Ten-year assessment of Caribbean Netherlands fisheries monitoring: data challenges and recommendations

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Summary

Over the last 10 years, the Caribbean Netherlands fisheries on Saba and St. Eustatius have been monitored and multiple assessment reports have been made by Wageningen Marine Research (WMR) in collaboration with local Data Monitoring Officers (DMOs). However, due to challenges in collecting the necessary data, there are gaps in the data which can lead to large uncertainties in the current stock assessments and make it difficult to deliver a more detailed assessment of the fisheries and the state of the stocks.

The specific objectives of this report were to present the data challenges and provide recommendations to address the shortcomings in the current data collection. By addressing these and providing solutions, improvements of the Caribbean Netherlands fisheries monitoring program can be made.

The main gaps identified in the data are:

- Limited coverage by the logbook data, especially the case in St. Eustatius. This implies that large raising factors are applied when estimating total effort and landing estimates, which leads to more uncertain estimates.
- Landings not reported by species (at least for the main species) and port sampling for species composition not frequent enough to be able to produce landing estimates and abundance indices at the species level (instead of species groups). For instance in Saba, the number of trips sampled to estimate the length-composition of the landings was on average 60 per year (excluding 2011), with mainly lobster and redfish trips being sampled. On average, around 40 trips per year were sampled for species composition, taken representatively from the different fishing methods. This is less than one catch sampled per week. This is too low and needs to be intensified if data availability and quality are to improve.
- While some species are over-sampled for length-composition, others are not sampled enough to be able to compute reliable length-based indicators.

Our key recommendations are:

- Port sampling and biological data collection-frequency must be stepped up to meet minimum targets.
- Going along with fishers on the vessels, in order to measure catches on location. (Then fishermen won’t have to wait at the harbor for the DMOs work to be done.)
- Facilitate working in morning/midday/evening shifts. This enables data collection after regular working hours, e.g. when fishers come home late in the day (5-6pm).
- Set quantitative targets for data collection. We suggest targeting for a minimum of 70% logbook declarations, activity surveys, catch species composition and weight data (tonnes), while doubling the effort on selected species of importance
- Data collection will now need to include exact biometric data to establish length-weight and fecundity curves, sex ratios and reproductive seasons for individual species, as well as the collection of otoliths from a range of sizes for each species as a basis for age and growth studies by the WMR otolith lab.
- Have DMOs sit in a workspace with a clear view of the harbor where fishers arrive with their catches, so they can immediately act when boats arrive with their catches. This is mainly an issue for the St. Eustatius DMO.
- For bycatch measurements photographing the fish on a cm grid surface can save measuring time in port or on vessels.
- Increase willingness of fishers to participate in data collection.
- Incentivize fishers to participate by organizing regular (bimonthly or quarterly) get-togethers where the DMOs update fishers on some monitoring results, providing snacks and drinks.
- Provide dedicated freezer storage space for fishers at the harbor, enabling DMOs more time for the port sampling. Fishers willingness to wait for port sampling is understandably limited. By providing dedicated freezer storage facility, the DMOs can take extra time needed for sufficient biological sampling (i.e. species composition, length, sex) while the catch of the fishers stays fresh. The same can be done for lobster catches if a port-based holding area is provided.

- Provide modern technologies to the fishers and/or DMOs, e.g. Electronic Reporting Systems (ERS) such as electronic logbooks, and GPS systems such as the Vessel Monitoring System (VMS).
- Arrange for closer involvement of WMR in work planning for the island DMO’s.

1 Introduction

Healthy coral reef ecosystems and sustainable fisheries are of utmost importance for the small island economies of Bonaire, Saba and St. Eustatius. In the Caribbean Netherlands, fisheries have a modest contribution to the GDP (1%; ~350 million (www.cbs.nl)), while the contribution of healthy coral reefs to the touristic and diving sector are manyfold greater. Fishing constitutes one of the greatest locally manageable anthropogenic impacts in the reef ecosystem and management of fisheries to prevent overfishing is hence essential to coral reef ecosystem health. Not surprisingly, healthier coral reefs and fish stocks are generally found in areas that have limited fishing or well-developed conservation and fisheries management, regulation and compliance (Jackson et al., 2014 and references therein). In order to monitor and adjust fishing for both sustainable ecosystem health and optimal fish yield management, reliable data collection on fisheries catches and impacts is essential. This is the basis for the necessary insight in local fisheries, for guidance to sustainable fisheries and for sustainable coral reef management. Importantly, simplifying and standardizing monitoring and ensuring regular data collection will help adaptive management by the responsible authorities of the Caribbean Netherlands. Since 2012, WMR (then named IMARES) has been commissioned by the Netherlands Ministry of Agriculture, Nature and Food Quality to work with local organizations on baseline marine resource studies and the development and implementation of robust, efficient and (internationally) standardized monitoring programs for fisheries and coral reef health indicators in the Caribbean Netherlands. As part of this activity, a fisheries research program was initiated for Saba and St. Eustatius, and data collection has since then been continued by the Saba Bank Management Unit and the St. Eustatius Data Monitoring Officers (DMOs) funded by the same ministry. This data collection program is primarily based on surveys of the fishing activity, describing effort and landings, complemented by biological sampling of the landings (at present only species composition and length measurements).

