheek cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
schoolmaster	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0
scrawled filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_2 to 19)(continued)

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
seaweed blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
secretary blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sergeant major	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	0.0	4.1
sharknose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharksucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharpnose puffer	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0
sharptail eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shortfin pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shy hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
slender filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
slippery dick	2.3	0.6	10.2	1.6	2.1	3.5	1.4	2.6	1.6	4.1	2.6	1.9	3.3	0.1	1.5	1.1	0.0	0.2
smallmouth grunt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.1	0.0	0.0	0.0
smooth trunkfish	0.0	0.8	1.7	0.6	0.0	0.1	0.0	0.0	0.0	0.6	0.0	0.6	0.0	0.0	0.3	0.0	0.0	0.3
southern sennet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
southern stingray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spanish grunt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spanish hogfish	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	5.2	0.0	0.0	2.3
spinyhead blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotfin butterflyfish	0.0	0.0	0.0	0.0	0.4	0.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.4
spotlight goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted eagle ray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted goatfish	0.0	3.0	0.4	0.0	0.0	0.3	0.8	0.6	1.1	1.9	0.0	0.3	0.8	0.0	15.7	0.0	0.5	1.4
spotted moray	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0
spotted scorpionfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted snake eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted trunkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
squirrelfish	2.0	4.5	0.4	0.0	1.2	0.0	4.9	4.9	0.0	3.1	1.5	3.8	1.3	0.0	0.0	0.8	2.8	0.8
stoplight parrotfish	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	14.9	0.0	0.0	18.9
striped parrotfish	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	2.6	0.0	0.0	1.8
sunshinefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tarpon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
threespot damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
tiger grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobaccofish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tomtate	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trumpetfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1.6
trunkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
twinspot bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_2 to 19)(continued)

SITE_ID	ARU_2	ARU_3	ARU_4	ARU_5	ARU_6	ARU_7	ARU_8	ARU_9	ARU_10	ARU_11	ARU_12	ARU_13	ARU_14	ARU_15	ARU_16	ARU_17	ARU_18	ARU_19
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	0.0	0.1	0.7	6.6	5.3	0.0	0.0
white grunt	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.2
whitestar cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellow goatfish	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.2
yellow jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowcheek wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowhead jawfish	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.1	0.0	0.0
yellowhead wrasse	0.0	0.1	0.1	0.1	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.7	0.9
yellowmouth grouper	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellownose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail damselfish	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
yellowtail hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail parrotfish	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	9.7
yellowtail snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3

