# BIONEWS

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## BIONEWS ISSUE 4



# Editor's Letter

Dutch Caribbean, October 2017

As part of DCNA's series of articles focusing on the status of reefs in all five of our islands, we here put the spotlight on Curaçao. The island's reefs have been the subject of much research in the past few years, and in this edition of BioNews we attempt to provide insight into some of the new findings. Commonly described as healthy and diverse and praised by divers and snorkelers for their beauty and rich marine fauna, the island's reefs appear to be following the Caribbean-wide trend of declining reef health. We look at the findings of several recent studies that highlight the significant shift that the island's coral reef communities have gone through over the past four decades, with a notable loss in both coral cover and fish biomass and a worrying increase in turf algae.

Research projects that assess the status and marine biota of the island's reefs help shed light on their resilience and what stressors need to be diminished to ensure they can endure through the intensification of regional and global threats. While Curaçao is not located in the Caribbean's hurricane belt and was spared the devastation of Hurricanes Irma and Maria, local stressors such as pollution and coastal development have had a drastic impact on reef health.

The scientific journal *Marine Biodiversity* has recently focused its attention on the reefs of the Dutch Caribbean with various articles reporting on recent coral reef research in St. Eustatius and Curaçao, such as a report on the deep reef community (70-85 m depth) discovered off the leeward coast of Curaçao. We highly encourage you to look at the list with all articles published by *Marine Biodiversity* on the Dutch Caribbean to find out more about the many new discoveries that have been made!

One exciting discovery was recently made by two researchers from Naturalis and Oxford University Museum of Natural History about the flamingo tongue, a colorful sea snail that lives on our reefs. Through genetic testing, they were able to confirm that the three known species of flamingo tongue are in fact one single species despite differences in their mantle morphology. We present a summary of their research and findings.

**Happy reading!**
***The DCNA Team***

Cover photo & Editor's Letter photo by:
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# Status of Curaçao's Reefs

**The island of Curaçao is almost entirely surrounded by narrow fringing reef that covers an estimated area of 7.85 km2 (Vermeij, 2012). These reefs, considered some of the healthiest and most diverse in the Wider Caribbean Region, have long supported the island's fishing industry and in recent decades have been the foundation for Curaçao's lucrative marine tourism industry. A number of studies have however highlighted the significant shift that the island's coral reef communities have gone through over the past four decades, with a sharp decline in both coral cover and fish biomass.**

## 1. Geography and Reef Structure

Curaçao is the largest island in the Dutch Antilles, with a total land area of 444km² and total maritime area of 4,915 km2 (Van Buurt, 2009). This includes the land area of Klein Curaçao, a small, uninhabited coral limestone island located some 10 km off the southeast point of Curaçao. The island has a total coastal length of 175 km. The leeward (west) and windward (east) coasts are strikingly different. The windward coast is characterized by limestone cliff formations that are pounded by high waves rolling in from the rough open seas.The leeward coast is sheltered from the trade winds and is therefore calm with turquoise lagoons and sandy shores.

Due to the vast differences in oceanographic conditions between the island's coasts, reef structure and abundance is very different on each side. On the west coast, fringing reefs are much better developed and have a much higher coral cover, especially in shallow waters (Vermeij, 2012). The sea floor drops off steeply within about 100 m from the shore, which is known locally as the "blue edge". At a depth of 50 to 60 meters, a sandy terrace begins to slope gently until a depth of about 80 to 90m, where a second steep drop off occurs (Van Duyl, 1985; Pors & Nagelkerken, 1999). Corals on the east coast only occur past a depth of 12 meters due to much rougher conditions, such as high wave energy (Van Duyl, 1985).

> *"As of 2010, live coral cover on Curaçao's reefs was assessed to be 23.2%, with a coral diversity of 65 species."*

As of 2010, live coral cover on Curaçao's reefs was assessed to be 23.2%, with a coral diversity of 65 species (Van Alfen & Van Vooren, 2010; Vermeij, 2012). The highest coral diversity is found on the reef slope, with a rapid decline below depths of 30-40 m (Bruckner & Bruckner, 2003). When mapping Curaçao's reefs, Duyl (1985) found a general pattern of vertical zonation of species and therefore concluded that the island's coral species are highly affected by both depth and wave energy (Van Duyl, 1985). Shallow waters (shallower than 20 meters) are dominated by reef-building stony Montastraea spp. (Bruckner & Bruckner, 2003). Deeper waters are dominated by Agaricia spp. (Bak, Nieuwland & Meesters, 2005).

***Map of Curaçao.***
*Image credit: DCNA*

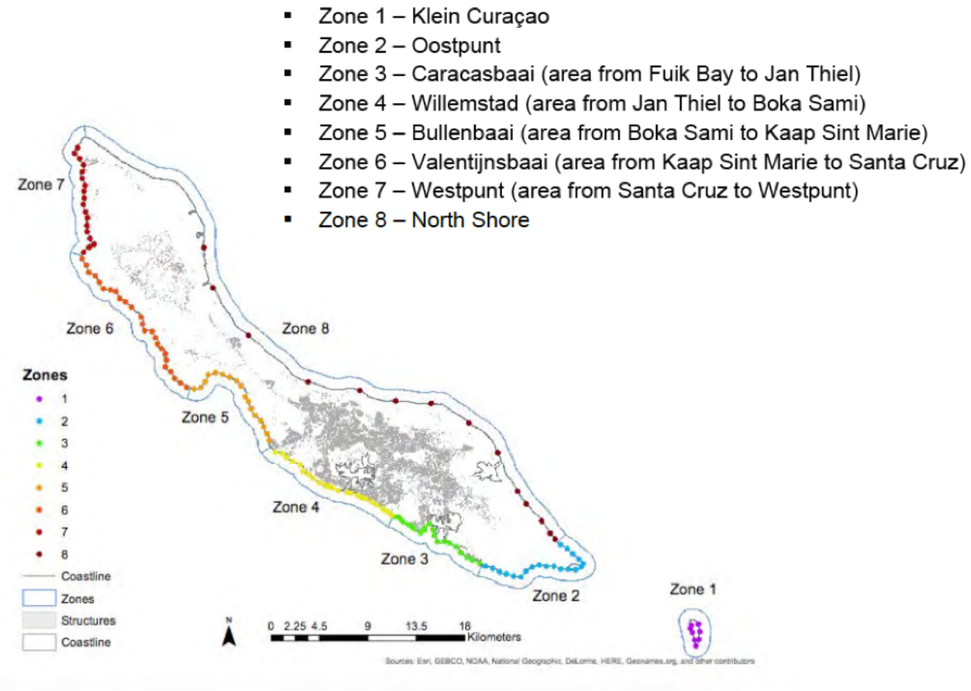


***Figure 1.*** *Based on the marine expedition eight zones with similar ecological conditions were identified and used for creating maps. In the Marine Scientific assessment report maps can be found with coral cover, juvenile cover density, turf- and macroalgae, fish biomass, infrastructure, sewage, trash, fishing pressure and diving pressure per zone.*
*Credit: WAITT Institute, Esri, GEBCO, NOAA, National Geographic, Delorme, HERE, Geonames.org, and other contributors*

## 2. Status of Curaçao's reefs

A number of studies of Curaçao's reefs have taken place over the past four decades and have helped understand how the island's reef communities have changed over this time period (Table 1). In fact, along with Bonaire, Curaçao has the most comprehensive reef monitoring data set of the entire Wider Caribbean region: coral cover, composition and mortality at depths of 10, 20, 30 and 40 meters have been recorded at select sites since 1973 using fixed photo quadrants (Bak et al., 2005). Please be aware that this study only targets three sites around Curacao and therefore we should be careful with island-wide statements.

The most recent assessment of Curaçao's reefs was carried out in 2015 by Blue Halo Curaçao (a partnership between the Waitt Institute and the Government of Curaçao in close cooperation with researchers from CARMABI and Scripps Institution of Oceanography). This Marine Scientific Assessment combined data from a marine expedition, interviews with divers and fishermen and historical sources (WAITT Institute, 2016). The expedition, which took place in November 2015, measured the abundance and composition of benthic and fish communities as well as water quality at 148 sites around the island using the Caribbean-Global Coral Reef Monitoring Network (GCRMN) baseline scientific monitoring methods. Based on this expedition Blue Halo Curaçao identified 8 zones with similar ecological conditions: Klein Curaçao (Zone 1), Oostpunt (Zone 2), Caracasbaai (Zone 3), Willemstad (Zone 4), Bullenbaai (Zone 5), Valentijnsbaai (Zone 6), Westpunt (Zone 7), North Shore (Zone 8) (Figure 1). This article focuses on the results of this island-wide most recent study.

Photo by: © Mark Vermeij

***Table 1:*** *Summary of major coral status surveys conducted on Curacao's coral reefs*
*(Source: Adapted from Sustainable Fisheries Group, 2015)*

| STUDIES | TIME PERIOD | SURVEY DESCRIPTION | # SITES SURVEYED |
|---|---|---|---|
| Bak et al., 2005; Bak, Nieuwland, 1995; De Bakker et al., 2016,2017. | 1973-ongoing | Photographs are frequently taken of permanent quadrats of 9m2 at 10, 20, 30 and 40 m depths at the Leeward side of the island (Carmabi Buoy One (sites I and II) and Carmabi Buoy Two (site III)) to analyze the changes in community structures. In addition to these three sites, another site that is located at the far south-eastern side of Curaçao, was included with a quadrat positioned at 10 m (since 1983) and 20 m (since 1992) depth. | 4 |
| Bruckner and Bruckner, 2003. | 1997, 1998 and 2000 | Belt transect surveys to determine coral abundance, diversity and health. | 9 |
| Nagelkerken & Nagelkerken, 2004. | 1969-2000 | Sampling quadrats to determine the change in occurrence, cover, and sociability of coral species of shallow (1–3 m depth) coral reefs along the entire southwest coast of Curaçao. | 16 |
| Nagelkerken et al., 2005. | 1973-2003 | Transect surveys to quantify benthic cover. | 9 |
| Reefcare Coral Monitoring. | 1997-ongoing | Transect surveys were used to classify benthic cover and data on coral cover, state of health, amount and algae cover and type. Four sites surveyed at a depth of 7 and 14 m every 3 months. | Currently: 6 |
| Sandin et al., 2008. | 2008 | Data collection on coral reef fish and benthic community structure. | 5 |
| Van Duyl, 1985. | 1981-1983 | Classified wave energy environments and benthic habitats using aerial photography and in situ reef ground truthing surveys (0-20m depth). | Entire leeward coast |
| WAITT Institute, 2016. | 2016 | A large marine scientific assessment combined data from a marine expedition (GCRMN method), interviews with divers and fishermen and historical sources. | 148 |

Photo by: © Mark Vermeij

## 2.1 Benthic cover
### Loss in coral cover

Like many reefs in the Caribbean, Curacao's reefs suffered over the past decades from anthropogenic and natural stressors such pollution, coastal development, overexploitation, bleaching events, tropical storms, the mass mortality of *Diadema antillarum* urchins in 1983 that greatly reduced herbivory levels on competitive algae (Bak et al., 1984; Figure 2) and the white-band disease that killed nearly 90% of elkhorn and staghorn from the late seventies to the mid-eighties (Bries et al., 2002; Mumby et al., 2014).