For Saba, such fisheries port-sampling data covers the period 2011 to 2021 and previous reports have presented assessments of the status of its commercial fisheries which all take place on and around the Saba Bank and are based on a fulltime fleet of about 10 diesel-driven Maine lobster boats (de Graaf et al. 2017; Brunel et al. 2018; Brunel et al. 2021). The Saba Bank is a 2200 km^2 shallow bank area that lies fully within the Dutch Kingdom's Caribbean exclusive economic zone (EEZ) waters. In recent years it has gained international recognition as an area of exceptional biodiversity value and been accorded increasingly higher and more extensive conservation status. However, previous studies on the Saba Bank ecosystem have raised concerns about the impact of fisheries on the main stocks, e.g. the depletion of large groupers (Meesters et al. 1996; Toller et al. 2010) and small catch-size of snappers (Dilrosun 2000; Toller and Lundvall 2008). For St. Eustatius, the fisheries port sampling data has been previously reported in De Graaf et al. (2015), Brunel et al. (2020) and Amelot et al. (2021). St. Eustatius is located in the north-eastern Caribbean, 27 km to the south-east of Saba, and is surrounded by the 2700-ha St. Eustatius National Marine Park (SNMP). A fleet of about 20 open, outboard-powered fishing boats operates here, although less than 5 boats fish actively full-time. Other vessels do so on a part-time recreational or subsistence basis.

For both Saba and St. Eustatius the main fishing métier is trap fishing, targeting spiny lobster and mixed reef fish. A trap fishery targeting snapper species is also conducted in deeper parts of Saba Bank. On St. Eustatius, spiny lobster, reef fish and conch are caught using different methods of free diving or scuba diving (spear gun/snare). The fleets also have different line fisheries, among which are trolling for large pelagic fish and bottom handlining. The Caribbean Netherlands has the potential to develop its sustainable fisheries further and increase the socio-economic benefits by means of well-developed fisheries management (Debrot and de Graaf, 2017; Debrot and van der Burg, 2019; Lotz et al., 2020). However, better management also requires better data and current fisheries monitoring needs to improve in order to better support management for sustainable development of the full potential of the Caribbean Netherlands Fisheries. As indicated previously in various reports (Debrot and de Graaf 2017, Brunel et al. 2018, Brunel et al. 2020, Brunel et al. 2021, Amelot et al. 2021) the data on fish stocks and fisheries in the Caribbean Netherlands is largely fragmentary or incomplete which greatly restricts its utility.

Evaluation of data collection can only be conducted within the context of principal fisheries management needs. This is because management needs define data requirements (in terms the nature of the data, its accuracy, and quantity). In turn, data requirements define what improvements in data collection may or may not be necessary to meet those requirements.

The objectives of this report are six-fold:

1) describe the current data collection approach,
2) provide an indication of what the data is already useful for,
3) describe additional or new data needs that are required to successfully address key management questions but which are not met under the current data collection approach.
4) discuss the challenges in data collection
5) describe any principal gaps and shortcomings to more reliable data analyses, and
6) provide a list of recommendations to improve data collection so that it can meet any more stringent data requirements.

By addressing these issues and identifying solutions to the data collection challenges, better data will allow more useful and accurate analyses which can form the basis for a more optimal fisheries management.

2 Data collection

2.1 Data collection protocol

Sample-based fishery surveys (Stamatopoulos, 2002) were implemented in September 2011 to collect basic data on catch, effort, species composition and length frequency of the fishery on the Saba Bank and in St. Eustatius. The data collection system was set up and run by WMR until November 2017. Since then, fisheries monitoring is being conducted by Saba Bank Management Unit and the St. Eustatius Data Monitoring Officers (DMOs).

The sample-based fishery surveys consist of different monitoring activities:

- *Frame Surveys:* A frame survey is a census-based approach to collate a list of homeports and boat/gear categories which is used as the basis for the Active Days, Boat Activity and Landings surveys.
- *Boat Activity Surveys:* Boat Activity Surveys serve to determine how many boats were active on a given day. This is done by observing which boats have left the harbour on a given day.
- *Landings Surveys:* For this, fishers are requested to fill in a form (thereafter referred to as logbook) with information on the catch of the trip (by generic species groups) and on the fishing operations (number of gears, location…). In addition to the standard landings data, information is also collected on the observations of lionfish, sharks, whales, and dolphins by the fishers.

In addition to this survey-based data collection for effort and landing, biological sampling is also conducted, both at the landing site and onboard. For a number of fishing trips, the landings (at the harbour) or catch (onboard) species composition is determined, and length measurements are taken.

2.2 Practical and operational challenges

On Saba there are currently two DMOs employed, while St. Eustatius has one DMO employed. The DMOs core task is to collect fisheries data and conduct fisheries port sampling. However, in practice the DMOs are asked to conduct and/or participate in a wide array of other activities.

On Saba, the two DMOs collect data principally by meeting fishers boats at the harbor as soon as they arrive with their catch. Interviews are conducted with willing fishers, to gather information on their fishing trip (details on the fishing operation, gears, location, and catches of groups of species). Biological sampling is conducted as fishers clean their boat and sort and pack their catch. In addition, a daily boat activity survey is conducted by counting the boats that leave the harbor each day.

On St. Eustatius, one DMO collects data by conducting a daily boat activity survey and port sampling interviews with willing fishers. Port sampling interviews are conducted either when a fisherman returns from a trip during which either a short or long interview is done, or a few hours or days after the fisherman returns during which a short interview is then done.

Due to their many other activities and tasks DMOs are often unable to fully commit to this work.
In addition, efficient and rapid data collection in port requires at least two or more people, depending on the data being collected. Usually, fish species composition and length measurements needs two people to make the work more time-efficient. Data collection by only one person measuring and recording data (as is now done on St. Eustatius) is difficult and time-consuming, which can deter fishers from participating. In addition, if the DMO joins a fisherman on a trip, data collection from fishers who return while the DMO is at sea is not possible.