Data sets: site averages for fish species (ARU_20 to 37)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
American whitespotted filefish	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	3.9	0.3	0.3	0.0	0.0	0.0	0.3	0.7
atlantic creolefish	0.0	0.0	0.0	0.0	1.4	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
balloonfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
banded butterflyfish	0.4	0.4	0.9	0.0	0.0	0.2	0.7	0.2	0.7	0.2	0.8	0.0	0.1	0.3	0.4	0.4	0.1	0.4
bandtail puffer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bar jack	0.0	0.0	0.0	0.0	0.2	0.0	0.7	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.4	0.0	0.0	0.0
barred cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
barred hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beaugregory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
belted cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bicolor damselfish	3.9	2.5	1.6	3.0	2.5	4.1	6.7	1.9	4.4	3.5	0.6	3.9	4.2	3.7	3.3	3.5	3.6	4.4
bigeye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.6	0.5	0.0	1.5	1.5
black durgon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
black grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black margate	0.0	1.9	0.3	0.0	0.0	3.0	0.0	1.2	0.0	3.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
blackbar soldierfish	6.2	1.0	0.0	0.0	0.4	0.4	1.4	0.0	2.5	0.6	0.9	0.8	1.4	1.4	0.3	0.7	0.0	0.0
blackear wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blackfin snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue chromis	1.3	0.6	0.4	2.8	0.1	0.7	2.2	1.1	3.4	2.0	1.8	3.3	6.6	7.8	4.2	6.7	5.8	9.6
blue parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue runner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue tang	4.3	5.0	0.9	2.8	12.8	5.1	4.7	1.4	14.1	40.8	34.8	3.2	7.5	5.0	2.0	9.5	3.6	18.0
bluehead	0.1	0.3	0.1	1.9	1.2	0.0	0.2	0.1	1.3	0.4	0.3	1.0	0.7	0.2	0.8	0.5	0.5	0.1
bluelip parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0
bluespotted cornetfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_20 to 37) (continued)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
bluestriped grunt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.1	0.0	0.3	1.1	0.0	1.1	1.1	0.0	0.0	0.0
bluestriped lizardfish	0.0	0.0	0.0	0.0	0.8	0.0	1.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
boga	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0
bonnetmouth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bridled goby	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
brown chromis	7.1	13.0	1.1	3.9	9.8	21.2	8.3	3.2	7.0	4.2	2.0	6.2	12.6	8.4	3.4	20.9	10.8	28.3
brown garden eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bucktooth parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
butter hamlet	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
caesar grunt	0.5	4.8	2.4	0.0	0.0	0.5	4.2	0.5	0.0	26.5	2.0	0.9	1.0	0.0	2.4	0.9	0.0	3.7
caribbean reef shark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cero	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chain moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chalk bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cherubfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chub (bermuda/yellow)	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.9	0.0	0.0	0.0	0.0	0.0	0.0
clown wrasse	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
cocoa damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
colon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
coney	0.0	3.0	3.0	0.6	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
cottonwick	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
creole wrasse	0.0	1.6	1.8	0.0	0.0	11.7	1.9	0.0	0.0	0.2	0.1	0.0	0.4	0.8	5.6	52.4	0.4	108.6
cubera snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dash goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
doctorfish	1.7	2.5	3.4	2.6	2.5	1.6	1.2	2.0	8.5	1.2	0.8	1.0	2.0	0.0	2.2	2.2	5.5	118.8
dog snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dusky damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
dusky squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
duskyjawfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
elacatinus species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
emerald parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
fairy basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flagfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flamefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flat needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
foureye butterflyfish	0.5	0.8	1.6	0.9	0.7	0.3	0.6	0.5	0.5	0.9	2.0	1.4	0.1	0.6	0.7	0.4	0.1	0.4
French angelfish	2.0	8.5	3.4	0.0	0.0	5.4	3.1	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	8.9
French grunt	3.3	9.3	9.5	0.6	2.8	1.1	2.3	0.8	3.3	1.7	1.7	2.0	2.2	2.7	0.8	1.9	0.8	1.9
fringed filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
giant manta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
glasseye snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
glassy sweeper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
goldentail moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
goldspot goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gray angelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gray snapper	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	57.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
graysby	4.1	3.6	0.6	1.0	0.6	0.8	8.6	1.0	1.8	6.4	1.6	8.3	29.2	3.4	1.8	1.9	11.6	6.8
great barracuda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greater soapfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_20 to 37) (continued)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
green moray	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	6.5	0.0
green razorfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greenbanded goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greenblotch parrotfish	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hairy blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hamlet species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harlequin bass	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
highhat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hogfish	0.0	0.0	0.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
honeycomb cowfish	0.0	0.7	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	2.1	1.2	0.0	0.0	1.2	1.2	0.0
horse-eye jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hovering goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
indigo hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
inshore lizardfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
jackknife fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
jolthead porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
lane snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lantern bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longfin damselfish	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.4	0.1	0.1	0.0	0.0
longjaw squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longsnout butterflyfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longspine squirrelfish	3.5	0.7	0.0	0.0	0.6	0.6	0.0	0.5	0.3	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
mackerel scad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mahogany snapper	7.3	3.9	3.0	0.0	0.0	0.9	2.2	1.1	0.6	5.0	2.1	0.0	0.3	0.0	0.3	1.4	0.0	0.0
margate (white)	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
masked/glass goby	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
midnight parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
molly miller	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton snapper	0.0	0.0	12.6	0.0	0.0	0.0	17.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
neon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ocean surgeonfish	0.0	2.5	7.4	32.3	0.0	2.0	1.3	2.5	0.0	0.4	1.7	0.6	0.0	0.5	1.6	0.8	0.0	0.6
ocean triggerfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
orangespotted filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0
painted wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pallid goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peacock flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peppermint basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peppermint goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
permit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pluma porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
porcupinefish	0.0	0.0	0.0	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	0.0	4.7	0.0
porkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
princess parrotfish	4.4	5.5	1.9	0.0	2.9	3.3	3.2	2.3	2.5	2.4	6.1	0.8	4.5	4.6	7.6	6.6	5.2	3.5
puddingwife	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
queen angelfish	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
queen parrotfish	0.0	2.2	0.0	0.0	4.1	1.7	1.6	0.5	4.0	4.2	12.8	8.0	6.9	14.3	3.6	10.4	12.6	11.2
queen triggerfish	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rainbow parrotfish	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9

