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Dutch Caribbean Nature Alliance
Safeguarding nature in the Dutch Caribbean



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- 2 Editor's Letter
- 3 Status of Nature: Bonaire
- 11 Satellites and Sharks: Latest in Saba Bank Shark Research
- 13 Rodent Control Implemented to Help Save Tropicbirds on Statia
- 15 Dutch Caribbean Biodiversity Database: The Future of Data Sharing
- 17 Research Overview
- 19 Long-Term Projects Overview
- 25 Monitoring Overview
- 28 Monitoring & Research Wishlist
- 33 List of Acronyms
- 34 Reports and Publications
- 35 Members and Contact
- 36 References

Editor's Letter

Dutch Caribbean, September 2019

Wageningen Research recently published an alarming report on the natural resources of the three Caribbean Netherlands islands (Bonaire, Saba and St. Eustatius). In this BioNews edition we summarized the results on the threatened natural resources on Bonaire. DCNA agrees with the conclusions of the research of Wageningen and recommends that all involved governments should sit down with (local) experts to work together to find integrated solutions to help reverse these trends. DCNA's members, nature conservation organizations such as STINAPA (Bonaire), STENAPA (St. Eustatius) and Saba Conservation Foundation (Saba), can use additional resources to take immediate action and, if necessary, carry out additional independent research. The same applies to the other members of DCNA, such as Parke Nacional Arikok (Aruba), CARMABI (Curaçao) and Nature Foundation (St. Maarten). For all islands, investing in nature and the environment is not a luxury, but a crucial investment in the future.

The Saba Bank is an important habitat within the Yarari Shark Sanctuary. Visited by a variety of different species, little is known about the life cycles of the sharks within these waters. A recent research expedition worked to gain new insight by using newly designed satellite tags and an underwater camera system to study local sharks. This research continues to build off of recent momentum to protect these critical species, an important priority for local conservation efforts.

Black rats probably arrived on St. Eustatius along with the first Europeans. While a nuisance for the human population, their negative impacts are

felt far more by the island's fragile ecosystems, and are a significant threat to its biodiversity. In response, a rodent control project, funded by the Ministry of Agriculture, Nature and Food Quality (LNV), was launched in 2017. This project was implemented by the Caribbean Netherlands Science Institute (CNSI). This article discusses the results of the ecological part of the project which focused on the red-billed tropicbird (*Phaethon aethereus*) nesting site on Pilot Hill, on the north-western coast of the island. Here, the decision was made to implement a rodent control project based on previous tropicbird monitoring programs that have been conducted since 2012.

A big obstacle in nature- policy, management and research is to access existing long-term data in an environment that experiences a high turnover in project funds and personnel. Besides, although there is now decades of observations and recordings, researchers and decision/policy makers have difficulty sifting through the information available to find what they need. The Dutch Caribbean Biodiversity Database (DCBD) was developed to resolve these issues, providing a web-based platform to store and share research and trends. Being able to properly store and access information is important in times of high personnel and funding changes, ensuring information isn't lost during these transitions. New additions to the database, along with updates on current research and monitoring programs are published in this newsletter.

Enjoy!
The DCNA Team

State of Nature: Bonaire

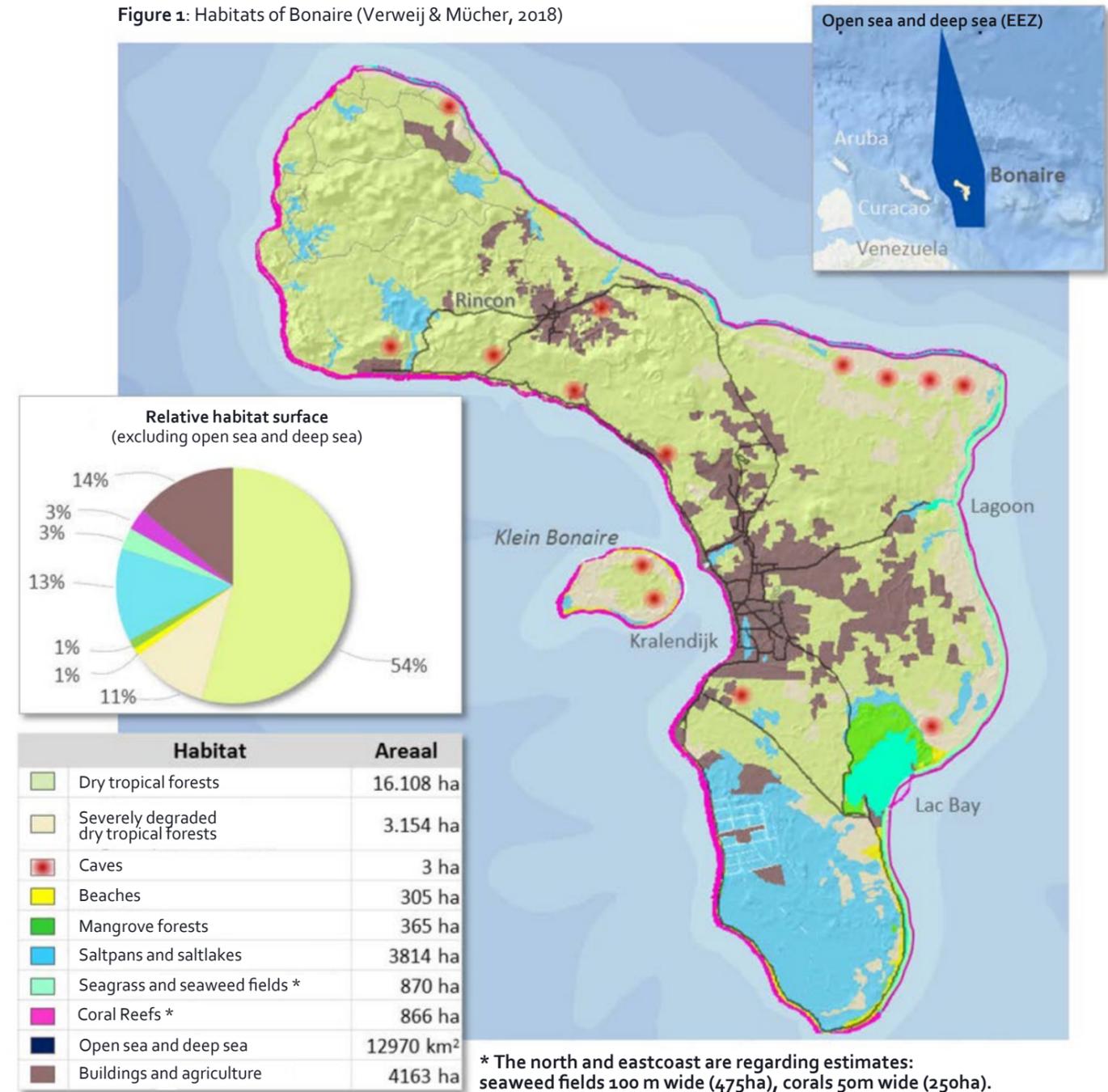
Wageningen Research recently published an alarming report on the natural resources of the three Dutch Caribbean islands Bonaire, Saba and St. Eustatius, commissioned by the Ministry of Agriculture, Nature and Food Quality (LNV). All 33 experts that worked on this report concluded that the "Conservation status¹ of the biodiversity in the Caribbean Netherlands is assessed as moderately unfavorable to very unfavorable".

The island of Bonaire has an incredible range of tropical habitats from dense mangrove forests to rich coral reefs. While many of these habitats have been considered pristine in the past with high species diversity, the

Wageningen Research report paints a bleak picture for the current state of Bonaire's ecosystems, stressing that things will only get worse if the island does not significantly increase its investment in conservation. If the current rate of habitat degradation is maintained, important ecological functions such as erosion control and storm protection will be lost and the economic repercussions will be disastrous. Recent TEEB (The Economics of Ecosystems and Biodiversity) research found that nature/ecosystem services of Bonaire have an annual economic value of 105 million USD, which represented 31% of the island's gross domestic product (GDP) in 2013 (Cado van der Lely et al., 2013; CBS, 2014).

1. The Conservation Status is used in the European Union for reporting on the status of species and habitats protected under the European Habitat Directive (see http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm).

Figure 1: Habitats of Bonaire (Verweij & Mûcher, 2018)



Dry Tropical Forest

Bonaire is dominated by dry tropical forests which do well in climates of high wind, high temperatures and low annual rainfall. In fact, Bonaire has the largest area of dry tropical forests in the entire Dutch Caribbean. These forests host a wide variety of life and are mostly dominated by cacti which play a critical role by providing fruit during dry periods to many species of bats and birds (Petit & Pors, 1996). Dry tropical forests are also important for retaining sediment, preventing coastal erosion, increasing the retention of freshwater and capturing CO₂ in soil and plants. Unfortunately, according to the WWF Neotropical Ecoregion classification, the rating for these forests on Bonaire has been set as “critical/endangered” (WWF, 2017).

Although there is not enough baseline data to draw long term conclusions, a considerable part of the dry tropical forests on Bonaire is considered severely degraded (Freitas et al, 2005, 2008). By comparing the current land area to historical values, it can be seen that these areas have become much smaller, mostly due to agriculture, overgrazing by free roaming feral livestock and human expansion (Freitas et al, 2005, 2008). Many invasive species also stress local forests as they’ve been seen to out compete local trees and scrubs (Debrot et al., 2011).

Fortunately, a number of reforestation projects have been started on Bonaire. This includes a project by NGO Echo, an organization that, since 2016, has worked to fence off threatened areas and has planted over 13,000 trees in nine areas (mainly in the northern part of Bonaire) as part of the nature funding projects commissioned by the Bonaire government and funded by the Ministry of LNV (pers. co. Julianka Clarendia, NGO Echo).

This is in addition to other similar projects on Klein Bonaire and San José.

Overall, the conservation status for the state of the dry tropical forests has been evaluated as “very unfavorable”. It is recommended that actions are taken to protect the local dry tropical forests, in both area and species diversity. This can be done through reforestation efforts, managing invasive species and prevent overgrazing by free roaming feral livestock.

Caves

Bonaire has hundreds of wet and dry caves which host a variety of unique life forms. Five different species of bats have been spotted on Bonaire, at least two of which are known to play a critical role in the terrestrial ecosystem as they are the only animal species that can pollinate the nocturnal columnar cacti (Nassar et al., 2003). Aside from bats, these caves are also important habitats for shrimp and many different freshwater crustaceans.

In 2016, the Caribbean Speleological Society (CARIBSS; www.caribss.org) was established to explore, map, protect and manage the caves of Bonaire. Since 2017, they have worked to establish a “Bonaire Cave and Karst Reserve” to manage the caves, certify guides and close off areas to protect local bat populations. This project, funded by the Ministry of LNV, is a collaborative effort between WILDCONSCIENCE, Public Entity Bonaire and CARIBSS (<http://www.bonairecaves.com>).

These delicate ecosystems can be easily unbalanced by excess visitation by people or contamination of soil and water by untreated sewage. It is recommended that these caves be mapped and studied to allow for a more complete management

of these systems. Efforts, such as the strategic bat protective program 2014-2018, are also important for the conservation of caves and local bat populations (Simal, 2013). Overall, the assessment for the state of caves has been evaluated as “moderately unfavorable”.

Beaches

Most of the beaches of Bonaire and Klein Bonaire are comprised of washed up coral rubble and a few “white” sand beaches. These beaches are an important breeding and foraging habitat for many species of coastal birds and sea turtles. Due to increased pressures from climate change (e.g. sea level rise and higher temperatures), tourism, urban development, invasive species, pollution and illegal mining of sand, these critical habitats are now being threatened more than ever (Henkens and Debrot, 2018). Sargassum has recently also become a significant stressor for the beaches of Bonaire, as improper removal of Sargassum can lead to excessive sand loss (CBC News, 2015; Mercopress, 2015).

Due to the steep bathymetry around Bonaire there is not a lot of sand available within the shallow waters. Coupled with high wave energy along the coasts, beaches tend to only form in protected areas with wide, shallow beachfronts. Although the beaches of Bonaire are not a huge driver for tourism, these beaches do provide important environmental services to locals as well as coastal protection.

It is recommended that current distribution and surface area of sandy beaches be maintained or improved. This should be done by protecting beaches from exploitation of illegal sand mining, pollution, excessive sand loss from Sargassum

management and over urbanization. Overall, the conservation status for the state of beaches has been evaluated as “very unfavorable”.

Mangrove forests

Bonaire has a mangrove forest of 365 hectares, which is less than 2% of the total mangroves of the Lesser Antilles. This area provides important ecosystem services in the form of coastal protection, important nursery and foraging areas for many species of fish, crustaceans and birds, along with supporting other important habitats such as seagrass and coral reefs. Traditionally, these forests are well adapted to rising sea-levels (McKee et al. 2007). However, additional pressures due to climate change, urbanization, tourism and over exploitation are now putting this habitat at risk (Simpson et al., 2011; Polidoro et al., 2010).

