Shark protection plan for the Dutch Caribbean EEZ

I.J.M. van Beek, A.O. Debrot, P.A. Walker[1,2], I. Kingma[2]

Report number C209/13

IMARES Wageningen UR
Institute for Marine Resources & Ecosystem Studies

[1] Hogeschool Van Hall Larenstein (VHL)
[2] Nederlandse Elasmobranchen Vereniging / Dutch Elasmobranch Society (NEV)

Client: Ministry of Economic Affairs (EZ)
Contact: Drs. H. Haanstra
P.O. Box 20401
2500 EK The Hague

BAPS code BO-11-011.05-030

Publication date: February 2014

IMARES is:

- an independent, objective and authoritative institute that provides knowledge necessary for an integrated sustainable protection, exploitation and spatial use of the sea and coastal zones;
- an institute that provides knowledge necessary for an integrated sustainable protection, exploitation and spatial use of the sea and coastal zones;
- a key, proactive player in national and international marine networks (including ICES and EFARO).

This research is part of the BO program Helpdesk Caribbean Netherlands (BO-11-011.05-030) and has been co-financed by the Ministry of Economic Affairs (EZ) under project number HD3468.

P.O. Box 68
1970 AB IJmuiden
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 26
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 77
4400 AB Yerseke
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 59
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 57
1780 AB Den Helder
Phone: +31 (0)317 48 09 00
Fax: +31 (0)223 63 06 87
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 167
1790 AD Den Burg Texel
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 62
E-Mail: imares@wur.nl
www.imares.wur.nl

Contents

Summary

Shark populations have steeply declined worldwide due to unsustainable overexploitation and in this the Caribbean region is no exception. Since the 1990s many initiatives have been developed to protect the most threatened species. Sharks play an important ecological role in tropical marine ecosystems and represent an important economic potential in the context of ecotourism. As the Netherlands has traditionally shown strong international leadership and commitment in biodiversity protection, a key ambition of the new Dutch Caribbean Nature Policy Plan 2013-2017, developed jointly with the Dutch Caribbean islands, is the effective implementation of shark protection.

This report provides the necessary review and background on which to base such an endeavour. In 2012 27 species of sharks and rays were documented to be present in a deskstudy by IMARES, and six other species were listed to be tentatively present according to the IUCN Shark Specialist Group. In 2013 three new species were documented in field surveys carried out by IMARES. For these species this report provides an overview of available scientific knowledge on life history characteristics, distribution, abundance and population status in the Caribbean. The life history characteristics of slow growth, late maturity and low fecundity make sharks very vulnerable to overfishing and reduce their ability to recover from past overfishing. Because of their life history characteristics and their coastal habitat use for specific life stages, destruction of their main habitats and nursery grounds also has a relatively large impact on shark populations.

The main threats to address in a shark protection plan are fishing mortality and habitat quality. Although directed shark fisheries are not occurring in the Dutch Caribbean, there are additional concerns to global shark populations, which are mixed-species fisheries, bycatch and Illegal, Unreported and Unregulated (IUU) fishing. Sharks do occur as bycatch in artisanal fisheries in the Dutch Caribbean and illegal fishing by foreign vessels also occurs occasionally.

Public environmental awareness and support for management measures are a key determinant for the successful implementation of a shark protection plan. As part of this research a questionnaire was distributed amongst three key coastal resource user groups: fishermen, sport divers and local residents. It appeared there was no consensus on the perception of the change in biodiversity and abundance of sharks and rays. However, a decisive majority of the respondents was in favour of shark protection and half of the fishers was in favour to manage bycatch. Respondents were asked to rank specific measures in order of importance. The most appreciated measure for fishermen was enforcement including meaningful penalties and the most appreciated measures for the other respondents were a ban on shark finning and landing of sharks, followed by enforcement and immediate release of bycatch. However, in the opinion of some fishermen sharks are considered a pest, which are not specifically targeted, but when caught are consumed or sold like any other fish. Awareness raising of especially fishermen and children was added by several divers and residents as an important additional protection measure.

Throughout the world, sharks are playing an increasingly important role in island economies as an important natural attraction for eco-based recreation and tourism. A recent study has shown that a single shark can represent an average touristic resource value of US$ 2.64 million. Consequently, shark protection is taking flight around the world, including the Caribbean. In the last 3 years the region has seen the implementation of shark National Plan Of Action (NPOA) in the Bahamas, Honduras and Venezuela. Because the most destructive industrial-scale fishery practices (directed shark fisheries, shark finning, long-lining and gillnetting) have never been important in the Dutch Caribbean, the development and effective implementation of a shark NPOA is much simpler than in most situations. The overall feasibility for successful shark conservation are high due to a number of other factors listed in this report.

Worldwide the use of sanctuaries is the main conservation tool. We therefore propose the establishment of a shark sanctuary as the main cornerstone to a Dutch Caribbean shark NPOA. This report outlines the ecological arguments for the establishment of a shark NPOA and sanctuary(ies), as well as the typical issues that need to be addressed. Legal designation of a shark sanctuary would form the first and most important step which provides the framework for all broader (international cooperation) and in depth (knowledge and conservation development) initiatives. Once a sanctuary is established, the fuller implementation of a shark NPOA should be seen as a gradual process, involving development of knowledge, policy, rules and regulations, public and stakeholder participation. In this, the Netherlands would follow and importantly reinforce the efforts of other nations who have already established NPOAs based on shark sanctuaries within the region.

The most promising area for establishment of a shark sanctuary is the little-fished Saba Bank as this area of unique biodiversity has the best shark population status, has recently already acquired national protected status and an active management structure, as well as international status as an EBSA and PSSA including IMO anchoring prohibition. Furthermore, a shark sanctuary for this area could importantly reinforce government plans to locate the first (part) of a Dutch Caribbean Marine Mammals Sanctuary at the Saba Bank. The shark population present presents unique research opportunities that could also generate considerable economic spin-off for the islands in terms of scientific research and knowledge development.

We conclude with three key recommendations:

- Develop a simple and holistic shark NPOA based importantly on the use of one (or more) shark sanctuaries
- Set up a shark research program combining on the one hand low tech opportunistic approaches (allowing participation of stakeholder groups for awareness and community support) and on the other hand using high tech approaches (genetic, telemetry, video-monitoring) to allow thorough insights even though abundance may be low
- Start actively participating in regional shark conservation and ecosystem initiatives and seek active collaboration with sister sanctuaries of the region (Venezuela, Honduras, Bahamas)

1 Introduction

Fish can be divided in bony fish (Osteichthyes) and cartilaginous fish (Chrondrichthyes). Sharks and rays form the subclass elasmobranchs in the class Chrondrichthyes. About 5% of all fish species are elasmobranchs (Heessen, 2010). Globally there are between 954 and 1,125 species of living elasmobranchs in 57 families and 182 genera (Fowler et al. 2005). For the purpose of this report, the term 'shark' includes all species of sharks and rays unless stated otherwise.

The occurrence of elasmobranchs in the Dutch Caribbean is poorly known (Meesters 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 km^2 and 21.803 km^2 (Debrot and Sybesma, 2000).

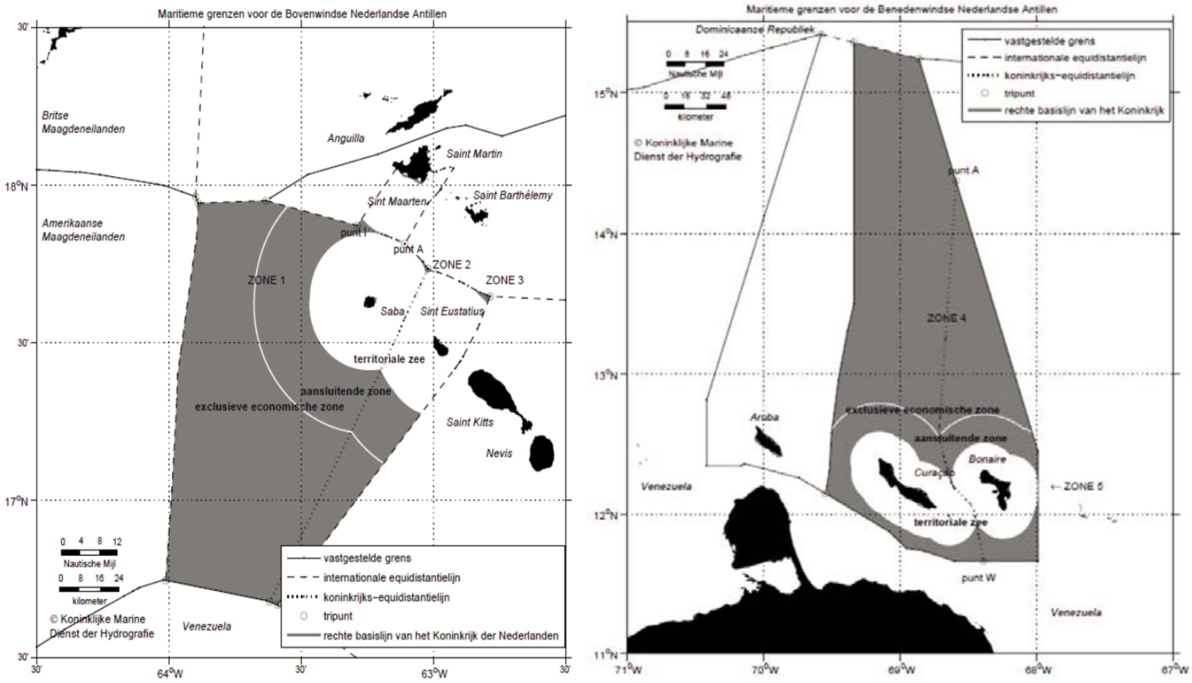


Figure 1. Left map: The leeward Dutch Caribbean EEZ around Aruba, Bonaire and Curaçao. Right map: The windward Dutch Caribbean EEZ around Saba, St. Eustatius and St. Maarten.

Based on anecdotal accounts from the six islands in the Dutch Caribbean a preliminary assessment of shark occurrence has been described in a study of IMARES commissioned by the Dutch Ministry of Economic Affairs (Van Overzee et al., 2012) and in two publications (Debrot et al., in press; Van Beek et al., 2013).
In the Dutch Caribbean EEZ at least 27 elasmobranch species have been documented and 6 more species are tentatively present (Appendix A). Of these, 10 are listed as "critically endangered" and 8 as "near threatened" by the IUCN. 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 (Van Beek et al., 2013).

The main threats to sharks are fishing and habitat loss and degradation (Field et al. 2009). Direct fishing mortality is a driver of decline in elasmobranchs biodiversity, although some smaller fisheries do not have associated declines, and particularly mixed-species fisheries and illegal, unreported and

unregulated (IUU) fishing are of concern (Field et al. 2009). The increase of shark catches is a concern for shark populations, because sharks often have a close stock-recruitment relationship (i.e. stock reduction reduces recruitment), complex spatial structures (size and sex segregation and seasonal migration) and long recovery times in response to overfishing due to their life history characteristics (late sexual maturity, few off-spring) (FAO, 1999). Because of their life history characteristics and their coastal habitat use for specific life stages, destruction of their main habitats and nursery grounds also has a relatively large impact on shark populations (Jennings et al. 2009).
Elasmobranchs are not a target fishery in the Dutch Caribbean, but do occur as bycatch in artisanal fisheries. Sharks are considered nuisance species by some fishermen. Most sharks caught are not discarded, but consumed locally, used as bait, or (reportedly) killed and discarded at sea (Van Beek et al., 2013). Illegal fishing on sharks by foreign vessels sporadically occurs, such as recently in March 2013 by a Venezuelan vessel at the Saba Bank [1].

Problems in the conservation and management of sharks are the current state of knowledge of sharks and the practices employed in shark fisheries, due to lack of catch, effort, landings and trade data as well as limited information on the biological parameters of many species and their identification (FAO, 1999).

The Dutch Ministry of Economic Affairs undertook several actions for the conservation and management of sharks in the Dutch Caribbean. In November 2011 the Kingdom of the Netherlands ratified the Memorandum of Understanding on the conservation of migratory sharks (MoU Sharks) of the Convention on the Conservation of Migratory Species (CMS). This MoU entered into force on 1 March 2010 with the aim to sustainably manage and protect migratory shark species, in particular the species included in appendices I en II of the CMS.
In the Nature Policy Plan for Bonaire, Saba and St. Eustatius for 2013-2017, a framework for decision making to set priorities for nature conservation for the coming five years, one of the strategic goals is the establishment of a shark sanctuary in the Exclusive Economic Zone (EEZ) of the Dutch Caribbean.
After a preliminary assessment of the status of shark species, shark catch and protection measures in the Dutch Caribbean by IMARES (Van Overzee et al. 2012), the Dutch Ministry of Economic Affairs has requested IMARES to research the opportunities and requirements for a shark protection plan in the Dutch Caribbean.

1.1 Assignment

The main objective of this helpdesk question report was to draft a plan of approach for a shark protection plan in the Dutch Caribbean.

The underlying goals were to:

- Describe regional and international shark protection initiatives and establish contacts with regional and international partners;
- Describe which anthropogenic threats are relevant for sharks in the Dutch Caribbean EEZ and should be incorporated in a shark protection plan;
- Do a feasibility study for a shark protection plan to identify conditions for successful implementation;
- Develop a methodology and instruments to monitor the shark population in the Dutch Caribbean, in order to monitor the shark population before and after implementation of a shark protection plan.

---

[1] http://www.thedailyherald.com/index.php?option=com_content&view=article&id=36636:coast-guard-stops-illegal-fishing-over-saba-bank&catid=1:islands-news&Itemid=54

The above research questions were answered by means of a desk study by IMARES. The Food and Agricultural Organization (FAO) guidelines for an International Plan of Action for the conservation and management of sharks (IPOA Sharks) were applied as guiding principles. Expert knowledge was provided by shark biologists of the Netherlands and European Elasmobranch Society, and the IUCN Shark Specialist Group. The desk study was carried out in cooperation with nature conservation organisations, fisheries government departments and dive operators on all six islands in the Dutch Caribbean.

1.2 Acknowledgments

We would like to thank the following people for their generous assistance in providing information and facilitating response to our questionnaire: Gisbert Boekhoudt and Robert Kock, resp. director of the Directorate Nature and Environment on Aruba and head of the research and monitoring department at the same directorate; Bruce Bowker of Carib Inn on Bonaire; Frank van Slobbe and Peter Montanus from the Department of Environment and Natural Resources (DROB) on Bonaire; Erik Noteboom of Carib Sea sports on Curaçao; Mark Vermeij, Scientific director at CARMABI Foundation on Curaçao; Brooke Rodgers, marine park ranger at Saba Conservation Foundation; Erik Boman, data monitoring officer on St. Eustatius; Menno Walther of Scuabaqua on St. Eustatius; and Tadzio Bervoets, St. Maarten Nature Foundation Marine Park Manager. We also like to thank Gerard van Buurt, fishery expert in Curaçao, and Kai Wulf, Marine Park Manager at Saba Conservation Foundation for sharing images and publications of recent (IUU) shark catches on their islands; Paul Hoetjes and Pieter van Baren, resp. policy coordinator Nature and policy advisor Fisheries of the Ministry of Economic Affairs at the national office for the Dutch Caribbean, for sharing information on shark protection initiatives of the PEW Environment Group; Nicholas Dulvy, co-chair of the IUCN Shark Specialist Group, for his advice on the species lists and management and conservation of sharks; Mariska Bottema, marine advisor at Wereld Natuur Fonds for sharing information on the shark inventory of the WWF Caribbean Marine Alliance; and Hayo Haanstra, policy advisor Dutch Caribbean for the Dutch Ministry of Economic Affairs, Agriculture and Innovation for arranging the funding of this study under grant no. BO-11-011.05-030.

2 Elasmobranch species in the Dutch Caribbean

As part of a desk study conducted by IMARES, a species list of elasmobranchs in the Dutch Caribbean was documented (Van Overzee et al. 2012) and published (Debrot et al., in press; Van Beek et al., 2013). Based on anecdotal accounts, 27 elasmobranch species have been documented in the Dutch Caribbean, and according to the IUCN Shark Specialist Group 6 more species are tentatively present (Appendix A). Based on recent research by IMARES in 2013, a marine mammal aerial survey and fisheries monitoring program, 3 additional shark species have been documented (S. Geelhoed et al., 2014, M. de Graaf, in prep., D. Debrot, in prep.).

2.1 Population status, distribution and relative abundance

The current status of elasmobranch populations in the Gulf of Mexico and the Caribbean remains generally poorly known (Fowler et al. 2005). There is no data available on population status, distribution and abundance of elasmobranchs in the Dutch Caribbean.

As part of the IMARES fisheries and fish monitoring programs on Saba and St. Eustatius a start has been made in 2012 to collect data on relative shark abundance and shark bycatch. These data are currently being analysed, and will be reported in 2014. However, some preliminary data on the relative abundance of sharks and shark species occurrence are presented in this report.

2.1.1 IMARES fish monitoring programs

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 program started in the waters around Saba at three depths, namely 15, 50 and 100m. The same program started in the waters around St. Eustatius in March 2013 and at the Saba Bank in May 2013. Data on species richness, relative abundance and length-frequency distribution were collected using stereo Baited Remote Underwater Video (sBRUV). Brooks et al. (2011) compared BRUV with traditional longline 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. The sBRUV method is being developed for long term monitoring of fish on Bonaire, Saba and St. Eustatius.

During the 45-minute camera deployments of the sBRUV surveys on Saba, St. Eustatius and the Saba Bank there were regular shark observations, mainly at 15 and 50m depth (Table 1).

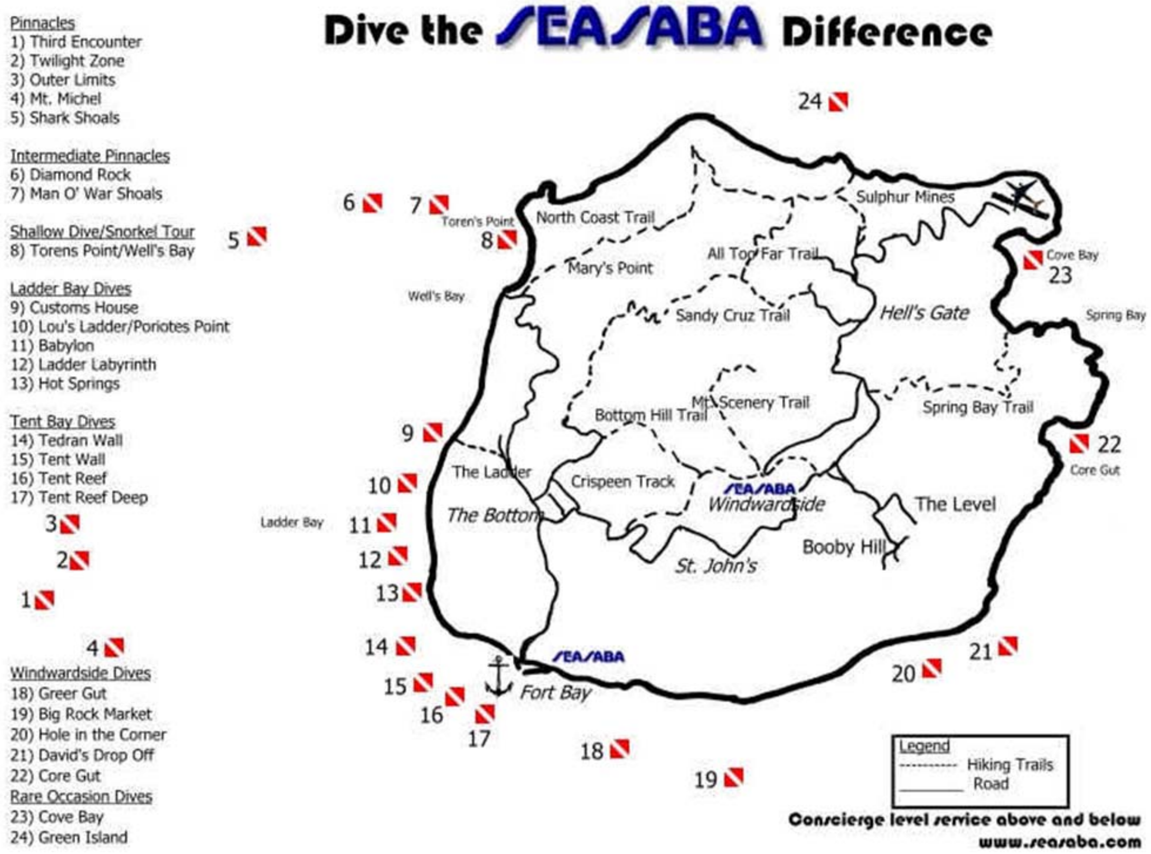
Table 1. Shark species relative abundance of sBRUV surveys on Saba, St. Eustatius and the Saba Bank.

	Saba	**Saba Bank**	**St. Eustatius**
Duration survey period	4 months	2 months	6 months
No. of BRUV drops with one or more shark observations	42 out of 110	11 out of 51	38 out of 104
No. and species observed			
• Nurse shark	10	8	11
• Caribbean reef shark	16	16	28
• Tiger shark	0	2	0
• Blacktip shark	1	2	2
• Silky shark	1	0	0
• Spotted eagleray	0	0	5
• Southern stingray	18	2	18
Total shark observations	46	30	64

In the waters around Saba there were 46 shark observations in 42 of the 110 camera deployments (38%) during the 4-month survey from 25 July 2012 until 2 December 2012: 10 nurse sharks, 16 Caribbean reef sharks, 1 silky shark, 1 blacktip shark and 18 southern stingrays (W. van Looijengoed, in prep.). At the Saba Bank there were 30 shark observations in 11 of the 51 camera deployments (22%) during the 2-month survey from 4 April 2013 until 5 June 2013: 8 nurse sharks, 16 Caribbean reef sharks, 2 blacktip sharks, 2 tiger sharks, 2 southern stingrays (J. Pander, in prep.). In the waters around St. Eustatius there were 64 shark and ray observations in 38 of the 104 camera deployments (37%) during the 6-month survey from 4 March 2013 to 29 August. Species observed were: 11 nurse sharks, 28 Caribbean reef sharks, 2 blacktip sharks, 5 spotted eagle rays and 18 southern stingrays (Van Kuijk, 2013).

2.1.2 Sea Saba diver observation program

Sea Saba is one of the dive operators on Saba. They are used to keeping record on their website of remarkable observations during their guided dives[2]. In April 2012 they set up a specific database to record shark observations, at the request and in collaboration with IMARES and as part of the fish and fisheries monitoring programs on the island. Figures 3 to 6 present the sighting of 1041 sharks during 1947 dives in 1,5 years from April 2012 until September 2013. Most observations were nurse sharks (n=516) and Caribbean reef sharks (n=497) (Figure 4). Most sharks were observed in deeper waters (Figure 6) and at dive sites further offshore at large underwater mounts, the so-called pinnacles (blue box Figure 3).



[2] http://www.seasaba.com/english_html/news_seen.htm

Figure 2 Map of the dive locations of Sea Saba.

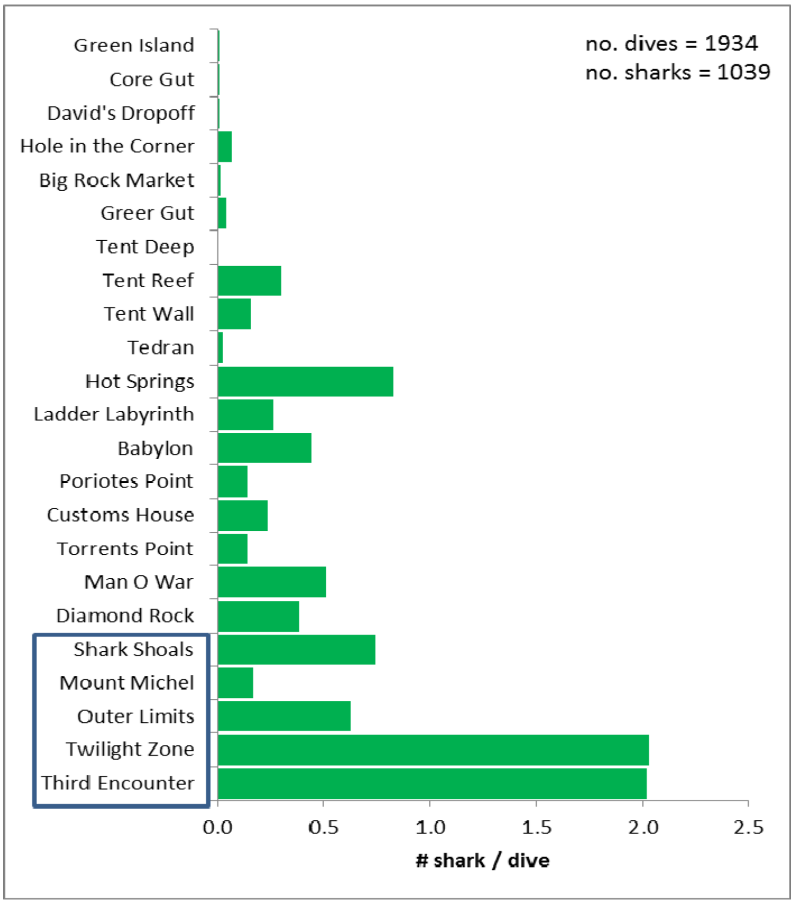


Figure 3. Shark observations by Sea Saba divers from April 2012 until September 2013 with the average number of sharks per dive per dive location.

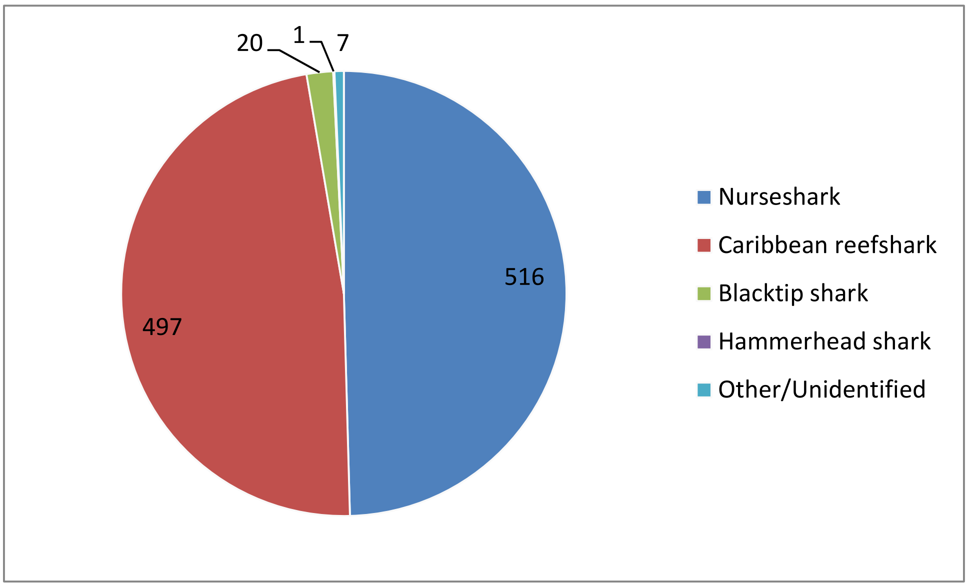


Figure 4. Shark species and numbers of sharks observed by Sea Saba divers during 1947 dives from April 2012 until September 2013

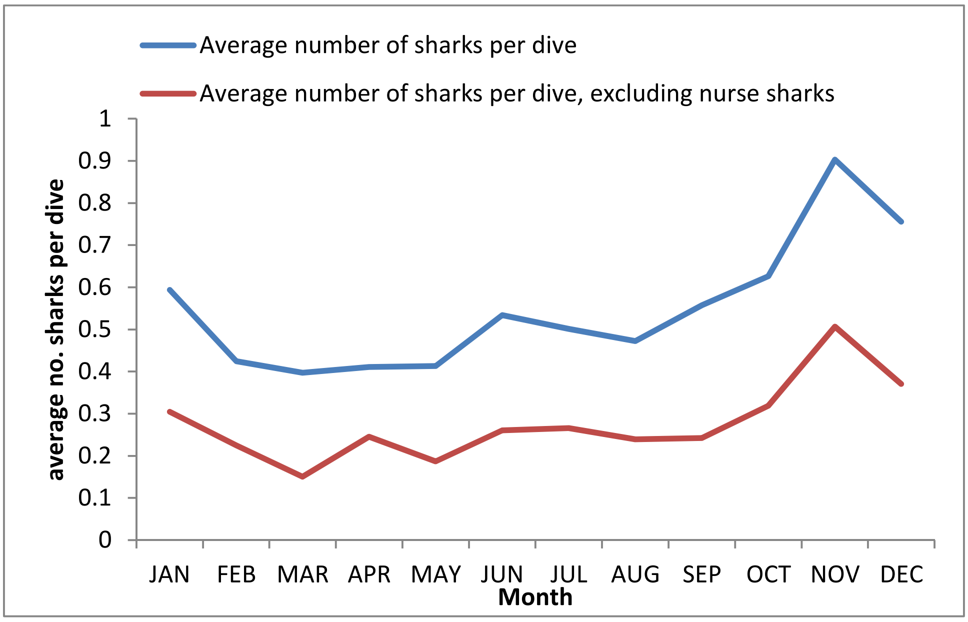


Figure 5. Trend of average number of sharks observed per dive per month in 2013

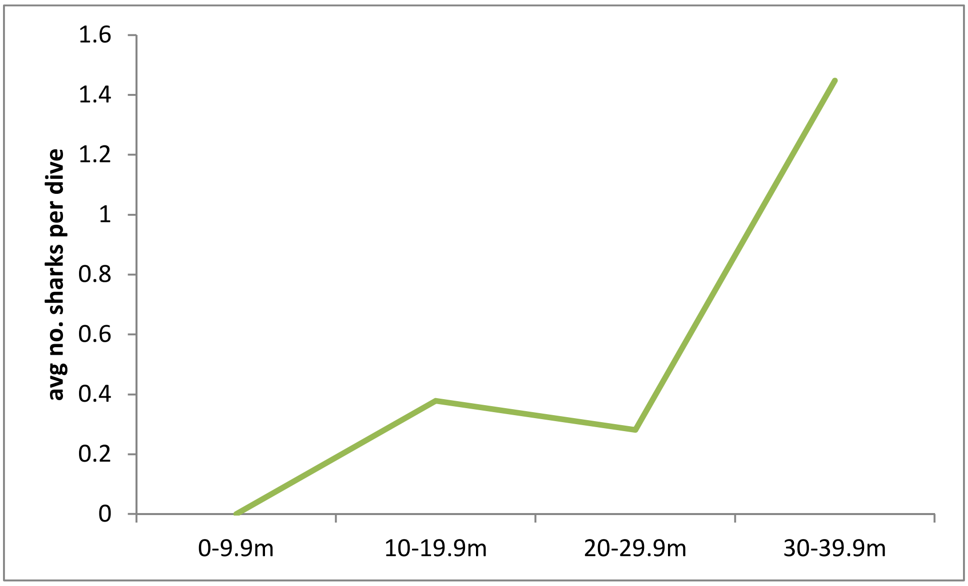


Figure 6. Trend of average number of sharks observed per dive at 4 depth zones in 2013

2.1.3 IMARES fisheries monitoring program

Landings and bycatch of sharks are generally not recorded except for the Saba Bank and St. Eustatius, because of the lack of regular fisheries monitoring programs. However, fisheries departments on some of the island do have information on shark bycatch. These anecdotal accounts from Aruba, Curaçao and St. Eustatius were used as input for the elasmobranch species list of the Dutch Caribbean (Appendix A).

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

In 2012 IMARES implemented a fisheries monitoring program on St. Eustatius and Saba and in 2013 a pilot study was conducted on Bonaire. These monitoring programs consist of four parts:

1. daily fish trip logs, recording the number of boats fishing each day;
2. port sampling "short interview", collecting basic information on gear, catch and fishing site from a sample (~30%) of fishing trips;
3. port sampling "long interview", collection in addition to the short interview also data on species composition and length frequency of the landed fish (~10% of the fishing trips);
4. and on-board sampling, collecting data on discards and reproductive biology of fish and lobster (<5% of the fishing trips).

The establishment of fisheries monitoring programs on the islands will provide basic information on shark catches, species composition and relative abundance.

The fishery in the waters surrounding St. Eustatius is small scale with around six fishermen. In Statia limited landings of nurse shark can be reported (R. Hensen and E. Boman, pers. comm.) 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 (Van Beek et al. 2013). Based on 2012 and 2013 fishery monitoring data of the St. Eustatius lobster trap fishery nurse sharks represented less than 1% of the annual landings in numbers and about 7% (2012:13, 2013:2) in weight (Poiesz, 2014).

The Saban commercial fishery is almost exclusively focussed on the Saba Bank with little or no effort allocated to the waters directly surrounding the island. This small scale fishery with 10 licenses is predominantly a trap fishery for lobster (shallow waters <30m) and redfish (assorted snapper species; deep waters >100m). 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, 2 nurse sharks and 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 sea alive. One dead Caribbean reef shark was recorded in a lobster trap. Furthermore a fisherman reported catching sixgill sharks while handlining in deep waters of 100-300m (Van Beek et al. 2013).

2.2 Life history per species

Life history parameters such as age and growth, along with basic information on reproduction, distribution, movements, habitat use and genetics, are essential to understand and predict how populations will grow and how they will respond to fishing pressure. Detailed information on life history is available only for a few of the between 954 and 1,125 species of living elasmobranchs worldwide, mainly those species which are of importance for directed fisheries (Fowler et al., 2005). Table 2 presents an overview of available knowledge on life history characteristics, distribution, habitat and fisheries pressure of 25 documented elasmobranch species in the Dutch Caribbean. This can be used as an orientation into the species. Furthermore it provides input for future research such as a Productivity Susceptibility Analysis to define biological sensitivity and fisheries susceptibility of shark species.

Table 2. Overview of life history characteristics, distribution, habitat use and fisheries pressure of all documented shark species occurring in the Dutch Caribbean.