Fishers willingness to participate in the data collection is another challenge DMOs have to face. Fishers have experienced significant interview fatigue from researchers over the years "hounding" them for access to their catch for research purposes while gaining nothing in return. More needs to be done to explain and show the results of the fisheries monitoring programs on the islands. Fishers put in a lot of effort (both physical and financial) into their craft and do not turn a profit from every trip. An incentives program might help to encourage willing participation.

2.3 Data analyses: methods and current limitations

2.3.1 Estimation of total catches and effort per fishery

Annual catches and effort are currently estimated per gear type for both Saba and St. Eustatius (see Brunel et al. (2021) and Amelot et al. (2021) for the latest estimations). The estimation is done at the scale of the month as summarised in figure 1 and 2. In Saba (Figure 1), calculations are done for each vessel. The effort is computed as the monthly number of trips carried out with each fishing gear, calculated based on the number of trips carried out (estimated from the boat activity survey) and the frequency with which each gear type was used (from the log-book information). Monthly average catch rates for each fishing gear (landings per trips) are also calculated from the log-book and multiplied (raised) by the (estimated) effort per gear to obtain the monthly landings. Species landings per trips are reported by species categories (spiny lobster, mixed reef fish bycatch, redfish, conchs).
In St. Eustatius, raising cannot be done at the vessel level because not all boats fill in logbooks. Therefore, an average catch rate per gear type and species categories is calculated across boats that fill in log-books and extrapolated to the whole fleet.

Finally, for both islands, the number of trips carried out per month for each vessel, based on the boat activity survey, is also the outcome of a raising procedure: the boat activity survey is not necessarily conducted every day of the month, and assumptions have to be made for the activity during the days without observation. The less complete and more variable the data, the greater the potential error that is introduced in these different "raising" steps.

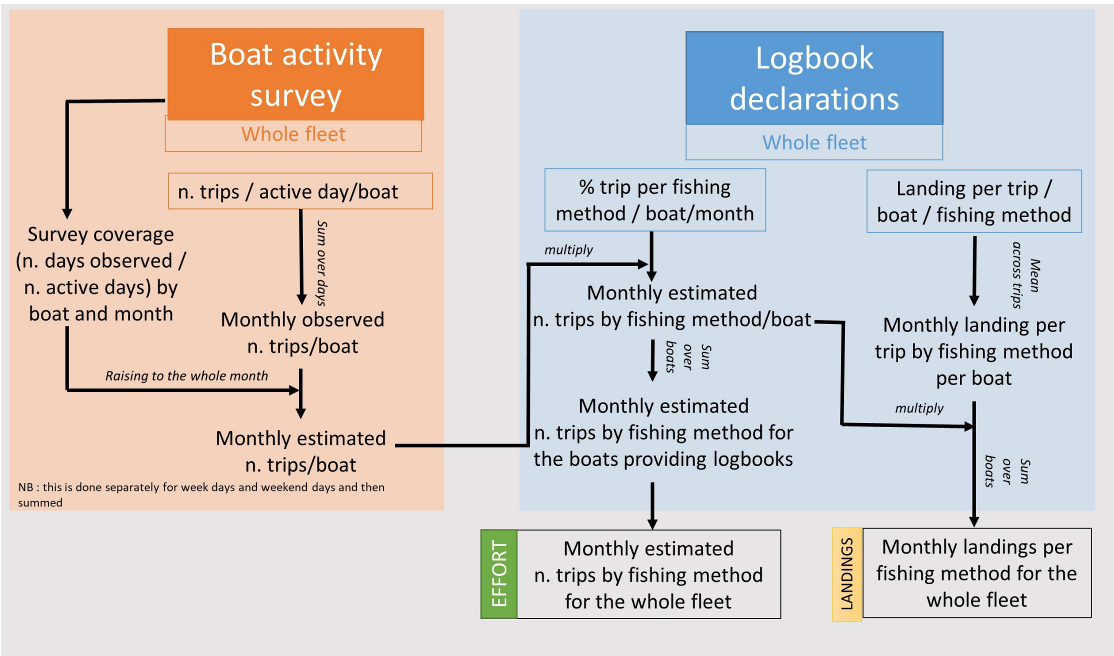

Figure 1 *'Raisings' procedure for the estimation for the monthly effort and landings per species category and 'métier' (fishing method) for Saba.*