Overall eutrophication of Lac Bay has led to an increase in lime sediment production, which is causing the mangroves to infill (Slijkerman et al., 2011). Overgrazing along the borders of the mangroves also causes land sediment to enter the mangroves, leading to an overall decrease in mangrove health which further harms seagrass and local fish health (Hylkema et al., 2014) and affects wading birds which rest and feed in these areas (Debrot et al., 2013; Debrot et al. 2014).

It is recommended to continue current efforts to improve water depth and circulation within the mangroves through the removal of accumulated sediments and opening of connection channels. Furthermore, reductions in overgrazing and human disruptions to the mangroves should be put in place.

State of Nature: Bonaire

Finally, overall water quality of the Lac Bay area can be improved by reducing contamination of ground water and run off through proper waste water treatment and protection of the upstream catchment area through spatial planning. Overall, the assessment for the state of mangroves has been evaluated as “moderately unfavorable”.

Salt pans and salt lakes (saliñas)

Bonaire also has salt pans and salt lakes, or saliñas, including five internationally recognized wetland areas that are under the protection of the Ramsar convention. Saliñas are semi-enclosed, saltwater bodies which form near the coast and experience salinity shifts from nearly fresh water to hypersaline conditions throughout the year (Jongman et al., 2009). Saliñas are important areas for many different species of seagrass, fish, crustaceans and coastal birds, specifically flamingos, terns and sandpipers (Kristensen, 1970; Kristensen and Hulscher-Emeis, 1972; Debrot et al., 2009; Wells and Wells, 2006). In fact, Bonaire is one of the most important breeding grounds for three species of regionally endangered terns, the common thief, the American dwarf and the American great tern (Debrot et al., 2009; Halewijn and Norton, 1984; Voous, 1983).

As saliñas are often used as important breeding grounds for birds, they are highly susceptible to human disturbances. In addition, soil and groundwater contamination and overgrazing by free roaming feral livestock further threaten the health and utility of these habitats (Neijenhuis et al.,

2015; Lagerveld et al., 2015; Debrot, 2016). With the exception of Goto lake, which has been well documented to be seriously affected by industrial pollution (Slijkerman et al., 2013, de Vries et al., 2017), little is known about the contamination of saliñas elsewhere on the island.

It is recommended that overgrazing by free roaming feral livestock and disruptions from humans and invasive species (specifically cats) be limited around the areas of saliñas. Furthermore, improvements to waste water treatment should be implemented to avoid groundwater contamination, along with more careful consideration of underlying drainage areas for future land development. Overall, the conservation status for the state of salt pans and salt lakes has been evaluated as “moderately unfavorable”.

Seagrass and algae fields

Seagrass fields are a very important habitat as they provide food, shelter and nurseries for many fish species, the queen conch and sea turtles. Seagrass fields also help prevent sediment erosion in near shore environments of beaches, can help improve water quality and capture CO₂. These fields are typically found in lagoons or shallow coastal zones, the most notable seagrass fields on Bonaire can be found in Lagun and Lac Bay. In fact, the seagrass fields of Bonaire constitute 75% of the seagrass within the entire Caribbean Netherlands. Seagrass fields often host a variety of algae as well. Algae fields, mainly the seaweed *Sargassum polyceratum*, can be found along the

entire east coast of Bonaire, especially in areas where strong water currents make it difficult for coral to flourish (Bak, 1975). Most seaweed fields have been known to provide food, shelter and nursery grounds for many species of reef fish (Chaves et al, 2013). However, these particular fields around Bonaire have not been fully studied or mapped, so little is known on the role they play.

It is recommended that seagrass fields be protected by limiting the damage done by tourists and by improving water quality by controlling land sediment run off, eutrophication, and pollution. Unfortunately, native seagrasses are being replaced with invasive species, as seen through an observational study which compared the years between 1999 - 2007 and 2001 - 2013 (Engel, 2013). Although sufficient data, which could be used to show long term trends is missing, based on recent mapping of Lac Bay, it is believed that suitable habitat for seagrass is decreasing due to an increase in available sediment causing the bay to infill (Erdman and Scheffers, 2006; Hylkema et al., 2014). Additional stressors such as trampling by tourists and windsurfers, coupled with negative effects of climate change such as increased water temperatures, Sargassum blooms and stronger storms will continue to threaten local seagrass fields (Debrot et al., 2010; CRFM, 2014; CAST, 2015). Overall, the conservation status for the state of seagrass fields has been evaluated as “very unfavorable” while the conservation status for the state of the algae fields has been evaluated as “moderately unfavorable”.



Caribbean Flamingo at saliña Slagbaai, Washington Slagbaai National Park, photo by: © Henkjan Kievit

Coral reefs

The coral reefs of Bonaire are biologically very diverse and play a critical role both environmentally and economically. While the coral reefs around Bonaire have suffered in recent decades from regional phenomena such as repeated bleaching events, urchin die-off, coral diseases and local impacts such as coastal development, pollution and overfishing, they are still considered some of the healthiest reefs in the Caribbean (Jackson et al., 2014). Healthy coral requires ample light, therefore decreases in water quality and over sedimentation caused by urbanization and overgrazing can threaten coral reefs. Overfishing of herbivorous fish can also offset the natural balance and lead to algal blooms, which outcompete local corals (Mumby, 2009). Further stressors due to climate change, such as increased water temperature, ocean acidification and increased strength in storms further threaten local reefs.

Coral cover on Bonaire's reefs has historically been high, with a coral cover of nearly 50% between 1999 and 2010 (Kramer, 2003). The study by de Bakker et al. (2016) at Karpata found that the abundance of corals declined between 14 and 65% over the past 40 years at 10, 20, 30, and 40 meters depth, with the biggest decline at a depth of 20 meters. A 2015 study, which estimated coral coverage along the west coast of Bonaire (data WMR), found that of 115 sites surveyed, there was an average live coral cover of only 11.2%, showing an alarming downward trend for local corals. For all Bonaire sites visited, 46% of the locations were scored as "poor" and 48% scored as "fair". Klein Bonaire, on the other hand, only had 2 of the 21 sites surveyed scored as "poor" showing healthier reefs on less frequented reefs. Overall, the 58% increase of sandy patches around the west coast of the island between the 1980s and 2013 indicates

a significant decline in coral cover (Mücher et al., 2017).

The Wageningen Research report recommended that long term efforts be taken to increase live coral coverage to at least an average of 30%. Maintaining healthy reefs is an important task which has long reaching consequences. A decrease in coral reefs will certainly have a negative effect on tourism, fisheries and coastal protection. Overall, the conservation status for the state of coral has been evaluated as "very unfavorable".

Open Sea and Deep Sea

For this report, any water depth deeper than 100 m is treated as "deep sea" and/or "open sea". One of the highest areas of productivity within the Caribbean can be found within the waters between Venezuela and Bonaire, where wind-driven upwelling brings cold nutrient-rich waters to the surface mostly between January and May (Rueda-Roa and Muller-Karger, 2013). Furthermore, the waters around Bonaire are part of a wider area considered to be the second richest 'hotspot' for biodiversity within the Caribbean (Smith et al., 2002).

Fishing has always played an important role for the people on Bonaire. A recent increase in marine pollution, physical changes due to climate change along with many human factors such as overfishing and noise pollution from shipping and exploration are threatening many commercially important fish stocks and large migrating predators. In general, too little is known about the deep sea environmental conditions to allow scientific predictions for the future.

Therefore, it is recommended that research be conducted to better understand the functions of

the deep sea to allow responsible management of this environment. Furthermore, the current state of fish populations should be better understood to ensure sustainable fishing practices are in place. Overall, the conservation status for the state of the open sea and deep sea has been evaluated as "moderately unfavorable".

Endangered Plant Species

In total, there are 43 plant species which have been designated as protected on Bonaire, which includes trees, cacti, bromeliads, orchids and ferns. Although many of the plants on this list are becoming very rare on Bonaire, some were included due to their critical role within the ecosystem, either providing fruit during the dry season or a strong interdependence with other locally endangered bats (Petit, 1997).

Based on data currently available, no long- or short-term trends could be determined. However, it is noted that the main concern is protecting species of limited numbers or those with little to no rejuvenation. The largest threat to these species is unsuitable habitat caused by overgrazing by free roaming feral livestock which leads to sediment erosion and decreased water retention and available nutrients (Vergeer, 2017).

It is recommended that free roaming feral livestock be reduced and controlled to improve quality of habitat for local plant species. In addition, more information concerning these rare or endangered plant species should be gathered to aid in their restoration efforts. Overall, the conservation status for the state of plant species has been evaluated as "very unfavorable".

Endangered Bird Species

The yellow-shouldered Amazon parrot, known

locally as the lora, has received an IUCN rating of 'vulnerable' meaning there is a 10% chance of extinction in the next 100 years. The lora population of Bonaire is the only native population outside of Venezuela and estimates put it at representing 16-64% of the total population worldwide (Echo, 2015; Birdlife International, 2017). The annual lora count that started in 1980, suggests that the number of parrots at the surveyed roosts on Bonaire is increasing steadily. While numbers of parrots counted has fluctuated each year, the overall trend seems to be improving. Even though it has not been statistically proven, these population increases might be related to the start of conservation efforts on the island, including population monitoring (Echo, STINAPA, DRO, Salba Nos Lora), nest site management (Echo), awareness campaign (STINAPA, Echo, Salba Nos Lora), rescue and release of injured birds (Echo), enforcement of protected status (Toezicht and Handhaving Police) and tree planting (Echo, STINAPA and Salba Nos Lora). Recently, a study by Rivera-Milán et al. (2018) in collaboration with STINAPA, US Fish and Wildlife Service and WILDCONSCIENCE found other results. Their systematic distance-sampling surveys in 2009-2017 show a slight decline in the population estimate for lora's in Bonaire over the past years most probably because of the drought, although other factors cannot be discarded including an increase in human-induced mortality.



Yellow-shouldered Amazon Parrot, photo by: © MMBockstael-Rubio

State of Nature: Bonaire



Green Sea Turtle, photo by: © DCNA/Nat Miller

State of Nature: Bonaire

Williams (2012) believes that as much as 80% of the population is unable to breed due to high age and lack of suitable breeding grounds. Overgrazing by free roaming feral livestock, urbanization and stresses brought on by climate change are the largest threats to lora's populations. Poaching and destroying the nests and habitat when doing so remains the largest threat to lora's populations. Overall, the conservation status for the state of loras has been evaluated as "very unfavorable".

The Caribbean flamingo is a both locally (on Bonaire) and internationally protected. This species is assessed by IUCN as 'least concern'. The breeding colony on Bonaire is considered one of the largest and most protected colonies within the south Caribbean (Voous, 1983). The largest threats to flamingos are a decrease in foraging areas and disruption, as they are easily frightened away from breeding nests, leaving eggs and their young vulnerable. Most of the flamingos breed in the flamingo sanctuary in Pekelmeer, a national reserve and Ramsar site, which is completely off-limits and managed by the Cargill company. Some breeding sites show an upward trend in breeding pair numbers and other seem stable or show a decreasing trend since the 1980s with differences between studies (Slijkerman et al., 2013; Prins et al., 2009; Kigon, 2006; <https://www.dcbd.nl/monitoring/flamingos>). Overall there are large fluctuations in counted breeding pairs between the years, and it is unclear what the underlying causes are.

Over the last two years, there seems to be more reports of far-wandering, mostly flightless and sometimes malnourished, juvenile flamingos (an annual occurrence with high winds). Cargill Salt Company, together with the Island government Bonaire and STINAPA Bonaire are setting up research projects to investigate food availability, health status, water quality and behavior. Bonaire Wild Bird Rehab is taking care of wandering

flamingo juveniles by nourishing them and returning them into the wild. Recent monitoring data shows that juvenile flamingo numbers increased during the last two years in relation to the prior 15 years (Public Entity Bonaire). However, the overall, conservation status for the state of Caribbean flamingos on Bonaire has been evaluated by WUR as "very unfavorable".

Bonaire hosts 5 different tern species which are regionally assessed between 'vulnerable' and 'endangered'. Bonaire has traditionally been an important nesting area for the common tern, cayenne tern and the least tern. Bonaire is also home to the royal and the roseate terns, both regionally considered endangered (Schreiber, 2000; USFWS, 2010). These birds are highly susceptible to disturbances, especially since they lay their eggs on bare stretches of ground which leaves them susceptible to human disturbances and predators. Overall, the conservation status for the state of roseate tern is still unknown, the common tern is rated as "very unfavorable" while the least, cayenne and royal terns have been rated "moderately unfavorable".

Marine Mammals

There are 11 marine mammal species known to inhabit the waters around Bonaire (Debrot et al., 2011). Most of the information on these species comes from opportunistic observations, meaning data could be insufficient or missing all together. Bonaire's proximity to the most important upwelling area and many migration routes makes it very appealing to a variety of marine mammal species (Debrot et al, 1998). Marine mammals are highly susceptible to disturbances related to recreation and ecotourism. Noise pollution from large ships and cruise boats can also result in physical collisions or hearing damage (Mann et al., 2010; Luksenburg, 2014). Due to the migratory nature of most marine mammals, it is very difficult to estimate current population sizes.