Data sets: site averages for fish species (ARU_20 to 37) (continued)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
rainbow wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
red hind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
red lionfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.8	1.0	0.0	0.0	1.2
redband parrotfish	5.7	3.6	2.2	4.6	4.1	1.0	5.5	2.9	2.5	2.6	1.3	4.7	10.1	6.4	4.2	11.1	15.3	8.4
redlip blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redspotted hawkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redtail parrotfish	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	3.6	0.0
reef butterflyfish	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
reef squirrelfish	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.2
rock beauty	0.5	0.0	1.4	0.0	0.0	0.5	0.5	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.2	0.0	2.2
rock hind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rosy razorfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
saddled blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailfin blenny 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailors choice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3
sand diver	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.4	0.0	0.5	0.0	0.3	0.9
sand tilefish	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
saucereye porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
sawcheek cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
schoolmaster	0.0	6.6	0.0	0.0	5.2	5.4	7.4	0.6	15.6	9.7	4.3	4.3	13.2	3.1	4.3	6.6	5.1	7.4
scrawled filefish	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0	4.1	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0
seaweed blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
secretary blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sergeant major	4.2	1.4	0.1	0.0	4.3	0.7	4.8	1.6	0.0	1.0	0.1	0.9	1.5	1.6	1.5	1.9	4.5	1.1
sharknose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharksucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharpnose puffer	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.7	0.0	0.0	0.1	0.0	0.0
sharptail eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shortfin pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shy hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
slender filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
slippery dick	0.0	0.0	0.0	1.9	1.1	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1
smallmouth grunt	0.0	0.0	0.0	0.0	0.0	6.8	32.5	0.0	0.0	2.6	1.0	1.9	1.8	1.1	1.5	0.9	0.0	6.9
smooth trunkfish	0.1	5.8	0.3	0.3	0.0	0.1	1.0	0.0	0.6	0.0	0.1	0.3	0.0	0.3	0.1	0.2	0.0	0.0
southern sennet	0.0	50.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
southern stingray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spanish grunt	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.6	0.0	0.0	0.0	0.0
Spanish hogfish	1.5	0.7	0.0	0.9	0.9	0.0	0.3	0.1	0.0	0.5	1.0	3.3	5.3	0.2	1.4	0.2	2.5	0.5
spinyhead blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotfin butterflyfish	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.4
spotlight goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted eagle ray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted goatfish	0.5	1.0	13.0	5.9	1.6	0.5	1.2	2.0	1.4	0.0	3.6	0.2	0.0	0.0	0.0	0.0	0.0	0.2
spotted moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted scorpionfish	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted snake eel	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted trunkfish	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	3.2	0.0	0.0	0.0	0.0
squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4

Data sets: site averages for fish species (ARU_20 to 37) (continued)

SITE_ID	ARU_20	ARU_21	ARU_22	ARU_23	ARU_24	ARU_25	ARU_26	ARU_27	ARU_28	ARU_29	ARU_30	ARU_31	ARU_32	ARU_33	ARU_34	ARU_35	ARU_36	ARU_37
stoplight parrotfish	9.7	30.2	19.8	12.2	16.6	16.8	24.2	16.4	38.6	27.2	35.4	20.6	33.1	33.2	25.0	29.1	41.5	23.3
striped parrotfish	2.4	1.7	0.5	0.5	1.4	3.2	1.1	2.1	0.1	6.1	4.8	4.3	7.2	5.4	4.5	3.6	3.1	4.7
sunshinefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tarpon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
threespot damselfish	1.0	0.2	0.0	0.0	1.7	1.3	1.1	0.5	0.8	0.6	1.1	1.3	2.0	2.3	2.9	1.4	1.9	1.3
tiger grouper	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobaccofish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
tomtate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trumpetfish	3.8	1.8	0.3	0.3	0.3	0.0	0.5	1.2	0.3	0.3	1.7	2.3	1.9	1.8	0.3	2.7	6.4	1.2
trunkfish	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
twinspot bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
white grunt	0.0	1.2	5.8	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
whitestar cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellow goatfish	0.0	1.4	0.0	0.0	3.2	1.6	15.1	2.2	6.6	6.2	3.5	4.5	3.1	4.2	0.0	0.5	0.7	4.7
yellow jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowcheek wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin grouper	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowhead jawfish	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
yellowhead wrasse	0.1	0.8	0.6	0.2	0.3	0.9	0.7	0.7	0.9	0.6	0.8	2.1	1.5	0.4	0.8	0.3	0.2	1.5
yellowmouth grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Yellownose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail damselfish	2.4	0.7	0.0	0.0	0.0	0.2	2.0	0.0	0.7	5.9	2.0	3.5	1.7	2.8	3.7	2.2	2.3	0.7
yellowtail hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0
yellowtail parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail snapper	24.1	24.8	28.1	33.6	7.3	8.3	4.2	10.4	1.2	6.3	2.6	3.3	2.5	5.2	3.0	11.3	0.4	7.7