The overall decline in coral cover for the island's reefs ranges from 42% [1980-2012] (Sustainable Fisheries Group, 2015) to over 50% [1982-2015] (WAITT Institute, 2016). Blue Halo Curaçao found that, with the exception of Klein Curacao and Oostpunt, the average coral cover for the island in 2015 was 15%. The north shore has the lowest coral cover (3-7%) due to the oceanographic conditions that inhibit coral reef growth. The area from Boka Sami to the North Shore (Zones 5 to 7) also has a low coral cover (7-11%) (Figure 3).

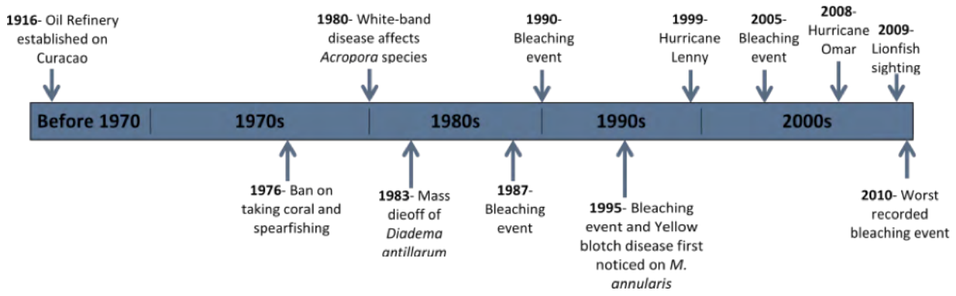


***Figure 2:*** *Timeline of major natural and anthropogenic events that have impacted coral reef habitats in Curaçao. Source: Sustainable Fisheries Group UC Santa Barbara, 2015.*

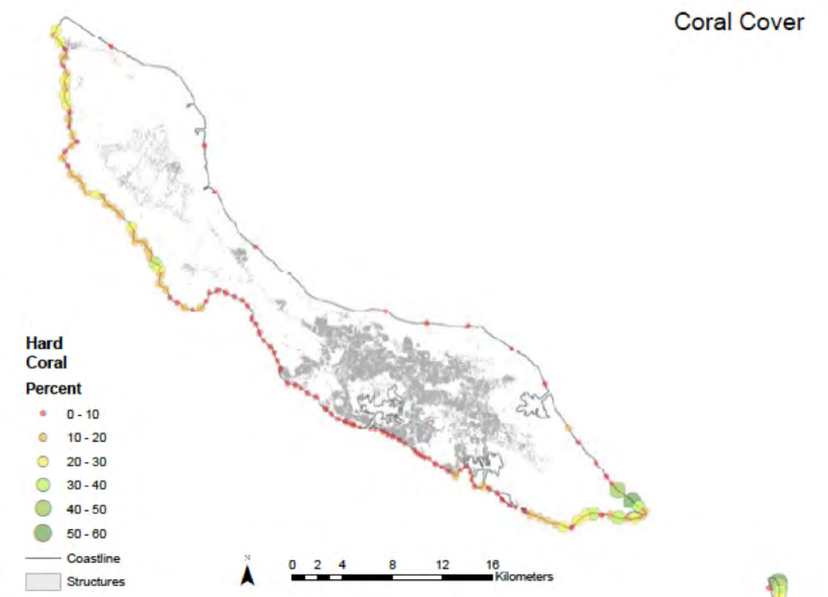


***Figure 3:*** *Coral cover by site level average. Credit: WAITT Institute, Esri, GEBCO, NOAA, National Geographic, Delorme, HERE, Geonames.org, and other contributors.*

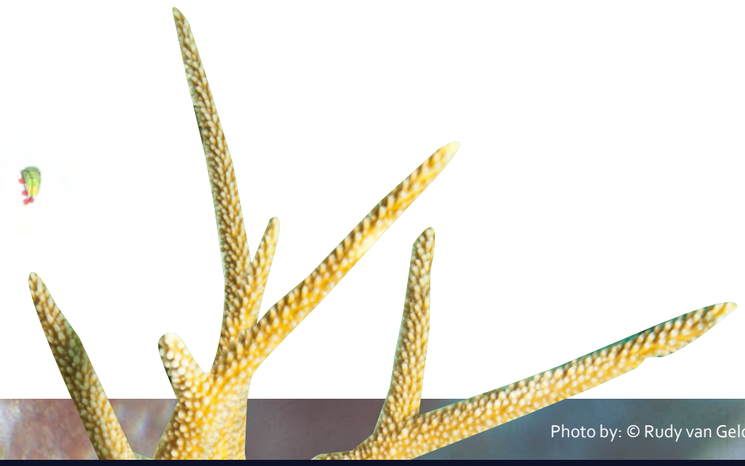

Photo by: © Rudy van Gelderen

The use of photo quadrants has also revealed an important loss in coral cover loss over the past 40+ years (De Bakker et al., 2016, 2017). Indeed, from 1973 to 2014 De Bakker et al. (2016) found that coral cover decreased between 5.5% to 47.4% at 10, 20, 30 and 40 m depths (Table 2). While overall cover and abundance declined for almost all species (De Bakker et al. 2016), reef-building species such as Orbicella spp. have suffered the biggest loss. There has been an overall shift towards small colonies with reefs now dominated by smaller, opportunistic species (e.g. *Madracis mirabilis, Porites astreoides, Diploria strigosa*, and *Agaricia lamarcki*), although even these species have suffered an overall loss in cover (De Bakker et al., 2016). Important consequences of reduced coral cover and the shift to smaller opportunistic species is reduced carbonate production, loss of reef structural complexity and its' associated loss of biodiversity, coastal protection and human food security (De Bakker et al., 2016).

Curaçao's healthiest reefs are located on the island's east side. Klein Curaçao (Zone 1) and Oostpunt (Zone 2) were found to have an average coral cover of 25%, with a number of individual sites on the eastern side of these zones averaging >40% cover (Figure 3) (WAITT Institute, 2016). A few sites near Rif Marie (Zone 6) and Playa Kalki (Zone 7) were also found to have a coral cover >40%. Current estimates suggest that healthy Caribbean reefs have a coral cover of over 40% (WAITT Institute, 2016). Both the Klein Curaçao and Oostpunt zones also have the most favorable conditions for reef growth, as juvenile corals of reef-building species are about twice as abundant in these zones than in other parts of the island (Figure 3). Juvenile corals (<4cm) on Curaçao's reefs decreased on average by 55% from 1975 to 2005 (these small corals could however be as old as 13 years) (Vermeij, 2011).

| Place | Reef | Depth (m) | Year span | Start coral cover (%) | End coral cover (%) | Net change (%) |
|---|---|---|---|---|---|---|
| **Curaçao** | **CARMABI Buoy 1 (1)** | **10** | **1973-2014** | **48.5** | **1.1** | **-47,4** |
| | | 20 | 1973-2014 | 34.6 | 8.7 | -25,9 |
| | | 30 | 1973-2014 | 22,4 | 4,4 | -18 |
| | | 40 | 1973-2014 | 12,9 | 1,4 | 11,5 |
| | **CARMABI Buoy 1 (2)** | 10 | 1973-2014 | 22.7 | 5.9 | -16,8 |
| | | 20 | 1973-2014 | 32,9 | 5,6 | -27,3 |
| | | 30 | 1973-2014 | 19,7 | 14,2 | -5,5 |
| | | 40 | 1973-2014 | 17,6 | 6,9 | -10,7 |
| | **CARMABI Buoy 2 (3)** | 10 | 1973-2014 | 37 | 24 | -13 |
| | | 20 | 1973-2014 | 34.9 | 16.6 | -18.3 |
| | | 30 | 1973-2014 | 31 | 9.6 | -21.4 |
| | | 40 | 1973-2014 | 36.1 | 18.4 | -17.7 |

***Table 2:*** *Change in coral cover of a 9 m2 quadrat at a depth 10, 20, 30 and 40 meters at three different sites on Curacao.*
*(Source: De Bakker et al., 2016)*

Vermeij et al. (2014) found that the abundance of juvenile corals may be another good measure of reef health alongside coral cover as such an abundance "reflects the relative success or failure of reef functional processes (recruitment, growth and survival) on a timescale meaningful to both ecology and conservation" (Vermeij, 2014). The relative abundance in juvenile reef-building coral species helps to predict how well a reef area will renew itself once existing corals die, with reef-building species most important in building calcified reef structures that protect shore communities from extreme weather events such as tropical storms (WAITT Institute, 2016). Curaçao is located on the southern edge of the hurricane belt, and on average one tropical storm passes within 200km (100mi) of the island every 4 years (Sustainable Fisheries Group, 2015). These create high seas and intense wave action that causes localised damage to the reefs and the coastal zone. Curaçao sustains considerable damage from hurricanes approximately once every 100 years. There have been no hurricanes in the past 20 years (Jackson et al., 2014).

## Macroalgae, turf algae and cyanobaterial mats

Macroalgae are a natural part of a reef community but many reefs in the Wider Caribbean Region have seen a shift from coral to algae dominated benthic communities. Studies have shown how damaging macroalgae can be to coral health, inhibiting coral settlement and recruitment, slowing coral growth and making them more prone to disease (Jackson et al., 2014). A study on Curaçao has revealed how macroalgae can negatively impact coral larval recruitment (Vermeij, 2006). Larval settlement was found to be good on the experimental panels that were totally covered in crustose coralline algae between 1979 and 1981. However, by the early 2000s the upper surfaces of these panels were totally covered in macroalgae and larval settlement declined five-fold.