It is recommended that basic management of the Yarari marine mammal and shark reserve is implemented to ensure proper conservation efforts are in place. Furthermore, passive acoustic monitoring of marine mammals should be continued and expanded to gain more information on local mammal populations. Overall, the conservation status for the state of marine mammals has been evaluated as "moderately unfavorable".

Sea Turtles

The Dutch Caribbean is home to five different species of sea turtles. Four out of these five species have been known to nest on Bonaire, one species (the Olive Ridley) only migrates through the waters of the Dutch Caribbean. Furthermore, Klein Bonaire historically had the second highest concentration of nesting hawksbill and loggerhead turtles in the south Caribbean (Becking et al., 2016). Although the annual number of nests varies, total numbers appear to be fairly stable (STCB, 2014). The largest threats to local turtle populations come from degrading seagrass foraging fields, poor beach quality and disorientation from light pollution (Salmon, 2003). Anthropogenic stresses such as pollution, coastal development and accidental bycatch by fisheries also threaten local turtle populations. Further stresses caused by climate change, such as an increase in Sargassum, are damaging seagrass fields necessary for foraging, affecting the turtles' ability to nest on beaches and causing hatchlings to become stranded in areas such as Lac Bay and Lagun.

It is recommended that foraging seagrass fields and nesting beaches be further maintained or improved to allow an expansion of the nesting sea turtle populations. Overall, the conservation status for the state of sea turtles has been evaluated as "very unfavorable".

Queen Conch

The queen conch has a wide habitat, although due to pressures caused by overfishing and poaching, their numbers have been declining throughout the Caribbean (Bell et al., 2005). Conservation efforts on Bonaire have led to a slight recovery in local populations. However, there is still insufficient data to support long- or short-term trends (Engel, 2008). Although hunting of queen conch is prohibited on Bonaire, poaching is still a significant issue. Furthermore, since these species are often found in shallow, sandy areas, they are highly susceptible to local land threats such as pollution, degraded water quality, sedimentation and invasive species. It is recommended that local queen conch populations be further protected to ensure that the population growth is able to reach a sustainable population size of between 100-570 adult specimens per hectare. Overall, the conservation status for the state of queen conch has been evaluated as “moderately unfavorable”.

Fishery

Fishing has been an important tradition on Bonaire, and until 50 years ago, fish served as the primary source of protein for most of the island’s population. Findings of recent studies show that Bonaire has a high density of small fish, however, larger predator fish have become very rare, especially along the west coast (Sandin et al. 2008; de Graaf et al. 2016). The current state of fishing hasn’t changed much over the last century, apart from motors replacing sails and nylon replacing cotton-braided nets, and a main focus on reef-associated pelagic fish.

Decreases in habitat due to loss in coral coverage, seagrass fields and mangroves further threatens fish stocks. In addition, overfishing and inefficient management has led to a recent decline in fish stocks, particularly in large predatory fish. It is recommended that actions be put into place to manage local fishing practices to ensure a sustainable future for fish stocks. The current status of unsustainable fisheries on Bonaire has a “very unfavorable” impact on the island’s marine biodiversity.

Local and Regional Stressors

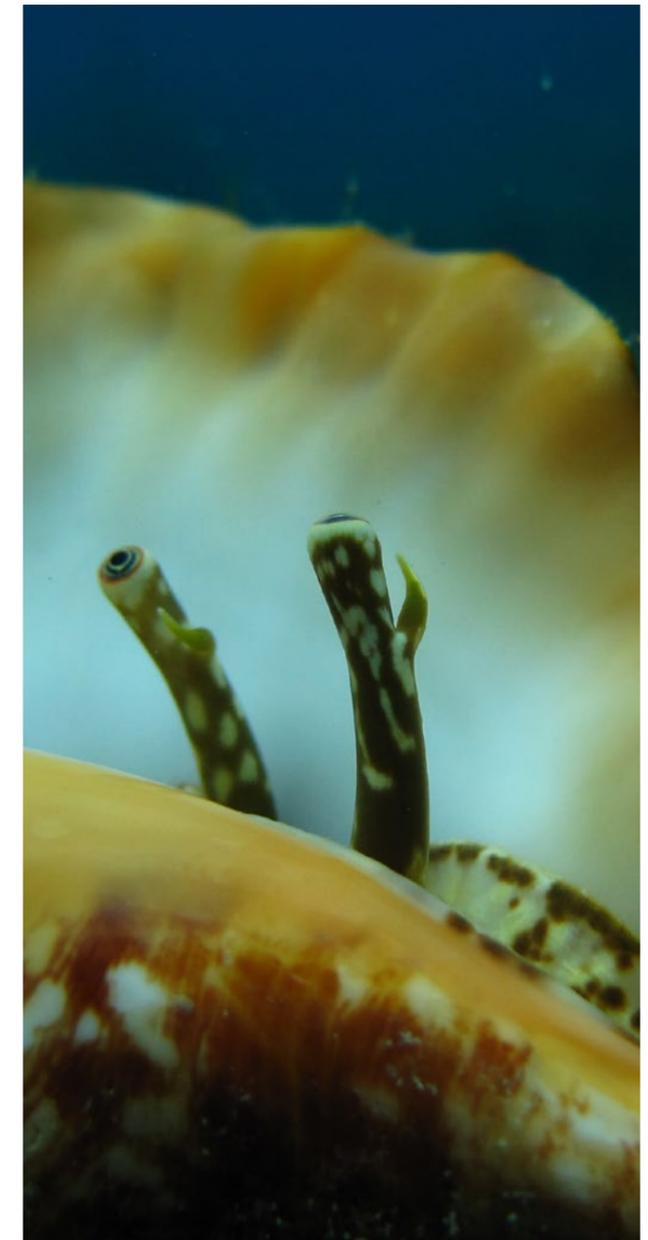
Overgrazing by introduced free roaming feral livestock (goats, sheep, donkeys and pigs) has been identified as the most significant threat to the terrestrial ecosystems (MinEZ, 2013; Smith et al., 2014). This overgrazing prohibits the retention of soil and small ground plants which has changed the overall structure, water management and even insect populations on the island (Debrot et al., 1999). In particular, it is common for stray donkeys and goats to strip the bark off column cacti which leads to the death of these cacti. The column cacti play a critical role on the island, as they provide fruit during the dry season, a food source many native animal species depend on (Petit, 1997).

It has been estimated that within the Slagbaai area the local goat population is capable of doubling every 1-1.5 years (Geurts, 2015). Based on studies on Curaçao, it is recommended that local goat and sheep populations be reduced to 1 per 10 hectares (from a current estimate of the entire island 1.4/ha and Washington-Slagbaai National Park of 2.7/

ha), a value determined to allow native plants to recover (Debrot, 2015). Further reductions in overall free roaming feral livestock populations on the island must be considered for the protection of the local ecosystem and to ensure a sustainable future for native plants. The current numbers of grazing livestock on Bonaire have a “very unfavorable” impact on the island’s biodiversity.

Invasive species are also a significant threat to the local ecosystem, whether they are introduced to the island knowingly or are brought accidentally as hitchhikers on luggage or in ballast tanks of ships. The largest invasive threat to the island is free roaming feral livestock. In addition to the animals previously listed, cats are also becoming an issue, as they threaten local birds. Plants such as the rubber vine, *Scaevola taccada* (known as beach cabbage) and Neem trees are quickly expanding, out competing many local plants. Underwater, Lionfish are rapidly increasing in number, capable of consuming a vast number of smaller fish each day, threatening local fish populations. Additionally, the invasive seagrass *Halophila stipulacea* is also increasing rapidly, and has become the dominant species within two years of its introduction (Becking et al., 2014).

Early action is recommended to identify, control and eradicate invasive species. This is only possible through public awareness, so efforts should continue to be made to help local populations quickly identify and understand the dangers of these invasive species. The current status of invasive species on Bonaire has a “very unfavorable” impact on the island’s biodiversity.



Queen Conch, photo by: © Mark Vermeij

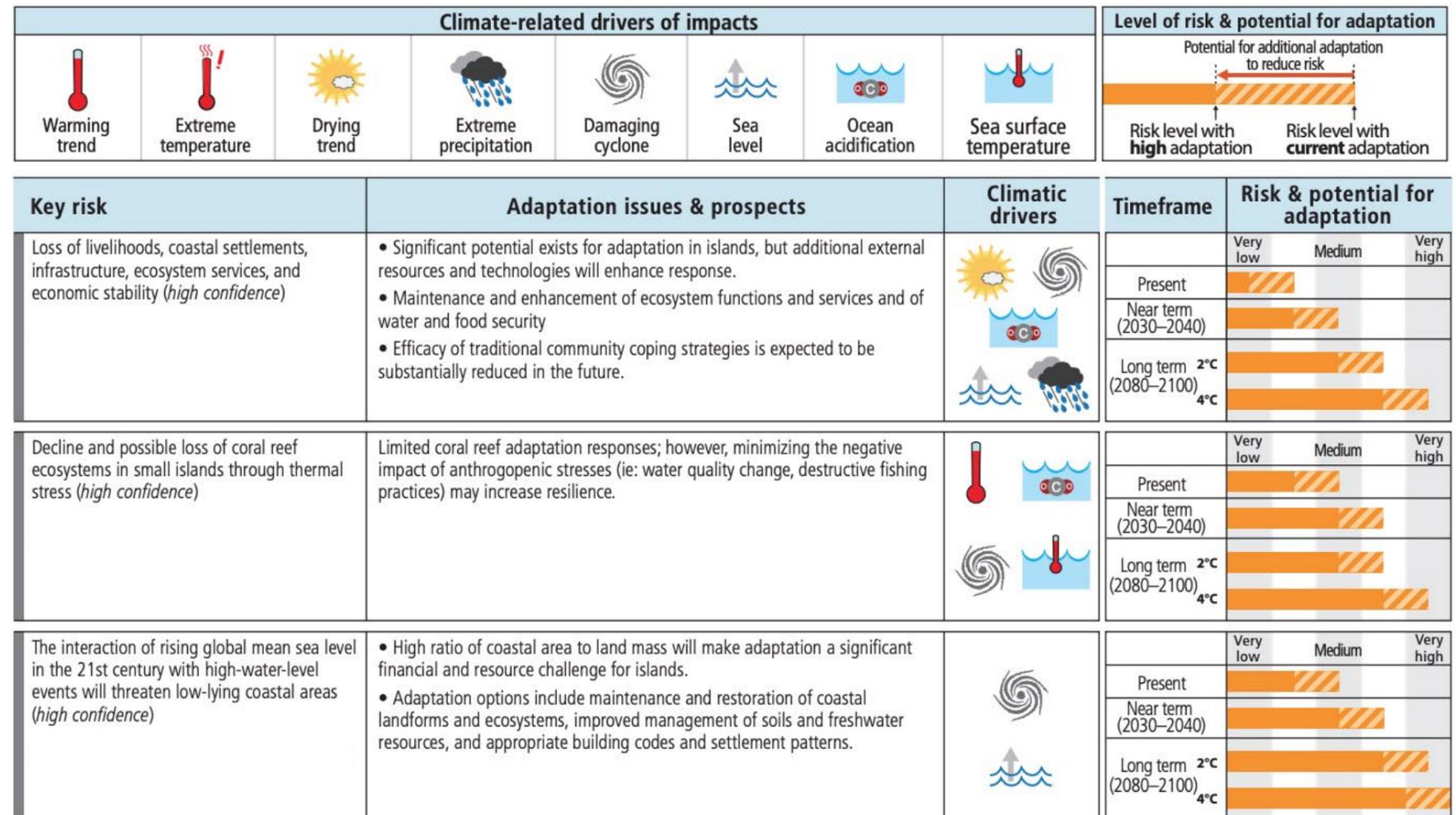
Climate Change

The Caribbean will continue to be affected by global stressors due to climate change. This includes, but is not limited to, more extreme weather patterns, worsening of overall water quality, and sea level rise. These changes will place even more pressure on the islands, and careful management will be required to minimize these effects. Although overall greenhouse emissions from these small islands are minimal when compared to the global scale, these islands will be the first and some of the most drastically impacted by global climate changes (IPCC, 2013).

The degradation of wave-breaking coral reefs coupled with worsening storms will likely contribute to more storm related damages (Frieler et al., 2013). Deterioration of coral reefs, shifts in migration patterns and the worsening of water quality conditions can also negatively affect fisheries, and could lead to a total collapse of specific commercial fish species (Bari and Cochrane, 2011). A warmer and more humid climate could also lead to a population boom for mosquitos, increasing the risk of mosquito-related diseases (EPA, 2014; de Hamer, 2015). Worsening of specialized habitats could also endanger local species which depend on these specific conditions to live (Myers et al., 2000; Roberts et al., 2005).

As the Nature Policy Plan of the Dutch Caribbean (Ministry of Economic Affairs, 2013) states, "It is not possible to influence climate change from the islands, however it is possible to improve the resilience of ecosystems so that they can adapt to changes better and the consequences are kept to a minimum". Therefore, it will continue to be of the utmost importance for each island to do its part in monitoring and implementing policies to minimize the damages caused by climate change. Efforts such as monitoring waste water treatment and reforestation can help minimize anthropogenic effects on each island. The current stressors experienced by Bonaire due to climate change have a "very unfavorable" impact on the island's marine and terrestrial biodiversity.

