TRANSBOUNDARY SPECIES
Editor’s note

There has been a recent increase in public awareness of environmental issues as the effects of climate change have become ever more noticeable in our daily lives. As we enter a new decade, it becomes useful to review what conservation efforts have worked so far, and take inventory of what efforts will be required for the future. Starting with the constitutional referendum creating the Caribbean Netherlands (Bonaire, St. Eustatius and Saba (BES), the response to conservation challenges of all six Dutch Caribbean islands have varied. Since 2010, the BES islands have seen an overall increase in funding support and conservation actions, and therefore presumably also saw greater improvements when compared to Aruba, Curaçao and Sint Maarten, though clearly not enough (Sanders et al, 2019).

The goal of this Transboundary Species special edition of BioNews is to provide an update on the latest published research results and highlight the need for transboundary protection. These species know no boundaries, and thus move between the Dutch Caribbean islands and beyond. Their protection will require broadscale conservation efforts which cover the entire Caribbean, including the six Dutch Caribbean islands. Collaboration between all six islands is of the utmost importance. This is one of the Dutch Caribbean Nature Alliance’s (DCNA) main goals: working together and sharing skills, knowledge and resources to maintain a solid network and support nature conservation in the entire Dutch Caribbean.

Overview

This 2019 special edition BioNews will review conservation accomplishments over the past year. The first section will give an annual update for recently published reports and legislative efforts along with the results of a few long-term projects. Sections two through nine will highlight the findings of recently published projects concerning various transboundary species and special habitats. The final section will discuss additional threats which will require special attention in the upcoming years.

There have been many important research projects completed this year which give additional insight into the delicate and complicated ecosystems present throughout the Caribbean. This research has allowed us to gain insights into migratory patterns, breeding habits and showcase major threats for a variety of critical species. This knowledge will be crucial in designing management and conservation plans as we head into the next decade.
2019 Research and Project Results

- Two species of endangered elasmobranch are recommended to receive additional protection in the Caribbean
- At least ten reef-associated shark species in the Dutch Caribbean

Dutch Government Announces New International Shark Strategy

Satellites and Sharks: Latest in Saba Bank Shark Research

Study reveals large number of new bird species for Saba

Rodent Control Implemented to Help Save Tropicbirds on Statia

Alarming Decline of Bridled Quail-Dove populations on Statia

40-year study: Changes on the Coral Reefs of Bonaire and Curaçao

Stony Coral Tissue Loss Disease Management Update for the Dutch Caribbean

New and Very Abundant Microbe Found Living in Corals

Human disturbance impedes growth of coral reefs around Bonaire

New marine biodiversity discoveries from Bonaire

Invasive seagrass found on Saba
INTERNATIONAL REPORTS
& LONG-TERM PROJECTS

Photo by: © Hans Leijnse
2019 marked the end of a decade and served as both the beginning and end for a number of different projects. Many conservation plans used 2020 as a benchmark year to take inventory of the successes and shortcomings of these efforts. The following section will provide a brief overview of some of the most impactful reports released this year. For each topic, when applicable, the BioNews title and issue number has been included. A condensed version of the articles has been included below; the full articles are available at dcnanature.org.

To review the full version of any of these reports, please visit the Dutch Caribbean Biodiversity Database at www.dcbd.nl.

Wageningen University State of Nature Report
Nature in the Caribbean Netherlands is critically threatened and intervention is necessary (BioNews 23)

Wageningen University recently published an alarming report on the state of nature for Bonaire, Saba and St. Eustatius, commissioned by the Ministry of Agriculture, Nature and Food Quality. Within this study, the term “State of Conservation” (SvI) is used to indicate the condition of an environment as it applies to a species or habitat.

The 33 experts who worked on this report concluded that “…the current SVI of biodiversity in the Caribbean Netherlands must be assessed as moderately unfavorable to very unfavorable. This applies to both the habitats and the dependent species and/or species groups. This contrasts strongly with the image for the European Union and the European Netherlands, where governments have been structurally investing in nature policy and management for decades.”

“...There are many threats to this, but the biggest threats are feral livestock, invasive exotic species (species that do not occur naturally on the islands), climate change and overfishing. In addition, coastal development, erosion and eutrophication by waste water should not be forgotten. Because the threats are not sufficiently addressed, the scientists view the future perspective as moderately unfavorable to very unfavorable…” stated Wageningen.

Necessary measures
For the largest threats, it is critical to immediately tackle the issue of overgrazing caused by free-roaming cattle and to improve solid waste management and wastewater treatment systems. In addition, there is a need for improved monitoring mechanisms to better understand the current state of the environment and evaluate its management. It is also important to improve the resilience of ecosystems so that they are better able to withstand the effects of climate change, such as warmer and more acidic seawater (coral bleaching) and extreme weather conditions (longer periods of drought and more powerful hurricanes). Other important management considerations include implementing coastal protection through spatial planning and reduction of erosion through reforestation of indigenous trees and shrubs.

High time for investment in nature and the environment
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 Fundacion Parque Nacional Aruba (FPNA), CARMABI (Curaçao) and Nature Foundation (St. Maarten).

Every island in the Dutch Caribbean has its own unique natural habitats but faces similar challenges to keep them protected. Climate change, deforestation, overfishing, sargassum influx events, overdevelopment and the effects of unsustainable tourism are only a few examples. Collaboration and knowledge sharing is critical in maximizing the efficiency of these efforts. It is especially important that the Kingdom, which connects us, keeps us together when it comes to cross-border problems. For all islands, investing in nature and the environment is not a luxury, but a crucial investment in the future.

For more information check:

Summary articles in English for each specific island can be found in BioNews: State of Nature in the Caribbean Netherlands.
A recent report issued by the Kingdom of the Netherlands has sounded the alarm that only four of twenty ‘Aichi Targets’ of the ‘Convention on Biological Diversity (CBD)’ have been achieved in the Dutch Caribbean, highlighting increased need for conservation management actions in the Caribbean part of the Kingdom.

The CBD is an international agreement under the United Nations Environment Program that aims to provide an international legal framework to support the conservation and sustainable use of natural resources, ensuring the preservation of biological diversity into the future. In order to achieve this, the contracting parties to the CBD have established a set of goals and targets to promote conservation and sustainable use of natural resources worldwide known as the Aichi Targets.

The current Strategic Plan for Diversity was signed by all contracting parties of the CBD convention in 2010 and runs through 2020. The plan highlights twenty biodiversity benchmarks, the “Aichi Biodiversity Targets”. Every five years, each participating country including the Kingdom of the Netherlands is expected to submit a National Report on the current status for these benchmarks, the latest report gives an update through 2018.

Since 2010, the Kingdom of the Netherlands consists of the Netherlands, with the public entities Bonaire, Saba and Sint Eustatius (BES islands); and three autonomous countries, Aruba, Curacao and Sint Maarten. Collectively Aruba, Bonaire, Curacao, Saba, Sint Eustatius and Sint Maarten are called the Caribbean part of the Kingdom of the Netherlands or the Dutch Caribbean.

Alarming Trends
This most recent report, released in April 2019, states that although there has been some significant progress toward meeting the national targets, the 2020 deadline will not be fully met. For the Dutch Caribbean, the largest threats to reaching the Aichi Targets are overgrazing by free roaming livestock, invasive species, overfishing, and pollution. These threats make island habitats less resilient to the major threat of climate change. The report also states that not enough is being done to deal with these local threats.

In total sixteen of the twenty Aichi targets are not on track for one or more of the Dutch Caribbean islands in achieving the 2020 targets. Additionally, a total of 13 targets are in progress but at an insufficient rate. Furthermore, it was found that an alarming five of the Aichi Targets had a worsening trend, while no significant change was seen for 50% of the targets for some of the Dutch Caribbean islands. The five targets with a worsening trend on some or all of the Dutch Caribbean islands includes (5) loss of natural habitats, (7) sustainable agriculture, (12) reducing risk of extinction, (14) ecosystem services, (15) ecosystem restoration and resilience.

Successes
The report did highlight some successes for the Dutch Caribbean for the four targets currently on track to reach the 2020 targets for some of the islands. These Aichi targets are (1) awareness of biodiversity, (2) biodiversity values integrated into national and local development and poverty reduction strategies and planning, (8) pollution reduction and (17) establishing biodiversity strategies and action plans. The report reflects positively on the public awareness campaigns across all of the Dutch Caribbean that stresses the importance of protecting nature, reducing pollution and encouraging sustainable use of resources.

In many cases, long-term monitoring data is lacking for several of the twenty Aichi Targets on each of the six Dutch Caribbean islands, therefore, the analysis completed was based on experts’ judgments and the actual success varied significantly across the six Dutch Caribbean islands. Since 2010, the BES islands saw an overall increase in funding support and conservation actions, and presumably therefore greater improvements when compared against Aruba, Curacao and Sint Maarten, though clearly not enough.

The full report for the Kingdom of the Netherlands (2019) can be found here:

A degraded Dutch Caribbean coral reef.
Photo by: © Erik Meesters (WUR)
## The 20 Aichi Targets for the Dutch Caribbean

### Key:
- **1. Public Awareness**
- **2. Integrated biodiversity values**
- **3. Removal of perverse incentives**
- **4. Sustainable production/consumption**
- **5. Loss of natural habitats**
- **6. Sustainable Fisheries**
- **7. Sustainable Agriculture**
- **8. Pollution**
- **9. Invasive Alien Species**
- **10. Climate Change/Ocean Acidification**
- **11. Protected Areas**
- **12. Reducing risk of extinction**
- **13. Genetic Diversity**
- **14. Ecosystem Services**
- **15. Ecosystem restoration and resilience**
- **16. Nagoya ABS Protocol**
- **17. NBSAP Revision**
- **18. Traditional Environmental knowledge**
- **19. Knowledge Transfer**
- **20. Resource Mobilisation**

### AUA - Aruba

### BON - Bonaire

### CUR - Curaçao

### SAB - Saba

### SXM - Sint Maarten

### EUX - Sint Eustatius

### All - All Six Dutch Caribbean Islands

### N/A - Not Applicable

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### A Year in Review: Critical Reports
Nature Policy Plan: Caribbean Netherlands

Earlier this year, stakeholders from each of the three Caribbean Netherlands islands Bonaire, Saba and St. Eustatius met to discuss updates to the previous Nature Policy Plan. The next policy plan will cover the years 2020 through 2030. Based on feedback from each of the stakeholders and building on the previous plan, the final draft for the updated plan is being reviewed now and is expected to be published soon.

This policy plan provides an important framework to help guide the management and sustainable use of the natural resources within the Caribbean Netherlands. This plan outlines specific strategic goals for nature conservation and creates a framework for each of the islands to develop a more specific local plan. The previous plan (2013-2017) was referenced throughout the CBD Report, and was credited for the successes of resource management within the Caribbean Netherlands. Similar Nature Policy Plans should be drafted and implemented for the other 3 autonomous Dutch Caribbean islands to ensure conservation efforts are maximizing their effectiveness.

In October 2019, DCNA co-hosted with Wereld Natuur Fonds - WWF and Stinapa Bonaire a local stakeholders workshop so that Bonaire environment stakeholders could provide their input for the draft Nature Policy Plan for the Caribbean Netherlands.

A Year in Review: Critical Reports
Nature Funds Projects
This year also marked the completion of the Nature Funds Projects. These projects of the Public Entities of Bonaire, Saba and St. Eustatius in cooperation with local organizations were funded by the Ministry of Agriculture, Nature and Food Quality (LNV). In total, $9.8 million was reserved, for a period of four years, to support overdue nature maintenance projects, in particular those targeting coral reef restoration, sustainability and the synergy of sustainable nature use, agriculture and tourism. 2019 marked the end of the implementation period for these projects, which included 10 projects on Bonaire, 7 on Saba and 6 on St. Eustatius. Projects included efforts to increase awareness of conservation efforts, reforestation, coral restoration, protection against overgrazing of free roaming animals, rodent control, the creation of a Bonaire Caves and Karst Nature Reserve, ecological restoration of Lac Bay, protecting sea turtle nesting sites and a sustainable agriculture and rural development program.

The success of these projects is evident on all three islands. These projects both increased public awareness and served as a foundation for future conservation efforts. Many of these projects were credited for helping the BES islands meet the Aichi Targets of the previously mentioned Convention of Biological Diversity.

Check out the Nature Funds Projects special “BioNews” edition that includes videos which highlight the results of some of these projects. These videos are the crowning glory of a successful cooperation between the Dutch and local governments and local nature conservation organizations.

Dutch Caribbean Biodiversity Database: The Future of Data Sharing
Conservation policies, reports and results from projects and research are only helpful if they can be easily accessed and used by stakeholders. Another great success story from the past few years has been the roll out of the Dutch Caribbean Biodiversity Database (DCBD). The DCBD is a web-based platform developed to aid in sharing important biodiversity publications and other documents, ongoing monitoring and trends, maps and other biodiversity information. 2019 brought about new additions to the database, increasing the usability and functionality of the database for all users.

The DCBD will continue to play a critical role in how data is obtained, maintained and utilized among all stakeholders. Having a centralized database shared by the six islands can help minimize duplication of 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. Further DCBD updates, along with updates concerning current research, monitoring programs and upcoming events are published in DCNA’s newsletter, BioNews.

Photo by: © Reef Renewal Bonaire
Long Term Projects

Dutchcaribbean.observation.org:
Citizens can help report animal and plant species

DCNA has also been working with Observation International to roll this platform out as the citizen science database to record field observations in the Dutch Caribbean. This free tool allows all interested parties to record and share information on their plant and animal sightings from both a desktop and mobile application. Since starting in 2004, over 100 million sightings have already been recorded. This easy to use platform allows users to submit and access data, including transect monitoring, photographic databases and data export and is available in all major languages.

DCNA intends to use this platform in the upcoming years to connect citizen science and other research projects across the Dutch Caribbean.

The goal is to have one overarching citizen science database for all 6 islands (https://dutchcaribbean.observation.org) along with island specific databases:

https://aruba.observation.org
https://bonaire.observation.org
https://curacao.observation.org
https://saba.observation.org
https://sintmaarten.observation.org
https://sinteustatius.observation.org

To register sightings Observation.org has developed apps for iPhone & Android

To get started:
1. Register with your full name on: https://observation.org/registreer.php
2. Watch this video on how to enter sightings https://youtu.be/zGklsc0xHr4
3. Download the app via the App Store / Google Play. Once installed download the species lists for the country 'Dutch Caribbean'
4. Use your personal account to login online and in the app
5. Start recording your sightings!

When using the apps:
• switch on you phone’s GPS
• GSM network reception is NOT needed to record sightings.
  Upload of your sightings and pictures can be done via GSM network or WiFi
• Do not forget to push the upload button! A list of sightings is stored on your phone. Once the sightings are uploaded they will be online in 10 minutes.

For questions you can contact research@DCNAnature.org or hans.verdaat@wur.nl

Mobile apps
Use our mobile apps to record your observations on your phone or tablet.

Our partners

Naturalis
NB Nationaal Biodiversity Centre
Natuurmonumenten
Zostera
Dutch Caribbean Species Register
On December 5, 2017, the launch of the Dutch Caribbean Species Register took place: www.dutchcaribbeanspecies.org. This website is another useful tool for nature conservation, biodiversity research, and education in the Dutch Caribbean;

An overview of the known biodiversity (animals, plants, fungi) of the Dutch Caribbean is presented in this database: over 8,270 species.

This online database is the result of an effort of Naturalis Biodiversity Center to gather all relevant records and publications on the biodiversity and natural history of the six islands of the Dutch Caribbean: Aruba, Bonaire, Curaçao, Saba, Sint Eustatius and Sint Maarten, together with the submerged Saba Bank. Naturalis is the Dutch national research institute for biodiversity, with a long tradition of terrestrial and marine research, fieldwork and natural history collections focused on the Dutch Caribbean.

The database contains a wide variety of information, which has been gathered from books, scientific articles, expedition reports, museum catalogues, websites, species lists, and photographs. The database includes, but is not limited to presence status per island, photos, literature references, and common/local names. The checklist can be searched and filtered in several ways and can also be navigated through a taxonomic tree. Species can also be searched by habitat, such as terrestrial, freshwater, brackish water, and marine environments. The presence status indicates per island which species are indigenous and which ones have been introduced. For species of the latter category also the natural distribution range can be found. For each island and for certain regions, such as the Leeward Islands and the Lesser Antilles, lists of endemic species can be generated and searched for additional information.

The species database is expected to grow over the coming years, as Naturalis processes the results of recent research expeditions. Species discovered on the islands as new to science and those representing new records are added after their publication as soon as possible. Photographic records can also be used as basis for new contributions.

Naturalis is looking for volunteers who are willing to supply documentation, photographs, and specimens that represent new species records for the islands. People with expert knowledge of the Caribbean fauna and flora are welcome to assist as validators. Those interested in contributing can contact Naturalis via speciesregister@naturalis.nl.
The Dutch Caribbean is home to a wide variety of bird species. Whether passing through during their seasonal migrations or residing permanently, these islands are a hot spot for bird activities. Starting in the early 1980s, Important Bird Areas (IBAs) gained world recognition as critical areas for birds. In total, there are now 23 IBAs within the Dutch Caribbean; four on Aruba, five on Curaçao, six on Bonaire, one on Saba, two on St. Eustatius and five on St. Maarten (DCNA, 2013). These IBAs are valuable for conservation efforts to protect key species.

