

Elasmobranchs in the Dutch Caribbean: Current Population Status, Fisheries, and Conservation

El Estado de Elasmobranchios y Medidas de la Pesca y Conservación en el Caribe Holandés

Le Statut des Élasmobranches et Les Mesures de Pêche et Conservation dans les Antilles Néerlandaises

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ABSTRACT

In the Dutch Caribbean EEZ, at least 27 elasmobranch species have been documented. Of these, nine are listed as “critically endangered” and eight as “near threatened” by the IUCN. Elasmobranchs are not a target fishery in the Dutch Caribbean, but do occur as bycatch in artisanal fisheries. Sharks are considered nuisance species by fishermen. Most sharks caught are not discarded, but consumed locally, used as bait, or (reportedly) killed and discarded at sea on the two islands where landing of sharks is illegal (Bonaire and St. Maarten). Based on recent data, published sport diver accounts, and anecdotal accounts, it is clear that shark populations in most areas of the Dutch Caribbean have been strongly depleted in the last half century.

Two of the six islands have implemented regulation to protect sharks due to their ecological importance and economic value. Two other islands have implemented fish- and fisheries monitoring programmes. The fisheries monitoring includes port sampling with low numbers of shark landings, and on-board sampling with bycatch of sharks on each fishing trip. The fish monitoring has introduced the use of stereo-Baited Remote Underwater Video, a new method for long-term monitoring of fish species composition and relative abundance of sharks.

We conclude there is an urgent need to better cooperate with fishermen to make fisheries and conservation measures more effective and to conduct research on gear modifications and fishing methods to mitigate bycatch of sharks. We also conclude that local fisheries and conservation measures cannot resolve the depletion of shark populations in the Dutch Caribbean due to the (semi-)pelagic habitat use across EEZ borders by most shark species.

KEY WORDS: Shark, elasmobranch, fisheries, conservation, Dutch Caribbean

INTRODUCTION

The current status of elasmobranch populations in the Gulf of Mexico and the Caribbean remains generally poorly known (Fowler et al. 2005). Based on commercial catch data, Bonfil (1997) recorded 36 shark species off the Caribbean coast of Mexico, while Chan A. Shing (1999) identified 36 shark species for Dominica, Guyana, Trinidad and Tobago. Twenty-three species were shared between lists. Due to a lack of directed elasmobranch fisheries, observer programmes and fishery-independent surveys, little remains known about the species composition, distribution, abundance and fisheries targeting cartilaginous species in Caribbean nations (Chan A Shing 1999), and the status of these species in coral reef ecosystems remains largely un-assessed (Ward-Paige et al. 2010).

The Dutch Caribbean EEZ consists of two separate sectors, a southern sector associated with the leeward ABC-islands (Aruba, Bonaire and Curaçao) lying off the coast of Venezuela, and a northern sector, associated with the islands of Saba, St. Eustatius and St. Maarten (Figure 1). Respectively these sectors have a surface area of approximately 71.198 km² and 21.803 km². The Dutch Caribbean EEZ, contains large surface areas of different marine habitat of value to a wide diversity of marine life (Debrot and Sybesma 2000).

The occurrence of sharks in the Dutch Caribbean is poorly known (Meesters et al. 2010). Two recent assessments (Toller et al. 2010, Williams et al. 2010) of the fish communities on the Saba Bank, documented five shark species. An assessment on the fish communities of Bonaire and Curaçao (Sandin et al. 2008) reported the complete absence of sharks. An analysis of 2000 fish surveys by REEF (Reef Environmental and Education Foundation) between 1993 and 1999 on Bonaire reported very low abundance of two sharks species (Pattengill-Semmens 2000). Another study documented 24 records of whale sharks *Rhincodon typus* across all six islands (Debrot et al. in press). In this study, we assembled anecdotal accounts for all six islands to provide a first preliminary assessment of shark and ray species occurrence.

We also provide an overview of the current marine conservation and fisheries legislation pertaining to sharks in the Dutch Caribbean. On 10 October 2010, the former islands of the Netherlands Antilles acquired a new status within the Kingdom of the Netherlands. Curaçao and St. Maarten opted for the status of separate nations within the Kingdom, the same as Aruba already had since 1986. Bonaire, Saba and St. Eustatius became special municipalities within the Netherlands. Following the declaration of an Exclusive Fishery Zone (EFZ) in 1993, an Exclusive Economic Zone (EEZ) was declared in the Dutch Caribbean on 10 June 2010. Consequently, there are eight jurisdictions at various levels of government involved in the management of sharks: the Kingdom maritime zones for EEZ waters, the national waters of four countries, and island maritime zones for the islands of Bonaire, Saba and St. Eustatius.

