Pilot study on behaviour of sharks around Saba using acoustic telemetry - Progress report 2014

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Summary

Worldwide many shark populations are in strong decline mainly due to fisheries. Population status of sharks in the Caribbean is still poorly known. In order to be able to take effective measures to protect sharks, insight in their spatial behaviour during different life stages is required. Do marine parks enhance shark populations and if so at what scale?

In the Caribbean Netherlands, a unique opportunity for research on spatial behaviour is provided by the still relative high abundance of sharks on the Saba Bank, Saba and St Eustatius. To study individual movement patterns and site fidelity of sharks species that use reefs, acoustic telemetry is a proven successful technology.

As a first step, we started a pilot study with acoustic telemetry on Caribbean reef sharks and nurse sharks on the reefs directly around Saba in October 2014. Our goals were to obtain: 1) experience with using existing infrastructure and organisations in setting up a shark telemetric study; 2) experience in catching methods and insight in effort needed for these target shark species; 3) a first indication of the scale of individual movement patterns in time; and 4) raise local awareness of importance of sharks.

An array of eight detection stations (VEMCO VR2W receivers) was deployed on or near existing anchored mooring buoys at the pinnacles and the reef surrounding the island of Saba. In the last week of October 2014, in total eight Caribbean reef sharks (115-184 cm) and four nurse sharks (94-210 cm) of different life stages were implanted with VEMCO V16 transmitters (with battery life of 4.5 years) and released at the catch site. For Caribbean reef sharks, rod and line, and for nurse sharks, long-line fishing for short duration during night proved most favourable, though catching nurse sharks required more effort than Caribbean reef sharks. In addition, two nurse sharks were obtained from bycatch in lobster pot fisheries.

A first read out of the receivers was carried out in early December 2014. The first preliminary results showed that all sharks were detected after release and that most Caribbean reef sharks were detected throughout the first six weeks and mostly around only a few receivers. This suggests a very local habitat use of the reefs around Saba. Two Caribbean reef sharks appear to use a larger proportion of the reefs around the island. For the three juvenile nurse sharks habitat use appeared to be even more local since they were only detected at one receiver throughout the first six weeks. The larger female nurse shark was only detected directly after release and her spatial behaviour thereafter remains unclear as of yet.

In the coming years these sharks will yield more data on year-round habitat use. In the autumn of 2015 we will also use a mobile receiver to detect tagged sharks present at the reefs around Saba in between the stationary receivers. Furthermore, to answer research questions about dispersal, migration, connectivity and meta-population structure we aim to expand the telemetry study to the Saba Bank and given sufficient budget also surrounding islands of St. Eustatius and St. Maarten in 2015.

This pilot study could only be performed through the support of many people and organisations, e.g. the Saba Conservation Foundation. The shark research of IMARES and partners was presented at Sea & learn in Saba and the fieldwork was documented for two Dutch Caribbean TV-programmes. WWF, Wereld Natuur Fonds the Netherlands (WNF), and the Dutch Ministry of Economic Affairs provided the funding for this study.

1 Introduction

Shark populations have steeply declined worldwide due to unsustainable overexploitation and habitat loss. The current status of elasmobranch populations in the Caribbean is poorly known (Fowler et al., 2005). There were no data available on the occurrence, distribution, abundance and population status of sharks and rays in the Dutch Caribbean until recently. In 2012 the presence of 27 species of sharks and rays was documented based on anecdotal accounts, and six other species were listed to be tentatively present (Van Overzee et al., 2012). In 2013 the results of fish monitoring programs on Saba (van Looijengoed, 2013), Saba Bank (Stoffers, 2014) and St. Eustatius (van Kuijk, 2013) and a citizen science program on Saba provided information on the occurrence and relative abundance of the most common shark species (Van Beek et al., 2013).

With respect to the rest of the Dutch Caribbean, a unique opportunity for research is provided by the relative high abundance of sharks (particularly nurse sharks) on the Saba Bank, an area that may be a nursery area for the species (Van Beek et al., 2012). 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., 2012) suggests that the Saba Bank may likewise serve such a function and that tagging studies may be fruitfully conducted to research this. Such studies on various species of Atlantic sharks which are also found in the Dutch Caribbean (e.g. Chapman et al., 2005; Ferreira et al., 2013, nurse shark; Werry et al., 2014, tiger sharks; Heupel & Simpfendorfer, 2002, black tip shark; Chapman et al., 2005, - 2007, Caribbean 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. IMARES has ample experience with tagging studies, including sharks in Dutch waters (e.g. Winter & Van Overzee, 2013).

2 Research questions

The overarching research question - which is addressed to investigate the effectiveness of a potential shark sanctuary in Caribbean Netherlands – is:
Do marine protected areas enhance shark populations and at what scale?

To answer this question, insight in the biology and movements patterns of sharks during different life-stages is needed.
- Which habitats are used (e.g. for feeding, nursery), and how strong is site fidelity to these habitats?
- What are seasonal distribution patterns?
- Meta-population structure; local populations or large scale mixing populations?
- Dispersal; do sharks disperse from natal areas, or from areas with high densities?
- Migration: do large scale cyclic movements occur for a substantial part of the population?
- Connectivity; what are exchange rates between local populations, e.g. between islands?

These factors will affect to what extent Marine Reserves are effective in rehabilitating shark populations; e.g. more effective when these reserves contain important habitats or when local populations with a low rate of exchange occur. Telemetry techniques can be used to get insight in the underlying movement patterns of sharks.

This pilot study mainly aims at determining the feasibility of using telemetry around Saba and at a later stage at the Saba Bank and surrounding islands, e.g. what logistics and which co-operation, catching and deployment methods are required to set-up telemetric experiments for target shark species, and to get a first insight of the scale of movement patterns of the target shark species.

Goals of the pilot study:
- Obtain experience with using existing infrastructure and organisations in setting up a shark telemetric study
- Obtain experience in catching methods and insight in effort needed for the target shark species
- Obtain a first indication of the scale of individual movement patterns in time for the target shark species
- Raise local awareness of importance of sharks.

3 Experimental set-up and fieldwork

Target shark species selection

Based on abundance and occurrence of sharks around Saba (van Looijengoed, 2013), and international literature on spatial behaviour (e.g. Chapman et al. 2005, - 2007; Ferreira et al., 2013), two target shark species were selected for this pilot study: Caribbean reef shark, *Carcharhinus Perezi* and nurse shark, *Ginglymostoma cirratum* (Fig. 1).