		Life history characteristics[1]										Distribution[1]			Habitat[1]		Fisheries pressure[1]			
Common name	**Scientific name**	**Age at maturity (years)**	**Size at maturity (cm TL)**	**Size at birth (cm TL)**	**Maximum size (cm TL)**	**Longevity (years)**	**Litter size**	**Annual rate population increase**	**Reproductive periodicity (years)**	**Gestation time (months)[3]**	**Reproductive guild (O, V, OV[2])**	**Geographic range**	**Habit (feeding zone)**	**Depth range (m)**	**Main habitat**	**Nursery grounds**	**Directed**	**Incidental**	**IUCN Red List status**	**Elasmobranch ID present[4]**
Family: Whale sharks – *Rhincodontidae*																				
1. Whale shark	*Rhincodon typus*	9-20 or 30	F: No data M: 900	48-58	1500-2000	60-100	300	0.08	No data	No data	V	Worldwide tropical and warm-temperate	Pelagic	1-700	Coral reefs, coastal, open ocean	No data	Some	Low	VU	X
Family: Nurse sharks – *Ginglymostomatidae*																				
2. Nurse shark	*Ginglymostoma cirratum*	F:15-20 M:10-15	F:~227 M:~215	29	250-300	No data	21-50	No data	2	5-6	OV	Widespread	Benthic	12-15 (75 max)	Coral reefs, inshore	Inshore	Low	Low	DD	X

Family: Requiem sharks – *Carcharhinidae*																				
3. Caribbean reef shark	*Carcharhinus perezi*	No data	150-170	< 73	295	No data	No data	No data	No data	No data	V	Regional Bermuda to Brazil, West Atlantic	No data	0-356	Coral reef	Reefs and lagoons	Yes	Yes	NT	No
4. Blacktip shark	*Carcharhinus limbatus*	F:6-7 M:4-5	F:146-156 M:130-145	F:53-65	206	9-10	2-3	0.054	2	11-12	V	Widespread tropical and warm-temperate	Pelagic	<30	Coral reefs, beaches, bays, estuaries	Coastal bays, estuaries	High	Some	NT	X
5. Lemon shark	*Negaprion brevirostris*	F:13 M:12	F:235 M:225	F:50-60	>350	>30	4-17	No data	2	10-12	V	Widespread tropical and warm-temperate	Demersal	<90	Coral reefs, coastal, mangrove, occasionally oceanic	Nearshore shallow waters	Some -high	Some	NT	X
6. Bull Shark	*Carcharhinus leucas*	F:>18 M:14-15	F:180-230 M:157-226	56-81	340	>24	1-13 (av. 6-8)	0.027-0.039	2?	10-11	V	Worldwide tropical and temperate	Semi pelagic	<30 (150 max)	Coastal, estuarine, freshwater continental shelves	Estuarine or fresh-water	Low	Some	NT	X
7. Tiger Shark	*Galeocerdo cuvier*	8-10	F:250-350 M:226-290	51-90	600	50	10-82 (av.30-35)	0.043 at MSY	2?	12-16	OV	Worldwide tropical and warm-temperate	Pelagic	Shallow (350 max)	Coastal, estuaries, oceanic islands and waters between	No data	Some	Some	NT	X
8. Oceanic white-tip shark	*Carcharhinus longimanus*	4-5	F:170-190 M:170-196	60-65	>350	22	1-14	No data	2	9-12	V	Worldwide, warm oceanic water	Pelagic	1-152	Oceanic, occasional inshore	Oceanic	None	High	VU	X
9. Silky shark	*Carcharhinus falciformis*	F:7-12 M:6-10	F:232-246 M:215-225	76	330	>22	2-15 (av.12)	0.043	1- 2		V	Worldwide tropical	Semi-pelagic	No data	Coastal, continental shelves and slopes, oceanic	Coastal	Some-high	High	NT	X
10.Blue shark	*Prionace glauca*	F:5-7 M:4-6	F:183-221 M:182-218	35-50	383	20	35	0.061 at MSY	1-2	9-12	V	Worldwide tropical and temperate	Pelagic	1-350	Oceanic	Offshore (NE Atlantic)	Low	High	NT	X
11.Sandbar shark	*Carcharhinus plumbeus*	13-18 or 29	F:179-183 M:170	56-75	F:234 M:226	>35	1-14 (av.8.4-9.3)	0.025-0.119	2	9-12	V	Worldwide tropical and warm-temperate	Pelagic	20-100	Coastal	Bays and estuaries	High	Some	VU	X
Family: Hammerhead sharks – *Sphyrnidae*																				
12.Smooth hammerhead	*Sphyrna zygaena*	No data	F:265 M:250-260	50-61	370-400	No data	20-50	No data	No data	10-11	V	Widespread warm-temperature	Pelagic	<60	Continental shelves	Offshore	Some	Some	VU	X

13.Scalloped hammerhead	*Sphyrna lewini*	F:15 M:10	F:210-250 M:140-198	31-55	F:346 M:340	F:<35 M:<30	12-38	0.028	1	9-12	V	Widespread tropical and warm-temperate	Semi pelagic	1-560	Continental and insular shelves	Coastal, estuaries and bays	Some -high	High	EN	X
14.Great hammerhead	*Sphyrna mokarran*	No data	F210-300 M:225-269	50-70	600	No data	6-42	No data	2	11	V	Widespread tropical	Semi pelagic	1-80	Coastal, continental and insular shelves	No data	None	Some	EN	X
15.Bonnethead shark	*Sphyrna tiburo*	F:2-3 M:2	F:80-95 M:68-85	27-35	F:130-150 M:110-125	F:6-12 M:5-6	6-10 (av.9)	0.304	1	4.5-5	V	Regional	Demersal	0-80 (10-25 mostly)	Costal estuaries and bays	Nearshore, shallow sea grass beds	Some -high	High	LC	No
Family: Basking sharks – Cetorhinidae																				
16.Basking shark	*Cetorhinus maximus*	F:16-20 M:12-15	F:800-900 M:500-700	150-200	>1200	50	6	0.013-0.0231	2-4?	12-36	OV	Worldwide temperate	Pelagic	Spring: surface Winter: deep	Coastal and surface, continental shelf and shelf edge	No data	Low	Some	VU	X
Family: Mackerel sharks – *Lamnidae*																				
17.Shortfin mako	*Isurus oxyrinchus*	F: ~6 M: ~2.5	F:265-280 M:~195	~70	394	~20	4-18	0.051 at MSY	2-3	15-18	OV*	Worldwide tropical and temperate	Pelagic	1-450	Oceanic	No data	Some	High	VU	X
Family: Thresher sharks – *Alopiidae*																				
18.Thresher shark	*Alopias vulpinus*	3-8	F:315-400 M:≥314	115 - 156	415-573	≤50	2-7	0.069 at MSY	?	9	OV*	Virtually worldwide, tropical to temperate	Pelagic	1-366	Oceanic and coastal, most <80km offshore	Nearshore	Some	Some	VU	X
19.Bigeye thresher	*Alopias superciliosus*	No data	No data	No data	No data	No dat a	No dat a	No data	No data	No dat a	No data	No data	Pelagic	No data	No data	No data	No data	No data	VU	X
Family: Six / sevengill sharks – *Hexanchidae*																				
20.Big-eyed sixgill shark	*Hexanchus nakamurai*	No data	142	40-43	178	No dat a	13-28	No data	No data	No dat a	OV	Worldwide tropical and temperate	Deep benthic	60-620	Outer shelf and upper slope	No data	Low	Some	DD	No
21.Bluntnose sixgill shark	*Hexanchus griseus*	No data	F:420 M:315	65-74	482	No dat a	22-108	No data	No data	No dat a	OV	Worldwide tropical and temperate	Deep benthic	60-2500	Young often coastal, adults often deep water	Outer shelf and upper slope	Low	Some	NT	No

Family: Sawfishes – *Pristidae*																				
22.Smalltooth sawfish	*Pristis pectinata*	No data	321.5	61	≥550	?	15-20?	0.08-0.12	1	No data	No data	Widespread tropical and warm-temperate	Benthic	1-10	Nearshore, estuarine	No data	Low	Some	CR	-
Family: Stingrays - *Dasyatidae*																				
23.Spotted eagle ray	*Aetobatus narinari*	4-6	?	26 DW	880 DW	?	≤4	?	continuous	?	OV	Worldwide tropical and warm-temperate	Pelagic	1-24 Up to 60 m	Coastal, lagoon estuaries	?	Low	Some	DD	X
24.Southern stingray	*Dasyatis americana*	No data	M: 510 F: 295-315	20-34 DW	200 DW	18	2-10		Bi-annual	4-11	V	(Sub)tropical southern Atlantic, Gulf and Caribbean	Bottom dweller	1-53 m	Shallow coastal sand/silt				DD	-
Family: Manta / devil rays - *Myliobatidae*																				
25.Giant manta ray	Manta birostris	F:6 M:?	M: 400 F: 500	120 DW	670 DW	M: > 10 > 20 yrs	1	?	2-3	?	V	Worldwide tropical	Epipelagic	1-40	Coastal, continental shelves	?	Low - high local	Low - high local	VU	X

1 Source for life history characteristics, distribution and habitat is Fowler et al. (2005) for all species except two. Data source for Caribbean reef shark (3.) and Southern stingray (26.) is fishbase (Froese and Pauly, 2011). Data for rays were retrieved from the website of the Florida Museum of natural History [http://www.flmnh.ufl.edu]

2 Reproductive guild refers to the reproductive strategy of elasmobranchs (Balon, 1975). Elasmobranchs are bearers and have three ways to bear their young; oviparity (O), viviparity (V) and ovoviviparity (OV). Oviparous species lay eggs in the water. Oviviviparous species are live-bearers, whereby the eggs hatch within the mother's body and the young are born alive and fully functional. Viviparous species are also live-bearers, whereby the young develop in a placenta and are born alive and fully functional. OV* are ovoviviparious whereby the developing embryos eat the eggs of their potential siblings.

3 Gestation time is the carrying time of an embryo inside female viviparous species.

4 Elasmobranch ID refers to the presence (x) or absence of the species in the Identification guide of the main shark and ray species of the eastern tropical Atlantic, for the purpose of fisheries observers and biologists [http://www.iucnssg.org/tl_files/Assets/Regional%20files/West%20Africa/ID_East_Trop_Atlantic_ENGLISH.pdf]

2.3 Species description

In this chapter we describe for 24 species their main life history characteristics, threats and protection measures, as well as available scientific knowledge on abundance and population status in the Caribbean. This selection was made based on several criteria: availability of historic data; apparent abundance; keystone species; and endangered species.
From the 33 elasmobranch species listed in Appendix A we selected 22 species. We omitted six species which are tentatively present according to the IUCN Shark Specialist Group – four shark species (*Carcharhinus acronotus*, Blacknose reef shark; *Rhizoprionodon lalandii*, Brazilian Sharp-nose Shark; *Rhizoprionodon porosus*, Caribbean Sharp-nose Shark; and *Scyliorhinus boa*, Boa catshark) and two ray species (*Himantura schmardae*, Chupare stingray; and *Dasyatis say*, Bluntnose stingray) – because these species are data deficient in the Dutch Caribbean as they have never been observed according to anecdotal accounts. We also omitted dogshark (*Squalus cubensis*, Cuban dogfish shark), catshark (*Apristurus canutus*, Hoary catshark) and houndshark (*Triakis spp.*) species, because these species are data deficient according to the IUCN red list and observations in the Dutch Caribbean have been very limited. Furthermore, we omitted two species (*Isistius brasiliensis*, cookiecutter shark; and *Etmopterus bullisi*, lined lanternshark) which are of least concern according to the IUCN red list. None of the 11 omitted species have a protected status on international (CITES and CMS) and regional treaties (SPAW) and availability of life history data is limited for these species.
In addition to the 22 selected species from the 2012 species list (Appendix A) we added three new species, which were respectively documented by IMARES in 2013 in a marine mammal aerial survey (*Cetorhinus maximus*, Basking shark) (S. Geelhoed et al., 2014), the Saba fisheries monitoring program (*Carcharhinus plumbeus*, Sandbar shark) (M. De Graaf, in prep.) and analysis of submarine explorations to depths of 900 m (*Hexanchus griseus*, Bluntnose sixgill shark) (D. Debrot, in prep.). Because the Sandbar shark was documented just prior to the presentation of this report, this species has only been added to Table 2, and has not been included in the following species description.

The remaining 24 species are either a keystone species (most sharks are top predators with a critical role in maintaining the structure of the ecosystem) or endangered species (Critically endangered: Smalltooth sawfish; Endangered: Scalloped hammerhead, Great hammerhead; Vulnerable: Giant manta ray, Whale shark, Oceanic white-tip shark, Smooth hammerhead, Shortfin mako, Thresher shark and Bigeye thresher. Because of their presence according to anecdotal account, sport diver observations and fish monitoring we included the other rays (Spotted eagle ray and Southern stingray) and other requiem sharks, which are all nearly threatened (Caribbean reef shark, Blacktip shark, Lemon shark, Bull shark, Tiger shark, Silky shark, Blue shark). Blacktip and blue sharks are species commonly caught in commercial tuna- and shark fisheries (Singh-Renton, 2010). We included Bonnethead shark, because it completes the list of present Hammerhead species. We included Big-eyed and Bluntnose sixgill sharks, because they are keystone species in deep water, have escaped from overfishing and play an important role in the coupling between pelagic and epipelagic ecosystems during day and night respectively.

2.3.1 Rhincodontidae (Whale sharks)

Whale shark, *Rhincodon typus* (Smith 1882)
The whale shark is the largest shark and fish species of the world and widespread throughout tropical-temperate seas. It feeds on aggregations of small marine organisms, ranging from coral spawn (Heyman *et al.*, 2001) to crab larvae, baitfish and even small tunas (Martin, 2007; Taylor, 2007). It is a highly migratory species and shows little genetic differentiation world-wide (Schmidt *et al.*, 2009).
Debrot et al (in press) document 24 records of whale sharks for the Dutch Caribbean, The results suggest a higher abundance of whale sharks in the southern, leeward part of the Dutch Caribbean, likely associated with seasonal upwelling-driven productivity known for the southeastern Caribbean area. A

bimodal seasonal pattern as documented elsewhere for Venezuela was not pronounced in the Leeward Dutch islands and whale sharks were recorded in 9 months of the year. In the Windward Dutch islands all (4) records so far were for the winter months of December-February.

Due to its population dynamic characteristics this species is very vulnerable to overfishing (Bonfil, 1997; Pauly, 2002). Most fishing on whale shark takes place in the Indian and Pacific Oceans (Alava, 2002; DEH, 2003). In the Caribbean, the whale shark is most often fished in Mexico (Bonfil, 1997). It is declining world-wide (e.g. DEH 2003, Schmidt et al 2009)and has been listed as vulnerable on the IUCN Red List of Endangered Species. It is further afforded international legal protection by enlistment in Appendix II of the Convention on Trade in Endangered Species of Flora and Fauna (CITES), Appendix II of the Convention on Migratory Species (CMS), and Annex I (Highly Migratory Species) of the United Nations Convention on the Law of the Sea (UNCLOS). The species enjoys local legal protection in various countries worldwide (Debrot et al., in press).

2.3.2 Ginglymostomatidae (Nurse sharks)

Nurse shark, *Ginglymostoma cirratum* (Bonaterre 1778)

The docile nurse shark is about the most abundant and well-studied of tropical sharks. It is found in tropical to subtropical waters of the Western and Eastern Atlantic and the Western Pacific. The nurse shark is principally a near-shore, shallow-water species common to seagrass beds, mangrove habitat and reefs, and also enters brackish water. It is an opportunistic predator taking a variety of fish and shellfish (Castro, 2000) and is equipped with barbels to help detect benthic prey. It is known to use shallow habitats as nursery and breeding grounds (Carrier and Pratt, 1998) and large aggregations have been documented (Castro 2000). Females produce a brood every two years. For Florida and the Bahamas reproduction peaks in June and July. Brood size in this ovoviviparous species ranges from about 20-50 offspring. According to Castro (2000) older references have a great deal of misinformation about the species, and he has pointed these out. In extensive studies from Florida and the Bahamas the maximum size recorded was 265 cm total length. Maximum life span documented is 25 years. The species has been widely used for its liver oil, hides and meat (Castro, 2000), but today it is the main species recorded during recreational dives throughout the region. The species is relatively common in the Dutch Caribbean except where fishing activity is highest. There, the species is principally considered a nuisance-species by fishermen (Van Beek et al., 2013). Due to its shallow-water habits and high site fidelity it is extremely vulnerable to gears such as coastal gillnets, long lines and spearfishing, and is prone to local extirpation. It has been extirpated from its southernmost range in the Western Atlantic and is actively targeted in various areas of the Caribbean. It is listed by IUCN as data deficient (Rosa et al., 2006a). In the Saba Bank lobster trap fishery nurse sharks were commonly caught according to fisheries assessments in 2000 and 2007 and used as bait rather than being landed or marketed (Dilrosun, 2000; Toller and Lundvall, 2008). The current fisheries monitoring program on Saba reports incidental bycatch of nurse sharks, some of which are recorded as landed and all of which are discarded alive during on-board discard monitoring (Van Beek et al. 2013). The fishery monitoring of the St. Eustatius lobster trap fishery reported nurse sharks represent less than 1% of the annual landings in numbers and 2% (2013) to 13% (2012) in weight (Poiesz, 2014).

The abundance of this species on the Saba Bank, the species' tendencies towards relatively small home ranges make the Saba Bank a potentially good locality for detailed study of the species' life history.

2.3.3 Carcharhinidae (Requiem sharks)

Caribbean reef shark, *Carcharinhus perezi* (Poey, 1876)

After the nurse shark, the Caribbean reef shark is often the second-most common shark on Caribbean coral reefs (Pikitch et al., 2005). Notwithstanding its abundance it is one of the least studied species. Densities of adults of this species in Belize were high on the reef, while small juveniles used the shallow reef and deep lagoon (Pikitch et al. 2005). These habitats are of great importance as nursery habitat in different areas of the Western Atlantic (e.g. Garla et al., 2006b) but are only visited by adults for short periods. In the nursery lagoons juveniles are highly vulnerable to longlining (Tavares 2009). The species is viviparous (Dulvy and Reynolds, 1997) and matures at between 150-170 cm. Maximum size is 295 cm. The species shows high site fidelity on the reef (Garla et al., 2006a, Bond et al., 2012). Chapman et al. (2007) document diving to depths of 356 m for this roving piscivorous species and suggest that it may be important ecological coupler of deep and shallow reef systems. It has very low fecundity with 3-6 offspring per litter and one litter every two years. Because of this in combination with high vulnerability to fishing and local extirpation, the species is listed as Near Threatened by IUCN (Rosa et al., 2006b).

Blacktip shark, *Carcharhinus limbatus* (Müller & Henle, 1839)
This circumtropical and subtropical coastal species shows a major population division within the Atlantic Ocean but not in the Pacific (Keeney and Heist, 2006). In the Western Atlantic the South American and North Western Atlantic populations are also distinct management units (Sodré et al., 2012). In the Los Roques archipelago of Venezuela the species forms an important part of the shark catch and uses atoll and coastal lagoons as nursery habitat (Tavares, 2008). In the nursery lagoons juveniles are highly vulnerable to longlining (Tavares, 2009). The main birthing season in Venezuela is June-August. The diet consists principally of teleost fishes, especially clupeids (Tavares, 2008; Hoffmayer and Parsons, 2003). The nursery function is likely important as juveniles suffer the highest mortalities in the first 15 months of Life (Heupel and Simpfendorfer, 2002). However, adults of this migratory species are uncommon in nearshore fisheries (Tavares, 2008) but are widely impacted by offshore longline fisheries (Tavares, 2008). Due to its vulnerability to fishing and its dependence on near shore nurseries, this species is vulnerable to human degradation and alteration, the species is listed as Near threatened by IUCN (Burgess and Branstetter, 2009).

Lemon shark, *Negaprion brevirostris* (Poey, 1868)
The lemon shark is a large coastal shark species attaining a maximum size of some 3.4 m in length. Its principal area of distribution is the central Western Atlantic with relict populations occurring in the Eastern Pacific and along the East African coast (Feldheim et al. 2001). The lemon shark has been best studied Bimini, the Bahamas, starting from about 1995 when a large annual tagging program was begun. Reproduction is once every two years with litters of 4-18 pups (Feldheim et al., 2002). There is no parental care and juveniles forage independently in shallow inshore nursery areas. Juveniles are highly site attached for at least three years with home ranges of no more than a few 100 square meters (Morrissey and Gruber, 1993). In contrast to shallow continental shelf habitats where this species is often a dominant species, at atoll and island situations in the Caribbean this species is often one of the less abundant coastal shark species. For instance Pikitch et al. (2005) found the lemon shark to represent less than 1% of all elasmobranchs recorded at Glover Reef Atoll in Belize, whereas the two most abundant species were the nurse shark and Caribbean reef shark. In the Eastern Caribbean commercial shark fisheries the species also only forms a small part of the catch (Chan A Shing, 1999). Even though the shark is a shallow water species and therefore possibly of local isolated populations, Feldheim et al. (2010) studied DNA microsatellite variation and found high levels of uniformity between wide-flung areas of distribution of this species in the Western Atlantic. From this the authors concluded that there was sufficient gene flow and consequently no distinct stocks in the western Atlantic. Because of the species dependence on shallow coastal habitat it is also vulnerable to habitat destruction due to coastal development (Jennings et al., 2008).

Bull shark, *Carcharhinus leucas* (J. P. Müller and Henle, 1839)
The Bull shark is a large coastal shark known to migrate long distances (Karl et al. 2011). Nevertheless, localized depletions in abundance and high site fidelity of of juveniles and females (Hammerschlag et al., 2012a) to nursery areas suggest that some genetic stock differentiation may occur. Karl et al. (2011) studies genetic differentiation in the Western Atlantic and demonstrated significant differentiation

between Brazilian and North Atlantic populations. This means that in contrast to for instance the similarly ranging Lemon shark, the Bull shark does show differentiation and should be considered as being composed of more than one management unit in the Western Atlantic. The stock size for the North Atlantic is estimated to be 221,000 individuals (Karl et al., 2011). The species appears vulnerable to shark fisheries and Heithaus et al. (2007a) demonstrated large long-term declines in abundance in certain areas of the Gulf of Mexico More recently Froeschke et al. (2013) found indications of increasing abundance and size of bull sharks off the Texas coast and ascribe this to the federal management of coastal gillnet fisheries in Louisiana that began in 1995 as part of a large shark management effort directed to 10 shark species (SEDAR, 2006). Likewise, following initial decades-long declines between 60-80% for various coastal shark species, Carlson et al. (2012) found reason for optimism in the apparent increase in abundance of this and several other species of sharks which have been managed federally in the USA since 1995. The habit of aggregating in fresh and brackish water inshore areas, to which the bull shark is uniquely adapted, makes it especially vulnerable to local extirpation. The species is known from the Venezuelan long-line fishery that takes place directly east of the Dutch Caribbean but is relatively uncommon (Arocha et al., 2002).

Tiger shark, *Galeocerdo cuvier* (Péron & Lesueur, 1822)

This circumglobal species of tropical and warm temperate oceans is found in wide diversity of habitats and with migratory habits moving north in summer and south into the Caribbean in winter (Randall, 1992). Within the Caribbean the species is also known to move great distances. For instance, one animal tagged in 1967 in Puerto Rico was recaptured off Venezuela 890 km to the south, after a period of 5 months (Randall, 1992). Tiger sharks are known to feed on a wide range of prey and carrion and are notorious for predation on seaturtles (Heithaus et al., 2002). Heithaus et al. (2002) further point to the preference of this species for hunting in shallow water, where it relies on stealth for surprize attacks on unsuspecting prey. It has been documented to depths of 350 m (Simpfendorfer, 2009). Males and females mature at well over 2 m in length (Randall 1992) and maximum sizes exceed 5 m in length (Simpfendorfer, 2009). The tiger shark is the only member of the Carcharhinidae that is ovoviviparous and also produces unusually large litters ranging in size from 10-80 offspring. The gestation period is 13-16 months and mating takes place in spring in the Northern Hemisphere (Randall, 1992). Tiger sharks are taken in many fisheries, particularly longline fisheries operating on or close to continental shelves (Simpfendorfer, 2009). The species has been targeted heavily in the past and has demonstrably declined in many areas. Consequently the IUCN classifies it as Near Threatened (Simpfendorfer, 2009). It is a relatively common large species of open waters in the Dutch Caribbean and is regularly seen and encountered on the Saba bank (Van Beek et al., 2013).

Oceanic White Tip Shark, *Carcharhinus longimanus* (Poey, 1861)

The oceanic white tip shark has some features that make it well recognizable within the Carcharhinidae family. It has a large first dorsal fin and very long and wide, elongated paddle-like pectoral fins which have distinctive rounded tips. All the fins, including pelvic and caudal fins, have whitish tips. Historically the oceanic white tip shark has had a world-wide distribution throughout tropical and subtropical waters, occurring in waters between 18°C and 28°C but with a preference for temperatures above 21°C. However due to increased fishing pressure abundance of this species has been estimated to have declined with over 70% (Baum et al., 2006). It’s usually found in deep water areas (>200m depth) but has also been reported in shallow areas near land, usually near oceanic islands. In open water it swims relatively slow near the water surface with pectoral fins spread widely. Tagging studies indicate that activity patterns do not alter during night-time hours. Average length for oceanic white tip sharks is 3 meters but individuals can grow up to 3,5 to 4 meters length with females reaching a greater maximum length than males. Males mature at 1.7-1.9 m in length while females mature at slightly longer sizes of 1.8-2.0 m, both corresponding to an age of 6 or 7 years. The longest-lived known specimen lived to an age of 22 years. It is an viviparous shark and embryos have a yolk sac placenta that attaches to the uterine wall of the mother. Pups are born after a yearlong gestation period at a length of 60 to 65cm. Litter size is can vary from 1 to 15 pups and is proportional to the size of the mother (large females have more of offspring). The food of the oceanic white tip shark consists of bony fish, sea turtles, sea birds, squid, crustaceans and mammalian carrion. Although this shark is primarily solitary, it has been observed in "feeding frenzies" when an abundant food source is present (Baum et al., 2006, FLMNH, 2013a).

Silky shark, *Carcharhinus falciformis* (J. P. Müller & Henle, 1839)
Silky shark is a large pelagic shark and grows up to 3,4 m in length. This species is found worldwide in tropical and subtropical seas and have experienced some of the largest declines due to overfishing (Baum and Meyers, 2004), particularly due to pelagic tuna and swordfish longline fisheries (e.g. Sanches-de Ita et al., 2011), but is also often a large part of coastal artisanal fish catches (Hall et al., 2012). Even though known as a fully pelagic shark, it appears most common in deep waters of continental or insular shelf edges (Clarke et al., 2011). In the Red sea Clarke et al. (2011) have found persistent site fidelity of adult and near-adult females aggregating near coastal reefs. Due to its largely pelagic habits, it has largely remained overlooked by science and practically nothing is known about its biology. Size of maturation exceeds 2 m in length for both males and females and average age of maturation for males and females are 13 and 15 years respectively. With 2 to 14 offspring per litter, in Indonesian waters reproduction appears to occur year-round (Hall et al. 2012). In subtropical areas, like the Gulf of California, age of maturation may be much lower (Sanchez-de Ita et al., 2011). The species is known from the Venezuelan longline fishery that takes place directly east of the Dutch Caribbean but is relatively uncommon (Arocha et al., 2002). Watson et al. (2008) have shown that if properly selected, the use of a series of relatively small fishery closure areas could greatly reduce bycatch of this species in the tuna fishery while having little effect on tuna catches.

Blue Shark, *Prionace glauca* (Linnaeus, 1758)
The blue shark is a slender shark with a distinctive dark blue dorsal surface, bright blue side and a white ventral surface. This counter-shading works as camouflage in the open ocean. A further identifying feature is it’s exceptionally long, pointy pectoral fins. It is one of the most widely distributed shark species living throughout tropical and temperate seas. Blue sharks are pelagic fish living in the open ocean and occurring form the surface to 350m depth. They tend to prefer cooler water (7-16°C), but tolerate warmer water. In the tropics they seek out deeper water with cooler temperatures. Blue Sharks are highly migratory with complex movement patterns and spatial structure related to reproduction and the distribution of prey. Blue sharks are known for their high fecundity, for elasmobranch fishes, with an average litter of 35pups and a gestation period of 9-12 months. Litter size is dependent on size (and age) of the mother with litters up to 135pups being reported from large females. They are viviparous, which means they give birth to live young that have hatched from eggs internally. After hatching the young are nourished by a placental yolk sack until they are fully developed. Males reach sexual maturity at 4-6 years at a length ranging from 182 to 218cm, Females mature later, at 5-7 years old not becoming fully mature until they are 220cm long (although pregnancy in sub-adult females has been recorded). They can live up to 20 years. Blue sharks feed mainly on small bony fishes and invertebrates, but are known as opportunistic feeders feeding from gill nets and scavenging dead marine mammals. (Stevens, 2009; FLMNH, 2013 d).

2.3.4 Sphyrnidae (Hammerhead sharks)

Smooth hammerhead, *Sphyrna zygaena* (Linnaeus 1758)
The smooth hammerhead is a cosmopolitan pelagic hammerhead found from inshore to offshore pelagic waters (Compagno, 1984). While Cortés et al. (2010) did an ecological risk assessment for a number of pelagic sharks and identified the smooth hammerhead (Sphyrna zygaena) as likely to be less vulnerable

to pelagic long-line fisheries due to its relatively high fecundity, they also pointed out the lack of good biological data on the species. Even though this species is among the most caught in longline fisheries it has been very little studied (Coelho et al., 2011). Maximum size for males and females was calculated as 272 and 285 cm, respectively. Neritic cephalopods, particularly loliginids, constitute an important part of the diet of the smooth hammerhead of the east coast of Africa (Smale and Cliff, 1998).

Scalloped hammerhead/Carolina hammerhead, *Sphyrna lewini* (Griffith & Smith, 1834), *Sphyrna gilberti*, spec. nov. (Quattro et al. 2013).

This semi-oceanic species is found throughout tropical and temperate seas (Compagno, 1984). Notwithstanding its common occurrence in the pelagic environment, the species depends on shallow coastal areas for pupping and as nursery habitat (Daly-Engel et al., 2012). Whereas females appear to be more site-bound, gene-flow is largely due to extensive pelagic movement by males (Daly-Engel et al., 2012). Because of its distribution it forms a major component of coastal and pelagic commercial shark catches. It has been known that this species probably consists of a number of highly related cryptic species (Pinhal et al., 2012) and a sibling species *S. gilberti* has just been described for the Western Atlantic (Quattro et al., 2013). *S. gilberti* can only be distinguished from *S. lewini* based on the number of vertebrae. Because of cryptic lineages, the biology and distribution of these related species is poorly understood and highly uncertain. Hazin et al. (2001) studied the reproductive biology of *S. lewini* off northeastern Brazil. Based on this size of sexual maturity for females was determined to be about 2.40 m and for males 1.80-2.00 m. Female fecundity was between 2 and 21 offspring. Chan A Shing (1999) reported the species as a frequent component of the commercial shark landings for both Trinidad and Tobago and Guyana, which is also the case in the Caribbean in general (Bonfil, 1997). Hayes et al. (2009) conducted a recent stock assessment on the scalloped hammerhead stocks of the Western North Atlantic and Gulf of Mexico and concluded that in 2005 the stock had been depleted by about 83% from virgin stock levels. While from 1996 to 2005 there was some recovery due to a reduction of fishing pressure, the chance of recovering by 2015 was about 60% if catch levels were maintained at the 2005 level. Cortes et al. (2010) conducted ecological risk assessments for several pelagic sharks and identified the scalloped hammerhead as likely to be less vulnerable to pelagic long-line fisheries than other pelagic species (such as the bigeye thresher *Alopias superciliosus*). So even though the resilience of this shark is limited by its long lifecycle and low fecundity, the implementation of catch restrictions can yield results.

Great hammerhead, *S. mokarran* (Rüppell, 1837)

This is a widely distributed and easility recognized tropical continental shelf shark species (Denham et al., 2007). Maximum size is 5-6 m but adults of 4 m are commonly reported. Males mature at a slightly smaller size (2.3 m) than females, whereas females typically grow larger than males. Females breed once every two years and 6-42 pups are born late spring to summer in the northern Hemisphere. High bycatch mortality and low reproduction make the species very vulnerable to overfishing. It is nowhere abundant and is believed to have been reduced in abundance by 80% in the last 25 years (Denham et al. 2007). In the Caribbean it forms only a small part of the commercial shark catch and catch statistics are largely lacking. Due to its scarcity, very little is known about its life history (Denham et al. 2007). It is regarded as an endangered species by the IUCN. The species is a common species caught by the Venezuelan long-line fishery that takes place directly east of the Dutch Caribbean (Arocha et al., 2002).

Bonnethead shark, *S. tiburo* (Linnaeus, 1758)

The Bonnethead shark is a small coastal shark growing to about 150 cm in total length. It is found only along the American continents and is typical of shallow muddy, estuarine and sea grass habitat (Ubeda et al., 2009). The species has been relatively well-studied (Cortes et al., 1996, Cortes and Parsons, 1996, Bethea et al., 2007, Froeschke et al., 2010). The species is placentally viviparous and reproduces annually with an average litter size of 9. Due to its high reproductive capacity it is capable of withstanding relatively high fishing levels (Cortes, 2005). In oceanic island settings it is rare and also uncommon in the Dutch Caribbean. However, in the continental areas of the Caribbean it forms a key component of the commercial shark catch (Chan A Shing, 1999).

2.3.5 Cetorhinidae (Basking sharks)

Basking shark, *Cetorhinus maximus* (Gunnerus, 1765)
The basking shark is from the lamniform shark family Cetorhinidae, the world's second largest fish and one of four types of large filter-feeding elasmobranchs (Sims 2008). Maximum documented size is about 9.8 m (Compagno, 1984). Other common names have been: *Squalus maximus*, *Halsydrus pontoppidani*, *Halsydrus maximus*, and *Selache elephas*. For the Dutch Caribbean the first record is from a stranding on Aruba in March 1973 (Carmabi, 1974), and the second based on a single fish observed north of Curacao during aerial cetacean surveys in early November 2013 (Geelhoed et al., in prep).
The species has been extensively hunted in the past for its liver oil and is now considered highly endangered. Collapsed stocks hardly show any recuperation even after 50 years. The species is circumglobal but most records are for boreal and warm temperate waters (Compagno, 1984). The species seems least abundant in the tropics. Pregnant females are very rare and the species also has very low fecundity. The species is highly migratory with low genetic diversity (Hoelzel et al. 2006) and is believed to overwinter in offshore deep waters. Skomal et al. (2009) tracked six basking sharks migrating during winter from Newfoundland into and beyond the Caribbean, five animals of which travelled more than 2400 km. A number of these sharks came by the Bahamas, Cuba, Jamaica, the Dominican Republic, the Puerto Rico trench, the Lesser Antilles, Barbados, Venezuela, the Guyana's and Brazil (Skomal et al., 2009). Several animals remained at depths of 250-1000 m for five months or more (Skomal et al., 2009).
These new findings suggest that records for the Caribbean which have remained sparse, should be more common. Past records have been documented for the Florida east coast (Choy and Adams, 1995) and Cuba (Claro and Parenti, 2001) while new recent records have been established for the Gulf of Mexico side of Florida, USA (Hoffmayer et al., 2011). For Colombia, the species is so far known only from the Pacific side (Rubio, 1987, Mejía-Falla et al., 2007). The records established for the Dutch Caribbean suggest that the species may be more abundant than previously believed and may use the deep cold waters of the region for overwintering.