Figure 2: Climate-related drivers of impacts on small islands (Nurse et al., 2014)



State of Nature: Bonaire

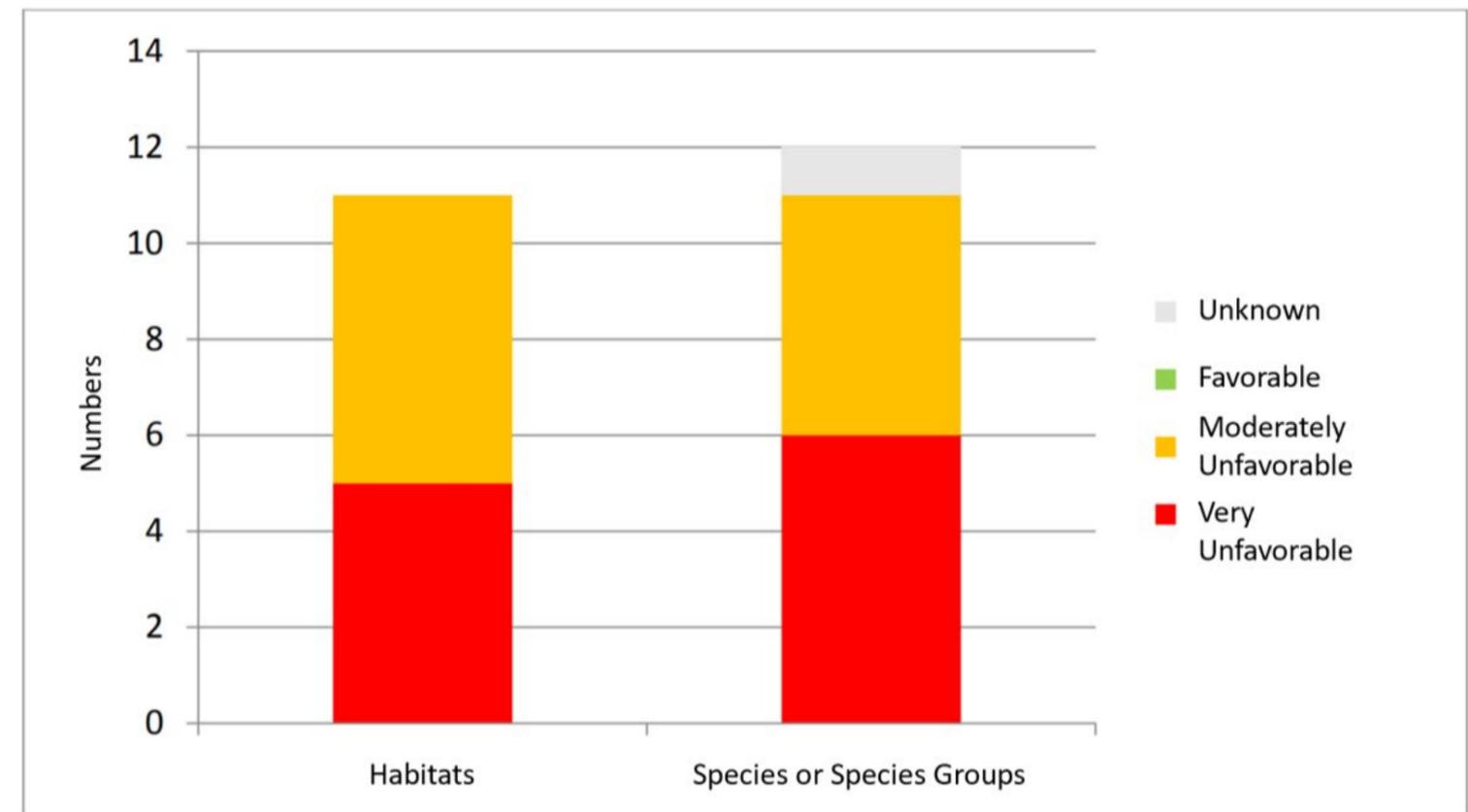
Conclusions and Recommendations

The assessment of the overall biodiversity within the Caribbean Netherlands has been assessed as moderately to very unfavorable. The main concern is for marine species such as marine mammals and sea turtles, since there is a substantial lack of data for at least 50% of these species (EEA, 2015). Figure 3 below illustrates the seriousness of these issues, as all categories have been evaluated as moderately to very unfavorable, given available data. The most significant threats to the future of these islands are largely related to overfishing, overgrazing, invasive species and climate change (with the first three being responsible for the quality rating of more than 80% of the habitats as moderate to very unfavorable).

Overall monitoring and management efforts need to be increased to meet the requirements to protect the rich biodiversity of the Caribbean Netherlands. There is a disturbing lack of information concerning many important species groups such as bats, sharks, orchids and pollinators. Understanding the current status of biodiversity for each of the islands will be crucial for planning the way forward.

Collaborative efforts between the government, NGOs, business and knowledge institutions (known as the Golden Triangle) will be increasingly important for a sustainable future. In 2013, the economic value of ecosystem services for Bonaire was estimated at 31% of GDP, yet less than one thousandth (0.1%) of Bonaire's governmental annual budget goes toward conservation efforts (van Beek et al., 2015). A fundamental shift in how governments view investing in their own environments will be required to accomplish the tasks necessary for a sustainable future.

Figure 3: Assessment of the current state of nature (2017) of 11 habitats and 12 species (group) and in the Dutch Caribbean



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Satellites and Sharks: Latest in Saba Bank Shark Research

The Saba Bank is an important habitat within the Yarari Shark Sanctuary. Visited by a variety of different species, little is known about the life cycles of the sharks within these waters. A recent research expedition worked to gain new insight by using newly designed satellite tags and an underwater camera system to study local sharks. This research continues to build off of recent momentum to protect these critical species, an important priority for local conservation efforts.

The Expedition

Between July 15 – 25, a research survey took place in Saba Bank to gain new information on the local shark populations. This was collaborative effort between The Dutch Elasmobranch Society (NEV), the Saba Conservation Foundation (SCF) and the Nature Foundation Sint Maarten (NFSM). A variety of sharks have been known to inhabit these waters, including tiger sharks, silky sharks, nurse sharks and Caribbean reef sharks, but the specific role Saba Bank plays within the life cycle of each of these sharks is still not fully understood.

The goal of the expedition was to gain more information in how these sharks are utilizing this region. This information will help in the development of new methods for protecting these important species. Irene Kingma, expedition leader from

the NEV, stated *"We brought scientists from six countries together to help solving the big questions we still have about sharks in this unique area, and to develop partnerships for future research."*

Connection Between Sharks and Their Habitats

During a previous study, which took place between 2015 and 2018, silky sharks, Caribbean reef sharks and nurse sharks were monitored using acoustic tags. These tags allowed the movements of these sharks to be tracked throughout the testing area. This gave scientists a new look to where the sharks were spending most of their time. An additional study used tissue samples from Caribbean reef sharks and Silky sharks to better understand the age and diets of each shark. This tissue analysis paired with the acoustic tag information gives a more encompassing view of how these sharks are utilizing their environment.

During the most recent expedition, new blood samples were taken to record the level of stress hormones within each shark. Understanding shark's stress levels will help researchers better understand the impact of these experiments on the overall health and well-being of the sharks. The goal is to maximize the efficiency of the catch and release program while minimizing the impact on each of the individuals.



Photo by: © Peter de Maagt

Tiger Sharks

Advances in satellite technology have led to an innovative way of tagging tiger sharks which allows the movement of these sharks to be tracked over much longer spatial and temporal scales. Designed by the European Space Agency (ESA) these cutting-edge tags are meant to be smaller, more robust, cheaper and less invasive to the shark (ESA, 2019). The new device has been engineered to last up to 5 times longer than tags previously used. In addition to being physically smaller and lighter, the new tags can also hold more information. "With this revolutionary new tag, we are able to better determine the migratory patterns of these critically important yet threatened apex predators and enact management solutions throughout their migratory range within the Caribbean basin" stated Tadzio Bervoets, director of the Nature Foundation Sint Maarten.

During the expedition 4 tiger sharks were tagged with the first round of data hopefully available as early as early September.

Nurse Sharks

Lobster traps can cause issues for local nurse shark populations as they can easily be caught as by-catch serving as a risk to the fishermen handling the traps, and trapped lobsters and the sharks themselves. The Caribbean spiny lobster is an important fishery species for Saba; however, these lobster traps catch hundreds of nurse sharks each year (Kettle, 2018). One of the goals of this study was to continue off the work of a study from July 2018 to increase awareness of this issue with local fishermen, along with better understanding nurse shark behavior in and around these traps. Using a camera system, Dr. Robert Nowicki from the Mote Marine Lab, was able to record nurse sharks' behavior to better understand how the traps can be modified or deployed differently to minimize the threat of by-catch.

Camera footage from last year proved very insightful. It was previously thought that the sharks were intentionally entering the traps to hunt the confined lobsters. However, after viewing the

footage, researchers now believe that sharks initially attempt to escape the traps, but when they are unsuccessful, they eventually eat their lobster cellmates. This has now driven the focus towards designing lobster traps where sharks can easily escape. This latest voyage will help provide insight to the success of this project.

Future of Shark Conservation

Research campaigns such as the July expedition, give us a deeper look into the lives of local shark species. This new information will help mold the future of shark conservation, which will be critical in maintaining a healthy ocean. Understanding how various species of sharks are entering and using the sanctuary space will allow researchers, conservationists and policy makers to work together to maximize the effectiveness of conservation efforts. Environmental stressors for these sharks will continue to increase, further emphasizing the importance of these conservation efforts.



Lobster cage being checked and cleared of trapped nurse sharks.

Photo by: © Linda Ferwerda

<https://duikeninbeeld.tv/saba-haaienexpeditie-2019-rolling-rolling>

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Satellites and Sharks: Latest in Saba Bank Shark Research

Rodent Control Implemented to Help Save Tropicbirds on Statia

By Eline Eggermont (University of Utrecht) and Hannah Madden (CNSI)

Black rats (*Rattus rattus*) probably arrived on St. Eustatius along with the first Europeans. While a nuisance for the human population, their negative impacts are felt far more by the island's fragile ecosystems, and are a significant threat to its biodiversity. In response, a rodent control project, funded by the Ministry of Agriculture, Nature and Food Quality, was launched in 2017. This project was implemented by the Caribbean Netherlands Science Institute (CNSI) and was previously presented in this magazine in 2017 (BioNews 6). This follow-up article will discuss the results of the ecological part of the project which focused on the red-billed tropicbird (*Phaethon aethereus*) nesting site on Pilot Hill, on the north-western coast of the island. Here, the decision was made to implement a rodent control project based on previous tropicbird monitoring programs that have been conducted since 2012.

Red-Billed Tropicbird

As the only species of seabird nesting on St. Eustatius, the red-billed tropicbird is an iconic species for the island. A pelagic seabird, it spends most of its life out on the open sea and as a result, little is known of their behaviour when they are away from land. Their breeding biology and behaviour is more easily - and thus more extensively - studied as they return to shore to nest within the

steep, rocky cliffs and slopes of Pilot Hill. Tropicbirds do not spend their time building nests. Instead, a pair will find a suitable cavity in which to lay their egg on the bare ground and shelter their offspring once it hatches. On average, the parents will spend six weeks protecting the egg, as they take turns incubating and hunting for flying fish and squid in the open sea. One parent usually remains in the nest constantly during incubation and during the first couple weeks of chick rearing. It takes roughly twelve weeks for a newly hatched chick to grow into a well-fed fledgling, although shortly before gaining their independence, fledgling chicks lose some of their weight as the parents stop feeding them.

Population Concerns

Like many other seabird species, the global red-billed tropicbird population is in decline. According to the latest IUCN assessment in 2018, there are between 3,300 and 13,000 mature individuals globally, with an estimated total population not exceeding 20,000 birds. Invasive rodents such as rats and mice are cited as one of the biggest threats to seabird populations on oceanic islands. Tropicbirds are especially vulnerable as their nest sites are easily accessible by rodents, they have a long incubation period, and chicks inside the nest are unable to escape from predators. On St. Eustatius, camera traps have documented egg

predation by rats inside nesting cavities. Over half of the nesting attempts fail each season, which is significant considering tropicbird females lay a single egg per clutch. The cause of most of these nest failures could not be determined, but rats are thought to be a factor.

Local Monitoring Programs

Monitoring of red-billed tropicbirds was started by Hannah Madden (STENAPA, CNSI) in 2012, and assisted by Kevin Verdel (Utrecht University), Max Oosterbroek (Van Hall Larenstein), and Eline Eggermont (Utrecht University) during the course of the rodent control project (2017-2019). Tropicbirds nest at several locations around the island, but the site on Pilot Hill is monitored because it is relatively accessible and thought to be the largest nesting area on St. Eustatius.