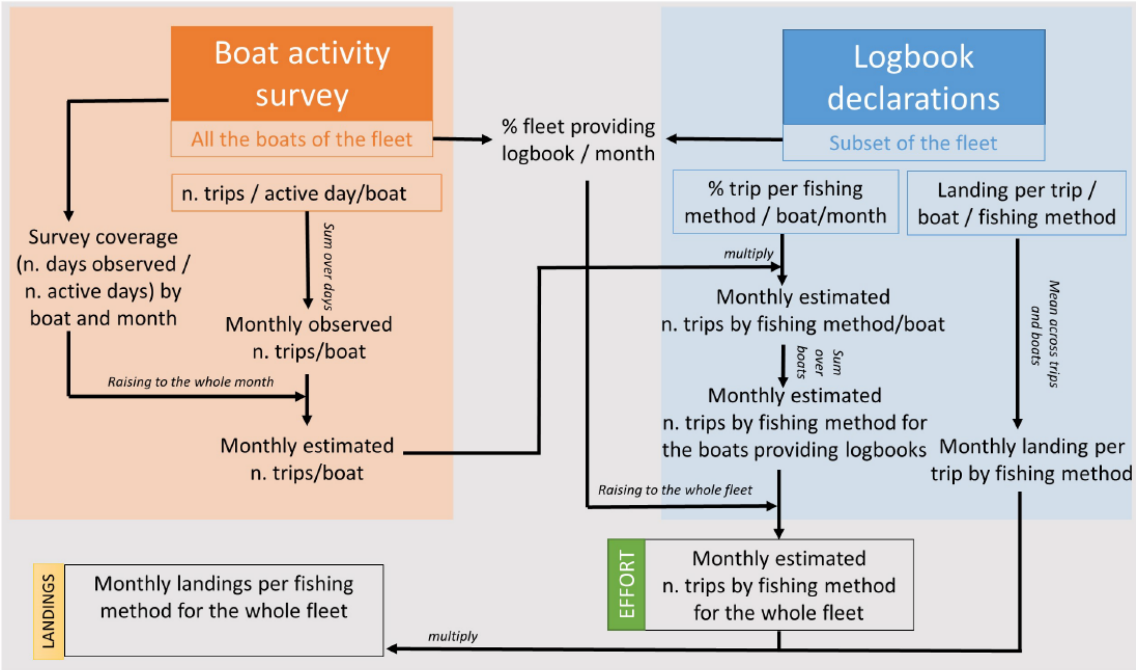

Figure 2: *'Raisings' procedure for the estimation for the monthly effort and landings per species category and 'métier' (fishing method) for St. Eustatius.*

The coverage of the fishing activity by the data monitoring program, both in terms of days and in term of number of vessels, is not exhaustive and there are gaps, and occasionally major hiatuses in the data collected (see section 3.1 and 3.2). How to properly correct for this missing data so as to be able to estimate the total effort, and hence the total catch, therefore requires a number of raising steps, which each introduce some uncertainty in the quantities estimated. Although this uncertainty is not currently well quantified, it is expected that it can sometimes be very large, given the proportion of what is unknown and therefore has to be assumed. Table 1 provides a list of the different types of data gaps, the corresponding raising steps and related assumptions made.

Table 1 : raising steps and related assumptions made for the estimation of effort and catches

Data limitation	Raising step	Assumption
Incomplete effort monitoring (active day survey)	Raising the observed fishing days to total number of days in the month	Same activity for the days without observation as for the days with observation
Incomplete coverage of the monthly activity and catches of a given boat by the logbooks	Effort and catches per gear for the observed days for a given vessel raised to the total number of days fished by this boat in the month	Activity and catch rates for the days with logbook are representative of the whole month
Incomplete coverage of the fleet for the logbooks (St. Eutatius)	Effort and catches of the fleet with observation are raised to the whole fleet	The boats that do not fill in logbooks have the same activity and catch rates as the average of the boat that fill in logbooks

2.3.2 Indicator for exploitation status (F/Fmsy proxy)

The length measurement data are used to establish the annual length frequency composition of the catches for the main species caught. Then, the length-based indicator (part of the ICES Data Limited Stock methods (ICES, 2018)), relying on the calculation of the mean length for the catches, is applied to these length frequencies to provide a proxy for the ratio of F/F_{MSY}. This proxy gives an indication of the level of exploitation of the stock with respect to the target level corresponding to MSY. Currently, this indicator is calculated for the lobster stock, the main reef fish species and (only for Saba) the four main snapper species.

For the fisheries from Saba, for the two main species - spiny lobster and silk snapper- the sampling intensity is high and the length based indicators can be calculated with a small level of uncertainty. Aside from the silk snapper, the other three less abundant snappers for which there are some data (vermillion, blackfin and lane snappers), there are occasional gaps for some years (no proxy for F/FMSY can be computed) or years with very few measurements (proxy has a large confidence interval, see Brunel et al. 2021). The situation is slightly worse for the reef fish species, for which the length based indicators can be calculated only for three species (Queen triggerfish, the Red hind and the White grunt) and even so only with big data gaps and/or large confidence intervals.

For the fisheries from St. Eustatius, the spiny lobster is also in a data-rich situation, and the situation for the reef fish is similarly poor as for Saba, with occasional years with very low sampling, even for the main species (see Amelot et al., 2021).

Apart from the limitations related to availability of length samples, an additional source of uncertainty comes from the life history parameters (growth) that are used as input for the F/F_{MSY} proxy estimations. Due to the lack of growth parameters estimates for the Saba/St. Eustatius area, the latest analyses by Brunel et al. (2021) and Amelot et al. (2021) used parameters from other areas of the Caribbean, as obtained from the literature (see Annex 2 in Amelot et al., 2021). However there are big differences in the value of these parameters between regions, between fish species or even between different populations (eg, Boman et al. 2018) Therefore, to improve the modelling exercises we really need to determine local parameter values for more accurate modelling (see reports by Amelot et al. 2021 and Brunel et al. 2021). This means that better and more biometric data will be needed on individual species of key interest. Data collection will now need to include exact biometric data to establish length-weight and fecundity curves, sex ratios and reproductive seasons for individual species, as well as the collection of otoliths from a range of sizes for each species as a basis for age and growth studies by the WMR otolith lab.

For the Saba Bank, the species of special interest are the snappers *Lutjanus buccanella, L. vivanus, L synagris, Pristipomoides aquilonaris, Rhomboplites aurorubens* and *Etelis oculatus*, the grouper *Epinephelus guttatus* and the triggerfish *Balistes vetula*. For St. Eustatius the species of special interest include the groupers *Epinephelus guttatus, Cephalophilis cruentatus, C. fulva*, and the triggerfish *Balistes vetula*.