2.3.6 Lamnidae (Mackerel sharks)

Shortfin Mako, *Isurus oxyrinchus* (Rafinesque, 1810)
The shortfin mako is the fastest shark species, reaching speeds of over 30km/hr and leaping high above to water when catching prey. Its extremely hydrodynamic body shape is one of the reason it can reach such speed the other is its ability to elevate its body temperature by the use of a highly-developed network of blood vessels that retain the heat produced by their muscles, trapping heat inside its body.
The dorsal side is dark blue to purple and the ventral side is white with a clear line of demarcation separating the two. The underside of the snout and the area around the mouth are white, this helps differentiate the shortfin from the longfin mako, which has a darkly pigmented mouth region. It is a fully pelagic shark living in tropical and subtropical waters swimming from the surface to 500m depth. It will only come close inshore in places where the continental shelf is narrow generally not visiting waters with temperatures below 16°C. Tag and release studies have shown these sharks to migrate to warm waters in the winter months. The reproductive cycle of shortfin mako sharks last three years with litter size ranging from 8-10 pups. Young are hatched from eggs with the uterus (oviviparous) where they feed on unfertilized or undeveloped eggs (oophagy) until they are born at a length of 70cm. Males are able to reproduce at an age of 8 years females not until they reach 18 years of age, average adult size is 3,2m (Bernal et al., 2001, Cailliet et al., 2009, FLMNH 2013c).

2.3.7 Alopiidae (Thresher sharks)

Thresher shark, *Alopias vulpinus* (Bonnaterre, 1788)
This shark of both oceanic and coastal waters is essentially circumglobal from tropical to cold-temperate waters but is most common in temperate waters where migration is common and segregation by depth and sex is common (Compagno, 1984). Maximum size exceeds 5.7 m and its diet is largely schooling fish. The species is ovoviviparous, has typical litter sizes of 2-4 pups and uses shallow warm-temperate shallow bays as nursery areas. Age of maturation is between 3 and 8 years and maximum age is estimated to be 45-50 years (Compagno, 1984). The conservation status of this shark is poorly known but it occurs in areas of heavy fishing and has limited rebound potential. It is highly prized as a food fish and sought after by sport fishermen. The species is caught by the Venezuelan longline fishery that takes place directly east of the Dutch Caribbean but is relatively uncommon (Arocha et al., 2002). Cortes et al. (2010) identified this shark as among the least vulnerable to pelagic long-line fisheries.

Bigeye thresher shark, *Alopias superciliosus* (Lowe, 1841)
The Bigeye thresher shark is found worldwide in tropical and temperate oceanic and coastal waters (Compagno, 1984). The species is known to migrate vertically on a diel basis, moving up to less than 100 m depths at night from daytime depths of between 400-600 m (Nakano et al., 2003). An extremely low litter size of 2 pups per litter means the species has a very low reproductive capacity and the lowest known intrinsic rate of increase of all elasmobranchs. It is a common bycatch in the pelagic longline fishery, where it is typically discarded, and very little is known about its biology (Fernandez-Carvalho et al., 2001). Gruber and Compagno (1981) summarized available information largely based on museum specimens but the only extensive study on age and growth was done in Taiwanese waters (Liu et al., 1999). Consequently, the IUCN has identified the species as one of the pelagic sharks most in need of additional biological data. It is classified as vulnerable due to worldwide declining populations (IUCN 2013). The species is an important part of the commercial long-line catch in the western North Atlantic (Simpfendorfer et al., 2002) and is found occasionally in the Caribbean but does not form an important part of the commercial shark catches in the region (Chan A Shing, 1999). The species is caught by the Venezuelan longline fishery that takes place directly east of the Dutch Caribbean but is relatively uncommon (Arocha et al., 2002).

2.3.8 Hexanchidae (Six- and Sevengill sharks)

The large size, high trophic level and wide distribution and preferred depth-zone make Hexanchiform sharks apex predators of deep-water benthic ecosystems. These are considered to be among the most primitive of modern sharks and are distinguished by having a single dorsal fin, an anal fin and six to seven gill slits (Barnett et al., 2012). Two species occur in the Caribbean.

Bigeyed sixgill shark, *Hexanchus nakamurai* (Teng 1962)
This is the smallest of the two hexanchid sharks known from the Caribbean and has been confirmed as bycatch from deep-water snapper fisheries from Curacao (Van Beek et al., 2013). It grows to a maximum of about 180 cm and is found in depths from 60 to 620 m. It has a patchy circumtropical to subtropical distribution and is also taken as bycatch of snapper fisheries elsewhere in the Caribbean (Barnett et al., 2012). The limited data available suggests that the species specializes on teleost prey. With a smaller geographic distribution, smaller size, smaller depth range, and narrower food nich breadth this species appears to be much more specialistic than its sympatric congener H. griseus. The IUCN lists it as data-deficient (Barnett et al., 2012). In the US commercial and recreational shark fisheries of the Atlantic the species is illegal to land (Cortés, 2002).

Bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre 1788)
This species has a relatively short blunt mouth, a smaller eye and a short dorsal to caudal distance compared to its only congener the smaller *H. nakamurai*. Maximum size is almost 5 m. The species is found from depths down to 2500 m. This species shows wide food habits, known to take carrion, fish and shell fish. Very little is known about the ecology of the species but it is known to show both seasonal and ontogenetic differences in movement pattern. But the species does not appear to migrate over very long distances Andrews et al., 2010). The species has been reported as bycatch from long-lines in Venezuelan waters (Arocha et al., 2002). In the US commercial and recreational shark fisheries of the Atlantic this sixgill shark species is illegal to land (Cortés, 2002). The species has a worldwide distribution, but based on its life history habits is considered Near Threatened (NT) by the IUCN.

2.3.9 Pristidae (Sawfishes)

Smalltooth Sawfish, *Pristis pectinata* (Latham 1794)
Sawfish are one of the most readily recognizable species of fish with the rostrum ('saw'), which can be up to a quarter of the total body length, as its most distinctive feature. The saw is used to slash through shoals of fish, impaling them on the teeth or to stir up the ocean floor to disturb prey animals. The smalltooth sawfish has an olive green color with a wide ventral side, as it is a ray species the gill slits are located on the ventral side of the body. Smalltooth sawfish are only found in shallow, tropical water of the Americas. They formerly had a wide distribution but due to habitat destruction and overfishing there are only two confirmed populations left in the Bahamas and Florida. Two records have been reported from the Leeward Dutch Caribbean (only Curacao) (Van Beek et al. 2013). This species prefers murky waters in estuaries and mangroves, living in water as shallow as 1 m depth. Very little is known about the reproductive cycle op smalltooth sawfish. They are an ovoviviparous species, hatch eggs internally. With 15-20 pups are born in a biyearly cycle. Adult sawfish can grow up to 7m length (including rostrum) with females being larger than males. Females do not mature before reachon 4m length (estimated at 10-12 years old) males mature around 3.70m (estimated at 7-8 years old) (Carlson et al., 2013, FLMNH 2013b).

2.3.10 Dasyatidae (Stingrays)

Spotted eagle ray, *Aetobatus narinari* (Euphrasen 1790)
The spotted eagle ray is distributed worldwide in tropical and warm temperate waters. In the western Atlantic Ocean, it is found in waters off North Carolina and Florida (U.S.), Gulf of Mexico, Caribbean and Bermuda south to Brazil. This ray can be found from Mauritania to Angola in the eastern Atlantic Ocean. In the Indo-West Pacific, it occurs in the Red Sea and from South Africa to Hawaii, including north to Japan and south to Australia. The spotted eagle ray also resides in the waters of the eastern Pacific Ocean from the Gulf of California south to Puerto Pizarro, Peru, including the Galapagos Islands (Ecuador).
The spotted eagle ray is commonly observed in bays and over coral reefs as well as the occasional foray into estuarine habitats. Although it occurs in inshore waters to depths of approximately 200 feet (60 m), the spotted eagle ray spends most of its time swimming in schools in open water. In open waters, spotted eagle rays often form large schools and swim close to the surface. It is known to swim long distances across open waters as evidenced by its presence in Bermuda. This species is capable of leaping completely out of the water when pursued. It swims by "flying" gracefully through the water via the undulation of the pectoral fins. When this ray is caught and taken out of the water, it produces loud sounds. Although much research is still needed on the life history of the spotted eagle ray, it is known that this species shows high site fidelity (individuals often stay in or return to the same location). This ray also interacts socially with other individuals within its own species.

The spotted eagle ray reaches a maximum length of 8.2 feet (2.5 m) not including the tail, with the total length including an unbroken tail reaching close to 16.4 feet (5 m). The maximum disc width is 9.8 feet (3 m) and maximum published weight is 507 pounds (230 kg).

Clams, oysters, shrimp, octopus, squid and sea urchins as well as bony fishes provide prey for the spotted eagle ray. This ray is well adapted with its shovel-shaped snout and duck-like bill for searching in the mud for benthic invertebrates. When a prey item is found, the ray crushes it with its plate-like teeth and uses the papillae located in the mouth to separate the shells from the flesh. Upon scientific observation, the stomach contents of spotted eagle rays contained intact prey items lacking any remnants of shells.

Mating behaviour often includes the pursuit of a female by one or more males. These males grab her dorsum with their upper tooth plate. One male then grasps the edge of the female's pectoral fin and rolls to her ventral side. The male then inserts a clasper into the female ray. The actual mating lasts 30-90 seconds while the pair are positioned venter-to-venter. Females have been observed to mate in this manner with up to four males over a short time period.

Spotted eagle rays are ovoviviparous meaning the eggs develop inside the body and hatch within the mother. After being released from the egg, the embryos are nourished by a yolk sac rather than through a placental connection with the mother. Up to 4 pups are born in each litter, each measuring 6.7-13.8 inches (17-35 cm) disc width.

The spotted eagle ray is considered of minor commercial fisheries importance. Presently, fishing grounds are primarily found within inshore surface waters throughout this species range. Methods of capture include trawls, trammelnets, and longlines. It is also fished as a gamefish and provides a good fight when captured on a line. This ray is rarely eaten due to the poor quality of the flesh. Instead, it is used for fishmeal and oil. The spotted eagle ray is a popular display aquarium specimen and is often seen in public aquaria facilities[3].

Southern stingray, *Dasyatis americana* (Hildebrand and Schroeder 1928)

This stingray is a bottom dwelling animal which continuously searches for prey mostly at night but also during the day. This species has been observed alone, in pairs or in large schooling groups. This stingray is non-aggressive, burying itself in the sand for camouflage and using its tail barb when threatened. It grazes slowly along the ocean floor relying on electro-reception in addition to a strong sense of smell and touch. It feeds on epibenthic prey such as crustaceans, mollusks, annelids, and small teleosts.

This is a coastal and estuarine species which lives in the tropical and subtropical waters of the Western Atlantic Ocean. It occurs from New Jersey to southern Brazil including the Gulf of Mexico and Caribbean. The species is most abundant around Florida and the Bahamas. This stingray prefers areas of sandy bottoms, sea grass beds, and lagoons.

The conservation status of this stingray is unknown due to being "Data Deficient" according to the World Conservation Union (IUCN), a global union of states, governmental agencies, and non-governmental organizations in a partnership that assesses the conservation status of species.

The Southern stingray is crucial to many coastal and island economies relying heavily upon ecotourism. Research is being conducted by the biomedical and neurobiological industries on the venomous component of the barb and its possible use in applications within these fields. The stingray has a brown/olive/grey dorsal surface with a mostly white ventral surface. Lifespan is 18 years[4].

D. *americana* is preyed on by many species of sharks and other large fishes.

The southern stingray reaches a maximum disc width of 79 inches (200cm) and weight of 214 lbs (97 kg). Little is known about its average life span and growth rate. Males become sexually mature at 20

---

[3] Source for this species: http://www.flmnh.ufl.edu/fish/Gallery/Descript/SERay/SERay.html

[4] Source for this species in the above section: http://www.auduboninstitute.org/animals/gulf-mexico-exhibit/southern-stingray-3031

inches (51cm) disc width (DW), while females mature at 29.5-31.5 inches (75-80cm) DW. A captive study has indicated a biannual reproductive cycle, however, this is still under investigation. Development of *D. americana* occurs through aplacental viviparity. The embryo subsists on a yolk sac for nourishment early in development. When the yolk sac is absorbed, nourishment is provided through uterine milk from maternal secretions rather than via a placenta. Gestation takes 4-11 months and litter sizes range from 2-10 pups, with an average of 4 pups per litter. There is a direct correlation between litter size and size of the female. Pup size in captivity ranges from approximately 7.9 to 13.4 inches (20-34 cm) DW and weight varies from 0.6 to 2.5 lbs (282-1128 g). The pups have long, slender tails and broad wing-like pectoral fins at birth[5].

2.3.11 Manta rays (Myliobatidae)

Giant manta ray, *Manta birostris* (Walbaum 1792)
The manta inhabits temperate, tropical, and subtropical waters worldwide, between 35° N and 35° S latitudes. In the western Atlantic Ocean, this includes South Carolina (US) south to Brazil and Bermuda. Occasionally this ray is observed as far north as New Jersey and San Diego. Other locations include the east coast of Africa, in the Gulf of Aden, Red Sea, Arabian Sea, the Bay of Bengal, as well as the Indo-Pacific.
Habitat of M. *birostris* ranges from near shore to pelagic, occurring over the continental shelf near reef habitats and offshore islands. It swims by flapping its large pectoral fins, and is usually observed near the surface or in the mid-waters of reefs and lagoons. It sometimes migrates into temperate waters.
M. *birostris* sometimes swim in loose aggregations and spends considerable time near the surface. Mantas have been observed breaching, jumping clear of the water and returning with a splash. Three types of jumps have been observed, forward jumps landing head first, forward jumps landing tail first, and somersaulting. Groups of these animals have been seen participating in this behaviour, breaching one after the other. While it is not understood why this behaviour is exhibited, some speculate it may play a role in attracting mates or is a form of play.
This ray can achieve a maximum disc width of 29.5 feet (9 m), with an average width of about 22 feet (6.7m). The largest specimens of the manta weigh up to 3,000 pounds (1350 kg). Estimated life span for these giants is approximately 20 years.
All mobulids are primarily filter feeders that occasionally consume small fish. The filtering mechanism consists of plates of pinkish-brown sponge-like tissue located between the successive gill bars that support the gills. When feeding, the cephalic lobs unfurl, directing plankton-rich water towards the mouth. Many have opportunistic remoras attached to their undersides, consuming scraps that result from feeding. Mantas have been observed swimming in slow vertical loops within rich feeding areas. They aggregate in areas that offer large concentrations of zooplankton, with up to 50 individuals within an area. Oceanic islands and submarine ridges provide precious few sites containing nutrient-rich waters and an abundance of zooplankton, in the otherwise nutrient poor tropical regions.
Males reach maturity at a disc width of at least 13 feet (4 meters) while females mature at a disc width of 16.5 feet (5 meters). During copulation male rays bite the pectoral fins of the females before aligning themselves, abdomen to abdomen, inserting one clasper into the female's cloaca. Manta rays reproduce by ovoviviparity with the birth of one pup during a breeding season. Embryos have been shown to reach 50 inches in disc width and weigh 20 lbs. or more. Parturition occurs in relatively shallow water where the young remain for a few years prior to expanding their range offshore.
Due to their size, the only predators of the manta ray are large sharks.
M. *birostris* has been harvested in tropical America. The manta ray was formerly harvested commercially off Australia and California waters for its liver oil and for its skin which is used as an abrasive. Today it is

---

[5] Source for this species in the above section: Henningsen (2000) and
http://www.flmnh.ufl.edu/fish/Gallery/Descript/southernstingray/southernstingray.html]

rarely hunted, although meat from the manta ray is considered a delicacy in the Philippines. Dive tourism has benefited greatly from the manta in locations where they are reliably encountered and sometimes approach divers. In these areas, where divers often touch and interact with mantas, the rays can develop skin lesions in response to the removal of the protective mucous layer[6].

[6] Source for this species: http://www.flmnh.ufl.edu/fish/Gallery/Descript/mantaray/mantaray.html

3 Threats

The main threats to marine biodiversity in general are over-harvesting, pollution and climate change, and sharks are particularly susceptible to extinction (Field et al. 2009). Field et al. (2009) have recently reviewed the various threats facing sharks. The most serious threat worldwide which has driven most declines of shark biodiversity is direct fishing. In this respect mixed-species fisheries, by-catch (Musick et al., 2000), illegal fishing and unreported fishing are additional concerns (Field et al., 2009). The recent documentation of the dependence of many shark species on near-shore habitats during part of their life cycle (as breeding and nursery habitat in particular) highlights their vulnerability to coastal habitat alteration and destruction through land-based activities by man (e.g. Jennings et al., 2008). The effects of pollution and invasive species on sharks are too poorly understood as yet to predict their impact on shark species survival. Risk for extinction in sharks correlates positively with body size and negatively with geographic distribution (Field et al., 2009). The large size and low fecundity of sharks compared to fishes makes that 52% of sharks are IUCN Red-listed as opposed to only 8% of marine fishes. Sharks are vulnerable to fishing mortality as they are unable to respond by increasing fecundity and reducing size at maturity (Ferretti et al., 2010). The synergistic impacts of harvest, habitat loss and climate change will likely be greatest for coastal shark species. Little remains known of how drivers of decline affect specific shark species. Field et al. (2009) indicate the ultimate need to estimate MVP (minimum viable population size) for use as a management tool in managing and protecting sharks in the long term, but the datasets needed for this are dearly lacking. Sexual segregation as is common in many pelagic sharks combined with spatially focussed exploitation may also serve to exacerbate effects of overexploitation (Mucientes et al., 2009). Techera and Klein (2011) point to the lack of progress in internationally stemming the decline of shark species in recent decades and highlight regulatory fragmentation as a key additional threat to the largely migratory and trans-boundary shark populations worldwide.

3.1 Threats to address in a shark protection plan

3.1.1 Fishing mortality

Sharks are valued in fisheries for a combination of their flesh, hide, oil and cartilage and have long been fished by man. The life history characteristics of slow growth, high age and large size of maturation, late maturity and low fecundity, and possibly even evolutionary inflexibility suggested by new genetic studies, make sharks very vulnerable to overfishing and reduce their ability to recover from past overfishing (Ferretti et al., 2010). Consequently, various sources of directed and incidental fishing mortality, such as the advent of long-lining and gillnet fishing have been the main reason for their recent decline (Field et al., 2009). Worm et al. (2013) have reviewed fishing mortality and potential rebound rates for 62 shark species and found potential rebound rates to average only 4.9% per year. Consequently even light fishing pressure can result in steep declines in abundance of sharks (Shepherd and Myers, 2005; Ferretti et al., 2008). Deep-water sharks may be especially vulnerable to overfishing (Ferretti et al., 2010). In contrast to many bony fish species which often respond to exploitation with increased fecundity and lowered size of maturation, sharks appear less able to compensate quickly to fishing pressure (Ferretti et al., 2010).

Even though many initiatives are being taken worldwide to address these declines, combined shark mortalities have shown no decline in recent years all the while the market for shark flesh continues to grow, especially in Oriental markets (Worm et al., 2013). Fortunately, many fishing nations have greatly restricted or altogether prohibited the practice of finning sharks for use of their fins in the market for sharkfin soup. This is a practice whereby sharks are caught and all fins are cut off, after which the incapacitated animal is thrown overboard to slowly perish due to a combination of bleeding and suffocation (Animal Welfare Institute: https://awionline.org/content/shark-finning).

Two kinds of fishing mortality are typically distinguished. First is that of directed fishing mortality wherein sharks are targeted as a fishery resource by any of several gears. Directed fisheries exist in many countries, among which the USA where management is successful and appears to be gradually reversing the trend in shark declines (Carlson et al., 2012, Froescke et al., 2013). Directed shark fisheries do not exist in the Dutch Caribbean.
The second main source of fishing mortality in sharks is that of bycatch in fisheries directed at other species. The main example is that of longline fisheries for swordfish and tunas as also very active in the Caribbean (Weidner et al 2001). As sharks are scavengers and top predators they will readily take bait placed for other species. Bycatch is also important in other gears such as in the use of purse seines for tuna (Watson et al., 2008). Several initiatives are underway to study how shark bycatch can be minimized as unwanted sharks may damage gear and waste bait. For tuna purse seining, Watson et al. (2008) have shown excellent potential of a network of small no-fishing zones to greatly reduce shark bycatch. Most of the above mentioned fishing methods which are threatening for sharks do not exist on Saba, Statia and Bonaire. Incidental bycatch of sharks does occur (Van Beek et al, 2013), i.e. nurse shark, Caribbean reef shark, blacktip shark and Cuban dogfish in the lobster trap fisheries on the Saba Bank (Dilrosun, 2000; Toller and Lundvall, 2008).

3.1.2 Habitat quality

Recent work is showing that large, oceanic sharks may actually depend on shallow coastal areas during part of their life cycle (e.g. Carrier and Pratt, 1998, Tavares, 2008, Clarke et al., 2011, Daly-Engel et al., 2012, Hammerschlag et al., 2012b). This makes many sharks vulnerable to habitat destruction in coastal areas, as caused by man (Jennings et al. 2008) and possibly, on the long-term by climate change (Field et al., 2009). Several shark species are also quite dependent on estuarine habitat (e.g. sawfishes and the bull shark) which are often under extreme development and anthropogenic pollution pressure. The dependence of sharks on habitat quality has been very little studied so far (Field et al., 2009). One dimension of habitat quality that has hardly been studied is that of food availability. Sharks are potentially affected by shortage of prey due to competition for the same resources by their largest piscivorous competitor, namely man, but this has even been less studied.

3.1.3 Habitat connectivity

Recent research shows that many sharks use a variety of different habitats during different stages of their life cycle. Nevertheless, knowledge on their true dependence on these habitats (facultative/vs. required use), how they use these, and the effect of their use of different habitats on population structure and health is very incomplete (Ferretti et al. 2010, Worm et al. 2013). Because of their likely key and complex ecological role as apex predators, and use (or even need) of different habitats during the course of their life cycle, all habitats required should minimally be available, close-by enough, and in sufficient quantity and quality to afford any species integral protection. Under these circumstances, and based on the cautionary principle (Musick et al. 2000b), sustainable management calls for a focus on large interconnected habitats for integral management and protection of sharks, until that time when detailed knowledge may allow fine-scaled tuning of management on a species by species basis.

3.1.4 Life cycle migrations

During the course of their typically long life span, sharks not only likely depend on a variety of different habitats but also often move or migrate over large distances (eg. Skomal et al., 2009). This means that sharks fully protected in one area or jurisdiction, may nevertheless be exposed to dangers and mortality in other areas. This can negate any positive effects of protection provided in delimited areas of their active range. The need for a joint ecosystem approach to the management and conservation of these typically transboundary, and migratory stocks is widely recognized and espoused (Fanning et al 2011).

However, as is evident from the many more localized yet successful shark conservation measures, this does not mean that local efforts are not effective or that local initiatives should wait for the more complicated and often tedious (or even impossible) joint implementation in the international setting. Recent research also shows that a network of smaller no-fishing zones can still be very useful to alleviate fishing mortality in a wide region (Watson et al., 2008).

Two positive consequences of the migratory life-history aspect are that areas that (i) have become devoid of certain species may be again replenished once conditions become favourable and (ii) wide interconnection precludes localized overfishing from the risk of wiping out unique gene pools.

4 Justification for a shark protection plan

4.1 Ecological importance

4.1.1 Ecological role as apex predator

Ferretti et al. (2010) provide a recent synthesis of what is known about the ecological role of sharks. Sharks are primordial predators that have evolved over eons of time for large size, continuous growth, delayed age of maturity and adaptations to the pelagic environment (Grogan and Lund, 2004). Because of their large size they occupy ecological niches first occupied by large predatory reptilians and have likely played a critical role in the evolution of marine mammals as well as other predators and prey species (Ferretti et al., 2010). Sharks are largely seen as feeding generalists and typically take a wide range of prey and therefore likely have limited effect on mortality rates in individual species (Ellis and Musick, 2007). Due to their jaw structure, their feeding is not gape-limited as in bony fish and they can take much larger prey than similar sized bony fishes (Ferretti et al. 2010). They are typically wide ranging and interconnect food webs across wide geographic ranges (Musick et al., 2004). The ecological role each species can play in this is likely influenced by their distribution across habitats. Most shark species (90%) are restricted to near-shore waters of the continental shelves whereas some species (e.g., hammerhead, tiger shark) migrate between the pelagic and near-shore habitats and only few are fully pelagic in habits (e.g. blue, oceanic white-tip mako) (Ferretti et al., 2010).

We know very little about the specific roles of sharks in Caribbean coral reef ecosystems, but current models and theories suggest that their loss causes multiple effects throughout local food webs and could lead to reef collapse[7]. 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 et al. 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.

4.1.2 Possible consequences of removal

Because of their role as apex predators in marine ecosystems world-wide, their population declines in the last 50 years, also in the Dutch Caribbean (Van Beek et al., 2012) allow a number of predictions of how ecosystems might respond. Large shark species (>3m) function as top predators, and many meso-predatory elasmobranchs (typically < 1,5m) are prey to larger shark species. Sharks are feeding generalists, which explains the high connectivity of sharks in food web models (Bascompte et al. 2005). Both theoretical and empirical studies suggest that large marine prey such as marine mammals and sea turtles may increase in abundance as a result of shark declines (Ferretti et al., 2010). But there remains a great paucity of empirical evidence for this, especially since large prey species likely also suffer from other man-induced problems such as food-species shortages due to competition from human fisheries and bio-accumulation of anthropogenic contaminants that reduce their recovery. Heithaus et al. (2007b) have found that even simple presence of large sharks can reduce foraging in sea turtles and make the latter avoid productive feeding areas, but that such avoidance is also affected by the body condition of individual turtles. Food web and bio-energetic models may also give conflicting predictions. While on the

---

7 http://www.earthwatch.org/europe/exped/chapman_research.html

one hand it is suggested that loss of top predators may allow meso-predator release resulting in low herbivore density and contribute to the shift from coral to algae-dominated reefs, others suggest that sharks might also directly affect herbivore prey and their predators, and that the effects of their removal on coral/algal domination may be more limited (Mumby et al., 2006). The ecological effects of loss of sharks as top predators is difficult to understand and generally obscured by the fact that ecosystems have simultaneously been undergoing many other major changes. Ferretti et al. (2010) capture the main ecosystem effects of sharks and shark removal.

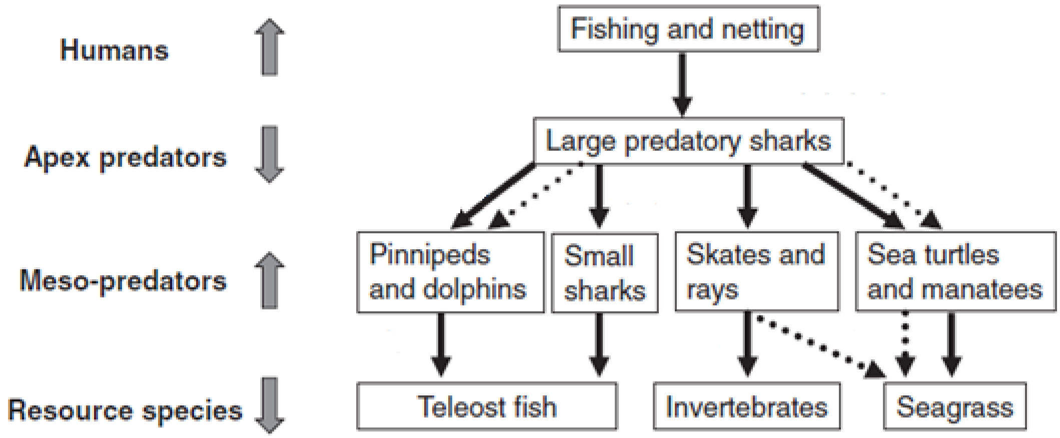


Figure 7. How ecosystem effects of removal of large shark species allows meso-predators to increase and resource species to decrease. Modified from Ferretti et al. (2010).

4.2 Economic potential

With exception of a few large, non-predatory species, shark protection has generally been overlooked because of a negative public image and lack of data (in part due to overfishing) (Cisneros-Montemayor et al., 2013). While globally the number of shark divers has grown to over 590,000 spending over US$ 314 million annually, the global value of fisheries-landed sharks, currently valued at 630 million annually, has declined consistently for the last decades (Cisneros-Montemayor et al., 2013). Based on current trends, the economic significance of shark diving and watching could well double in the next 20 years. It is therefore also not surprising that as (especially) tropical tourism-oriented nations recognize the plight, importance and economic potential of sharks (Gallagher and Hammerschlag, 2011), shark conservation implementation is now taking flight worldwide.

Recent studies show that shark management measures take time but do work if properly implemented (Carlson et al., 2012, Froeschke et al., 2013). In a related effort a review of 80 marine reserves using 114 independent performance measures shows that the concept of reserves and sanctuaries simply works (Halpern and Warner, 2002), even though it is not fully clear why they work nor how exactly to optimize their effectiveness. For the silky shark in the Pacific, Watson et al (2008) have shown that a network of even relatively small, but well-chosen no-fishing areas can greatly reduce combined fishing mortality in this shark species.

This year (2013) French Polynesia and the Cook islands declared their EEZs as shark sanctuaries. As these island groups are contiguous, this has created a shark sanctuary of 6.7 million km^2, the largest in the world. This year in April New Caledonia also declared its whole 480000 km^2 EEZ off-limits to shark fishing. In March 2013, CITES decided to grant all manta ray species and five shark species (oceanic white-tip shark, smooth hammerhead, scalloped hammerhead, great hammerhead and porbeagle) additional to the previous three shark species (whale shark, basking shark and great white shark) CITES

protection against international trade. Eight of the CITES species occur in the Dutch Caribbean (Appendix A).
After years of debate on how to close the various loopholes in the EU 2003 ban on shark finning, in June 2013 the EU finally required all sharks to be landed with fins attached. In June 2013 the IATTC (Inter-American Tropical Tuna Association) (not active in the Atlantic or Caribbean) banned the setting of tuna nets around whale sharks and prohibited the use of entangling fish attracting devices. Finally, in Micronesia several of the federated states have banned fishing, sale, trade and possession of sharks as of June 2013. It is expected that this will later be expanded to official shark sanctuaries encompassing the full EEZ.
At present there are shark sanctuaries in no less than nine nations (Palau, Maldives, Honduras, The Bahamas, Marshall Islands, French Polynesia, Cook Islands and the U.S. Pacific Territories, namely N. Mariana Isls., Guam and Samoa, and Venezuela). Notwithstanding the Caribbean region being highly tourism-oriented, in the Caribbean, shark watching expenditures lag behind, with exception of the Bahamas where annual shark watching expenditures now exceed $ 82 million per year (Cisneros-Montemayor et al., 2013). For all other Caribbean nations combined the current estimate lies at only $ 41 million per year, which indicates considerable potential for expansion. In the last two years two large new Caribbean shark sanctuaries have been established in Honduras and in Venezuela to add to the growing regional network of shark protected areas (Bahamas, and the USA).

Case studies from Mexico, French Polynesia and the Seychelles show that shark watching and related economic activity can be ideal for community involvement and development and can have a broad and positive socio-economic impact and spin-off (Cardenas-Torrez et al., 2007, Rowat and Engelhardt, 2007). At present there are more than 267 shark viewing sites world-wide (Carwardine and Watterson, 2002) and for the Seychelles a 14-week whale shark season represents an economic injection of US$ 4,99 million per year (Rowat and Engelhardt, 2007). In French Polynesia, 13 sharks at one dive site alone generated US$ 5.4 million in revenues annually and each shark represented a total contribution of US$ 2.64 million during its lifetime (not counting its ecosystem value) (Clua et al., 2011).

There has been considerable debate over the past decade about the potential effect of provisioning (shark feeding or chumming) on shark behaviour. There is a general lack of empirical evidence and there are conflicting conclusions (Hammerschlag et al. 2012b). A study of Caribbean reef sharks in the Bahamas by Maljkovic and Cote (2011) concluded that despite more than twenty years of provisioning there is no evidence for shifts in behaviour which might affect the ecological function of these sharks.

4.3 Local support for shark protection

Public environmental awareness and support for management measures are a key determinant for the successful implementation of a shark protection plan. As part of this research a short questionnaire was distributed amongst three key coastal resource user groups - fishermen, sport divers and local residents - to assess opinions and perceptions of the status of sharks and the support for shark protection. A total of 90 questionnaires were sent, 15 to each of the six island. 60 filled questionnaires were returned, of which 16 from fishermen, 16 from local residents and 28 from sport divers living on the islands (Table 3). The responses per island are also shown in Table 3.

Table 3. Sample statistics per respondent group and per island

Repondents	***Aruba***	***Bonaire***	***Curaçao***	***Saba***	***St. Eustatius***	***St. Maarten***	***n***
Fishers	5	0	0	5	5	1	*16*
Residents	5	1	0	5	5	0	*16*
Divers	5	7	6	5	4	1	*28*
Total sample	*15*	*8*	*6*	*15*	*14*	*2*	*60*

The respondent group of sport divers has been diving at their island of residence for 15.6 years on average. The non-diving local residents were living on average 35.2 years on the islands, of which 69% (11 respondents) were born on the island of residence and the remaining respondents were born on another Dutch Caribbean island or in the Caribbean region (Suriname, Colombia, Saint Kitts and Saint Lucia). The respondent group of fishers has been fishing for 28.1 years on average.

Due to the relatively small sample size in this orientative enquiry all data were pooled for presentation and as a consequence, potentially significant differences between islands could not be demonstrated. Furthermore sample selection was left at the discretion of the local collaborating organisations who approached respondents, hence there might be a bias in the selection of respondents. We are not aware of a non-response bias. Non-response in table 3 is because organisations who were asked to hand out questionnaires were unable to do so. Due to the sample size and sample selection our results should only be considered as being broadly indicative.

4.3.1 Perception on shark biodiversity, abundance and size

The three species mostly seen by divers and fishers and best known to residents were for all respondent groups the same species in the same order: nurse sharks, Caribbean reef sharks and Southern Stingray. Respondents were asked for their perception on changes in biodiversity, abundance and individual size of sharks and rays in the past 5-10 years (Figure 8).