Macroalgae cover on Curaçao remains low compared to the rest of the Caribbean, largely due to the relatively high biomass of parrotfish that keep macroalgae in check (Figure 6). However, one worrying trend is the increase in turf algae, most likely due to an increase in nutrients in the water. Turf algae rapidly overgrows coral and unlike macroalgae, herbivore fish have no effect on the rate by which turf algae overgrow corals (at a rate of 0.34 mm/3 wk) (WAITT Institute, 2016; Vermeij, 2010). Except for the east coast of the island, all zones have a much higher percentage cover of turf algae than macroalgae, with turf algae covering 40.3% of the reef bottom on Curaçao's southern shore (Figure 4). The windward coast (Zone 8) has an unusually high cover of macroalgae; it is almost completely covered by Sargassum species due to the area's strong wave action and resulting low coral cover (WAITT Institute, 2016).

Another worrying trend is the rise of benthic cyanobacterial mats (Mumby et al., 2014) that can also negatively impact reef communities by "*inhibiting recruitment (Kuffner et al., 2006), act as pathogens (Carlton and Richardson 1995), overgrow and smother reef benthos (Ritson-Williams et al., 2005; De Bakker et al., 2016b), create an anoxic environment (Brocke et al., 2015b) and produce chemicals that cause coral and fish mortality (Nagle and Paul 1998)*" (De Bakker et al., 2017). This trend is further described in in BioNews 3-2017 ("Status of Bonaire's reefs" ("Harmful seaweed and the rise of cyanobacterial mats" on page 7: *http://www.dcnanature.org/wp-content/uploads/2017/09/1.-Bionews-Issue-3-online.pdf)).*

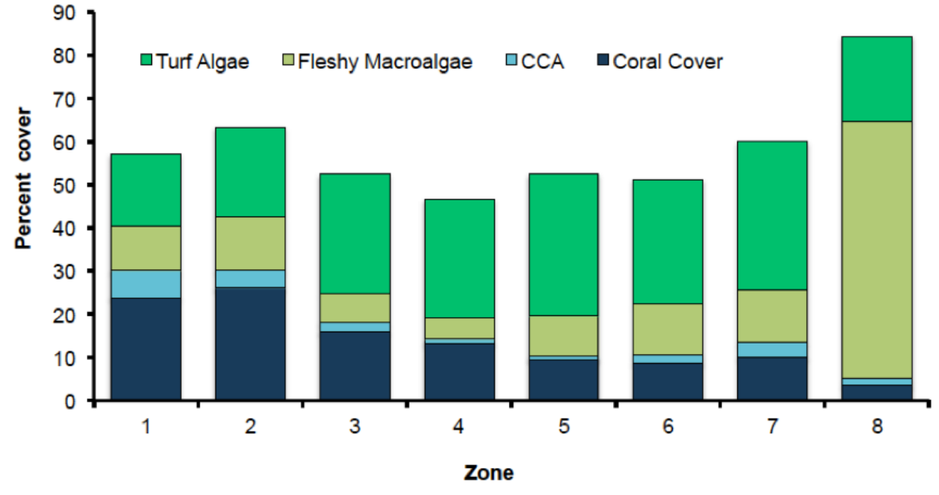


***Figure 4:*** *Average abundance (in percentage cover) of reef building organisms: corals and crustose coralline algae (CCA) and abundant algal groups (turf algae and fleshy macroalgae) that compete with reef builders for space. Other bottom cover not shown in this figure includes sponges, sand and rubble.*
*Source: WAITT Institute, 2016.*

Photo by: © Hans Leijnse

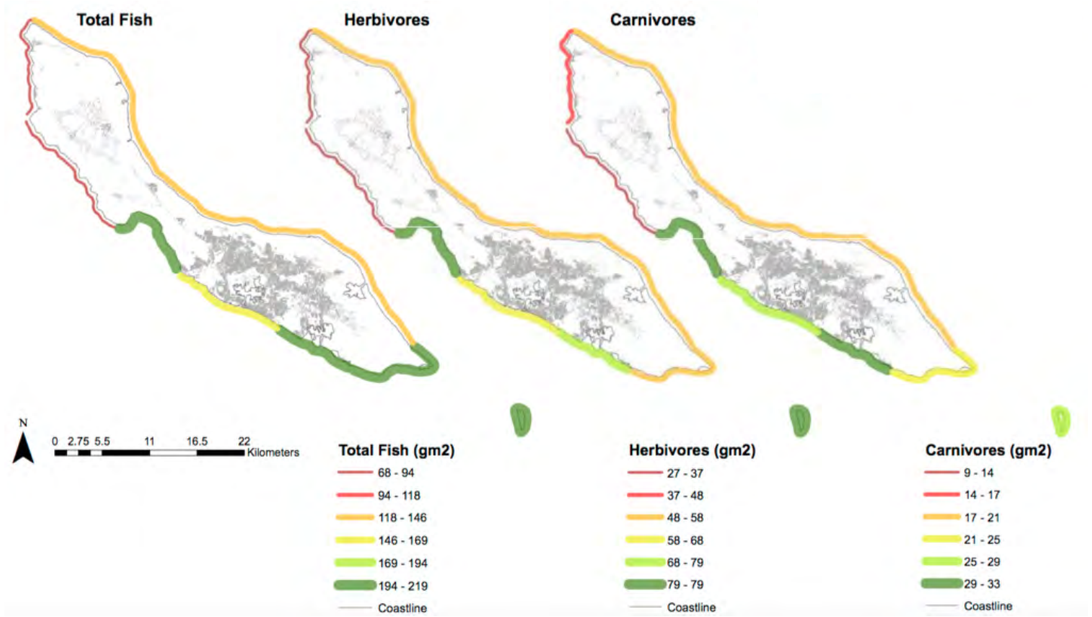


***Figure 5:*** *Spatial distribution of fish around Curaçao.*
*Source: WAITT Institute, 2016*

## 2.2 Fish biomass

There is currently no indicator within the Caribbean of what total fish biomass indicates a "healthy" reef, although healthy reefs in the Pacific have been found to show total fish biomasses between 270 – 510 g/m2 (WAITT Institute, 2016; Sandin et al., 2008). While the three areas in Curaçao that have the highest fish biomass (>200 g/m2) do not fall within this "healthy" range, their value is still high compared to other parts of the Caribbean. Klein Curaçao (Zone 1) has the highest total fish biomass of the island (219 g/m2), closely followed by Caracasbaai (Zone 3). Fish biomass is higher east of Kaap Sint Marie (Zones 1 to 5) with a range of 159 – 219 g/m2 and lower in the north-east of the island (Valentijnsbaai and Westpunt, Zones 6 and 7) (Figure 5).

The abundance of carnivorous and of herbivorous fish are important indicators of functional reef communities. High densities of predatory fish such are groupers dominate healthy reef fish communities. If their abundance diminishes, the trophic structure of the reef fish assemblage is affected, which in turn affects reef health – for example, fewer predatory fish may lead to an increase in damselfish, which are known to hurt the reef when their population becomes too high (Vermeij, 2015). Herbivorous fish species, notably parrotfish, have a crucial ecosystem role within reefs as they keep algae from overgrowing coral (Jackson et al., 2014).

Currently, the biomass of carnivorous fish is low across all zones, with the lowest abundance found from Kaap Sint Marie to Westpunt and all down the east coast (Zones 6 to 8) (Figure 5) (WAITT Institute, 2016). The biomass of herbivorous fish is still quite high (58 – 89 g/m2) in certain areas (Klein Curaçao to Willemstad) when compared to other parts of the Caribbean. The highest biomass is found near Bullenbaai and falls within the range at which herbivorous fish are able to keep algae from overgrowing coral (>70 g/m2) (Figure 5). However, certain areas have shown a significant decrease in herbivorous fish populations, with the lowest biomass (26 g/m2) found from Kaap Sint Marie to Santa Cruz (Zone 6).

## 3. Local stressors on Curaçao's reefs

As is the case for most reefs around the world, Curaçao's coral reefs have suffered from a sharp increase in local stressors over the past few decades. These stressors, such as pollution and coastal development, have had a drastic impact on reef health and led to an important decline in coral cover and fish biomass. It is important to reduce local threats to increase the resilience of the reefs to the global stressors caused by climate change such as coral bleaching events.

Coral cover loss has been the highest around the island's densely populated areas, especially around the capital city of Willemstad. Curaçao has a population of 160,337 inhabitants and is the second most densely populated island of the leeward islands with just over 354 inhabitants per km2 (CBS, 2017). The Blue Halo Curaçao study assessed the island's coastal pollution from both at sea and land sources. Land-based pollutants were found to contaminate ocean waters through run-off, sewage, industrial pipes and trash. As expected, sewage pollution was found to be the highest around Willemstad, the island's biggest agglomerate of urban area (Zone 4). Lots of trash was found in Bullenbaai (Zone 5) and Westpunt (Zone 7).

While fishing pressure is limited on the island's reefs due to the fact that most fishing now takes place offshore and in deep waters, there are still certain reef areas around the island that have historically been overfished or are being over-fished (Vermeij, 2012; Kraan, 2017). The two areas with the highest fishing pressure are Westpunt (Zone 7) and Klein Curaçao (Zone 1) (WAITT Institute, 2016). The total fish biomass at Klein Curaçao remains high (likely because most fishermen target pelagics rather than reef fish), but the low fish biomass at Westpunt indicates that the area is severely overfished (Figure 5). Westpunt is also one of the most visited dive areas and greatly valued by both fishermen and divers, meaning that there is great potential for conflict between these two user groups (WAITT Institute, 2016). The windward side of the island has a low fishing pressure due to rougher waters that deter most fishermen. Fishing is also limited around Willemstad (Zone 4), most likely due to the presence of large ships, and near Oostpunt (Zone 2), which has limited shore access for fishermen.

## 4. Condition of Curaçao's reefs compared to other reefs within the Caribbean Region

Curaçao's reefs are considered relatively healthy compared to the rest of the Caribbean (WAITT Institute, 2016) and rate favorably on some critical indicators of reef health and functional reef communities (Figure 6). The coral cover of the island's leeward coast (31%) is amongst the five highest of the Caribbean, just below Bonaire's leeward coast (35%). Coral cover of the east coast is much lower (12%) due to the oceanographic conditions of that coast, but still higher than Saba (9%). Parrotfish abundance of Curaçao's leeward coast is also amongst the five highest in the Caribbean, just below Bonaire's leeward coast (31 g/m2). The north shore has a much lower parrotfish abundance (15 g/m2), around the same range as Saba (13 g/m2). The macroalgal cover for both the east and west coast rate low (both 8%), while Saba rates even lower (5%).