2.3.3 Stock biomass/abundance indicators

Abundance and biomass indicators are obtained by standardizing the landings-per-unit-effort reported (LPUE) in the logbooks during the interviews. The standardization is done using a statistical model (GLM) that separates the effect of the year on the LPUE, which can be ascribed to interannual variations in abundance/biomass, from the effect of other factors affecting the landings, such as number of gear, season, boat and location. Models are fitted for the main fisheries, but since the landings are reported for groups of species (mixed reef fish, redfish, pelagic fish), it is not possible to do the analysis at the species level (except for the spiny lobster). As different species which may have totally different dynamics are mixed for analysis the results for individual species may be totally different from the "overall" trend. This means that for reliable assessment different sampling intensities and hence different raising factors are needed for the different species while the highest sampling intensity will be needed for the rarer species. Finally, another limitation is that for the smaller fisheries (bottom long-line, trolling), with a low fishing effort, the number of logbooks is too low to fit a GLM model and it is not possible to compute abundance/biomass indices.

2.3.4 Description of species composition

Port sampling is conducted to among others establish the species composition of the landings. There is also a number of trips with sampling conducted at sea, giving information on the composition of the catch, including the discards. This information is currently not used for any analysis, and is simply presented in the form of pie-charts depicting landing and discards species composition in weight and numbers on average over the years.

If data resolution allowed, species composition data could potentially be used to compute annual landing estimates and abundance indices at the species level, instead of the “species group” level, thereby providing a much better diagnostic on the state of the resource in both islands.

3 Overview of data collection intensity and identification of potential gaps

3.1 Fishing days

For Saba, Figure 3 shows the coverage rate of the fishing activity survey per month (numbers of days with observation in the harbor divided by the number of days in the month). Coverage for the individual week days was good, and largely at 75-100%. But for weekends coverage was much lower and raised estimates of effort become more uncertain (high raising factor applied to a small number of observations). However, the activity level is usually low in the weekend, so this uncertainty is expected to have a small impact on the raised number of fishing days, which are mainly based on the week days.

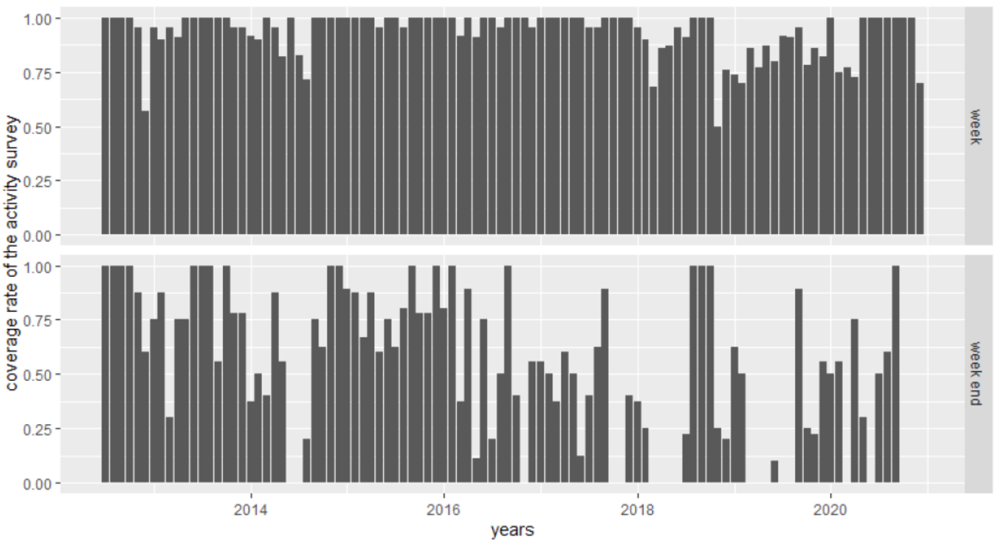

Figure 3: *Saba coverage rate of the activity survey.*

For St. Eustatius, figure 4 shows the coverage of the fishing activity survey. The survey coverage rate was typically around 40% for the period before 2018, but has since increased and has been close to 100% in the last three years. This is a positive development, which, if sustained, will result in a much better quantification of the fishing effort. Still, over the period 2012-2017 an assumption must be made that boat activity for the days without activity survey is similar to the activity for the days with surveys, leading to an extrapolation representing more than 50% of the effort over this period. There is also a gap for several months at the end of 2017-begin of 2018 during which no information was collected. To provide a catch estimate, it was assumed that the activity in these months was equal to the average across years for the same months, which introduces a very high level of uncertainty for the resulting estimates.

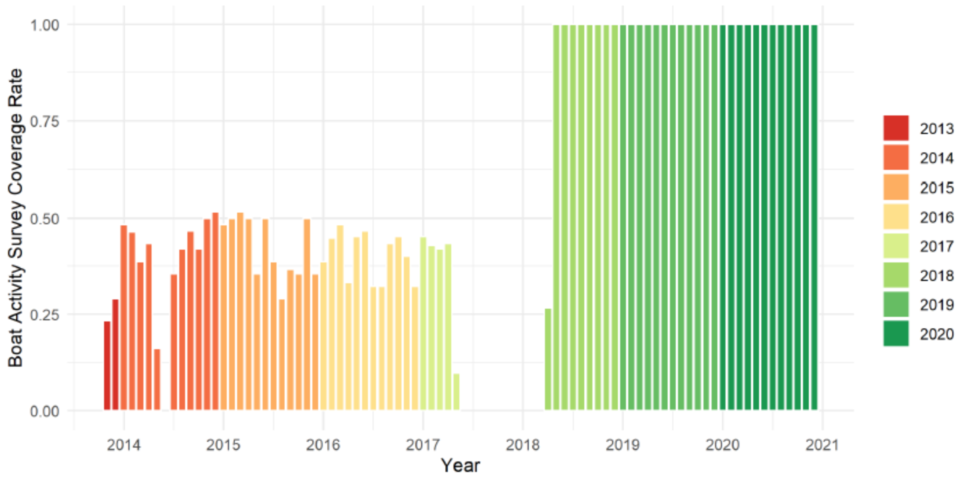

Figure 4: *St. Eustatius coverage rate of the boat activity survey.*

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3.2 Logbook information on fishing methods and landings

The logbooks delivered at the end of a fishing trip provide information on the type of fishery that has been conducted, the number of gear used (and other information of the fishing operations) and the resulting catches for different groups of species. These logbooks are filled-in during interviews with the fishers at the harbor at the end of a fishing trip. Due to the limited availability of both fishers and DMOs, logbooks do not provide an exhaustive coverage of all the fishing activity. In Saba, the number of logbooks annually filled-in represent between 25% (2019-2020) and 65% (2012) of the estimated annual number of fishing trips (figure 5). In St. Eustatius, the percentage of trips with logbook information is lower, with often less than 20% of the trips covered, but with higher values in the latest years (around 50%).