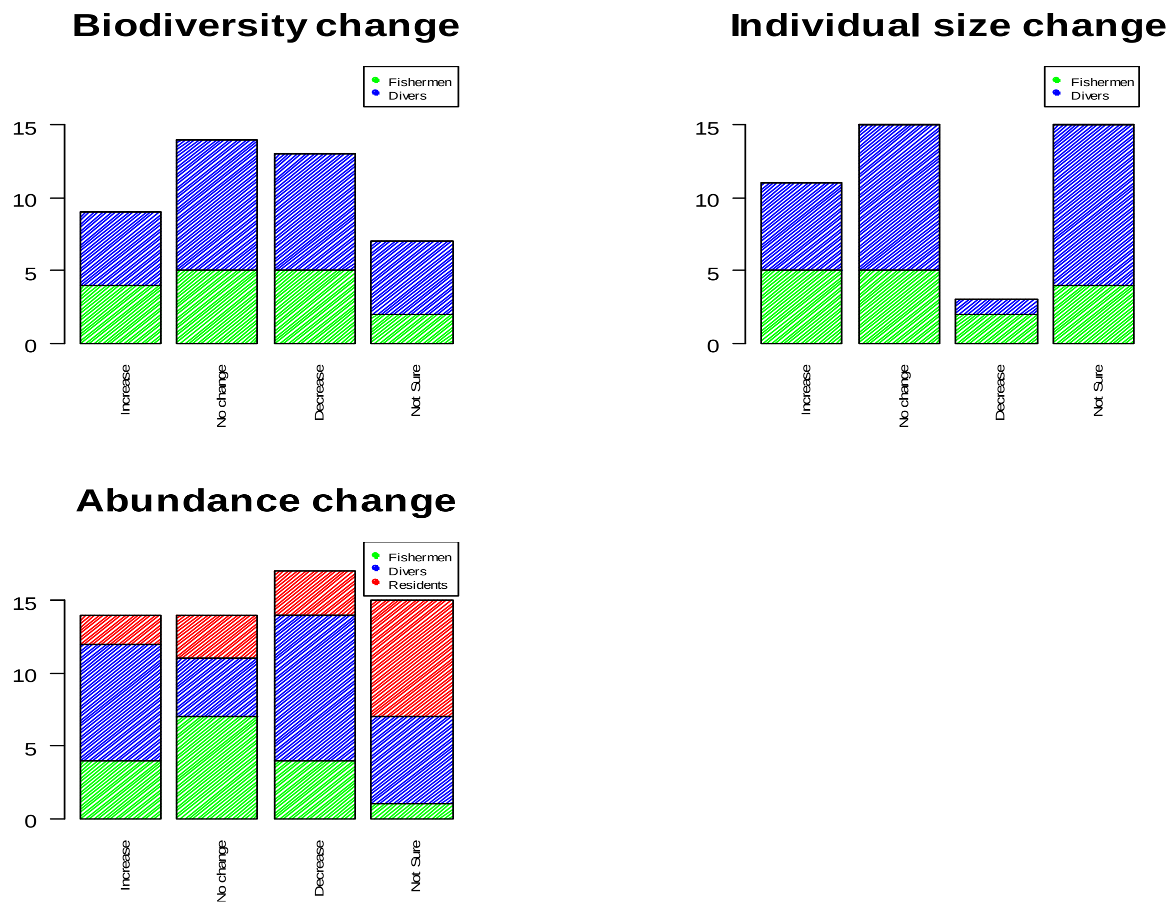


Figure 8. *Top left: Perception of fishermen and divers on changes in biodiversity of sharks and rays in the past 5-10 years. Bottom left: Perception of fishermen, divers and residents on changes in abundance of sharks and rays in the past 5-10 years. Top right: Perception of fishermen and divers on changes in individual size of sharks and rays in the past 5-10 years. Residents were only asked for their opinion on abundance, not on biodiversity and individual size.*

Divers and fishermen were expected to have a perception based on personal experience. Residents were only asked for their opinion on abundance, not on biodiversity and individual size, because we assumed species identification and size estimates were more difficult to recognize for them. One can also argue non-diving residents do not have first-hand information to answer the abundance question either. Which may be the reason why half of the residents selected as answer to be "not sure" about changes in abundance.
Biodiversity change of the number of species (Figure 8 top left) is perceived to have not changed (32%), decreased (30%) or increased (20%) for both fishers and divers. The remaining 18% of the fishers and divers is not certain about a change in the number of different species. Abundance change in the number of individuals (Figure 8 bottom left) is perceived to have decreased (28%), increased (23%) or not changed (23%). A quarter of all respondents is not certain about a change in the number of individual sharks and rays. The change in size of individuals (Figure 8 top right) seems more difficult to judge, as 34% of the fishers and divers is not certain. The others perceive no change (34%), an increase (25%) or a decrease (7%). Overall, these figures show that there is no clear consensus on the perception of biodiversity, abundance and size.

4.3.2 Perception on shark protection and fisheries management

The only major contrast that did seem evident from our data is the large difference between fishermen and divers in the perceived desirability of shark protection. Whereas divers appeared almost unanimous about the need to protect sharks, fishermen were clearly split on this issue (figure 9). This supports the notion that more can likely be gained by directing public information on sharks towards fishermen than towards divers.
The opinion of respondents on the protection and management of sharks and rays was investigated differently for fishers and diving and non-diving residents. The focus for residents was on protection and the focus for fishers was on fisheries management. Fishers were asked for their opinion if and how shark bycatch should be managed. Divers and residents were asked for their opinion if and how sharks and rays should be protected.

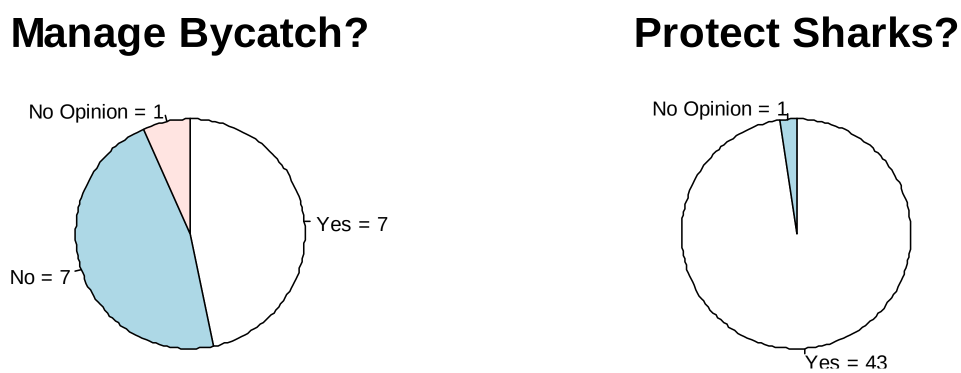


Figure 9. Left: Opinion of fishermen if bycatch of sharks and rays should be managed. Right: Opinion of divers and residents if sharks and rays should be protected.

Results divers and residents
The majority of the divers and residents (98%) were in favour of shark protection (Figure 9 right). Only one non-diving resident had no opinion about shark protection. The motivation for resident divers to protect sharks can be explained by the importance of sightings of sharks and rays for the enjoyment of their dive (Figure 10). It is either important or very important to see sharks for 71% of the divers (20 respondents) and for 93% of the divers (26 respondents) the same is true for rays. The importance of rays is a justification to include these charismatic species in a shark protection plan.

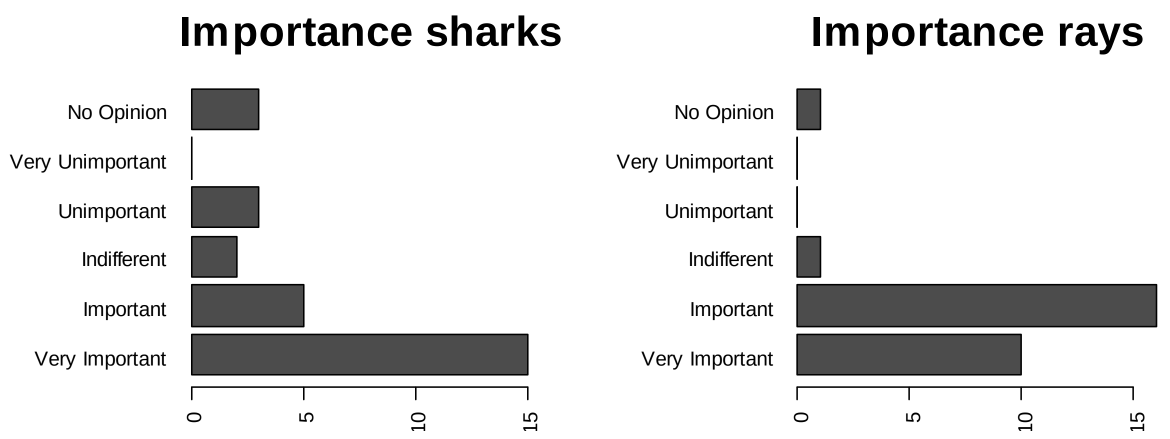


Figure 10. Left: Importance of the sighting of sharks to divers for the enjoyment of their dive. Right: Importance of the sighting of rays to divers for the enjoyment of their dive

When asked to rank four potential conservation management measures on a scale from 1 to 5 (Table 4), the vast majority of all respondents, 67% to 79% depending on the protection measure, ranked them as excellent (scale 5). The protection measures considered worse (scale 1) were no-fish reserves (1 diver and 3 residents), increased enforcement including meaningful penalties (1 diver and 2 residents) and prevention of overfishing (5%, 1 diver and 1 resident). Several divers and residents mentioned the importance to raise awareness and educate fishermen, children and the community, as locally sharks are perceived as a threat. Two divers suggested to join PADI project aware. One diver stated that "*a no-fish zone would be better off if you make it a no-diving zone as well*" which is "*better for all marine life*". One resident acknowledged about fishing that "*for some it's a living*". Another resident remarked "*artisanal fishing of sharks should be controlled, commercial fishing (i.e. longlines) should be banned and bycatch should be immediately released*".

Table 4. Potential shark protection and fisheries management measures which respondents ranked on a scale from 1 (worst) to 5 (excellent).

	Ranking fishers					Ranking divers and residents				
Management measures: Scale:	1	2	3	4	5	1	2	3	4	5
1. Introduce legislation for protection i.e.	60%	7%	0%	7%	27%					
1.1 Shark finning ban						5%	0%	7%	9%	79%
1.2 Prohibit landing of sharks						2%	2%	12%	5%	79%
1.3 Require immediate release of bycatch						0%	2%	10%	14%	74%
1.4 Protect shark and ray habitats						0%	2%	7%	21%	69%
2. Increase enforcement and penalties	47%	7%	7%	7%	33%	7%	2%	5%	10%	76%
3. Introduce no-fish reserves	53%	7%	20%	0%	20%	9%	2%	14%	7%	67%
4. Prevent overfishing, i.e.						5%	2%	7%	18%	68%
4.1 Limit number of fish traps	67%	0%	13%	0%	20%					
4.2 Limit soak time of fish traps	80%	0%	7%	7%	7%					
4.3 Guidelines for handling of bycatch	73%	0%	7%	0%	20%					
4.4 Guidelines for handline fishing	79%	0%	0%	0%	21%					
4.5 Guidelines for gillnet fishing	91%	0%	0%	0%	9%					
4.6 Guidelines for seine fishing	90%	0%	0%	0%	10%					
4.7 Limit number of fishermen	53%	13%	7%	7%	20%					
5. Introduce fisheries management to record bycatch (landed and discarded)	53%	7%	13%	7%	20%					
6. Modify fishing gear and/or method	79%	0%	7%	7%	7%					

Results fishers

Half of the fishers was in favour to manage bycatch and the other half was not (Figure 9 left). When fishers were asked how bycatch of sharks is handled (Figure 11), the responses reveal bycatch is discarded in 45% of the cases (according to the fishers most are discarded alive). From the responses in Figure 11 it appears the majority of the bycatch (55%) is either consumed (32%), sold (18%) or used as bait (5%). One fisher noted that small sharks are used for consumption, while big sharks are discarded alive.

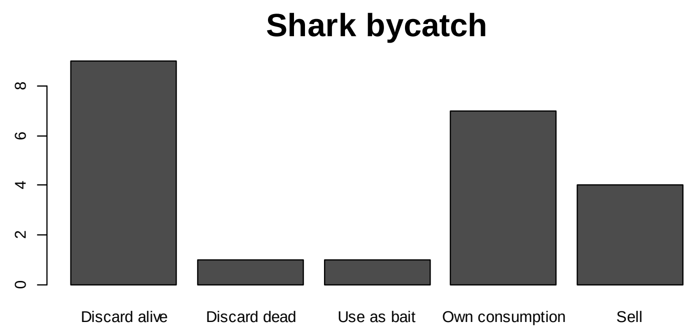


Figure 11. Potential ways fishers handle shark bycatch. Multiple answers were possible.

Because of the small sample size data were pooled. However, due to different approaches to fishery on each island it was considered useful to also present the data for each island separately. Table 5 shows Aruban fishermen were in favour of management, St. Eustatius fishermen not and Saban fishermen were divided. Also the responses for each island on the handling of sharks caught is shown here.

Table 5. Responses of fishermen per island on the management of bycatch: 1) should bycatch be managed and 2) how to handle bycatch (multiple answers possible). One fisher (from Aruba) noted that small sharks were used for consumption, while big sharks were discarded alive.

	1) Manage bycatch?			***2) How to handle bycatch?***				
	Yes	***No***	***No opinion***	***Discard alive***	***Discard dead***	***Use as bait***	***Consume***	***Sell***
Aruba	4	0	1	*3*	*0*	*0*	*4*	*0*
Saba	3	2	0	*4*	*0*	*0*	*1*	*0*
St. Eustatius	0	5	0	*2*	*1*	*1*	*2*	*4*

In the follow-up question to rank six potential fisheries management measures on a scale from 1 to 5 (Table 4) the measure to record landed and discarded bycatch was given the lowest rank by 53% of the fishers. The various measures to prevent overfishing were considered worse by 67% to 91% of the fishers, depending on the measure. The most supported management measures included enforcement (33% rank 5, 40% rank 4 and 5 added up), legislation for shark and ray protection (27% rank 5, 33% rank 4 and 5), and keeping records of bycatch (20% rank 5, 27% rank 4 and 5). One fisherman suggested as additional measure "*there should be a closed season*". Another fisherman in favour of most management measures stated "*don't wait until it is too late*". According to fishermen not in favour of any management measure "*fishermen see the sharks as pest, which interferes with him catching fish*" reason why if "*he catches one he will kill it as it otherwise will continue to interfere with him throughout the day*"; "*all the sharks should be catched out*"; and two of them did "*not consider sharks caught to be bycatch*", because "*sharks are pests which are not specifically targeted but when caught are consumed just like any other fish*" and "*sharks caught are used for different purposes and are most of the time landed and sold*".

Finally, respondents were asked if they were willing to contribute financially to the protection and management of sharks. Of the fishers 94% was not willing to pay and the fisher who stated "*don't wait* *until it is too late*" was willing to pay $500 annually. Of the divers 54% was willing to pay an average of $110 annually and 46% of the non-diving residents was willing to pay an average of $24 annually. Of the 13 divers not willing to contribute, half of them made a remark that the current marine park fees should cover this, fees tend to be diverted currently, fees should be sufficient if everyone would pay, and that an additional fee would only be paid if results are seen. One diver was not willing to pay for damage created by fishers.

5 Protection initiatives in the Wider Caribbean and abroad

There are since the 1990s several shark protection plans, both internationally at intergovernmental and non- governmental level, as well as at national level by several nations in the Wider Caribbean region. This chapter describes such international, European and Caribbean protection initiatives.

5.1 International

5.1.1 FAO IPOA Sharks

Within the framework of the Code of Conduct for Responsible Fisheries the FAO (*Food and Agriculture Organization*) developed the International Plan of Action for the Conservation and Management of Sharks (IPOA Sharks) in 1999. The objective of IPOA Sharks is to ensure the conservation and management of sharks and their long-term sustainable use. IPOA Sharks is voluntary and intends to give states guidelines on how to establish a National Plan of Action (NPOA) through guiding principles and procedures for implementation. Guiding principles for states are participation, sustaining stock and nutritional and socio-economic considerations. States that contribute to fishing mortality on sharks should participate in its management. To sustain stocks the precautionary approach should be applied. In low-income and food-deficit states where shark catches are a traditional and important source of food, employment and/or income, catches should be sustainable to continue to provide food, employment and income to local communities (FAO, 1999).

To ensure the conservation and management of sharks and their long-term sustainable use the shark plan should (FAO, 1999):

- Ensure that shark catches from directed and non-directed fisheries are sustainable;
- Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with the principles of biological sustainability and rational long-term economic use;
- Identify and provide special attention, in particular to vulnerable or threatened shark stocks;
- Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management and educational initiatives within and between States;
- Minimize unutilized incidental catches of sharks;
- Contribute to the protection of biodiversity and ecosystem structure and function;
- Minimize waste and discards from shark catches in accordance with article 7.2.2.(g) of the Code of Conduct for Responsible Fisheries (for example, requiring the retention of sharks from which fins are removed);
- Encourage full use of dead sharks;
- Facilitate improved species-specific catch and landings data and monitoring of shark catches;
- Facilitate the identification and reporting of species-specific biological and trade data.

In their 10-year review of the FAO IPOA Sharks (on behalf of the PEW Charitable Trust) Lack and Sant (2011) concluded that little has been achieved in 10-years' time within FAO context towards better shark management and protection. Others have recently criticised the plan for lacking time lines, priorities, action plans and performance indicators (Davis and Worm, 2013), and stress the need for more proactive national plans. Notwithstanding all the attention given to the topic, global fishing mortality rates of sharks have not declined significantly at the global level and average annual exploitation rates range between 6.4 and 7.9% which exceeds the minimum rebound rate for most sharks (4.9% based on 62 species) (Worm et al., 2013).

5.1.2 CMS Shark MoU

In November 2011 the Kingdom of the Netherlands ratified the Memorandum of Understanding on the conservation of migratory sharks (Sharks MoU) of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). The CMS and its legal context for the protection of sharks is further addressed in chapter 6.1.4. The Sharks MoU is a legally non-binding instrument of the CMS and the first global instrument for the conservation of migratory shark species.
The Sharks MoU entered into force on 1 March 2010 with the aim to sustainably manage and protect migratory shark species, in particular the species included in appendices I en II of the CMS. As of November 2013 the Sharks MoU has 27 members, 26 national governments and the European Union. Seven shark species are currently listed under Annex I of the CMS Sharks MoU.[8] These are the same shark species as those listed under the appendices of the CMS. For the Dutch Caribbean relevant sharks listed under the CMS Sharks MoU and CMS at present are the whale shark, the basking shark and the shortfin mako (Appendix A). .
Annex III of the CMS Sharks MoU contains a conservation plan. The objectives of the conservation plan are to: 1) improve the understanding of migratory shark populations through research, monitoring and information exchange; 2) ensure directed and non-directed fisheries for sharks are sustainable; 3) ensure the protection of critical habitats and migratory corridors and critical life stages of sharks; 4) increase public awareness of threats to sharks and their habitats, and enhance public participation in conservation activities; and 5) enhance national, regional and international cooperation.

5.1.3 RFMOs

The European Commission on behalf of the European Union member states is operating in 17 management RFMOs (*Regional Fisheries Management Organisations*). Figure 12 presents an overview of these management RFMOs. The EC is also operating in two advisory RFMOs: CECAF (*Fishery Committee for the Eastern Central Atlantic*) and WECAFC (*Western Central Atlantic Fisheries Commission*). Another advisory RFMO of which the EC is not a member is the CRFM (*Caribbean Regional Fisheries Mechanism*) in the Caribbean. Besides the CRFM, the other RFMOs which includes the Wider Caribbean are WECAFC and ICCAT (*International Commission for the Conservation of Atlantic Tunas*). Because sharks are migratory species, their fisheries management falls under the ICCAT.

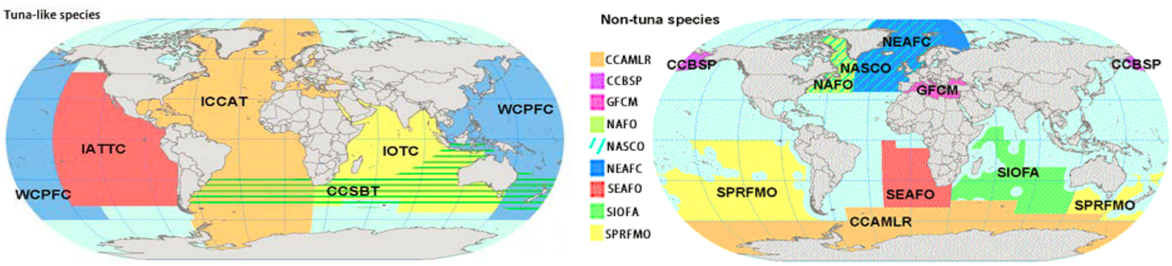


Figure 12. Overview of RFMOs for tuna-like species (left) and non-tuna like species (right)

WECAFC is the most important RFMO for the Caribbean other than ICCAT, the CRFM is strictly a Caricom (Commonwealth countries) organization, though it also includes Surinam and they have an MOU with Dominican Republic.

---

[8] http://sharksmou.org/

5.1.3.1 WECAFC

The Western Central Atlantic Fisheries Commission (WECAFC) was established in 1973 and has 33 member states (32 national governments and the European Union). The general objective of WECAFC is to promote the effective conservation, management and development of the living marine resources in accordance with the FAO Code of Conduct for Responsible Fisheries (CCRF), and address common problems of fisheries management and development faced by members of the WECAFC. One of its guiding principles is to ensure adequate attention to small-scale, artisanal and subsistence fisheries.[9]
WECAFC shark related activities include support for development and implementation of NPOAs. The work programme of the WECAFC for 2012-2013 aimed at five additional WECAFC members to develop and implement a NPOA. In the Regional Policy and Planning Workshop on the CCRF, held during the 14th session of the Commission in 2012, two recommendations with regards to the exploitation and management of sharks were:[9]

- NPOAs Sharks be developed in Caribbean countries that catch substantial quantities of sharks in their fisheries and that all Caribbean countries improve their data collection on shark catches and landings, as well as the skills to identify different species, in line with the FAO Technical Guidelines on the IPOA Sharks and ICCAT recommendations.
- The precautionary approach be applied for deep sea sharks fisheries, in order to avoid fishing to depletion of stocks we do not know enough about as yet.

At the same workshop a conclusion was that the eastern Caribbean sharks are generally caught within a multi-species, multi-gear fishery, often untargeted. Nevertheless, it is important to note that shark catches are not discarded as they are sold and consumed, without waste, by the locals.[9]

5.1.3.2 ICCAT

The International Commission for the Conservation of Atlantic Tunas (ICCAT) has been established in 1970 and has 48 member states. ICCAT has adopted two resolutions and five recommendations with regard to the exploitation and management of sharks.
The most important is resolution 2003-10 which states that each contracting party shall provide information to the working group of the sub-committee on bycatch on their shark catches, effort by gear type, landings and trade of shark products. Furthermore each contracting party shall fully implement a National Plan of Action in accordance with the FAO IPOA.[10]
Important recommendations to prohibit retaining onboard, landing or selling sharks are recommendation 2010-08 for hammerhead sharks of the family *Sphyrnidae*, with the exception of the *Spyrna tiburo*; recommendation 2010-07 for the Oceanic whitetip shark (*Carcharhinus longimanus*); and recommendation 2010-06 for the shortfin mako (*Isurus oxyrinchus*). Recommendation 2004-10 advices to review stock assessments of the Blue shark (*Prionace glauca*); to require fishermen to fully utilize their entire catches of sharks. Full utilization is defined as retention by the fishing vessel of all parts of the shark except head, gut and skin, to the first point of landing; to require that shark fins onboard shall not total more than 5% of the weight of sharks onboard and that it is forbidden to land only shark fins without the shark; to encourage fisheries not directed at sharks to release sharks alive and not use it for food and/or subsistence; to conduct research to identify shark nursery areas and to make fishing gear more selective. All these recommendations apply to sharks caught in association with fisheries managed by ICCAT[11]. In 2009 ICCAT parties prohibited the take and landing of thresher sharks. In 2010 similar prohibitions were extended to hammerheads and oceanic whitetips.

---

9 http://www.fao.org/fishery/rfb/wecafc/en
10 www.iccat.int
11 www.highseasmpas.org (Bos, 2012)

However, as of November 2013, none of the governments that are part of ICATT have actually chosen not to implement any limits on catches of endangered sharks like the porbeagle and the shortfin mako (PEW Charitable Trusts, press release, Nov, 2013). An advisory report of Berry and Tietze (2012), based on a FAO workshop end of 2011, mentioned the shortcomings in policy, monitoring, research and awareness, such as incomplete and outdated policy and legislation; low priority to fisheries resource management and development; lack of coordination in information on sustainable fisheries and management and lack of enforcement.

5.1.3.3 CRFM

CRFM provides data on commercial tuna and shark fisheries to ICCAT (Table 6). CRFM takes part in ICCAT meetings since the 1990s and the CRFM secretariat provides member countries technical and management support for ICCAT activities, especially ICCAT contracting parties. CRFM member states are not necessarily ICCAT member states (Singh-Renton, 2010).

Table 6. Total shark catches in CRFM area (2000-2009), as reported to ICCAT (Singh-Renton 2010)

Species name	Catch from 2000-2009 (tonnes)
Dogfish sharks, unclassified	16821
Atlantic sharpnose shark	3849
Smooth hounds, unclassified	2499
Various sharks, unclassified	1210
Blacktip shark	850
Blue shark	770
Smalltail shark	753
Smooth hammerhead	320
Shortfin mako	93
Ground sharks	60
Hammerhead sharks, unclassified	57
Tiger shark	32
Thresher sharks, unclassified	18
Nurse shark	14
Thresher shark	10
Longfin mako	7
Sand tiger shark	6
Great hammerhead	3
Lemon shark	3
Oceanic whitetip shark	2
Bull shark	1
Nurse sharks, unclassified	1

Some earlier data on the species composition of shark catches in the Caribbean are discussed by Chan A Shing (1999). For Trinidad and Tobago Chan A Shing (1999) reported the following species in the 1970s, 1980s and 1990s catches: *Carcharhinus altimus*, *C. brevipinna*, *C. falciformis*, *C. leucas*, *C. limbatus*, *C. obscurus*, *C. perezi*, *C. plumbeus*, *C. signatus*, *Galeocerdo cuvieri*, *Ginglymostoma cirratum*, *Negaprion brevirostris*, *Sphyrna lewini* and *S. mokarran*, *C. acronotus*, *C. isodon*, *C. porosus*, *Mustelus canis*, *M. higmani*, *Rhizoprionodon lalandii*, *R. porosus*, *S. tiburo* and *S. tudes.* The three small coastal sharks *M. higmani*, *R. lalandii*, and *R. porosus* were the most common in the catches (Chan A Shing 1999).
Sharks documented from commercial catches in Guyana during 1957 and 1961 were as follows: *Scoliodon (Rhizoprionodon) terra novae*, *Scoliodon sp*, *Carcharhinus acronotus*, *C. maculipinnis*, *C. porosus*, *C. obscurus*, *C. limbatus*, *C. leucas*, *Aprionodon (Carcharhinus) isodon*, *Sphyrna tiburo*, *S. tudes* and *S. lewini* (Chan A Shing, 1999).

Recreational fisheries are important in the Caribbean, but there is no monitoring of catch data and no information available at CRFM (Singh-Renton, 2010).

5.2 European Community

5.2.1 CPOA Sharks

In 2009 the European Commission adopted the European Community Action Plan for the Conservation and Management of Sharks (CPOA). The CPOA has the following three objectives:

1. To broaden the knowledge both on shark fisheries and on shark species and their role in the ecosystem.
    a. To have reliable and detailed species-specific quantitative and biological data on catches and landings as well as trade data for high and medium priority fisheries.
    b. To be able to efficiently monitor and assess shark stocks on a species-specific level and develop harvesting strategies in accordance with the principles of biological sustainability and rational long term economic use.
    c. To improve and develop frameworks for establishing and coordinating effective consultation involving stakeholders in research, management and educational activities.
2. To ensure that directed fisheries for shark are sustainable and that bycatch of shark resulting from other fisheries are properly regulated.
    a. To adjust catches and fishing effort to the available resources with particular attention to high priority fisheries and vulnerable or threatened shark stocks.
    b. To minimize waste and discards from shark catches requiring the retention of sharks from which fins are removed and strengthening control measures.
3. To encourage a coherent approach between the internal and external Community policy for sharks.

5.3 Wider Caribbean

5.3.1 FAO CCRF

There is an FAO Code of Conduct for Responsible Fisheries (CCRF) under development in the Caribbean to achieve improved fisheries management and exploitation in the Wider Caribbean region. The most recent regional policy and planning workshop was held in December 2011 in Barbados. The Netherlands was not present at this workshop.

The workshop paid particular attention to the IPOA sharks and conclusions and recommendations were:

- To develop a NPOA for Caribbean countries with considerable shark catches in their fisheries;
- For other Caribbean countries to improve the collection of shark catch and landing data;
- For all countries to improve species identification skills according to the technical recommendations of the FAO and ICCAT;
- To apply the precautionary principle for deep water shark fisheries, to prevent overfishing of shark species with insufficient knowledge on the status of these stocks.

5.3.2 CCCFP

A Caribbean Community Common Fisheries Policy (CCCFP) is under development. In September 2013 a meeting was held in Belize by CRFM, CARICOM and OSPECA to develop this regional treaty on conservation, management and sustainable utilisation of fisheries resources and related ecosystems. The policy, which was mandated by the CARICOM heads of state, will enter into force as soon as at least eight CARICOM heads of state have signed it[12]. There is attention for transboundary species such as migratory pelagic fish stocks[13], but it is unknown to us if there is special attention to the management and exploitation of sharks.

5.3.3 OLDEPESCA, and OSPESCA

The main purpose of the Latin American Organization for Fisheries Development (Organización Latinoamericana de Desarrollo Pesquero, OLDEPESCA) is to "*meet Latin American food requirements adequately, making use of Latin American fishery resource potential for the benefit of Latin American peoples, by concerted action in promoting the constant development of the countries and the permanent strengthening of regional cooperation in this sector*"[14]. The member states are Belize, Bolivia, Costa Rica, Cuba, Ecuador, El Salvador, Guyana, Honduras, Mexico, Nicaragua, Peru, and Venezuela. In 2007 OLDEPESCA met to draft a shark strategy as a contribution to the regional plan for shark management and conservation. In light of the alarming collapse of fisheries worldwide, environment is an important theme to OLDEPESCA. In this OLDEPESCA especially espouses the ecosystem approach and participates actively in the Caribbean large Marine Ecosystem (CLME) initiative.

OSPESCA (Organization of Fishing and Aquaculture in Central America) encourages regionally harmonized sustainable fisheries and aquaculture development[15]. Since 2007 it has supported Central American countries in developing their shark NPOAs (FAO WECAFC 2009). The organization is active in promoting sustainable fishing practices. With regards to sharks, in 2012 OSPESCAs shark working group held a meeting in Honduras on the 25-27 of April and hosted a two-day workshop 18-19 October in Nicaragua on standardization of commercial shark catch reporting in its member states.

5.3.4 CARICOM

One of the earlier reports to express concern about sharks in the Caribbean is the 1998 FAO review by Chan A Shing titled "Shark fisheries in the Caribbean: The status of their management including issues of concern in Trinidad and Tobago, Guyana and Dominica" in which available data is assembled on shark catches for the CARICOM countries of the WECAFC area (Chan A Shing, 1999). The data on reported catches available for those countries during the period 1974-1996 provide no clear trends for the region, but these data come at a time when most overfishing and population decline in the region had long since occurred (e.g. Van Beek et al., 2013). While the study clearly identifies the need for management measures, it also point to several longstanding problems that form major impediments to any implementation of measures in the most CARICOM countries.

5.3.5 Regional fisheries initiatives

US Caribbean Region:
NOAA fisheries service presented the amendment 4 to the 2006 Consolidated Atlantic Highly Migratory Species (HMS) Fishery Management Plan (FMP). The powerpoint states that "*in 2010, Puerto Rico reported approximately 11.8 mt of commercial shark landings and less than one mt was reported by St. Thomas and St. John combined. These landings were not species specific and it is unknown if they were harvested from Federal or Territorial waters*". Proposed management measures for small-scale HMS commercial fisheries include specific authorized gears and retention limits for sharks.

---

12 http://www.caribbeannewsnow.com/caricom.php?news_id=17981&start=0&category_id=39
13 http://www.caricom.org/jsp/communications/belize_declaration.pdf
14 http://www.oldepesca.com/
15 http://www.sica.int/ospesca

US Gulf of Mexico and (Caribbean) Florida:

Following years of declines in catches, and concern about the protection status of many shark species, in 1993 the USA established a Federal Management Plan for Shark Fisheries in the Atlantic Ocean, particularly directed at the coastal bottom long-line fishery. Since 1993 several amendments of the original plan have been implemented and local state governments have tied in by implementing complementary legislation. Measures included successively restrictive catch quotas, finning limitations, area closures, seasonal closures, adjustments of size limits, limits to retention in recreational fisheries, establishment of protected species lists, establish a shark research fishery and the use of regional and species specific quotas[16].

Carlson et al. (2012) provide a synoptic overview of the measures successively implemented measures and conducted an evaluation of subsequent changes in stock status using a generalized linear model (GLM). Since 1994 for most species average size has not continued to decline as would be expected under conditions of growth overfishing (see also Froeschke et al., 2013). Also numerical abundance has not declined but has generally shown small to medium increases. These findings suggest that the US FMP may be one of the first, if not first example of successful shark protection. This may in no small part be due to its large area, ambitious species coverage and effective implementation.

Honduras:

In June 2011 Honduras created the first shark sanctuary in America and declared all its marine waters in both the Pacific and Caribbean as a permanent shark sanctuary. This had been preceded in 2010 by a shark fishing moratorium and created the first shark sanctuary of the Americas amounting to about 240,000 km2 of national waters, most of which lie along the 700 km-long Caribbean coast of the nation.[17]

Bahamas:

The Bahamas have had a longline fishing ban since 1993 and consequently there has been no commercial shark fishing activity. This longline ban has effectively made the whole archipelago of the Bahamas a shark “no-take” zone. The last export of shark from the Bahamas was a lot of 2 metric tons in 2004. In July 2011 the Bahamas went a step further and legally banned all shark fishing. That law firmly turns all 630,000 sq km of Bahamian waters into a shark sanctuary[17]. The fines for shark fishing were raised from 3000 to 5000 USD per incident. In 2011 there were only three other countries with a shark fishing ban. These were Palau, the Maladives and Honduras, the latter of which regards the Caribbean Sea. Shark diving brings the Bahamas 80 million USD per year in tourism revenues and according to the US Pew Environmental Group each reef shark represented a 250,000 dollar asset to the economy of the Bahamas.