Data sets: site averages for fish species (ARU_38 to 54)

SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
American whitespotted filefish	0.0	0.7	0.3	0.0	0.0	3.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	2.5	2.2	2.4	1.5
atlantic creolefish	0.0	0.0	0.0	0.0	0.2	0.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
balloonfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
banded butterflyfish	1.3	0.7	0.2	0.7	0.4	0.1	0.0	0.2	0.4	0.2	0.0	0.4	0.4	0.4	0.7	0.0	0.5
bandtail puffer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bar jack	0.7	0.0	0.0	0.0	0.0	1.2	0.0	0.7	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
barred cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
barred hamlet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beaugregory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
belted cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bicolor damselfish	4.6	6.0	2.2	6.1	6.2	2.6	12.0	2.8	89.5	2.2	3.0	4.2	1.0	5.7	6.3	3.7	46.7
bigeye	1.0	0.5	0.0	0.0	0.0	1.0	0.0	1.0	3.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
black durgon	0.0	4.2	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	16.1	52.8	10.7	102.6
black grouper	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black hamlet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_38 to 54)(continued)

SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
black margate	4.4	0.0	0.0	5.3	0.0	0.0	0.0	3.9	1.2	1.2	0.0	0.0	0.0	7.9	1.9	0.0	0.0
blackbar soldierfish	1.1	7.5	0.8	0.3	4.3	0.9	1.3	4.1	0.8	0.0	0.3	4.0	0.0	4.8	2.6	0.2	0.3
blackear wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
blackfin snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue chromis	5.9	6.0	2.1	4.0	3.1	2.4	1.1	3.1	5.2	1.9	0.5	2.8	0.0	4.5	1.7	0.9	0.0
blue parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue runner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
blue tang	6.0	4.5	4.3	14.3	56.8	14.2	48.0	18.9	144.3	23.8	20.5	4.6	5.3	76.7	8.5	5.2	1.7
bluehead	0.3	0.8	0.2	0.9	0.6	1.3	1.0	3.3	0.1	0.5	0.4	0.6	0.8	2.5	1.3	2.4	18.1
bluelip parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bluespotted cornetfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bluestriped grunt	0.0	0.0	1.1	3.7	1.9	0.0	0.0	0.0	4.0	1.9	5.6	3.7	2.4	14.9	1.9	0.0	0.0
bluestriped lizardfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
boga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bonnetmouth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bridled goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
brown chromis	8.5	12.0	7.0	7.8	11.2	10.3	6.0	11.2	14.4	11.5	0.6	5.9	2.0	5.9	11.8	2.6	8.4
brown garden eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bucktooth parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
butter hamlet	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
caesar grunt	0.0	0.3	0.5	2.8	0.3	0.0	0.0	6.2	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.8
caribbean reef shark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cero	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chain moray	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chalk bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cherubfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chub (bermuda/yellow)	0.0	0.0	0.0	132.4	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0	19.4	0.0	0.0	159.1
clown wrasse	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.2	0.0	0.1	0.0	0.3	0.4	0.4
cocoa damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
colon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
coney	0.0	0.0	0.0	0.0	0.0	2.0	1.1	7.0	2.5	4.5	1.4	1.9	4.8	8.6	4.8	3.9	2.0
cottonwick	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
creole wrasse	1.4	9.8	2.8	0.2	0.2	9.1	9.4	1.5	10.4	0.4	0.0	1.5	0.0	0.0	0.1	0.0	28.8
cubera snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dash goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
doctorfish	1.3	4.5	1.1	2.9	49.9	2.5	6.6	5.5	33.4	11.6	12.0	1.6	4.4	8.9	1.6	5.4	2.6
dog snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dusky damselfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dusky squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
duskyjawfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
elacatinus species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
emerald parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
fairy basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flagfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flamefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flat needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
foureye butterflyfish	1.3	1.3	0.6	3.1	1.3	1.2	1.8	0.8	0.4	1.7	0.0	0.5	0.4	0.6	1.3	0.7	0.7
French angelfish	3.4	3.4	0.0	8.6	1.1	2.0	1.1	1.1	0.0	3.1	0.0	0.0	2.5	1.1	0.5	0.1	0.2
French grunt	2.0	4.9	1.1	2.9	2.0	2.4	2.2	11.2	4.4	2.6	2.2	3.3	3.1	10.2	3.7	1.1	1.5