Aruba has four IBAs, an estimated 254 species (Aruba BirdLife Conservation, 2016) and has been known to provide habitat for over 30,000 seabirds along with various other important bird populations (Delnevo, 2008). Specifically, Aruba hosts a significant population of breeding terns, along with an estimated 25% of the world’s population of Cayenne Terns and 90% of the Caribbean population of Common Terns (Delnevo, 2009). A 2001 study found 6,600 nests of Sooty Terns and 100 nests of Bridled Terns, two species which nest at Aruba’s San Nicolas reef islands between April and August (Prins et al., 2009). Brown and Black Noddies are also present on San Nicolas reef islands (Prins et al., 2009).

Aruba’s most famous bird, the Aruban burrowing owl (Athene cunicularia arubensis) - locally known as Shoco - is locally considered to be an island endemic subspecies and an important part of the local culture. Unfortunately, the Shoco population has declined considerably over the past few decades and Fundacion Parque Nacional Aruba and Aruba Birdlife Conservation are running projects to protect them.

Aruban burrowing owl, photo by: © Diego Marquez
The Yellow-shouldered Amazon parrot population of Bonaire is the only native population outside Venezuela and it is estimated to represent 16-64% of the global population (Echo, 2015; Birdlife International, 2017). The Yellow-shouldered Amazon parrot, known locally as the lora, has received an IUCN assessment of "vulnerable", meaning there is a 10% chance of extinction in the next 100 years. Bonaire provides important breeding grounds within the Caribbean for the iconic Caribbean Flamingo (STINAPA). Some breeding sites show an upward trend in breeding pair numbers, whereas others 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 years, however the underlying causes of these fluctuations are unclear.

Bonaire is also home to 5 different tern species which are regionally assessed between 'vulnerable' and 'endangered' (Schreiber, 2000; USFWS, 2010; Debrot et al., 2018). 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 Tern, both considered regionally endangered (Schreiber, 2000; USFWS, 2010). Recent estimates put Bonaire’s bird population at more than 255 species, with a large variety of terrestrial and sea bird species passing through during their seasonal migrations or residing permanently (Schets, 2019).

Curaçao has recorded 259 species of birds on the island, however, only 57 are considered year-round residents (Debrot & Wells, 2015; eBird, 2019). Curaçao is globally important for nesting Least Terns (Debrot & Wells, 2015). A recent study carried out by Bos et al. (2018) resulted in a preliminary checklist of extant endemic animal and plant taxa (species and subspecies) of Saba, the Saba Bank, St. Eustatius and St. Maarten. This list includes 23 endemic bird subspecies. Endemic species are defined as "native and restricted to a certain place" (Merriam-Webster, 2018) and have an especially important ecological value due to their limited geographical range. Their increased vulnerability to natural and anthropogenic threats such as hurricanes and habitat destruction stems from their uniqueness: their population is small and limited to a certain habitat/area and typically has low genetic diversity.

The entire coastline of Saba is considered an IBA, which is known to support all seven of the Lesser Antilles Endemic Bird Area’s restricted-range birds, including Bridled Quail Doves and Brown Tremblers. Notably, Saba supports a significant proportion of the world’s Red-billed Tropicbirds (DCNA, 2013; Boeken 2016). The Saba Bank is also an important foraging ground for many seabirds, and conservative estimates indicate that ¼ million sea birds are dependent on the Saba Bank. This includes birds from Saba, St. Eustatius and Dog Island, which alone supports 100,000 pairs of nesting seabirds including Magnificent Frigatebirds, Tropicbirds, Sooty Terns and Masked Boobies, all of which are in decline (Delnevo, A. personal communication, 2017).
St. Eustatius has two IBAs, and along with Saba, hosts a globally significant population of Red-billed Tropicbirds (Delnevo, A. personal communication, 2017). The slopes of the Quill provide suitable habitat for the Bridled Quail-dove, a regionally endemic species. The island also supports eight additional restricted-range species listed in the Lesser Antilles Endemic Bird Area, adding to its conservation importance for the region. Furthermore, based on preliminary data collected using GPS loggers, Red-billed Tropicbirds have been documented foraging along the Aves Ridge, to the south/southwest of St. Eustatius (Hannah Madden unpubl. data).

Lastly, St. Maarten has five IBAs, and is known to support breeding pairs of the American Coot. St. Maarten also hosts a globally significant population of Laughing Gulls. In addition, the local population of Brown Pelican and Royal Tern are also considered regionally important (DCNA, 2013). The Brown pelican population took a big hit from Hurricane Irma in 2017 but is back on track after two very successful breeding seasons since the hurricanes (Binkie van Es, personal communication 2019).

This section will outline the current state of birds within the Dutch Caribbean and highlight some research and ongoing project results from the past year. For more information, please see the full BioNews articles, which have been indicated along with the article titles below.
Study reveals large number of new bird species for Saba (BioNews 23).

A two-year study of the local bird population of Saba was completed resulting in an updated checklist of all recorded bird species. This updated list shows that the island has an even richer bird population than previously known, with a total of 107 species including 31 new species recorded (Boeken, 2018).

The majority of new bird species recorded for Saba were residents or visitors from North America and the neighboring island of St. Maarten. Saba is situated just 45 km southwest of St. Maarten, a short distance for birds to travel. A number of birds that are common or breed on St. Maarten have now been established as either occasional visitors to Saba and its surrounding seas [American Oystercatcher, Snowy Egret, Least Tern] or vagrants [Blue-winged Teal, Black-necked Stilt, Ruddy Turnstone] (Boeken, 2018). A number of passage migrants and visitors to St. Maarten are now confirmed as also stopping on Saba, either regularly [White-winged Dove], occasionally [Semipalmated Plover, Louisiana Water-thrush, Ring-billed Gull] or rarely [Wilson’s Snipe and Sandwich Tern] (Boeken, 2018). Other species have been mentioned as vagrants to the Lesser Antilles (Raffaele et al., 2003) and are now confirmed as vagrants to Saba [Rose-breasted Grosbeak, Yellow-throated Vireo, Cliff Swallow, Black-throated Green Warbler] (Boeken, 2018). Additionally, five new species of bird have become established on the island, three of which have begun to breed [House Sparrow, Eurasian Collared Dove, and recently: Brown-throated Parakeet], while the other two species remain feral [Rock Pigeon and Red Junglefowl] (Boeken, 2018).

Saba’s rocky shores and islands are especially significant for seabirds in the region since breeding habitats for seabirds are under strain all over the Caribbean. Boeken (2018) confirmed the importance of Saba for Red-billed Tropicbirds, with recent estimate of 1,200 - 1,500 pairs (Boeken, 2016). The breeding status of the Sooty Tern was confirmed; however, the breeding status of others could not be confirmed [Cattle Egret, Green Heron, Yellow-crowned Night-Heron, Black-whiskered Vireo] (Boeken, 2018). Two species were also confirmed as locally extirpated: the White-tailed Tropicbird, which was once recorded as breeding on Saba, and the Antillean Euphonia, which has not been seen on the island for over 50 years (Boeken, 2018).

Despite being nicknamed “the Unspoiled Queen”, a newly published report by Wageningen University (Debrot et al., 2018) on the state of Saba’s nature has revealed that most of the island’s habitats are under strain and are now degraded to varying extents. This is of great concern for Saba’s avifauna which depends on the health of these habitats for their well-being. Saba’s cloud forest at the top of Mt. Scenery is a critical habitat for the regionally rare and endemic sub-species of Brown Trembler that inhabits and breeds on Saba (Cinclocerthia ruficauda tremula) but the vegetation has suffered severe damage from hurricanes over the past decade. Invasive species also pose a significant threat, notably rats and feral cats. Feral cats and rats are an especially serious threat for nesting seabirds (Debrot et al., 2014). The status of key and endangered bird species on Saba will need to be closely monitored to understand how growing local, regional and global threats to the island’s habitats are impacting the avifauna. This includes three endangered species that have just been added to Saba’s bird checklist: the White-crowned Pigeon (Near Threatened), whose population on St. Maarten has dramatically declined due to hunting; the Chimney Swift (Vulnerable) and the Blackpoll Warbler (Near Threatened) (Boeken, 2018).
Rodent Control Implemented to Help Save Tropicbirds on Statia

As the only species of seabird nesting on St. Eustatius, the Red-billed Tropicbird (*Phaethon aethereus*) is an iconic species for the island. 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 black rats (*Rattus rattus*) 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. Over half of the nesting attempts fail each season, which is significant considering tropicbird females lay a single egg per clutch.

To better understand the impact of rodents on the 2018-2019 nesting season, a study was conducted in which half of the study area was treated with brodifacoum rodenticide and the half was left untreated. Brodifacoum is a second-generation anti-coagulant that kills rats and other rodents within 5 days of ingestion. The relative abundance of rodents at the nest site was assessed via tracking tunnels, which were set out at 25m intervals every month in a predetermined grid. Tracking tunnels are rectangular pieces of cardboard with an ink section, baited with peanut butter to attract rodents and capture their footprints. Using these methods, the relative abundance of rodents was found to have decreased significantly from 86.7% before treatment to < 2.0% post-treatment. In addition to rat and mouse prints, tracks of small lizards, crabs, and insects were also recorded. Estimated nest survival rates were 33.6% in the 2017-2018 season and 35.7% in 2018-2019. Temporal factors had the highest influence on survival in the incubation and chick-rearing stage, and overall, with results suggesting that nests and chicks were more likely to survive as chick age or Julian date increased.

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. A number of factors may have limited the success of the project; including: the limited number of accessible nests, the absence of a ‘control’ nest site for comparison, factors away from the nest site, 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.

Tropicbirds at the Pilot Hill study site exhibit high nest mate and nest cavity fidelity following failure of their first breeding attempt (Madden, 2019). Such fidelity makes pairs vulnerable to disturbances at the nest site in case of predation, extreme weather, and other disturbances (Mejías et al. 2017). High levels of predation at the nest site could have implications for pairs that make a second nesting attempt following loss of the initial clutch or chick (Naves et al. 2006). Nest monitoring should continue in the future to better understand the complex ecology of these seabirds. This will help guide conservation efforts in the future.
Alarming Decline of Bridled Quail-Dove populations on Statia (BioNews 27)

The Bridled Quail-dove is a regionally endemic species that, on Statia, is only found in upper elevations of the Quill (above ~150m) and inside the crater. Since 2017, annual surveys have highlighted an alarming decline in populations. With an estimated population decrease of 77% following Hurricanes Irma and Maria in 2017, this species has caught the attention of local scientists and requires immediate conservation actions.

Once thought to have been a common resident of the West Indies, declining Bridled Quail-dove populations are now isolated within coastal dry forest patches of the Eastern Caribbean. Introduced, non-native predators such as feral cats, mongooses and rats are thought to negatively impact Bridled Quail-dove populations by preying on adults, eggs and/or chicks. Other external factors that contribute to population declines include hunting, volcanic activity, hurricanes, and habitat loss and degradation. Furthermore, this species is sensitive to openings in the forest canopy, which also affects nesting. The Bridled Quail-dove lays clutches of two eggs in a nest up to six meters above ground level.

Despite its current classification as a species of Least Concern by the IUCN (in 1992 it was classified as Near Threatened), the Bridled Quail-dove is likely of conservation concern due to data deficiency and population declines across its entire range.

The pre-hurricane assessment in May 2017 was initially encouraging, with an estimated 1,039 (minimum 561 - maximum 1,621) Quail-doves across its local habitat of 440 hectares, possibly the highest known density in the region. This survey was repeated post-hurricanes season, in November 2017, and a decrease of 22% to 803 (451 - 1,229) was recorded. Furthermore, in May 2018, a decline to 253 individuals (83 - 486) was recorded (Madden, Rivera-Milán and Verdel, in prep.).

The surveys were repeated across the entire Quill (440 hectares) during May 2019, coinciding with the Quail-dove’s peak breeding season. The results were very concerning since the population has continued to decline to 238 individuals (118 – 390; Madden, Rivera-Milán and Verdel, in prep.). The 2018 and 2019 surveys suggest that little, if any, successful post-hurricane reproduction has occurred. Additionally, the majority of detections were recorded inside the crater and near the crater rim, with very few detections at lower elevations. This means that the population is highly clumped at low numbers, which increases the chance of local extinction.

Indirect effects of hurricanes, human-induced habitat degradation and increased predation continued to affect Quail-dove survival and reproduction in 2019. Rat and other invasive predator species may increase in density following hurricane-induced changes in foraging resources, affecting Quail-dove survival and reproduction even further. A feral cat was detected during surveys inside the crater, probably as a result of forest openness after the hurricane. Due to the fact that Quail-doves have early maturity and short lifespans, conservation efforts should focus on successful reproduction through invasive species management. In addition, the overall health of the Quill should be improved to help forest-dependent birds and other wildlife recover in order to enhance their prospects for long-term survival on Statia.

2019 Research and Project Results
The bat populations of the Dutch Caribbean play a critical role within local ecosystems. There are certain plants, such as the columnar cacti, calabash and agave, which depend on bats to pollinate and disperse their seeds (Nassar et al., 2003). Insectivorous species of bats are capable of eating large numbers of insects each night and are therefore crucial in controlling insect populations. Unfortunately, bats are facing difficulties due to loss of habitat, reduction in food sources and human disturbance in their daily roosts, which are mainly caves in the Dutch Caribbean (Pedersen et al., 2013).

The southern Dutch Caribbean Islands (Aruba, Bonaire and Curaçao) are home to 11 species of bats, of which, at least one species (Leptonycteris curasoae) travels between these islands and Venezuela (Simal et al., 2015). Aruba supports eight different species while Bonaire and Curaçao both support nine. An overview of these species can be found in the table below. While most of these species live in caves (which can include rock crevices, ledges or other small structures) some have been known to roost in tree holes or roofs of human structures.

An important organization dedicated to the research, education and conservation of the ABC Islands’ bat populations is the Programa Proteché Raton dj’anochi (PPRABC). Many of the efforts, which will be further detailed below, were conducted by PPRABC, led by STINAPA Bonaire, Fundacion Parque Nacional Aruba, and CARMABI Curaçao and under the guidance of the Venezuelan Institute for Scientific Research (IVIC) and the Latin America and Caribbean Bat Conservation Network (RELCOM). There has also been a large number of volunteers which have been instrumental in completing these efforts.

Since 2012, Fundacion Parque Nacional Aruba has established a bat monitoring team to further study the local bat populations to help guide future conservation efforts. This team monitors four different cave and mineshaft locations around the island to gain insight into which bat species are present along with their population dynamics, eating patterns, living conditions and to document any stressors or disruptions (Parque Nacional Arikok). A follow-up survey is planned for 2020. Curaçao has also established a bat monitoring program, which has helped to draw attention to the fact that several of their local species have dwindling populations (Petit et al., 2006).

In 2011, STINAPA Bonaire worked to map many of the caves on Bonaire. Since 2016, Bonaire’s Caribbean Speleological Society (CARIBSS) has worked to explore, map, protect and manage the caves of Bonaire (Simal, 2016). In 2017, CARIBSS and WILDCONSCIENCE initiated the “Bonaire Caves & Karst Nature Reserve” project, aiming to manage caves, certify guides and close off maternity caves to protect local bat populations. Already, this organization has been able to partition off important nursery chambers to help minimize human impact.

While protecting these caving systems is important, it represents only part of the conservation requirements. It is also important to protect the food sources for these species. This includes natural vegetation on the islands, freshwater drinking sources, along with the biodiversity of insects, both as a food source and as a means of maintaining the biodiversity of native plant species.

Lesser long-nosed bat, photo by: © Christian König
The Dutch Caribbean islands to the north (Saba, St. Eustatius and St. Maarten) are known to host 8 different species of bats. Due to Saba and St. Eustatius' volcanic origin, they do not have as many caves as the ABC islands. St. Eustatius completed its first ever comprehensive assessment of its local bat population in 2015, which identified five different species inhabiting the island (Pedersen et al., 2018). Seven species of bats known to inhabit Saba (Pedersen et al., 2013). Saba's Sulphur mine serves as a type of cave, along with natural erosion cavities which form along the steep cliff edges along the coast. Caves on St. Eustatius are threatened by urbanization, invasive species (such as feral cats, dogs and rats) and disruption by visitors (Pedersen et al., 2018). In addition, on St. Eustatius, it is believed that clearing of the island's vegetation for agriculture and charcoal production has negatively impacted the local bat populations, shifting the balance towards species more able to adapt to these newer environmental conditions (van Andel et al., 2016).

St. Maarten hosts seven known bat species (Pedersen et al., 2013), of which, two species were recorded for the first time during a 2007 study (Genoways et al., 2007). Local populations on St. Maarten appear to be slightly lower than neighboring islands, highlighting the importance of conservation efforts on the island for these species (Genoways et al., 2007). Furthermore, the rapid decrease of native flora paired with limited freshwater sources additionally stresses local bat populations. An important cave on the island, Devil's Den along with two associated tunnels which previously housed bat populations, have been filled and leveled to allow a housing development project to build on this site. If St. Maarten hopes to preserve its native bat populations, increased efforts need to be made to preserve the remaining habitat.

There has been a significant push recently to increase public awareness of the importance of these species, to encourage minimizing negative human impact. This section will outline the current state of bats within the Dutch Caribbean and highlight the research and ongoing projects which took place over the past year. For more information, please see the full BioNews articles, which have been indicated along with the article title below.