While the health of Curaçao's reefs has significantly worsened over the past decades, they are still healthy enough to provide the island with important economic gains. In 2016, Curaçao's reefs were valued at more than USD 442 million per year (Sustainable Fisheries Group, 2016). These economic benefits will however disappear if Curaçao's reefs become too damaged, alongside invaluable functions such as storm protection and carbonate production. So far, the loss in Curaçao's coral cover has led to a 67% reduction in reef carbonate production (De Bakker et al., 2016). Drastic actions to ensure the proper management and conservation of the island's reefs, such as the designation of no take zones and the repair of its water treatment facility, is therefore urgently needed and must become an absolute priority for the island.

Photo by: © Marion Haarsma

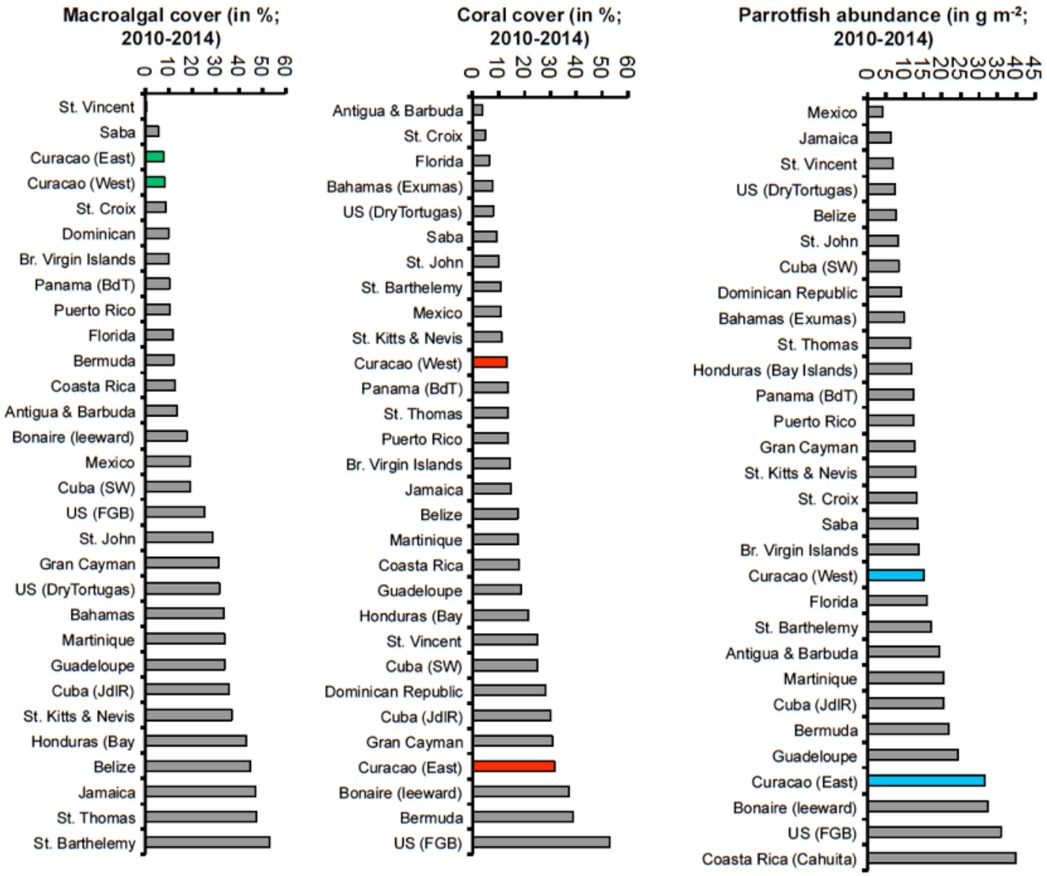


***Figure 6:*** *Overview of commonly used metrics for coral ecosystem health of Curaçao's coral reefs in comparison to other Caribbean islands and nations. High coral cover and high abundance of parrotfish are considered signs of functional reef communities, whereas high macroalgal abundance is indicative of degraded reefs. (Note: the more common turf algae and cyanobacteria are not included in this comparison).*
*Source: WAITT Institute, 2016.*



Photo by: © Marion Haarsma

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# Researchers discover that the three known flamingo tongue snail species are in fact just one species

Two researchers at Naturalis and Oxford University Museum of Natural History, Bastian Reijnen and Sancia van der Meij, recently carried out research on flamingo tongue snails and found that the three known species (*Cyphoma gibbosum* – flamingo tongue; *C. signatum* ¬fingerprint flamingo tongue and *C. mcgintyi* - McGinty's flamingo tongue) are in fact one single species despite differences in their mantle morphology. *Cyphoma signatum* and *C. mcgintyi* have different color patterns than C. gibbosum (fingerprint pattern and brown dots) and *C. gibbosum* and *C. signatum* have different shell outlines and color (Reijnen & Van der Meij, 2017).

Flamingo tongue snails are easily recognizable thanks to their light colored coat, known as mantle, which has a pattern of orange dots with an encircling black line *(Naturalis, 2017).* The mantle is made up of soft tissue that covers the entire shell. The colors and patterns of the snail's coat help protect it against predators by warning predators of its toxicity. Flamingo tongue snails live on gorgonians and feed on them. They consume the living tissue of the gorgonians as they move across it; their digestive system secretes chemicals that break down the octocoral tissue into nutrients. The snail also ingests toxins from the gorgonians but stores them in its tissues and uses them as a defense mechanism against predators.

Reijnen and Van der Meij (2017) collected 31 flamingo tongue specimens from Curaçao and St. Eustatius and obtained material from Florida. The specimens belonged to the three known species as well as one unidentified black morphotype. *"We found some patterns that were set between the striped and spotted one" explains Reijnen, "it was therefore not clear which kind of snail species they belonged to, which is why we carried out genetic testing"* (Naturalis, 2017). The researchers used data obtained from a previous study on Caribbean *Cyphoma* (Reijnen et al., 2010) and carried out genetic testing on each of the 31 collected specimens to investigate the genetics behind the morphological differences in shell shape, mantle patterns and coloration in Cyphoma spp. (Reijnen & Van der Meij, 2017). Four molecular markers were studied: COI mtDNA, 16S mtDNA, 28S tDNA and $H_3$ nDNA.

The results of the study revealed that there is no genetic difference between the three species and that they are in fact a single, genetically homogeneous species (Reijnen & Van der Meij, 2017). *"We have now shown that all these patterns are just a variation of one and the same kind."* explains Van der Meij. *"Instead of describing new species, we synonymize snail species (Cyphoma signatum and C. mcgintyi) with the oldest available species name (C. gibbosum)".* These findings are in line with anatomical studies by Ghiselin & Wilson (1966) and Simone (2004), who found that interpretation of the anatomical features in *Cyphoma* are troublesome and observed no clear differences between species. The researchers suggest that the prominent differences in mantle morphology between the species are the result of one of three possible scenarios: rapid divergence, supergenes or incipient speciation (Reijnen & Van der Meij, 2017).

Photos by: © Bastian Reijnen

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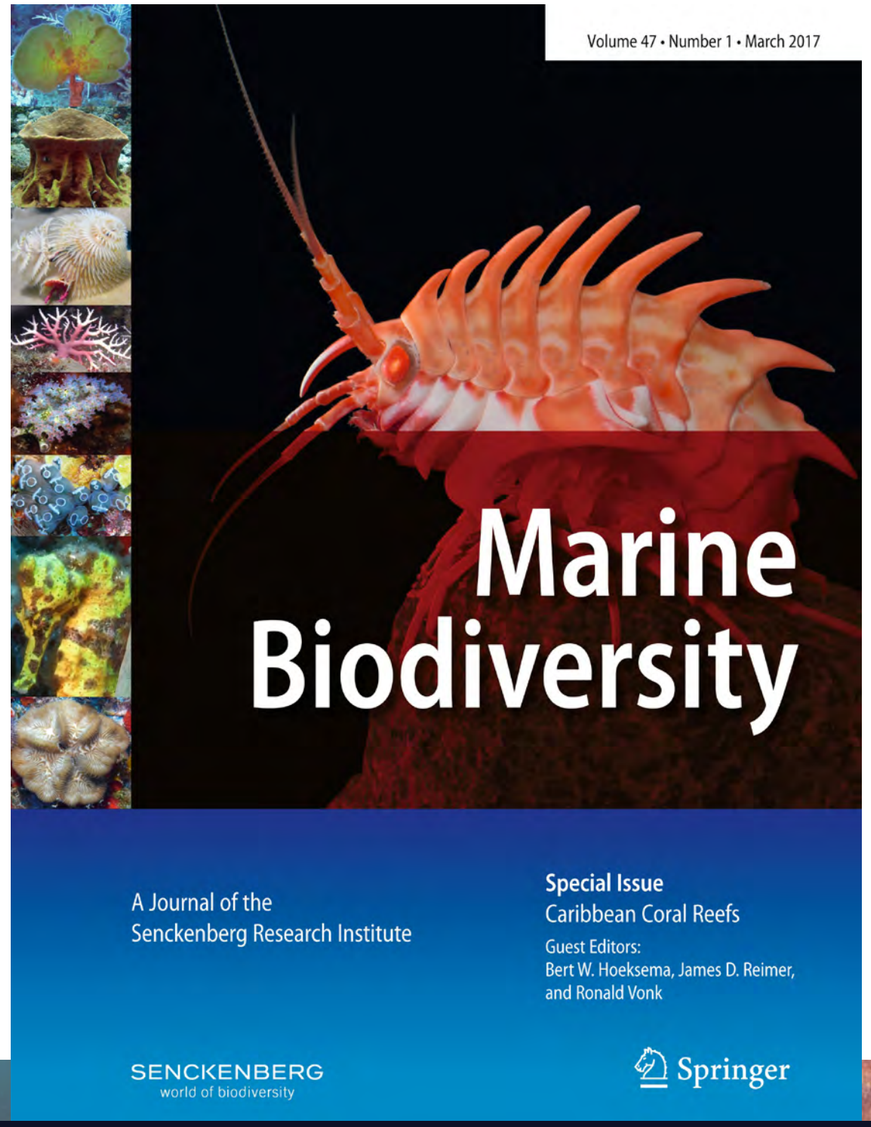
# Biodiversity of Dutch Caribbean Reefs

*By Bert W. Hoeksema (Naturalis Biodiversity Center, Leiden, The Netherlands)*




*Cover of the special issue of Marine Biodiversity on Caribbean Coral Reefs*

The coral reefs of the Dutch Caribbean have recently received much attention in the scientific journal Marine Biodiversity. The first issue of 2017 contained various articles about coral reef research carried out in the Caribbean and particularly St. Eustatius and Curaçao. The new findings suggest that much remains to be discovered regarding the marine fauna and flora of Caribbean coral reefs.