***Fig. 1**. Caribbean reef shark, Carcharhinus Perezi (left) caught at Saba, nurse shark, Ginglymostoma cirratum on the Saba Bank (right, photo © Frank Mazéas).*

Telemetric method selection

The selected tracking method was acoustic telemetry using Vemco VR2W receivers (Fig. 2 left) and V16 transmitters (Fig. 3 right). V16 transmitters can be detected by the VR2W receivers within a range of about 450 m up to 850 m depending on the environmental conditions. The life span of the batteries in the transmitters is 4.5 year. The battery life of the receivers is 15 months after which the batteries need to be replaced. The V16-4H transmitters were programmed to emit a unique acoustic signal with an average interval of 80 seconds (programmed with random delays between 50-110 seconds to minimize collision rate between signals from different transmitters).

***Fig. 2**. Vemco receiver (left) and V16 transmitter (right) (photo's Vemco)*

Permits for this pilot study

Permits to carry out the pilot telemetry study on sharks at Saba were received from the Animal Experiments Commission ('DEC') for the Dutch Act on Animal Experiments ('Wet op de Dierproeven') under code 2014120.b, and from the Executive Council of the public entity Saba (letter of 20-10-2014 ref. nr. 1026/2014).

Location selection for the array of detection stations

Based on shark observation frequency derived from the Dutch Caribbean Biodiversity Database containing an observation database from dive operator Sea Saba (www.dcbd.nl/monitoring/shark), six locations (moorings Sea Saba nr. 1,2,3,5,6,13) had the highest shark encounter rates. This was used to choose a set-up that covered at least these moorings. The array of locations with moorings that were selected for deployment of a VR2W receiver is: Twilight Zone (covers mooring 2 and with a detection range of at minimum 450 m this will then also cover moorings 1 and 3), Shark Shoal (mooring 5) and Diamond Rock (mooring 6) as more offshore locations, and at Otto Limits (also covers mooring 8), Green Island (mooring 13), Core Gut (mooring 19), Big Rock Market (Mooring 22) and Hot Springs (Mooring 24) to cover the coastline and detect sharks swimming around the island. See Fig. 3.

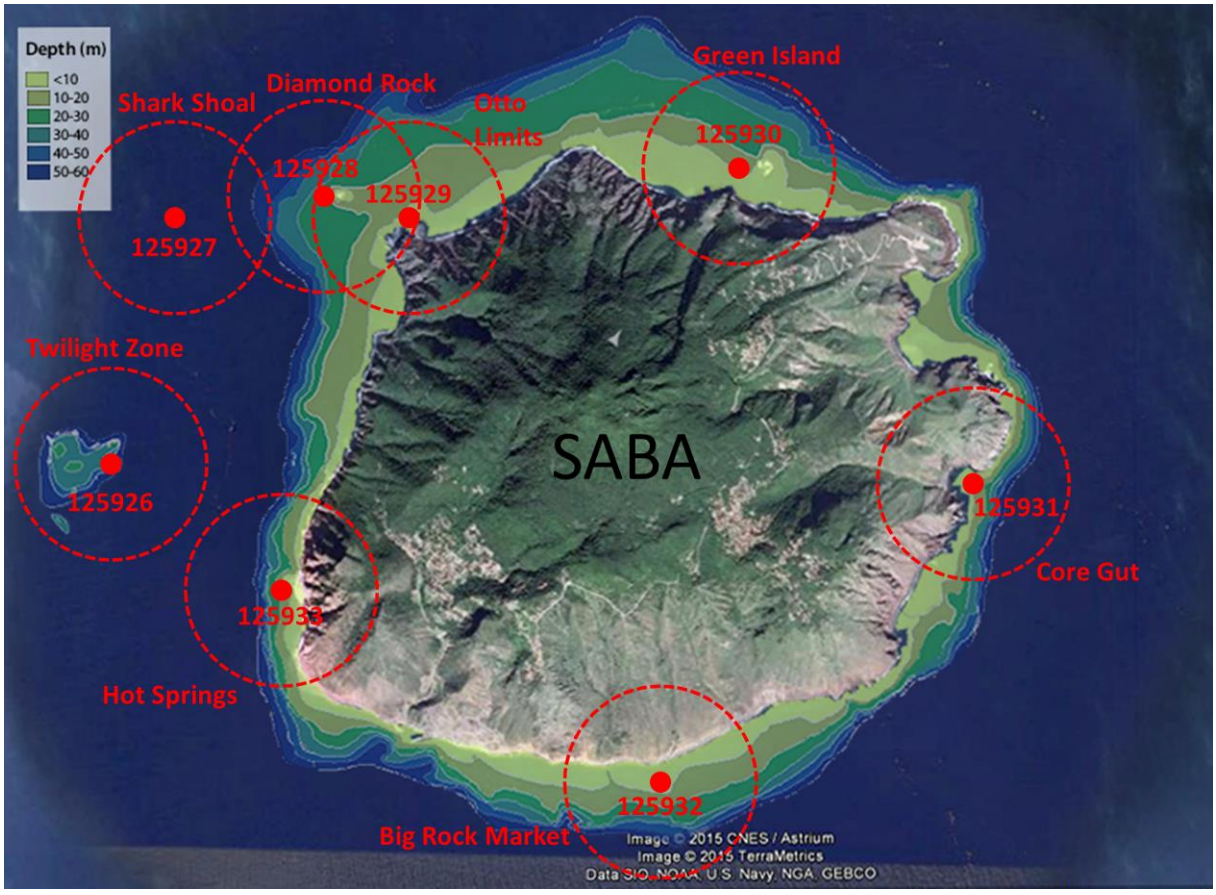

Fig. 3. *Map of Saba with the names (in red next to each red dotted circle) of the mooring locations and position of the placed receivers. The minimum detection range of 450 m is indicated by the red dotted circles. Detection range might further increase up to 850 m under ideal environmental conditons. The red numbers correspond to the receiver ID numbers in Table 1. For water depth colouring see legend in top left corner (map Saba from Google Earth)*

Placing of the receiver array around Saba

The receivers were placed with the vessel Lady Rebecca of the Saba Conservation Foundation (Fig. 4) using two deployment methods: For the deeper locations (> 15 m water depth, Twilight Zone, Shark Shoal, Diamond Rock) and one shallow location that is exposed to waves (Otto limits) we deployed the receivers on the mooring line of the buoy (Fig. 6) by scuba diving. For the other shallower locations (< 15 m water depth, Green Island, Core Gut, Big Rock Market, Hot Springs) we used a concrete block of about 10 kg with a line of 1.5-2 m and a float, and attached the receiver to this (Fig. 6). This was prepared on board and then stand-alone placed on a sandy patch close to the mooring anchor point by free diving (Fig. 5).