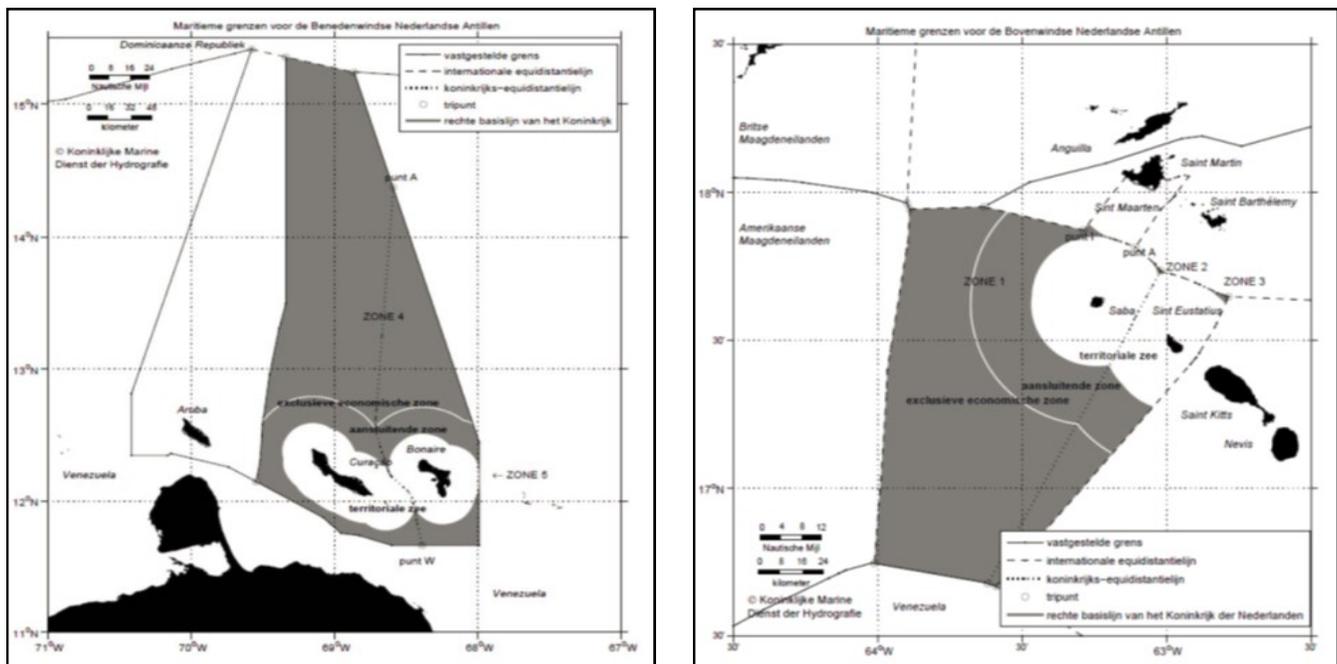


Figure 1. Left map: The leeward Dutch Caribbean EEZ around Aruba, Bonaire, and Curaçao. Right map: The windward Dutch Caribbean EEZ around Saba, St. Eustatius, and St. Maarten.

There are no directed elasmobranch fisheries in the Dutch Caribbean, only small-scale artisanal fisheries around the islands and small-scale commercial fisheries on the Saba Bank. Recently, Saba and St. Eustatius started a fisheries monitoring program and Saba also started a fishery-independent fish monitoring program. In this study, we present initial results on shark catches and shark observations from these monitoring programs

METHODS

In August 2012, a questionnaire was sent to fisheries departments and marine conservation foundations on each of the six islands to compile available information with regards to shark occurrence, conservation and fisheries management measures. The results were verified by the IUCN Shark Specialist Group. A literature search was done to find published studies on shark occurrences in the Wider Caribbean. Of a total of 99 papers found, a third regarded studies of a particular species. Only one paper included a comprehensive shark species list for a particular region of the Caribbean (Bonfil 1997, Chan A. Shing 1999) and four papers documented the occurrence of shark species in the Dutch Caribbean (Pattengill-Semmens 2000, Sandin et al. 2008, Toller et al. 2010, Williams et al. 2010).

Shark Species Occurring in the Dutch Caribbean

A total of 24 shark species and three ray species can be documented for the Dutch Caribbean based on the three published accounts and the queries we held amongst island fisheries and conservation managers (Table 1). The IUCN Shark Specialist Group was able to add four additional

shark species and two ray species (N. Dulvy, Pers. comm.). The potential number of elasmobranch species present in the Dutch Caribbean amounts to 33 species, comprising 28 species of sharks and five species of rays.