For the 2017-2018 season, a grid of bait stations was established across the entire study area. For the 2018-2019 nesting season, half of the study area was treated with brodifacoum rodenticide, whereas the other was left untreated. Brodifacoum is a second-generation anti-coagulant that kills rats and other rodents within 5 days of ingestion. Bell Laboratories, Inc., which has supported a number of invasive species management projects on other islands, generously donated FINAL™ blox and AMBUSH bait stations for the project.



Red-Billed Tropicbird, photo by: © Albert Beintema

Preliminary Results

The relative abundance of rodents at the nest site was assessed via tracking pads, which were set out at 25m intervals every month in a predetermined grid. Tracking pads (pictured below) are rectangular pieces of cardboard with an ink section, baited with peanut butter to attract rodents and capture their prints. Using these methods, the relative abundance of rodents was found to have decreased significantly from 86.7% before treatment, to <2.0% post-treatment. Apart from rat and mouse prints, we also tracked small lizards, crabs, and insects.

Using the nest survival model in the program MARK, the survival rates of nests from the best-fitting model was 33.6% in the 2017-2018 season and 35.7% in 2018-2019. Nest age was the most important explanatory variable for survival in the incubation and chick rearing stage, and overall, suggested that nests and chicks were more likely to survive as nest age increased. For every one day increase in nest age, the odds of an egg surviving increased by 5.9%. For every one day increase in nest age, the odds of a chick and nest surviving increased by 4.6% and 4.3% respectively. The figure below represents the increase in daily survival rate percentage as nest age increases. Our results are consistent with various studies that have demonstrated an increase in nest survival rates as nest age increases.

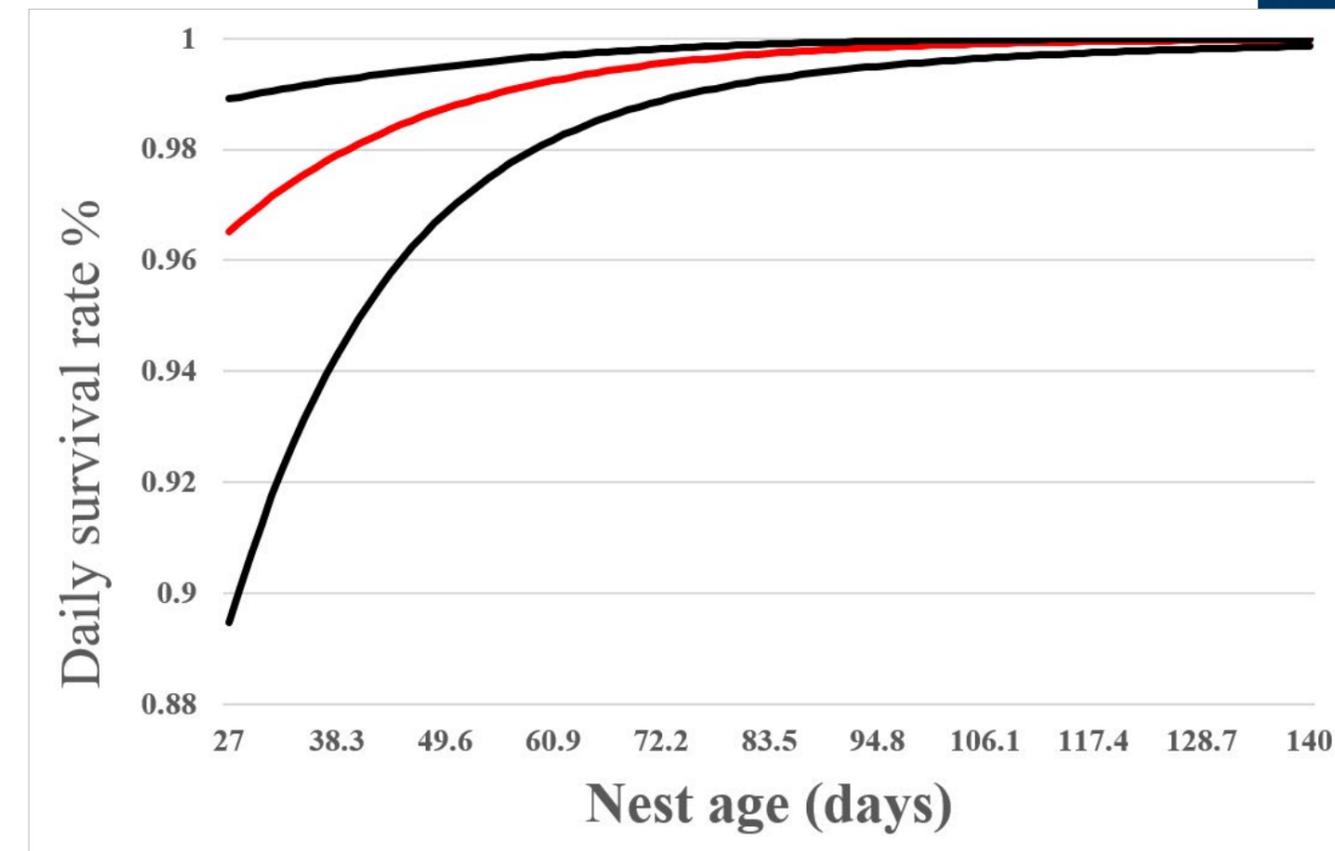
Rodent Control Alone is Not Enough to Save Tropicbirds

Much has been written about the detrimental impacts of rodents on seabird populations. Contrary to expectations, however, rodenticide treatment over the study period did not result in an increase in nest survival rate compared with

previous years. This could be because adult tropicbirds may be large and aggressive enough to fend off invasive rodents. Furthermore, a number of factors may have limited the success of the project. These include the limited number of accessible nests, the absence of a 'control' nest site for comparison, and crab interference with bait stations. Thus, despite successful rodent control, nesting success still declined compared with previous years. Although this might seem alarming, natural fluctuations in nest survival rates are common among seabirds.

Tropicbird survival is likely affected by other, undetermined factors. Possible external factors include pollution, foraging areas, prey availability, oceanographic conditions, and/or extreme weather. It should be noted that our study commenced following two category five hurricanes, which impacted the island in September 2017. Nevertheless, this is the first study of its kind focusing on rodent control and red-billed tropicbird survival, and we hope that our results will be useful for conservation efforts on other islands.

This February, one tropicbird chick regurgitated ± 10 cm of plastic tape, after it was fed by its parents. Plastic ingestion is a growing problem among many oceanic bird species and requires further research as little is known about the exact scale of this problem and its long-term health effects. Finally, we suggest that red-billed tropicbird monitoring continue, as more information will aid in the conservation and survival of the species. All the information collected between 2012 and now will form an essential tool to help us determine the most effective conservation strategies to safeguard this majestic seabird on St. Eustatius.



Above: Daily survival rates of Red-billed Tropicbird chicks in 2018-2019

Rodent Control Implemented to Help Save Tropicbirds on Statia

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Dutch Caribbean Biodiversity Database: The Future of Data Sharing

A big obstacle in nature- policy, management and research is to access existing long-term data in an environment that experiences a high turnover in project funds and personnel. Besides, although there is now decades of observations and recordings, researchers and decision/policy makers have difficulty sifting through the information available to find what they need. The Dutch Caribbean Biodiversity Database (DCBD) was developed to resolve these issues, providing a web-based platform to store and share research and trends. Being able to properly store and access information is important in times of high personnel and funding changes, ensuring information isn't lost during these transitions. New additions to the database, along with updates on current research and monitoring programs are published in DCNA's monthly newsletter, BioNews.

What is the DCBD?

Local and national authorities are obliged to give regular updates on the status and trends of the state of their environments to meet international treaty requirements. A wide variety of biodiversity web-platforms already exist which focus on specific target groups. However, in spite of the wealth of information available, many policy makers find themselves limited by missing target data and

indicators (Geijzendorffer et al, 2016) due to the data being difficult to find or in the wrong format.

The DCBD (www.dcbd.nl) is a central knowledge platform used for policy making, nature management, spatial planning and for the exchange of scientific research. It guarantees long-term data availability in an environment that experiences a high turnover in project funds and personnel. The DCBD allows the user to assess the status of ecosystems, species, threats and pressures, to explore spatial data on biophysical, socio-economic, ecological and topo-graphical properties, to navigate a listing of biodiversity and ecosystem-based information portals and to search in a library for reports, journal articles, documents and raw data.

DCBD Development

The DCBD was created using the co-design method, where the database was specifically created to meet the needs of its stakeholders. The design is meant to maximize utility by providing a centralized location for researchers and policy makers to input and access data. Together with stakeholders from Aruba, Bonaire, Curaçao, Saba, St. Eustatius and St. Maarten the initial prototype was created in 2011 and included maps, encyclopedic functionality, observation functionality and document sharing. Since then, bilateral meetings between

the DCBD maintainers and the various NGO data collectors (e.g. local governments, conservationists and park managers) have provided updated information and data, helped to clarify the data structure and have shared interpretation of the data.

Together with data collectors, indicators were created to highlight changes in the environment's health, biodiversity and pressures for evidence-based policy and measurement needs (Laihonen et al, 2004).. Currently, indicators have been grouped into 20 categories, distinguishing between ecosystems, pressures and species. Along with the indicator graphs, a short narrative is included to explain sudden shifts in trends which helps explain visible trends. Furthermore, Statistics Netherlands provides independent analysis and review of the statistical methods used.

Results

Data collectors expressed an interest in having a secure database to centrally store their data. Based on their preferences, the data is made either fully publicly available, or if sensitive, only the derived indicators are published. DCBD's maintainers and data collectors jointly created tailor-made data entry forms, using software that

the data collectors are familiar with (e.g. Excel), allowing for their independent use of analysis tools and methods. Data entry spreadsheets were designed to minimize data entry errors. For example, ranges and limitations were placed on specific data entry fields to limit incorrect data entries. Additionally, DCNA's Research Communication Liaison provides assistance with follow-up reports, publications and datasets to ensure they are stored in the DCBD.

Impact

The national government has reported using the DCBD status and trends indicators for their obligatory reports to meet requirements from various treaties (ministry of Economic Affairs, 2014; Verweij et al., 2015). Local authorities and management bodies use the DCBD to find information concerning spatial planning and to aid in local nature management and spatial planning. Local businesses, namely dive schools, use the DCBD to report observational data and to find information and marketing material. Lastly, researchers find the DCBD as a crucial source of information which can be used in current research and as inspiration for future studies.

Lessons Learned

In general, the DCBD has been successful due to three main reasons. Firstly, it is actively supported and funded by the national and regional governments. Continual support and maintenance of the database ensures it can evolve to meet the needs of its various stakeholders. Secondly, DCBD simplifies mandatory tasks of local managers and reporters by providing a single location to access clear and useful data. By controlling how the data is entered into the system, errors are reduced, semi-automatic analysis is possible, and reporting needs are facilitated even with a high turnover of staff. Lastly, the DCBD continually evolves to meet the changing needs of the stakeholders and to ensure its functionality is maintained

Looking Towards the Future

The DCBD will continue to play a critical role in how data is obtained, maintained and utilized among all stakeholders. Having a centralized database between each of the six islands can help minimize redundant work and allow researchers to more easily access information. Furthermore, by providing instructive graphs and data to policy makers, a closer link can be made between researchers and decision makers. DCBD provides a robust and evolving solution to meet the demanding requirements for understanding our environment and closing the gap between researchers and policy makers.

The image shows a screenshot of the Dutch Caribbean Biodiversity Database (DCBD) homepage. The homepage is divided into several sections: a search bar at the top, a 'MAPS' section with a map of the Caribbean islands, a 'MONITORING INDICATORS' section with various icons, and a 'PORTALS' section with links to different portals. Red arrows point from text labels to specific features on the homepage:

- Search the repository and download resource:** Points to the search bar at the top.
- Interactive maps:** Points to the 'MAPS' section.
- Trends and states:** Points to the 'MONITORING INDICATORS' section.
- Information portals:** Points to the 'PORTALS' section.

Four inset images show examples of resources and data from the database:

- Search results:** A search result for 'Pileated woodpecker' showing a photo and a brief description.
- Interactive map:** A map of the Caribbean islands with a red circle highlighting a specific location.
- Trends and states:** A graph showing the 'Number of parrots in nests on Bonaire' over time, with a 'Further reading' section.
- Information portals:** A detailed portal page for the 'Yellow-shouldered parrot' with various data fields and a search bar.