The receivers were tested with transmitter ID 23809 in the field for proper functioning. After placement the light signal on the receiver was checked to be working as well.

The details on time and date, method of placement and location names and position of the array of eight receivers are given in Table 1.

Fig. 4. *The Lady Rebecca of the Saba Conservation Foundation was used to install the receivers*.

Fig. 5. *On the shallow locations, the receivers were placed by free diving*.

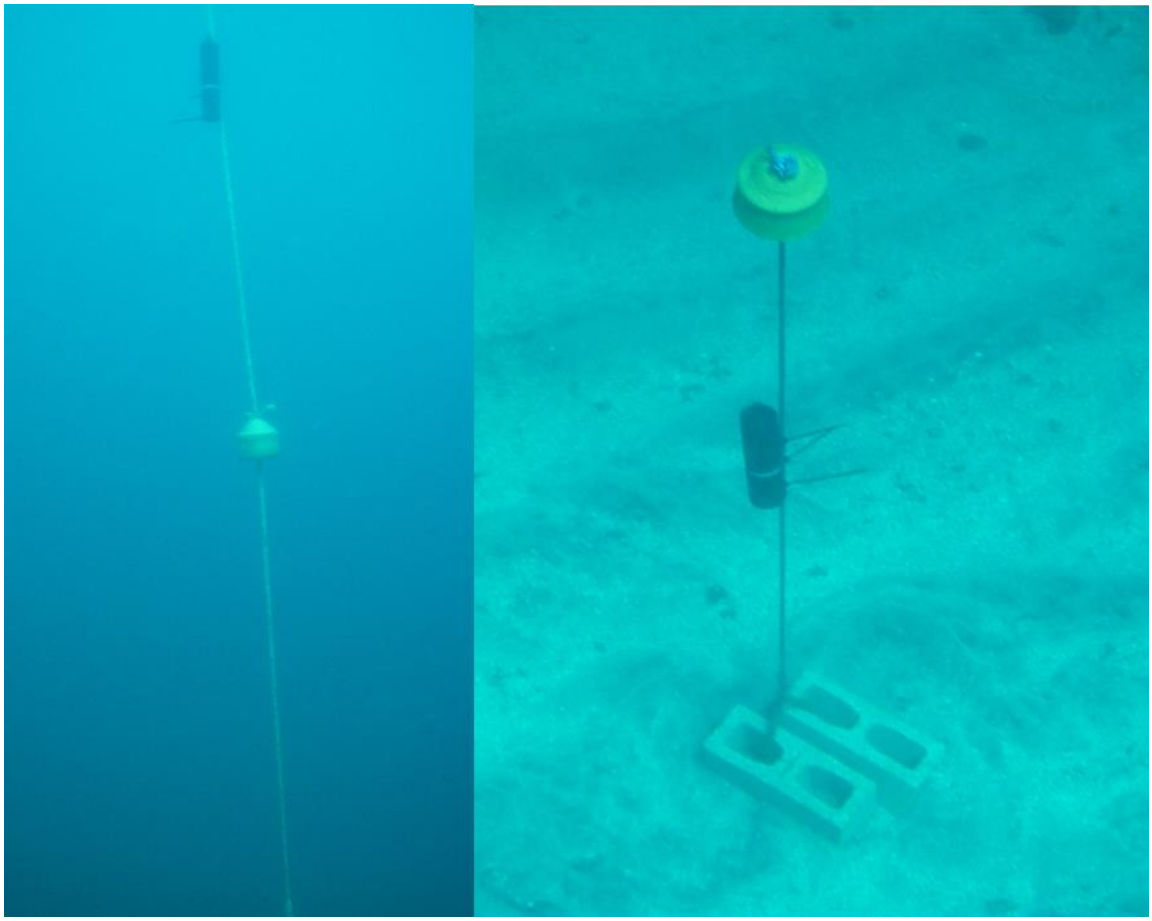

Fig. 6. *Two deployment methods were used: on deep locations the receivers were attached on the mooring lines of buoys ('mooring' left), on shallow locations the receivers were placed next to a mooring using a concrete block and short line with a pop-up float ('block' right).*

***Table 1**. Details of the placement of eight receivers around Saba.*

Name Location	Receiver ID	Position Lattitude	Postion Longitude	Mooring SCF nr	Mooring SEASaba	Receiver depth m	Water depth m	Installation date	Installation time	Deploy method
Twilight Zone	125926	17.63280	-63.27462	2	2	17	30	21-10-2014	11:20	Mooring
Shark Shoal	125927	17.64614	-63.26499	4	5	19	28	21-10-2014	11:55	Mooring
Diamond Rock	125928	17.64755	-63.25658	6	6	17	25	21-10-2014	12:25	Mooring
Otto limits	125929	17.64632	-63.25190	9	8	6	7	22-10-2014	11:00	Mooring
Green Island	125930	17.64888	-63.23110	26	24	14	8	21-10-2014	12:55	Block
Core Gut	125931	17.63113	-63.21750	25	22	12	13	21-10-2014	13:15	Block
Big Rock Market	125932	17.61252	-63.23623	22	19	13	13	21-10-2014	13:35	Block
Hot Springs	125933	17.62463	-63.25958	15	13	13	13	21-10-2014	10:45	Block

Catching and handling procedures of the sharks

Based on a literature study and contact with other shark researchers fishing with a short long-line was chosen as the catching method for both species of sharks, with rod and line as a back-up or parallel method depending on the results with long-lining. We used rounded hooks to enhance optimal hooking in the outer jaw with minimal chance on deeper hooking (during this pilot all sharks were neatly hooked and could easily be unhooked). On six days during the period 23-29 October 2014), operating from two different fishing boats (Donna Mae and Roselyn) and one research vessel (Queen Beatrix), rod and line proved most successful for catching Caribbean reef shark (Fig. 7), whereas nurse sharks required more effort to catch. The four nurse sharks were caught by long-line (Fig. 7; one during day, one during night) and from bycatch in lobster pots (two nurse sharks). In total eight Caribbean reef sharks and four nurse sharks were caught and tagged (Fig. 8, Table 2) which were two sharks more than targeted for.