Population Structure, Distribution and Relative Abundance

The status of the shark population structure, distribution and relative abundance remains largely unknown, mainly due to a lack of observer programs and fishery-independent research. The responses obtained from the questionnaire were inadequate for an analysis of distribution and relative abundance, because of the anecdotal nature of the observations. Recent studies suggest some shark species are still relative abundant, particularly on the Saba Bank and in the deeper waters of the leeward islands. For instance, a study on the spatial distribution of the blue shark *Prionace glauca* in the Venezuelan pelagic longline fisheries found high year-round concentrations around the leeward islands of the Netherlands Antilles (Tavares et al. 2012). A study of the fish communities on the Saba Bank found a notable number of nurse sharks *Ginglymostoma cirratum*, Caribbean reef sharks *Carcharhinus perezi*, blacktip sharks *C. limbatus* and tiger sharks *Galeocerdo cuvier* (Toller et al. 2010, Williams et al. 2010). The preliminary results from the fishery-dependent and fishery-independent surveys do provide some information on shark bycatch and shark populations and show that these surveys are promising for monitoring distribution and relative abundance of sharks and rays in the future.

Table 1. Documented shark and ray species in the Dutch Caribbean and their status according to international (CITES, CMS) and regional (SPA) conventions and the IUCN Red list of endangered species. X = observations * = tentatively present (IUCN SSG, N.Dulvy pers. comm.) Referees were not explicitly asked for the presence of sharks, hence the limited observations thereof. IUCN Red List categories of threatened species are: **CR** = Critically Endangered; **EN** = Endangered; **VU** = Vulnerable. Other categories are: **NT** = Near Threatened; **LC** = Least Concern en **DD** = Data Deficient. Habitat indicates which species are pelagic, indicating observations are more difficult and therefore less common. P = oceanic en SP = Semi-pelagic (Camhi et al. 2009).

| Common name | Scientific name | Observed species per island | | | | | | Status species per | | | | Habitat |
|---|-----------------------------------|-----------------------------|---------|---------|------|---------------|-------------|----------------------|-----|----------------------|------|---------|
| | | Aruba | Bonaire | Curaçao | Saba | St. Eustatius | St. Maarten | CITES ^{1,4} | CMS | SPA ^{10,14} | IUCN | |
| Family: Whale sharks – Rhincodontidae | | | | | | | | | | | | |
| 1. Whale shark | <i>Rhincodon typus</i> | X(2) | X(2) | X(1) | X(1) | X(1) | X(2) | II | II | (10) | VU | P |
| Family: Nurse sharks – Ginglymostomatidae | | | | | | | | | | | | |
| 2. Nurse shark | <i>Ginglymostoma cirratum</i> | X(2) | X(2) | X(4) | X(2) | X(10) | X(2) | | | | DD | |
| Family: Requiem sharks – Carcharhinidae | | | | | | | | | | | | |
| 3. Caribbean reef shark | <i>Carcharhinus porosus</i> | X(2) | X(2) | | X(2) | X(10) | X(2) | | | (10) | VI | |
| 4. Blacktip shark | <i>Carcharhinus limbatus</i> | X(2) | | | X(2) | | X(2) | | | | VI | SP |
| 5. Lemon shark | <i>Negaprion brevirostris</i> | X(2) | | X(4) | | | X(2) | | | | VI | |
| 6. Big shark | <i>Carcharhinus leucas</i> | X(2) | X(2) | | X(2) | X(10) | X(2) | | | | VI | SP |
| 7. Tiger shark | <i>Galeocerdo cuvier</i> | X(2) | X(2) | | X(2) | X(10) | X(2) | | | | VI | SP |
| 8. Oceanic whitetip shark | <i>Carcharhinus longimanus</i> | X(2) | | X(4) | | | | | | (10) | VU | P |
| 9. Scalloped shark | <i>Carcharhinus falkenberryi</i> | | | X(4) | | | | | | | VI | P |
| 10. Blue shark | <i>Prionace glauca</i> | | | X(4) | | | | | | | VI | P |
| 11. Blacknose reef shark | <i>Carcharhinus acronotus</i> | * | * | * | * | * | * | | | | VI | |
| 12. Bull shark | <i>Carcharodon carcharias</i> | * | * | * | * | * | * | | | | DD | |
| 13. Caribbean shark | <i>Megachasma pelagios</i> | * | * | * | * | * | * | | | | DD | |
| Family: Hammerhead sharks – Sphyrnidae | | | | | | | | | | | | |
| 14. Smooth hammerhead | <i>Sphyrna tiburo</i> | X(2) | | | | | | | | (10) | VU | SP |
| 15. Scalloped hammerhead | <i>Sphyrna lewini</i> | X(2) | | X(11) | | | | II | | (10) | EN | SP |
| 16. Bonnet hammerhead | <i>Sphyrna tiburo</i> | X(2) | | | | | X(2) | | | (10) | EN | SP |
| 17. Bonnet hammerhead | <i>Sphyrna tiburo</i> | X(2) | | X(5) | | | | | | | LC | |
| 18. Hammerhead | <i>Sphyrna spp.</i> | | X(2) | X(4) | X(4) | | | | | | | |
| Family: Mackerel sharks – Lamnidae | | | | | | | | | | | | |
| 19. Shortfin mako | <i>Isurus paucus</i> | X(2) | | | | | | | II | (10) | VU | P |
| Family: Threshers sharks – Alopiidae | | | | | | | | | | | | |
| 20. Thresher shark | <i>Alopias vulpinus</i> | X(2) | | | | | | | | (10) | VU | P |
| 21. Bigeye thresher | <i>Alopias superciliosus</i> | X(2) | | | | | | | | (10) | VU | P |
| Family: Six/sevengill sharks – Hexanchidae | | | | | | | | | | | | |
| 22. Bigeye sevengill shark | <i>Hexanchus nakamurai</i> | | | X(4) | X(4) | | | | | | DD | |
| Family: Sawfishes – Pristidae | | | | | | | | | | | | |
| 23. Smalltooth sawfish | <i>Pristis perottensis</i> | | | X(4) | | | | I | | (10) | CR | |
| Family: Dogfish sharks – Squalidae | | | | | | | | | | | | |
| 24. Cuckoo dogfish shark | <i>Squalus cubensis</i> | | X(4) | X(7) | | | | | | | DD | |
| Family: Kitefin sharks – Dalatiidae | | | | | | | | | | | | |
| 25. Cownose shark | <i>Rhizoprionodon terraenovae</i> | | | X(5) | | | | | | | LC | P |
| Family: Lantern sharks – Etmopteridae | | | | | | | | | | | | |
| 26. Red lantern shark | <i>Etmopterus baxteri</i> | | | | X(7) | | | | | | LC | SP |
| Family: Hound sharks – Triakidae | | | | | | | | | | | | |
| 27. Hound shark | <i>Triakis sp.</i> | | | X(4) | | | | | | | | |
| Family: Cats sharks – Scyliorhinidae | | | | | | | | | | | | |
| 28. Manx shark | <i>Scyliorhinus retifer</i> | * | * | X(5) | * | * | * | | | | DD | |
| 29. Blacktip shark | <i>Scyliorhinus torosus</i> | * | * | * | * | * | * | | | | DD | |
| Family: Stingrays – Dasyatidae | | | | | | | | | | | | |
| 30. Spotted stingray | <i>Maculabatis omurae</i> | * | * | * | * | * | * | | | | DD | |
| 31. Black stingray | <i>Dasyatis sayi</i> | * | * | * | * | * | * | | | | LC | |
| 32. Spotted eagle ray | <i>Aetobatus narinari</i> | X | X(5) | X(5) | X | X | X | | | | DD | |
| 33. Spotted eagle ray | <i>Dasyatis americana</i> | X | X(5) | X(5) | X | X | X | | | | DD | |
| Family: Mantas/devil rays – Myliobatidae | | | | | | | | | | | | |
| 34. Giant mantaray | <i>Megachasma pelagios</i> | * | X(2) | * | * | * | * | | II | (10) | VU | P |