Data sets: site averages for fish species (ARU_38 to 54)(continued)

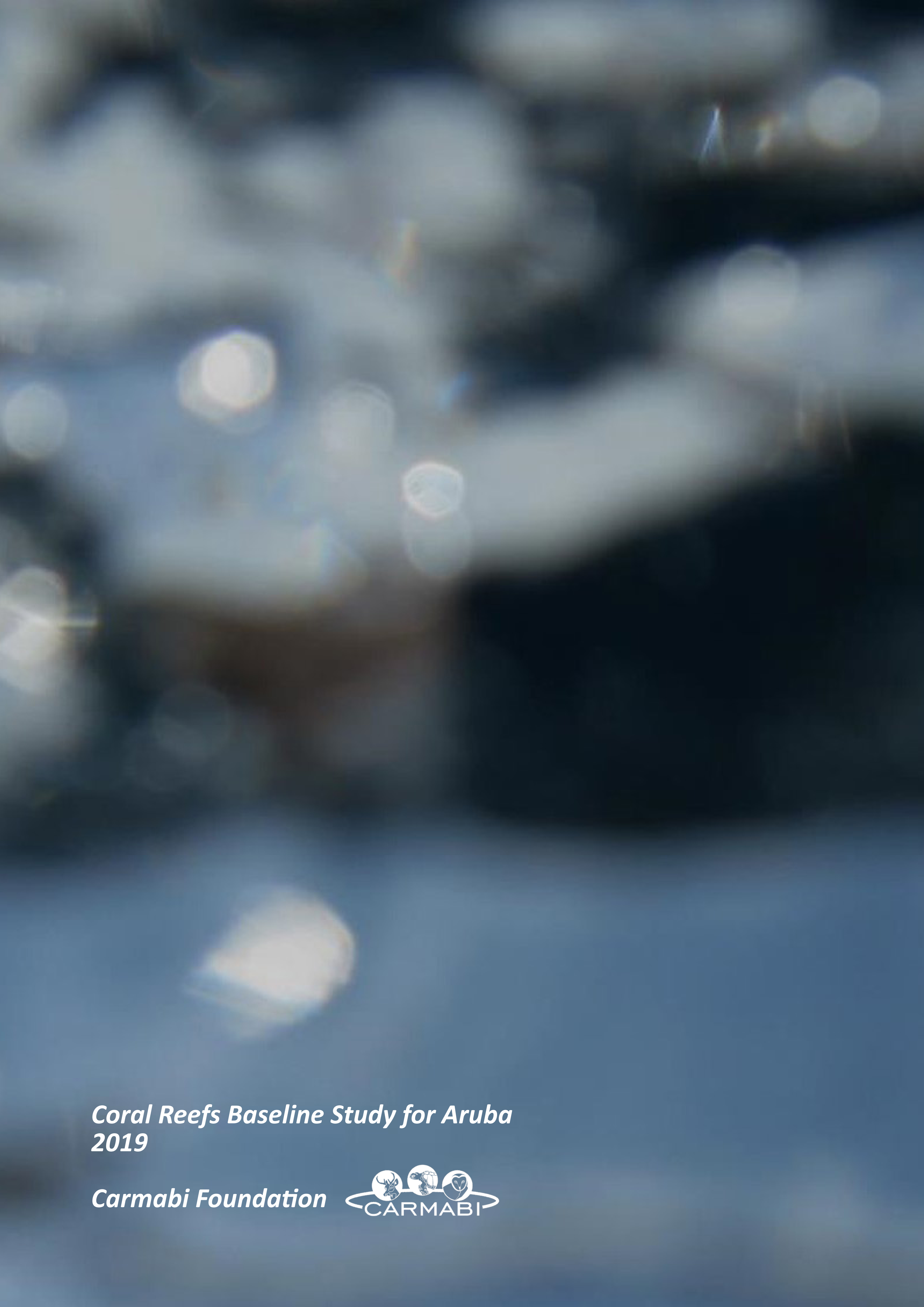
SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
fringed filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
giant manta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
glasseye snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
glassy sweeper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
goldentail moray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
goldspot goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
gray angelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
gray snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
graysby	4.9	3.6	2.8	2.6	1.0	4.4	1.0	6.1	19.9	1.5	2.4	7.8	0.0	11.6	2.9	1.8	0.0
great barracuda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	6.3
greater soapfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.1	0.0	0.0
green moray	0.0	0.0	0.0	3.3	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
green razorfish	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greenbanded goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
greenblotch parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hairy blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hamlet species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harlequin bass	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.1	0.0
highhat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hogfish	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
honeycomb cowfish	1.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.0	0.3	0.0
horse-eye jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hovering goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
indigo hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
inshore lizardfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
jackknife fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
jolthead porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lane snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lantern bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longfin damselfish	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longjaw squirrelfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
longsnout butterflyfish	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
longspine squirrelfish	0.0	5.0	1.1	0.0	1.0	1.4	0.5	6.0	2.0	2.5	0.9	0.9	0.2	6.6	1.9	2.5	0.0
mackerel scad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mahogany snapper	0.0	0.6	0.0	1.7	6.7	1.3	0.3	0.8	0.0	0.0	3.1	0.3	0.0	2.8	0.0	0.0	0.0
margate (white)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0
masked/glass goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
midnight parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
molly miller	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mutton snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
neon goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ocean surgeonfish	1.6	0.1	0.0	1.2	1.1	1.4	2.0	2.1	0.0	6.0	0.0	0.3	3.0	0.0	1.1	0.1	1.2
ocean triggerfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
orangespotted filefish	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.3	0.0	0.0	0.3	0.0	0.6	0.0	0.1
painted wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pallid goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peacock flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
peppermint basslet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data sets: site averages for fish species (ARU_38 to 54)(continued)

SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
peppermint goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
permit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pluma porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
porcupinefish	0.0	0.0	0.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
porkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
princess parrotfish	4.4	4.9	5.3	3.3	5.0	0.9	1.8	0.9	3.6	6.0	0.0	2.7	1.8	0.3	0.3	0.0	1.9
puddingwife	0.0	0.3	0.1	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
queen angelfish	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	6.6
queen parrotfish	6.5	0.2	0.0	0.5	3.3	1.6	1.0	8.2	0.0	0.0	0.2	0.0	1.0	4.1	1.1	0.0	0.2
queen triggerfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.8	0.0	1.3	0.0	0.0
rainbow parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.4	0.0	0.0	3.9
rainbow wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
red hind	0.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
red lionfish	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.0	0.0	1.5	0.0	0.0	2.0	0.0	1.0
redband parrotfish	4.5	6.0	0.8	5.0	8.3	3.7	3.9	0.0	3.4	4.4	4.7	7.3	3.5	5.7	4.5	1.9	4.4
redlip blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redspotted hawkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
redtail parrotfish	0.0	1.3	0.0	0.0	0.0	6.3	0.8	0.8	0.0	0.0	22.2	0.0	0.8	0.0	0.0	0.0	2.2
reef butterflyfish	0.0	0.0	0.0	0.4	0.4	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
reef squirrelfish	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0
rock beauty	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0
rock hind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rosy razorfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
saddled blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailfin blenny 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sailors choice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0	0.0	0.0
sand diver	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
sand tilefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0
saucereye porgy	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sawcheek cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
schoolmaster	3.7	0.0	0.0	4.9	0.6	1.4	3.0	9.8	0.3	2.8	0.0	3.8	0.0	89.7	0.0	0.3	1.2
scrawled filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seaweed blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
secretary blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sergeant major	2.5	4.5	0.1	2.5	0.2	1.8	1.5	1.5	0.9	1.2	0.0	0.6	1.6	3.5	0.0	0.0	3.7
sharknose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharksucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sharpnose puffer	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
sharptail eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shortfin pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
shy hamlet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
slender filefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
slippery dick	0.0	0.0	0.0	0.0	0.0	2.1	1.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0
smallmouth grunt	3.1	3.6	6.4	1.4	0.0	9.7	0.6	2.2	7.7	1.1	0.0	1.1	0.0	18.2	0.1	0.0	0.9
smooth trunkfish	0.9	8.6	0.9	0.5	0.3	1.0	0.0	0.3	0.0	0.3	0.0	1.4	0.0	2.1	2.2	0.3	0.3
southern sennet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.7	0.0
southern stingray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spanish grunt	0.0	0.0	0.0	0.0	0.0	1.2	0.0	11.8	0.0	0.6	0.0	0.0	0.0	0.0	1.1	0.0	0.0
Spanish hogfish	0.5	3.3	0.1	0.0	0.0	1.1	3.7	2.2	0.7	1.1	0.0	5.9	1.8	3.3	4.4	2.2	0.9