<table>
<thead>
<tr>
<th>Species</th>
<th>Aruba</th>
<th>Bonaire</th>
<th>Curaçao</th>
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</thead>
<tbody>
<tr>
<td>Artibeus planirostris</td>
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<tr>
<td>Artibeus jamaicensis</td>
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<tr>
<td>Brachyphylla cavernarum</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Molossus molossus</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Molossus molossus</td>
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<td>Myotis nigricans</td>
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<td>Natalus tumidirostris</td>
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<tr>
<td>Noctilio leporinus</td>
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<tr>
<td>Peropteryx macrotis</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Pteronotus dasyi</td>
<td>x</td>
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Summary of Bat Species of the ABC islands (Hoffman et al., 2019)

<table>
<thead>
<tr>
<th>Species</th>
<th>Saba</th>
<th>St. Eustatius</th>
<th>St. Maarten</th>
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</thead>
<tbody>
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<td>Ardops nichollsi</td>
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</tr>
<tr>
<td>Antiebus jamacensis</td>
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<tr>
<td>Brachyphylla cavernarum</td>
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<td>Molossus molossus</td>
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<tr>
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<tr>
<td>Monophyllus plethodon</td>
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<td>Natalus stramineus</td>
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<tr>
<td>Noctilio leporinus</td>
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<tr>
<td>Tadarida brasiliensis</td>
<td>x</td>
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</table>

Summary of Bat Species from Saba (Pedersen et al., 2013), St. Eustatius (Pedersen et al., 2018) and St. Maarten (Pedersen et al., 2013)
2019 Research and Project Results

Bonaire Caves and Karst Nature Reserve Project

A 2-year pilot project, started in the summer of 2017, created the 30-hectare Bonaire Caves & Karst Park in Barkadera (Simal, 2016). This project, funded by the Ministry of Agriculture, Nature and Food Quality, was a collaborative effort between WILDCONSCIENCE, Openbaar Lichaam Bonaire (Public Entity Bonaire) and The Caribbean Speleological Society (CARIBSS). This park comprises zones identified as “Important Areas and Sites for the Conservation of Bats in Latin America and the Caribbean” or AICOMs and SICOMs Projects. The goal is to provide overall management of these areas and protect the five species of local bats which play a critical role in the environment, serving as an important pollinator of local cacti and insect control (particularly mosquitos).

Caves are still available for public visits, however, new control and management of tourism within these areas will help reduce the impact of visitors as much as possible. This project hopes to give an upgraded and educational experience to visitors in a way which is “controlled, safe, educative, non-damaging and non-disturbing” (Simal, 2016). The Bonaire Caves & Karst Nature Reserve Project is planned to include nine geographic units which will be classified according to their fragility and value. Education is one of the most important first steps, which is why CARIBSS now offers a “Bonaire dry cave guide certification course”. This certification trains guides to sustainably interact with the caves and to appropriately respond to emergency situations (bonairecaves.com).

In addition to increased educational awareness of the park, fencing has been put into place to keep feral livestock (donkeys, goats, sheep and pigs) from grazing. This should give native plants the opportunity to recover and reforest the area (Simal, 2016). In addition, existing waste has been removed and large boulders have been put into place near the entrances of the caves to keep motor vehicles from entering to reduce the likelihood of additionally illegal dumping.

This project has also shed light on the previously unknown life cycles of two species of insect-eating bats on Bonaire. These species were found in a cave located in the Bakuna area, where scientific research has never been conducted before. This research worked to define the annual usage patterns for the three different species of bats which inhabit this cave. They conducted monthly captures at the cave’s entrance for 12 continuous months, using one harp trap and two 6-meter mist nets. Captured specimens provided basic but essential information: species ID, gender, age, their reproductive condition (sexually active males, pregnant females, lactating females, post-lactating females), weight, parasites load and overall health. Additionally, they collected feces to look for microplastics and other contaminants. All individual bats captured were released after the data was collected. After 12 of these sessions, it was determined what species of bats are using this cave as a maternity chamber at different points throughout the year. A second year of collection is still ongoing in order to corroborate the reproduction cycles. This information is crucial to provide proper protection and management to these bat populations (bonairecaves.org).

A sustainable future on Bonaire must include protection both above and below the surface. The caves and karsts of Bonaire provide habitat and breeding grounds for a variety of critical species. Proper management and increased education of the importance of these areas will help ensure the protection of these fragile areas in the future.
MARINE MAMMALS
An important step in the conservation of marine mammals was the establishment of the Yarari Marine Mammal and Shark Sanctuary on September 1, 2015. The Yarari Sanctuary comprises all the waters of Bonaire and Saba, and since September 2018, St. Eustatius. Of the 33 species of marine mammals known to reside in the Caribbean, at least 20 species are known to inhabit the waters of the windward and leeward Dutch Caribbean islands (Debrot et al., 2011). For many of these species, the waters in this region serve as primary habitat for critical activities such as feeding, mating and calving. Information concerning these species comes mostly from visual observations that have been reported, although a new emphasis on the importance of research and conservation means more quantitative data will be collected in the upcoming years.

Each island provides a different, yet important habitat for a variety of marine mammals. It is thought that the waters around Saba and Saba Bank provide important areas for migration, wintering and food foraging for many species of marine mammals. These waters are especially important for wintering humpback whales, migrating dolphins and a local population of sperm whales (Debrot et al. 2013, 2014). Bonaire’s proximity to an important upwelling area and several migration routes makes it very appealing to a variety of marine mammal species (Debrot et al, 1998). Little is known about the marine mammals around St. Eustatius, highlighting a knowledge gap which can hopefully be filled with future research such as the hydrophones which will be installed next year as part of the Cari’mam project.

There are many issues threatening marine mammals, such as: overfishing of prey, physical collisions with vessels and ships, noise and water quality pollution, and degraded habitats due to climate change. 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. The most recent State of Nature Report, published by Wageningen University assessed the “conservation status” of marine mammals for the Dutch Caribbean as “moderately unfavorable”.

This section will outline the current state of marine mammals within the Dutch Caribbean and highlight the research and ongoing projects which took place over the past year. For more information, please see the full BioNews articles, which have been indicated (when applicable) along with the article titles below.

For more information on marine mammals in the Dutch Caribbean, please see the 2018 Special Edition BioNews on the Yarari Sanctuary.

Toothed Whales
Over 20 different species of toothed whales are suspected to inhabit the waters around the Dutch Caribbean islands. Although historical data is lacking, new research is giving scientists more insights into how these waters are utilized by these species. The table below gives an overview of the species believed to reside in these waters. As it can be seen, 2 species are suspected but not confirmed, and many of the other species have only been identified through visual reports. Previous research, such as that conducted by Debrot (1998), Risch et al. (2014), Risch and de Haan (2016) and Heenehan & Stanistreet (2017) have provided scientific data to support these visual sightings through visual and acoustic detection.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SCIENTIFIC NAME</th>
<th>Aruba</th>
<th>Bonaire</th>
<th>Curaçao</th>
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<tr>
<td>Spinner dolphin*#</td>
<td>Stenella longirostris</td>
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<tr>
<td>Pantropical spotted dolphin*</td>
<td>Stenella attenuata</td>
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<tr>
<td>Striped dolphin</td>
<td>Stenella coeruleoalba</td>
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<tr>
<td>Risso’s dolphin</td>
<td>Grampus griseus</td>
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<td>Melon-headed whale</td>
<td>Peponocephala electra</td>
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Marine mammal occurrences in the windward and leeward Dutch Caribbean (Based on Debrot et al. 2011a; Witte et al. in prep)
T = possible occurring no sightings confirmed; S = stranded or found dead; V = (visual) sighted alive; B = both (stranded and sighted alive); † = extinct; * documented from the area before 1998; # recorded by Debrot (1998); ♪ acoustic detection by Risch et al. (2014), Risch and de Haan (2016) or Heenehan & Stanistreet (2017)
**Transboundary Species - Content**

Marine mammal occurrences in the windward and leeward Dutch Caribbean (Based on Debrot et al. 2011a; Witte et al. in prep)

? = possible occurring no sightings confirmed; S = stranded or found dead; V = (visual) sighted alive; B = both (stranded and sighted alive); † = extinct;

* documented from the area before 1998; # recorded by Debrot (1998); ♪ acoustic detection by Risch et al. (2014), Risch and de Haan (2016) or Heenehan & Stanistreet (2017)

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<td>Kogia breviceps</td>
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<tr>
<td>False killer whale</td>
<td>Pseudorca crassidens</td>
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<tr>
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<td>Blainville's beaked whale</td>
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<td>Gervais' beaked whale#*</td>
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<td>S</td>
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<td>Dwarf sperm whale*</td>
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<tr>
<td>Sperm whale*</td>
<td>Physeter macrocephalus</td>
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**Overview**
**Baleen Whales**

There are 6 species of baleen whales which are suspected to inhabit the waters around the Dutch Caribbean islands. Unfortunately, there is a lack of quantitative data for these species, with four of the six having no confirmed sightings. Acoustic research conducted in Saba and Saba Bank detected both the common minke whale and the humpback whale in 2016. Previous research, such as that conducted by Debrot (1998), Risch et al. (2014), Risch and de Haan (2016) and Heenehan & Stanistreet (2017) have provided scientific data to support these visual sightings through visual and acoustic detection.

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**Marine mammal occurrences in the windward and leeward Dutch Caribbean** (Based on Debrot et al. 2011a; Witte et al. in prep)

- \( ? \) = possible occurring no sightings confirmed; \( S \) = stranded or found dead; \( V \) = (visual) sighted alive; \( B \) = both (stranded and sighted alive); \( † \) = extinct;
- \( * \) = documented from the area before 1998; \( # \) = recorded by Debrot (1998); \( ♪ \) = acoustic detection by Risch et al. (2014), Risch and de Haan (2016) or Heenehan & Stanistreet (2017)

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**Overview**

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<td><em>Balaenoptera acutorostrata</em></td>
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<tr>
<td>Humpback whale*# ♪</td>
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<td>V ‡</td>
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</table>
Manatees

The Antillean manatee, (*Trichechus manatus manatus*) a subspecies of the West Indian Manatee has become quite rare within the Dutch Caribbean. With an estimated population size of less than 6,700 (Castelblanco-Martínez et al., 2012), they are sparsely distributed within the Caribbean waters ranging from the Bahamas to Brazil (Deutsch et al. 2008). There is a small subpopulation which inhabits the northern Caribbean coast of South America, which has been estimated at around 400 individuals (Castelblanco-Martínez et al., 2012). Recently, a few sightings both along the South American coast and around the ABC islands, give a brief insight to this remaining population.

In 2018, manatee sightings were reported first on Aruba (January) and then later on Bonaire (July), which suggests that they still use these waters (Debrot et al., 2006). Historically, the Antillean manatee could have been spotted around all six of the islands, thus stressing the importance of establishing and maintaining sanctuaries throughout the Dutch Caribbean, to hopefully rehabilitate this species and protect it from extinction.

A recent study worked to compile these sightings with historical records to better understand the southeastern Caribbean subpopulation. With only 4 known sightings within the last decades, manatees are very rare around Bonaire and Curaçao. With little freshwater available for manatees, coupled with deep waters and strong currents separating these islands from the mainland Venezuelan population, researchers are doubtful that movement between the islands and mainland is common (Debrot et al., 2019). Therefore, manatees sighted around these islands have most likely drifted accidentally, or have wandered away from their normal habitat in search of food. It is believed the nearest population comes from Lake Maracaibo, Venezuela, where daytime sightings are common, despite the fact that the conservation status of these species is still in question and actual population counts are still unknown (Boede et al., 2015). This study concluded that the sporadic manatee sightings along the islands are most like the result of stray individuals originating from Lake Maracaibo (Debrot et al., 2019).
New Study Sheds Light on Marine Traffic’s Impact on Whales

The Caribbean Humpback Acoustic Monitoring Program (CHAMP) used acoustic recorders to gain insight into local humpback whale populations, expanding previous coverage and encouraging collaboration between many organizations. This study took place between December 2016 and June 2017 around the islands of the Dominican Republic, Saint Martin, Guadeloupe east and west, Martinique, Aruba and Bonaire. The results of this study were published in July 2019 under the title “Caribbean Sea Soundscapes: Monitoring Humpback Whales, Biological Sounds, Geological Events, and Anthropogenic Impacts of Vessel Noise” (Heeneman et al., 2019).

Acoustic Monitoring

Sound travels much faster in water than it does through air, making acoustic sensors much more adapted for studying marine life than more traditional visual methods (NOAA, 2018). Oceanic sounds can typically be broken down into three categories: sounds which come from geological or physical processes (e.g., earthquakes or strong winds), sounds from living things (e.g., marine mammals or fish) and anthropogenic noise (ship traffic, military testing, surveying) (Krause and Gage, 2003; Pijanowski et al., 2011). Passive acoustic monitoring allows researchers to record these noises to better understand what species are utilizing an area, how they move throughout the space and to what extent human activity is impacting a particular environment.

During the CHAMP study, two different types of acoustic devices were used. The first, Marine Autonomous Recording Units (MARU) was used in six of the locations, including Bonaire and Aruba. These devices are typically used to record low frequency sounds, useful for picking up whale songs and noises from passing ships. The second type of device, SoundTrap, was used in three locations, including Saint Martin and Bonaire. SoundTrap records at a high sampling rate, which allowed for the detection of higher frequency sounds, useful for recording dolphin and sperm whale related noises.

Interference with Whales

Anthropogenic noise can have many negative consequences within an environment. One of the most notable issues is a phenomenon known as “masking”, when a particular noise disturbs or inhibits a receiver’s ability to interpret a sound (American National Standards Institute, 1994; Clark et al., 2009; Erbe et al., 2016). One well documented example of masking is shipping noise impeding the ability for whales to communicate amongst each other (e.g. Cholewiak et al., 2018; Hatch et al., 2012, 2016).

The Caribbean economies, more so than almost any other area in the world, are heavily depend ent on marine traffic. These waters are constantly being crossed by large container ships and cruise ships, resulting in a significant amount of low-frequency anthropogenic noise pollution which could potentially mask important sounds for a wide variety of marine fish and animals (e.g., Weilgart, 2007; Hatch et al., 2008; Hildebrand, 2009; Erbe et al., 2012; McKenna et al., 2012; Merchant et al., 2014; Williams et al., 2015). Since these waters are also home to many protected species, understanding how these noises are affecting local populations is critical in managing their protection. Humpback whales are a particularly important protected species which can be found throughout most of the Caribbean. The research sites for this study were specifically selected to line up with humpback whale breeding grounds (Kennedy, 2018). Furthermore, male humpback whales are known for their loud songs, audible throughout these breeding grounds (Herman, 2017; Payne and McVay, 1971; Vu et al., 2012), which made them the perfect subject for these experiments.

CHAMP Dutch Caribbean Results

Acoustic recordings were made using a MARU device on Aruba, a SoundTrap device on Saint Martin, and one of each device on Bonaire. The recorder near Aruba was the only recorder to be located outside of a marine protected area during this study. Located on the northern side of the island, it was located near a heavily used shipping channel. The site selected for Bonaire was located within the marine park, removed from the main ports. The device on Saint Martin was located within the National Nature Reserve, off of the French owned northern coast.

Although humpback whales were detected within five of the seven research sites, this study did not detect humpback whales around either Aruba or Bonaire. However, humpback whales have been reported in previous studies around Aruba and Bonaire (Debrot et al., 2011). No marine mammals were detected from the Aruba recordings, this is most likely due to its proximity to a major shipping lane. In the future, a site located in less trafficked waters may give researchers a better idea of the biodiversity within Aruba’s waters. Humpback whales were detected near Saint Martin throughout the entire deployment period (January through June of 2017). Recordings detected humpback whale songs on 90% of the days throughout the test. Due to the fact that the whale songs were detected on the first and last day of recording, researchers believe that the whale songs are present over a wider window not fully characterized by this study.

Acoustic readings from Bonaire did register both dolphin and sperm whale, along with a variety of other fish sounds which were not further evaluated during this study. Due to Bonaire’s proximity to a deep underwater trench which runs between Bonaire and Venezuela, it is not surprising that sperm whales, known for being a deep-diving species, would be found in these waters. In addition, there are at least six species of dolphins known to inhabit the waters around Aruba, Bonaire and Curacao (Luksenburg, 2014; Geelhoed et al., 2014). For Saint Martin, dolphins were recorded only once during testing.

Marine boat traffic was analyzed over a two-week period in March of 2017. During this time in Aruba, 93% of the hours recorded ship noise, the second highest value in the study. The actual number of ships could not be calculated as it was difficult to distinguish between specific ships with near constant noise being recorded. Bonaire ranked right in the middle, with 54% of the hours showing the presence of ships. During this test, very few ships were detected at night which suggests that a large portion of this noise signature could be attributed to shipping.
to smaller recreational or fishing ships. Saint Martin had the second lowest amount of vessel noise detected, at 30%, which overlapped with humpback whale songs being detected 29.8% of the time. However, due to the location of the recorder, far away from the main port, along with the limited number of hours recorded each day, 6 hours, this may not represent the full overlap of both the vessel and whale song noise.

Another interesting note from the study was that on April 17th, 2017, a 5.6 magnitude earthquake was registered with an epicenter near the Flinn Engdahl region of Antigua and Barbuda. The earthquake was registered on all acoustic device within 8.75 minutes. Aftershocks of the earthquake were also registered on all recording devices.