***Fig. 7.** Two catch methods were used: rod and line (left) that proved to be most effective for Caribbean reef sharks and long-lining during short periods (right) that yielded both nurse sharks and Caribbean reef sharks. In addition, two nurse sharks that were bycaught in lobster pots were used for this telemetry study.*

Fig. 8. *In total four nurse sharks ranging from 94 cm (bottom right) to 210 cm (left) and eight Caribbean reef sharks ranging from 115-184 cm (top right) were tagged during this pilot study.*

The sharks were fixed with a rope around the tail and then while supporting their belly lifted on board (Fig. 9). The sharks were laid on their back to induce tonic immobility (Fig. 10). A small incision of 2-3 cm was made in the ventral side just in front of the pelvic fins, after which the transmitter was inserted. The incision was closed with 2 stitches. The shark was measured (total length in cm), sex was determined and then released at the site where it was caught (Fig. 11). All sharks swam off immediately.

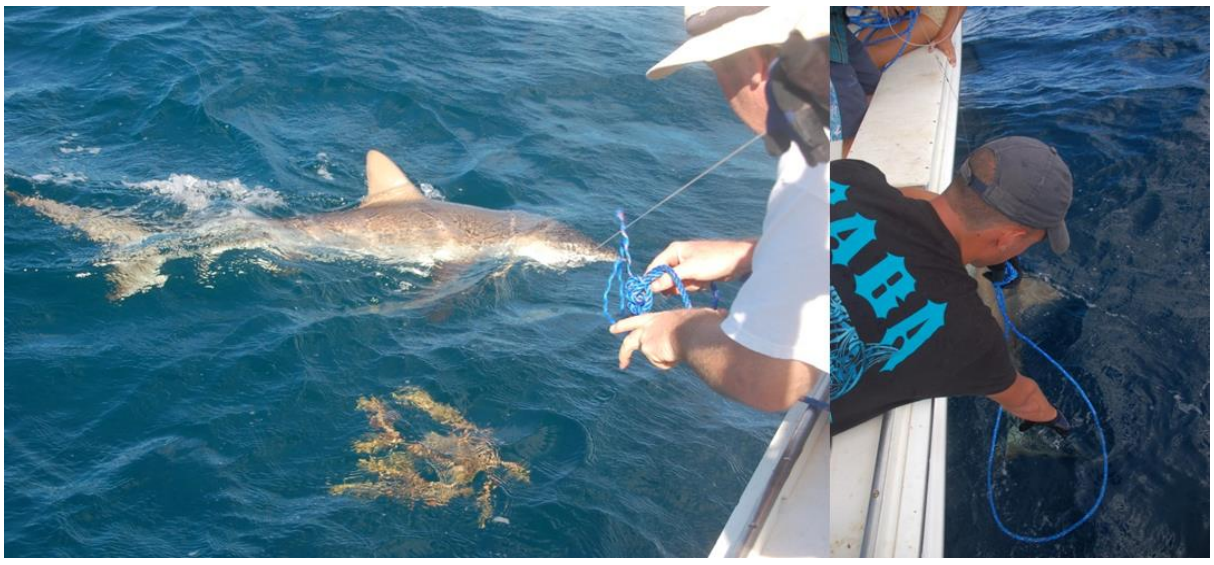

Fig. 9. *Sharks were brought alongside the boat and a rope was used to fix the tail. Sharks were then lifted on board while supporting the belly*.

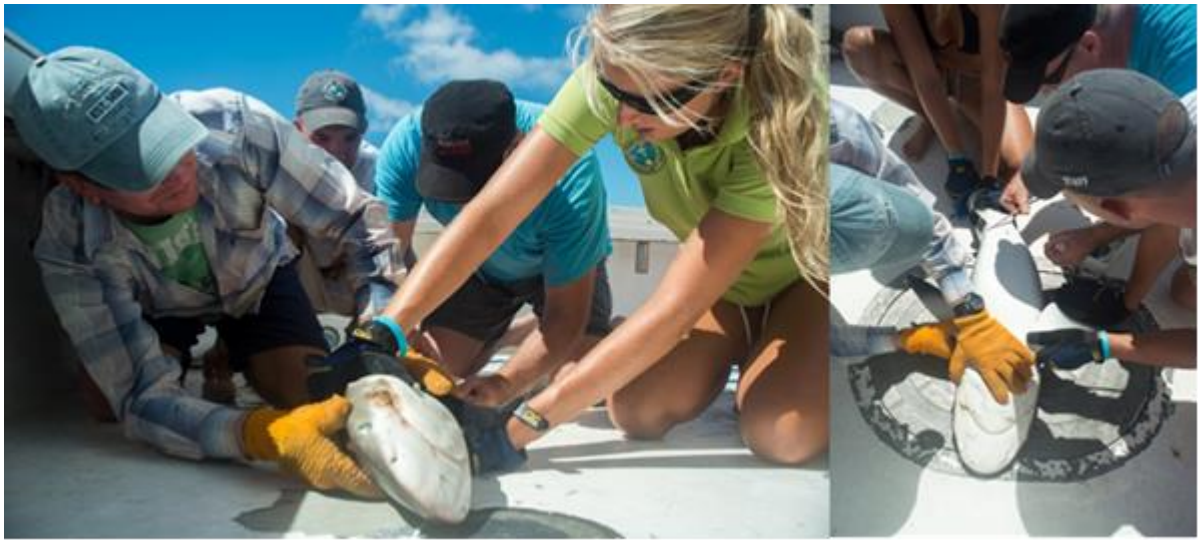

Fig. 10. *Sharks were placed on their back to induce tonic immobility and with a short lasting procedure a transmitter was implanted in the body cavity and the small incision was closed with stiches*.

Fig. 11. *After tag implantation and measuring, the sharks were released on the place they were caught*.

Table 2*. Detailed data of the 12 sharks that were implanted with V16 transmitters around Saba*.