Data sets: site averages for fish species (ARU_38 to 54)(continued)

SITE_ID	ARU_38	ARU_39	ARU_40	ARU_41	ARU_42	ARU_43	ARU_44	ARU_45	ARU_46	ARU_47	ARU_48	ARU_49	ARU_50	ARU_51	ARU_52	ARU_53	ARU_54
spinyhead blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotfin butterflyfish	0.2	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotlight goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
spotted eagle ray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	0.0	0.0	0.0
spotted goatfish	1.5	0.3	0.2	0.2	0.2	1.5	1.9	0.2	0.7	1.0	0.3	0.5	0.5	0.0	0.5	0.2	0.0
spotted moray	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted scorpionfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted snake eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spotted trunkfish	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
squirrelfish	0.0	0.0	0.0	0.4	0.2	0.8	0.0	2.4	0.0	3.6	0.0	0.4	3.6	2.0	1.2	0.0	0.4
stoplight parrotfish	36.7	28.2	5.7	17.4	23.1	0.6	20.7	12.6	8.6	20.6	24.8	9.9	15.9	14.1	8.0	6.0	16.9
striped parrotfish	1.1	1.8	1.1	0.2	0.6	3.2	0.0	0.1	0.0	0.2	0.1	5.1	0.2	0.7	1.5	1.4	0.0
sunshinefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tarpon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
threespot damselfish	0.4	0.3	0.1	0.4	0.4	0.6	0.3	0.4	0.2	0.0	0.0	0.8	0.0	0.2	0.0	0.0	0.1
tiger grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobaccofish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tomtate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trumpetfish	3.2	0.3	0.0	0.8	3.7	0.4	1.4	0.0	4.0	2.1	0.0	0.5	0.8	1.4	0.8	2.8	0.7
trunkfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
twinspot bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
white grunt	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	1.1	5.9	2.4	0.0	0.3
whitestar cardinalfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellow goatfish	5.9	2.2	3.0	0.2	6.9	1.3	2.8	11.4	3.5	1.5	0.0	8.8	0.0	37.6	0.0	0.5	0.0
yellow jack	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowcheek wrasse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowfin mojarra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowhead jawfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowhead wrasse	1.9	1.9	0.6	1.6	3.0	2.4	1.6	1.9	0.2	1.2	0.7	0.4	0.1	0.6	0.5	0.7	0.3
yellowmouth grouper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellownose goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail damselfish	0.7	3.4	0.2	1.7	0.7	0.2	0.2	0.5	0.5	0.3	0.0	0.0	0.0	0.8	1.3	0.3	0.8
yellowtail hamlet	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
yellowtail parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	1.3	0.0	0.0
yellowtail snapper	16.4	8.1	2.8	8.4	4.8	10.3	5.6	4.5	12.0	3.5	1.2	3.8	5.8	3.1	1.2	40.2	24.3



Coral Reefs Baseline Study for Aruba
2019

Carmabi Foundation