The plan for this issue started to develop during preparations for the marine biodiversity expedition to St. Eustatius in 2015, which was organized by Naturalis Biodiversity Center and ANEMOON Foundation and hosted by the Caribbean Netherlands Science Institute (CNSI). The expedition resulted in various new discoveries of algae, coral, crustacean, fish, hydroid, mollusk and sponge species for the eastern Caribbean. These new findings included undescribed species and new species records for St. Eustatius, some of which were even new for the whole Atlantic.

Most marine biodiversity research executed in the Dutch Caribbean by scientists of Naturalis Biodiversity Center and other Dutch research institutes was performed on Curaçao, which was possible thanks to the hospitality offered by the research station of Caribbean Marine Biological Institute (CARMABI). This resulted in many reports on the marine biota of Curaçao, most of which were published in the journals Studies on the Fauna of Curaçao and other Caribbean Islands (1940–1980), Studies on the Flora of Curaçao and other Caribbean Islands (1956–1968), and Studies on the Natural History of the Caribbean Region (1992–2000). The special issue of Marine Biodiversity adds to these previous studies by including new reports on corals, fishes, mollusks, and worms.

With the availability of Substation Curaçao for scientific work (since 2010), marine biodiversity studies in the deepest reef zones of Curaçao became more easy. The manned submersible Curasub can reach depths down to ca. 300 m. It can be transported by its mothership RV Chapman, which enables deep reef surveys at various localities off Curaçao and other Caribbean islands. This has already led to many new species discoveries, distribution records, and species depth records. The Marine Biodiversity special issue features a report on the deep reef community (70-85 m depth) discovered off the leeward coast of Curaçao.

Additional scientific reports of the 2015 expedition to St. Eustatius and recent research by Naturalis in the Dutch Caribbean have been published in other journals. All these publications can be found in the list on *page 29*.

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# Research Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Birds | Suitability study and reforestation of exclosures facilitating the Yellow-shouldered Amazon Parrots (Amazona barbadensis) on Bonaire. | BON | **Echo:** Lauren Schmaltz, Quirijn Coolen |
| Coral Reef ecosystems | Surveys (based on AGRRA and GCRMN) for the assessment of fish and benthos communities including corals, algae, sponges to 20 m depth. | BON | **WUR:** Erik Meesters |
| Coral Reef ecosystems | Coral-associated fauna of Curaçao | CUR | **Naturalis:** Bert Hoeksema<br>**Leiden University**<br>**CARMABI** |
| Coral Reef ecosystems | Distribution and impact of the invasive reef coral Tubastraea coccinaea on the coral reefs of Curaçao | CUR | **Naturalis**: Bert Hoeksema<br>**Leiden University**: Auke-Florian Hiemstra (student)<br>**CARMABI** |
| Coral reef ecosystems | Distribution and impact of the aggressive ascidian Trididemnum solidum on the coral reefs of Curaçao | CUR | **Naturalis**: Bert Hoeksema<br>**Leiden University**: Gabriël Olthof (student)<br>**CARMABI** |
| Coral reef restoration | 3D reconstruction as a monitoring strategy for coral reef restoration of Acropora palmata on Bonaire | BON | **University of Oxford**: Julia Huisman<br>**School of Geography and the Environment**<br>**CRFB** |
| Economics of ecosystems | The Economics of Ecosystems and Biodiversity (TEEB) on Aruba | AUA | **Wolfs Company:** Esther Wolfs, Boris van Zanten<br>**VU:** Pieter van Beukering<br>**YABI consultancy:** Francielle Laclé |
| Environmental damage | Environmental Damage after Hurricane Irma and Maria | SAB<br>EUX<br>SXM | **SCF**: Kai Wulf<br>**STENAPA**: Clarisse Buma<br>**NFSXM**: Tadzio Bervoets |
| Erosion | Erosion around Kralendijk<br>*Part of Nature Funding Project: Erosion control and nature restoration | BON | **DRO**<br>**VU:** Nick Roos (student) |