Marine Park Management

The Yarari Marine Mammal and Shark Sanctuary was established in the Dutch Caribbean on September 1, 2015. The name of the Sanctuary “Yarari” is a Taino Indian word, meaning “a fine place”. It is intended to provide “a fine place” for marine mammals, sharks and rays where they will receive the necessary attention to ensure their protection. It is intended to eventually also include the other Dutch Caribbean islands: Aruba, Curaçao and St. Maarten.

This study gives researchers and policy makers a more detailed look at the impact of human activities on species inhabiting local waters. The clear lack of marine animal noises registered off Aruba shows how excess noise pollution may drive marine life away. Understanding ship traffic’s noise patterns and its effect on local marine mammals can help shape the legislation required to properly protect these species in the future.
The importance of both commercial shipping and recreational cruise ships will remain a driving force in Caribbean economics. It will continue to be of the upmost importance that governmental agencies, researchers and conservationists continue to work together to minimize human impact on these waters to ensure a healthy ecosystem in the future. More long-term monitoring studies are needed to fully understand our impact on the marine environment. A more complete understanding of which species are present and how various species are using these waters can help mold how marine parks are managed in the future. One important step could be minimizing ship traffic within migration lanes needed for many of these critical species. Research such as CHAMP is vital in filling in knowledge gaps and will help shape a more comprehensive conservation plan of our marine protected areas and sanctuaries into the future.

### 2019 Research and Project Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Hourly Vessel Presence (%)</th>
<th>Vessel passes (n)</th>
<th>Average vessel duration (min)</th>
<th>Vessel duration range (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aruba (AR)</td>
<td>100%</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Bonaire (BO)</td>
<td>53.57%</td>
<td>441</td>
<td>7.01</td>
<td>0.09-105.10</td>
</tr>
<tr>
<td>Dominican Republic (DR)</td>
<td>20.23%</td>
<td>209</td>
<td>0.33</td>
<td>0.02-2.08</td>
</tr>
<tr>
<td>Guadeloupe East (GE)</td>
<td>76.78%</td>
<td>1084</td>
<td>7.56</td>
<td>0.02-119.46</td>
</tr>
<tr>
<td>Guadeloupe West (GW)</td>
<td>99.11%</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Martinique (MA)</td>
<td>52.38%</td>
<td>1241</td>
<td>2.22</td>
<td>0.02-66.78</td>
</tr>
<tr>
<td>St. Martin (SM)</td>
<td>29.76%</td>
<td>60</td>
<td>0.55</td>
<td>0.02-5.43</td>
</tr>
</tbody>
</table>

The number of vessel passages, average passage duration, and range of passage durations were measured for all sites where it was possible to visually distinguish individual vessel passages in spectrograms (Aruba and Guadeloupe West had near-continuous vessel presence and individual passage durations could not be measured).
New Insight into the Caribbean’s Marine Mammal Populations

The Caribbean Marine Mammals Preservation Network (CARI’MAM) project aims to develop a network of marine protected areas dedicated to the conservation of marine mammals in the Greater Caribbean and beyond. A project is set up which uses a network of underwater hydrophones to detect and identify marine mammals across the Caribbean. This project will grant researchers access to continuous, wide-ranging information on these critical species and will help guide conservation efforts into the future.

It is suspected that at least a third of the world’s whale and dolphin population use the wider Caribbean region at some point throughout their life cycle. Although these animals have significant cultural and economic value, little is known about their presence. There are still significant knowledge gaps concerning which species are present, how they use these waters and how they move throughout the Caribbean. Filling these gaps will be crucial in designing, implementing and managing conservation plans to protect these dynamic species in the future.

Modern Research

Historically, most research on these species have been gathered through visual, opportunistic sightings. Marine mammals can be hard to track due to their presence. There are still significant knowledge gaps concerning which species are present, how they use these waters and how they move throughout the Caribbean. Filling these gaps will be crucial in designing, implementing and managing conservation plans to protect these dynamic species in the future.

Fortunately, researchers have found a way to exploit an important feature of these species. Whale and dolphins use sound to navigate, find food and to communicate with each other over long distances. A new, non-invasive method, using an underwater microphone (hydrophone), can take advantage of this fact and can be used to track these creatures as they use or pass through an area.

Known as Passive Acoustic Monitoring (PAM), this method is a cost effective, year-round solution for monitoring and tracking whales and dolphins. An advantage of using PAM is that it is acoustic based and deployed underwater, therefore data can be collected 24 hours a day regardless of extreme weather conditions or luminosity. In addition, the automated detection and classification of sounds allows for data to be collected throughout a wide network in a standardized way.

CARI’MAM Project

The CARI’MAM project is working to create a Caribbean wide network for these hydrophones. Initially started in 2018, this project will continue through 2020. In February 2020 more than 20 hydrophones will be deployed around 16 islands including Aruba, Bonaire and St. Eustatius. Installations will continue into late 2020, with probably more island interring the network. Saba has already deployed similar hydrophones as part of a preliminary study and has AMAR noise loggers. St. Martin was unable to attend the required training session; however, researchers are still working to find a way to include them in the network as well.

Saba leading the way

Before the project could get into full swing, researchers wanted to run preliminary test to decide which hydrophone to use. St. Barthélemy and Saba were selected to host a single hydrophone each for a 10-day trial. These tests were so successful it was decided that full deployment could begin.

Although detailed analysis has not yet been completed, there has been a few preliminary results which the team is happy to present. They’ve found that humpback whale sounds have been easily detected and identified through simple algorithms. Next, the algorithms have had difficulty distinguishing between specific dolphin species, however the delphinid group (oceanic dolphin) can be detected and identified from other dolphin groups. Lastly, they’ve had success detecting and identifying sperm whales. In fact, algorithms have been able to identify sperm whales sizes to allow minimum abundance population estimates and possible nurseries area.

Data Analysis

In order to improve the neural network analysis, a project have been set up by the Agoa Sanctuary to create a song database. Recording of the maximum of species confirmed by visual observation will be made in a standardized way with information on the number of individuals, behavior and distance from the hydrophone. This study will also give information on anthropogenic noises to allow their classifications. This database will be accessible for all, after publication.

The use of hydrophones to collect information on marine mammals will allow researchers to collect wide-range, continuous data beyond what has ever been done before in this region. Furthermore, by applying algorithms and removing the human factor, researchers will be able to sort and analyze large volumes of information in a standardized way with increased accuracy.

Through this project, researchers are hoping to analyze species richness, seasonality and distribution throughout the Caribbean. They are also hoping to expand this to include information such as: relationships between species, anthropogenic impacts, behavior shifts, habitat preferences, and more. This information will be vital in helping local governments, scientists and conservationists alike in managing efforts to protect marine mammals throughout the Caribbean. We look forward to seeing future results from the CARI’MAM project and to see its positive impact on the Caribbean’s marine mammal populations.
New Information on the Migratory Patterns of Caribbean Humpback Whales

Once thought to be of a single population, new research indicates key differences between migration routes and seasonality between humpback whales of the north and southeastern Caribbean. Understanding that there are two separate population groups is key in designing conservation plans to protect these vital species throughout both the Caribbean and Northern Atlantic regions.

The Caribbean plays an important role in the life cycle of humpback whales, as they often use these waters for mating and calving, especially during the winter months. Historical evidence shows that this was particularly true around the southern Lesser Antilles islands (Reeves et al., 2001). Overhunting of these whales during the 19th and 20th century has led to much lower current populations (Winn et al., 1975; Levenson and Leapley, 1978; Swartz et al., 2003). Recent research has focused on the humpback whale population which moves between winter breeding and calving areas off the shores of Dominican Republic and Puerto Rico to their summer feeding grounds of the western North Atlantic (Mattila and Clapham, 1989; Stevick et al., 1999; Smith et al., 1999; Fleming and Jackson, 2011).

Although it is also known that there are humpback whales located within the southeastern Caribbean (south of Antigua), information on their migration patterns is very limited. In the past five years, over 200 individuals have been spotted off the coast of Guadeloupe alone. To fill in this knowledge gap, a recent study worked to compile information on the different migratory routes and patterns of the Caribbean humpback whales to gain insight into the differences in these two populations.

Photography to Track Whales

This study, led by Peter Stevick from the College of the Atlantic, focused on the waters south of Antigua and north of the Venezuelan coast. Using tail fluke patterns, 262 individual humpback whales were identified and documented between 1972 and 2014, and with the exception of 8, all have been photographed since 2000 (Stevick et al., 2018). These recent photographs were then cross-examined against documented individuals from the North Atlantic Humpback Whale Catalogue (NAHWC) and the Northern Norway Humpback Whale Catalogue (NNHWC). Next, these photographs were then compared against sightings within known feeding grounds in two areas, western and eastern North Atlantic.

For the whales documented in the southeastern Caribbean, the number of re-sighted individuals found near Norway (western North Atlantic) was nine times that of those documented off the Gulf of Maine (eastern North Atlantic). This result highlights a preference for the southeastern Caribbean whales to migrate towards Norway.

Another unique way to distinguish between individual whales is to look for visible scarring along their flukes caused by altercations with killer whales. When comparing all 262 whales spotted in the southeastern Caribbean with populations from Norwegian waters it was found that they exhibited nearly identical scarring rates (McCordic et al., 2014). Furthermore, these values were significantly different when comparing scarring rates to populations in the Gulf of Maine, Canada and Greenland (McCordic et al., 2014). Overall, whales which use feeding grounds of the eastern North Atlantic had a much lower scarring rate, implying fewer physical interactions with killer whales than those of the western North Atlantic.
Visual and Acoustic Methods
Through direct observations and acoustic surveys, researchers were able to track the time of year humpbacks passed through these waters. Using information recorded by the Association Evasion Tropicale (AET) between 1998 and 2009, researchers gathered 7,700 hours of data (Rinaldi and Rinaldi, 2011). Visual observations were collected near Guadeloupe through the Observatoire des Mammifères Marins de l’Archipel Guadeloupeen (OMMAG).

Migration timing for the humpback whales were analyzed based on visual and acoustic sampling. Visual observations were reported as early as November, but the number of sightings in this region were very low until early February. The highest number of visual sightings occurred in March and April, and then declined quickly in May with only a few sightings reported in June. Interestingly, acoustic detections peaked slightly earlier than what was visually reported.

Differences in Populations
This research highlighted two ways in which the population of the southeastern Caribbean humpback whales differ from the northern Caribbean population. Firstly, through comparing visual observations, along with scarring rates of individual flukes, it is clear that there is a tendency for the southeastern Caribbean population to migrate and feed in the eastern North Atlantic, closer to Norway. This is different from the population of humpback whales off the Dominican Republic which are more likely to be spotted in the western North Atlantic, near the Gulf of Maine and Canada.

The second largest difference between these populations is related to the migratory patterns. It appears that the southeastern Caribbean whales peak about six weeks later than their northern counterparts. The peak season for humpback whales near the Dominican Republic is between January and March (Balcomb and Nichols, 1982; Whitehead and Moore, 1982; Whitehead, 1982).

Impact on Conservation Efforts
Understanding the differences in populations of humpback whales and how they utilize and move through the Caribbean will help guide conservation efforts and management into the future. Once thought to be a single population, it is now clear that the humpback whales of the Caribbean represent two separate groups. Knowing that these two populations exhibit different migratory patterns will help local governments, conservationists and researchers build holistic management plans to ensure the protection of this species into the future.
SHARKS AND RAYS

Photo by: © Jim Abernathy
As stated in the previous section, the establishment of the Yarari Marine Mammal and Shark Sanctuary was an important step in protecting the shark and ray species of the Dutch Caribbean. Overall, there is a significant lack of information concerning these vital species within Dutch Caribbean waters. Fortunately, this trend is changing and in the last few years there has been a push to increase research, filling in the historic knowledge gap. Sharks and rays are difficult species to protect as they tend to have long reproduction cycles, varying between 3 and 30 years, small litters, which means they do not recover quickly when overfished and can travel over great distances which makes them difficult to track.

Early in 2019, the Ministry of Agriculture, Nature and Food Quality (LNV) published a strategy document to manage and protect sharks and rays within waters the Netherlands influences (this includes the North Sea, Dutch Caribbean and other international waters). This new strategy officially makes fishing for or possessing shark parts punishable by law in Bonaire, St. Eustatius and Saba. This new plan offered unprecedented protection of sharks and rays through the use of international treaties, research and public awareness. This strategy now officially forbids owning or fishing for sharks in the Netherlands and places new pressure on fishermen to implement new techniques and updated fishing gear to avoid accidentally catching sharks and rays as bycatch.

There are several different international treaties and legislation which offer protection to these species. This includes the Convention on International Trade in Endangered Species (CITES), the Specially Protected Areas and Wildlife (SPAW) protocol and the Convention on Migratory Species (CMS). Scientists are just beginning to uncover the complexities of managing conservation efforts for these species, as they often have long migration routes which put them in danger if international waters are not managed and protected equally.

There are more than thirty different species of sharks and rays which are known to inhabit the waters around the Dutch Caribbean. The list below is an overview of documented species, but does not include any that are possibly occurring, meaning there are no confirmed sightings (Beek et al., 2014; Davies & Piontek, 2017).

For more information on sharks and rays in the Dutch Caribbean, please see the 2018 Special Edition BioNews on the Yarari Sanctuary. For more information on DCNA’s Save Our Sharks: please see the Special Project report.
This section will walk through an overview of the shark and ray species known to inhabit the waters of the Dutch Caribbean. It will also cover important research projects which were completed over the last year. For more information, please see the full BioNews articles, which has been indicated along with the article titles below. Hopefully, the prioritization of shark and ray protection, coupled with new information on these species, will allow for a comprehensive plan to be put in place to better protect these important species into the future.

<table>
<thead>
<tr>
<th>FAMILY</th>
<th>SPECIES</th>
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<tr>
<td>Whale Shark</td>
<td>Whale shark</td>
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<tr>
<td>Nurse Shark</td>
<td>Nurse shark</td>
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<td>Requiem Sharks</td>
<td>Caribbean reef shark</td>
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<td>Blacktip shark</td>
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<td>Lemon shark</td>
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<td>Bull shark</td>
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<td>Sandbar shark</td>
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<td>Smooth hammerhead</td>
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<td>Scalloped hammerhead</td>
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<td>Basking shark</td>
<td>Basking shark</td>
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<td>Mackerel sharks</td>
<td>Shortfin mako</td>
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<td>Thresher sharks</td>
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<td>Six/sevengill sharks</td>
<td>Big-eye sixgill shark</td>
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<td>Blunt nose sixgill shark</td>
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<td>Dogfish sharks</td>
<td>Cuban dogfish shark</td>
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<td>Cookiecutter shark</td>
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<td>Gulf Chimaera</td>
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<td>Sawfishes</td>
<td>Smalltooth sawfish</td>
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<td>Stingrays</td>
<td>Spotted eagle ray</td>
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<td></td>
<td>Southern stingray</td>
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<tr>
<td>Manta/Devil rays</td>
<td>Giant manta ray</td>
</tr>
</tbody>
</table>

Table: Overview of documented species, but does not include any that are possibly occurring, meaning there are no confirmed sightings. (Beek et al., 2014; Davies & Piontek, 2017.)
Two species of endangered elasmobranch are recommended to receive additional protection in the Caribbean (BioNews 22). Sharks have been vilified and exploited for decades, and the International Union for Conservation of Nature (IUCN) now estimates that one-quarter of the world’s sharks and rays are threatened with extinction due to human activities. From the destruction of important nursery grounds to the endless appetite for shark fin soup, these formidable apex predators have been treated as if they are an infinite resource. Once abundant in reefs throughout the Caribbean, sharks are now often a scarce sight. Other species of elasmobranch, such as rays and sawfish, are also rapidly declining.

The Kingdom of the Netherlands has been at the forefront of shark conservation since 2015 when the DCNA, with generous funding from the Dutch Postcode Lottery, launched the “Save Our Sharks” project. This project has achieved much through local research, monitoring and education. In addition, the establishment of the Yarari Marine Mammal and Shark Sanctuary in 2015 was a major achievement in shark conservation. Unfortunately, due the migratory behavior of sharks, these measures only go so far in helping to protect these species. A cooperative approach is needed providing protection within the waters of all countries through which the sharks and rays migrate, especially near establish nursing grounds.

In a bid for regional cooperation and cross-border protective management of endangered species and habitats, 25 Caribbean countries, including the Kingdom of the Netherlands, have legally pledged to work together to protect and manage the Wider Caribbean Region’s coastal and marine resources through the Specially Protected Areas and Wildlife (SPAW) Protocol. This legally binding environmental treaty requires signatory countries to cooperate with each other to either fully protect species (those listed in Annex II) or ensure their sustainable use (those listed in Annex III).

The year 2017 saw a huge win for elasmobranch conservation when, following a request from the Netherlands, the first seven species of sharks and rays were added to the Protocol’s Annex III (oceanic whitetip shark, whale shark, two species of manta ray and three species of hammerhead shark) and the smalltooth sawfish to Annex II.
Thanks to the efforts of the Dutch Ministry of Agriculture, Nature and Food Quality (LNV) and the Dutch Elasmobranch Society (NEV), the critically endangered largetooth sawfish and the threatened silky shark have been recommended by the SPAW scientific and technical advisory committee for addition to Annex II and Annex III of the SPAW Protocol. “Through the SPAW protocol, signatory countries have made firm commitments to ensure the protection of these unique animals throughout their Caribbean range” explains Paul Hoetjes, Coordinator of nature policy for the Caribbean Netherlands of LNV.