DCBD homepage, highlighting 4 key services: resources, maps, trends and states and portals (www.dcbd.nl) (Verweij et al., 2019)

Dutch Caribbean Biodiversity Database: The Future of Data Sharing

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Research Overview

August 2019

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|-------------------------------------|--|-------------------|--|
| Bats | Impact of barriers in maternity caves | BON | HAS: Jilly Sarpong (student) Wildconscience: Fernando Simal VISR: Jafet Nassar |
| Birds | Suitability study and reforestation of exclosures facilitating the Yellow-shouldered Amazon Parrots (<i>Amazona barbadensis</i>) | BON | Echo: Julianka Clarendá |
| Birds | Perception of local people on the conservation of Yellow-Shouldered Amazon Parrot | BON | WUR: Younes Zian (student), Luuk Fleskens Echo: Julianka Clarendá |
| Climate change | Teatime4science (seagrass and mangroves http://www.teatime4science.org) | BON | STINAPA: Sabine Engel |
| Coral Reef Ecosystems | Larval biology of corals and reef microbiology | CUR | MC: Kristen Marhaver CARMABI |
| Coral Reef Ecosystems | A first study of myxozoan diversity in the Caribbean: new insights into host range and life cycles? | EUX | SMNH: Inga Martinek CNSI |
| Coral Reef Ecosystems | Parrotfishbehavior and population trends | BON | Calpoly: Hannah Rempel Dive friends Bonaire (citizen scientist) |
| Coral Reef Ecosystems | NIOZ-MARUM Expedition Caribbean coral reefs, between resilience and warmer climates (drones, bathymetric surveys and different types of sensors) | CUR | NIOZ: Fleur van Duyl, Paulo Stocchi, Andi Haas MARUM: Alessio Rovere, Ciro Cerrone (PhD student) ZMT: Elisa Casella |
| Environmental friendly alternatives | Industrial Compostable Alternatives for Styrofoam (Literature study Funded by WWF-NL) | BON SAB EUX | WWF-NL: Arjan de Groene, Claudia Alessio |
| Fisheries | Market & Supply Chain Analysis study (Funded by WWF-NL) | BON SAB EUX | WWF-NL: Pieter van Baren The Good Fish Foundation: Irene Kranendonk |

Research Overview

August 2019

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|-----------|---|-------------------|--|
| Fisheries | Historical fisheries (Funded by WWF-NL) | BON SAB EUX | WWF-NL: Pieter van Baren Terramar Museum Bonaire: Ruud Stelten |
| Fisheries | Co-management in small scale fisheries (Literature study Funded by WWF-NL) | BON SAB EUX | WWF-NL: Pieter van Baren, Simaima Petzold, Philipp Pattberg |
| Fisheries | Testing and comparing various lionfish traps to study their potential use in a directed lionfish fishery (funded by WWF-NL) | SAB | SCF (SBMU): Ayumi Kuramae Izioka VHL: Tom Brokke and Marc Veldman (students) |
| Fish | Killifish Genome Size Variability | AUA | FPNA: Giancarlo Nunes BU: Nicholas Sakich |
| Fish | Shark telemetry project | BON | STINAPA: Caren Eckrich and Roxanne-Liana Francisca HAS: Brent Hoogervorst (student) |
| Plants | Testing effective ways to grow native plants | BON | Echo: Johan van Blerk |
| Plants | Germination of seeds of indigenous trees of Curaçao | CUR | CARMABI: John de Freitas |
| Plants | Vegetation Christoffel Park | CUR | CARMABI: Erik Houtepen |
| Reptiles | Lesser Antillean iguana nest research (funded by WWF-NL) | EUX | RAVON: Tim van Wagensveld, Ronald Zollinger |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|------------------------|--|------------|---|
| Anthropogenic impact | Anthropogenic Impact Analyses, Aruba National Park | AUA | FPNA: Giancarlo Nunes |
| Coral Reef Ecosystems | Deep Reef Observation Project (DROP) (ARMS: Autonomous Reef Monitoring Structures) | CUR | Smithsonian: Carole Baldwin |
| 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 | Waite Institute (Blue Halo Curaçao): Kathryn Mengerink |
| Coral Reef Ecosystems | Diadema Antillarum Population Assessment | EUX | CNSI: Kimani Kitson-Walters VHL: Alwin Hylkema STENAPA: Jessica Berkel |
| Coral Reef Ecosystems | Bloom dynamics of benthic cyanobacterial mats on coral reefs | BON | FSU: Ethan Cissell (Ph.D. student), Sophie McCoy |
| Coral Reef Ecosystems | The role of parrotfish behavior in structuring benthic coral reef communities | BON | FSU: Joshua Manning (Ph.D. student), Sophie McCoy |
| Coral Reef Restoration | Epigenetic responses to environmental stressors in Acropora corals, and applications to coral reef conservation | BON | FIU (EEL): Serena Hackerott (PhD student), Jose Eirin-Lopez RRFB: Francesca Viridis |
| Coral Reef Restoration | St. Maarten's Coral Restoration Project | SXM | NFSXM: Tadzio Bervoets, Melanie Meijer zu Schlochtern CRF |
| Coral Reef Restoration | Plant a million coral initiative (IntelliReefs) | SXM | NFSXM: Tadzio Bervoets, Melanie Meijer zu Schlochtern SeaLagacy, Reeflife Restoration and Sea to Sky ventures |
| Coral Reef Restoration | Development of restoration methods for threatened Caribbean coral species | BON, CUR | RRFB: Augusto Montbrun, Francesca Viridis SCORE Project CARMABI: Mark Vermeij Score: Valerie Chamberland |
| Coral Reef Restoration | Postsettlement dynamics of Caribbean corals & Reef restoration | CUR | CARMABI: Mark Vermeij Score: Valerie Chamberland |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|---------------------------|---|------------|---|
| Coral Reef Restoration | Artificial structures that encourage larvae settlement and discourage the growth of competitor species | CUR | University of Illinois: Amy Wagoner Johnson, Bruce Fouke, Gabriel Juarez San Diego State University: Forest Rohwer CARMABI: Kirsten Marhaver, Mark Vermeij |
| Database | Dutch Caribbean Species Register: Taxonomic knowledge system Dutch Caribbean (http://www.dutchcaribbeanspecies.org/) | All | Naturalis: Sander Pieterse, Hannco Bakker, Bert Hoeksema |
| Interstitial biodiversity | Moleculair biodiversity analysis of marine communities by metabarcoding | EUX | Naturalis: Arjen speksnijder ANEMOON: Niels Schrieken |
| Invasive species | Impact of <i>Halophila stipulacea</i> on the availability of benthic diatoms as a food source for a commercially important deposit feeders in a native and invasive habitat | EUX | CNSI: Johan Stapel, Kimani Kitson-Walters, Anna Maitz |
| Mangrove ecosystems | Mangrove habitat compensation and reforestation | AUA | FPNA: Giancarlo Nunes |
| Marine ecosystems | Taxonomy and biodiversity in Lac Bay | BON | STINAPA Sabine Engel, Caren Eckrich Ecosub: Godfried van Moorsel CEAB: Daniel Martin |
| Marine ecosystems | Marine species discoveries in the Dutch Caribbean | All | Naturalis: Bert Hoeksema CNSI CARMABI |
| Marine Park | Marine Park Aruba | AUA | FPNA: Sietske van der Wal DNM: Gisbert Boekhoudt |
| Marine Litter | Clean Coast Bonaire (Citizen science project, OSPAR methodology) | BON | Boneiru Duradero: Sharon Bol, Carolyn Caporusso |
| Plants | Botanical Garden Aruba | AUA | FPNA: Natasha Silva |
| Plants | Wildlife Garden Reserve | AUA | FPNA: Giancarlo Nunes |
| Public Health | DNA waterscan: Monitoring disease vectors in the Caribbean (mosquitoes and midges) | CUR EUX | Naturalis: Klaas-Douwe B. Dijkstra ECPHF: Teresa Leslie CBHRI: Delia-Maria Goilo (NWO DUCAMID project) |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|-------------------------------------|---|------------|---|
| Reforestation | Reforestation Project on St. Eustatius | EUX | Mac & Field: Tim van Wagensveld & Stacey Mac Donald STENAPA: Clarisse Buma LVV: Gershon Lopes |
| Reptiles | Behavior of the endemic Aruban Whiptail lizard | AUA | FPNA: Giancarlo Nunes Eckerd College: Jeff Goessling |
| Reptiles | Boa Life History | AUA | FPNA: Giancarlo Nunes Eckerd College: Jeff Goessling |
| Sponges | The role of sponges as key ecosystem engineers of coral reef ecosystems Pumping iron: can iron availability fuel the sponge loop and affect coral reef community structure? (Misha Streekstra) | CUR | Uva: Jasper de Goeij, Benjamin Mueller CARMABI: Mark Vermeij PhD students: WUR: Misha Streekstra UvA: Sarah Campana*, Meggie Hudspich*, Niklas Korner* * Part of the ERC project "SPONGE ENGINE — Fast and efficient sponge engines drive and modulate the food web of reef ecosystems" |
| Threats and risks | Are human activities (related to an oil terminal and dive tourism) a risk for ecosystem services ? | EUX | WUR: Diana Slijkerman |
| NWO Projects in the Dutch Caribbean | | | |
| Bioproducts | Stand-alone production of algal products for food, feed, chemicals and fuels - Bioprospecting and directed evolution of microalgae from Bonaire | BON | WUR: R.H. Wijffels, Rin Barten, Rocca Chin-on, Robin Barten (PhD students) Institute for Sustainable Technology: Rita Peachey |
| Coral restoration | Artificial Reefs On Saba and Statia (AROSSTA) | SAB EUX | VHL: Alwin Hylkema, Marlous Heemstra WUR: Dolfi Debrot STENAPA: Jessica Berkel SCF: Kai Wulf, Aymi Kuramae Izioka CNSI: Johan Stapel Students: Marnik van Cauter (VHL) & Martijn Peters (VHL) |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|--|--|------------------------------|---|
| Environmental psychology | Confronting Caribbean Challenges: Hybrid Identities and Governance in Small-scale Island Jurisdictions - Behavioral differences between/within the BES islands when it comes to nature conservation and cultural heritage. | BON, SAB, EUX | KITLV, Leiden University: Gert Oostindie (Project director) KITLV, Leiden University: Stacey Mac Donald (PhD student) |
| Invasive species | Exotic plant species in the Caribbean: foreign foes or alien allies? (1) Socio-economic impacts of invasive plant species (2) Ecological impacts of invasive plant species | 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. CNSI |
| Invasive species | Global defaunation and plant invasion: cascading effects on seagrass ecosystem services | BON | WUR: Marjolijn Christianen, Fee Smulders (PhD student) Smithsonian: Justin Campbell (coordinator Caribbean wide research project), Olivier Kramer STINAPA: Sabine Engel, Jessica Johnson |
| BO-projects in the Dutch Caribbean (Min EZ) | | | |
| Coral Reef Ecosystems | BO-43-021.04-003 –Inventory corals Includes monitoring and research of the longest coral reef time-series in the world (since 1973) | BON, CUR | WUR: Erik Meesters |
| DCBD | BO-43-021.04-001 - Expansion knowledge system Dutch Caribbean | AUA, BON, CUR, SAB, EUX, SXM | WUR (Alterra): Peter Verweij |
| Invasive species | Socio-ecological connectivity of tropical coastal ecosystems: how to enhance restoration and conservation of ecosystem services (Study on (1) carbon and nutrient fluxes between the mangroves, seagrass bed and coral reef at Lac Bay 2) the impact of Sargassum events on seagrass beds and mangroves in Lac Bay and 3) Lac Bay as a socio ecological system.) | BON | RU: Luuk Leemans (PhD student), Marieke van Katwijk WUR: Marjolijn Christianen |
| Fisheries | BO-43-021.04-006 - Fish stocks and fisheries Caribbean Netherlands | EUX, SAB, BON | WUR: Dolfi Debrot CNSI: Kimani Kitson-Walters PiskaBon, STINAPA SCF: Kai Wulf, Ayumi Kuramae |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|--|---|---------------|---|
| Marine biodiversity | BO-43-021.04-002 – Saba Bank – Marine biodiversity | SAB | WUR: Erik Meesters (benthic communities), Dolfi Debrot, Thomas Brunel, Leo Nagelkerke (fish stocks) |
| Marine mammals & sharks | BO-43-021.04-005 – Management plan marine mammal and shark sanctuary Yarari | SAB, EUX | WUR: Dolfi Debrot, Dick de Haan, Meike Scheidat, Ayumi Kuramae Izioka SCF (SBMU): Ayumi Kuramae Izioka |
| Marine mammals | BO-43-021.04-007 – Marine mammals in the Dutch Caribbean | BON, SAB, EUX | WUR: Dolfi Debrot, Dick de Haan, Meike Scheidat |
| World Heritage nomination | BO-43-021.04-004 – World Heritage nomination Bonaire National Marine Park | BON | WUR: Dolfi Debrot Wolfs Co.: Esther Wolfs UNESCO: Josephine Langley DRO: Frank v Slobbe CARMABI: Mark Vermeij, John de Freitas 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 WUR: Klaas Metselaar STCB: Mabel Nava DRO: Frank van Slobbe |
| Invasive species | Feral Pig Control | BON | Echo: Julianka Clarenda DRO: Frank van Slobbe |
| Reforestation | Reforestation Project | BON | Echo: Julianka Clarenda DRO: Frank van Slobbe |
| Invasive species | Goat eradication and control in Washington Slagbaai National Park | BON | STINAPA 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 DRO: Frank van Slobbe |