Hence, the situation differs between the two Islands. In Saba, there is usually logbook information from all the boats in each month, giving some idea of the activity and the landings for the whole fleet, although the number of logbooks delivered monthly can sometimes be low. In St. Eustatius, there is in each month a substantial part of the fleet that does not fill in any logbook. As a consequence, it remains unknown which type of fishery was carried out and what the resulting catches were (around 50% of trips on average, figure 6). This means that a raising factor of around 2 is applied to effort per gear and catch estimates of the vessel providing logbook to obtain total estimates, which introduces a large uncertainty.

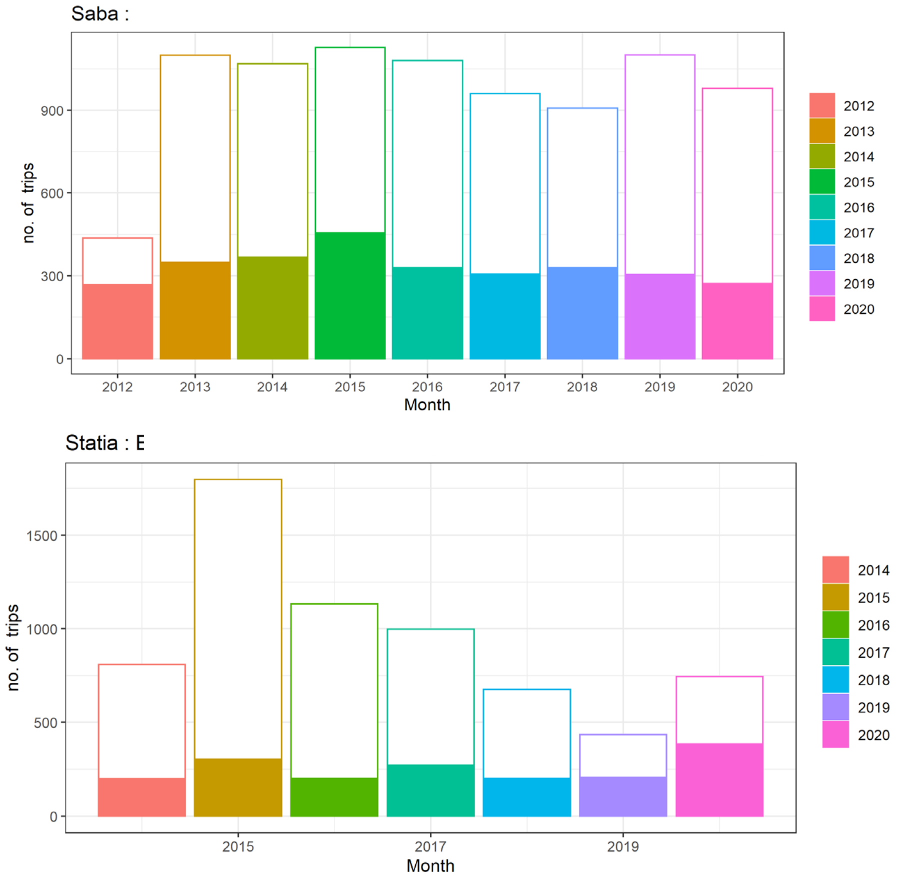


Figure 5: *Estimate of the annual number of fishing trips (empty bars) and total number of trips with logbooks (filled bars) for Saba (upper panel) and St. Eustatius (lower panel).*

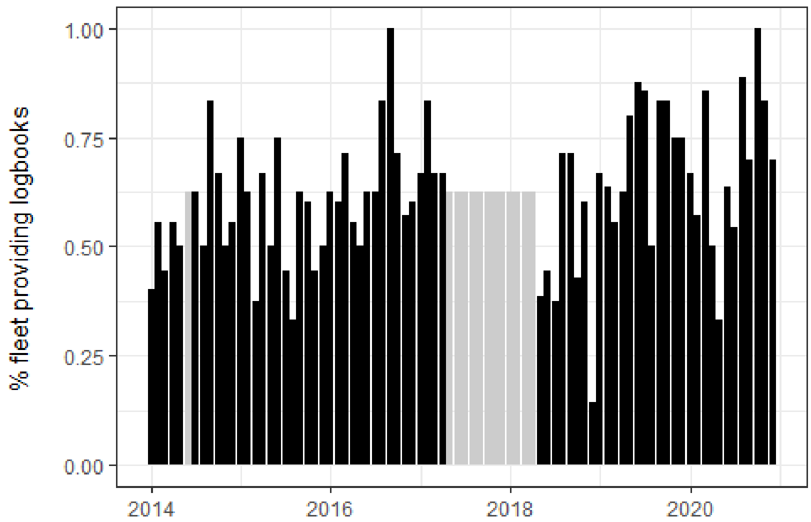
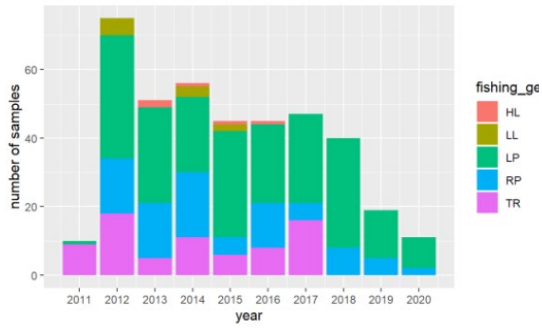