Table 1 (continued).

- (1) 24 observations in the past 50 years, 4 for the windward islands of Saba, St. Eustatius and St. Maarten and twenty for the leeward islands of Aruba, Bonaire and Curaçao. The majority of observations (67%) are from the past 5 years (Debrot et al. In press)
- (2) Observations of bycatch by the Fisheries Department on Aruba in the past 20 years. More species have been reported, but these have not been identified with certainty by the Fisheries Department and have not been included in the species list (B. Boekhoudt, Pers. comm.)
- (3) Observations by the Bonaire National Marine Park manager in the past 15 years: Whale sharks in 2001 (Klein Bonaire and 18 Palm), Hammerheads in 2000 (east coast) and 2002 (Belnem), Bull sharks in 2002 (east coast and Lac) and 2012 (Harbour Village Marina), Caribbean reef sharks (common, 15-20 in past 15 years), Nurse sharks (common, 25-30 in past 15 years, especially at the east coast and Washington Slagbaai National Park, unidentified group of sharks in 2010 (3 miles offshore from Cargil) (R. de León, Pers. comm.)
- (4) Observations by the Head of Fisheries Department on Curaçao: Oceanic white tip in the 60s (harbour) and 70s (at sea), Smalltooth sawfish in the 70s (St. Jorisbaai), Blue shark, Bigeyed sixgill shark, Silky sharks (used to be common), Lemon sharks (Oostpunt lagune), Hammerhead sharks (daily in the 70s and occasionally nowadays), Tiger shark in 2011 (Patrick). Cuban dogfish shark, houndshark species, sixgill shark species and sometimes nurse sharks are bycatch (G. van Buurt, Pers. comm.)
- (5) Observations by A. Debrot between 1990 and 1995 around Curaçao and Bonaire: Big-eyed sixgill shark and Cuban dogfish shark in 2000 (Reed and Pomponi 2001; A. Debrot, pers. comm.). Cookycutter shark (Debrot and Barros 1992; Debrot and Barros 1994)
- (6) (Boeke 1907) Observation in the Schottegat Curaçao
- (7) (Williams et al. 2010)
- (8) Observations around Saba and the Saba Bank by I. van Beek, A. Debrot en M. de Graaf and at Harbour Village Marina Bonaire by I. van Beek.
- (9) Observations by the St. Maarten Nature Foundation Marine Park Manager: Whale shark in October 2010 (reported, not confirmed with certainty). Frequency of other observations is at least once per year and $X^{1,2,3, \text{etc.}}$ denotes the frequency from high to low (T.Bervoets, Pers. comm.)
- (10) Observations by the St. Eustatius National Park Foundation Manager between 2003 en 2010 (N. Esteban, pers. comm.)
- (11) Antilliaans Dagblad 19 March 2007
- (12) Catch by A. Debrot Sr. in the 50s at Washington Slagbaai (A. Debrot, Pers. comm.)
- (13) CITES appendices I, II en III list 3 shark species that occur in the Dutch Caribbean. The Scalloped hammerhead in appendix III is added to the update of 25 September 2012 by Costa Rica.
- (14) SPAW appendices do not list shark species currently, but the revision that is being considered at the COP7 in October 2012 contains a number of shark species in appendix II, denoted as (II) (P. Hoetjes, Pers. comm.)