The largetooth sawfish resembles a shark but is in fact a species of ray with a flattened head and distinct saw-like snout (rostrum) that protrudes from the head and has protruding teeth along its margins. The population of this sawfish species, which was labelled as “the elasmobranch species most in danger of extinction” in a 2014 study, has drastically declined and the sawfish has been listed as Critically Endangered since 2013.

The silky shark is a large but slender oceanic shark that gets its name from the smooth and silky texture of its skin. The IUCN Red List status of the silky shark was adjusted in 2017 from “Near Threatened” to “Vulnerable” due to an estimated 47-54% decline of the global population over three generations.

Both species are under pressure from a large number of threats, including overfishing and accidental bycatch. The silky shark is favored for its fins, and is ranked amongst the three most important sharks in the global shark fin trade, with up to 1.5 million fins being traded annually from this species alone. Silky sharks are also highly susceptible to incidental capture in tuna and swordfish fisheries due to their dietary preference, and the long snout of the largetooth sawfish easily gets tangled in fishing nets. The life history characteristics of elasmobranchs, notably their slow growth, late maturity and low fecundity (produce few young), means that these species have an especially hard time rebounding from exploitation.

The Dutch Caribbean islands are home to 26 shark species, among which are some of the most iconic species; such as whale sharks, tiger sharks and hammerheads (Beek et al., 2014; Davies & Piontek, 2017). Safeguarding these highly migratory species will require a continued cooperative approach between all countries through which they migrate, and an increase in safe havens like the Saba Bank and the Yarari Sanctuary. Thankfully, many countries in the Wider Caribbean Region are now working to protect these spectacular species, on which healthy oceans and island economies are so dependent.

**2019 Research and Project Results**

Largetooth Sawfish, photo by: © Simon Fraser University - University Communications.
At least ten reef-associated shark species in the Dutch Caribbean (BioNews 25).

There is a lack of knowledge concerning the distribution and abundance of shark and ray species throughout the Dutch Caribbean. To combat this knowledge gap, from 2015-2018, DCNA ran the “Save Our Sharks” (SOS) project for the Dutch Caribbean, funded by the Dutch Postcode Lottery. In this project, DCNA collaborated with local fishermen and scientists to build popular support for shark and ray conservation amongst the local community, as well as increasing knowledge about shark and ray species within the region by conducting a number of research projects.

Shark Research

A recently published study by Wageningen Marine Research, as part of DCNA’s SOS Project, established a baseline for current shark diversity, distribution, abundance, spatial behavior and population structure for inshore reefs around the Dutch Caribbean islands.

There were two methods used by the researchers to study sharks. One method used Baited Remote Underwater Video (BRUV) which used a device consisting of two cameras set in front of a baited feed bag. The idea is that as sharks come near the bait bag to feed, video footage can be collected to identify and count local shark populations. The other method used acoustic telemetry to track sharks. In this method, a small acoustic tracking device is implanted within the shark. Acoustic receivers are installed at specific locations, and whenever sharks with these transmitters travel near the receiver (within a range of 450 to 850 meters) they are recorded.

The first studies using BRUV were conducted on Saba, Saba Bank and St. Eustatius to better understand the local population of sharks and rays and their relative abundances, and were funded by the Dutch Government. Starting in 2015, as part of the SOS project, additional studies were conducted to include the waters around Bonaire, Curaçao and Sint Maarten. In 2017 a BRUV survey was done in Aruba, financed by Global Finprint by Masters-student Miranka van Breugel of the University of Groningen, in partnership with Wageningen University.

Acoustic telemetry was also used to better understand the movements of sharks, habitat use, migration and connectivity between islands. The telemetry study tracked two shark species, Caribbean reef shark (Carcharhinus perezi) and nurse shark (Ginglymostoma cirratum) around Saba (from 2014) and then around Saba Bank, Sint Maarten and Sint Eustatius (from 2015).

Findings

During the BRUV studies around Sint Maarten, Curaçao and Bonaire the most common detected shark species was the Caribbean reef shark, with Sint Maarten also frequently showing the greatest number of research projects.

The telemetry study tracked two shark species, Caribbean reef shark (Carcharhinus perezi) and nurse shark (Ginglymostoma cirratum) around Saba (from 2014) and then around Saba Bank, Sint Maarten and Sint Eustatius (from 2015).

Findings

During the BRUV deployments around Sint Maarten, Curaçao and Bonaire the most common detected shark species was the Caribbean reef shark, with Sint Maarten also frequently showing the presence of reef associated sharks. During the BRUV deployments around Sint Maarten, Curaçao and Bonaire the most common detected shark species was the Caribbean reef shark, with Sint Maarten also frequently showing the greatest number of research projects.

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There was an additional BRUV submarine test at a depth of 300 meters off Curaçao which found an additional shark species (Cuban dogfish). In total, at least 10 shark species were seen within the Dutch Caribbean during the different BRUV surveys.

The acoustic telemetry studies demonstrated that both the Caribbean reef shark and nurse shark have small home ranges and strong site fidelity. Large crossings between areas were rare, although there were a few cases in which two Caribbean reef sharks and one nurse shark travelled between Saba and Saba bank. The two Caribbean reef sharks made short directed journeys back and forth, whereas the nurse shark was detected in the Saba Bank after a two-year absence and then returned to Saba. One nurse shark from another study from the US Virgin Islands was detected in the network on the Saba Bank, a distance of at least 160 kilometers.

Importance of Protected Areas

Both the BRUV and acoustic telemetry studies showed higher presence of reef associated sharks within the conservation zones, along with high site fidelity and small home ranges. Furthermore, as some longer distance movements were also documented, interconnectivity between these areas is just beginning to be understood. The ongoing study on acoustic telemetry (funded by the Ministry of Agriculture, Nature and Food Quality (LNV)) will yield more data on this. Therefore, not only are local marine parks crucial for the conservation efforts of sharks and rays, but larger conservation networks, such as the Yarari Marine Mammal and Shark Sanctuary which includes all the waters of Bonaire, Saba and Sint Eustatius, are vital to protect entire populations.
Dutch Government Announces New International Shark Strategy
(BioNews 25)

The Dutch Ministry of Agriculture, Nature and Food Quality (LNV) has recently published a strategy to manage and protect sharks and rays within waters of the Netherlands, Caribbean Netherlands and international waters. This new strategy officially makes fishing for or possessing shark parts punishable by law in Bonaire, St. Eustatius and Saba.

On May 1st, Minister Carola Schouten, from the Ministry of LNV announced a new International Shark Strategy. This new plan will offer unprecedented protection of sharks and rays through the use of international treaties, research and public awareness. This strategy now officially forbids owning or fishing for sharks and places new pressure on fishermen to implement new techniques and updated fishing gear to avoid accidentally catching sharks and rays as bycatch.

This is exciting news for the Yarari reserve for sharks and marine mammals, a marine sanctuary around the islands of Bonaire, Saba and St. Eustatius. Since its establishment in 2015, with St. Eustatius joining in 2018, fishing for sharks and rays within the reserve has been prohibited. With the addition of this new strategy, legislation will be added to officially make this punishable by law. This also includes possessing shark parts, specifically shark fins. Tadzio Bervoets, DCNA’s Save Our Sharks (SOS) project leader states that “This is really good news for the endangered sharks around the BES-islands. We hope that also the three other, neighboring, Dutch Caribbean islands, Aruba, Curaçao and St. Maarten, will eventually be included in the Yarari Sanctuary to effectively protect these transboundary species.”

Important conservation strategies such as this, paired with initiatives such as DCNA’s SOS project (2015-2018) are crucial to ensuring a sustainable future for our oceans. An increase in research and public awareness will play key roles in the overall management and conservation efforts going forward.

More information:
Download the Internal Shark Strategy.
Satellites and Sharks: Latest in Saba Bank Shark Research (BioNews 26)

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), the Nature Foundation Sint Maarten (NFSM) and the European Space Agency (ESA). 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 on 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 study area. This gave scientists a new look into where the sharks were spending most of their time. An additional study used tissue samples from Caribbean reef sharks and Silky sharks to document the age and diets of each shark. This tissue analysis paired with the acoustic tag information gave a more holistic view on how these sharks are using 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

2019 Research and Project Results
**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 tracking 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 Dutch Caribbean Nature Alliance. During the expedition 4 tiger sharks were tagged.

**Nurse Sharks**

Lobster traps can cause issues for local nurse shark populations as they can easily be caught as bycatch 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 the work of a study from July 2018 to increase awareness of this issue with local fishermen, along with increasing researcher’s understanding of 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 determine 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.](https://duikeninbeeld.tv/saba-haaienexpeditie-2019-rolling-rolling)

Photo by: © Linda Ferwerda

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2019 Research and Project Results
SEA TURTLES
Overview

The Dutch Caribbean is home to five species of sea turtles. Each of these islands plays a slightly different, yet important role in the life cycle of sea turtles. Three out of these five species have been known to frequently nest on Bonaire (Eckert & Eckert, 2019), especially Klein Bonaire, which has historically had the second highest concentration of nesting hawksbill and loggerhead turtles in the south Caribbean (Becking et al., 2016). Aruba and Curaçao both provide important nesting and foraging areas for four of the five species known to visit the islands, although leatherback sea turtles nests are less common on Curaçao than Aruba (Eckert & Eckert, 2019). Saba and the Saba Bank provide important foraging areas for sea turtles, namely hawksbill and green sea turtles, who come to feed on algae and sponges (Lundvall, 2008; Eckert & Eckert, 2019). St. Maarten provides important foraging and nesting grounds for green and hawksbill sea turtles and nesting grounds for Leatherback turtles (Eckert & Eckert, 2019). Lastly, the beaches on St. Eustatius may be few but they are significant sea turtle nesting grounds within the Dutch Caribbean (Esteban et al. 2015).

The largest threats to local turtle populations come from degrading seagrass foraging fields, poor beach quality and disorientation from light pollution (Salmon, 2003). Further stresses caused by climate change, such as an increase in sargassum, are damaging seagrass fields necessary for foraging and affecting the turtle’s ability to nest on beaches. The most recent State of Nature Report, published by Wageningen University assessed the “conservation status” of sea turtles for the Caribbean Netherlands as “moderately unfavorable” (Debrot et al., 2018).

Sea turtle conservation has become a great success story for the Dutch Caribbean. There are a variety of different organizations which identify, monitor and protect known nests to ensure maximum success for hatchlings. These organizations also help to increase public awareness of the importance of these species, and what precautions should be taken while visiting local beaches to minimize detrimentally impacting any nests. This was an exciting year for sea turtle nesting, as all six Dutch Caribbean islands hosted sea turtle nests, including Saba, which is a rare occurrence.

Presence of Sea Turtles by Island (Eckert & Eckert, 2019)

<table>
<thead>
<tr>
<th>Island</th>
<th>Loggerhead Turtle</th>
<th>Green Turtle</th>
<th>Leatherback Turtle</th>
<th>Hawksbill Turtle</th>
<th>Olive Ridley Turtle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aruba</td>
<td>N, IF</td>
<td>N, F</td>
<td>N</td>
<td>N, F</td>
<td>I</td>
</tr>
<tr>
<td>Bonaire</td>
<td>N, IF</td>
<td>N, F</td>
<td>I</td>
<td>N, F</td>
<td>I</td>
</tr>
<tr>
<td>Curaçao</td>
<td>N</td>
<td>N, F</td>
<td>N, IF</td>
<td>N, F</td>
<td>I</td>
</tr>
<tr>
<td>St. Maarten</td>
<td>I</td>
<td>N, F</td>
<td>N</td>
<td>N, F</td>
<td>A</td>
</tr>
<tr>
<td>Saba</td>
<td>I</td>
<td>N, F</td>
<td>I</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>St. Eustatius</td>
<td>A</td>
<td>N, F</td>
<td>N</td>
<td>N, F</td>
<td>A</td>
</tr>
</tbody>
</table>

N = Nesting; F = Foraging; IN = Infrequent Nesting; IF = Infrequent Foraging; I = Infrequent (further detail unavailable); A = Absent

Genetic Testing of Green Sea Turtles in Lac Bay, Bonaire

Researchers from University of Groningen recently used genetic testing to identify the geographical birthplaces of green sea turtles foraging within Lac Bay, Bonaire (van der Zee et al., 2019). These tests helped provide insight in how variations in recovery rates of sea turtle populations affected the overall genetic diversity within Lac Bay. Researchers are able to use mitochondrial DNA (mtDNA) from juveniles to identify genetic tags for the geographical regions where they hatched (Bowen et al., 2005).

Between 2006 and 2016, genetic samples from 332 juvenile green sea turtles were collected and sequenced. From this, 19 genetic markers were identified and used throughout the study. Researchers were able to divide the sea turtles as coming from rookeries in four geographical areas: north-western Caribbean, south-western Caribbean, eastern Caribbean and southern Atlantic (van der Zee et al., 2019).

Overall, researchers were able to show that the genetic makeup of green sea turtles within Lac Bay demonstrated an increase in populations originating from the north-western Caribbean. Interestingly, overall juvenile green turtle population did not significantly increase within Lac Bay throughout these ten years (Christianen et al., 2018). The stability of the Lac Bay green turtle population could mean that this foraging area is nearing or at carrying capacity (van der Zee et al., 2019). If at carrying capacity, the competition for resources may lead some green sea turtles to find other foraging areas.

Recent conservation efforts have helped Suriname increase green sea turtle nesting, which could result in an increase in eastern Caribbean sea turtle populations within Lac Bay in the upcoming years. Furthermore, scientists believe turtles may shift foraging grounds as they develop due to their natal homing capabilities (Naro-Maciel et al., 2016). This could possibly explain why, in Lac Bay, recruitment from south-western Caribbean was high when studying the entire population, however, if only smaller juveniles were analyzed, recruitment from north-western and eastern Caribbean was proportionately higher. This shift could represent larger juveniles leaving Lac Bay to return closer to where they hatched.

This study highlights the success of current efforts to protect sea turtle nesting beaches by demonstrating the increase in juveniles originating from areas with increased conservation efforts. This study also demonstrates how genetic testing can be an effective way to monitor trends within different populations.
Another recent study conducted by Sea Turtle Conservation Bonaire (STCB) shed light on the abundance, population trends and the negative impacts of both natural and anthropogenic disturbances to the green and hawksbill turtle populations around the west coast of Bonaire and Klein Bonaire between 2003 and 2018. Over the sixteen-year study, they found an average annual abundance of 555 green turtles and 70 hawksbill turtles and no significant population trends. They also looked within Lac Bay, a popular foraging ground for many turtles. Within Lac they found an average annual abundance of 348 green turtles and a slightly positive population trend (Rivera-Milán et al., 2019).

Overall, this study found that green turtles had a higher population growth rate and carrying capacity when compared with hawksbill turtles. This is important as it means green sea turtles may be more resilient to both natural and anthropogenic pressures and increased mortality rates than hawksbill turtles. This study also designed models to predict turtle population trends through the year 2030 (Rivera-Milán et al., 2019).

This study is important in understanding how changing environmental conditions will affect Bonaire’s turtle populations. Understanding both the natural and human driven stressors for sea turtles can help guide conservation efforts in the future.

Hawksbill Turtle, photo by: © Brenda Kirkby
QUEEN CONCH

Photo by: © Mark Vermeij
The queen conch, or *Lobatus gigas*, is an iconic species found within the Caribbean, being both economically and socially important (Brownell & Stevely, 1981; Appeldoorn, 1994). Famous for its unique and beautiful shell, along with its role as a popular item in local dishes, this species is heavily fished (Stoner, 1997) and in some areas, pushed to the point of overfished (Stoner et al., 2019). To aid in the restoration efforts of this species, it is often listed as regionally protected and in 1992, it was added to the list of protected species in the Convention of International Trade in Endangered Species of Fauna and Flora (CITES). Adult conchs inhabit a wide variety of environments, including areas of sand, algae and coral rubble (Acosta, 2001, Stoner & Davis, 2010). Juvenile conchs prefer a more specific habitat and can normally be found within seagrass beds where they forage for food and are protected from predators (Ray & Stoner, 1995; Stoner, 2003; Stoner & Davis, 2010).

Conservation efforts on Bonaire, Saba and St. Eustatius have led to a notable recovery of the conch populations for these islands, although there is still a lot of work to be done. For Bonaire, a lack of long- or short-term trends means that the recovery efforts are still not fully understood (Engel, 2008). However there are data for 1999, 2007, 2010, 2013 and 2015 for Lac Bay that show very low numbers per ha (6 - 52) (Engel, S. 2019 personal communication). These were all juvenile conch, below the threshold for successful mating (at least 80 adult conch per ha) (Stoner and Ray-Culp, 2000). Although taking of queen conch is prohibited on Bonaire, poaching is still a significant issue. Due to a moratorium put in place in 1996 on fishing for conch, local populations around Saba and Saba Bank are healthy by comparison (Meesters et al., 2010). In addition, St. Eustatius was also found to have healthy populations of queen conch (Boman, 2017). Although local numbers seem to have bounced back for these islands, it is still important to carefully monitor and manage conch populations. These populations could play an important role in safeguarding this species in the future. The most recent State of Nature Report, published by Wageningen University assessed the “conservation status” of conch for the Caribbean Netherlands as “moderately unfavorable” (Debrot et al., 2018).