Shark species name	Transmitter ID number	Stage juv/ad	Length cm	Sex m/f	Catch date	Catch time	Location name	Location Lattitude	Location Longitude	Catch Method
Caribbean reef	23809	juv	150	m	23-10-2014	13:00	Shark Shoal	17.64614	-63.26499	Rod-Hook
Caribbean reef	23810	ad	184	f	23-10-2015	13:40	Shark Shoal	17.64614	-63.26499	Rod-Hook
Caribbean reef	23811	ad	180	f	24-10-2014	9:30	Third Encounter	17.63205	-63.27430	Rod-Hook
Caribbean reef	23812	juv	131	f	24-10-2015	12:35	Twilight Zone	17.63280	-63.27462	Rod-Hook
Caribbean reef	23813	juv	115	m	24-10-2016	12:50	Twilight Zone	17.63280	-63.27462	Rod-Hook
Caribbean reef	23814	juv	125	f	24-10-2017	13:45	Twilight Zone	17.63280	-63.27462	Rod-Hook
Caribbean reef	23815	ad	178	m	25-10-2015	12:15	Green Island	17.64888	-63.23110	Longline
Caribbean reef	23816	ad	163	m	26-10-2014	17:00	Hole in the Corner	17.61771	-63.22617	Longline
Nurse	23817	juv	94	f	29-10-2015	10:55	Green Island (400 m E)	17.64888	-63.23110	Lobster Pot
Nurse	23818	juv	105	f	29-10-2014	10:45	Green Island (200 m E)	17.64888	-63.23110	Lobster Pot
Nurse	23819	juv/ad	210	f	25-10-2016	12:15	Green Island	17.64888	-63.23110	Longline
Nurse	23820	juv	104	m	28-10-2014	20:35	SE Big rock market	17.61252	-63.23623	Longline

Read out of the detections

A first read-out of the receivers took place during 2-4 December 2014 by retrieving the receivers and reading out the data, i.e. registrations logged so far, with a blue tooth connection between receiver and laptop. Directly thereafter the receivers were placed back at the location.

A second read-out of the data and replacement of the receiver batteries is scheduled in October-November 2015. A 3-monthly check of the position of the receivers is scheduled and to be carried out by Saba Conservation Foundation.

4 First telemetry results during 23 October – 4 December 2014

All tagged sharks were detected at least at one station. The detections will be presented per tagged shark (Figs. 12-24) and subsequently discussed per shark species below. The tag 23809 was also used for a field test of all stations, which all worked good (Fig. 12). No range tests were yet performed.

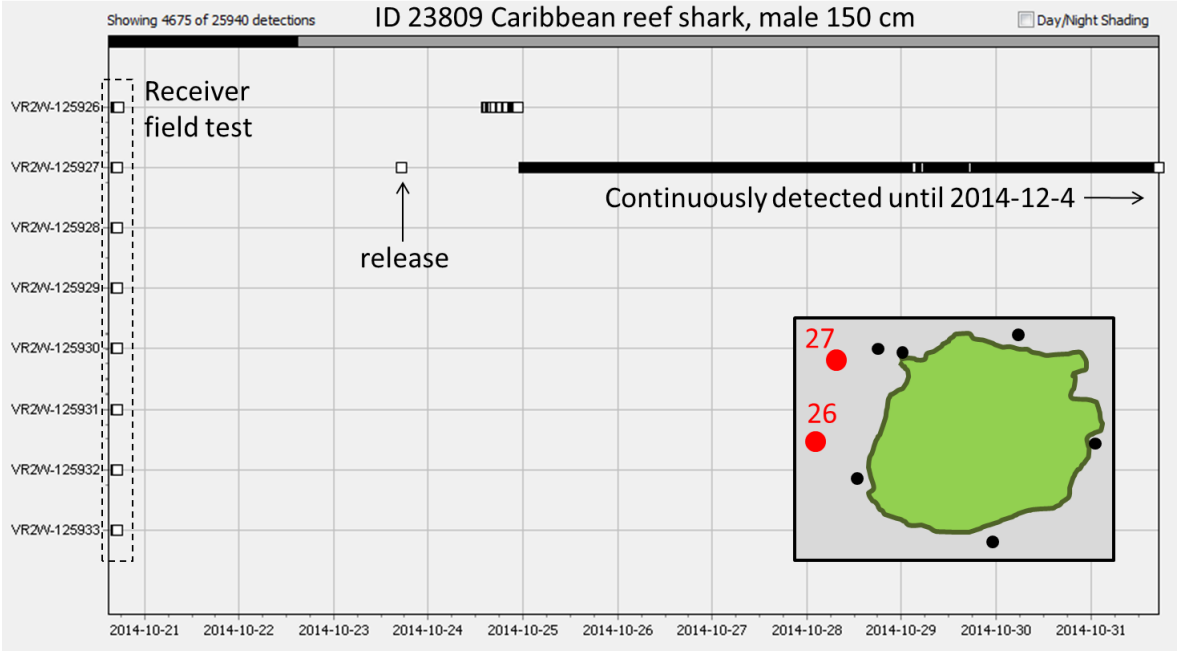

***Fig. 12**. Tag ID 23809 was first used for a field test of the functioning of all the eight receivers on 21-10-2014 and then implanted in a male Caribbean reef shark of 150 cm on 23-10-2014. Inset shows map with the receivers (with last 2 digits of the ID number) where the tagged shark was detected in red.*