# Research Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Fish | Baited Remote Underwater Video (BRUV) to study sharks | BON | **WUR:** Erwin Winter, Dolfi Debrot, Martin de Graaf, Twan Stoffers<br>**STINAPA**<br>**HAS**: Mavelly Velandia (student)<br>**WUR**: Sander Delacauw (student) |
| Fish | Distribution of local and regional surgeonfish disease using a novel technique - Google Images. | BON | **CIEE**: Rita Peachey, Franziska Elmer, Madeline Roth, Lucia Rodriguez, Sasha Giammetti, Megan Hoag |
| Fish | Identification of the parasite and hosts of the turbellarian infecting reef fish species in Bonaire | BON | **University of North Texas**: Zac Kohl (PhD Candidate)<br>**CIEE:** Franziska Elmer; Rita Peachey; Lisa Kram; Ashley Novak; Andrew Paton |
| Invasive species | Research into mitigation measures for Sargassum Seaweed | SXM | **NFSXM:** Tadzio Bervoets<br>**Government of St. Maarten** |
| Invasive species | Environmental DNA (eDNA) of lionfish in Lac Bay: A tool for detecting the invasive species in complex habitats (mangroves) | BON | **CIEE:** Rita Peachey<br>**Indiana University:** Stephen Glaholt |
| Mangrove ecosystems | Pilot-scale testing and evaluation of mangrove ecosystem intervention options<br>(fish fauna, epibionts on mangrove prop roots)<br>*Part of Nature Funding Project: Ecological restoration Lac Bay and South coast, Bonaire | BON | **WUR:** Dolfi Debrot, Douwe Boerstra (student), Laura Timmermans (student)<br>**STINAPA:** Sabine Engel |
| Nature Policy Planning | Developing a nature policy plan for Bonaire | BON | **Wolfs Company:** Boris van Zanten, Esther Wolfs, Sacha van Duren<br>**DRO** |
| Plants | Germination of seeds of indigenous trees of Curaçao | CUR | **CARMABI:** John de Freitas |
| Plants | Testing effective ways to grow native plants | BON | **Echo:** Quirijn Coolen, Johan van Blerk |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Coral Reef Ecosystems | Deep Reef Observation Project (DROP) (ARMS: Autonomous Reef Monitoring Structures) | CUR | **Smithsonian:** Carole Baldwin |
| Coral Reef Ecosystems | Postsettlement dynamics of Caribbean corals & Reef restoration | CUR | **UvA:** Valerie Chamberland (PhD candidate)<br>**CARMABI**<br>**SECORE International** |
| Coral Reef Ecosystems | Bioersion of reefs by coral-excavating sponges | BON,CUR, SAB, EUX | **NIOZ:** Fleur van Duyl<br>**WUR:** Erik Meesters, Didier de Bakker (PhD student) |
| Coral Reef Ecosystems | Development of restoration methods for threatened Caribbean coral species | BON, CUR, SAB | **CRF Bonaire:** Augusto Montbrun, Francesca Virdis<br>**SECORE Project**<br>**CARMABI:** Mark Vermeij<br>**UvA:** Valerie Chamberland (PhD candidate)<br>**SCF, Sea Saba, Samford University:** Jennifer Rahn |
| Coral Reef Ecosystems | Developing a plan to manage the waters around Curaçao sustainably, profitably, and enjoyably for this and future generations - including mesophotic reef dropcam project | CUR | **Waitt Institute (Blue Halo Curaçao):**<br>Kathryn Mengerink |
| Database | Dutch Caribbean Species Catalog: Taxonomic knowledge system Dutch Caribbean (http://www.dutchcaribbeanspecies.org/) | All | **Naturalis:** Sander Pieterse & Berry van der Hoorn |
| Environmental | Effects of dispersants on the fate of oil in realistic conditions (C-IMAGE consortium, TripleP@Sea Program) | EUX | **WUR:** Tinka Murk, Marieke Zeinstra-Helfrich (PhD student)<br>**CNSI** |
| Environmental | Ecotoxicological aspects of rational application of chemicals in response to oil spills to reduce environmental damage (C-IMAGE consortium, TripleP@Sea Program) | EUX | **WUR:** Tinka Murk, Justine van Eenennaam (PhD student)<br>**CNSI** |
| Environmental | Ecotoxicological aspects of rational application of chemicals in response to oil spills to reduce environmental damage<br>Development of an area specific net environmental and economic benefit analysis (NEEBA) to support oil spill mitigation decisions; with St. Eustatius as example | EUX | **WUR:** Tinka Murk, Sophie Vonk (PhD student)<br>Lei Wageningen UR: Stijn Reinhard<br>**CNSI** |
| Interstitial biodiversity | Moleculair biodiversity analysis of marine communities by metabarcoding | EUX | **Naturalis:** Arjen speksnijder<br>**ANEMOON:** Niels Schrieken |
| Invasive species | Combatting the economic and ecological impacts of overgrazing on inhabited islands | BON | **UsA:** Michaela Roberts (PhD student) |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Marine ecosystems | Taxonomy and biodiversity in Lac Bay | BON | **STINAPA** Sabine Engel, Caren Eckrich<br>**Ecosub:** Godfried van Moorsel<br>**CEAB:** Daniel Martin |
| Marine ecosystems | Marine species discoveries in the Dutch Caribbean | All | **Naturalis:** Bert Hoeksema<br>**CNSI**<br>**CARMABI** |
| Molluscs | Population dynamics and role in the food chain of the Queen Conch Lobatus gigas in the Dutch Caribbean Territories | EUX, SAB | **WUR:** Aad Smaal, Leo Nagelkerke, Martin de Graaf<br>Erik Boman (PhD student)<br>**SCF (SBMU):** Jens Odinga<br>**CNSI** |
| Public Health | DNA waterscan: Monitoring disease vectors in the Caribbean (mosquitoes and midges) | EUX | **Naturalis:** Kevin Beentjes<br>**ECPHF:** Teresa Leslie |
| Sustainability | Sustainable development Dutch Caribbean (TripleP@Sea Program)<br>- Are human activities a risk for ecosystem services?<br>- Green Statia or how to regain balance between nature and agriculture? | EUX | **WUR:** Diana Slijkerman<br>**WUR (Alterra):** Rene Henkens<br>**CNSI** |
| Terrestrial biodiversity | Baseline assessment and DNA barcoding of specimens | EUX | **Naturalis:** Michael Stech, Berry van der Hoorn<br>**STENAPA**<br>**CNSI** |
| Terrestrial biodiversity | Testing surrogates to establish conservation priorities | EUX | **Naturalis:** Jeremy Miller<br>**STENAPA** |
| NWO Projects in the Dutch Caribbean | | | |
| Bioproducts | Stand-alone production of algal products for food, feed, chemicals and fuels | BON | **WUR:** R.H. Wijffels<br>**CIEE:** Rita Peachey |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Coral Reef Ecosystems | Caribbean coral reef ecosystems: interactions of anthropogenic ocean acidification and eutrophication with bioerosion by coral excavating sponges<br>- Bioerosion and climate change | BON, SAB, EUX | **NIOZ:** Fleur van Duyl, Steven van Heuzen (PostDoc), Alice Webb (PhD student)<br>**STENAPA**<br>**CNSI** |
| Coral restoration | Artificial Reefs On Saba and Statia (AROSSTA) | SAB<br>EUX | **VHL**: Alwin Hylkema, Marlous Heemstra<br>**WUR:** Dolfi Debrot<br>**STENAPA**: Jessica Berkel, Erik Houtepen<br>**SCF:** Kai Wulf, Jens Odinga, Aymi Izioka<br>**CNSI**: Johan Stapel<br>**Students**: Callum Reid,<br>Esmee vd Griend, Daniel Heesink |
| Environmental | Caribbean island biogeography meets the anthropocene | AUA, BON, CUR, EUX, SXM | **VU:** Jacintha Ellers, Matt Helmus, Wendy Jesse (PhD. Student), Jocelyn Behm (Postdoc)<br>**CNSI** |
| Environmental psychology | Confronting Caribbean Challenges: Hybrid Identities and Governance in Small-scale Island Jurisdictions<br>- Behavioral differences between/within the BES islands when it comes to nature conservation and cultural heritage. | BON, SAB, EUX | **KITLV, Leiden University:**<br>Gert Oostindie (Project director)<br>**KITLV, Leiden University:**<br>Stacey Mac Donald (PhD student) |
| Geosciences | Stability of Caribbean coastal ecosystems under future extreme sea level changes (SCENES)<br>- The effects of climate change on calcifying algae | BON, EUX, SXM | **UU:** Henk Dijkstra, **NIOZ:** Peter Herman, Rebecca James (PhD student) **TU Delft:** Julie Pietrzak<br>**STENAPA**<br>**CNSI** |
| Geomorphological | 4D crust-mantle modelling of the eastern Caribbean region: toward coupling deep driving processes to surface evolution<br>- Reconstructing past climate change | EUX | **UU:** Wim Spakman<br>**NIOZ:** Lennart de Nooijer<br>**Alfred Wegener Institute Germany**<br>**CNSI** |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Invasive species | Exotic plant species in the Caribbean: foreign foes or alien allies?<br>(1) Socio-economic impacts of invasive plant species (2) Ecological impacts of invasive plant species-Utrecht University | BON, SAB, EUX | **(1) UU:** Jetske Vaas (PhD student), Peter Driessen, Frank van Laerhoven and Mendel Giezen **(2) UU:** Elizabeth Haber (PhD student), Martin Wassen, Max Rietkerk,Maarten Eppinga.<br>**CNSI** |
| Reptiles | Ecology and conservation of green and hawksbill turtles in the Dutch Caribbean | AUA, BON, CUR, SAB, EUX, SXM | **RuG:** Per Palsbøll, Jurjan van der Zee (PhD student)<br>**RU**: Marjolijn Christianen,<br>**WUR:** Lisa Becking<br>**STCB:** Mabel Nava<br>**CARMABI**<br>**STENAPA**<br>**CNSI** |
| Tourism and sustainable development | Vulnerability is dynamic: Enhancing adaptive governance to climate change for Caribbean tourism through interactive modelling | CUR | **WUR**: Jillian Student, Machiel Lamers<br>**UOC:** Filomeno A. Marchena |
| **BO-projects in the Dutch Caribbean (Min EZ)** | | | |
| Coral Reef Ecosystems | BO-11-019.02-038– Analysis photomaterial coral reefs | BON, CUR | **WUR:** Erik Meesters |
| Coral Reef Ecosystems | BO-11-019.02-022 –Inventory corals<br>Includes monitoring and research of the longest coral reef time-series in the world (since 1973) | BON, CUR | **WUR:** Erik Meesters |
| Conservation | BO-11-019.02-060 – Status of nature conservation of the Caribbean Netherlands (for new nature policy plan) | BON, SAB, EUX | **WUR:** Dolfi Debrot, Rene Henkens, Peter Verweij<br>**EZ:** Paul Hoetjes, Yoeri de Vries (eds.) |
| DCBD | BO-11-019.02-002 - Expansion knowledge system Dutch Caribbean | AUA, BON, CUR, SAB, EUX, SXM | **WUR (Alterra):** Peter Verweij |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Fisheries | BO-11-019.02-055 – Fisheries Dutch Caribbean | SAB, EUX | **WUR:** Dolfi Debrot<br>Thomas Brunel, Martin de Graaf<br>**SCF (SBMU):** Jens Odinga, Ayumi Izioka<br>**NIOZ:** Kimani Kitson-Walters<br>Students: Fedor den Elzen, Ivo Damen |
| Marine biodiversity | BO-11-019.02-008 – Saba Bank – Marine biodiversity | SAB | **WUR:** Erik Meesters (benthic communities), Dolfi Debrot, Thomas Brunel, Leo Nagelkerke (fish stocks) |
| Marine mammals & sharks | BO-11-019.02-054 – Marine mammal sanctuary | SAB, EUX | **WUR:** Dolfi Debrot, Dick de Haan, Meike Scheidat, Ayumi Izioka<br>**SCF (SBMU):** Jens Odinga |
| Marine mammals | BO-11-019.02-005 – Marine mammals in the Dutch Caribbean | BON, SAB, EUX | **WUR:** Dolfi Debrot |
| World Heritage nomination | BO-11-019.02-050 – World Heritage nomination Bonaire National Marine Park | BON | **WUR:** Dolfi Debrot<br>**Wolfs Co.**: Esther Wolfs<br>**UNESCO**: Josephine Langley<br>**DRO**: Frank v Slobbe<br>**CARMABI:** Mark Vermeij, John de Freitas<br>**Curacao Footprint Foundation:** Leon Pors |
| "Nature Funding" Projects in the Dutch Caribbean (Min EZ) | | | |
| Coastal ecosystems (Lac Bay: Mangroves and seagrass beds) | Ecological restoration Lac Bay and South coast, Bonaire | BON | **STINAPA:** Sabine Engel<br>**WUR:** Klaas Metselaar<br>**STCB:** Mabel Nava<br>**DRO:** Frank van Slobbe |
| Sustainable Agriculture | The sustainable agriculture and rural development program (POP Bonaire) | BON | **Bonaire Agri & Aqua Business BV:** Sherwin Pourier<br>**Wayaká Advies BV:** Jan Jaap van Almenkerk<br>**DRO:** Frank van Slobbe |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Invasive species | Feral Pig Control | BON | **Echo:** Julianka Clarenda<br>**DRO:** Frank van Slobbe |
| Reforestation | Reforestation Project | BON | **Echo:** Lauren Schmaltz, Quirijn Coolen<br>**DRO:** Frank van Slobbe |
| Invasive species | Goat eradication and control in Washington Slagbaai National Park | BON | **STINAPA**<br>**DRO:** Frank van Slobbe |
| Coral ecosystems | Coral Restoration | BON | **CRF Bonaire:** Augusto Montbrun<br>**DRO:** Frank van Slobbe |
| World Heritage nomination | World Heritage Nomination Bonaire Marine Park and/or other interconnected sites | BON | **Wolfs Company:** Esther Wolfs, Boris van Zanten, Amilcar Guzman, Viviana Lujan<br>**DRO:** Frank van Slobbe |
| Terrestrial ecosystems | Erosion control and nature restoration | BON | **Bonaire Agri & Aqua Business BV:** Sherwin Pourier<br>**Wayaká Advies BV:** Jan Jaap van Almenkerk<br>**DRO:** Frank van Slobbe |
| Terrestrial ecosystems | Cave and karst nature reserve | BON | **DRO**: Frank van Slobbe<br>**CARIBSS**: Fernando Simal |
| Nature communication | Campaign environment en nature on  Bonaire | BON | **DRO:** Frank van Slobbe, Peter Montanus |
| Agriculture | Agricultural Project | SAB | **Government of Saba:** Menno van der Velde |
| Recreation | Hiking trails | SAB | **Government of Saba:**  Robert Zagers |
| Pollution | Tent Reef Protection | SAB | **Government of Saba:**  Robert Zagers |
| Invasive species | Goat buy-back program | SAB | **Government of Saba:** Menno van der Velde |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| | Yacht mooring project | SAB | **Government of Saba**<br>**SCF**: Kai Wulf |
| | Saba national park | SAB | **Government of Saba**<br>**SCF**: Kai Wulf<br>**SABARC:** Ryan Espersen |
| | Crispeen trail project | SAB | **Government of Saba:** Robert Zagers<br>**SCF:** Kai Wulf |
| Community outreach | Nature Awareness project | EUX | **Government of St Eustatius**<br>**STENAPA:** Clarisse Buma<br>**CNSI:** Johan Stapel, Hannah Madden |
| Nature management | Strengthening management of nature | EUX | **Government of St Eustatius**<br>**STENAPA:** Clarisse Buma |
| Invasive species | Rodent assessment and control | EUX | **Government of St Eustatius**<br>**CNSI:** Johan Stapel, Hannah Madden<br>**ECPHF:** Teresa Leslie |
| Coral ecosystems | Coral restoration | EUX | **Government of St Eustatius**<br>**STENAPA:** Jessica Berkel<br>**CNSI:** Johan Stapel |
| Erosion | Erosion control | EUX | **Government of St Eustatius**<br>**CNSI:** Johan Stapel |
| **EU-BEST funded Projects in the Dutch Caribbean** | | | |
| Marine ecosystems | Marine Park Aruba | AUA | **Directie Natuur en Milieu:** Gisbert Boekhoudt<br>**TNO:** Kris Kats |

# Long Term Projects

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Coral Reef Ecosystems | Restoration Ecosystem Services and Coral Reef Quality (Project RESCQ) | SAB, EUX, SXM | **WUR:** Erik Meesters<br>**SCF**<br>**STENAPA**<br>**NFSXM**<br>**Turks & Caicos Reef Fund**<br>**Students:** Niels Wagenaar, Silvan Allard, Pam Engelberts, Roxanne Francisca, Lotte Staat, Carmen Carpendale, Daniela Simal, Emma Louise Pratt, Renate Olie, Amber Mulder |
| Conservation | Watershed & Biodiversity Conservation of Roi Sangu valley | BON | **Echo:** Lauren Schmaltz, Quirijn Coolen |
| Terrestrial habitat restoration | Restoration of Key Biodiversity Areas of St. Maarten | SXM | **EPIC**: Kippy Gilders<br>**Les Fruits des Mer**: Mark Yokoyama (reptile, amphibian, and invertebrate assessment)<br>**The Leon Levy Native Plant Preserve, Bahamas**: Ethan Freid (plant assessment) |