The three other Dutch Caribbean islands, Aruba, Curacao and St. Maarten are also working to protect their queen conch populations. Aruba has banned hunting for queen conch since 1987. Enforcement remains an issue on Aruba, hence the population is still very vulnerable and needs to be carefully monitored. Curacao has a very limited population of queen conch and are considered rare for this island (NOAA, 2014). St. Maarten’s conch population is recovering, although an invasive seagrass, *H. stipulacea*, could threaten these recovery efforts. Nature Foundation St. Maarten is conducting research and monitoring the situation to better understand the impact of this invasive seagrass.


Invasive Seagrass and its effects on Juvenile Queen Conch

Juvenile conchs have been known to primarily feed on seagrass detritus (or debris), red and green macroalgae, organic material within the sediment and cyanobacteria (Randall, 1964; Stoner & Sandif, 1995; Stoner & Waite, 1993; Serviere-Zaragosa et al., 2009; Stoner et al., 1995). In recent years, invasive seagrasses have become much more common throughout the Caribbean (Kairo et al., 2003). This shift in seagrass types can change both food availability as well as the level of protection for juvenile conchs. This shift in sea grasses, including H. stipulacea, native to the Red Sea, was first observed in Granada in 2002 and can now be found around at least 19 islands within the Caribbean (Ruiz & Ballantine, 2004; Vera et al., 2014; Willette et al., 2014). A specific invasive seagrass, Halophila stipulacea, native to the Red Sea, was first observed in Granada in 2002 and can now be found around at least 19 islands within the Caribbean (Ruiz & Ballantine, 2004; Vera et al., 2014; Willette et al., 2014).

Both studies used juvenile conchs in native, invasive and mixed seagrass areas, and the main objective was to highlight the effects of invasive H. stipulacea on their development. The goal of the first experiment was to better understand the diet of conchs. By defining the isotopic signatures of carbon and nitrogen (δ13C and δ15N) of conchs and their environment, researchers were able to gain insight on their diet, as well as how the baseline levels of these elements within the study areas are affecting local populations. This baseline data can help highlight areas of pollution, which can also be used to understand its effects on juvenile conch’s development. The second part of the study involved collecting juvenile conchs and placing them in an enclosure where measurements could be taken for specific growth rates over a period of time.

Through stable isotopic analysis, it was determined that the diets between all three habitats were similar, with organic material from the sediment being the primary source of nutrition. Cyanobacteria was only found in St. Eustatius and was determined to have a medium contribution to the diet. Furthermore, seagrass detritus and epiphytes were found to contribute very little to the juvenile conch’s diet. An important finding of this study was that although organic material within the sediment was a major contributor to their diet, their isotopic signatures showed variances which matched other unique food items found in each of the sites. This confirms previous research which showed juvenile conchs to be opportunistic feeders (Robertson, 1961; Randall, 1964; Stoner & Waite, 1991).

In addition, enriched values δ15N were found at the sites of St. Barthelemy and St. Maarten when compared to St. Eustatius. This was likely caused by the limited water flow and more anthropogenic nutrient pollution (Tett et al., 2003). Both of these sites were located near outlets of enclosed waterbodies and large hotels (120 and 650 hotel rooms in St. Barthelemy and St Maarten respectively). The site off St. Eustatius was further from shore and neighboring hotels were significantly smaller (40 rooms) (E.M. Boman pers. obs). Therefore, this enriched δ15N signature of the conchs located off St. Barthelemy and St. Maarten are likely a result of this anthropogenic pollution.

The growth experiment included 60 juvenile conchs which were collected and placed in six enclosures, three with invasive seagrass H. stipulacea and three with a mix of native seagrasses. Originally, the test was to be run for 16 weeks, however, due to a direct hit by Hurricane Irma, the experiment ended after 47 days. In the end, 19 of the conchs from within the native seagrass enclosures measured positive growth, the maximum individual growth being 0.17 mm/d. In the invasive seagrass enclosure, only 5 conchs showed positive growth, with a maximum individual growth being only 0.03 mm/d. Therefore, it was concluded that dense H. stipulacea seagrass beds limit sediment available for grazing and thus limits conch development, which aligns with similar results from a previous study by Stoner & Sandif in 1993.

The enrichment of δ15N signatures of conchs found within areas of higher anthropogenic pollution demonstrates the role the environment plays in conch’s development. It is becoming increasingly more apparent that polluted waters are having long term and lasting effects on species dependent on these habitats. Furthermore, the lower growth rates of juvenile conchs in invasive seagrasses give us some insight into struggles these, and similar, species may face as the composition of seagrasses within the Caribbean continue to shift. Since this invasive seagrass tends to flourish in nutrient rich waters, as climate change and human expansion continues, we can expect to see invasive species such as these continue to spread. It will continue to be of the utmost importance for researchers and individuals to continue to monitor the situation and to do whatever is necessary to ensure a healthy environment for the queen conch’s population to repopulate and stabilize.
CORAL REEFS

Photo by: © Hans Leijnse
Overview

The coral reefs of the Dutch Caribbean have gotten a lot of attention over the past year. Along with numerous studies to monitor and better understand these reefs, the Kingdom of the Netherlands announced it would be drafting a Coral Action Plan to provide a framework to protect these national treasures moving forward. This section will outline the current state of coral reefs within the Dutch Caribbean and highlight some research and ongoing projects which took place over the past year.

The most recent State of Nature report, published by Wageningen University assessed the "conservation status" of coral reefs for the Caribbean Netherlands as “very unfavorable” (Debrot et al., 2018). In this report, it was stated that the largest threats to coral reefs are erosion from coastal development and overgrazing by free roaming feral livestock, eutrophication from inadequate wastewater treatment and changing environmental conditions due to climate change.

Coral reefs are a driving factor for tourism for all six of the Dutch Caribbean islands. Tourists have traditionally come to admire the uniqueness of the region’s nature, including their world-renowned coral reefs. In surveys from 2013, the economic value of the ecosystem services provided by nature on Bonaire, Saba and St. Eustatius represented 31%, 63% and 24% respectively of the annual Gross Domestic Product (GDP) of the islands (Cado van der Lely et al., 2013; CBS, 2014). On Sint Maarten recent studies by the Nature Foundation have shown that coral reefs contribute USD 50 million to the economy of the island. A 2015 study from Aruba projected that nearly 30% of its GDP would be derived directly from travel and tourism by the year 2025 (World Travel and Tourism Council, 2015). Curacao’s Tourism Master Plan estimates that tourism constitutes 26% of the islands GDP (Croes et al., 2015). This clearly shows the importance of nature in the economies of each of the islands. If there is no adequate action against the current threats to coral reefs, the value will decrease considerably with major consequences for the well-being of the population.

Check out the following publications for an overview of the status of the Dutch Caribbean reefs:


State of Nature Report for the Caribbean Netherlands 2017 (Debrot et al., 2018): https://www.wur.nl/upload_mm/87/e/a/qcbbq4_s4_e/3be5-3be5_bebe-8b54ac5ec520_rapport436340.pdf


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40-year study: Changes on the Coral Reefs of Bonaire and Curaçao (BioNews 24)

Although it’s now becoming widely accepted that coral reefs are degrading quickly on a global scale, there have been very few long-term studies where this is measured. Humans can have drastic impacts on the environment, prompting changes in coral reefs through acts such as overfishing, pollution and coastal development (de Bakker et al., 2016). Shifts in water quality have led to a change in reef dynamics, with many areas experiencing a loss of corals and an increase in species which benefit from these nutrient rich environments, such as algae and cyanobacteria (Broche et al., 2015).

Earlier this year, Didier de Bakker from Wageningen University defended his thesis, in which he documented and studied the ecological degradation of coral reefs around Curaçao and Bonaire. This project continued upon research which started in the 1970s. The findings of this study were previously published in a 2017 paper titled “40 Years of benthic community change on the Caribbean reefs of Curaçao and Bonaire” (de Bakker et al., 2017).

This 40-year study worked to link changes in the coral reefs to human population growth on both islands. This research highlighted the shift from large reef-building coral species to an increase in benthic cyanobacteria and macroalgae. There was also a shift from large reef-building corals that form complex structures to more weedy corals that form smaller colonies which do not facilitate the same structural complexity needed for proper reef functioning and coastal protection, such as protection against flooding and erosion. This research also showed that areas of the reef where entry by people is prohibited exhibited the least amount of degradation, illustrating the importance of actively managing and preserving these ecosystems (de Bakker et al., 2017).

Benthic Cyanobacterial Mats

Although cyanobacteria have always played a small part within reef ecosystems, there is new evidence to support that it is becoming much more prevalent (Ford et al., 2018; de Bakker et al., 2017). Some species of cyanobacteria will group together to form benthic cyanobacterial mats ( BCM). These BCMs lay along the bottom of the ocean and flourish in nutrient rich water. BCMs were first noticed in the early 1990s on reefs worldwide. Many human driven factors can lead to algal blooms, creating direct competition between BCMs and corals (Ford et al., 2018). In fact, a study conducted off the coast of Curaçao found a higher occurrence of BCMs in sheltered reefs near areas of high coastal development, strongly supporting a link between shifts in water quality and blooms of BCMs (Broche et al., 2015). This same study also noted that areas with higher BCM populations also hosted higher benthic macroalgae and significantly less corals. This is most likely due to the BCMs’ ability to fix nitrogen, and an increase of nitrogen in a system may promote the growth of these macroalgae (Broche et al., 2015).

Cyanobacteria are not only a competitor for coral reefs, but one particular species has also been directly linked to coral’s black band disease (Frias-Lopez et al., 2003). Black band disease was first spotted in the Caribbean off the coast of Belize in 1973 (Antonius, 1973). Since then, it’s been documented in coral reefs all around the world. This disease comes from BCMs and can infect coral at a rate of 1 cm/day. This disease spreads from the top to the bottom, destroying healthy tissue and leaving behind dead skeletal remains (Antonius, 1973). Furthermore, with over 60 different cyanobacterial toxins documented, BCMs can cause a range of issues for humans and other animals living within these waters. Cases of fatal poisonings of domestic and wild animals have been linked to cyanobacteria, and highlight the importance of monitoring BCMs (Bell and Codd, 1994).

Curaçao and Bonaire

A team of researchers conducted a 40-year study off the coasts of Curaçao and Bonaire, documenting shifts in local reef populations, specifically: corals, algal turfs, benthic cyanobacterial mats, macroalgae, sponges and crustose coralline algae. To do this, permanent quadrats were placed at varying depths (50, 20, 30, 40 m) and photographed in 3- and 6-year intervals starting in 1973, and annually since the early 1990s. Three sites were selected off Curaçao (CARMABI Buoy One [I and II] and CARMABI Buoy Two [III]) and Bonaire (Karpata) (de Bakker et al., 2017).

The results of this study found that in 40 years the following shifts occurred. Overall, there was a decrease in the cover of calcifying organisms from 32.6% to 9.2% for corals and 6.4% to 1% of crustose coralline algae. At first, coral cover was replaced with algal turfs and macroalgae, with a growth from 24.5% to 38% in the early 1990s. Their reign shifted once again as a decline in algae turfs from 22% in 2002 to 2% in 2013 gave way to the rise in benthic cyanobacterial mats. BCMs increased from 7% in 2002 to 22% in 2013. There was also a slight increase in sponges over these 40 years, from 0.5% to 2.3%. This breakdown can be seen in table below. It is important to note that coral’s slow growing nature puts it at a disadvantage when up against faster growing organisms. However, it is believed that coral’s slow growing nature puts it at a disadvantage when up against faster growing organisms when battling invasion or recovery after damage (McCook et al., 2001).
It’s very likely that decreased water quality paired with an increase in water temperature are the main catalysts for the increase of BCMs (Brocke et al, 2015a). Each of the four locations studied in the 40-year project were contaminated with untreated sewage water through both direct discharge and groundwater (Buth and Ras, 1992; Lapointe and Mallin, 2005). Without waste water being properly treated and managed, this is a problem that will continue to grow as these islands further develop. Increased impact of pressures related to the increase in local populations and tourists, such as increased coastal development, increased physical damage due to humans interacting with the reef and an increase of land-based pollution will only further stress these environments. If the coral reefs are to be protected, these issues will require a complex, interdisciplinary approach to carefully manage the growth and development of both islands.

Future of Coral Reefs

If current trends continue, these reefs will continue to experience a decrease in calcifying corals, which could lead to a decrease in the structural complexity of the entire reef system (Alverez-Filip et al., 2011). Furthermore, once BCMs dominate reef areas, they will impair coral recruitment and their contribution to the release of dissolved organic compounds will further exacerbate the degradation of the entire reef (Brocke et al, 2015b). Understanding the underlying causes of these BCM blooms may be the key to reversing this trend.

Long term studies, such as these, highlight the importance of understanding the entire reef benthic system, as small population shifts can be indicators of much larger issues. If human factors are the driving force behind these changes, this means that humans can also be driving force for correction. As climate change continues to demonstrate the fragility of these systems, it will become increasingly important to understand our role in the environment.

2019 Research and Project Results
Stony Coral Tissue Loss Disease Management Update for the Dutch Caribbean (BioNews 28).

Since 2014, a new coral disease has been spreading through the reefs of the Caribbean. Known as Stony Coral Tissue Loss Disease (SCTLD), this disease appears to be fast spreading and extremely lethal to the corals that are susceptible to it. In August 2019 a meeting was organized by MPA Connect where experts met to discuss lessons learned from Florida’s management of this disease and discuss best practices for identifying and treating infected corals for the future. These results have been summarized in DCNA’s Stony Coral Tissue Loss Disease Management Letter for the Dutch Caribbean. The capacity building efforts done throughout the Caribbean were presented at the yearly Gulf and Caribbean Fisheries Institute (GCFI) meeting in November 2019 in the Dominican Republic by DCNA’s director Tadzio Bervoets.

The Disease

A new coral disease was first identified off the coast of Florida in 2014. Since then, it has spread throughout much of the Caribbean, including Mexico, Jamaica, Sint Maarten, Sint Eustatius, the Dominican Republic, and the U.S. Virgin Islands (AGGRA, 2019). This disease is known as SCTLD. To date SCTLD has only been seen in stony corals and causes significant tissue loss within affected hosts. This disease spreads fast and can have devastating affects on the reef if not treated immediately (Florida DEP, 2019). Dr. Andy Bruckner, Research Coordinator at Florida Keys National Marine Sanctuary stated “Stony Coral Tissue Loss Disease affects some of the slowest-growing and longest-lived reef-building corals, including the iconic brain corals, star corals and pillar corals.”

Symptoms

When a coral contracts SCTLD it begins with visible lesions which spread out from around the host’s edge. Here the coral tissue can become detached or completely removed, which leaves the coral structure as a bare skeleton typically covered in algae within a week (Florida DEP, 2018). This disease has been documented in over 20 different species of coral, including five species listed under the Endangered Species Act (Florida DEP, 2019). Onset appears to infect highly susceptible species first. The disease spreads rapidly with total mortality of infected specimens ranging between 1 week to 2 months (AGGRA, 2019). Typically, a month after the disease has been reported in highly susceptible species, it begins to infect immediately susceptible species. Within these species, smaller colonies have been seen to die off over the course of months and larger colonies have been seen to host the disease for years without suffering complete mortality.

Transmission

It is now believed the SCTLD is transmitted through direct contact and water circulation (Reef Resilience, 2019). To minimize its spread, officials are now recommending extreme caution for divers around infected corals, and urge divers to fully decontaminate their gear between dive sites to avoid spreading the disease (Florida DEP, 2019). In addition, it is strongly encouraged that if a coral is suspected of being infected, it should be reported to the appropriate authority immediately for immediate action (Florida DEP 2019).

Knowledge Sharing

On August 1st of this year, a group of 22 experts from 22 countries met in Key West, Florida to share information and discuss how to best manage SCTLD outbreaks (GCFI, 2019). Participants were able to work directly with leading SCTLD experts from Florida and learn how to properly identify the disease and manage infected corals effectively. Florida has had positive results treating infected corals with a variety of antibiotic regimes; however, this is still being tested and regulatory frameworks concerning the use of such treatments varies between countries (Reef Resilience, 2019).

During the 2019 Gulf and Caribbean Fisheries Institute (GCFI) meeting DCNA director Tadzio Bervoets presented the Stony Coral Tissue Loss Disease Management Letter for the Dutch Caribbean which provides Marine Resource Managers in the Dutch Caribbean the information necessary to prepare for, monitor and respond to the disease. Bervoets also presented the Stony Coral Tissue Loss Disease Management Letter for the Mexican Caribbean where experts from 17 countries met in Key West, Florida to share information and discuss how to best manage SCTLD outbreaks (GCFI, 2019). Participants were able to work directly with leading SCTLD experts from Florida and learn how to properly identify the disease and manage infected corals effectively. Florida has had positive results treating infected corals with a variety of antibiotic regimes; however, this is still being tested and regulatory frameworks concerning the use of such treatments varies between countries (Reef Resilience, 2019).

Protecting the Future

With harsher environmental conditions stressing corals, these species will continue to become more susceptible to disease in the future. SCTLD is of particular concern as it appears to be long lasting, wide ranging, highly contagious for a large number of slow growing, reef building species and has been seen to result in total colony mortality once infected (Martinelli, 2019). Increasing public awareness and proper diving practices will be crucial for divers and researchers to carefully track its progression. If you believe you’ve spotted an infected coral, please report the date, GPS location, and if possible, a photograph, to your local marine park authority.
New and Very Abundant Microbe Found Living in Corals (BioNews 24)

Although coral reefs occupy less than 1% of the ocean floor, nearly a third of all marine species can be found on or around these reefs (McAllister, 1991). This is why their rapid degradation is of great concern. New research has identified a new, abundant microorganism that occurs in a large number of tropical coral species, which they have dubbed “corallicolids” coming from Latin meaning “coral-dwellers”.