Figure 6: *Proportion of the active boats providing logbooks each month in St. Eustatius (in grey: for months without activity log, the mean value is assumed).*

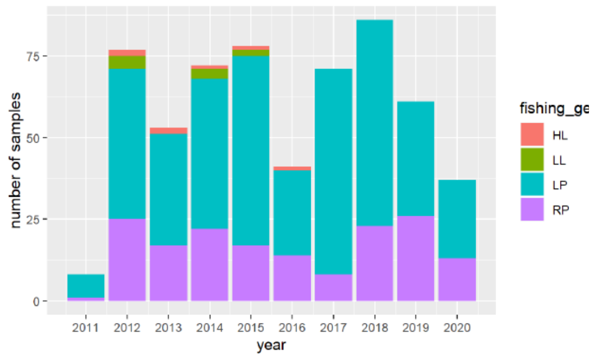
3.3 Biological sampling

In Saba, the number of trips sampled for landings length-composition of species was on average 60 per year (excluding 2011), with mainly lobster and redfish trips being sampled (Figure 7). On average, around 40 trips per year are sampled for species composition, taken representatively from the different fishing methods (Figure 7). However, for the last two years, the number of samples has been even much lower.

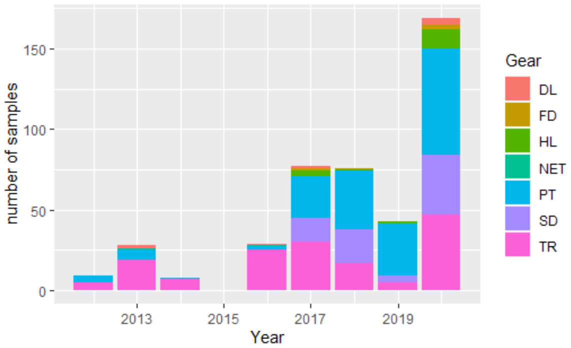
In St. Eustatius, the number of trips sampled for species composition has been very variable, with years without any (2015), or very limited (2012 and 2014) sampling and years with higher sampling (75 samples in 2017 and 2018 and up to 169 in 2020), for an overall mean of 55 samples per year. The number of trips sampled for length measurement has also been very variable, ranging from only 2 trips in 2011 to 162 in 2020. In addition, length composition data have generally not been linked to a trip number, making it impossible to know how many trips have been sampled, as some samples of (e.g.) fish and lobster come from the same trip.



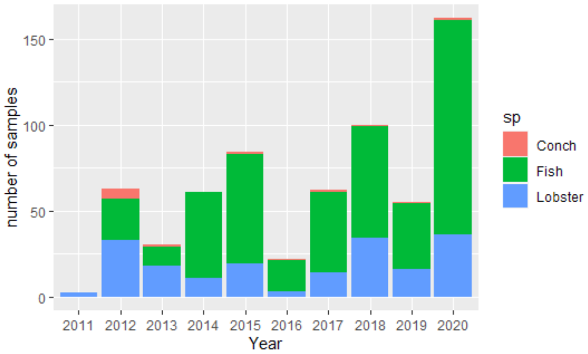
Number of fishing trips sampled for species composition in Saba.



Number of fishing trips sampled for length composition in Saba.



Number of fishing trips sampled for species composition in St. Eustatius.



Number of fishing trips sampled for length composition in St. Eustatius.

Figure 7: *Number of fishing trips samples for length and species composition per gear and year. Gear codes Saba : HL- handline; LL- longline; LP- lobster traps; RP : redfish traps; TR- trolling. Gear codes St. Eustatius : DL- dropline; FD- free diving; HL- handline; NET- nets ; PT- pots; SD- scuba diving; TR- trolling.*

3.4 Specifics per métier

3.4.1 Lobster Trap fishery

In Saba, biological sampling of the lobster fishery is conduced almost every month, but with a quite variable sampling intensity (figure 8). Length measurements are taken from samples representative of around 6% of the landings on average, while only 3% of the landings are sampled for species composition. Given the large landings, this sampling intensity corresponds to an annual number of lobster measured varying between 466 and 2,168 per year, which is well enough for an accurate description of the length-frequency distribution of the landings. Regarding the bycatch of reef fish, several species landed have more than 100 individuals measured on average per year which could potentially be enough to try to compute meaningful length-based indicators (these are currently computed only for the main three species). The species composition is however sampled less consistently with too many months with no or too little sampling, which makes it impossible to derive accurate estimates of the landings per species and accurate species-specific abundance indices.

In St. Eustatius (Figure 9), it is not possible to know the sampling intensity for lobster (information on fishing trips is not reported), but the number of lobster measured is usually over 300 per year, except in 2016 with only 66 measurements. The number of samples for the recent years (450 between 2017-2020) is sufficient to estimate fairly accurate length-based indicators for F/F_{MSY}. The sampling intensity for the reef fish caught in the traps in St. Eustatius is higher than in Saba, with samples representing around 10% of the landings between 2014 and 2018, and higher values in the last 2 years (up to 30% in 2020). For a number of species (7 species that dominate the landings), more than 100 individuals are measured on average per year, and the length-based indicators appear to be well estimated (see Amelot et al. 2021). The sampling for species composition started in 2018, and the recent levels are high, and occurs consistently throughout the year, which could open the possibility to conduct assessments at the species level.