The IUCN Red List of threatened species lists ten of the 33 species in the Dutch Caribbean as threatened with extinction (CR = 1, EN = 2, VU = 7, Table 1), eight as “near threatened” (NT = 8) and nine as “data deficient” (DD = 9).

The populations status of most species has unquestionably declined dramatically from former times. In the 1940s -1950, the popular writers Hass (1949, 1956) and Hakkenberg van Gaasbeek (1955) recount the high abundance of large fishes in the near shore waters surrounding Curaçao and Bonaire. In those times, sharks were observed on practically every snorkeling trip, whereas today sharks are only sporadically encountered during dives (Auster et al. 2005, A. Debrot, R. de Leon, H. Meesters, M. Vermeij, Pers. comm.). Based on recent data, published sport diver accounts, and anecdotal accounts, it is clear that shark populations in most areas of the Dutch Caribbean have been strongly depleted in the last half century. The drastic reduction in reef predators such as sharks is the fingerprint of marine fisheries (Branch et al. 2010), and is inversely related to increased human population density throughout the wider Caribbean (Stallings 2009).

Fisheries Monitoring and Shark Bycatch

Fisheries specifically targeting sharks do not occur on any of the Dutch Caribbean islands (Figure 2). However, sharks are incidentally caught in the small-scale coastal fisheries around the islands. Sharks are often regarded as a nuisance, because they damage gear, consume bait or catch (Toller and Lundvall 2008, B. Boekhoudt and R. de Leon, Pers. comm.) or are a danger to get and keep on board, particularly the sixgill shark species *Hexanchus spp.* (G. van Buurt, pers. comm.). Although by law sharks should be released alive upon capture on Bonaire and St Maarten, this is unlikely to occur all the time and sharks are regularly killed before being returned to the sea (Toller and Lundvall 2008, R. de Leon, Pers. comm.), used as bait in fish traps (Dilrosun 2000) or as feed for lobsters kept in holding cages (Toller and Lundvall 2008). Furthermore, sharks are sometimes kept by fishermen for their own

consumption (Toller and Lundvall 2008, B. Boekhoudt and E. Boman, Pers. comm.) or sold on the island (F. van Slobbe, pers. comm.). The low-grade flaked flesh of sharks and rays is typically used in traditional recipes for “karikari” and “balchi di piska”. On St. Maarten illegal shark fishing and trophy hunting has been reported despite the temporary ban on shark fisheries (Bervoets 2012a), and one fisherman was caught in May 2012 with a Caribbean reef shark with its head and fins removed (Bervoets 2012b).

Landings and bycatch of sharks are generally not recorded except for Saba and St. Eustatius, because of the lack of regular fisheries monitoring programs. Some of the fisheries departments did provide some anecdotal information on shark bycatch. All shark observations on Aruba were from bycatch (Table 1). On Curaçao bycatch of Cuban dogfish shark *Squalus cubensis* and houndshark species *Triakis spp.* is rare nowadays in the deep water snapper fisheries and there is no longline fisheries anymore with bycatch of sixgill shark species and nurse sharks (G. van Buurt, pers. comm.). The fisheries department on St. Eustatius reported bycatch of nurse sharks and Caribbean reef sharks (E. Boman, Pers. comm.).