Corals have a well-studied symbiotic relationship with a photosynthetic microorganism (Symbiodiniaceae dinoflagellates), where corals provide shelter and protection in exchange for the energy Symbiodiniaceae produce through photosynthesis. It would now appear that a newly identified microorganism living inside corals, corallicolids, have entered this equation. These corallicolids appear to be very abundant and are only outnumbered by the Symbiodiniaceae. Weirdly, this newly discovered microbe contains all four genes required for producing chlorophyll, but lacks the genes needed for photosynthesis.

Professor Patrick Keeling, a botanist from the University of British Columbia and senior author of the study, stated that “having chlorophyll without photosynthesis is actually very dangerous because chlorophyll is very good at capturing energy, but without photosynthesis to release the energy slowly it is like living with a bomb in your cells”. Furthermore, genome sequencing of corallicolids shows that this microbe is likely an ancestor of parasitic Apicomplexa as Plasmodium, which causes malaria. This leaves scientists to wonder: What do these light harvesting microbes do and what important role do they play being within coral’s microbiomes?

Research around Curacao

A group of researchers from the University of British Columbia and the CARMABI Foundation have collaborated to better understand the eukaryotic microbial community composition of wild and commercial corals, specifically to determine the distribution of corallicolids. 43 wild coral samples were collected off the coast of Curacao, representing the most common species of hard corals. Commercial species were purchased directly from vendors, comprising of 102 samples, representing at least 65 species from all over the world. 85% of the wild corals contained corallicolids, whereas 53% of the commercially obtained corals contained corallicolids, showing that these newly identified microorganisms are very abundant within corals from around the world. They also noted that almost all of the corals studied appeared to be healthy, hinting that corallicolids were not detrimental to the coral’s health. It is still unclear how corallicolids are able to process the energy gained from chlorophyll without the photosynthesis process.

Previous studies have not linked the presence of chlorophyll to another process other than photosynthesis. Therefore, if corallicolids do not use chlorophyll to photosynthesis energy, this leads scientists to wonder what role chlorophyll plays in its lifecycle. Furthermore, scientists found these corallicolids in both sun coral (Tubastrea sp.) and black coral (order Antipatharia), both of which are considered to be non-photosynthetic corals. Corals are under immense stress due to harshening conditions brought by climate change, maybe understanding the total life processes within corals can help scientists find a way to protect them in the future.

Sun Coral, photo by: © Bernard DUPONT
Human disturbance impedes growth of coral reefs around Bonaire (BioNews 29)

The coral reef around Bonaire is known to be one of the healthiest in the Caribbean. However, new research by Wageningen Marine Research shows that a large part of these reefs is not in good shape: most of the shallow parts are hardly growing and in some cases they are even eroding away. The researchers found a negative correlation between local human activity and the growth capacity of the reef.

Coral reefs around the world are under pressure. The Caribbean reefs in particular have seen large scale ecological degradation in recent decades due to various factors, including the warming of seawater, deteriorated water quality, pathogens and acidification. Didier de Bakker of Wageningen Marine Research (WMR) and fellow researchers Erik Meesters (WMR), Fleur van Duyl (NIOZ) and Chris Perry (Exeter University) studied the vertical growth capacity of the reefs around Bonaire and published their findings in the scientific journal Global Change Biology.

De Bakker calculated the growth rate of reefs based on growth factors (coral, haptophytes, sand input) and degradation factors (erosion due to factors such as sponges, parrotfish and wave motion). His calculations paint a worrying picture: in most places, the growth rate is low or even negative. Only a small part of the reef is able to keep up with sea level rise.

Consequences for man and nature

The consequences of this development for man and nature could be significant. The growth of corals on a healthy reef creates a complex 3-dimensional structure through the deposition of large quantities of limestone. As a consequence of the reduced growth rate and increased erosion, this physical structure is disappearing, which in turn causes the loss of biodiversity and endangers the functioning of the reef.

Furthermore, the risk of flooding on Bonaire may increase, as reefs with intricate structure form a natural protective barrier of low-lying coastal areas. In recent years, there have already been more frequent floods in the lower-situated southern part, which includes the capital Kralendijk. Finally, De Bakker points out that his research results likely do not bode well for other Caribbean coral reefs because most of the reefs in the area are actually in a worse ecological state than those around Bonaire.

Act locally

An important additional finding of the research is that local human disturbance appears to have a major influence on the state of the adjacent reef. In locations with considerable human activity, such as around Kralendijk, the salt evaporation ponds and the oil storage tanks, the reef appears to hardly grow or even erode away. At the same time, the reefs in the marine reserves, to which access is strictly prohibited, are relatively healthy. This wide variation in growth rate within one reef system has not previously been so accurately linked to human land-bound activity.

This implies that acting on a local scale can be vital, according to De Bakker: “The well-developed reefs in the marine reserves, with rich coral cover, complex structure and high fish abundance, show that healthy reefs are indeed able to survive under the current global climate conditions. But this is only the case if the influence from the adjacent coastal region (from run-off, sewage, etc.) is minimized.” By taking the right measures at the local level, the reef might get a renewed opportunity to grow.

Photo: Coral eroded from the inside out by a sponge (yellow). © Didier de Bakker
New marine biodiversity discoveries from Bonaire (BioNews 30)

An international research team has investigated the marine biodiversity of Bonaire from 21 October to 9 November. Although Bonaire’s reefs have been well monitored by researchers and documented by underwater photographers, its marine biodiversity has been poorly explored. In previous decades, more research was performed on the neighboring island Curaçao, which resulted in many new species discoveries from there. Therefore, it was assumed that Bonaire also has a high potential for the discovery of undescribed species. The preliminary results from the expedition suggest that this assumption was correct. These results will be formally published in scientific journals and on the internet, where they will be accessible to all who want to learn more about the marine biodiversity of Bonaire.

A call from WWF-Netherlands to consider applications for funding research on the biodiversity of the Netherlands (including its Caribbean islands) triggered marine biologists of Naturalis Biodiversity Center and ANEMOON Foundation to submit a joint-proposal. This proposal was rewarded with a research grant. In addition, matching funding was provided from Naturalis’ research program on the Nature of the Netherlands. The research team consisted of Naturalis’ experts in marine biodiversity, ANEMOON, and foreign universities (Belgium, Italy, Japan, Puerto Rico, and Russia), as well as a marine biology student from the University of Groningen. The expedition was under leadership of Bert Hoeksema (senior scientist at Naturalis and honorary professor at the University of Groningen) and Godfried van Moorsel (ANEMOON). The expedition received local support from Stichting Nationale Parken Bonaire (STINAPA) and the Dutch Caribbean Nature Alliance (DCNA).

The expedition resulted in many new discoveries, among which were at least seven undescribed species of invertebrates that are new to science, as well as numerous new records for the marine fauna and flora of Bonaire. Among the new species was an unknown shrimp while another shrimp was found in association with a species of coral that had never before been seen to host shrimps. These shrimps will be studied further by Charles Fransen of Naturalis. Adding to these discoveries, four new species of encrusting sea anemones known as zoantharians were discovered. Compared to Curaçao and St. Eustatius (where the team has previously studied biodiversity), the number of zoantharian species was surprisingly high. Some of these species live in association with sponges, forming colorful combinations of species. The new species have very small polyps that are less than 4 mm wide. These new discoveries were made by James Reimer from Okinawa, who is the world-leading scientist of zoantharians.

Sponges may also harbor many kinds of animal associates, amongst which small shrimp-like animals known as copepods. These animals are very small (usually less than 1 mm long) and many of them belong to species that are still undiscovered. Some copepods are known to cause diseases. Fan corals, which are very common at Bonaire, were found to show a condition known as Multiple Purple Spots Syndrome, which can be linked to the presence of an undescribed species of copepod. This relation between the coral and copepods was first discovered at St. Eustatius, during a similar expedition of Naturalis and ANEMOON. All new discoveries related to copepods were made by Slava Ivanenko from Moscow, who specializes in copepods that live in association with corals, sponges and other invertebrates. Another group of small crustaceans, amphipods – also known as beach fleas, was investigated by Ronald Vonk of Naturalis. Some of these species live in between sand grains on beaches or in the sea floor. He was able to find species of a particular family that needs to be studied with the help of molecular analysis for a better understanding of the amphipod evolution.
Expedition member Jaaziel Garcia-Hernandez, who is a PhD student from the University of Puerto Rico-Mayagüez, searched for small calcareous sponges, which are called so because their skeleton is composed of limestone needles (spicules). They are poorly known because they usually live in crevices and underneath overhangs. Nevertheless, a total of 15 species were recorded. Together with Bert Hoeksema he also studied how sponges interact with corals. Simone Montano from Italy was looking for associations between tiny hydroids and corals. He is interested to know how these hydroids are able to settle on corals. Moreover, he also searched for particular coral diseases caused by ciliates, and how the hydrozoan-coral association may reduce the susceptibility to diseases. PhD candidate Luna van der Loos from Gent (Belgium) participated in the expedition to study algae. She was able to find approximately 100 large species, while small species could only be identified down to genus level. Among all species that she found, approximately five constitute new records for Bonaire. In addition, more than 165 species of fish were observed by Floris Bennema and Godfried van Moorsel of ANEMOON and 45 species of stony coral by various expedition members. Team members Marianne Ligthart and Marco Faasse of ANEMOON Foundation recorded sea anemones and echinoderms. They found an association between a brittle star and a scale worm, which was only known from Belize, Mexico and Venezuela. PhD candidate Werner de Gier of Naturalis and the University of Groningen studied the association between small pea crabs and their invertebrate host species. Finally, MSc student Lukas Verboom (University of Groningen) recorded the abundance of snails that eat corals and can cause damage to them.

All together about 35 localities were visited by SCUBA diving, snorkeling, wading, and beach combing. Among them four were at Klein Bonaire and several locations at the poorly studied exposed east coast of Bonaire. The results need further analyses after which new species and new records will be added to the Dutch Caribbean Species Register of Naturalis (https://www.dutch-caribbeanspecies.org/). Eventually, the results will also show, which localities around Bonaire are particularly rich or poor in species. It will also be interesting to compare the marine fauna and flora of Bonaire with those of other localities in the Caribbean. The outcome of the expedition has certainly revealed that the marine underwater life of Bonaire is very rich in species, which will be demonstrated in the scientific publications that will follow.
OTHER MARINE ECOSYSTEMS
Overview

Although the coral reefs of the Dutch Caribbean are by far the most famous of the marine ecosystems, mangroves, seagrass and algae fields also play a critical role. Seagrass and algae fields can be found around all six Dutch Caribbean islands, whereas mangroves are mostly found on the southern islands Aruba, Bonaire, Curaçao and Sint Maarten. This section will outline the current state of these marine ecosystems within the Dutch Caribbean and highlight the research and ongoing projects which took place over the past year. For more information, please see the full BioNews article, which have been indicated along with the article title below.

Seagrass and Algae Fields

Seagrass and algae fields are critical ecosystems as they provide important habitats for many different reef species (Chaves et al., 2013). In addition to this, seagrass can capture CO2, improve water quality and mitigate erosion by stabilizing sediment. A lack of monitoring data across all six islands means that no clear trends can be established, however, recent studies have highlighted the rapid spread of the invasive seagrass Halophila stipulacea along with a decrease in coverage of seagrass fields due to an increase in eutrophication of shallow waters, excessive land sediment run off, damage done by tourists and pollution.

Since 2011, a floating seaweed, Sargassum, has been a Caribbean wide problem. This algae floats into shallow waters or onto shore where it decomposes, creating a thick mat along the sandy bottom. This mat can cause immense damage to the local algae and seagrass fields. This is an issue that is continuing to get worse and will need to be carefully monitored in the future. More information on this issue will be covered in chapter 10, Environmental Threats.

Within the Dutch Caribbean, the largest seagrass and algae fields can be found on Bonaire, which constituting nearly 75% of all the seagrass within the entire Dutch Caribbean. St. Eustatius’ has the second largest area of seagrass and algae fields while Saba has only a few small seagrass and algae areas. Saba Bank does not have any known seagrass beds but it does have a very large algae field. The algae fields of Saba Bank are considered to be the most diverse area for algae in the Caribbean. The surface area of the algae fields of Saba Bank do not appear to be shrinking over time, however, they are threatened by degraded water quality due to climate change and pollution. Unfortunately, due to the threats of these ecosystems caused by climate change, pollution and physical damage by people and severe weather, the most recent State of Nature report, published by Wageningen University assessed the conservation status of seagrass fields for the Caribbean Netherlands as “very unfavorable” while the assessment of the conservation status of the algae fields were assessed as “moderately unfavorable” (Debrot et al., 2018).

Aruba has two protected seagrass and seaweed conservation areas, around the Oranjestad Reed and San Nicolas Bay Reef Islands, both of which are designated as Important Bird Areas. Curaçao has a variety of inland bays which supports the island’s seagrass and algae fields. The seagrass beds of St. Maarten can be found at Simpson Bay, Great Bay, Little Bay and Simpson Bay Lagoon, and host seven types of seagrasses (Nature Foundation St. Maarten, 2016). A significant portion of the seagrass beds of St. Maarten have been destroyed by hurricanes, however, efforts are underway to protect the remaining beds.

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Mangroves

The mangrove forests of the Dutch Caribbean are limited to the ABC islands and Sint Maarten. Aruba and Curacao both have small mangrove areas with Bonaire hosting the largest of all of the islands’ mangrove forests. Mangroves provide vital 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 have been 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).

Aruba’s mangroves are mostly found within Spaans Lagoen and Mangel Halto. The mangroves of Curacao are limited to an area of 55 hectares, an equivalent of only 0.12% of land surface for the island. Bonaire, on the other hand, is unique as it is the only Dutch Caribbean island to have a significant mangrove forest, which is mostly located around Lac Bay. Unfortunately, overall eutrophication of Lac Bay has led to an increase in lime sediment production, which is causing the mangroves to infill (Slijkerman et al., 2012). Overgrazing along the borders of the mangroves also allows land sediment to enter the mangroves, leading to an overall decrease in mangrove health which further harms seagrass and local fish well-being (Hylkema et al., 2014) and affects wading birds which rest and feed in these areas (Debrot et al., 2013, Debrot et al. 2014). The most recent State of Nature report, published by Wageningen University assessed the conservation status of mangroves for Bonaire as “moderately unfavorable” (Debrot et al., 2018).

Of the 19 mangrove ponds on St. Maarten, only four remain today: Red Pond, Fresh Pond, Little Bay Pond and Mullet Pond. Development pressures and pollution threaten these remaining mangroves areas. The start of the construction of the Simpson Bay Lagoon Causeway in 2012 has meant the clearing of much of the lagoon’s mangrove forest. To compensate for this loss, the St. Maarten Nature Foundation has replanted thousands of juvenile mangroves in the lagoon as well as at other locations on St. Maarten (NFSXM, 2016).

Each of these marine ecosystems plays a crucial role in maintaining a sustainable environment for each island. Healthy seagrass and algae beds along with mangroves provide important support for the coral reefs they neighbor, both in improving water quality and promoting an increase in biomass and diversity of marine life. It is becoming increasingly important that these ecosystems are monitored, conserved and restored as the pressures of global climate change further stresses their limits.
Invasive seagrass found on Saba (BioNews 21)

Park ranger Jelle van der Velde has identified the presence of *Halophila stipulacea* near Saba’s Queen B. II mooring, east of Fort Bay. The discovery, made early 2019, marks the first time this invasive species of seagrass has ever been recorded on the island. All five other Dutch Caribbean islands (Aruba, Bonaire, Curacao, St. Eustatius and St. Maarten) have documented the presence of *H. stipulacea* since it was first recorded in Lac Bay, Bonaire, in 2010 (Engel, 2013).

A native seagrass of the Red Sea and parts of the Indian Ocean, and established in the Mediterranean Sea since the opening of the Suez Canal in 1869, *H. stipulacea* is believed to have first entered the Caribbean in 2002 (Smulders et al., 2017). It has since spread rapidly through the region. The exotic seagrass is fast growing compared to the native species *Thalassia testudinum* and tolerates higher levels of salinity, irradiance and temperature as well as a wider range of substrate types (Smulders et al., 2017).

Invasive species have a wide range of potential environmental impact, including outcompeting local species for space. The arrival of *H. stipulacea* is of great concern as the dense mats it forms can outcompete native seagrass species and impair the functioning of local seagrass ecosystems (Smulders et al., 2017). Seagrass meadows composed of *H. stipulacea* are less structurally complex than *T. testudinum* and not as firmly rooted, and are therefore likely to alter ecological functions such as coastal protection, productivity, habitat structure and food availability (Smulders et al., 2017).

Monitoring at Lac Bay, Bonaire, found that *H. stipulacea* threatens the native seagrass species *T. testudinum*, the preferred food of the endangered green turtle (*Chelonia mydas*) (Becking et al., 2014; Smulders et al., 2017). From 2011 to 2015, cover of the exotic seagrass increased from 6% to 20%, while cover of *T. testudinum* decreased from 53% to 33% (Smulders et al., 2017). On St. Eustatius, monitoring for the 2015 Statia Marine Expedition uncovered seagrass fields dominated by *H. stipulacea* (Hoeksema, 2016).