Venezuela:

Towards implementing its Plan de Acción Nacional (PAN) de conservación for sharks, in June 2012 Venezuela joined the rest of the Americas in outlawing the finning of sharks in its waters and established a 3,730 km2 shark sanctuary surrounding the touristic archipelago of Los Roques. Recent research (e.g Tavares 2005, 2008 2009) had demonstrated the importance of the shallow waters of Los Roques as a shark nursery area.

---

[16] http://www.nmfs.noaa.gov/sfa/hms/Linkpages/regulations.htm/

[17] http://sharksmou.org/shark-sanctuaries

SICA:
The Dominican Republic has, together with Belize and six other Central American countries, united under the name SICA (*Central American Integration System*), signed an agreement to prohibit shark finning. This ban is also applicable to fishing vessels in international waters under the flag of SICA member states. This arrangement OSP-05-11 entered into force in 1 January 2012[18].

5.4 NGO protection initiatives

5.4.1 IUCN Red List of Threatened Species

The IUCN Red List of Threatened Species is widely recognized as the most comprehensive global source of information on the conservation status of plant and animal species and as an important indicator of the changing status of biodiversity. It has no statutory force, but occupies a prominent role in setting priorities and guiding the conservation activities of governments, NGOs and scientific institutions. The Red List has a scientific base and is established in cooperation with numerous IUCN specialist groups (Fowler et al., 2005). The IUCN Shark Specialist Group (SSG) has been established in 1991 as a result of the increasing awareness and concern about the negative effects of fisheries on shark populations and biodiversity. The objective of the SSG is to promote the long-term conservation of sharks and related species, effective management of their fisheries and habitats, and the recovery of their population, if applicable[19]. SSG members worldwide do assessments in an attempt to address the global status of a species. For some species, however, information is not yet available throughout their entire range, hence regional assessments have been undertaken by SSG members in the interim to provide useful guidance for conservation and management on a regional basis. Only global assessments are available on the IUCN Red List website (Fowler et al., 2005).
The threatened species are categorized as following from high to low: Critically endangered; Endangered; Vulnerable. The categories for less threatened species are from high to low: Near threatened; Least concern en Data deficient. Critically endangered, endangered and vulnerable are species facing respectively an extremely high, very high and high risk of extinction in the wild in the immediate future. Near threatened are species close to qualifying or likely to qualify for a threatened category in the near future. Least concern are species not threatened or not likely to become threatened in the foreseeable future. Data deficient are species for which appropriate data on their abundance and/or distribution is lacking[20].

5.4.2 The Pew Charitable Trusts Environmental Initiatives

The Pew trust has played a central role in several major recent advances in shark protection around the world, including the establishment of the recent shark sanctuaries in the Bahamas and Honduras in the Greater Caribbean. Their global shark conservation program presently lists 13 worldwide shark conservation spear-points. The focus of their ten shark team members is international cooperation with allies through advocacy[21].

Recent contact was established between Paul Hoetjes and Max Bello and Liz Karan of PEW in Washington D.C. At present PEW is providing policy support and advice to Costa Rica as well as to Venezuela. PEW

---

18 http://www.greenantilles.com/2012/02/03/belize-and-the-dominican-republic-sign-an-agreement-to-outlaw-shark-fishing/
19 www.iucnssg.org
20 www.iucnredlist.org
21 www.pewenvironment.org

has helped develop educational material for the Bahamas and other shark sanctuaries and would be willing to make that available to Dutch Caribbean initiatives as well as to give local presentations to the public and decision makers. PEW told of plans of the Dominican Republic to designate a shark sanctuary as well, and plans of several other countries for shark conservation measures, among which Jamaica.

PEW will send us:

- A compendium of shark management methods as applied in other nations
- Contact information and introduction to the shark sanctuary managers and researchers in Venezuela
- Material of the public education campaign against the "nuisance killing" of shark bycatch in the Bahamas
- Further information on the Caribbean Sea Commission meeting in Trinidad & Tobago of 6 November [22]. The Dutch islands (Netherlands Antilles) have been associated members, but this needs to be picked up again, if it hasn't been done already.

5.4.3 PADI project AWARE

Project AWARE Foundation is a global movement of scuba divers protecting oceans. Since there are millions of divers across the globe, their actions can have a huge impact. The focus is on two major ocean issues – Sharks in Peril and Marine Debris - where scuba divers are uniquely positioned to directly and positively affect real, long-term change in these two areas[23]. For the Sharks in Peril program, actions focus on leading grassroots change and influencing effective environmental policies. Project AWARE developed an instructor guide and study guide[24] to raise awareness amongst divers about the ecology, threats and value of sharks. It calls for action, e.g. to advocate for shark protection amongst local policy makers, join campaigns and support local marine protection measures. It also provides responsible environmental guidelines for diving with sharks.

5.4.4 Earthwatch

Shark conservation in Belize[25] researches whether protected reef areas are effective in helping populations recovery. A goal of the project is to better describe the niche of the dominant shark species on the Belize Barrier Reef, including Caribbean reef shark, nurse shark, Caribbean sharpnose, great hammerhead, blacktip shark, lemon shark, silky shark, night shark and tiger sharks. A tag and release program is implemented using hook-and-line shark fishing gear (and seine nets?). Tissue samples are collected from tagged sharks and from local fishermen's catches. Associated environmental data like water quality, salinity and pH are collected. Habitats are recorded by means of snorkel surveys and video is used to record abundance and diversity of coral and fish species.

5.4.5 The Shark Alliance

The Shark Alliance is a not-for-profit coalition of NGOs dedicated to restoring and conserving shark populations by improving European fishing policy. Because of the influence of Europe in global fisheries

22 http://www.acs-aec.org/index.php?q=csc
23 http://www.projectaware.org/about-movement
24 http://www.projectaware.org/resource/aware-shark-conservation-diver-action-kit
25 http://www.earthwatch.org/europe/exped/chapman.html

and the importance of sharks in ocean ecosystems, these efforts have the potential to enhance the health of the marine environment in Europe and around the world[26].

5.4.6 WWF Caribbean Marine Alliance

The Caribbean Marine Alliance is a collaboration between World Wildlife Fund (WWF) offices in the Caribbean region to lobby for common interests i.e. sharks, turtles and Marine Protected Areas. Currently the Caribbean Marine Alliance is in the process of developing a shark and turtle inventory in selected countries in the Caribbean. The latter is not an official document as part of the WWF Global Shark strategy (M. Bottema, pers. comm.).

5.4.7 Curacao Yacht Club Annual International Billfish Tournament

The Leeward Dutch islands are in an important area for billfishes and the nearby La Guaira Bank of Venezuela is about the best billfishing area of the whole Caribbean (Levine, 2006). Consequently, the Curacao Yacht Club (CYC) and many other regional yacht clubs hold annual billfish tournaments in the first months of the year. In March 2013 the CYC 47th Annual International Billfish Tournament was held by the CYC. Typically a total of some 30 teams from the Dutch Islands, USA, Venezuela and the Dominican Republic participate. During these tournaments all billfishes are released but other species are typically retained. Sharks are rarely caught but the awareness of sport fishermen with respect to the plight of billfishes, could also be applied to sharks and represents a valuable opportunity for community involvement in shark conservation.

26 http://www.sharkalliance.org/v.asp?rootid=3&level1=3&level1id=3&level2=7076&level2id=7076&nextlevel=7076&depth=2

6 Legal context for a shark protection plan

This chapter describes the legal context that needs to be considered when establishing a shark protection plan. Such legal context that applies to a shark protection plan can refer to international, regional, national and insular levels.

6.1 International

6.1.1 Stockholm, 1972

The UN 1972 Stockholm "Declaration on the Human Environment" and the "Action Plan for the Human Environment" highlight and recognize international obligations and point to the means to ensure compliance (via the 109 recommendations from the Action Plan). The Stockholm conference was the first global environmental meeting of governments, which stated that long-term economic progress needs to be linked with environmental protection. According to this declaration, natural resources, including flora, fauna and representative samples of natural ecosystems, must be safeguarded for present and future generations through careful planning and management (Sohn, 1973). In Rio 1992 (see CBD below) this Declaration was reaffirmed and built upon.

6.1.2 CITES, 1973

The Convention on International Trade in Endangered Species of Flora and Fauna (CITES) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of endangered species. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties. Although CITES is legally binding, it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level (CITES, 1979).

The convention is legally binding for signatory parties under which also the Kingdom of the Netherlands. For the Caribbean Netherlands, the national legislation that makes implementation possible is the Nature Conservation Framework Act BES (*Wet grondslagen natuurbeheer- en bescherming BES*). For Aruba, Curaçao and St. Maarten this has also been seperately arranged via their national legislation.

CITES only applies to international traffic and trade but not to local protection. Such needs to be arranged separately, both with respect to species protection and habitat protection. Up to now only few shark species have been included in the three CITES listings (Appendices I, II and III).

- Appendix I is a list of about 820 species in danger of extinction (Fowler et al., 2005) for which all international trade is forbidden. As for sharks, this category only includes the sawfishes (*Pristidae spp*), two of which are known from the Caribbean, and at least one of which has been documented in the Dutch Caribbean.
- Appendix II is a list with approximately 29.000 species (Fowler et al., 2005) that may be threatened with extinction unless trade is regulated and controlled. Trade is only allowed if taking has been legal, and has been demonstrated to be sustainable. Until the beginning of this year, for sharks this pertained to three species, the Basking shark *Cetorhinus maximus*, the Great white shark *Carcharodon carcharias* and the whale shark *Rhincodon typus*.

However, in March 2013, CITES decided to grant an additional five species of sharks and all species of manta rays CITES protection against international trade by including them in Appendix II. These are the oceanic whitetip (*Carcharhinus longimanus*), scalloped hammerhead (*Sphyrma lewini*), great hammerhead shark (*Sphyrna mokarran*), smooth hammerhead shark (*Sphyrna zigaena*) and the porbeagle shark (*Lamna nasus*). Entering into effect as of 14 September 2014, they will have to be traded with CITES permits and evidence will have to be provided that they are harvested sustainably and legally. Marine species have traditionally been difficult to qualify for CITES listings due to lack of knowledge and due to their often wide distribution which makes it difficult to demonstrate the need for listing. Therefore, 2013 represents a major milestone in CITES involvement in marine species protection.

- Finally, Appendix III is a listing of about 230 species (Fowler et al., 2005) that are identified by member nations as endangered and managed unilaterally in their national legislation. Listing in Appendix III obligates all member states to cooperate the registration and control of all trade concerning these species. At present there are no shark species on this listing.

6.1.3 MARPOL, 1973/1978

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the most important convention for the protection of the marine environment from ship pollution from accidental or operational causes. This convention is of ultimate relevance to the conservation of marine sharks, because as apex predators they are probably vulnerable to the trophic concentration of dangerous man-made contaminants (e.g. Kumar et al. 2009). The convention has been ratified by the majority of states relevant for international maritime transport based on the percentage of the world tonnage they represent. The Convention contains regulations for the prevention of pollution and Annex I requires all new oil tankers to have double hulls to reduce the risk of accidental discharge. Annex II contains regulations and discharge criteria and measures for noxious liquid substances in bulk. Annex III governs pollution by harmful substances carried in packaged form. Annex IV governs the control of sewage pollution at sea and Annex V regulates pollution by garbage and totally prohibits the dumping of all forms of plastic, which are consumed by large sharks (Cliff et al., 2002). Annex V also allows for the designation of some seas as special areas where stricter rules may apply. The Caribbean Sea including the Gulf of Mexico and Wider Caribbean Area were included in that list of special areas and this took effect in May 2011.

6.1.4 CMS, 1979

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Important countries for Caribbean large migratory species like sharks, such as Venezuela, Colombia, Guiana and Suriname are not parties to this convention. This convention currently lists 3 shark species (great white shark, basking shark and giant manta ray) under Appendix I as "migratory species in danger of extinction throughout all or a significant proportion of their range" and 8 shark species (great white shark, basking shark, whale shark, shortfin mako, longfin mako, porbeagle, spiny dogfish and giant manta ray) under Appendix II as "migratory species that have an unfavourable conservation status or would benefit significantly from international cooperation". Appendix I aims to a) conserve and restore habitats of the species which are of importance in removing the species from danger of extinction; b) prevent the adverse effects of activities that seriously impede or prevent the migration of the species; and c) prevent factors that are endangering the species, including the strict control of introduced exotic species. For species listed under Appendix II CMS provides a mechanism for the development of

international agreements for their conservation and management, ranging from legally binding treaties to less formal instruments, such as Memoranda of Understanding. [27]
The Kingdom of the Netherlands is party to this convention as well. The for the Dutch Caribbean relevant sharks listed under this treaty at present are the whale shark, the basking shark, the shortfin mako and the manta ray (Appendix A).

6.1.5 UNCLOS, 1982

The most comprehensive international agreement on the seas is the United Nations Convention on the Law of the Sea of 1982 (UNCLOS III) which came into force in 1994, and the Kingdom of the Netherlands is a contracting party. UNCLOS lists 72 species of migratory sharks as needing international management. Twenty of these species are reported in the ICCAT catches.
Article 194(5) further states that "*measures must be taken to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species*". Finally, Article 244(2) encourages States to "*actively promote the flow of scientific data and information and the transfer of knowledge resulting from marine scientific research*."

6.1.6 CBD, 1992

The Convention on Biological Diversity is dedicated to promoting sustainable development. Conceived as a practical tool for translating the principles of Agenda 21 (of the 1992 UN Conference on Environment and Development) into reality, the Convention recognizes that biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live. Therefore it puts sustainable development as the foundation for environmental protection. The Kingdom of the Netherlands has been party to the Convention of Biological Diversity since 1992.
Principle 4 of this convention is instructive: "*In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it*". Principle 7 emphases that states should "*cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem*". Principle 12 encourages consensus before taking action to deal with global or trans-boundary environmental issues. It recognizes that effective environmental governance will only be sustainable with the participation of all stakeholders.
In the context of the Convention on Biodiversity (CBD), at present there is a process underway to designate Ecologically or Biologically Significant Marine Areas (EBSAs). While this initiative and the criteria used are much broader than only shark protection, this initiative could also be used to help bolster shark protection. In a CBD EBSA workshop in March 2012 in Recife the Saba Bank was nominated for EBSA status (pp: 84-95 in UNEP CBD, 2012) which was granted at the COP 11 in October 2012 in Hyderabad.

6.1.7 Ramsar, 1971

The oldest international treaty of importance to coastal habitat important to marine sharks is the Ramsar wetlands convention, particularly with respect to habitat on Bonaire. Parties are obligated to protect and conserve designated aquatic habitat. For Bonaire the Ramsar wetlands of relevance to marine sharks are the 800 ha Lac Bay (a mangrove lagoon with important nursery function for several species), and the shallow coastal areas surrounding Klein Bonaire, an official Ramsar wetland and habitat to coastal sharks. In 2007 important jurisprudence was created when the Crown halted construction plans at Lac

[27] http://www.cms.int/documents/index.htm

based on Ramsar treaty obligations (Verschuuren, 2008). Hence, this legislation provides very real protection to potential shark nursery habitat.

6.2 Regional

6.2.1 SPAW, 1990

The principal international convention that relates to the protection of cetaceans at the regional level in the Caribbean area is the Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region of 1983 and its protocols, particularly the "*Specially Protected Areas and Wildlife Protocol*"[28]. This convention was signed by the Netherlands Antilles on 24 March 1983. It was ratified on 16 April 1984. The SPAW protocol was signed on 18 January 1990 and ratified on 2 March 1992.

The Cartagena Convention was adopted in Cartagena, Colombia on 24 March 1983 and entered into force on 11 October 1986, for the legal implementation of the Action Plan for the Caribbean Environment Programme.

The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region is a comprehensive, umbrella-agreement for the protection and development of the marine environment. This regional environmental convention provides the legal framework for cooperative regional and national actions in the Wider Caribbean Region.

The Kingdom of the Netherlands is party to the United Nations Environment Programme's Specially Protected Areas and Wildlife Protocol (SPAW) which consequently applies to all of the Dutch Caribbean entities. This Protocol has been internationally recognized as the most comprehensive treaty of its kind. The SPAW Protocol preceded other international environmental agreements in utilizing an ecosystem approach to conservation and was entered into force on 18 June 2000.

The Protocol acts as a vehicle to assist with regional implementation of the broader and more demanding global Convention on Biological Diversity (CBD). The objective of the Protocol is to protect rare and fragile ecosystems and habitats, thereby protecting the endangered and threatened species residing therein. The Caribbean Regional Co-ordinating Unit pursues this objective by assisting with the establishment and proper management of protected areas, by promoting sustainable management (and use) of species to prevent their endangerment, and by providing assistance to the governments of the region in conserving their coastal ecosystems.

The Protocol also assists with the promotion of and linkages to the Ramsar and CITES Conventions. The Protocol calls for the development and implementation of protection plans for endangered species. Three Annexes to the Protocol list species which are threatened or endangered, for which members of the Protocol are required to adopt appropriate measures to ensure their protection and recovery. For species listed under Annex I all forms of destruction or disturbance or commercial trade are prohibited. Annex II prohibits the taking, possession or killing (including the incidental taking, possession or killing) or commercial trade, and to the extent possible, the disturbance of species, particularly during periods of breeding, incubation or migration, as well as other periods of biological stress. Species listed under Annex III may be utilized on a rational and sustainable basis, but require management for their protection and conservation.[29]

Sharks are not included in the Annexes yet. At the Conference of the Parties (COP 7) in October 2012 a very long list of species was proposed for listing, including 11 of the shark species present in the Dutch Caribbean (table 1 in Van Overzee et al. 2012). This longlist was not accepted, instead a shortlist of

---

28 http://www.cep.unep.org/cartagena-convention/spaw-protocol

29 http://www.cep.unep.org/cartagena-convention/spaw-protocol/cartagena-convention/spaw-protocol/spaw-protocol-en.pdf

priority species was requested, which will be discussed for inclusion in the next COP 8 in 2014/2105. This shortlist of 15 shark species includes 9 shark species present in the Dutch Caribbean (Appendix A). Clearly, Kingdom members are called upon to take active measures by implementing shark protection and management on a national basis.

6.3 National

The Kingdom of the Netherlands is formed by four constituent countries, the Netherlands (including the Caribbean Netherlands islands of Bonaire, St. Eustatius and Saba), Aruba, Curaçao, and St. Maarten. The jurisdictional zones involved in managing sharks in the Dutch Caribbean involve Kingdom maritime zones (EEZ waters), national waters of four countries, and island maritime zones for the islands of Bonaire, Saba and St. Eustatius. This amounts to eight jurisdictions at the various levels of government. In addition, several island governments have apportioned either all or part of the waters that fall under their authority a special legal status as "marine parks". These form an additional jurisdictional category at the island (or national) level.
In these various zones, sharks may be afforded protection by means of treaty obligations, or national or insular ordinances concerning general nature management, fisheries management, or marine parks. Another often-used possibility would be ordinances regarding animal welfare (particularly as regards captive live animals). However the latter type of legislation does not exist in the Dutch Caribbean.
In this section we provide a rough assessment of the principal laws and ordinances which do (or which should) offer sharks legal protection so as to arrive at key recommendations on how to proceed further.

6.3.1 Kingdom jurisdiction

The Kingdom of the Netherlands declared an EEZ over which they carry authority with regard to the exploitation and management of biological marine resources. A management plan has recently been drafted for the EEZ (Meesters et al. 2010). In the Kingdom maritime zone the various international treaties (discussed above) to which the Kingdom is party provide the legal grounds for shark conservation and protection.
Within the EEZ, surrounding the islands, lie the areas of insular jurisdiction. In the case of Aruba, Curacao and St. Maarten the island territorial waters actually concern national waters as these islands are separate nations within the Kingdom. These waters stretch out to 12 nautical miles from land. In the case of Bonaire, Saba and St. Eustatius, the 12 mile zones correspond to island-level legislation as these islands now are part of the Netherlands. Within the territorial waters several islands have further declared marine parks which may or may not extend outwards to the 12 mile zone, and may or may not encircle the whole island.

6.3.2 Netherlands jurisdiction (Bonaire, Saba, St. Eustatius)

Dutch mainland nature legislation does not apply to nature management in Bonaire, Saba and St. Eustatius. The EU Habitats Directive and the EU Birds Directive which together form the legal context for the Natura 2000 network of protected areas in European Netherlands do not apply. At the national level in the Caribbean Netherlands it is the Nature Conservation Framework Act BES (*Wet grondslagen natuurbeheer- en bescherming BES*) and Fishery Act BES (*Visserijwet BES*).

The Nature Conservation Framework Act BES and Fishery Act BES provide the legal envelope for nature and fisheries management. Through these framework laws, the topics for which the Ministry of EZ carry significant and/or final responsibility include:
1. nature policy research "BO" (*Beleidsondersteunend Onderzoek*),
2. nature policy development,

3. legally required scientific research tasks "WOT" (*Wettelijke Onderzoekstaken*) which largely refer to baseline description and monitoring as required via various international treaty obligations,
4. international representation and reporting for the various nature treaties,
5. a national biological inventory "Milieu en Natuurbalans" and information systems, and
6. nature policy, management, implementation in Kingdom seas (such as the EEZ, Saba Bank and sharks).

While the island governments continue to carry their own management responsibility for island territory waters, this list does address many critical needs that are required for sustainable management of sharks, particularly with respect to the Kingdom waters.

By this framework law, once every five years the Minister of Economic Affairs issues a nature management plan for Bonaire, Saba en St. Eustatius wherein attention is given to implementation of international treaty obligations (Art. 2). The island governments of each island separately issue a nature plan every five years which also addresses international treaty obligations (Art. 9), including that of protecting species listed in the CMS convention (Art. 12) and the SPAW protocol (Art. 13). Outside the territorial waters the nature management plan falls under full responsibility of the Minister of Economic Affairs. The first 5-year Dutch Caribbean Nature Policy Plan was completed in the beginning of 2013 (MinEZ, 2013) and affords sharks a high priority for conservation policy development and implementation. The expressed ambition is for cetacean and shark conservation to reinforce each other (MinEZ, 2013).

The Fishery Act BES also provides the Netherlands with instruments to regulate (shark) fisheries in all the waters surrounding the BES islands. This act regulates measures concerning fishing licence, fishing gear, and target species.

6.3.3 Insular jurisdiction within the Caribbean Netherlands

Each of the BES islands is required to pass island legislation implementing all international requirements as stipulated in the Nature Conservation Act BES. Only Bonaire is actually in compliance with this.

6.3.3.1 Saba

<u>Saba Marine Environmental Ordinance (AB 1987, No. 10)</u>
The Saba Marine Environmental Ordinance makes no specific mention of sharks or of internationally protected species. Therefore sharks are not yet protected in Saba island waters. In the interim, and until which time that this situation is improved, Art. 8 provides a possible framework for partial protection. This article states that "*activities which are harmful to the marine environment are not permitted in the Saba Marine Park*" and that "*it is prohibited to intentionally destroy the marine environment in the Saba Marine Park*". If these are interpreted broadly, then the article may afford sharks partial protection. However, no jurisprudence to this extent yet exists. Art. 17 further provides penalties for infractions (max. one month in prison of a fine up to NAF 5000,--), while Art. 18 defines infractions as "*misdemeanors*". Art. 7 provides a framework for additional regulations to be issued based on a General Island Resolution. From this we conclude that grounds for legal protection of sharks in Saba is still deficient and Saba has to update its nature legislation to comply with the Nature Conservation Act BES.

6.3.3.2 St. Eustatius

<u>St. Eustatius Marine Environmental Ordinance (AB 1996, No. 3)</u>
The St. Eustatius Marine Environmental Ordinance makes no specific mention of sharks or of other internationally protected species. Therefore sharks are not yet protected in St. Eustatius island waters. In

the interim, and until which time that this situation is improved, Art. 3 provides a possible framework for partial protection. This article namely states that "*It is prohibited to commit acts that conflict with this Ordinance and damage the interests of the nature and environment within the underwater park of St. Eustatius*". Also, Art. 9 states that "*It is forbidden to commit acts within the Statia Marine Park that damage or can damage the underwater environment*", and that "*It is forbidden to commit acts intentionally that can destroy the underwater environment of the marine park*". If these articles are interpreted broadly then it may afford sharks partial protection. As far as known no jurisprudence to this extent yet exists. Art. 24 further provides penalties for infractions (max. one month in prison of a fine up to NAF 5000,--). Art. 25 defines violations as "*misdemeanors*". In contrast to the Saba Marine Ordinance, the ordinance itself does not foresee possibilities for additions or amendments by General Island Resolution. However, (according to the St. Eustatius National Parks marine parks management plan) treaties implemented by the National (Netherlands Antilles) Nature Conservation Ordinance, such as CITES, SPAW protocol of the Cartagena Convention, CMS, and the CBD overrule regulations stipulated within this island ordinance. From this we can conclude that there appear to be some grounds of support for effective legal protection of sharks in St. Eustatius, but that an update is dearly needed and St. Eustatius needs to update their nature legislation to comply with the Nature Conservation Act BES.

6.3.3.3 Bonaire

<u>Bonaire Island Nature Ordinance (AB 2008, No. 23) and Island Resolution (AB 2010, No.15)</u>
Under Art. 11, the Island nature Ordinance establishes all CITES Appendix I, Bonn-convention Appendix I, SPAW Appendices I and II and the FAO International Action plan for Sharks (IAS) Appendix I species as protected in the territory of Bonaire. The same article provides the ability to include additional protected species based on an island resolution. This has been done by means of Island Ordinance AB 2010, No. 15 in which all sharks and three rays (Manta ray *Manta birostris*, Southern stingray *Dasyastis Americana* and Spotted eagle ray *Aetobatus narinari*) are added as protected species in Bonaire island waters. Art. 27 further provides penalties for infractions (max. one month in prison and fines up to NAF 5000,--). Up to now, of all Dutch Caribbean islands, Bonaire has the most extensive protective legislation. Nevertheless, enforcement remains a problem.

6.3.4 Insular jurisdiction for Kingdom island nations

6.3.4.1 St. Maarten

<u>St. Maarten Nature Conservation Ordinance (AB 2003, No. 25)</u>
This St. Maarten ordinance designates all species listed in the Appendices of the Bonn Convention, Appendices I and II of the SPAW Protocol, and Appendix I of the CITES Treaty as protected species in St. Maarten (Art. 16). This article also provides the possibility to designate additional species as protected or to set special regulations for species listed in addendum III of SPAW by means of a General Island Resolution. Art. 17 provides additional scope for protection in that it adds that it is forbidden to kill, wound, capture or even disturb or upset protected species. However, no definitions are provided for the concepts of "*disturb*" or "*upset*", leaving these definitions open for interpretation. Also, the whole ordinance provides no mention of sanctions or fines. As a consequence, of inbuilt weaknesses, this ordinance only provides limited scope for actual protection of sharks in St. Maarten waters.

<u>St. Maarten National Ordinance on Maritime Management (PB 2007, No. 18) and National Fisheries Ordinance (PB 1991, No 74)</u>
Notwithstanding these limitations, on 12 October 2011 the government of St. Maarten via the Ministry of TEATT (Tourism, Economic Affairs, Transport and Telecommunications) issued a temporary moratorium on shark fishing in accordance with Art. 4 of the St. Maarten National Ordinance on Maritime Management (landsverordening Maritiem Beheer (PB 2007, No. 18) and Art. 5 of the National Fisheries

Ordinance (*Visserijlandsverordening* (PB 1991, No. 74) which provides for temporary closures and moratoria. The shark fishing moratorium prohibits the take and landing of sharks and requires immediate release of incidentally caught sharks, under penalty of a maximum of 500,000 Antillean Guilders or 3 months in prison.

6.3.4.2 Curaçao

Curacao Fishery Laws of 2007 and 2009 (AB 2007, No. 117 and AB 2009, No.48) and National Fisheries Ordinance (PB 1991, No 74)

The Curacao Fishery Laws of 2007 and 2009 (AB 2007, No. 117 and AB 2009, No.48) provide no restrictions on shark fishing and do not provide the possibility of adding species for protection. However, as in St. Maarten the National Fisheries Ordinance (*Visserijlandsverordening* (PB 1991, No. 74) of the former Netherlands Antilles has also been inherited by Curaçao. This does offer a mechanism for additional fishery regulation such as temporary closure and moratoria of certain types of fisheries.

National Nature Policy Ordinance (PB 1998, No. 49)

In addition, the National Nature Policy Ordinance (*landsverordening grondslagen natuurbeheer en -bescherming* (PB 1998, No. 49) of the former Netherlands Antilles does provide legal protection for all species listed in Appendix I of the CMS (art. 8c), Appendix I of CITES (Art. 6 en7) en appendices I en II of the SPAW protocol (Art. 8a en 8b). The available legislation provides only limited scope for implementing effective protection of sharks.

Figure 13. A valuable dive touristic potential in Curacao lost, juvenile Caribbean reef sharks landed in Daaibooi, Curaçao in November 2013 (Photo: G van Buurt)

6.3.4.3 Aruba

Aruba has a 5-year nature policy plan with realistic and achievable goals and objectives as well as a longerterm vision on sustainable nature conservation and development**.** The nature policy ordinance of 1995 (*natuurbeschermingsverordening* (AB 1995 No. 2) prohibits the killing or wounding of all CITES and SPAW species (Art. 13). Not only the nature management ordinance n*atuurbeschermingsverordening* but also the fishery ordinance *visserijverordening* (AB 1992 No. 116) and supplemental fishery ordinance (AB 1993 No. 15) mention measures towards protection of the fishery resources, but sharks are not specifically mentioned.

6.3.5 Overall assessment

In general terms it can be concluded that the network of legislation offering protection to sharks in the Dutch Caribbean is largely incomplete. In some cases sharks are not defined as protected species and in others legislation is in place but no sanctions are stipulated and no enforcement implemented, etc. Upgrading insular and island community legislation on a case by case basis is recommended. However, it may be advisable to develop separate new legislation specifically for shark protection (especially for the EEZ) and that the various jurisdictions may (then) upgrade island legislation as best as possible.

7 Feasibility for a shark sanctuary

The following main objectives can be identified for a national shark plan:

1. Broaden the knowledge of shark species and the status of shark populations
2. Ensure that fisheries activities are sustainable either by prohibiting catch, or by regulating catch and bycatch of sharks and Illegal, Unreported and Unregulated (IUU) fishing of sharks
3. Ensure that an adequate management framework is in place.
4. Ensure that an effective communication, education and outreach strategy is implemented.

These objectives were inspired by the FAO International Plan of Action Sharks and the European Union Action Plan for the Conservation and Management of Sharks.

One highly successful measure to achieve objective 2 is through the implementation of large shark sanctuaries of which there are nine worldwide, three of which have been established in the Greater Caribbean since 2011 (Bahamas, Honduras, Venezuela).

Favourable pre-conditions for establishment of a Dutch Caribbean shark sanctuary include the fact that:

a) many sharks occurring in the Dutch Caribbean are internationally recognized as Red-list species,
b) in St. Maarten and Bonaire sharks are presently afforded legal protection (respectively in part and all of the island waters),
c) the most deleterious fishing practices (longlining, purse seining and gillnetting) are already significantly limited and controlled within Kingdom waters,
d) the key enforcer at sea, namely the Coastguard, is already strongly present (largely due to other reasons),
e) the islands generally have a strong tradition of marine protected areas in coastal habitat,
f) the incremental costs for research and enforcement needed to establish a sanctuary is modest,
g) there is no significant shark fishery and indigenous fishery practices do not conflict with shark conservation,
h) shark watching is growing in popularity (starting in St. Maarten),
i) there is a growing regional network of shark sanctuaries (even nearby in Venezuela) which enriches the ecological context in support of sanctuary establishment,
j) a shark sanctuary would significantly reinforce and (in turn) be reinforced by the presently advanced Kingdom plans to establish a Marine Mammal Sanctuary.

The typical conditions for success in shark management are dependent on having a broad enough scientific database and an understanding of the drivers of shark populations and ensuring that measures are embedded in policy and management. However, by the use of large shark sanctuaries, which is a holistic approach which provides simultaneous protection to sharks as species and their required habitat the information need for success is simplified. Typically a Shark Sanctuary and Action Plan (SAP) will consider the following aspects that define the prospects for success:

A. **Database**: are species-specific data available for the relevant aspects of biology and fisheries (life-history characteristics; distribution and habitat requirements; role in commercial or recreational fisheries; data on catch, by-catch and/or discards; ease of determination; protection in international treaties (CITES, CMS, IUCN)).
B. **Theoretical framework**: is there a scientific base and understanding of the effects of fisheries or other forms of exploitation or threats on shark populations, or of the benefits of current management measures.
C. **Institutional/management framework**: is there a management body capable of implementing the necessary management measures or a research institute capable of carrying out the relevant research and monitoring; are there mechanisms in place for the management of

transboundary species. Insight into present and future funding will also be needed, as well as cost effectiveness of measures, but has not been addressed yet.

D. **Stakeholder support;** Implement a communication/outreach strategy to build support and engage key stakeholder groups such as fishermen and the dive sector (making use of A)

The four levels of conditions for success can be addressed for the different aspects of a SAP in order to analyse the gaps in knowledge and institutional frameworks. This is shown in Table 7 as an example for the three broad SAP objectives. Following, in Tables 8-11 indicators to measure the conditions for success and data availability to quantify the indicators are listed for each of the specific actions.

Table 7. Assessment of the feasibility of a Shark Sanctuary and Action Plan with the conditions for success to achieve the three main objectives

Shark Plan Objectives	A. Database	B. Theoretical framework	C. Institutional / management framework	D. Stakeholder support
1. Broaden knowledge of shark species and the status of stocks and populations	Overview of available biological and ecological data	Estimates of biomass or CPUE available; length-frequency data; insight into habitat use	Identification of relevant research institute(s) and research programs	Communicate knowledge to the general public and stakeholders to build support
2. Ensure that fisheries activities are sustainable	Fisheries data Market surveys Trade data	Estimates of exploitation rates or (fishing) mortality Insight into threats to shark populations	Legislation from government Relevant fisheries institutes Participation of RFMOs	Outreach program to build support among (commercial, recreational and game) fishers
3. Ensure that an adequate management framework is in place	Overview of current management plan(s) and protection in (inter)national treaties	Method for measuring effectiveness of management measures	Government, local government and NGOs RFMOs (Inter)national treaties	Regularly report achievements to stakeholders
4. Ensure that an effective communication, education and outreach strategy is implemented	Communication of and easy access to knowledge to build stakeholder support	Adequate methods and tools for effective consultation, involving all stakeholders in research, management and educational initiatives	Dedicated capacity for communication and education among government, local government and NGOs	

Once a gap analysis has been done, the level of compliance with the needs for a successful SAP will be clear and a plan for extra research, management actions, political lobby etc. can be made.