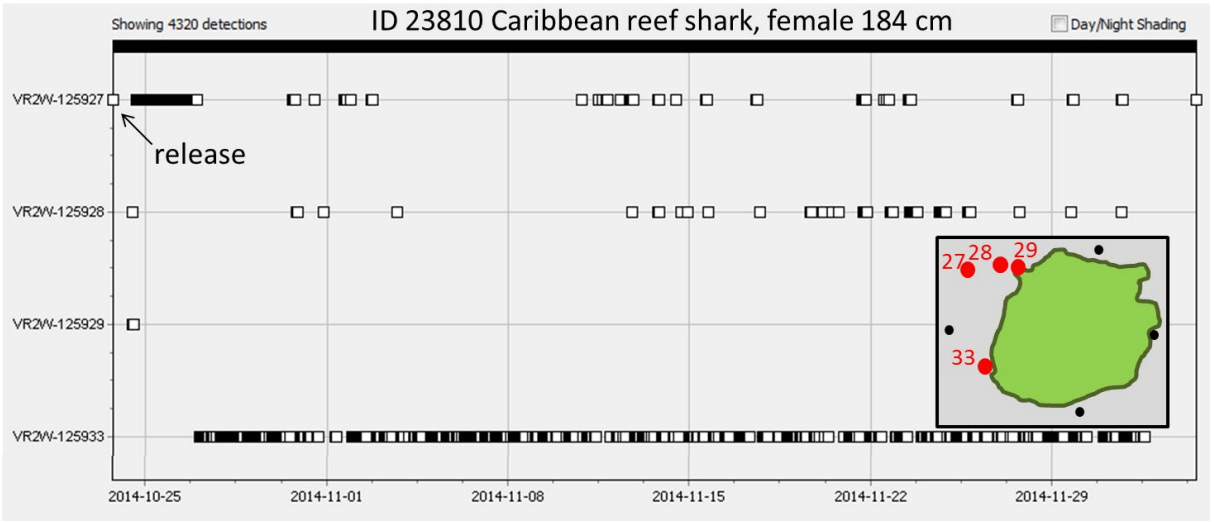

***Fig. 13**. Detections of tag ID 23810, a female Caribbean reef shark of 184 cm. Legend map see Fig. 12.*

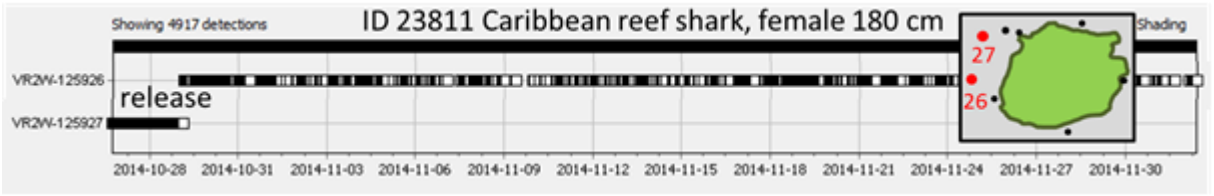

***Fig. 14**. Detections of tag ID 23811, a female Caribbean reef shark of 180 cm. Legend map see Fig. 12.*

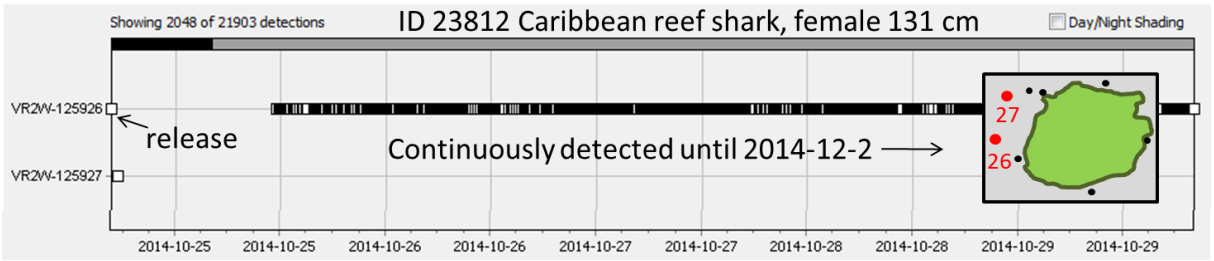

***Fig. 15**. Detections of tag ID 23812, a female Caribbean reef shark of 131 cm. Legend map see Fig. 12.*

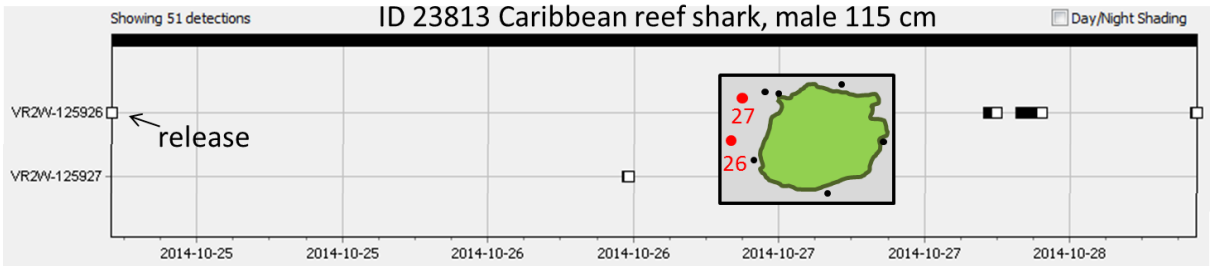

***Fig. 16**. Detections of tag ID 23813, a male Caribbean reef shark of 115 cm. Legend map see Fig. 12.*

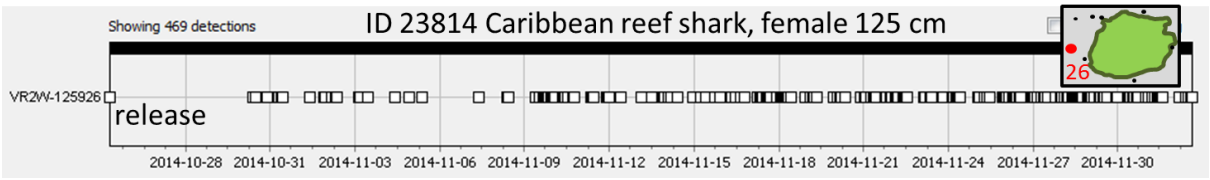

***Fig. 17**. Detections of tag ID 23814, a female Caribbean reef shark of 125 cm. Legend map see Fig. 12.*

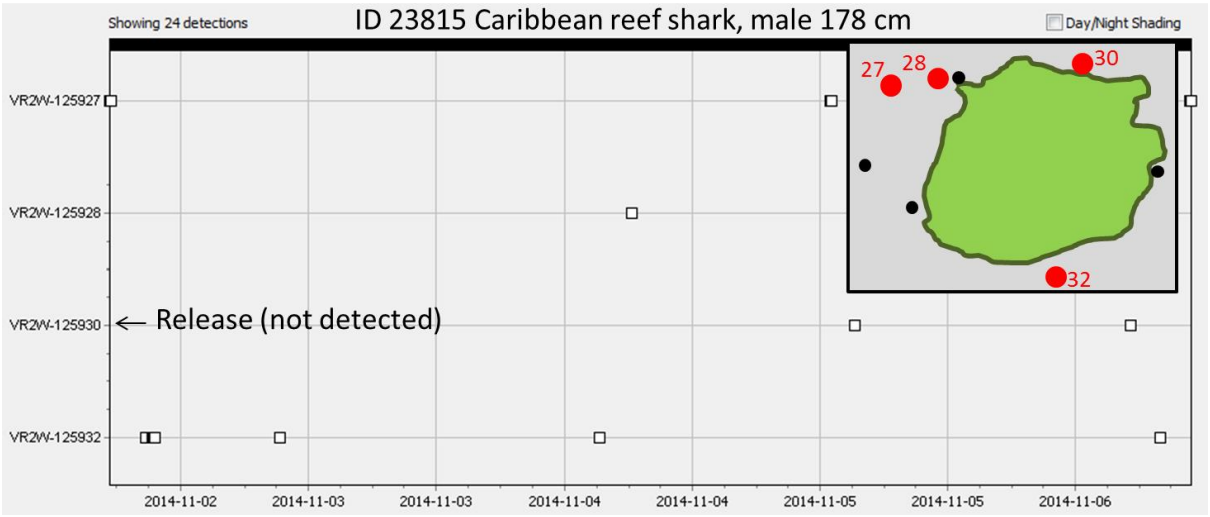

***Fig. 18**. Detections of tag ID 23815, a male Caribbean reef shark of 178 cm. Legend map see Fig. 12.*

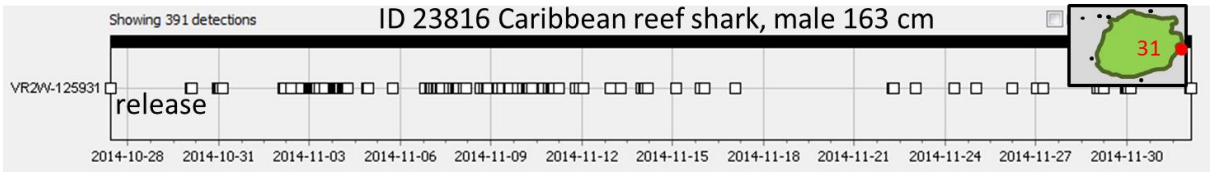

***Fig. 19**. Detections of tag ID 23816, a female Caribbean reef shark of 163 cm. Legend map see Fig. 12.*

The eight Caribbean reef sharks were all detected during most of the period since release until December 2-4, 2014. Most of the Caribbean sharks were detected only in a small part of the waters around the island and were detected by minimum of one (two sharks), mostly two (four sharks) or up to four (two sharks) receivers around the place where they were caught. Only one Caribbean shark was detected at four different receivers around the island (tad ID 23815, Fig. 18). This shark was released off Green Island and was not detected by receiver 30. Probably it was swimming fast westward after release and being outside the detection range within 80 s between emitted signals. In contrast to the other sharks that were detected throughout November, this shark was not detected after November 6.