Two fisheries assessments on the Saba Bank fisheries in 2000 and 2007 reported on shark bycatch. Dilrosun (2000) monitored the landings for a 12-month period and reported nurse sharks were caught in the lobster trap fishery, but were not landed and used as bait instead. According to Toller and Lundvall (2008) nurse sharks were common bycatch species in the lobster trap fishery, but rarely marketed. During the 6-month study of Toller and Lundvall (2008) the following shark species were recorded in addition to nurse sharks: Blacktip shark (1 specimen; landed), Cuban dogfish (1 specimen; released), and Caribbean reef shark (4 specimens; landed).

In 2012 a fisheries monitoring program was implemented on St. Eustatius and Saba and a pilot study will start on Bonaire in 2013. The fishery in the waters surrounding St. Eustatius is small scale with around six fishermen. During port sampling on St. Eustatius between January and June 2012, 108 interviews were conducted and 18 catches were sampled, in which four nurse sharks

between 90 – 160 cm were recorded as landed. The Saba commercial fishery is almost exclusively focussed on the Saba Bank with little effort allocated to the waters directly surrounding the island. This small fishery (10 licenses) is predominantly a trap fishery for lobster (shallow waters < 30 m) and redfish (assorted snapper species; deep waters > 100 m). Sharks are not specifically targeted by any of these fisheries, but are incidentally caught as bycatch. During port sampling on Saba between January 2012 and October 2012, only 3 sharks (2 nurse sharks, 1 Caribbean reef shark) were recorded as landed so far. However, during each of the five on-board discard monitoring trips of the lobster trap fishery, nurse sharks were observed as bycatch. All were returned to the sea alive. One dead Caribbean reef shark (~50 cm) was recorded in a lobster trap. Furthermore a fisherman reported catching “sixgill sharks” while handlining in deep waters (100 – 300 m).

The establishment of fisheries monitoring programmes on the islands should soon start providing basic information on shark catches, species composition and relative abundance.

Fish Monitoring and Shark Abundance

Fish surveys have been conducted incidentally on most of the islands, but not in a regular, structured and standardised way. In July 2012 a fish monitoring programme started in the waters around Saba at three depths, 15, 50, and 100 m. Data on species richness, relative abundance and length-frequency distribution is collected using stereo Baited Remote Underwater Video (sBRUV, Figure 3). Brooks et al. (2011) compared BRUV with traditional long line surveys to study diversity, distribution and abundance of sharks on the Bahamas and concluded that BRUV is a viable, less invasive and more cost effective method than longline surveys when studying sharks, especially suited for long term monitoring of species richness and relative abundance over a wide range. During the current sBRUV survey at 15m depth around Saba, four nurse sharks and four Caribbean reef sharks were observed in 21 (45 minute) camera deployments. In 2013 the sBRUV fish surveys will be conducted on the Saba Bank and around St. Eustatius. The sBRUV method is being developed for long term monitoring of fish on Bonaire, Saba and St. Eustatius.



Figure 2. Scalloped hammerhead (*Sphyrna lewini*) bycatch on Curaçao (Photo: M. Vermeij).

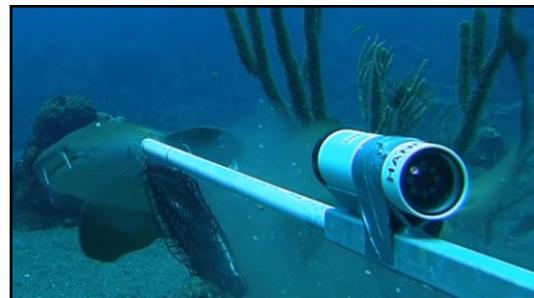


Figure 3. Nurse shark (*Ginglymostoma cirratum*) observation using sBRUV in the fish survey on Saba.

Ecological and Economical Value of Sharks

The functional role of sharks as apex predators makes them important contributors to a number of ecosystem services. As a small part of the fisheries catch and bycatch, sharks contribute to the provisioning service provided by marine ecosystems, but in the Dutch Caribbean this is negligible. However, living sharks are important for the cultural and regulating services provided by the marine ecosystem. The cultural value of sharks is most evident, because sharks are a charismatic megafauna for dive tourism (Maljkovic and Cote 2011) which contributes importantly to the economic value of coral reef ecosystems. There are non-consumptive forms of exploitation such as diving with sharks offered by the diving industry, for example on St. Maarten. The diving industry is quite important for the economy of the Dutch Caribbean islands and in branding the islands within the dive tourism market.