7.1 Broaden knowledge of shark species and status of stocks and populations

Table 8. Indicators to measure conditions of success to achieve the first objective of a Shark Sanctuary and Action Plan: broaden the knowledge of shark species and the status of stocks and populations

	Indicator	Data availability
A. Database Overview of available biological and ecological data	Life history characteristics Ease of determination Main habitat Distributional range	All indicators and ID key for species identification are available for most species (see chapter 2.2). However, not for one of the most common species, the Caribbean reef shark. No detailed information on distributional range and habitat, also connectivity of habitats is important in distributional range.
B. Theoretical framework Estimates of biomass or CPUE available; length-frequency data; insight into habitat use	Habitat use - nursery areas Lesley matrix: determine replacement mortality based on fecundity and age at maturity Stock assessment biomass or CPUE Stock assessment length-frequency data	No detailed information, but coastal areas have been identified as important, also for large oceanic sharks during their life cycle Information available for 14 species[30] to do a rough estimate of replacement mortality. Not yet, IMARES fish and fisheries surveys started in 2012 Not yet, IMARES fish and fisheries surveys started in 2012
C. Institutional / management framework Identification of relevant research institute(s) and research programs	Identification of research institutes and programs	IMARES fish and fisheries monitoring programs (since 2012) Sea Saba diver observation program (since 2012) Local support from fishermen, divers and native residents (see outcome questionnaire stakeholder perception in chapter 4.3) Investigate further as part of this project

[30] Whale shark (*Rhincodon typus*); Blacktip shark (*Carcharhinus limbatus*); Lemon shark (*Negaprion brevirostris*); Bull shark (*Carcharhinus leucas*); Tiger shark (*Galeocerdo cuvier*); Oceanic white-tip shark (*Carcharhinus longimanus*); Silky shark (*Carcharhinus falciformis*); Blue shark (*Prionace glauca*); Scalloped hammerhead (*Sphyrna lewini*); Bonnethead shark (*Sphyrna tiburo*); Shortfin mako (*Isurus oxyrinchus*); Thresher shark (*Alopias vulpinus*); Spotted eagle ray (*Aetobatus narinari*); Giant manta ray (*Manta birostris*)

D. Stakeholder support Communicate knowledge to the general public and stakeholders to build support	Raise national awareness of the vulnerability of sharks and their role in the ecosystem, current threats, population status, safe swimming and safe diving guidelines. Educate resource users about the rationale for and use of recorded shark catch data, and techniques to improve shark species identification	 Sea Saba diver observation program (since 2012) can be used as a model to build upon

Special attention for:

IUCN: implement as a matter of priority scientific advice for protecting habitat

7.2 Ensure that fisheries activities are sustainable

Table 9. Indicators to measure conditions of success to achieve the second objective of a Shark Sanctuary and Action Plan: ensure fisheries are sustainable

	Indicator	Data availability
A. Database Fisheries data Market surveys Trade data	Role in commercial or recreational fisheries: • In the Dutch Caribbean • In the Wider Caribbean Catch data Discard data and/or observer programs Market data Trade data	Yes, only bycatch in commercial fisheries, some IUU, ask fisheries departments for recreational fisheries Yes, some information on shark fisheries in Caribbean region available (see chapter 5.1.2). Investigate further if needed. Yes, monitoring program on Saba, Statia and (pilot) Bonaire registers bycatch during port sampling as well as discards during onboard sampling; also anecdotal information Unknown, try to investigate further at CITES or CMS Unknown, but 6 of the 24 species are listed on most recent (2013) CITES Appendix II and 1 species is listed on Appendix I
B. Theoretical framework Estimates of exploitation rates or (fishing) mortality Insight into threats to shark populations	Threats to shark populations PSA: Productivity & Susceptibility Analysis at meta-population level (NOAA method) Exploitation rate Fishing mortality – including bycatch	IUCN status and descriptions Not yet, planned in 2014 for 14 species[31] No, investigate further, also for the Caribbean region No, investigate further, also for the Caribbean region
C. Institutional / management framework Legislation from government Relevant fisheries institutes Participation of RFMOs	Improvements to current national legislation Identification and participation in RFMOs Identification of relevant fisheries institutes and/or universities dealing with shark fisheries	Not yet, recommendations made as part of this project Yes ICCAT and CRFM (see chapter 5.1.2) Yes, various initiatives see chapter 5.3.5. In this context it is important to learn from initiatives in the region, such as Honduras (see also chapter 4.2)

[31] A qualitative PSA (high, medium, low) can be attempted for the 14 species mentioned in Footnote 1, based on the generalised fisheries information. More detailed information on the distribution and type of fisheries is needed for a quantitative approach.

D. Stakeholder support Outreach program to build support among (commercial, recreational and game) fishers	Raise awareness amongst resource users of threatened species provisions, local regulations, reporting requirements and penalties. Raise awareness amongst resource users of the cumulative impact of shark bycatch, the need to return sharks to the sea and to maximise their chances of survival.	

Special attention for:

IUCN: implement as a matter of priority scientific advice for preventing overfishing

IUCN: protect sharks through ecological risk assessments

IUCN: prohibit the removal of shark fins while onboard fishing vessels and thereby require landing of sharks with fins naturally attached

IUCN: promote research on gear modifications, fishing methods and habitat identification aimed at mitigating shark bycatch and discard mortality

7.3 Ensure that an adequate management framework is in place

Table 10. Indicators to measure conditions of success to achieve the third objective of a Shark Sanctuary and Action Plan: ensure that an adequate management framework is in place

	Indicator	Data availability
A. Database Overview of current management plan(s) and protection in (inter)national treaties	Current national legislation/regulation and international treaties	Yes
B. Theoretical framework Method for measuring effectiveness of management measures	Development of indicators for compliance and effectiveness for management measures such as closed areas or restrictions of exploitation Identify any confounding issues such as subsidies that increase overexploitation	Partly, available from similar areas around the world only anecdotal data available for Dutch Caribbean Unknown – to be investigated
C. Institutional / management framework Government, local government and NGOs RFMOs (Inter)national treaties	Identification management body capable of implementing management measures e.g. local and national government, NGOs, RFMOs, regional and international treaties Identification of mechanisms in place for the management of transboundary species Ensure compliance with international treaties	There are 6 relevant national initiatives but there is little coordination or specific attention for sharks. Regional: there is a Caribbean protocol - the UNEP Specially Protected Areas and Wildlife Protocol (SPAW) which assists with regional implementation of CBD and RAMSAR, although sharks on not yet high on the agenda. ransboundary: CBD (2012) recommendation for protection of Saba Bank (EBSA status) (see chapter 5.1.2) and PSSA FAO Code of Conduct for Responsible Fisheries for wider Caribbean under development but Netherlands not (yet) engaged (see chapter 5.3.1)
D. Stakeholder support Regularly report achievements to stakeholders	Incorporate this in a communication and education strategy (see 7.4)	

Control of access, technical measures including strategies for reduction of shark bycatches and support for full use of sharks (FAO, 1999).
Given the wide distribution range of sharks, including on the high seas, and the long migration of many species it is increasingly important to have international cooperation and coordination of shark management plans (FAO, 1999).

7.4 Ensure that an effective communication and education strategy is implemented

Table 11. Indicators to measure conditions of success to achieve the forth objective of a Shark Sanctuary and Action Plan: ensure that an effective communication/outreach strategy is implementedbroaden the knowledge of shark species and the status of stocks and populations

	Indicator	Data availability
A. Database Communication of and easy access to knowledge to build stakeholder support	Raise national awareness of the vulnerability of sharks and their role in the ecosystem, current threats, population status, safe swimming and safe diving guidelines. Raise awareness amongst resource users of threatened species provisions, local regulations, reporting requirements and penalties. Raise awareness amongst resource users of the cumulative impact of shark bycatch, the need to return sharks to the sea and to maximise their chances of survival. Educate resource users about the rationale for and use of recorded shark catch data, and techniques to improve shark species identification	Not known, some level of awareness raising by fisheries departments and marine parks in youth programs may be available. Regional awareness raising programs may be available through e.g. PEW Environment Sea Saba diver observation program (since 2012) can be used as a model to build upon
B. Theoretical framework Adequate methods and tools for effective consultation, involving all stakeholders in research, management and educational initiatives	Identification of stakeholder groups (fisheries and conservation agencies, commercial fishers, recreational fishers, game fishers, tourism operators e.g. shark diving, scuba operators and research agencies). Development of an appropriate communication strategy through awareness raising and education programs aimed at the above stakeholder groups and incorporating the above indicators (see A.) Assessment existing shark species identification guides and development of island specific (if applicable), culturally appropriate (local names) guides. Develop measures to monitor effectiveness of the communication strategy and species guides.	Not known, some communication and education strategy may be available. Regional awareness raising programs may be available through e.g. PEW Environment ID key for species identification available for most species

C. Institutional / management framework Dedicated capacity for communication and education among government, local government and NGOs	Identification management body capable of implementing a communication and education strategy e.g. local and national government, NGOs Identification of mechanisms in place for the management of transboundary species Ensure compliance with international treaties	IMARES fish and fisheries monitoring programs (since 2012) Sea Saba diver observation program (since 2012) Local support from fishermen, divers and native residents (see outcome questionnaire on stakeholder perception in chapter 4.3) Investigate further as part of this project

7.5 Gap analysis

From the tables above it is clear that the level of compliance with the needs for a successful Shark Action Plan and the implementation of a shark sanctuary are not met in many cases. Specifically it is important to address the following:

1. Broaden the knowledge of shark species and the status of stocks an populations
    - Set up collaborative research projects to collect species specific information on abundance, distribution, life cycle and habitat use
    - Engage local awareness and coordinate with international research initiatives
2. Sustainable fisheries
    - Improve fisheries data – also for recreational fisheries
    - Communicate protected status of species – especially those on the CITES list
    - Learn from initiatives in the region – e.g. Honduras, Venezuela and Bahama's
3. Adequate management
    - Coordinate initiatives at local, regional and international levels and ensure that the Netherlands engages in the wider Caribbean initiatives such as the FAO CCRF – contact Dutch representatives from the relevant ministries (EZ, OC&W)
    - As in 2. – learn from, but specifically **engage with**, initiatives in the area – e.g. Honduras, Venezuela and Bahama's

8 Research

The biology of elasmobranchs is among the most poorly known and least understood of all the major marine vertebrate groups (Fowler, 2005). This is particularly so for the Caribbean region and the Dutch Caribbean in specific, where our best information on sharks amounts to no more than a list of opportunistic and incidental observations. As of now, no actual data has been published on density, population structure or life-history characteristics (not even size and length measurements, or reproductive stage) of any native elasmobranch (e.g Van Beek et al., 2012). The conservation and scientific communities of the islands need to be much more aware and make better use of the opportunity of even opportunistic specimens to provide samples and data on the species found in the Dutch Caribbean.
Even just the better use of opportunistic specimens and observations should allow important advances in knowledge for the Dutch Caribbean and should be included in any research plan. Due to their lack of sophistication, opportunistic approaches allow the involvement of non-specialist stakeholders which also helps stimulate public involvement, awareness and appreciation.

One unique (with respect to the rest of the Dutch Caribbean) opportunity for research is provided by the easy availability of sharks (particularly nurse sharks) on the Saba Bank, an area that may be a nursery area for the species (Van Beek et al., 2013). The observations of high abundance (Toller et al., 2010) and high by-catch rates for juvenile nurse sharks in the lobster fisheries on the Saba Bank (Van Beek et al., 2013) suggests that the Bank may likewise serve such a function and that tagging studies, as which IMARES has experience with (e.g. Winter and Van Overzee, 2013), may be fruitfully conducted. Such studies on various species of Atlantic sharks which are also found in the Dutch Caribbean (e.g. Heupel and Simpfendorfer, 2002, black tip shark; Chapman et al., 2007, reef shark; Campana et al., 2009, blue shark; Gifford et al 2007, whale shark) may yield a wealth of information on growth, movements, survival and reproduction and can be of direct use in conservation and management.

Further interesting research leads are the apparent healthy populations of deep-water sharks around the ABC islands (Debrot et al., in prep) and a second rare record for the basking shark which suggests that the deep waters of the Dutch Caribbean EEZ forms part of the migration route or wintering area for this globally endangered species.

The skilful use of modern techniques (such as genetic analyses, telemetry and Baited Remote Video monitoring) can help circumvent the often low abundance (and low sampling) of many species, and should help develop powerful new insights and introduce new techniques to the region where capacity and technology have lagged behind.

8.1 Genetic research

Molecular genetic approaches provide a unique tool for the study of elasmobranchs. The great value lies in small tissue samples from live or dead individuals containing the complete nuclear and mitochondrial genomic information. Ecological and evolutionary research questions may be addressed by analyzing such samples that could hardly be investigated in such organisms by means of other methods. The application of molecular genetic techniques in sharks is especially useful as many of these nonmodel[32]

[32] a model organism is a nonhuman species that is extensively studied to understand particular biological phenomena or patterns, with the expectation that discoveries made in this organism will then provide insight into the biology, life history, etc. of other organisms. A non-model organism on the other

marine species have an enigmatic life style that makes direct observation challenging. Application of genetic tools provides us with the opportunity to infer information about abundance and connectivity on a long-, medium-, and short-term spatial scale. This in turn facilitates inference of population status and reactions to anthropogenic and environmental impacts over time (Fietz, 2013).

IMARES has established relationships with researchers of the Marine Evolution and Conservation (MARECon) working group of the Rijksuniversiteit Groningen, part of the Centre for Ecological and Evolutionary Studies (CEES), to apply genetic research in the Dutch Caribbean. Their specific area of expertise, the application of population genetic and genomic methods to basic and applied questions in conservation, ecology and evolution, has become a popular research tool[33]. PhD candidate Katharina Fietz, under supervision of Professor Per Palsbøll, has written a proposal for a genetic research component to complement the shark protection plan in the Dutch Caribbean.
She proposed to select and investigate a key shark species as a model system that is affected by fisheries pressure, and to analyze the degree of isolation between different localities as well as past and current population sizes within the Dutch Caribbean and Greater Caribbean. Understanding the level of spatial heterogeneity as well as current and past population size will add to the knowledge foundation needed and enhance the predictive abilities regarding long-term effects of anthropogenic impacts on this marine apex predator.
She further suggested to develop a more general long-term monitoring system integrating molecular methodology of directed and incidental shark fisheries. Combination of these approaches and complementation with other scientific techniques such as chemical fingerprinting, telemetry studies, and molecular investigation of prey species provides an ecosystem approach and promises acquisition of the data necessary to ensure the sustainable use of sharks by establishing appropriate conservation and management measures.

8.1.1 Broader impacts of proposed activity

Information for policy and management
Results will have direct relevance for formulating fisheries management policies for the Dutch Caribbean. As sharks regulate the systems that fishermen rely on, implications are not only relevant for the respective shark populations, but also for associated ecosystem components (e.g. prey species), and in this regard for the local economy that depends on them as a food and income resource.

Enhance infrastructure for research and education
The proposed study enhances research on an 'international' level throughout the kingdom of the Netherlands. The use of new molecular technologies (e.g. ddRAD sequencing) will further the introduction of these genomic applications in wild non-model organisms and in marine populations that in the past have been particularly difficult to investigate.

8.1.2 Focal key species

The Caribbean reef shark *Carcharhinus perezi* is a suitable model organism to investigate the degree of spatial isolation in an exploited demersal shark. Despite a widespread distribution, it has low productivity with only 3-6 pups born every two years (Ebert et al. 2013). It is among the most common sharks encountered in the Caribbean and displays an inshore, bottom-dwelling distribution. Former acoustic monitoring studies have indicated year-round residency in certain areas and have shown that despite its

---

hand then is an organism that so far has not been so intensively studied and of which in return not so many details are yet known.

[33] http://www.rug.nl/research/marine-evolution-and-conservation/

ability for extensive movements, it displays high site fidelity (Bond et al. 2012). These characteristics suggest high levels of population structure, with consequences for isolation and impacts on local populations by exploitation. Former studies have provided knowledge on population genetic structure and evidence of heterogeneous population structure in various shark species (e.g. Pardini et al. 2001, Duncan et al. 2006); however to our knowledge no such investigations have yet been conducted on *C. perezi*.

8.1.3 Project description, sampling and experimental setup

Objective and Sample Collection

The project aims for a high-resolution population genetic approach in two areas of the Dutch Caribbean. The overall objective of this study is to shed light on the degree of isolation, dispersal, and connectivity of *C. perezi* populations in these areas and on a broader spatial scale. Further, past and current effective population size is to be estimated to help infer their current status.

Samples may be collected from fisheries catches and landings as well as from biopsy sampling. In order to allow for unbiased and representative sampling, fisheries-dependent as well as independent sampling should be integrated and gathered from sharks throughout the regions of interest (i.e. both the ABC islands and the windward Dutch Caribbean islands). For the fisheries-independent samples, representative areas for biopsy sample collection are to be established in the course of this project in order to facilitate feasibility. Preliminary data analyses on a subset of already available samples will yield first results upon which a more directed sampling scheme can be defined.

Laboratory Methods

DNA Extraction: Total genomic DNA will be extracted according to the Qiagen DNeasy protocol.

Genetic markers: A number of different types of genetic markers can be applied to investigate isolation between localities. The proposed study will apply Single Nucleotide Polymorphisms (SNPs). These have become the marker of choice for population genetic analyses in recent years as they are distributed evenly across the nuclear genome, are associated with both neutral and adaptive variation, and are relatively easy to genotype and reliably transferable among laboratories (Morin et al. 2004).

Sequencing: Samples will be sequenced by double-digest restriction site associated DNA (RAD) sequencing and SNP markers will subsequently be identified.

Data Analyses to investigate isolation between localities and population size

Diversity and Structure: Population genetic statistics (major allele frequency, percent polymorphic loci, nucleotide diversity (π) and Wright's F statistics F_{IS} and F_{ST}) can be calculated for every SNP using e.g. the program Stacks. For bi-allelic SNP markers, π is a measure of expected heterozygosity and therefore a useful overall measure of genetic diversity in a population (Catchen et al. 2013). F_{IS} measures the reduction in observed heterozygosity as compared to expected heterozygosity for an allele in a population, and positive values indicate nonrandom mating or cryptic population structure (Nei 1975, 1987; Nei and Kumar 2000; Hartl and Clark 2006; Holsinger and Weir 2009). STRUCTURE analyses may be used to investigate the number of populations present in the dataset.

Current and Past Effective Population Size: The effective population size (Ne) versus the census population size may be calculated. Supposing the presence of migration between populations, contemporary Ne may be estimated on the basis of linkage disequilibrium (LD) (Waples and England 2011). Provided the presence of historic shark samples from the same area, a combined approach of LDNe calculation and ddRAD sequencing might be used to integrate Ne estimates from the historic population and thus be able to provide precise population size estimates of the past versus current populations. A sufficiently large historic sample set from the same study area and the same time period is required to facilitate this last step.

Adaptive Traits: Molecular methods can inform about unique genetic adaptations. Identification of SNPs that appear to show signs of divergent selection between populations can be conducted using outlier scans. These will be carried out between all population pairs using a Bayesian approach with the program BAYESCAN (for a detailed methods description, see Foll and Gaggiotti 2008).

Protocol and Ex- and Import Permits
A protocol for tissue sample collection in the field will be provided by K. Fietz and P. Palsboll.
Permit issues have yet to be resolved. At this stage, K. Fietz and P. Palsboll do not hold import permits for the respective shark species.

8.1.4 Expected outcomes

Due to its observed high site fidelity and inshore life style *C. perezi* is expected to display considerable levels of isolation between sample localities. The proposed study will shed light on the degree of heterogeneity within the Dutch Caribbean populations of the species. Precise estimates of current and past effective population sizes will further provide detailed insight into the population development through time, and thereby facilitate estimations of the amount of anthropogenic impact this species has experienced. Outlier scans and the investigation of the underlying genes may provide indications on the factors driving adaptive divergence.

8.1.5 Integrative opportunities of genetics and additional research

Rather than being viewed as the sole, or a redundant tool, genetic studies should be considered complementary to other studies such as **satellite tagging** and **chemical fingerprinting**. A combination of the different methods can yield a very comprehensive picture of shark movements, connectivity patterns, and the degree of isolation, providing valuable baseline information for a shark conservation and management plan in the Dutch Caribbean. A combination of tagging and genetic studies for instance is valuable for addressing the differentiation between movement and real mixing (Do they breed while moving?), as well as for comparing present and past movements. Molecular analyses may for example detect multiple genetic stocks in the presence of adult movement throughout a region as demonstrated by tag/recaptures studies (Camhi et al. 2008).

An Ecosystem Approach for the Dutch Caribbean
In addition to a high-resolution population genetic study of a model study system, we propose the development of a long-term ecosystem approach to facilitate comprehensive assessment of shark stocks in the Dutch Caribbean and on a broader spatial scale. We suggest various research activities that may contribute to this assessment.

Development of a long-term Fisheries Monitoring and Biopsy Sampling System
Two particularly important conservation issues lie in the abundance of species of concern: i) species that are very common, but at the same time heavily exploited and/or their habitats are threatened (e.g. blue shark); and ii) species that are rare, might have only low effective population sizes, and are therefore vulnerable. Especially the latter are often understudied as data acquisition is difficult, but may be the most threatened ones. The development of a long-term fisheries monitoring and biopsy sampling system can provide the data necessary to investigate these two species groups of special management needs. In addition to collecting port and onboard samples in the already established monitoring system, we propose to assist in a) an expansion of the fisheries monitoring system in the Dutch Caribbean, and b) the development of a biopsy sampling system. Both will contribute substantial information on the amount and composition of elasmobranch bycatch in order to estimate whether direct and non-direct shark fisheries are sustainable. As mentioned above, fisheries-dependent as well as independent sampling schemes should be integrated, and representative areas should be chosen for fisheries-independent sampling to facilitate feasibility and to avoid bias. Regarding biopsy sampling, we suggest to investigate

opportunities to take advantage of the already in-use BRUVs. Possibilities may exist to install remote biopsy sampling devices on BRUVs that would greatly expand the amount of individuals and diversity of species sampled, while circumventing shark netting.

Installation of a Video Monitoring System of Fishing Vessels
Installation of a video monitoring system on fishing vessels complements tissue sampling and facilitates a) investigation whether random tissue samples taken from catches are representative, or if there is a bias towards e.g. exclusion of rare species; b) calculation of data biases collected from landed sharks (more precise information on species-specific catch versus landings data); and c) estimation of the reliability of interview data. This system may be particularly important for pelagic species (e.g. blue, thresher, silky, hammerhead sharks); these are more difficult to monitor due to their rare occurrence, though are in particular need of appropriate conservation measures due to their wide dispersal and exposition to international fishing fleets.

Mapping of Feeding Habits
It is possible to map the feeding habits of sharks caught in fisheries activities to yield information of prey composition and origin. This may be achieved by molecular stomach contents analyses to a) identify prey species, and to b) sample these same prey fish/cephalopod species on site. Possibilities then exist to assign prey to its source population and thereby acquire knowledge on shark spatial habitat use. The outcomes will be valuable on various scales: i) addressing the Dutch Caribbean at two dimensions (within the leeward and windward Dutch Caribbean islands, respectively, and between the two groups), and ii) on a more regional scale (historic and current Ne estimates).

8.2 Telemetric research

Telemetry is a sophisticated method to collect data at remote or inaccessible locations, using data storage (archival) tags or data transmitters to transfer data. Common wireless data transfer mechanisms are electromagnetic radiation (radio), acoustics (sound), satellite and GSM. Selection of the most appropriate telemetry method is determined by the research questions and species characteristics. Depending on the telemetry method, information is collected on shark populations, habitat use, dispersal, migration, connectivity between regions, nursery grounds and aggregations of individuals. The selection of a telemetry method depends on the biological, ecological and behavioural characteristics of the shark species e.g. the time it spends at the surface and the spatial distribution or home range of a species.
In this paragraph an overview and explanation of different telemetry methods is given, including the suitability of each method considering the research questions and characteristics of shark species.

Potential research objectives of tagging of sharks in the Dutch Caribbean are:

- Habitat use: how is a specific area used by shark species? Which area are used as nursery grounds by shark species?
- Distribution: what is the spatial arrangement of a shark species, whereby distribution patterns may change over time (seasonally)?
- Population structure: local populations or large mixing population?
- Dispersal: how do individual sharks move from the area of origin (birth grounds) to breeding grounds or from area of high population density?
- Migration: what are the long distance movement of individuals (usually seasonal)?
- Connectivity: how do subpopulations of shark species exchange e.g. between islands?

These research questions help to meet the first objective of a shark protection plan: to broaden the knowledge of shark species. This, in turn, provides information to meet the third objective: to ensure an adequate management framework is in place.

Table 12. Overview of telemetric research methods, the research objectives of each method, and the requirements of shark species to apply such method.

Telemetry method	**Research objectives**	**Species requirements**
1. Acoustic telemetry	Habitat use, spatial distribution and depth range	Medium to small home range (approx. <1.5km) Depending on arrays of detection stations and configuration.
2. Radio telemetry	Not applicable for shark species	Very shallow water (< 10 m depth)
3. Transponder (PIT) tag	Not applicable for shark species	Very short detection ranges (few meters)
4. Data storage/archival tag	Habitat use in terms of environmental parameters: e.g. temperature and depth, spatial tracks difficult	Either recapture or popup with satellite transmission
5. Satellite telemetry	Dispersal, migration, connectivity	Frequent intervals of time spend at surface
6. GSM telemetry	Connectivity between islands (with large blind spots or gaps)	Frequent intervals of time spend at surface

Of the telemetry methods listed in Table 12, three methods are not feasible for shark research: radio telemetry, transponder/pit tags and GSM telemetry. Radio telemetry is mainly used for terrestrial species and is not suitable for marine species as the radio signals travel well in air, but poorly in water and therefore is only applicable in shallow water of up to a few meter deep. Transponder or Passive Integrated Transponder (PIT) tags consist of an integrated antenna coil encased in glass (Roussel *et al.* 2000). A detection station detects its electromagnetic field. Detection range is very small (up to few meters). Moreover, since elasmobranch have the ability to sense electromagnetic fields, they may be well capable of detecting and avoiding detection stations, which is the main reason why PIT tags are not suitable for shark research, only as mark-recapture tags with hand held readers. GSM telemetry (Global System for Mobile communication) can be used in marine mammal research such as seals. It requires the marine mammal to frequently spend time at the surface within the range of a coastal GSM zone (up to about 20km from the coast). Within the Dutch Caribbean EEZ this is not feasible.

8.2.1 Acoustic telemetry

Acoustic telemetry employs acoustic transmitters, a small device emitting high frequency signals, which are detected by detection stations, consisting of an acoustic hydrophone and reciever. High frequency signals (69 kHz or higher) are above the threshold of audibility of fish and marine mammals. Acoustic telemetry is being used in shark research, for example to study habitat use of nurse sharks in Brazil (Ferreira, 2012) and movements of nurse sharks and Caribbean reef sharks in Belize (Chapman et al. 2005).

The tag (Figure 14 right) can be a simple pinger or can be equiped with a depth and/or temperature sensor. The transmission range is dependent of the battery strength, i.e. size of the tag, and can range from several hundred meters to more than one kilometer. The detection range also depends on the environmental conditions (turbulance and bubbles in the water), but is independent of current velocity. For long-term studies, it is best to surgically implant the tag in the abdominal cavity of sharks, which has the advantage that it is not lost and there is no fouling of organisms on the tag. The disadvantage is that it has to be deployed by an expert. The life span of the tag depends on battery type and size, power output, delay between code transmissions (duty cycle of pings per second, minute, hour, day, etc.) and

type of sensors included. This can be up to 10 years for the VEMCO V16 with 90 seconds delay and without sensors.
The detection station (Figure 14 left) can be deployed by divers by attaching it to the seafloor, with a subsurface float to ensure an upright positioning of the detection station somewhere in the water column. Battery life of the VR2W detection station is 15 months and data can be transferred via blue tooth. The resulting data set is simple to analyse, for example distribution over time and depth range over time. 3D analysis is possible to determine the track of a shark, using cross technique, provided that sufficient detection stations are present in a small area enabling triangulation.

The detection stations need to be place on a number of strategic points in the study area. A grid of detection stations within the study area depends on the number of sharks tagged. Since most likely not many sharks will be tagged, it is best to have a smaller grid with higher detection probability. A smaller grid is also favourable in case one station falls out. In the Brasil study (Ferreira, 2012) 25 stations were deployed in a 20x3km study area.
It is advised to deploy an externally placed tag, for ease of visual identification of tagged sharks, especially when they are caught outside the study area. Acoustic telemetry can also be combined with data storage tags.
The costs of acoustic telemetry are approximately €250-400 per transmitter (i.e. tag) depending on size of the transmitter and extra sensors, e.g. VEMCO V16 [http://vemco.com/] and €1200 for a detection station, e.g. VEMCO VR2W [http://vemco.com/].

Figure 14. Left: VEMCO VR2W-69 kHz acoustic receiver. Right: WEMCO V16 coded transmitter [http://vemco.com/]

8.2.2 Data storage tag

Data storage or archival tags record and store measurements of ambient light levels, depth and temperature at pre-programmed intervals, but do not record the position of the tagged individual. The only position known is the location where the individual is tagged and the location where the recorded data are retrieved (i.e. place of recapture or position of pop-up of the tag). However, there are methods to derive position data from ambient light levels recorded by the tag during deployment, although the spatial accuracy is not conducive for evaluating small-scale movements (Hammerschlag et al. 2011). Depth data also provide some information on the position. For example, if the depth of the individual is deeper than the depth range of the study area (e.g. the Saba Marine Park with the 60m depth contour line as boundary) its position is outside the study area. For ray species it is possible to analyse its

position if the tidal range of the study area is large enough, using depth information and the timing of the tidal period.
There are two ways of data retrieval. The first way is to recapture the tagged individual, which has as disadvantage that return rates are low, for sharks recapture rates for conventional tagging is usually less than 5%. The other way is to remotely transmit data from the tagged individual to a satellite or other receiver, e.g. by means of a pop-up archival tag (PAT tag) which is programmed to detach from the individual and float to the surface on a pre-programmed date or after a pre-programmed time.
The latest generation PAT tag collects data at 15 minute intervals during 4 months of deployment, at half hour intervals if deployment exceeds 4 month but less than 8 months, and every hour over 8 but less than 16 months of deployment. Prices range between €2700 and €3100 per tag[34].

8.2.3 Satellite telemetry

Satellite tagging and tracking provides the opportunity to measure home range, movements and habitat use of marine predators such as sharks (Weng et al. 2008). It records the position of a tagged individual, as well as the water temperature and depth at which it is swimming. The data reveal migratory routes and residency patterns, which can be used to identify which locations are used by sharks for mating, breeding and feeding and where sharks are vulnerable to fishing.
Satellite telemetry is a suitable method to record data from sharks which frequently spend time at the surface, such as whale sharks, basking sharks and great white sharks, as the signal of a satellite does not travel through water.
A review of satellite tagging studies by Hammerschlag et al. (2011) examined 48 studies between 1984 and 2010. Questions addressed included the purpose, location and method of shark satellite tagging studies and the kind of tags used and data provided. A total of 17 studies in the Atlantic Ocean involved species occurring in the Dutch Caribbean: 8 of them studied basking sharks (Gore et al., 2008; Priede 1984; Priede and Miller 2009; Shepard et al., 2006; Sims et al., 2003; Sims et al., 2006; Skomal et al., 2004; Skomal et al., 2009); 3 of them studied bull sharks in the Bahamas and the coastal waters of the US and the Gulf of Mexico (Brunnschweiler et al., 2010; Brunnschweiler and Van Buskirk, 2006; Carlson et al., 2010); 2 of them studied whale sharks in Honduras and Belize (Gifford et al., 2007; Graham et al., 2006) and the remaining studies concerned Caribbean reef shark in Belize (Campana et al. 2009a), blue shark bycatch in the Canadian Atlantic fisheries (Campana et al. 2009b), a shortfin mako off the coast of the US (Loefer et al. 2005) and a big-eye thresher shark in the Gulf of Mexico (Weng and Block 2004).
Methods used in the above studies included pop-up archival tags (PAT tags) and satellite-linked transmitters (SAT tags). PAT tags record and store measurements of ambient light levels, depth and temperature at pre-programmed intervals. These tags are the same as the data storage tags discussed in the previous chapter and only transmit stored data to satellites upon detachment. SAT tags have only been used in two of the above studies, on basking sharks (Priede 1984; Priede and Miller 2009) and on whale sharks (Gifford et al., 2007). SAT tags, the majority of which are SPOT tags (smart position or temperature transmitting tags), transmit data whenever the tag reaches the surface. The main advantage of SAT tags is the more accurate, near-real time position data. The disadvantage of SAT tags is that the tag needs to surface for prolonged periods to allow for successive transmissions for obtaining accurate position data, which makes shark species which rarely surface less suitable candidates for SPOT tag deployment (Hammerschlag et al., 2011). Another difference between SAT and PAT tags is that PAT tags can be applied easily from a boat using a tagging lance, while SPOT tags need to be mounted to the shark's dorsal fin (see Weng et al., 2005) which often requires catching and temporarily removing the shark from the water (Hammerschlag et al., 2011).

---

34 http://www.microwavetelemetry.com

A new satellite tracking technology, called “fast-GPS” tags, provide the ability to achieve accurate GPS locations while the tag only needs to be above the surface for less than one second[35]. Recent applications of this method are with a whale shark[36] and a shortfin mako[37].
Other recent research in the Wider Caribbean applies satellite tagging of tiger sharks: R.J. Dunlap Marine Conservation Program of the University of Miami[38] using SPOT tags on tigers sharks in the Bahamas and Florida (Hammerschlag et al., 2012b); and Guy Harvey Research Institute of the Nova Southeastern University in Florida using two types of satellite tags in combination with acoustic tags in the Bahamas, Bermuda, Cayman and US Virgin Islands[39]. They both collaborate with the Bimini Biological Field station at the Bahamas, which also conducts telemetric and genetic research on lemon sharks[40].