Number of detections per shark ranged from 24 detections of shark 23815 (Fig. 18) to >20.000 detections for shark 23809 (Fig. 12) and 23812 (Fig. 15), indicating almost permanent presence around a receiver. With an 80 s interval between emitted acoustic signals as used in this pilot study, one month could yield a maximum of ~33.000 detections per transmitter when all signals would be registered.

The first results during only the first six weeks of detections suggest high site fidelity using only a relatively small part of the waters directly around the island Saba for most Caribbean reef sharks, except perhaps for one Caribbean shark.

The four nurse sharks were all detected at only one receiver (Figs 20-23).

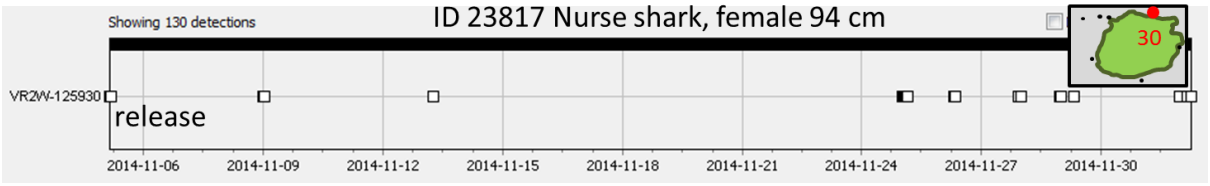

***Fig. 20**. Detections of tag ID 23817, a female Nurse shark of 94 cm. Legend map see Fig. 12.*

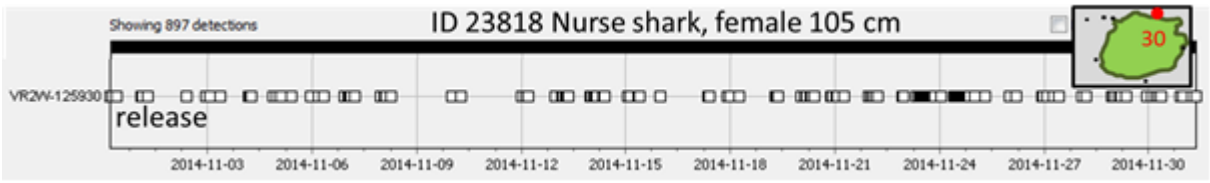

***Fig. 21**. Detections of tag ID 23818, a female Nurse shark of 105 cm. Legend map see Fig. 12.*

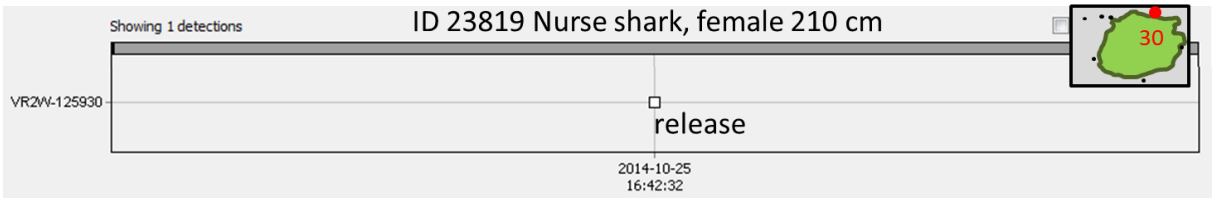

***Fig. 22**. Detections of tag ID 23819, a female Nurse shark of 210 cm. Legend map see Fig. 12.*

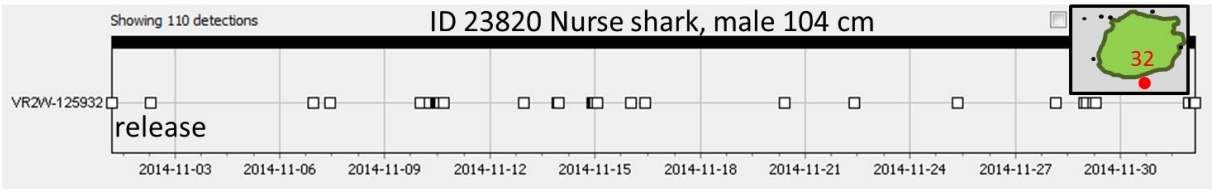

***Fig. 23**. Detections of tag ID 23820, a male Nurse shark of 104 cm. Legend map see Fig. 12.*

The three smaller juvenile nurse sharks were detected throughout the month November with hundreds of detections.