# Monitoring Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Birds | Flamingo Abundance | BON | **DRO:** Frank van Slobbe<br>**Cargill**<br>**STINAPA:** Paulo Bertuol |
| Birds | Monitoring vulnerable parrot nests (remote camera sensing work) | BON | **Echo:** Laura Schmaltz, Sam Williams |
| Birds | Yellow-shouldered Amazon parrot roost counts | BON | **Echo:** Lauren Schmaltz<br>**DRO:** Peter Montanus<br>**STINAPA:** Paulo Bertuol |
| Birds | Bird Monitoring (Caribbean Waterbird Census) | AUA<br>BON<br>SXM | **FPNA**<br>**DLVV:** Tatiana Becker<br>**STINAPA:** Paulo Bertuol<br>**EPIC**: Nathalia Collier |
| Birds | Tern monitoring(artificial nesting islands) | BON | **STINAPA:** Paulo Bertuol<br>**Cargill**<br>**DRO**<br>**WUR:** Dolfi Debrot |
| Birds | Terrestrial Bird Monitoring Program for Bonaire | BON | **Echo:** Lauren Schmaltz<br>**STINAPA** |
| Birds | Red-billed Tropicbird monitoring | SAB<br>EUX | **STENAPA**<br>**SCF:** Kai Wulf |
| Birds | Pelican monitoring | SXM | **NFSXM:** Melanie Meijer zu Schlochtern |
| Birds | Monitoring Survivorship, Population Trends, and Habitat Requirements in Lesser Antillean Birds | SXM | **EPIC**: Nathalia Collier |
| Birds | Monitoring of Black-capped Petrels and Granadine's seabirds | SXM | **EPIC**: Nathalia Collier, Adam Brown |
| Coral reef ecosystems | Coral Bleaching Monitoring | SXM | **NFSXM:** Tadzio Bervoets |

# Monitoring Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Coral reef ecosystems | Global Coral Reef Monitoring Network | BON<br>CUR<br>SAB<br>EUX<br>SXM | **STINAPA:** Caren Eckrich<br>**CARMABI:** Mark Vermeij<br>**SCF (SBMU):** Jens Odinga<br>**STENAPA:** Jessica Berkel<br>**NFSXM:** Tadzio Bervoets<br>**CNSI:** Johan Stapel |
| Corals reef ecosystems | Doobies Crack reef damage recovery survey | EUX | **STENAPA:** Erik Houtepen |
| Corals reef ecosystems | Staghorn coral field monitoring survey | EUX | **STENAPA:** Jessica Berkel |
| Coral reef ecosystems | Monitoring and research of the longest coral reef time-series in the world (since 1973)<br>(Part of BO-11-019.02-022 –Inventory corals) | BON<br>CUR | **WUR:** Erik Meesters, Didier de Bakker (PhD student)<br>**NIOZ:** Fleur van Duyl, Rolf Bak |
| Coral reef ecosystems | Coral reef monitoring (Since 2007 using AGRRA methods and filming of permanent transects) | BON | **CIEE**: Rita Pearchey |
| Environmental | Water quality testing | SXM | **NFSXM:** Tadzio Bervoets<br>**EPIC:** Natalia Collier |
| Environmental | Nutrient (phosphate, ammonium, nitrate and nitrite) monitoring of St Eustatius' coastal waters | EUX | **CNSI:** Johan Stapel |
| Fish | Shark monitoring:<br>-Shark sightings<br>- Shark Abundance, distribution and movements (tagging, acoustic telemetry) | BON<br>CUR<br>SAB<br>SXM<br>EUX | **WUR:** Erwin Winter, Dolfi Debrot, Martin de Graaf<br>**STINAPA:** Caren Eckrich<br>**CARMABI:** Mark Vermeij<br>**SCF(SBMU):** Jens Odinga, Ayumi Izioka<br>**STENAPA:** Jessica Berkel<br>**NFSXM:** Tadzio Bervoets |
| Fish | Spawning monitoring: Red hind surveys on Moonfish Bank | SAB | **SCF (SBMU):** Jens Odinga, Ayumi Izioka |
| Insects | Bee tracking | BON | **Echo:** Lauren Schmaltz |

# Monitoring Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Invasive species | Goat and/or donkey removal:<br>-Washington Slagbaai National Park<br>- Lac Bay area (exclusion plots)<br>- Quill National Park (exclusion plots) | BON<br>EUX | **STINAPA: Paulo Bertuol**<br>**WUR:** Dolfi Debrot<br>**DRO:** Frank van Slobbe<br>**STENAPA** |
| Invasive species | Lionfish abundance and control | BON<br>CUR<br>SXM<br>SAB<br>EUX | **STINAPA:** Paulo Bertuol (50 meter traps)<br>**CARMABI:** Mark Vermeij<br>**NFSXM:** Tadzio Bervoets<br>**SCF (SBMU):** Jens Odinga<br>**STENAPA:** Jessica Berkel |
| Invasive species | Monkey Monitoring: abundance and distribution | SXM | **NFSXM:** Tadzio Bervoets |
| Invasive species | Feral pig population assessment (trapping) | BON | **Echo:** Nathan Schmaltz, Sam Williams |
| Mammals | Bat monitoring | AUA<br>BON | **FPNA**<br>**WildConscience:** Fernando Simal, Linda Garcia |
| Mammals | Dolphin monitoring (since 1999) | BON | Ron Sewell |
| Mammals | Caribbean Humpback Acoustic Monitoring Programme (CHAMP) | BON, AUA | **NOAA**: Heather Heenehan, Sofie Van Parijs, Peter Corkeron, Fred Wenzel<br>**STINAPA**: Wijnand de Wolf<br>**AMMF**: Angiolina Henriquez<br>**RCN**: Paul Hoetjes |
| Mammals | Marine Mammal Monitoring (noise loggers Saba Bank) | SAB | **WUR:** Dick de Haan, Dolfi Debrot<br>**SCF (SBMU)**: Jens Odinga, Ayumi Izioka |
| Molluscs | Conch (Strombus gigas) on St. Eustatius, Saba Bank, Anguilla | SAB<br>EUX | **WUR:** Martin de Graaf, Erik Boman (PhD student)<br>**SCF (SBMU):** Jens Odinga |

# Monitoring Overview

*September 2017*

| CATEGORY | SUBJECT | ISLANDS | ORGANIZATION(S): LEAD SCIENTIST |
|---|---|---|---|
| Natural resource use | Fishery monitoring (including lionfish, shark bycatch and marine mammal sightings)<br>(* Part of BO-11-019.02-055 – Fisheries Dutch Caribbean) | SAB<br>EUX | **SCF (SBMU):** Jens Odinga, Ayumi Izioka<br>**Gem City Consulting:** Erik Boman<br>**LVV:** Kiman Kitson-Walters<br>**WUR:** Dolfi Debrot, Fedor den Elzen (student), Ivo (student) Damen |
| Plants | Phenology of bats in cacti landscapes of Aruba | AUA | **WildConscience:** Linda Garcia, FPNA |
| Plants | Monitoring of tree growth and survivorship in reforestation areas | BON | **Echo**: Quirijn Coolen, Nicholas Verhey |
| Plants | Terrestrial Habitat Monitoring Program for Bonaire | BON | **Echo**: Lauren Schmaltz |
| Reptiles | Lesser Antillean Iguana: Monitoring population density & removing invasive Green Iguana and hybrids | EUX | **STENAPA**<br>**RAVON:** Tim van Wagensveld<br>**EcoPro:** Hannah Madden |
| Reptiles | Boa and Cascabel Monitoring | AUA | **FPNA, Toledo Zoological Society:** Andrew Odum |
| Reptiles | Behavior of the endemic Aruban Whiptail lizard | AUA | **FPNA, Auburn University:**<br>Jeff Goessling (PhD candidate) |
| Seagrass and mangrove ecosystems | Seagrass and mangrove monitoring<br>(BON: also conch and benthic fauna) | BON<br>SXM | **STINAPA:** Sabine Engel, Caren Eckrich<br>**WUR:** Klaas Metselaar<br>**NFSXM:** Tadzio Bervoets |
| Seagrass and mangrove ecosystems | Seagrass restoration BESE elements | BON | **RU:** Marjolijn Christianen<br>**STINAPA** : Sabine Engel |
| Reptiles | Sea turtle monitoring:<br>-Satellite tracking<br>-Nest monitoring<br>-In water surveys (BON, CUR, SXM)<br>-Fibropapillomatosis presence (BON) | AUA, BON, CUR, SAB, EUX, SXM | **TurtugAruba Foundation**<br>**STCB:** Mabel Nava<br>**CARMABI (STCC):** Sabine Berendse<br>**STENAPA:** Jessica Berkel<br>**SCF:** Kai Wulf<br>**NFSXM:** Tadzio Bervoets |