8.2.4 Tag and release

Tag and release is a conventional tagging method used to study the life history, migrations and movements and population structure of sharks by tagging, releasing and recapturing individuals. Unlike telemetry, which is a sophisticated method to collect data at remote or inaccessible locations using data storage or data transmitters, conventional tags can be identified visually without the use of special detection equipment. It is mentioned here, because it has long been recognized as a valuable means to collect data and because numerous cooperative shark tagging programs exist worldwide. Cooperative programs depend on the joint participation of scientists and public volunteers to accomplish research objectives (Kohler and Turner, 2001). One such example is the shark tagging program of the starry smooth-hound shark (*Mustelus asterias*) and some other species of sharks and rays in the Netherlands, which was initiated by the Dutch Angler association in cooperation with IMARES and NGO ‘Stichting de Noordzee’. It aims to collect biological data, and to raise awareness on the status of sharks and rays (Winter and Van Overzee, 2013).

In a review of 64 conventional shark tagging studies by Kohler and Turner (2001), benefits and problems of conventional tagging are discussed. The cost/benefit ratio for cooperative tagging programs is extremely low and for an individual institution it is impossible to mark and recapture large quantities of sharks over extensive areas, which requires thousands of knowledgeable volunteer recreational and commercial fishermen. As a result the costs of a tagging study are mainly limited to the costs of the tags and the managing institution. Nowadays many anglers only practice catch and release, and tagging is a socially acceptable component to recreational fishing (van der Elst 1990 in Kohler and Turner 2001). The recapture of sharks often happens opportunistically by recreational and commercial fishermen. More than half of the reviewed studies reported a recapture rate of less than 5%. This is mainly due to fishing pressure (e.g. chance that individuals are caught by fishing and not released nor reported back) and in addition natural mortality, tagging induced mortality, immigration from and emigration to a non-tagging area, tag loss, and experience level of the fishermen in species identification and recording data. Recapture rate only provides information on the size of the population if it is a closed system without migration and with a known dwelling time (E. Winter, pers. comm.) A recapture rate of 10% or more is usually an indication of small areas being used or high fishing pressure (E. Winter, pers. comm.).
When choosing tags with clearly visible numbers or letters, sharks with tags might also be visually ‘recaptured’ by scuba divers, e.g. easy to approach species such as nurse sharks. This method is applied

---

35 www.wildlifecomputers.com
36 http://swfsc.noaa.gov/textblock.aspx?Division=FRD&id=16327
37 http://www.livescience.com/26067-mako-shark-migration.html
38 http://rjd.miami.edu/research/projects/gps-for-sharks
39 http://www.nova.edu/ocean/ghri/tiger-sharks/index.html
40 http://www6.miami.edu/sharklab/research_telemetry.html

with a small number of nurse sharks and reef sharks in the waters around St. Maarten (T. Bervoets, pers. comm.).

8.2.5 Proposed telemetric research

Conventional tag, release and recapture research is a valuable means to collect biological data, but given low recapture rates it requires the cooperation of thousands of volunteer recreational and commercial fishermen to collect data. Although this creates awareness amongst all those volunteers at the same time, it might be difficult to implement at such scale in the Dutch Caribbean EEZ alone.
Telemetric research is a promising research method to broaden our knowledge of shark species occurrence in the Dutch Caribbean. It can answer research questions about distribution, habitat use, aggregation and nursery area, dispersal and migration.

Of the six existing telemetric methods (Table 12), three methods are appropriate for shark research, depending on the research question which need to be answered and the life history characteristics of the shark species: acoustic telemetry, satellite telemetry and archival pop-up tags. The method chosen should deliver data independent if the individual is recaptured or not. It is best to combine each method with a conventional tag, for external identification purpose if a tagged individual is caught outside the boundaries of the study area or by people not involved in the research.

Acoustic telemetry qualifies as research method for species with a medium to small home range such as nurse sharks and Caribbean reef sharks, as the acoustic signal transmits over a shorter distance. Satellite telemetry qualifies as research method for highly migratory species with regular surface intervals such as whale sharks, basking sharks and tiger sharks, as the tag only transmits stored data to the satellite at the surface. Archival pop-up tags has the advantage that it covers a larger area than acoustic telemetry, which makes it suitable for highly migratory species. The disadvantage is it does not record locations, and therefore is less suitable to study habitat use, distribution, dispersal and migration patterns. Data storage tags give good insight in how sharks use environmental conditions and whether there are clear day-night patterns in habitat use, but the disadvantage is that it does not record locations, and therefore is less suitable to study spatial patterns. Sometimes the data allows spatial patterns to be reconstructed up to a certain level, using e.g. depth, day-light length and timing, place of introduction and recapture.

A consideration in the selection of a telemetric research method and species is the size of the study area (a potential shark sanctuary in the Dutch Caribbean EEZ) compared to the habitat use and home range of the species. A highly migratory species is less likely to be protected by the shark sanctuary and the chance to capture and tag an individual in the shark sanctuary is low. For a species with a smaller home range it is more likely that the collected telemetry data actually result in information which broadens the knowledge of that species. In addition, it is more likely that the shark sanctuary provides protection to species with a smaller home range. So a network with acoustic detection stations and probable more local shark populations (e.g. carribean reef shark, nurse sharks) appear most feasible to yield valuable data in relation to issues concerning installing sanctuaries. Perhaps in combination with other techniques.

9 Conclusions and recommendations

Shark populations have steeply declined worldwide due to unsustainable overexploitation by man and in this the Caribbean region is no exception (Bascompte et al. 2005). In response to this awareness, many initiatives are now ongoing to protect the most threatened species, including major regional restrictions on the cruel practice of finning sharks. Sharks play an important ecological role in tropical marine ecosystems and represent an impressive economic potential in the context of ecotourism. As the Netherlands has traditionally shown strong international leadership and commitment in biodiversity protection, a key ambition of the new Dutch Caribbean Nature Policy Plan 2013-2017, developed jointly with the islands in the Dutch Caribbean, is the effective implementation of shark protection in its kingdom waters.

This report provides the necessary review and background on which to base such an endeavour. Our updated review establishes that the Dutch Caribbean possesses a rich and diverse, though for the most part strongly depleted, shark fauna which urgently need more extensive protection. For many of the species found in the Dutch Caribbean, the Kingdom even carries treaty obligations.

Throughout the world, sharks are playing an increasingly important role in island economies as an important natural attraction for eco-based recreation and tourism. A recent study has shown that a single shark can represent an average touristic resource value of US$ 2.64 million. Consequently, shark protection is taking flight around the world as well, including the Caribbean. In the last 3 years the region has seen the implementation of shark NPOAs in the Bahamas, Honduras and Venezuela.

The Dutch Caribbean also possesses major shark economic potential, and based on this two Dutch Caribbean islands have already implemented forms of legal protection for sharks. Because the most destructive industrial-scale fishery practices (shark fishery, shark finning, long-lining and gillnetting) have never been important in the Dutch Caribbean, the development and effective implementation of a shark NPOA is much simpler than in most situations. Scientific information-needs for detailed management of complicated fisheries is also less, and holistic approaches to shark management are proving to be especially feasible. Center and foremost among these worldwide is the use of sanctuaries as the main conservation tool. The survey conducted among key island stakeholders as part of this study demonstrates wide support for shark protection and management, with 94% of the non-diving residents, 100% of the diving residents and half of the fishermen being in favour of shark protection and management of bycatch. The overall feasibility for successful shark conservation is high due to a number of factors as listed in chapter 7.

We therefore propose the establishment of a shark sanctuary as the main cornerstone to a NPOA Sharks for the Dutch Caribbean. This report outlines the ecological arguments for the establishment of a shark NPOA and sanctuary(ies) in chapter 4, as well as the typical issues that need to be addressed in chapter 7. Legal designation of a shark sanctuary would form the first and most important step which provides the framework for all broader (international cooperation) and in depth (knowledge and conservation development) initiatives. Once a sanctuary is established, the fuller implementation of a shark NPOA should be seen as a gradual process, involving development of knowledge, policy, rules and regulations, public and stakeholder participation. In this, the Netherlands would follow and importantly reinforce the efforts of other nations who have already established NPOAs based on shark sanctuaries within the region.

New and remarkable values of the Dutch Caribbean with respect to sharks include apparently healthy deepwater shark populations around the ABC islands (as apparent from submarine explorations down to depths of 900 m) and the recent detection of a second Dutch Caribbean record for the globally endangered basking shark. New findings for this species suggest they use deep tropical waters (such as possibly those of the Dutch Caribbean) as wintering grounds. The most promising area for establishment of a shark sanctuary is the little-fished Saba Bank as this area of unique biodiversity has the best shark population status (Toller et al. 2009; Van Beek et al. 2012), has recently already acquired national protected status and an active management structure, as well as international status as a PSSA and an IMO anchoring prohibition. Furthermore, a shark sanctuary in this area could importantly reinforce governments plans to locate the first (part) of a Dutch Caribbean Marine Mammal Sanctuary in the Northern EEZ waters including the Saba Bank. The shark population present presents unique research opportunities that could also generate considerable economic spin-off for the islands in terms of scientific research and knowledge development.

We conclude with three key recommendations:

- Develop a simple and holistic shark NPOA based importantly on the use of one (or more) shark sanctuaries
- Set up a shark research program combining on the one hand low tech opportunistic approaches (allowing participation of stakeholder groups for awareness and community support) and on the other hand using high tech approaches (genetic, telemetry, video-monitoring) to allow thorough insights even though abundance may be low
- Start actively participating in regional shark conservation and ecosystem initiatives and seek active collaboration with sister sanctuaries of the region (Venezuela, Honduras, Bahamas)

10 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

11 References

Alava, M. 2002. Conservation and Management of Whale Sharks in the Philippines. In: *Shark Conference 2002*: Sustainable Utilization and Conservation of Sharks, Taipei, Taiwan, May 13-16, 2002.

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

Andrews, K. S., Williams, G.D., Levin, P. S. 2010. Seasonal and Ontogenetic Changes in Movement Patterns of Sixgill Sharks. PLoS ONE 5(9): e12549.

Arias-Gonzalez, J.E., C. Gonzalez-Gandara, et al. (2011) Predicted impact of the invasive lionfish Pterois volitans on the food web of a Caribbean coral reef. *Environmental Research*, 111(7), 917-925.

Arocha, F., Arocha, O. & Marcano, L. (2002). Observed shark bycatch from the Venezuelan tuna and swordfish fishery from 1994 through 2000. *ICCAT Collective Volume of Scientific Papers* **54,** 1123–1131.

Balon, E. K. (1975). Reproductive guilds of fishes: a proposal and definition. *Journal of Fisheries Research Board of Canada* 32: 821-864.

Barnett, A., J. M. Braccini J.M., Awruch, C.A. and Ebert, D. A. 2012. An overview on the role of Hexanchiformes in marine ecosystems: biology, ecology and conservation status of a primitive order of modern sharks. Journal of Fish Biology 80, 966–990.

Bascompte, J. Melian, C.J., and Sala, E. 2005. Interaction strength combinations and the overfishing of a marine food web. PNAS 102: 5443–5447.

Baum, J. K., and Myers, R. A. (2004). Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. Ecology Letters 7, 135–145.

Baum, J., Medina, E., Musick, J.A. & Smale, M. 2006. Carcharhinus longimanus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>.

Bernal D., Sepulveda C, Graham J.B., Water-tunnel studies of heat balance in swimming mako sharks, The Journal of Experimental Biology 204, 4043–4054 (2001)

Berry DS, Tietze U, Draft 2012. CRFM Consultancy Report on Review of Existing Policy, Legal and Institutional Arrangements and Investments for Governance and Management of Large Pelagic Fisheries in the Caribbean Large Marine Ecosystem.

Bethea, D.M., Hale L., Carlson J.K., Cortes E., Manire C.A., Gelsleichter J.. 2007. Geographic and ontogenetic variation in the diet and daily ration of the bonnethead shark, Sphyrna tiburo, from the eastern Gulf of Mexico. Mar Biol (2007) 152:1009–1020.

Boeke, J. (1907). Rapport betreffende een voorlopig onderzoek naar den toestand van de visscherij en de industrie van zeeproducten in de kolonie Curaçao, ingevolge het Ministerieel Besluit d.d. 22 november 1904, pp. 201 pp. Den Haag: Belinfante.

Bond, M.E., Elizabeth A. Babcock, Ellen K. Pikitch, Debra L. Abercrombie, Norlan F. Lamb, Demian D. Chapman 2012. Reef Sharks Exhibit Site-Fidelity and Higher Relative Abundance in Marine Reserves on the Mesoamerican Barrier Reef. PloS ONE, March 2012 | Volume 7 | Issue 3 | e32983. 14 pp.

Bonfil R (1997) Status of shark resources in the Southern Gulf of Mexico and Caribbean: implications for management. Fish Res 29:101–117

Brooks, E.J., K.A. Sloman, et al. (2011) Validating the use of baited remote underwater video surveys for assessing the diversity, distribution and abundance of sharks in the Bahamas. . Endangered species res, 13, 231-243.

Brunnschweiler, J. M. and Van Buskirk, J. (2006). Satellite tagging of bull sharks at Walker's Cay in the Bahamas. *Bahamas National Journal of Science*, 30-34.

Brunnschweiler, J. M., Queiroz, N. and Sims, D. W. (2010). Oceans apart? Short-term movements and behaviour of adult bull sharks Carcharhinus leucas in Atlantic and Pacific Oceans determined from pop-off satellite archival tagging. *Journal of Fish Biology* 77, 1343-1358.

Burgess, H. G. & Branstetter, S. 2009. *Carcharhinus limbatus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 26 September 2013.

Cailliet, G.M., Cavanagh, R.D., Kulka, D.W., Stevens, J.D., Soldo, A., Clo, S., Macias, D., Baum, J., Kohin, S., Duarte, A., Holtzhausen, J.A., Acuña, E., Amorim, A. & Domingo, A. 2009. Isurus oxyrinchus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>

Camhi MD, Pikitch EK, Babcock EA. 2008. Sharks of the open ocean: Biology, Fisheries and Conservation. Blackwell Publishing.

Camhi, M. D., Valenti, S. V., Fordham, S. V., Fowler, S. L. and Gibson, C. (2009). The conservation status of pelagic sharks and rays: Report of the IUCN Shark Specialist Group pelagic shark Red List workshop. Newbury, UK: IUCN Species Survival Commission Shark Specialist Group.

Campana, S. E., Joyce, W., Francis, M. P. and Manning, M. J. (2009a). Comparability of blue shark mortality estimates for the Atlantic and Pacific longline fisheries. *Marine Ecology Progress Series* 396, 161-164.

Campana, S. E., Joyce, W. and Manning, M. J. (2009b). Bycatch and discard mortality in commercially caught blue sharks Prionace glauca assessed using archival satellite pop-up tags. *Marine Ecology Progress Series* 387, 241-253.

Cardenas-Torres, N. Enrıquez-Andrade, R., Rodrıguez-Dowdell, N. 2007. Community-based management through ecotourism in Bahia de los Angeles, Mexico. Fisheries Research 84: 114–118.

Carlson, J. K., Ribera, M. M., Conrath, C. L., Heupel, M. R. and Burgess, G. H. (2010). Habitat use and movement patterns of bull sharks Carcharhinus leucas determined using pop-up satellite archival tags. *Journal of Fish Biology* 77, 661-675.

Carlson J. K., L. F. Hale, A. Morgan and G. Burgess. 2012. Relative abundance and size of coastal sharks derived from commercial shark longline catch and effort data. Journal of Fish Biology 80, 1749–1764.

Carlson, J., Wiley, T. & Smith, K. 2013. Pristis pectinata. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>.

Carmabi, 1974. Jaarverslag 1974 (annual report 1973). Carmabi, Curacao, 47 pp.

Carrier, J.C and Harold L. Pratt. 1998. Habitat management and closure of a nurse shark breeding and nursery ground. Fisheries Research 39: 209-213.

Carwardine, M., Watterson, K., 2002. The Shark Watcher's Handbook. BBC

Castro, J.I. 2000. The biology of the nurse shark, *Ginglymostoma cirratum*, off the Florida east coast and the Bahama Islands. *Environmental Biology of Fishes* **58:** 1–22.

Catchen J, Hohenlohe PA, Bassham S, Amores A, Cresko WA. 2013. Stacks: an analysis tool set for population genomics. Molecular Ecology.

Chan A Shing, C. 1999. Shark fisheries in the Caribbean: the status of their management including issues of concern in Trinidad and Tobago, Guyana and Dominica. Pp. 149–173 in R. Shotton, ed. Case studies of the management of elasmobranch fisheries. *FAO Fisheries Technical Paper* No. 378, Part 1. FAO, Rome, Italy.

Chapman DD, Pikitch EK, Babcock E, Shivji MS 2005. Marine reserve design and evaluation using automated acoustic telemetry: a case study involving coral reef associated sharks in the Mesoamerican Caribbean. Mar Technol Soc J 39:42–55

Chapman, D.D.F., E.K. Pikitch, et al. (2006) Marine parks need sharks? *Science*, 312(5773), 526-527.

Chapman, D.D., Pikitch, E.K., Babcock, E.A., Shivji, M.S. 2007. Deep-diving and diel changes in vertical habitat use by Caribbean reef sharks *Carcharhinus perezi*. Mar. Ecol. Progr. Ser. 344: 271–275.

Choy B.K. and Adams D.H. 1995. An observation of a basking shark, Cetorhinus maximus, feeding along a thermal front off the east central coast of Florida. Florida Scientist 58, 313–319. (Florida)

Cisneros-Montemayor, A. M., Barnes-Mauthe, M., Al-Abdulrazzak, D., Navarro-Holm, E. and Sumaila, U. R. (2013). Global economic value of shark ecotourism: implications for conservation. *Oryx* 47, 381-388.

Clarke, J. S. E. Lea, and R. F. G. Ormond. 2011. Reef-use and residency patterns of a baited population of silky sharks, Carcharhinus falciformis, in the Red Sea. Marine and Freshwater Research 62: 668–675.

Claro, R. and L.R. Parenti, 2001. The marine ichthyofauna of Cuba. p. 21-57. In Claro, R., K.C. Lindeman and L.R. Parenti (eds) Ecology of the marine fishes of Cuba. Smithsonian Institution Press, Wahsington and London. 253p. (Cuba)

Cliff, G. Dudley, S.F.J., Ryan, P.G. and Singleton, N. 2002. Large sharks and plastic debris in KwaZulu-Natal, South Africa. Mar. Freshwater Res. 53: 575–581.

Clua, E., Buray, N., Legendre P, Mourier, J., Planes, S. 2011. Business partner or simple catch? The economic value of the sicklefin lemon shark in French Polynesia. *Marine and Freshwater Research*, 2011, **62**, 764–770.

Coelho, R., Joana Fernandez-Carvalho, Sérgio Amorim and Miguel N. Santos. 2011. Age and growth of the smooth hammerhead shark, Sphyrna zygaena, in the Eastern Equatorial Atlantic Ocean, using vertebral sections. Aquat. Living Resour. 24, 351–357.

Compagno L.J.V., 1984, Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. Rome, FAO.

Cortés E, Manire CA, Hueter RE (1996) Diet, feeding habits and diel feeding chronology of the bonnethead shark, Sphyrna tiburo, in southwest Florida. Bull Mar Sci 58:353–367.

Cortés E, Parsons GR (1996) Comparative demography of two populations of the bonnethead shark (Sphyrna tiburo). Can J Fish Aquat Sci 53:709–718.

Cortés, E. 2002. CATCHES AND CATCH RATES OF PELAGIC SHARKS FROM THE NORTHWESTERN ATLANTIC, GULF OF MEXICO, AND CARIBBEAN. Col. Vol. Sci. Pap. 54(4) 1164-1181.

Cortés, E. 2005. Sphyrna tiburo. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 20 November 2013.

Cortés, E., Freddy Arocha, Lawrence Beerkircher, Felipe Carvalho, Andrés Domingo, Michelle Heupel, Hannes Holtzhausen, Miguel N. Santos, Marta Ribera and Colin Simpfendorfer. 2010. Ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. Aquat. Living Resour. 23, 25–34.

Daly-Engel TS, Seraphin KD, Holland KN, Coffey JP, Nance HA, et al. (2012) Global Phylogeography with Mixed-Marker Analysis Reveals Male-Mediated Dispersal in the Endangered Scalloped Hammerhead Shark (Sphyrna lewini). PLoS ONE 7(1): e29986. doi:10.1371/journal.pone.0029986

Davis, B. and Worm, B. 2013. The International Plan of Action for Sharks: How does national implementation measure up? Marine Policy 38: 312–320.

Debrot, A. O. and Barros, N. B. (1992). Notes on a Gervais' beaked whale, *Mesoplodon europaeus*, and a dwarf sperm whale, *Kogia simus*, stranded in Curaçao, Netherlands Antilles. *Marine Mammal Science* 8, 172-178.

Debrot, A. O. and Barros, N. B. (1994). Additional cetacean records for the leeward Dutch Antilles. *Marine Mammal Science* 10, 359-368.

Debrot, A. O. and Sybesma, J. (2000). The Dutch Antilles, Chapter 38. In *Seas at the Millennium: an Environmental Evaluation, Vol. I Regional Chapters: Europe, The Americas and West Africa*, (ed. C. R. C. Sheppard), pp. 595-614. Amsterdam: Elsevier.

Debrot, A. O., R. de Leon, N. Esteban and H.G.W. Meesters (in press) Observations on the whale shark *(Rhincodon typus)* in the Dutch Caribbean.

DEH (Australia Department of the Environment and Heritage) 2003. Whale Shark (*Rhincodon typus*). *Recovery Plan-Issues Paper*. Threatened Species Scientific Committee, Australia. 1:26.

Denham, J., Stevens, J., Simpfendorfer, C.A., Heupel, M.R., Cliff, G., Morgan, A., Graham, R., Ducrocq, M., Dulvy, N.D, Seisay, M., Asber, M., Valenti, S.V., Litvinov, F., Martins, P., Lemine Ould Sidi, M. & Tous, P. and Bucal, D. 2007. Sphyrna mokarran. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 20 November 2013.

Dilrosun, F. (2000) Monitoring the Saba Bank Fishery. Environmental Section Department of Public Health and Environmental Hygiene, Curacao, Netherlands Antilles.

Dulvy, N.K. and J.D. Reynolds, 1997. Evolutionary transitions among egg-laying, live-bearing and maternal inputs in sharks and rays. Proc. R. Soc. Lond., Ser. B: Biol. Sci. 264:1309-1315

Duncan KM, Martin AP, Bowen BW. 2006. Global phylogeography of the scalloped hammerhead shark (Sphyrna lewini). Molecular Ecology 15.

Ebert, DA, Fowler S, Dando M, Compagno L. 2013. Sharks of the world: a fully illustrated guide.

Ellis, J.K. & Musick, J.A. (2007). Ontogenetic changes in the diet of the sandbar shark, Carcharhinus plumbeus, in lower Chesapeake Bay and Virginia (USA) coastal waters. Environiron. Biol. Fish., 80, 51–60.

Fanning, L., Mahon, R., and McConney, P. 2011. Towards marine ecosystem-based management in the wider Caribbean. MARE Publication Series No. 6, Amsterdam Univ. press. 425 pp.

FAO WECAFC 2009. Report of the thirteenth session of the Commission and of the tenth session of the Committee for the Development and Management of Fisheries in the Lesser Antilles: Cartagena de Indias, Colombia, 21-24 October 2008. 78 pp.

FAO. (1999). International Plan of Action for the Conservation and Management of Sharks. Rome: Food and Agriculture Organization.

Feldheim, K. A. , S.H. Gruber, M.V. Ashley. 2010. Population genetic structure of the lemon shark (Negaprion brevirostris) in the western Atlantic: DNA microsatellite variation. Molecular Ecology 10: 295–303.

Feldheim, K.A., Gruber, S.H. & Ashley, M.V. 2002. The breeding biology of lemon sharks at a tropical nursery lagoon. Proc. R. Soc. Lond. B 269: 1655–1661.

Fernandez-Carvalho, J., Rui Coelho, Karim Erzini and Miguel Neves Santos. 2001. Age and growth of the bigeye thresher shark, Alopias superciliosus, from the pelagic longline fisheries in the tropical northeastern Atlantic Ocean, determined by vertebral band counts. Aquat. Living Resour. 24, 359–368.

Ferretti, F., Bori Worm, Gregory L. Britten, Michael R. Heithaus and Heike K. Lotze. 2010. Patterns and ecosystem consequences of shark declines in the ocean. Ecology Letters 13: 1055–1071.

Ferretti, F., Myers, R.A., Serena, F. & Lotze, H.K. (2008). Loss of large predatory sharks from the Mediterranean Sea. Conserv. Biol., 22, 952–964.

Field, I.C, Meekan, M.G., Buckworth, R.C. Bradshaw, C.J.A. 2009. Susceptibility of Sharks, Rays and Chimaeras to Global Extinction. Advances in Marine Biology, 56, 275-363.

Fietz, K. (2013) Proposal for genetic research component to complement the IMARES beschermingsplan haaien in Caribisch Nederland 2013-2017. MarECon working group, CEES, Rijksuniversiteit Groningen (Prof. Dr. P.J. Palsbøll and PhD candidate Katharina Fietz)

FLMNH 2013a. http://www.flmnh.ufl.edu/fish/Gallery/Descript/OceanicWT/OceanicWT.html

FLMNH 2013b. http://www.flmnh.ufl.edu/fish/Gallery/Descript/stsawfish/stsawfish.html

FLMNH 2013c. http://www.flmnh.ufl.edu/fish/Gallery/Descript/shortfinmako/shortfinmako.html

FLMNH 2013d. http://www.flmnh.ufl.edu/fish/Gallery/Descript/blueshark/blueshark.html

Foll M, Gaggiotti O. 2008. A genome-scan method to identify selected loci appropriate for both dominant and codominant markers: a Bayesian perspective. Genetics.

Fowler, S. L., Cavanagh, R. D., Camhi, M., Burgess, G. H., Cailliet, G. M., Fordham, S. V., Simpfendorfer, C. A. and Musick, J. A. (2005). Sharks, rays and chimaeras: The status of the Chondrichthyan fishes. Status survey. Gland Switzerland and Cambridge UK: IUCN Shark Specialist Group.

Froeschke, J.T., Bridgette F. Froeschke, and Charlotte M. Stinson. 2013. Long-term trends of bull shark (Carcharhinus leucas) in estuarine waters of Texas, USA. Can. J. Fish. Aquat. Sci. 70: 13–21.

Froeschke, J.T., Stunz, G.W., and Wildhaber, M.W. 2010. Environmental influences on the occurrence of coastal sharks in estuarine waters. Mar. Ecol. Prog. Ser. 407: 279–292

Froese, R. and Pauly, D. (2011). Fishbase: World Wide Web electronic publication.

Gallagher, A. J. and Hammerschlag, N. 2011. Global shark currency: the distribution, frequency, and economic value of shark ecotourism, Current Issues in Tourism, 14: 797-812

Gallagher, A. J. and Hammerschlag, N. (2011). Global shark currency: the distribution, frequency, and economic value of shark ecotourism. *Current Issues in Tourism* 14, 797-812.

Garla RC, Chapman DD, Shivji MS, Wetherbee BM, Amorim AF (2006b) Habitat of juvenile Caribbean reef sharks, *Carcharhinus perezi*, at two oceanic insular marine protected areas in the southwestern Atlantic Ocean: Fernando de Noronha Archipelago and Atol das Rocas,Brazil. Fish Res 81:236–247.

Garla RC, Chapman DD, Wetherbee BM, Shivji MS (2006a) Movement patterns of young Caribbean reef sharks, *Carcharhinus perezi*, at Fernando de Noronha Archipelago, Brazil: the potential of marine protected areas for conservationof a nursery ground. Mar Biol 149:189–199

Geelhoed SCV, N Janinhoff, JP Verdaat, RSA van Bemmelen and M Scheidat (2014) Aerial surveys of marine mammals and other fauna around Aruba, Curaçao and Bonaire, November 2013. Vol. C012/14. IMARES Wageningen UR

Geelhoed SCV, N Janinhoff, JP Verdaat (submitted) First visual record of Basking shark *Cetorhinus maximus* around the Dutch Leeward Islands in the Caribbean Sea. Marine Biodiversity Records.

Gifford, A., Compagno, L. J. V., Levine, M. and Antoniou, A. (2007). Satellite tracking of whale sharks using tethered tags. *Fisheries Research* 84, 17-24.

Gore, M. A., Rowat, D., Hall, J., Gell, F. R. and Ormond, R. F. (2008). Transatlantic migration and deep mid-ocean diving by basking shark. *Biology Letters* 4, 395-398.

Graham, R. T., Roberts, C. M. and Smart, J. C. R. (2006). Diving behaviour of whale sharks in relation to a predictable food pulse. *Journal of the Royal Society Interface 3* 6, 109-116.

Grogan, E.D. & Lund, R. (2004). The Origin and relationships of early chondrichthyes. In: Biology of Sharks and Their Relatives (eds Carrier, J.C., Musick, J.A. & Heithaus, M.R.). CRC press, Boca Raton, FL, pp. 3–31.

Gruber S.H., Compagno L.J.V., 1981, Taxonomic status and biology of the bigeye thresher Alopias superciliosus. US Fish. Bull. 79, 617–40.

Hall N. G., C. Bartron, W. T. White, Dharmadi and I. C. Potter. 2012. Biology of the silky shark Carcharhinus falciformis (Carcharhinidae) in the eastern Indian Ocean, including an approach to estimating age when timing of parturition is not well defined. Journal of Fish Biology 80: 1320–1341.

Hammerschlag N, Luo J, Irschick DJ, Ault JS (2012a) A Comparison of Spatial and Movement Patterns between Sympatric Predators: Bull Sharks (Carcharhinus leucas) and Atlantic Tarpon (Megalops atlanticus). PLoS ONE 7(9): e45958. doi:10.1371/journal.pone.0045958

Hammerschlag, N., Gallagher, A. J. and Lazarre, D. M. (2011). A review of shark satellite tagging studies. *Journal of Experimental Marine Biology and Ecology* 398, 1-8.

Hammerschlag, N., Gallagher, A. J., Wester, J., Luo, J. G. and Ault, J. S. (2012b). Don't bite the hand that feeds: assessing ecological impacts of provisioning ecotourism on an apex marine predator. *Functional Ecology* 26, 567-576.

Hartl DL, Clark AG. 2006. Principles of Population Genetics, 4th edn. Sinauer Associates, Sunderland, Massachusetts.

Hayes, C.G., Y. Jiao and E. Cortes. 2009. Stock Assessment of Scalloped Hammerheads in the Western North Atlantic Ocean and Gulf of Mexico. North American Journal of Fisheries Management 29:1406–1417.

Hazin, F., Alessandra Fischer & Matt Broadhursta. 2001. Aspects of reproductive biology of the scalloped hammerhead shark, Sphyrna lewini, off northeastern Brazil. Environmental Biology of Fishes 61: 151–159.

Heessen, H. J. L. (2010). State of the Art - Haaien en roggen in de Noordzee, vol. C011/10: IMARES Wageningen UR.

Heithaus MR, Burkholder D, Hueter RE, Heithaus LI, Pratt HL, Carrier JC (2007a) Spatial and temporal variation in shark communities of the lower Florida Keys and evidence for historical population declines. Can J Fish Aquat Sci. 64:1302–1313

Heithaus, M.R., Frid, A., Wirsing, A.J., Dill, L.M., Fourqueran, J.W., Burkholder, D., et al. (2007b). State-dependent risk-taking by green sea turtles mediates top-down effects of tiger shark intimidation in a marine ecosystem. J. Anim. Ecol., 76, 837–844.

Heithaus, M. R., Dill, L. M., Marshall, G.J., Buhleier, B.. 2002. Habitat use and foraging behaviour of tiger sharks in a seagrass ecosystem. Mar. Biol. 140: 237-248.

Henningsen, AD. 2000. Notes on reproduction in the southern stingray, *Dasyatis americana* (Chondrichthyes: Dasyatidae), in a captive environment. Copeia 2000(3):826-828.

Heupel, M. R. and C. A. Simpfendorfer. 2002. Estimation of mortality of juvenile blacktip sharks, *Carcharhinus limbatus*, within a nursery area using telemetry data. *Can. J. Fish. Aquat. Sci.* 59:624-632.

Heyman, W. D., R. T. Graham, B. Kjerfve and R. E. Johannes. 2001.Whale sharks *Rhincodon typus* aggregate to feed on fish spawn in Belize. *Mar. Ecol Prog. Ser.* 215: 275–282.

Hoelzel, A.R., Shivji, M.S., Magnussen, J., and Francis, M.P. (2006). Low worldwide genetic diversity in the basking shark (Cetorhinus maximus). Biol. Lett. 2, 639–642.

Hoffmayer, E. R. and G. R. Parsons. 2003. Food habits of three shark species from the Mississippi sound in the Northern Gulf of Mexico. Southeastern Naturalist: 271-280.

Hoffmayer, E.R., Driggers III, W.B., Franks, J.S., Hanisko, D.S., Roffer, M.A. and Cavitt, L.E. 2011. Recent occurrences of basking sharks, Cetorhinus maximus (Chondrichthyes: Cetorhinidae), in the Gulf of Mexico. Marine Biodiversity Records 4: 4 pp, doi:10.1017/S1755267211000844; Vol. 4; e87.

Holsinger KE, Weir BS. 2009. Genetics in geographically structured populations: defining, estimating and interpreting Fst. Nature Reviews Genetics.

Jennings, D.E. & Samuel H. Gruber & Bryan R. Franks & Steven T. Kessel & Anne L. Robertson. 2008. Effects of large-scale anthropogenic development on juvenile lemon shark (Negaprion brevirostris) populations of Bimini, Bahamas. Environ Biol Fish 83:369–377.

Karl S. A. • A. L. F. Castro • J. A. Lopez • P. Charvet • G. H. Burgess. 2011. Phylogeography and conservation of the bull shark (Carcharhinus leucas) inferred from mitochondrial and microsatellite DNA. Conserv Genet 12:371–382.

Keeney D and Heist E. 2006. Worldwide phylogeography of the blacktip shark (*Carcharhinus limbatus*) inferred from mitochondrial DNA reveals isolation of western Atlantic populations coupled with recent Pacific dispersal. Mol Ecol 15:3669-3679.

Kohler, N. E. and Turner, P. A. (2001). Shark tagging: A review of conventional methods and studies. *Environmental Biology of Fishes* 60, 191-223.

Kumar, K.S., Zushi, Y., Masunaga, S., Gilligan, M., Pride, C., Sajwan, K.S. 2009. Perfluorinated organic contaminants in sediment and aquatic wildlife, including sharks, from Georgia, USA. Marine Pollution Bulletin 58: 601–634.