The first findings of detections for nurse sharks limited to only one receiver suggest a strong site fidelity and a spatial use on even a smaller scale than observed for the Caribbean sharks. This appeared for the three smaller juvenile nurse sharks, whereas the spatial use of the larger probably adult female nurse shark is still unclear since it was only detected directly after release and not anymore thereafter. It has obviously swam out of the detection range of the receiver where it was caught and released but its faith thereafter remains unknown as of yet.

5 Outreach and communication

The pilot study was carried out in cooperation with local nature conservation agencies (Saba Conservation Foundation and Nature Foundation St Maarten) and local fishermen. The set-up and first fieldwork of this pilot shark study, together with work for the Caribbean Shark Management Plan (lead researcher Ingrid van Beek) and BRUV remote camera studies (lead researcher Martin de Graaf) was presented at 27 October as part of the Sea & Learn program for October 2014 (fig. 24). Chizzilala Productions (Video Productions for the Caribbean, www.chizzilala.com) filmed the fieldwork and recorded interviews on the pilot shark study (Fig. 24). Sea & Learn on Saba 2014 TV report is available to view online (https://vimeo.com/111405565). The footage and interviews are also used for the documentary on the shark protection plan "Sharks Demystified" which is broadcasted on the local Saba TV and online available (https://vimeo.com/119110462).

Fig. 24. *The field work was documented by Adam from Chizzilala productions for a TV report on Sea & Learn (left) and "Sharks Demystified" and a presentation on the shark study was given by Erwin Winter on Sea & Learn (right, photo Adam Watkins, Chizzilala Productions).*

6 Discussion and preliminary conclusions

The pilot study on behaviour of sharks around Saba so far proved to be very successful in terms of cooperation with local organisations, selecting successful catching methods for sharks, getting sufficient numbers of sharks for the pilot study, the deployment and placing of the receivers, and yielding good results during the first 6 weeks of the study.

Catching Caribbean reef sharks around Saba required less effort (where rod and line proved most favourable) than catching nurse sharks. For nurse sharks, catching with long-lines during night and making use of sharks that are bycaught in lobster pots might be the most effective way to get sufficient numbers in future studies. Whether this is due to differences in densities or behaviour between the two species is not clear, but presumably both play a role in this.

Using the shark observation frequencies derived from the Dutch Caribbean Biodiversity Database (provided by scuba diving from Sea Saba) we were able to identify the optimal locations for receiver placement. Data from citizen science projects like this proved to be very valuable when designing a set-up for telemetry studies. In later integral analyses of shark data, it will probably be very useful as well.

All tagged sharks were detected at least at one receiver and at each receiver one or more sharks were detected. Only one nurse shark has been detected once. In general, nurse shark detections were less frequent than Caribbean reef shark detections.

This lower number of detections for nurse sharks than found on average for the Caribbean reef sharks might be related to their behaviour. Nurse sharks spend considerable time hiding in crevasses of the reef and swim very close to the reef or bottom. This might result in a substantial larger part of the signals being blocked by obstacles in between the transmitter and receiver, such as rocks or coral reef, than for a more pelagic swimming species like the Caribbean reef shark. Although other explanations like temporarily being outside the detection range are also likely. Most probably both explanations occur. Although telemetry has been successfully used for nurse shark research (Ferreira et al., 2013) we will do additional measurements to test this hypothesis during the next field study in October/November 2015.

The results of the read-out of the first six weeks suggest that most of the nurse sharks and Caribbean reef sharks show high site fidelity. Most of the Caribbean reef sharks were seen throughout the six weeks and usually only at a few adjacent locations, where the pinnacles (receivers 26 and 27) were frequented more often than other sites. So far, only two Caribbean reef sharks appear to use a larger proportion of the reefs around Saba. For the smaller juvenile nurse sharks there appears to be an even more local use of the reefs around Saba, since all three were only detected throughout the period at one single location. The spatial behaviour of the large probably adult female nurse shark remains unclear as of yet, since it was only detected directly after release and not anymore thereafter.

With respect to the goals set for this pilot study, we can conclude that so far goal 1) 'obtain experience with using existing infrastructure and organisations in setting up a shark telemetric study' has been successful. The mooring line infrastructure around the island proved very helpful in building the array and we received much support from local organisations; goal 2) 'obtain experience in catching methods and insight in effort needed for these target shark species' has been achieved as well; goal 3) 'obtain a first indication of the scale of individual movement patterns in time'. The first results are promising and indicate very local use for both species. Getting the (multi) year-round data later on in this study will make this more clear; and goal 4) 'raise local awareness of importance of sharks' worked well, in addition to the wide support we received from local organisations also because the timing of the fieldwork coincided with ongoing local initiatives such as the Sea & Learn event and TV-reporting for this event and a documentary on shark protection plan.

For the coming year(s) these sharks will yield more data on year-round habitat use. This insight in habitat use is important for the successful establishment of a shark sanctuary. During the coming fieldwork we will also use a mobile receiver to research if tagged sharks are present at the reefs around Saba in between detection stations. Individuals with very local habitat use but being present outside the detection ranges of the array of receivers will then also be located.

To answer the research questions about dispersal, migration, connectivity and meta-population structure we aim to expand the telemetry study to the Saba Bank and given sufficient budget also surrounding islands of St. Eustatius and St. Maarten in 2015. Furthermore, the findings of the read-out in Oct/Nov 2015 will be analysed together with the shark observations in the fish monitoring studies from 2012-2014 at the Saba Bank (Stoffers, 2014), Saba (Looijengoed, 2013) and St. Eustatius (van Kuijk, 2013).

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8 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 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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Approved: Ir. O.A. van Keeken
Researcher

Signature:

Date: 13-2-2015

Approved: Drs. J.H.M. Schobben
Head of Department Fish

Signature:

Date: 13-2-2015

All photos are from Erwin Winter unless stated otherwise.