Long Term Projects

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|------------------------|---|------------|--|
| Terrestrial ecosystems | Combating Erosion and Nature Restoration on Bonaire | BON | Bonaire Agri & Aqua Business BV: Sherwin Poirier Wayaká Advies BV: Jan Jaap van Almenkerk DRO: Frank van Slobbe |
| Terrestrial ecosystems | Cave and karst nature reserve | BON | DRO: Frank van Slobbe, CARIBSS: Fernando Simal |
| Nature communication | Campaign environment and nature on Bonaire | BON | DRO: Frank van Slobbe, Peter Montanus |
| Agriculture | Horticultral Project | SAB | Government of Saba: Randall Johnson |
| 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: Randall Johnson |
| | Yacht mooring project | SAB | Government of Saba, SCF: Kai Wulf |
| | Saba national park | SAB | Government of Saba, SCF: Kai Wulf SABARC: Ryan Espersen |
| | Crispeen trail project | SAB | Government of Saba: Robert Zagers, SCF: Kai Wulf |
| Community outreach | Nature Awareness project | EUX | Government of St Eustatius STENAPA: Clarisse Buma CNSI: Johan Stapel, Hannah Madden |
| Nature management | Strengthening management of nature | EUX | Government of St Eustatius STENAPA: Clarisse Buma |
| Invasive species | Rodent assessment and control | EUX | Government of St Eustatius CNSI: Johan Stapel, Hannah Madden ECPHF: Teresa Leslie |
| Coral ecosystems | Coral restoration | EUX | Government of St Eustatius STENAPA: Jessica Berkel, CNSI: Johan Stapel |
| Erosion | Erosion control | EUX | Government of St Eustatius CNSI: Johan Stapel |

Monitoring Overview

August 2019

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|----------|---|---------------------------------|--|
| Birds | Flamingo Abundance | BON | DRO: Frank van Slobbe Cargill STINAPA: Paulo Bertuol |
| Birds | Monitoring vulnerable parrot nests (remote camera sensing work) | BON | Echo: Julianka Clarenda, Sam Williams |
| Birds | Aruban Brown-Throated Parakeet Conservation | AUA | FPNA: Giancarlo Nunes , ABC: Greg Peterson |
| Birds | Aruban Burrowing Owl Conservation | AUA | FPNA: Giancarlo Nunes ABC: Greg Peterson GLOW: David Johnson |
| Birds | Yellow-shouldered Amazon parrot roost counts | BON | Echo: Julianka Clarenda DRO: Peter Montanus, Diego Marquez STINAPA: Albert Christiaan |
| Birds | Bird Monitoring (Caribbean Waterbird Census) | BON SXM | STINAPA: Paulo Bertuol EPIC: Adam Brown |
| Birds | Tern monitoring (artificial nesting islands) | BON | STINAPA: Paulo Bertuol Cargill, DRO WUR: Dolfi Debrot |
| Birds | Terrestrial Bird and Habitat Monitoring | BON CUR SAB SXM EUX | Echo: Julianka Clarenda STINAPA: Paulo Bertuol, Caren Eckrich STENAPA CNSI Curassavica: Michelle da Costa Gomes CARMABI: Erik Houtepen Nature Foundation: Binkie van Es |
| Birds | Red-billed Tropicbird monitoring | SAB | STENAPA, SCF: Kai Wulf |
| Birds | Pelican monitoring | SXM | NFSXM: Melanie Meijer zu Schlochtern |

Monitoring Overview

August 2019

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|-----------------------|---|--|--|
| Coral reef ecosystems | Global Coral Reef Monitoring Network | BON CUR SAB EUX SXM | STINAPA: Caren Eckrich CARMABI: Mark Vermeij SCF (SBMU): Ayumi Kuramae Izioka STENAPA: Jessica Berkel NFSXM: Tadzio Bervoets CNSI: Johan Stapel, Kimani Kitson-Walters Students: Julia Stuijtzand (WUR) en Wiebke Homes |
| Coral reef ecosystems | Monitoring and research of the longest coral reef time-series in the world (since 1973) (Part of BO-11-019.02-022 –Inventory corals) | BON CUR | WUR: Erik Meesters, Didier de Bakker (PhD student) NIOZ: Fleur van Duyl, Rolf Bak |
| Environmental | Water quality testing | SXM | NFSXM: Tadzio Bervoets, EPIC: Natalia Collier |
| Environmental | Nutrient (phosphate, ammonium, nitrate and nitrite) monitoring of St Eustatius' coastal waters | EUX | CNSI: Johan Stapel |
| Fish | Shark monitoring: - Shark sightings - Shark Abundance, distribution and movements (tagging, acoustic telemetry) | AUA BON CUR SAB SXM EUX | WUR: Erwin Winter, Dolfi Debrot, Martin de Graaf FPNA: Giancarlo Nunes, STINAPA: Caren Eckrich CARMABI: Mark Vermeij SCF(SBMU): Ayumi Kuramae Izioka, Guido Leurs STENAPA: Jessica Berkel, NFSXM: Tadzio Bervoets |
| Fish | Spawning monitoring: Red hind surveys on Moonfish Bank | SAB | SCF (SBMU): Ayumi Kuramae Izioka |
| Fish | Fish and fishery monitoring (Barracuda's, sharks and eagle rays, tarpons, marine mammals, (fishing) boats, fisherman) | BON | STCB: Mabel Nava |
| Hydrology | Hydrology Lac Bay | BON | STINAPA: Sabine Engel WUR: Klaas Metselaar |
| Insects | Bee tracking | BON | Echo: Julianka Clarendia STINAPA: Sabine Engel, Johan Blerk |
| Invasive species | Goat and/or donkey removal: - Washington Slagbaai National Park - Lac Bay area (exclusion plots) - Quill National Park (exclusion plots) | BON EUX | STINAPA: Paulo Bertuol WUR: Dolfi Debrot DRO: Frank van Slobbe STENAPA |

Monitoring Overview

August 2019

| CATEGORY | SUBJECT | DC ISLANDS | ORGANIZATION(S): LEAD SCIENTIST(S) |
|----------------------------------|---|------------------------------------|---|
| Invasive species | Lionfish abundance and control | BON, CUR SXM, SAB EUX | STINAPA: Paulo Bertuol (50 meter traps) CARMABI: Mark Vermeij, NFSXM: Tadzio Bervoets SCF (SBMU): Ayumi Kuramae Izioka STENAPA: Jessica Berkel |
| Invasive species | Feral pig population assessment (trapping) | BON | Echo |
| Mammals | Bat monitoring | AUA, BON | FPNA, WildConscience: Fernando Simal, Linda Garcia |
| Mammals | Dolphin monitoring (since 1999) | BON | Ron Sewell |
| Mammals | Marine Mammal Monitoring (noise loggers Saba Bank) | AUA SAB EUX SXM | WUR: Bart Noort, Dolfi Debrot SCF (SBMU): Ayumi Kuramae Izioka AMMF: Angiolina Henriquez STENAPA: Jessica Berkel (sighting forms) NFSXM: Tadzio Bervoets (sighting forms), SCCN |
| Molluscs | Conch (<i>Strombus gigas</i>) on St. Eustatius, Saba Bank, Anguilla | SAB EUX | WUR: Martin de Graaf, Erik Boman (PhD student) SCF (SBMU): Ayumi Kuramae Izioka |
| Plants | Monitoring of tree growth and survivorship in reforestation areas | BON | Echo: Julianka Clarenda |
| Reptiles | Lesser Antillean Iguana: Monitoring population density & removing invasive Green Iguana and hybrids (Mohamed bin Zayed Species Conservation Fund) | EUX | STENAPA: Clarisse Buma, RAVON: Tim van Wagenveld, UvA: Thijs van den Burg |
| Reptiles | Red-bellied racer snake monitoring | EUX | CNSI: Kimani Kitson-Walters |
| Reptiles | Boa Life History | AUA | FPNA: Giancarlo Nunes, Eckerd College: Jeff Goessling |
| Reptiles | Behavior of the endemic Aruban Whiptail lizard | AUA | FPNA, Eckerd College: Jeff Goessling |
| Seagrass and mangrove ecosystems | Seagrass and mangrove monitoring (BON: also conch and benthic fauna) | BON EUX SXM | STINAPA: Sabine Engel, Caren Eckrich WUR: Klaas Metselaar, NFSXM: Tadzio Bervoets CNSI: Kimani Kitson-Walters |
| Seagrass ecosystems | Seagrass restoration BESE elements | BON | STINAPA: Sabine Engel, WUR: Marjolijn Christianen |
| Reptiles | Sea turtle monitoring: -Satellite tracking -Nest monitoring -In water surveys (BON, CUR, SXM) -Fibropapillomatosis presence (BON) | AUA, BON, CUR, SAB, EUX, SXM | TurtugAruba Foundation STCB: Mabel Nava, STCC: Sabine Berendse STENAPA: Jessica Berkel SCF: Kai Wulf, NFSXM: Tadzio Bervoets |

Monitoring and Research Wishlist

The Dutch Caribbean nature conservation organisations are in need for research projects on specific topics to safeguard biodiversity and promote the sustainable management of the natural resources of the islands.

1. Coastal water quality/nutrients and interaction with groundwater:

Note: Recently during the NICO expedition researchers looked at this around Bonaire and Curaçao.

- Possible link to fish diseases/incidence of Fibropapillomatosis in green turtles in Lac, Lagoon and Curaçao can be used to determine the linkages with water quality, pollutants in sediments, etc serving as indicators, or sentinels for the health of these important ecosystems.
- Pollutants (oil, heavy metals, pesticides, endocrine disruptors, plastics, microbial etc) entering coastal waters (subterraneously) from land and their effects on marine organisms (Curaçao).
- Quantifying terrestrial hydrological controls on nutrient and sediment fluxes into shallow seas (Bonaire).
- Stoichiometric aspects of nutrient enrichment on Caribbean reefs (Curaçao).
- What do coral communities do "well" in places where they are not expected? What makes corals cope with more nutrients, warmer waters etc? (Curaçao)
- Design of cheap but effective waste water systems (using waste to generate biomass, energy etc.) (Curaçao)
- Water quality & pollutants in sediment of Spanish Lagoon (Aruba).
- Economical and feasible waste and waste water management options (St. Maarten).
- Water quality testing and impacts of poor water quality on marine life (St. Maarten).
- Monitoring the sedimentation on the reefs around Saba.

2. Climate Change

- Evaluation of the most probable effects of climate change and sea level rise (all islands), including risk analysis in coastal zones including coral reefs and recommendations for coastal zone management and climate proofing.
- Effects on sea turtles and their nesting beaches.
- Effects of changing temperatures and hurricane damage on cloud forest of Saba.
- Develop an effective terrestrial monitoring program to enable hurricane damage and recovery assessment.
- Island specific mitigation measures for climate change effect (St Maarten).

3. Hydrology

- Mapping of groundwater levels and flows [Bonaire].
- Nearshore-offshore mixing (Curaçao).
- A thorough study of Simpson Bay 's hydrology and water quality, particularly related to land-based sources of pollution. Identify key sources of pollution and track them back to their source (St. Maarten).

4. Morphodynamics

(near shore coastal hydrodynamics, current models):

- Currents and sand transportation (and production from Halimeda) in Lac (Bonaire) – very important to management of this Ramsar site. **Note:** HVL student has started to investigate this
- Investigate all sand producing organisms to better understand where sand (and beaches) come from (Curaçao).
- Effects on beach accretion and depletion Statia and potential of reef restoration/beach restoration.
- Sedimentation rates (St. Maarten).

5. Yarari Sanctuary

- Marine mammals: aerial survey (SSS islands (Saba Bank and waters surrounding Saba, St. Maarten and St. Eustatius), seasonal presence, isolation and abundance as well as seasonal migratory destination(s) and population history of humpback and Bryde's whales in the Dutch Caribbean.
- Sharks: Ecological role of Saba Bank for sharks (nursery for nurse sharks, tigersharks, silky sharks?).
- Analyze 10 year dolphin sighting database (Bonaire)
- Ecological role of the Saba Bank passage (between Saba and Saba Bank) for deepwater sharks (e.g. dog fish).

Monitoring and Research Wishlist

The Dutch Caribbean nature conservation organisations are in need for research projects on specific topics to safeguard biodiversity and promote the sustainable management of the natural resources of the islands.

6. Invasive species:

- Follow up studies of impact of rats (and cats) on nesting tropic birds.
- The effects of the invasive seagrass *Halophila stipulacea* on the native seagrasses in the area of Lac Bay, St. Eustatius and St. Maarten, and the ecological impacts (e.g. on green turtles feeding in Lac [and Lagun], Bonaire and St. Eustatius; on conch feeding and recruitment [aggregations of juvenile conch under *Halophila* in Statia], sea urchins, etc.)
Note: NWO funded Projects by Marjolijn Christianen (WUR) looked at this in relation to sea turtles. Also Erik Boman (WUR) & CNSI looked at this in relation to conch.
- *Scaevola taccada* (White inkberry/Beach naupaka) spread and potential impact on sea turtle nesting on Klein Bonaire.
- Donkey, cat, pig population size distribution and grazing impact on Bonaire. **Note:** Echo is working on a pig control programme.
- Management of *Corallita*
Note: A running NWO project looked at this.
- Trapping lionfish in deep waters. **Note:** A project is running by WUR and WNF on the Saba Bank.
- Impact and potential management plans for invasive species. This includes: monkeys, iguanas, mongoose, african land snail, racoons, red eared slider (St. Maarten).
- Invasive species (size, distribution, threat management): boa, rubber vine, tilapia, goats, rats, cats, dogs, cane toad (Aruba).