Lack, M. and Sant G. (2011). The Future of Sharks: A Review of Action and Inaction. TRAFFIC International and the Pew Environment Group. 41 pp.

Levine, C. 2006. Finding Blues in the Nether Antilles. Marlin Magazine, International Sportfishing Magazine.

Liu K.M., Chen C.T., Liao T.H., Joung S.J., 1999, Age, growth, and reproduction of the pelagic thresher shark, Alopias pelagicus in the Northwestern Pacific. Copeia 1999,68-74.

Loefer, J. K., Sedberry, G. R. and McGovern, J. C. (2005). Vertical movements of a shortfin mako in the western North Atlantic as determined by pop-up satellite tagging. *Southeastern Naturalist* 4, 237-246.

Martin, R. A. 2007. A review of behavioural ecology of whale sharks (*Rhincodon typus*). *Fish. Res.* 84: 10-16.

Meesters, H. W. G., Slijkerman, D. M. E., de Graaf, M. and Debrot, A. O. (2010). Management plan for the natural resources of the EEZ of the Dutch Caribbean., vol. C100/10: IMARES Wageningen UR.

Mejía-Falla, P.A., Navia, A.F., Mejía-Ladino, L.M., Acero, A. , Rubio, E.A. 2007. TIBURONES Y RAYAS DE COLOMBIA(PISCES ELASMOBRANCHII): LISTA ACTUALIZADA, REVISADA Y COMENTADA Bol. Invest. Mar. Cost. 36: 111-149.

MinEZ (Dutch Ministry of Economic Affairs) 2013. Natuurbeleidsplan Caribisch Nederland 2013-2017. The Hague, the Netherlands. 55 pp.

Maljkovic A and IM Cote (2011) Effects of tourism-related provisioning on the trophic signatures and movement patterns of an apex predator, the Caribbean reef shark. Biological Conservation vol.144:2, 859-865

Morin P, Luikart G, Wayne RK, SNP workshop group. 2004. SNPs in ecology, evolution and conservation. TREE.

Morrissey, J.F. & Gruber, S.H. 1993. Habitat selection by juvenile lemon sharks, Negaprion brevirostris. Env. Biol. Fishes 38: 311–319.

Mucientes, G.R., Queiroz, N. Sousa, L.L., Tarroso, P. Sims, D. W. 2009. Sexual segregation of pelagic sharks and the potential threat from fisheries. Biol Letters 5: **156-159**

Mumby, P.J., Dahlgren, C.P., Harborne, A.R., Kappel, C.V., Micheli, F., Brumbaugh, D.R., et al. (2006). Fishing, trophic cascades, and the process of grazing on coral reefs. Science, 311, 98–101.

Musick JA, Berkeley SA, Cailliet GM, Camhi M, Huntsman G, Nammack M, et al. 2000a. Protection of marine fish stocks at risk of extinction. AFS policy statement. Fisheries 25:6–8.

Musick, JA, Burgess, G, Cailliet, G, Camhi, M, and Fordham, S. 2000b. Management of Sharks and Their Relatives (Elasmobranchii). American Fishery Society Policy Statement. Fisheries 25: 9-13.

Musick, J., Harbin, M. & Compagno, L. (2004). Historical zoogeography of the Selachii. In: The Biology of Sharks and Their Relatives (eds Carrier, J.C., Musick, J.A. & Heithaus, M.R.). CRC Press, Boca Raton, FL, pp. 33–78.

Nakano H., Matsunaga H., Okamoto H., Okazaki M., 2003, Acoustic tracking of bigeye thresher shark Alopias superciliosus in the eastern Pacific Ocean. Mar. Ecol. Prog. Ser. 265, 255–261.

Nei M. 1975. Molecular Population Genetics and Evolution. Elsevier, New York.

Nei M. 1987. Molecular Evolutionary Genetics. Columbia University Press, New York.

Nei M, Kummar S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press, New York.

Pardini AT, Jones CS, Noble LR, Kreiser B, Malcolm H, Bruce BD, Stevens JD, Francis M, Duffy CAJ, Martin AP. 2001. Sex-biased dispersal of great white sharks. Nature brief communications.

Pauly, D. 2002. Growth and mortality of the basking shark *Cetorhinus maximus* and their implications for management of whale sharks *Rhincodon typus*. In: S.L. Fowler, T.M. Reed and F.A. Dipper (eds), Elasmobranch Biodiversity, Conservation and Management. Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997, pp.

Pikitch, E.K., Chapman, D.D., Babcock, E.A., Shivji, M.S. 2005. Habitat use and demographic population structure of elasmobranchs at a Caribbean atoll (Glover's Reef, Belize). Mar. Ecol. Progr. Ser. 302: 187–197.

Pinhal, D., M. S. Shivji • M. Vallinoto • D. D. Chapman • O. B. F. Gadig • C. Martins. 2012. Cryptic hammerhead shark lineage occurrence in the western South Atlantic revealed by DNA analysis. Mar Biol (2012) 159:829–836.

Poiesz, S. 2013. The status of the Caribbean spiny lobster (*Panulirus argus*) and its fishery in the coastal waters of St. Eustatius. *MSc Thesis Aquaculture and Fisheries Group Wageningen University, T1917*

Priede, I. G. (1984). A Basking Shark (Cetorhinus-Maximus) Tracked by Satellite Together with Simultaneous Remote-Sensing. *Fisheries Research* 2, 201-216.

Priede, I. G. and Miller, P. I. (2009). A basking shark (Cetorhinus maximus) tracked by satellite together with simultaneous remote sensing II: New analysis reveals orientation to a thermal front. *Fisheries Research* 95, 370-372.

QUATTRO, J.M., WILLIAM B. III DRIGGERS, JAMES M. GRADY, GLENN F. ULRICH, MARK A. ROBERTS. 2013. Sphyrna gilberti sp. nov., a new hammerhead shark (Carcharhiniformes, Sphyrnidae) from the western Atlantic Ocean. Zootaxa 3702 (2): 159–178.

Randall, J. E. 1992. Review of the Biology of the Tiger Shark *(Galeocerdo cuvier). Aust. J. Mar. Freshwater Res., 1992, 43, 21-31.*

Reed, J. K. and Pomponi, S. A. (2001). Final cruise report. Submersible and scuba collections in the coastal waters of the Netherlands Antilles (Curaçao, Bonaire) and Aruba: biomedical and biodiversity research of the benthic communities with empahsis on the Porifera and Gorgonacea. , pp. 196 pp. Ft. Pierce Fla.: Harbor Branch Oceanographic Institution, Inc.

Rezende, E.L., E.M. Albert, et al. (2009) Compartments in a marine food web associated with phylogeny, body mass, and habitat structure. *Ecology Letters*, 12(8), 779-788.

Rosa, R.S., Castro, A.L.F., Furtado, M., Monzini, J. & Grubbs, R.D. 2006a. *Ginglymostoma cirratum*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 26 September 2013.

Rosa, R.S., Mancini, P., Caldas, J.P. & Graham, R.T. 2006b. *Carcharhinus perezi*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 26 September 2013

Rowat, D., Engelhardt, U. 2007. Seychelles: A case study of community involvement in the development of whale shark ecotourism and its socio-economic impact. Fisheries Research 84: 109–113.

Roussel, J. M. *et al.*Field test of a new method for tracking small fishes in shallow rivers using passive integrated transponder technology. *Canadian Journal of Fisheries and Aquatic Sciences* **57**, 1326-1339 (2000).

Rubio E. A. 1987. Lista sistematica de peces costeros y de profundidad del Pacifico Colombiano. Centro de Publicaciones, Facultad de Ciencias, Universidad del Valle, Cali. 258 pp.

Sanchez-de Ita, J.A., C. Quinonez-Velazquez, F. Galvan-Magana, N. Bocanegra-Castillo and Felix-Ura, R. 2011. Age and growth of the silky shark Carcharhinus falciformis from the west coast of Baja California Sur, Mexico. J. Appl. Ichthyol. 27: 20–24.

Schmidt, J. V., C. L. Schmidt, F. Ozer, R. E. Ernst, K. A. Feldheim, M. V. Ashley and M. Levine. 2009. Low genetic differentiation across three major ocean populations of the whale shark, *Rhincodon typus*. *PLoS ONE* 4: e4988. doi:10.1371/journal.pone.0004988

SEDAR. 2006. Highly migratory species management division: stock assessment report of SEDAR 11. Large coastal shark complex, blacktip and sandbar shark. Department of Commerce National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Highly Migratory Species Management Division, Silver Spring, Md.

Shepard, E. L. C., Ahmed, M. Z., Southall, E. J., Witt, M. J., Metcalfe, J. D. and Sims, D. W. (2006). Diel and tidal rhythms in diving behaviour of pelagic sharks identified by signal processing of archival tagging data. *Marine Ecology Progress Series* 328, 205-213.

Shepherd, T.D. & Myers, R.A. (2005). Direct and indirect fishery effects on small coastal elasmobranchs in the northern Gulf of Mexico. Ecol. Lett., 8, 1095–1104.

Simpfendorfer C.A., Hueter R.E., Bergman U., Connett S.M.H., 2002, Results of a fishery-independent survey for pelagic sharks in the Western North Atlantic, 1977–1994. Fish. Res. 55, 175–192.

Simpfendorfer, C. 2009. *Galeocerdo cuvier*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 26 September 2013.

Sims, D. W., Southall, E. J., Richardson, A. J., Reid, P. C. and Metcalfe, J. D. (2003). Seasonal movements and behaviour of basking sharks from archival tagging: no evidence of winter hibernation. *Marine Ecology Progress Series* 248, 187-196.

Sims, D. W., Witt, M. J., Richardson, A. J., Southall, E. J. and Metcalfe, J. D. (2006). Encounter success of free-ranging marine predator movements across a dynamic prey landscape. *Proceedings of the Royal Society B-Biological Sciences* 273, 1195-1201.

Sims, D.W. (2008). Sieving a living: a review of the biology, ecology and conservation status of the plankton-feeding basking shark Cetorhinus maximus. Adv. Mar. Biol. 54, 171–220.

Singh-Renton S., 2010. Sustainable Development and conservation of Tuna and Tuna-like Species in the Caribbean – The Role of ICCAT. CRFM Technical & Advisory Document, No. 2010/ 2. 25 pp. (http://www.caricom-fisheries.com/LinkClick.aspx?fileticket=19SgM73Xt34%3d&tabid=87)

Skomal, G. B., Wood, G. and Caloyianis, N. (2004). Archival tagging of a basking shark, Cetorhinus maximus, in the western North Atlantic. *Journal of the Marine Biological Association of the United Kingdom* 84, 795-799.

Skomal, G. B., Zeeman, S. I., Chisholm, J. H., Summers, E. L., Walsh, H. J., McMahon, K. W. and Thorrold, S. R. (2009). Transequatorial Migrations by Basking Sharks in the Western Atlantic Ocean. *Current Biology* 19, 1019-1022.

Smale, M.J. & G. Cliff 1998. Cephalopods in the diets of four shark species (Galeocerdo cuvier, Sphyrna lewini, S. zygaena and S. mokarran) from KwaZulu-Natal, South Africa, South African Journal of Marine Science, 20:241-253.

Sodré, D., Rodrigues-Filho, L.F.S., Souza, R.F.C., Rêgo, P.S., Schneider, H., Sampaio, I., Vallinoto. M. 2012. Inclusion of South American samples reveals new population structuring of the blacktip shark (*Carcharhinus limbatus*) in the western Atlantic. Genetics and Molecular Biology, 35, 4, 752-760.

Stevens, J. 2009. Prionace glauca. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>

Tavares R. 2008. Occurrence, Diet and Growth of Juvenile Blacktip Sharks, *Carcharhinus limbatus*, from Los Roques Archipelago National Park, Venezuela. *Caribbean Journal of Science*, 44: 291-302.

Tavares, R. 2005. Abundance and distribution of sharks in Los Roques Archipelago National Park and other Venezuelan oceanic islands, 1997-1998. *Cienc. Mar.* 32:441-454.

Tavares, R. 2009. ANÁLISIS DE ABUNDANCIA, DISTRIBUCIÓN Y TALLAS DE TIBURONES CAPTURADOS por PESCA ARTESANAL EN EL PARQUE NACIONAL ARCHIPIÉLAGO LOS ROQUES, VENEZUELA. Interciencia 34: 463-470.

Taylor, J. G. 2007. Ram filter-feeding and nocturnal feeding of whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia. *Fish. Res.* 84: 65-70.

Techera, E.J. Klein, N. 2011. Fragmented governance: Reconciling legal strategies for shark conservation and management. Marine Policy 35: 73–78.

Toller, W., A. O. Debrot, M. J. A. Vermeij and P. C. Hoetjes. 2010. Reef fishes of Saba Bank, Netherlands Antilles: assemblage structure across a gradient of habitat types. PloS ONE 2010/5/5/e9202.

Toller, W., S. Lundvall (2008) Assessment of the commercial fishery of Saba Bank. Saba Conservation Foundation, Saba, Dutch Caribbean.

Ubeda, A.J., & C. A. Simpfendorfer & M. R. Heupel 2009. Movements of bonnetheads, Sphyrna tiburo, as a response to salinity change in a Florida estuary. Environ Biol Fish 84:293–303.

UNEP, CBD 2012. REPORT OF THE WIDER CARIBBEAN AND WESTERN MID-ATLANTIC REGIONAL WORKSHOP TO FACILITATE THE DESCRIPTION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS1. UNEP/CBD/SBSTTA/16/INF/7 23 April 2012. 241 pp

Van Beek, I. J. M., Debrot, A. O. and De Graaf, M. 2013. Elasmobranchs in the Dutch Caribbean: current population status, fisheries and conservation. *GCFI proceedings of the 65th GCFI meeting*.

Van Kuijk, T. 2013. The effect of marine reserve protection and habitat type on the structure of tropical reef fish assemblages around St. Eustatius. *MSc Thesis Aquaculture and Fisheries Group Wageningen University, T1918*

Van Overzee, H.M.J. & H.J.L. Heessen, 2011. Haaien en roggen: analyse en platform. IMARES Rapport C007/11, 26p.

Van Overzee, H. M. J., Van Beek, I. J. M., De Graaf, M., Debrot, A. O., Hintzen, N. T., Coers, A. and Bos, O. G. 2012. Kennisvraag haaien: wat is er bekend over haaien voor de voor Nederland relevante gebieden vol. C113/12: IMARES Wageningen UR.

Verschuuren, J. 2008. Ramsar soft law is not soft at all. Discussion of the 2007 decision by the Netherlands Crown on the Lac Ramsar site on the island of Bonaire. Milieu en Recht 35 (1): 28-34

Waples RS, England PR. 2011. Estimating contemporary effective population size on the basis of linkage disequilibrium in the face of migration. Genetics.

Watson, D.L., E.S. Harvey, et al., 2005. A comparison of temperate reef fish assemblages recorded by three underwater stereo-video techniques. *Marine Biology*, 148(2), 415-425.

Watson, J. T.; Essington, T. E.; Lennert-Cody, C. E.; Hall, M. A. 2008. Trade-offs in the design of fishery closures: management of silky shark bycatch in the Eastern Pacific Ocean tuna fishery. Conserv. Biol. 23, 626–635.

Weidner, D.M., G.E. Laya and J.A. Serano, 2001. World swordfish fisheries: an analysis of swordfish fisheries, market trends and trade patterns, past-present-future, Vol. IV. Latin America, Part B. Caribbean, Section 4. Montserrat to Puerto Rico. Chapter 17. The Netherlands Antilles and Aruba. Pp. 1053-1145. NOAA Tech. Memo. NMFS-F/SPO-53. NMFS: Silver Spring, Maryland.

Weng, K. C. and Block, B. A. (2004). Diel vertical migration of the bigeye thresher shark (*Alopias superciliosus*), a species possessing orbital retia mirabilia. *Fishery Bulletin* 102, 221-229.

Weng, K. C., Castilho, P. C., Morrissette, J. M., Landeira-Fernandez, A. M., Holts, D. B., Schallert, R. J., Goldman, K. J. and Block, B. A. (2005). Satellite tagging and cardiac physiology reveal niche expansion in salmon sharks. *Science* 310, 104-106.

Weng, K. C., Foley, D. G., Ganong, J. E., Perle, C., Shillinger, G. L. and Block, B. A. (2008). Migration of an upper trophic level predator, the salmon shark Lamna ditropis, between distant ecoregions. *Marine Ecology Progress Series* 372, 253-264.

Williams, J. T., Carpenter, K. E., Van Tassell, J. L., Hoetjes, P., Toller, W., Etnoyer, P. and Smith, M. (2010). Biodiversity Assessment of the Fishes of Saba Bank Atoll, Netherlands Antilles. *PLoS ONE* 5.

Winter, H. V. and Van Overzee, H. M. J. (2013). Langlopend merkprogramma voor haaien en roggen in de Zeeuwse kustwateren: de resultaten van 2011-2012: Institue for Marine Resources and Ecosystem Studies (IMARES).

Worm, B., B.l. Davis, L. Kettemer, C.A. Ward-Paige, D. Chapman, M.R.Heithaus, S.T. Kessel, S.H. Gruber 2013. Global catches, exploitation rates, and rebuilding options for sharks. Marine Policy 40: 194–204.

12 Justification

Report: C209/13
Project Number: 430.870.10.26

The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of IMARES.

Approved: H.M.J. van Overzee MSc
Researcher

Signature:

Date: February 2014

Approved: Drs. F.C. Groenendijk
Head Department Maritime

Signature:

Date: February 2014

Appendix A: Species list of sharks and rays in the Dutch Caribbean

Table A: *Documented shark and ray species in the Dutch Caribbean and their status according to international (CITES, CMS) and regional (SPAW) conventions and the IUCN Red list of endangered species. X=observations documented by Van Beek et al. (2012) XX=new observations in 2013 *=tentatively present (IUCN SSG, N.Dulvy pers. comm.). 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).*

		Observed species per island						**Status per species**			
Common name	**Scientific name**	**Aruba**	**Bonaire**	**Curacao**	**Saba**	**St. Eustatius**	**St. Maarten**	CITES (13) and [i]	**CMS [ii]**	**SPAW (14) and [iii]**	**IUCN**
1. Whale shark	*Rhincodon typus*	X(1,2) xx(15)	X(1,3)	X (1)	X (1)	X (1)	X(1,9)	II	II	(II)	VU
2. Nurse shark	*Ginglymostoma cirratum*	X (2)	X (3)	X (4)	X(7,8)	X (10)	X[1](9)				DD
3. Caribbean reef shark	*Carcharhinus perezi*	X (2)	X (3)		X(7,8)	X (10)	X[2](9)				NT
4. Blacktip shark	*Carcharhinus limbatus*	X (2)			X (8)		X[3](9)				NT
5. Lemon shark	*Negaprion brevirostris*	X (2)		X (4)			X[4](9)				NT
6. Bull Shark	*Carcharhinus leucas*	X (2)	X (3)		X (8)	X (10)	X[5](9)				NT
7. Tiger Shark	*Galeocerdo cuvier*	X (2)	X (12)		X(7,8)	X (10)	X[6](9)				NT
8. Oceanic white-tip shark	*Carcharhinus longimanus*	X (2)		X (4)				II[1]		(II)	VU
9. Silky shark	*Carcharhinus falciformis*			X (4)							NT
10.Blue shark	*Prionace glauca*			X (4)							NT
xx Sandbar shark	*Carcharhinus plumbeus*				xx(17)						VU
*Blacknose reef shark	*Carcharhinus acronotus*	*	*	*	*	*	*				NT
*Brazilian Sharpnose Shark	*Rhizoprionodon lalandii*	*	*	*	*	*	*				DD
*Caribean Sharpnose Shark	*Rhiziprionodon porosus*	*	*	*	*	*	*				LC
11.Smooth hammerhead	*Sphyrna zygaena*	X (2)						II[1]		(II)	VU
12.Scalloped hammerhead	*Sphyrna lewini*	X (2)		X (11)				II[1]		(II)	EN
13.Great hammerhead	*Sphyrna mokarran*	X (2)					X[7](9)	II[1]		(II)	EN
14.Bonnethead shark	*Sphyrna tiburo*	X (2)		X (5)							LC
Hammerhead unspecified	*Sphyrna spp.*		X (3)	X (4)	X (8)						
xx.Basking shark	*Cetorhinus maximus*	xx(15)						II	I,II	(II)	VU
15.Shortfin mako	*Isurus oxyrinchus*	X (2)							II	(II)	VU
16.Thresher shark	*Alopias vulpinus*	X (2)									VU
17.Bigeye thresher	*Alopias superciliosus*	X (2)								(II)	VU
18.Big-eyed sixgill shark	*Hexanchus nakamurai*			X(4,5)	X (8)						DD
xx.Bluntnose sixgill shark	*Hexanchus griseus*		xx(16)								VU
19.Smalltooth sawfish	*Pristis pectinata*			X(4,6)				I		(II)	CR
20.Cuban dogfish shark	*Squalus cubensis*			X (4)	X (7)						DD
21.Cookiecutter shark	*Isistius brasiliensis*			X (5)							LC
22.Lined lanternshark	*Etmopterus bullisi*				X (7)						LC

23.Houndshark unspecified	Triakis spp.			X (4)							
24.Hoary catshark	Apristurus canutus			X (5)							DD
*Boa catshark	Scyliorhinus boa	*	*	*	*	*	*				DD
*Chupare stingray	Himantura schmardae	*	*	*	*	*	*				DD
*Bluntnose stingray	Dasyatis say	*	*	*	*	*	*				LC
25.Spotted eagle ray	*Aetobatus narinari*	X	X (5)	X (5)	X	X	X				DD
26.Southern stingray	*Dasyatis americana*	X	X (5)	X (5)	X	X	X				DD
27.Giant manta ray	Manta birostris		X (9)					II[1]	I,II		VU

Documented as part of the study in 2012 (Van Overzee, 2012)

(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, 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 listed 3 shark species that occur in the Dutch Caribbean at the time of the research of IMARES in 2012. Now the number has increased to 8 species in the Dutch Caribbean, which enters into effect as of 14 September 2014 (species marked as II[1]).
(14) SPAW appendices do not list shark species currently. The revision that was considered at the COP7 in 2012 contained a long list of shark species in appendix II. This was not accepted and a shortlist of priority species was requested. The 15 priority species which will be considered at the COP8 in 2014/2015 are denoted as (II) (P. Hoetjes, pers. comm.)

Additions as part of this research in 2013

(15) A Basking Shark was recorded in the Dutch Caribbean EEZ north from Aruba and Curuçao (Geelhoed et al submitted) and a Whale Shark was recorded north-northwest from Aruba (Geelhoed et al 2014)
(16) Analysis of submarine explorations to depths of 900 m (D. Debrot, in prep.)
(17) Saba fisheries monitoring program (M. De Graaf, in prep.)

Internet webpages

[i] CITES appendices I, II and III assessed 7/1/2014 at http://www.cites.org/eng/app/appendices.php

[ii] CMS appendices I, II assessed 7/1/14 http://www.cms.int/documents/appendix/appendices_e.pdf

[ii] SPAW bijlagen I, II en III. Assessed 11/09/2012 from http://www.cep.unep.org/cartagena-convention/spaw-protocol/spaw-final-act-resolution-and-appendix/view

Appendix B: International & national legislation and regulation

Table B1. Overzicht van alle beschermde haaien- en roggensoorten (elasmobranchii) in de internationale CITES [2 en 3] en CMS verdragen.

		CITES bijlagen*			CMS bijlagen***	
Populaire naam ('common name')	**Wetenschappelijke naam**	**I**	**II**	**III**	**I**	**II**
Whale shark	*Rhincodon typus*		X			X
Basking shark	*Cetorhinus maximus*		X		X	X
Great white shark	*Carcharodon carcharias*		X		X	X
Sawfishes	*Pristis spp.*	X				
Scalloped hammerhead	*Sphyrna lewini*		X*			
Smooth hammerhead	*Sphyrna zygaena*		X*			
Great hammerhead	*Sphyrna mokarran*		X*			
Oceanic white-tip shark	*Carcharhinus longimanus*		X*			
Porbeagle shark	*Lamna nasus*		X*	X**		X
Shortfin mako	*Isurus oxyrinchus*					X
Longfin mako	*Isurus paucus*					X
Piked dogfish	*Squalus acanthias*					X
Manta ray	*Manta birostris*		X*		X	X
Overige Manta's	*Manta spp.*		X*	X**		

* CITES bijlagen met ingang van 14 september 2014
** CITES bijlagen tot 14 september 2014
*** CMS bijlagen met ingang van 23 februari 2012

Table B2. Overzicht van de internationale, regionale, nationale en eilandelijke rechtsgronden voor de bescherming van haaien.

	Internationale en regionale verdragen			Specifieke wetgeving haaien	
Rechtsgebied	**CITES**	**CMS**	**SPAW**	**Bescherming**	**Sancties**
Koninkrijk der Nederlanden	Ja	Ja	N.v.t.		
Caribisch Nederland • Wet grondslagen natuurbeheer- en bescherming BES • Visserijwet BES	Ja Art.6 Nvt	Ja Art.12 Nvt	Ja Art.13 Nvt	Nee	Nee
Bonaire • Natuurverordening: AB 2008 No. 23 • Natuurbesluit: AB 2010 No. 15 • Marien: AB1991 No. 8	Bijlage I Art.11.1 AB2008	Bijlage I Art.11.1 AB2008	Bijlage I&II Art.11.1 AB2008 Bijlage III mogelijk	Ja alle haaien en drie roggensoorten (*Manta birostris*, *Aetobatus narinari*, *Dasyastis Americana)* Art.11.1 AB2010 Dit als toevoeging op CITES/CMS/SPAW cf. Art.11.2 AB2008	Nee
St. Eustatius • Natuur: AB 1996 No. 3	Nee	Nee	Nee	Nee Toevoeging op vangst	N.v.t. voor haaien, wel bij overtreding AB1996

				wel mogelijk cf art. 8	(max 1mnd/ 5.000 NAF)
Saba • Marien: AB 1987 No. 10	Nee	Nee	Nee	Nee Toevoeging op vangst wel mogelijk cf art. 7	N.v.t. voor haaien, wel bij overtreding AB1987 (max 1mnd/ 5.000 NAF)
Aruba • Natuur: AB 1995 No. 2 • Cites register: AB 1995 No. 69 • Visserij: AB 1992 No. 116, AB 1993 No. 15	Bijlage I&II &III Art. 11&12&13 AB1995#2 AB1995#69	Nee	Art. 11&13 AB1995	Nee	Nee
Curaçao • Natuur: PB 1998 No. 49 • Visserij: AB 2007 No. 117 AB 2009 No. 48 PB 1991 No. 74	Ja Art.6&7 PB2001	Ja Art.8c PB2001	Ja Art.8a&8b PB2001	Nee	Nee
St. Maarten • Natuur: AB 2003 No. 25 • Maritiem: PB 2007 No. 18 • Visserij: PB 1991 No. 74 • Tijdelijk verbod haaienvisserij dd 12 oktober 2011	Bijlage I Art.16.1 AB2003	Bijlage I Art.16.1 AB2003	Bijlage I&II Art.16.1 Bijlage III mogelijk Art.16.3 AB2003	Nee Toevoegingen op CITES/CMS/SPAW wel mogelijk cf. Art.16.2 AB2003	Niet voor overtreding op CITES/CMS/SPAW in AB2003 Wel op haaienvangst in tijdelijk verbod 2011 (max 3mnd/500,000 NAF)

Appendix C: Questionnaire

Questionnaire on the support for shark conservation measures

Sharks and rays in the waters surrounding the Dutch Caribbean islands have been strongly depleted in the last half century, mainly due to illegal fishing (sharks are not a target species in the Dutch Caribbean), bycatch in local fisheries and destruction and disturbance of their habitats.

This is alarming because of the fact that these animals play an important role in ecosystem health, and are of increasing value to the growing dive and ecotourism industry. Many are internationally endangered species.

IMARES was asked by the Dutch Ministry of Economic Affairs to develop a shark protection plan. Sharks are migratory species, so local fisheries and conservation measures alone cannot resolve the depletion of shark populations in the Dutch Caribbean due to their (semi-)pelagic habitat use across EEZ borders. Therefor regional cooperation will be essential.

Public environmental awareness and support for management measures are another key determinant for the successful implementation of a shark protection plan. Therefor we would like to assess opinions and perceptions of key coastal resource users, which are 1) fishermen 2) sport divers and 3) native residents.

We hope you can answer a few questions, which will take approximately 10 minutes of your time.

Questionnaire fishermen

1. Since how many years do you fish on island xxx? _______ years

2. Which species do you catch as bycatch (multiple answers possible)?
   a. Nurse shark
   b. Caribbean reef shark
   c. Hammerheads, please specify species ____________________
   d. Rays, please specify species ___________________________
   e. Other, please specify _________________________________
   f. No answer

3. Would you say that during the last 5–10 years the **variety of sharks and rays** caught has:
   a. Increased
   b. Stayed the same
   c. Decreased
   d. Not sure

4. Would you say that during the last 5–10 years the **number of sharks and rays** caught has:
   a. Increased
   b. Stayed the same
   c. Decreased
   d. Not sure

5. Would you say that during the last 5–10 years the **size of sharks and rays** caught has changed:
   a. Smaller individuals
   b. No change
   c. Larger individuals
   d. Not sure

6. What do you do if you catch a shark or ray (multiple answers possible)?
   a. Discard alive
   b. Kill and discard
   c. Use as bait
   d. Land and use for own consumption
   e. Land and sell at the local market

7. Do you think shark and ray bycatch should be managed?
    a. Yes
    b. No
    c. No opinion

8. What are in your opinion good measures to reduce shark and ray bycatch?
   Rank each option on a scale from 1 (worst) to 5 (excellent)
    a. Modify fishing gear and/or fishing method 1 2 3 4 5
       Please specify modification
       ____
    b. Prevent overfishing by means of guidelines or limits to:
        i. number of fish traps 1 2 3 4 5
        ii. soak time of fish traps 1 2 3 4 5
        iii. handling of caught sharks 1 2 3 4 5
        iv. handline fishing 1 2 3 4 5
        v. gillnet fishing 1 2 3 4 5
        vi. seine fishing 1 2 3 4 5
        vii. number of fishermen 1 2 3 4 5
    c. Introduce no-fish reserves 1 2 3 4 5
    d. Introduce legislation for shark and ray protection 1 2 3 4 5
       (e.g. shark finning ban, habitat and species protection)
    e. Increase enforcement on legislation 1 2 3 4 5
       (including meaningful penalties)
    f. Introduce fisheries management to record bycatch 1 2 3 4 5
       (landed and discarded)
    g. Other, please specify
       ____

9. What additional costs (e.g. for modification of gear or fishing method) are you willing to contribute to bycatch reduction? $_______ annually

10. Any other comments or remarks?
    ____
    ____
    ____
    ___

Thank you very much for your cooperation!

Questionnaire local sport divers (residents)

1. Since how many years do you dive on island xxx? ___ years

2. Which species did you see during your dives (multiple answers possible)?
    a. Nurse shark
    b. Caribbean reef shark
    c. Hammerheads, please specify species
       ____
    d. Rays, please specify species
       ____
    e. Other, please specify
       ____
    f. No answer

3. Would you say that during the last 5–10 years the **variety of sharks and rays** seen has:
    a. Increased
    b. No change
    c. Decreased
    d. Not sure

4. Would you say that during the last 5–10 years the **number of sharks and rays** seen has:
    a. Increased
    b. No change
    c. Decreased
    d. Not sure

5. Would you say that during the last 5–10 years the **size of sharks and rays** seen has changed:
    a. Smaller individuals
    b. No change
    c. Larger individuals
    d. Not sure

6. When diving, how important is the sighting of **sharks** to your enjoyment of the dive?
    a. Very important
    b. Important
    c. Indifferent
    d. Unimportant
    e. Very important
    f. No opinion

7. When diving, how important is the sighting of **rays** to your enjoyment of the dive?
    a. Very important
    b. Important
    c. Indifferent
    d. Unimportant
    e. Very important
    f. No opinion

8. Do you think sharks and rays should be protected?
    a. Yes
    b. No
    c. No opinion

9. What are in your opinion good measures to protect sharks and rays?
   Rank each option on a scale from 1 (worst) to 5 (excellent)

a. Prevent overfishing	1	2	3	4	5
b. Protect shark and ray habitats	1	2	3	4	5
c. Introduce no-fish reserves	1	2	3	4	5
d. Require immediate release of sharks	1	2	3	4	5
e. Prohibit landing of sharks	1	2	3	4	5
f. Introduce legislation (e.g. shark finning ban)	1	2	3	4	5
g. Increase enforcement (including meaningful penalties)	1	2	3	4	5
h. Other, please specify					

   ____

10. What are you willing to contribute to shark and ray protection by means of an increase of your annual diving fee? $_______ annually

11. Any other comments or remarks?
    ____
    ____
    ____
    ___

Thank you very much for your cooperation!

Questionnaire local inhabitants (non-sport divers)

1. How long have you lived on island xxx? ___ years

2. Are you:

a. Born on the island
b. Not born on the island, but your family is from the island
c. No family ties to the island, but from another (former) Dutch island
d. From the Netherlands
e. From elsewhere, please specify
   ____
f. No answer

3. Which species of sharks and rays do you know (multiple answers possible)?
   a. Nurse shark
   b. Caribbean reef shark
   c. Hammerheads, please specify species
      ____
   d. Rays, please specify
      species____
   e. Other, please specify
      ____
   f. No answer

4. Do you think that during the last 5–10 years the number of sharks and rays has:
   a. Increased
   b. Stayed the same
   c. Decreased
   d. Not sure

5. Do you think sharks and rays should be protected?
   a. Yes
   b. No
   c. No opinion

6. What are in your opinion good measures to protect sharks and rays (multiple answers possible)? Rank each option on a scale from 1 (worst) to 5 (excellent)

a. Prevent overfishing	1	2	3	4	5
b. Protect shark and ray habitats	1	2	3	4	5
c. Introduce no-fish reserves	1	2	3	4	5
d. Require immediate release of sharks	1	2	3	4	5
e. Prohibit landing of sharks	1	2	3	4	5
f. Introduce legislation (e.g. shark finning ban)	1	2	3	4	5
g. Increase enforcement (including meaningful penalties)	1	2	3	4	5
h. Other, please specify					

   ____

7. What are you willing to contribute to shark and ray protection by means of an annual nature fee?
   $_______ annually

8. Any other comments or remarks?
   ____
   ____
   ____
   ___

Thank you very much for your cooperation!