While there are still many unanswered questions about how quickly *H. stipulacea* spreads and what factors influence its growth within the Caribbean region, one study (Tussenbroek et al., 2016) found a correlation between growth of the invasive species and pollution. The extremely dense seagrass meadows found at about half of the studied sites on Bonaire and St. Maarten had consistently higher nutrient concentrations. Another study carried out on Bonaire attributes fast growth of *H. stipulacea* to the higher temperatures and light availability in shallow bays (Smulders et al., 2017). Careful monitoring of the newly discovered *H. stipulacea* on Saba is needed to gather more information about how the invasive seagrass affects native biodiversity and what influences its expansion.
ENVIRONMENTAL THREATS
Overview

There are many environmental threats which put additional stress on these islands, arguably the two harshest challenges moving forward relate to changes due to climate change and the introduction of invasive species. This section will outline the current state of these threats within the Dutch Caribbean and highlight the research and ongoing projects which took place over the past year. For more information, please see the full BioNews articles, which have been indicated along with the article titles below.

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 requiring careful management 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 lead to a population boom for mosquitoes, 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 Caribbean Netherlands (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". The most recent State of Nature Report, published by Wageningen University assessed the preparedness of the Caribbean Netherlands to handle these additional stressors of climate change as "very unfavorable". The situation is similar for the three remaining Dutch Caribbean islands, Aruba, Curaçao and St. Maarten. 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.

Invasive Species

Invasive species are also a significant threat to local ecosystems, whether they are introduced to the island knowingly or are brought accidentally as hitchhikers on luggage or from ballast tanks of ships. The Ministry of LNV (Agriculture, Nature and Food Quality, previously Ministry of Economic Affairs) requested a study to document the number of invasive species within the Dutch Caribbean. This study found 211 potentially invasive species ranging from lionfish to boa constrictors, rats, iguanas and plants. Invasive species can wreak havoc on the local environment, as seen by the invasive cattle on local plants, or cats on the nesting Red-billed tropic birds (Debrot et al., 2014). This LNV study documented 27 invasive marine species, 65 terrestrial plants, 72 terrestrial and freshwater animals and 47 agricultural pests and diseases.

The impact of these species varies widely. Some species pose a serious public health concern (such as diseases spread through mosquitos and rats) while others cause severe ecological damage (such as feral goats, pigs and donkeys). Invasive species often outcompete or prey on local species, such as the boa constrictor of Aruba, hunting on birds, or stray cats, dogs and rats threatening endangered nesting sea birds.

Early action is recommended to identify, control and eradicate invasive species. This is only possible through public awareness, so efforts should be taken to help local residents quickly identify and understand the dangers of these invasive species. The most recent State of Nature Report, published by Wageningen University assessed the impact of invasive species on the Caribbean Netherlands as "very unfavorable". The situation is similar for the three remaining Dutch Caribbean islands, Aruba, Curaçao and St. Maarten.
Corallita, we’re gonna beat ya! (BioNews 21)
Having started in 2015, Utrecht University researchers Elizabeth Haber and Jetske Vaas (a.k.a. The Corallita Girls) thought it time to discuss their findings with stakeholders on Statia and Saba. The botanist and social scientist have studied the alien invasive Corallita vine (Antigonon leptopus) with a view of supporting the local communities in decision-making management of the pesky vine.

Mid-October of 2018, they guided an invasive species hike, led ecologist-for-a-day-activities with primary school students and built Elephant ear umbrellas with SCF’s junior rangers. In addition, they sat down with the SCF rangers, Island Council members and the Governor to exchange ideas on how to deal with Corallita in different areas. Previously created maps which highlighted areas of high value for the people of Saba, it became clear there was a need to keep Mt. Scenery free from Corallita. They were able to prepare a list of suggested areas which should be cleared of Corallita as soon as possible. Wanting to set an example, Haber and Vaas organized a successful Tamarind tree clean-up on Saba on October 27, 2018, acting on the winning slogan of a small contest: “Corallita, we’re gonna beat ya.”

In Statia the team met with STENAPA, CNSI, LVV and Deputy Government Commissioner Stegers, sharing ideas for management approaches and priority areas. The attendees agreed that reforestation of the Corallita fields along the trail to The Quill on Upper Round Hill would be a good idea, as well as keeping a buffer zone on the lower slopes of Signal Hill. There was also enthusiasm for a testing-and-research area below the cliffs near Scubaqua, to test the effectiveness of mowing, covering the vine with a tarp or having pigs dig for the tubers. Also, the idea of Community Nature Rangers was suggested, with people in different neighborhoods adopting trees to keep clear of Corallita.

Jetske ran a short participatory action research project on Saba, using a piece of land in St. John’s where lemon trees were planted on a former Corallita field. This showed the expenses involved with fencing against the feral goats, water for irrigation, and also the time required to maintain the area. It also set an example of what can be done when a group comes together. Based on this experience, Elizabeth and Jetske recommended that the Statian government set up a similar pilot in a more visible place, for example the Deep Yard in Oranjestad. Turning this into a fruit orchard shows that it is feasible and worthwhile to get Corallita off the land.

As for removal methods, digging and mowing are still the best approaches. The steep slopes of both islands result in a high risk of run-off of herbicides, potentially damaging other plants and coral reefs. This calls for constant monitoring and immediate removal when Corallita is found somewhere along trails, and therefore they recommended to make Corallita-monitoring part of trail maintenance. Apart from keeping the trails clean, for larger areas the best method to keep Corallita under control is getting people to use their land. To that end, Elizabeth and Jetske handed out seeds, encouraging people to grow vegetables. After all, the farmers are least fazed by the vine, since they weed regularly.
Sargassum Management Brief

In light of recent and recurring influxes of sargassum on the islands of the Dutch Caribbean, the DCNA has drafted a management brief, "Prevention and clean-up of Sargassum in the Dutch Caribbean", to help guide the process of collecting and disposing of large quantities of the invasive seaweed. The management brief is heavily adapted from the Management Brief put together by Hinds et al. (CERMES/GCFI/SPAW Management Brief, 2016) for the Caribbean region.

Large quantities of pelagic sargassum began washing onto the shores of Caribbean nations in 2011, and by 2018 the problem had become so severe that some beaches were covered in piles of seaweed meters high. All six islands of the Dutch Caribbean have suffered to a varying degree depending on currents, winds and the topography of each island. On Saba, for example, the impact has been limited as the island has few bays and its coastline primarily consists of rocky shores. Other islands have been hit much harder. March 2018 saw the worst sargassum invasion to date for Bonaire, and bays such as Lac Bay and Lagun are experiencing fish die-offs and damage to important seagrass beds and mangrove forests.

The two species of pelagic sargassum that are washing onto the shores of our islands are Sargassum natans and S. fluitans. The sargassum grows into large, dense mats that wash ashore and threaten fragile and endangered coastal ecosystems such as mangroves and seagrass beds as well as significantly disrupting the livelihoods of communities, especially those associated with the tourism and fishing sectors. Pelagic sargassum is typically associated with the Sargassum Sea in the Atlantic where it occurs naturally; the sargassum coating Caribbean coastlines is believed to originate from a region located off the northeast of Brazil, in the North Equatorial Recirculation Region (NERR) of the Atlantic Ocean.

Figuring out how to clean and dispose of the large quantities of sargassum washed up has been a real headache for the coastal communities affected. So far, no real solution has been found, and options are often difficult to implement and expensive. The fact that the episodes are highly variable in terms of quantity and sites affected makes these irregular events hard to predict and therefore mitigate. The main goal of this management brief is therefore to assist government officials, coastal managers, beach caretakers and coastal residents of the Dutch Caribbean by offering guidance on how best to sustainably manage the sargassum, based on up-to-date information on the recent ‘sargassum influxes’ and lessons learned to date. We present a range of feasible, cost-effective and environmentally sound solutions for removing sargassum close to shore and on beaches in the least damaging way, as well as current solutions for the use and valorization of collected sargassum.

A Decade of Lionfish Management on Bonaire (BioNews 23)

Lionfish were first spotted off the coast of Bonaire back in 2009. Since then, STINAPA has been working alongside a cast of dedicated volunteers to continuously track, monitor and control this expanding invasive species.

STINAPA lionfish density surveys started in 2011, tracking 24 locations on Bonaire and 12 locations on Curaçao. These surveys measured lionfish densities along a 200m² transect, at 3 different depths (15, 25 and 35m deep). These annual surveys found that the number of lionfish was significantly larger around Curaçao than Bonaire (in 2011). Over the following 3 years, this population on Curaçao began to fall, whereas the density of lionfish around Bonaire remained relatively constant. It was also found that although there were small shifts between the years of 2011 and 2018, the relative population of lionfish was slightly higher at deeper depths with an exception of 2018 which showed the highest density at 15 m. When comparing between fish and unfished areas, it was found that unfished areas had larger lionfish populations densities.

Overall, the average size of lionfish has been decreasing over time, which could be a result of successful hunting campaigns removing older lionfish from the population. Lionfish densities outside of recreational dive limits seem higher but long-term data is missing to draw conclusions on trends at these depths. Although some of these lionfish could be hunted by specialty trained technical divers, this too has its own risks and concerns. Another option to consider is the use of traps. These traps would be located outside of recreational dive limits and would require regular monitoring to ensure other species have not been inadvertently caught.

Overall, current monitoring and removing procedures have managed to keep the local lionfish population growth to a minimum within recreational dive limits. Areas inaccessible to divers, such as in the reserved areas, still require monitoring by marine park staff. Thanks to the hard work of BNMP and their dedicated patrol of volunteers, local lionfish populations have been kept under control.
Environmental DNA FOR Lionfish Mapping (BioNews 24)

When a new species is introduced to a foreign environment, it can upset the natural balance. One such example was the introduction of the Pacific Red Lionfish (Pterois volitans) into the Atlantic Ocean during the 1980’s (Morris and Whitfield, 2009). Lionfish are capable of reproducing very quickly, with an individual female laying approximately 2 million eggs per year (Morris and Whitfield, 2009). The combination of high reproduction rates and a lack of natural predators led this species to populate quickly, rapidly spreading throughout the Caribbean Sea.

Lionfish have a seemingly insatiable appetite, capable of consuming up to 20 reef fish within 30 minutes. There have been cases where up to 80% of local fish populations are consumed by invading lionfish (Albins and Hixon, 2008). This large appetite is destructive to the reef in other ways as well. They consume a significant number of algae eating fish. Without these fish to keep local algae under control, algae can spread choking out native coral populations (Albins and Hixon, 2011).

Historically, marine parks have relied on visual surveys to track lionfish numbers and population shifts. This requires a significant investment in both time and money, as lionfish can be hard to spot because they often hide within the coral structures during the day. Fortunately, a new technique using environmental DNA (eDNA) is emerging which has the potential to reduce the time, money and labor required to conduct lionfish surveys. All living organisms leave DNA evidence in their environment (through hair, scales, excrement, etc.), which means, if scientists are able to detect this DNA, it’s possible to have a comprehensive list of each species living within an area (Pilliod et al, 2013).

**eDNA Research on Bonaire**

Researchers from Indiana University and CIEE Bonaire completed a series of studies to apply eDNA sampling techniques within the waters of Bonaire. During these controlled laboratory experiments, scientists worked to better understand if eDNA detection strength was related to the number of lionfish present. They hypothesized that the more lionfish within an area, the stronger the eDNA signal would be, even as fish density was held constant. There was also a question concerning the length of time eDNA would be detectable after a lionfish had left an area. To complete these tests, laboratory environments were set up to mimic conditions similar to waters around Bonaire. These tests found that eDNA strength does directly correlate to number of lionfish present. Therefore, a stronger signal could indicate the presence of multiple lionfish within a particular area. However, distance and time are still important covariates that could mask or enhance signal strength and more research is needed. This study also found that eDNA was detectable up to 48 hours after a lionfish had been removed. Knowing this expiration data on eDNA is critical in understanding when an organism was present in that area.

Once the laboratory portion of the experiments were completed, a field study was conducted to validate these findings within the lionfish’s habitat. Using a caged lionfish, sitting 50 cm off the sandy bottom, researchers took water samples both upstream and downstream at varying distances and depths. Upstream sampling would take into account lionfish eDNA already within the sampled area. The measurements downstream would then measure the existing eDNA from lionfish in the water plus the eDNA from the caged lionfish.

One interesting finding during this study was that although divers visually inspected the area for three days leading up to the start of the experiment and found no lionfish, these background samples proved that lionfish had in fact been within (or near) the testing area prior to the start of the test. One suggestion was that lionfish were moving into the shallow areas to hunt at night. This experiment also proved that traces of lionfish eDNA could be detected both on the surface and at the bottom with similar strengths. Due to the eDNA of lionfish already in the water during the field tests, they were unable to determine exactly how far away from the caged lionfish eDNA could be detected. Knowing that lionfish eDNA signals can be detected with similar strengths throughout the water column is very important, as this means sampling can be conducted at the sea surface, removing the need for divers. This also means that more samples can be collected within a shorter period of time, allowing larger regions to be patrolled for lionfish. Furthermore, knowing the length of time it takes for eDNA to breakdown (48 hours), the high sensitivity of detecting eDNA and the speed of the current at your site of interest, one can predict the detection distance of eDNA for any aquatic species of interest.
The Future of eDNA Research

This study illustrates the important role that eDNA could play on the future of environmental monitoring. The results of this study show that under controlled laboratory settings, eDNA strength can indicate presence and abundance of local lionfish. This experiment also demonstrated the high sensitivity of eDNA. This sensitivity could allow researchers to detect rare or difficult to find species in conditions where visual inspections fail short. For example, this could have significant implications for shark conservation efforts. Around Bonaire, shark populations can be difficult to inspect visually as they tend to stay in areas not visited by divers, especially on the east side of the island. STINAPA is currently trying to implement eDNA measuring techniques to monitor the species, timing and areas visited by sharks on Bonaire.

New eDNA sampling techniques could prove to be a game changer in understanding species composition of local environments. The processing of samples in this study cost approximately $0.05 per sample for a standard laboratory to collect and process. If these samples can be taken using surface water, this saves even more time and reduces risk to researchers, having eliminated the need for diving, especially in areas which could be hazardous or difficult to sample. The ability to detect multiple species out of a single sample could allow scientists to gain insight into rare or difficult to find species. The possibilities of this application to conservation biology and environmental monitoring are very exciting.
Emergency assistance contributes to the spread of invasive exotics

Hurricane Maria devastated several Caribbean islands in 2017. A major relief campaign was launched to help the affected population of the Commonwealth of Dominica. It has now been established that in addition to emergency aid, exotic invasive vertebrate species were introduced to Dominica. These famous exotics now threaten the survival of endemic species and urgent action is needed to protect them. This case study serves as a warning to other Caribbean islands as emergency assistance becomes increasingly necessary as climate change related storms worsen.

Biosecurity

In general, both exporting and importing countries are responsible for preventing the spread of exotic species. Unfortunately, devastating natural disasters paralyze local governments and their economies, severely impacting infrastructure and services. The authors of a new publication, Biological Invasions, state that during natural disaster relief efforts, the responsibility to prevent the spread of exotics should lie with the assisting party / parties. Despite the urgency of providing rapid assistance, the removal of invasive exotics will be extremely costly in the long term, both physically and financially. For example, more than $5 million has been spent in the Cayman Islands to reduce the invasive green iguana population. As a result, more attention must be paid to biosecurity during relief operations in the aftermath of natural disasters.

Spread

It is known that species can spread on floating material that entered the sea as a result of hurricanes. Due to the fact that all locations on Dominica where exotics have been found are located on or directly next to ports, researchers find this method of distribution very unlikely. Two exotics also occur on nearby islands, from which most of the relief supplies arrived. These relief goods either came directly from these neighboring islands, or were kept there for several months at storage locations since the Dominican ports could not handle the large amount of aid at once.

The invasive exotics

Researchers have identified the presence of three exotic species, two of which have since established themselves with a large population. These species are the green iguana (Iguana iguana) and the Cuban tree frog (Osteopilus septenri- onalis), both of which also occur as invasive exotic species on other Caribbean islands. The main threat caused by the Cuban tree frog is its explosive growth combined with predation of both vertebrate and invertebrate endemic species. The biggest environmental threat of the green iguana is oppression and hybridization with the sister species, the Antillean iguana. This seriously endangered species has already become extinct on several islands after the introduction of the green iguana. Originally the Antillean iguana was found on Sint Maarten but it is now extinct, and on Sint Eustatius, where the population is seriously threatened with extinction.

Preventing against invasions of non-native species can also help to protect damaged and recovering environments in areas that have experienced a natural disaster.
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DCNA produces “BioNews”, a free monthly digital newsletter featuring recent nature related news-items about the Dutch Caribbean as well as overviews of recent publications, current research and monitoring programmes and upcoming events.

Want to know more? Check the BioNews archive (https://www.dcnanature.org/resources/research-monitoring/)
You can sign-up here (https://www.dcnanature.org/subscribe/) or send an email to research@DCNAnature.org

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References

Editor's Note

Birds

Bats
References

Bats


Marine Mammals


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


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**Sharks**


**Sea Turtles**


**Queen Conch**

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Transboundary Species - Content

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Coral Reefs

Other Marine Ecosystems
References

Other Marine Ecosystems

Environmental Threats

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