The regulation function of sharks as apex predators is related to their ecological role in the food web. A study by Rezende et al. (2009) highlighted the importance of sharks for the organization, and potentially also for the stability and biodiversity of the Caribbean food webs. Modelling suggests that sharks are important regulators of grouper biomass on Caribbean reefs (Bascompte et al 2005 in Chapman et al. 2006) and potentially important for the biological control of the invasive lionfish *Pterois volitans* (Albins and Hixon 2008, Arias-Gonzalez et al. 2011). Other work suggests the role of sharks in regulating grouper biomass has an indirect positive effect on parrotfish biomass and grazing capacity (Chapman 2006). This indirect positive effect of sharks on parrotfish biomass may be countered by the direct negative effect of sharks preying on larger parrotfish (Mumby 2006). The model of Arias-Gonzalez et al. (2011) predicts that lionfish will replace sharks as apex predators as a result of a decrease in sharks due to overfishing throughout the region.

The economic value of shark fisheries is an important driver for their consumptive exploitation, but the key to reduce or reverse population declines due to shark fisheries may be to raise the economic value of non-consumptive forms of exploitation (Maljkovic and Cote 2011) and to better understand and value the role sharks may have in ecosystem functioning.

Conservation Management Measures

A number of studies have investigated the effects of marine conservation on the distribution and abundance of sharks in coral reef ecosystems. A review of 76,340 underwater diver surveys over a period of 15 years by Ward-Paige et al. (2010) concluded that sharks, with the exception of nurse sharks, were mainly found in areas with very low human population or strong fishing regulations and marine conservation. A study by Bond et al. (2012) concluded that reef dwelling sharks benefit from marine reserves and are more abundant inside no-take marine reserves, likely due to a reduction in fishing pressure.

In the Dutch Caribbean there are various conservation and fisheries management regulations to directly or indirectly protect elasmobranchs, which differ between islands and at jurisdictional level. A number of species are protected under international or regional treaties, such as the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Special Protected Area (SPA) protocol of the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean. For the species in the Dutch Caribbean, Table 1 shows if they are protected under these treaties. Table 2 shows at which jurisdictional level (Kingdom, national, or island level) these treaties are implemented and what additional legislation is in place. At Kingdom level, all international treaties are ratified and implemented through legislation of the Kingdom of the Netherlands. Most islands further specify the implementation of CITES and CMS in relevant island resolutions (Aruba, Bonaire, Curaçao, St. Maarten). At national level all four countries (Caribbean Netherlands, Aruba, Curaçao, and St. Maarten) implemented the regional SPA protocol. At island level, as part of the Netherlands, Bonaire also specifies the implementation of SPA. Finally, two islands have specific legislation for the protection of shark species. Since 2010, in Bonaire all shark species and three ray species are offered special protection through a nature ordinance, but sanctions for violation remain wanting. In 2011, the ministry of Tourism, Economic Affairs, Telecommunication and Transportation on St. Maarten established a temporary ban on shark fisheries, including a meaningful sanction. This ban will remain in effect for 10 years, in which period the St. Maarten Nature Foundation (SMNF) is required to compile data on the status and threats facing sharks. After 10 years the ban will be reviewed and a decision made based on the recommendations of the SMNF (T. Bervoets, Pers. comm.).

DISCUSSION AND RECOMMENDATIONS

This paper shows how in a relatively short time, a compilation of anecdotal information can provide valuable insight into the occurrence and status of large cartilaginous fish species. Nevertheless, more detailed and accurate information on population structure, distribution and relative abundance would be very valuable. Fortunately, various fish monitoring schemes have been implemented and should soon provide reliable new insights into the status of these important species. Aside from the planned fishery and sBRUV monitoring we also recommend establishing an opportunistic observer network to get a broad overview of trends in distribution and relative abundance. Such a volunteer opportunistic observer network has also been used successfully for whale observations in the past (Debrot et al. 1998), but is equally applicable to other large charismatic marine species. A training including the development of a species identification key is recommended to

enhance participation of and implementation by all dive operators and leading fishermen on the island.

On those islands where conservation and fisheries legislation is in place to protect sharks, shark bycatch is supposed to be released alive upon capture. This does not always occur, because sharks are considered a nuisance by fishermen or are used either as bait or for personal consumption. This means that fisheries government officials and fisheries researchers implementing monitoring programs should invest time and effort in compliance of fishermen by raising awareness and through enforcement and establishment of meaningful penalties for violations. Furthermore, it must be recognized that local legislation and enforcement alone, will not be sufficient to protect shark populations, as many of them are (semi-)pelagic species (Table 1) that should be considered transboundary fish stocks.

Of the 33 elasmobranchs occurring in the Dutch Caribbean, more than half are listed as threatened with extinction or as near threatened. To rebuild threatened shark popula-

tions the following fisheries management measures are recommended by the IUCN Shark Specialist Group:

- i) Protect habitats and prevent overfishing,
- ii) Increase observer coverage, monitoring and enforcement,
- iii) Record species-specific elasmobranch bycatch, including discards,
- iv) Prohibit on-board shark finning,
- v) Promote research on gear modifications, fishing methods to mitigate shark bycatch and discard mortality,
- vi) Draft and implement a National Plan Of Action (NPOA) pursuant to the Food and Agriculture Organization's International Plan Of Action for sharks (IPOA-shark), and
- vii) Conduct population assessments.