7. Birds

- Migratory birds – patterns, habitat use with an emphasis on nesting species (Bonaire).
- **Yellow shouldered parrot:**
 - ◇ Genetics of yellow shouldered parrot (establish uniqueness of Bonairean Parrot as compared to Venezuelan islands).
 - ◇ What is the effective (i.e., breeding) population size of lora as compared to the total population.
- **Flamingos**
 - ◇ Ecology of the flamingos, in particular the Pekelmeer and flamingo sanctuary. Food availability and fluctuations and effects on breeding success.

8. Carrying capacity/management effectiveness

- BNMP reef carrying capacity and implications for management (only old and dubious data available, urgent need for an update under current circumstances and how carrying capacity is influenced by management, e.g. can carrying capacity be increased with proper management. Consider also new types of recreation such as kite surfing and assess actual effects).
- Effectiveness of nature management, both marine and terrestrial (is management having an effect and what management actions should be improved or instated?)
- Saba/Statia trails (effects of use, potential mitigation measures?)
- Assess effectiveness of restoration efforts (e.g. reforestation, are the right species being planted, is the focus on rare species correct or counterproductive? **Note:** Echo is working on this on Bonaire). Aruba would like to see reforestation of native, endangered, and key fauna supporting flora.
- Study the difference between cruise tourism and stay-over tourism regarding their pressure on the terrestrial and marine environment, taking into consideration the infrastructure needed to accommodate these types of tourism [Bonaire]. **Note:** Wolfs Company did a study on this.



Photo by: © Miro Zumrik

Monitoring and Research Wishlist

The Dutch Caribbean nature conservation organisations are in need for research projects on specific topics to safeguard biodiversity and promote the sustainable management of the natural resources of the islands.

9. Fisheries research

- **Conch:** vertical (depth) migration of conch.
- **Commercial fish species:** identify reproductive season or peak spawning period and area and assess connectivity between islands.
- **Saba Bank:**
 - ◇ carrying capacity of main target species (red snappers and lobster (also part of BO program) Feasibility of habitat restoration/artificial habitat for lobster fisheries on the Saba Bank.
 - ◇ Unused stocks: identify potential and sustainability of currently unused fish stocks such as diamond-back squid, swimming crabs.



Photo by: © Mark Vermeij

10. Sociological study of nature perception in the community

- How does the local community perceive nature and nature conservation and to what degree do they enjoy nature, how might this be improved? How effective is current communication, if any, to improve enjoyment of nature in the community and perception of the need to protect nature?
- Sustainable tourism – perception/expectations of tourists and residents as tourism grows (Bonaire).
- Invasive species control on islands where free-roaming livestock is a cultural norm – changing traditions in a changing world (Bonaire).
- Sociological/anthropological study of the cultural value of the endangered Lesser Antillean iguana *Iguana delicatissima*. How often is it caught? Perceived as a delicatessen? (St. Eustatius)
- Assess the extent of current pollution from land by plastic bags, styrofoam and other plastic debris. How willing are people to change their behavior vis a vis plastic bags, and what would be needed to effectively curb the continued generation of this type of marine debris.
- Sustainable development opportunities for tourism dependant islands (St. Maarten).

11. DNA barcoding to monitor biodiversity (is already running on St Eustatius by Naturalis)

- Biodiversity inventory: terrestrial. (St. Maarten and Aruba (also marine))
- Endemic, Endangered, and Keystone species (size, distribution, conservation management): Shoco (continue program), Bats (continue program), Prikichi, Santanero, Cascabel (renew program), Pollinators, Key fauna supporting flora (Aruba).
- Natural history Flora and Fauna distribution.

12. Improve baseline data on sharks (continue Shark research, especially shark tagging, movement and abundance).



Photo by: © Stan Shea

Monitoring and Research Wishlist

The Dutch Caribbean nature conservation organisations are in need for research projects on specific topics to safeguard biodiversity and promote the sustainable management of the natural resources of the islands.

13. Coral reefs

- Which herbivores can be used to reverse coral to algal phase shifts? Which algae are consumed and which ones aren't? (Curaçao)
- Effects of habitat fragmentation and its effect on gene flow on coral reefs (Curaçao).
- The contribution of waterflow to reef health (Curaçao).
- Shipping impacts to nearshore coral reef environments (Bonaire).
- GCRMN reef monitoring (St. Maarten needs funding for long-term project).
- To battle and research the impact of stony coral tissue loss disease (St. Maarten)
- Coral restoration, as we lost about 60% of our corals or more in the last 2 years (St. Maarten).

14. Economic valuation of key habitats (St. Maarten)

15. Environmental impact assessment landfill (St. Maarten)

16. Anthropogenic stressors:

- Effects, potential mitigation measures: Off-road vehicles (Aruba).
- Carrying capacity of (1) Off-road vehicles, (2) Conchi – (3) Natural Pool, Caves (Aruba).

17. Sargassum and Seagrass:

- Sargassum predictions, impacts, management (All).
- Sea grass research such as abundance, distribution and status (St. Maarten).

18. Turtles:

- Fibropapillomatosis in green turtles: cause, spread and severity of the disease (Bonaire, Curaçao).
- Sea Turtle Research (St. Maarten).

19. Mangrove Restoration (St. Maarten)



Photo by: © Brenda Kirkby

Monitoring and Research Wishlist

The Dutch Caribbean nature conservation organisations are in need for research projects on specific topics to safeguard biodiversity and promote the sustainable management of the natural resources of the islands.

Additional notes:

The following are research questions from previous years and still very much valid for Aruba, Curaçao and St. Maarten. They are mostly completed or underway on the Caribbean Netherlands' islands but some are still valid.

Collection and evaluation of baseline data

including species inventories and production/updating of habitat maps for key habitats and species including:

- **Marine environments**
(coral reefs, seagrass beds, mangrove forests):
 - ◇ **Habitat maps** for all marine ecosystems: Aruba, Bonaire (windward side), Saba [done], Saba Bank, St Eustatius [done], St Maarten
 - ◇ **Revised habitat maps for the leeward shore:** Bonaire [done], Curacao [note that there are habitat maps for Bonaire and Curaçao produced by Fleur van Duyl but these are now decades out of date. Recently a report from WUR came out (Mücher et al. Hyperspectral Coral Reef Classification of Bonaire). During the NICO expedition bathymetric data has been collected by Dr. Henk de Haas (NIOZ) for the Dutch Caribbean islands but this data still needs to be analyzed.
- **Terrestrial environments:**
 - ◇ **Habitat maps** for Aruba [habitat maps produced and ground truthed by CARMABI exist for all islands except Aruba]
 - ◇ **Species inventories** (all islands) [Statia starting soon]
 - ◇ **Cost effective methods for assessing terrestrial habitat change** [remote sensing is now being proposed for monitoring]
 - ◇ **Detailed inventories and mapping for key ecosystems** including
 - › Cactus habitats (Bonaire)
 - › Elfin forest (Saba)
 - › Boven forest types (Statia)
 - ◇ **Baseline data and population dynamics** (including reproductive biology and conservation ecology) for **key species** including:
 - › Caribbean coot
 - › Northern Caracara
 - › Red bellied racer (Saba, Statia)



Photo by: © Diego Marquez

List of Acronyms

| | |
|------------|---|
| AUA | Aruba |
| BON | Bonaire |
| CUR | Curaçao |
| SAB | Saba |
| EUX | St. Eustatius |
| SXM | St. Maarten |
| ABC | Aruba Birdlife Conservation |
| AMMF | Aruba Marine Mammal Foundation |
| BEST | Biodiversity and Ecosystem Services in Territories of European overseas |
| BO project | Policy Supporting Research project |
| BU | Brock University, Canada |
| Calpoly | Cal Poly Marine Conservation Lab |
| CARIBSS | Caribbean Speleological Society |
| CARMABI | Caribbean Research and Management of Biodiversity Foundation |
| CEAB | The Blanes Centre for Advanced Studies, Spain |
| CRF | Coral Restoration Foundation |
| DCNA | Dutch Caribbean Nature Alliance |
| DCBD | Dutch Caribbean Biodiversity Database |
| DNM | Directie Natuur en Milieu, Aruba |
| DRO | Directorate of Spatial Planning and Development, Bonaire |
| EcoPro | Ecological Professionals Foundation |
| ECPHF | Eastern Caribbean Public Health Foundation |
| EPIC | Environmental Protection in the Caribbean |
| ETH | ETH Zürich, Switzerland |
| FIU (EEL) | Florida International University Environmental Epigenetics Lab |

| | |
|-------------------|--|
| FSU | Florida State University |
| FPNA | Fundacion Parke Nacional Aruba |
| GLOW | Global Owl Project |
| HAS | HAS University of Applied Sciences, the Netherlands |
| LVV | Department of Agriculture, Animal Husbandry & Fisheries, St. Eustatius |
| MinLNV | Ministry of Agriculture, Nature and Food Quality |
| MC | Marhaverlab, Curacao |
| MARUM | MARUM – Center for Marine Environmental Sciences, Bremen |
| NFSXM | Nature Foundation St. Maarten |
| Naturalis | Naturalis Biodiversity Center, Leiden, The Netherlands |
| NEV | Dutch Elasmobranch Association |
| NIOZ Sea Research | Royal Netherlands Institute for Sea Research |
| NTU | Nottingham Trent University, UK. |
| NWO | Netherlands Organisation for Scientific Research |
| RAVON | Reptielen Amfibieën Vissen Onderzoek Nederland |
| RRFB | Reef Renewal Foundation Bonaire |
| RuG | University of Groningen, the Netherlands |
| RU | Radboud University Nijmegen, the Netherlands |
| SCCN | Southern Caribbean Cetacean Network |
| SABARC | Saba Archaeological Center |
| Scripps | Scripps Institution of Oceanography, U.S.A. |
| SDSU | San Diego State University, U.S.A. |
| SLA | SeaLife Arizona, U.S.A. |
| SBMU | Saba Bank Management Unit |

| | |
|----------------|--|
| SCF | Saba Conservation Foundation |
| SCORE | SCORE International, U.S.A. |
| 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 |
| SU | Swansea University, UK |
| TU | Temple University, USA |
| UIU | University of Illinois Urbana-Champaign, U.S.A. |
| UC | University of California, Berkeley, U.S.A |
| UF | University of Haifa, Israel |
| UAA | University of the Algarve, Portugal |
| UU | University of Utrecht, the Netherlands |
| UvA | University of Amsterdam, the Netherlands |
| VHL | University of Applied Sciences VHL, the Netherlands |
| VISR | Venezuelan Institute of Scientific Research |
| VU | VU University Amsterdam, the Netherlands |
| Wildconscience | Wildlife Conservation, Science and Education |
| WNF | World Wide Fund for Nature |
| WMR | Wageningen Marine Research, the Netherlands |
| WUR | Wageningen University and Research Centre, the Netherlands |
| WUR (Alterra) | Wageningen Environmental Research, the Netherlands |
| ZMT | Das Leibniz-Zentrum für Marine Tropenforschung, Bremen |

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.

"Assour, H.R., Behm, J.E. (2019)

[First Occurrence of *Cheilomenes sexmaculata* \(Coleoptera: Coccinellidae\) on the Caribbean Island of Curaçao. *Neotrop Entomol* 48:863–865"](#)

"Braks, M. et al. (2019).

[Making Vector-Borne Disease Surveillance Work: New Opportunities From the SDG Perspectives. *Front. Vet. Sci.*"](#)

"Cissell, E.C. et al. (2019).

[Consumption of benthic cyanobacterial mats on a Caribbean coral reef. *Scientific Reports* 9."](#)

"Convention on Biological Diversity (2019).

[Sixth National Report of the Kingdom of the Netherlands."](#)

"Debrot, A.O. et al. (2019).

[Patterns of distribution and drivers of change in shallow seagrass and algal assemblages of a non-estuarine Southern Caribbean mangrove lagoon. *Aquatic Botany* 159"](#)

"Debrot, A.O. et al. (2019).

[The Antillean manatee \(*Trichechus manatus manatus*\) in the southern Caribbean: A compilation and review of records for the Dutch Leeward islands and the central Venezuelan coast"](#)

"Elmer, F. et al. (2019).

[Black spot syndrome in reef fishes: using archival imagery and field surveys to characterize spatial and temporal distribution in the Caribbean. *Coral Reefs*"](#)

"Geelhoed, M.L.F. et al. (2019).

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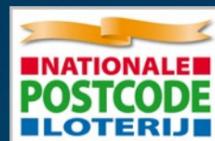
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