# List of Acronyms

| | |
|---|---|
| **AUA** | **Aruba** |
| **BON** | **Bonaire** |
| **CUR** | **Curaçao** |
| **SAB** | **Saba** |
| **EUX** | **St. Eustatius** |
| **SXM** | **St. Maarten** |
| AMMF | Aruba Marine Mammal Foundation |
| ANEMOON | Analyse Educatie en Marien Oecologisch Onderzoek |
| ASDF | Aruba Sustainable Development Foundation |
| BEST | Biodiversity and Ecosystem Services in Territories of European overseas |
| BO project | Policy Supporting Research project |
| BU | Bangor University, United Kingdom |
| CARIBSS | Caribbean Speleological Society |
| CARMABI | Caribbean Research and Management of Biodiversity Foundation |
| CEAB | The Blanes Centre for Advanced Studies, Spain |
| CIEE | Council of International Educational Exchange, Bonaire |
| CRF | Coral Reef Foundation |
| DCNA | Dutch Caribbean Nature Alliance |
| DCBD | Dutch Caribbean Biodiversity Database |
| DRO | Directorate of Spatial Planning and Development, Bonaire |
| DLVV (Santa Rosa) | Department of Agriculture, Livestock, Fishery and Farmers market (Santa Rosa), Aruba |
| EcoPro | Ecological Professionals Foundation |
| ECPHF | Eastern Caribbean Public Health Foundation |
| EPIC | Environmental Protection in the Caribbean |
| FPNA | Fundacion Parke Nacional Arikok, Aruba |
| HAS | HAS University of Applied Sciences, the Netherlands |
| LVV | Department of Agriculture, Animal Husbandry & Fisheries, St. Eustatius |

| | |
|---|---|
| NFSXM | Nature Foundation St. Maarten |
| Naturalis | Naturalis Biodiversity Center, The Netherlands |
| NIOZ | NIOZ Royal Institute for Sea Research, the Netherlands |
| NWO | NWO Netherlands Organisation for Scientific Research |
| PL | Project leader |
| RAVON | Reptielen Amfibieën Vissen Onderzoek Nederland |
| RuG | University of Groningen, the Netherlands |
| SBMU | Saba Bank Management Unit |
| SCF | Saba Conservation Foundation |
| Smithsonian | Smithsonian's National Museum of Natural History |
| STCB | Sea Turtle Conservation Bonaire |
| STCC | Sea Turtle Conservation Curacao |
| STENAPA | St. Eustatius National Parks Foundation |
| STINAPA | National Parks Foundation Bonaire |
| TUD | Delft University of Technology, the Netherlands |
| UsA | University of St. Andrews, Scotland |
| UU | University of Utrecht, the Netherlands |
| UvA | University of Amsterdam, the Netherland |
| VHL | University of Applied Sciences VHL, the Netherlands |
| VU | VU University Amsterdam, the Netherlands |
| Wildconscience | Wildlife Conservation, Science and Education |
| WNF | World Wide Fund for Nature |
| WUR | Wageningen Universitwy and Research Centre, the Netherlands |
| WUR (Alterra) | Wageningen Environmental Research, the Netherlands |

Photos by: © Marion Haarsma

# Reports and Publications Overview

*Below you will find an overview of the reports and publications on biodiversity related subjects in the Dutch Caribbean that have recently been published.*

These reports and publications can be found in the Dutch Caribbean Biodiversity Database (DCBD) (http://www.dcbd.nl). The DCBD is a central online storage facility for all biodiversity and conservation related information in the Dutch Caribbean.

If you have research and monitoring data, the DCNA secretariat can help you to get it housed in the DCBD. *Please e-mail us: research@DCNAnature.org*


**"Bosker, T., Behrens, P., & Vijver, M.G. (2017).**
Determining global distribution of microplastics by combining citizen science and in-depth case studies. Integrated Environmental Assessment and Management, 13(3), 536-541."

**"Feller, I.C., Friess, D.A., Krauss, K.W., & Lewis, R.R. (2017).**
The state of the world's mangroves in the 21st century under climate change. Hydrobiologia, 1-12."

**"Lemaitre, R., Felder, D. L., & Poupin, J. (2017).**
Discovery of a new micro-pagurid fauna (Crustacea: Decapoda: Paguridae) in the Lesser Antilles, Caribbean Sea. Zoosystema, 39(2), 151-195."

**"Thorpe, R.S. (2017).**
Predictability in evolution: Adaptation of the Bonaire anole (Anolis bonairensis) to an extreme environment. PloS one, 12(5), e0176434."

**"Truelove, N.K., Box, S.J., Aiken, K.A., Blythe-Mallet, A., Boman, E. et al. (2017)**
Isolation by oceanic distance and spatial genetic structure in an overharvested international fishery, Diversity and Distributions, 10.1111/ddi.12626"

**"Willis, S., Nava, M., Schut, K., Rivera-Milán, F.F. (2017)**
Research and Monitoring of Bonaire's Sea Turtles: 2016 Technical Report, 1-23."


Photo by: © Marion Haarsma

# Calendar

## September

| | | |
|---|---|---|
| 4-8 | Congress | 4th International Marine Protected Areas Congress (IMPAC4), La Serena-Coquimbo, Chile |
| 18-22 | Workshop | Capacity-building workshop for Caribbean small island developing States towards achieving Aichi Biodiversity Target 9, Jamaica |

## October

| | | |
|---|---|---|
| whole month | Event | Sea and learn, Saba. |
| 2-4 | Workshop | 2nd Technical Workshop of the Transatlantic MPA Network: Marine mammals' protection, a way to enhance transatlantic cooperation between MPAs, Iceland. |
| 5-6 | Conference | Our Ocean' Conference, Malta. |
| 12 | Reception | Save Our Sharks reception, Amsterdam, the Netherlands. |
| 12-14 | Conference | 21st Annual European Elasmobranch Association Scientific Conference, Amsterdam, the Netherlands. |
| 17-19 | Meeting | WECAFC/CITES/OSPESCA/CRFM/CFMC Working Group on Shark Conservation and Management, Barbados. |
| 18-20 | Meeting | 14th Scientific Committee Meeting of the IAC, Panama. |
| 20 | Meeting | Fishery Commission BES, Barbados. |
| 23-28 | Conference | 12th COP to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), in Manila, the Philippines. |
| 25 | Event | Sustainability Day |
| 30-2 Nov | Conference | 19th RedLac Assembly, Dominican Republic. |

## November

| | | |
|---|---|---|
| 6-10 | Meeting | 70th Meeting of GCFI, Merida, Mexico. |
| 16-17 | Conference | Green Aruba, sustainability in motion, Aruba. |
| 20-24 | Meeting | 2nd Meeting of the Advisory Committee and 2nd Workshop of the Conservation Working Group of the Sharks MoU, Habitat, Bonaire. |
| 25 | Event | Fundraising Auction (STCB) El Encanto Boutique Hotel, Bonaire. |
| 26-01 Dec | Meeting | 69th meeting of the CITES Standing Committee, CICG, Geneva, Switzerland. |
| 26-01 Dec | Meeting | 69th meeting of the CITES Standing Committee, CICG, Geneva, Switzerland. |

## December

| | | |
|---|---|---|
| 6-7 | Conference | 6th Statia Sustainability Conference (SSC6), St. Eustatius. |
| 7-9 | Meeting | ICRI General meeting, Nairobi. |
| 13 | Symposium | European Coral Reef Symposium, Oxford, UK. |

2018 declared International Year of the Reef by the International Coral Reef Initiative (ICRI)

***More events to add to this calendar?***
*Please e-mail us: research@DCNAnature.org*

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**Bonaire**
STINAPA Bonaire
+599 717 84 44
www.stinapa.org

**St. Maarten**
Nature Foundation
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www.naturefoundationsxm.org

**Curaçao**
CARMABI
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**Curaçao**
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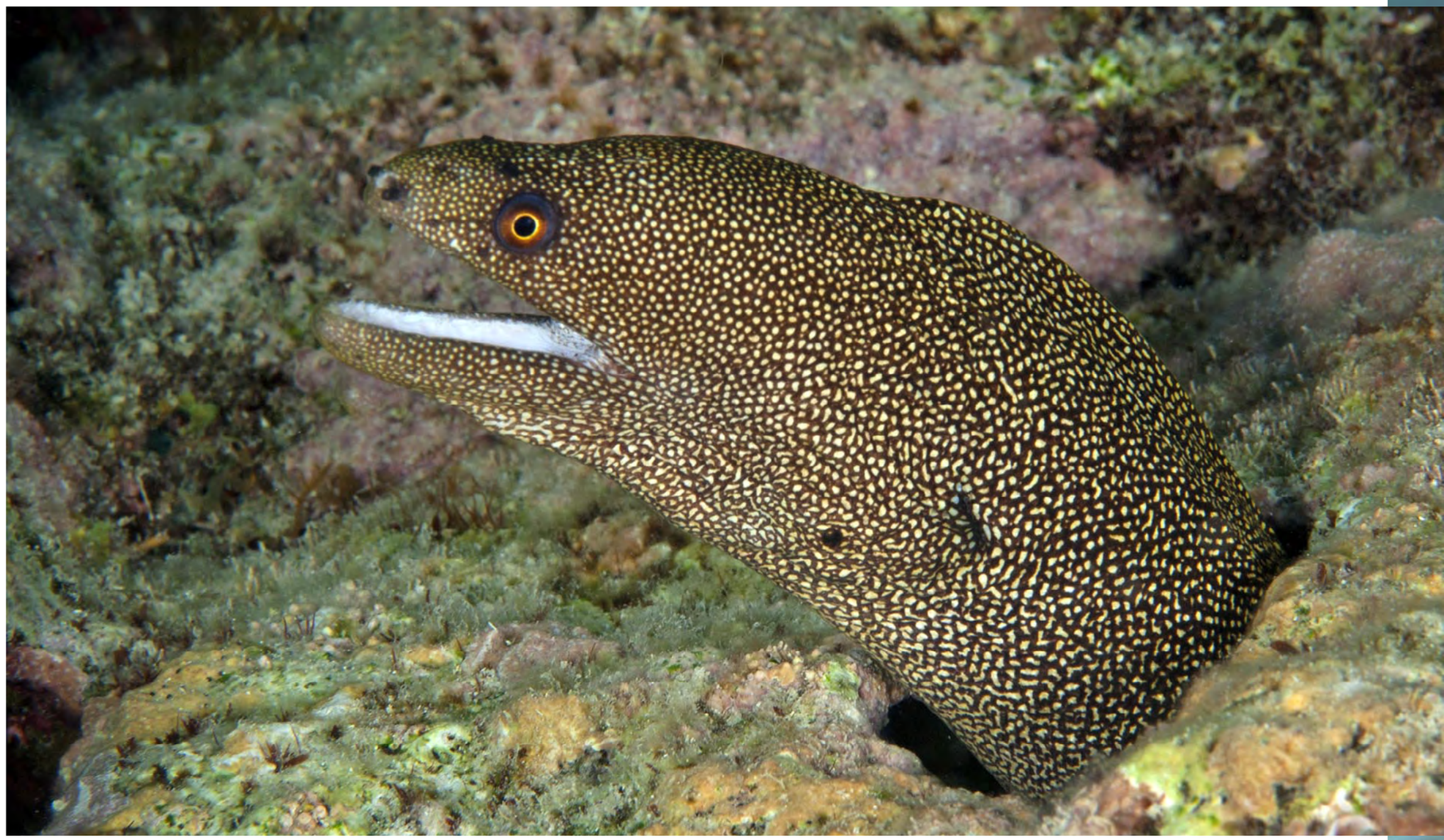
The reports and publications on biodiversity related subjects in the Dutch Caribbean can be found in the Dutch Caribbean Biodiversity Database (DCBD) *(http://www.dcbd.nl)*. The DCBD is a central online storage facility for all biodiversity and conservation related information in the Dutch Caribbean.



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