To this list we would add: viii) the promotion of local awareness of the economic and ecological value of healthy shark populations.

Table 2. Jurisdiction levels at which the conservation and fisheries of elasmobranchs at international, regional and national level is regulated in the Dutch Caribbean EEZ

| | International & regional treaties | | | National legislation | | |
|--------------------------------------|--|---------------------------------|---------------------------|------------------------------|--|---|
| | Jurisdiction level | CITES | CMS | SPAW | Protection | Penalties |
| | <u>1. Kingdom of the Netherlands</u> | Yes | Yes | N.a. | | |
| N a t i o n a l | <u>2. Netherlands Caribbean</u> | Yes | Yes | Yes | | |
| | "Wet grondslagen natuurbeheer- en bescherming BES" | Art.6 | Art.12 | Art.13 | | |
| | <u>3. Aruba</u> | Yes | No | Yes | No | No |
| | Nature ordinance AB 1995 No. 2 | Art. 11&12&13 | AB1995 No. 2 | Art. 11&13 AB1995 No.2 | | |
| | Cites register AB 1995 No. 69 | AB1995 No. 2 AB1995 No.69 | | | | |
| I e v e l | <u>4. Curaçao</u> | Yes | Yes | Yes | No | No |
| | Nature ordinance PB 1998 No. 49 | Art.6&7 PB1998 No.49 | Art.8c PB1998 No.49 | Art.8a&8b PB1998 No.49 | | |
| | <u>5. St. Maarten</u> | Yes | Yes | Yes | Yes | Yes |
| | Nature ordinance AB 2003 No. 25 | Art.16.1 | Art.16.1 | Art.16.1 | Temporary ban on shark fisheries since 12 October 2011 | On shark fishing ban (3mth/500,000 NAF) |
| | Fisheries ordinance PB 1991 No. 74 | AB2003 No.25 | AB2003 No.25 | Art.16.3 AB2003 No.25 | | |
| I s l a n d | <u>6. Bonaire</u> | Yes | Yes | Yes | Yes | No |
| | Nature ordinance AB 2008 No. 23 | Art.11.1 | Art.11.1 | Art.11.1 | All shark and 3 ray species (<i>Manta birostris</i> , <i>Aetobatus narinari</i> , <i>Dasyatis americana</i>) Art.11.1 AB2010 | |
| | Nature resolution AB 2010 No. 15 | AB2008 | AB2008 | AB2008 | | |
| I e v e l | <u>7. Saba</u> | No | No | No | No | Yes |
| | Marine ordinance AB 1987 No. 10 | | | | | On violation AB 1987 (1mth/ 5,000 NAF) |
| I e v e l | <u>8. St. Eustatius</u> | No | No | No | No | Yes |
| | Nature ordinance AB 1996 No. 3 | | | | | On violation AB 1996 (1mth/ 5,000 NAF) |

CONCLUSIONS

The total number of elasmobranch species present in the coastal and deeper waters and adjacent high seas of the Dutch Caribbean amount to a combined total of at least 33 species, comprising of 28 sharks and 5 rays. Ten of these 33 species are IUCN-listed as threatened with extinction (CR, EN or VU), eight are near threatened (NT) and nine are data deficient (DD). Shark populations in most areas of the Dutch Caribbean have declined precipitously in the last half century.

Two of the six islands, namely Bonaire and St. Maarten, currently have specific legal protection for sharks. In addition all islands have implemented various levels of habitat protection through which critical habitat for sharks is also afforded some degree of protection. Because the Dutch Caribbean does not have a directed shark fisheries and regular, standardized fisheries monitoring programs have only recently been implemented on some of the six Dutch Caribbean islands, we collected data based on a review of the literature and especially anecdotal accounts.

While there are no directed elasmobranch fisheries in the Dutch Antilles, nevertheless bycatch of sharks does occur, even where specifically prohibited. The standardized fisheries monitoring programs which started in 2012 on Saba and St. Eustatius are recording species-specific data on bycatch, both landed and discarded. In addition the fishery-independent fish monitoring program on Saba is recording relative abundance of sharks. Both of these monitoring schemes can be expected to provide dearly needed new insights into shark species distribution and abundance in the years to come. Nevertheless, we also propose to set up an opportunistic observer network on all islands through dive operators, as a relatively simple and effective method to obtain useful insights into trends in distribution and relative abundance of sharks the in coastal coral reef ecosystems of the Dutch Caribbean.

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