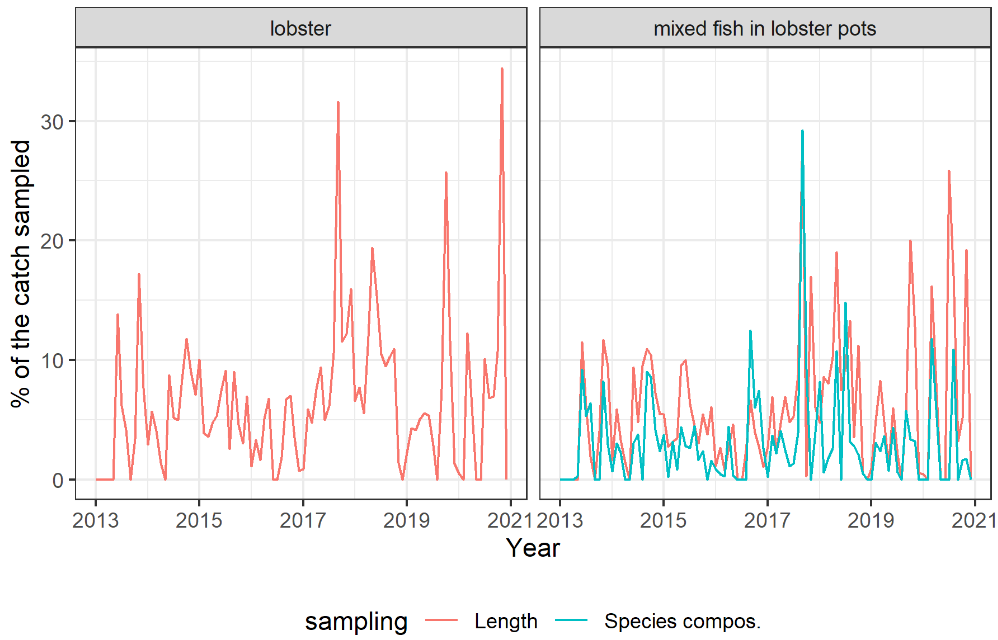


Figure 8: *Sampling intensity in the lobster trap fishery on Saba.*

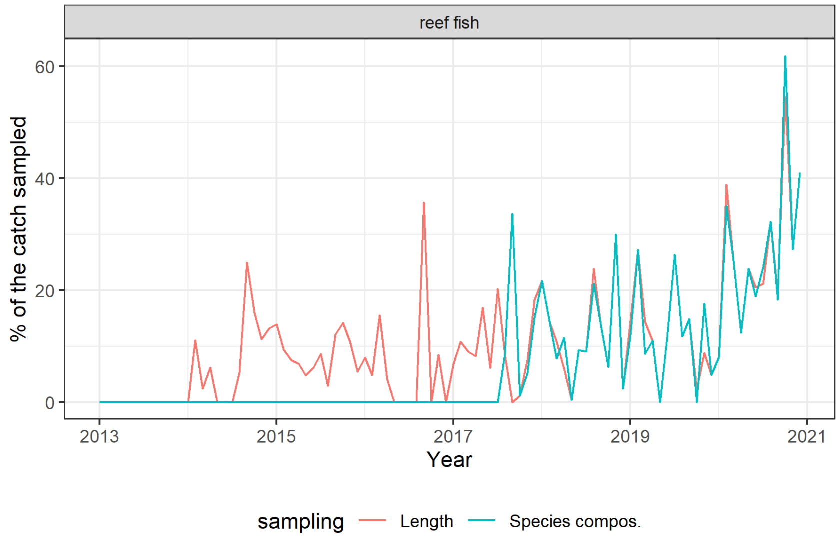


Figure 9: *Sampling intensity in the lobster trap fishery on St. Eustatius.*

3.4.2 Redfish trap fishery

This fishery takes place on the deeper parts of the Saba Bank and principally targets a mix of deep water snappers, with silk snapper (*Lutjanus vivanus*) representing 2/3 of the landings, and vermillion snapper (*Rhomboplites aurorubens*), blackfin snapper (*Lutjanus buccanella*) and lane snapper (*Lutjanus synagris*) representing the remaining 1/3 of the landings.

A major problem here is the limited ability to accurately estimate the status of individual redfish species. The level of biological sampling to estimate species composition is low for most of the months (the sampled landings represent on average 2% of the estimated monthly landings) and there are many months with no sampling (Figure 10). The level of sampling is too limited to be able to estimate total landings per species and to derive species specific abundance indices (standardized catch rates). Being able to split the landings per species, either by encouraging the fishers to report landings per species or by increasing the DMO intensity of biological sampling, will provide a significantly better framework with which to assess and manage the snapper stocks.

The sampling intensity for catch length composition is slightly higher (4% on average) than for species composition, especially since 2018, and there are fewer month with no sampling conducted. With the current sampling intensity, the main species landed (silk snapper) is highly sampled (on average, more than 2,000 per year), which allows for a good accuracy of the length-based indicators used as proxy for fishing mortality. The number of fish sampled for length-frequency for the less abundant species (blackfin, vermillion and lane snappers) is much lower, but remains high enough for a the blackfin and vermillion snapper (except for some years with lower sampling), but is often too low for the lane snapper. To achieve a better sampling of the lane snappers (and ensure enough samples are collected for the blackfin and vermillion snappers), additional directed sampling is needed for these species. If it is necessary to achieve a better sampling of these three species, the sampling effort on the silk snapper can be reduced without reducing the accuracy of the length-based indicator for this species.

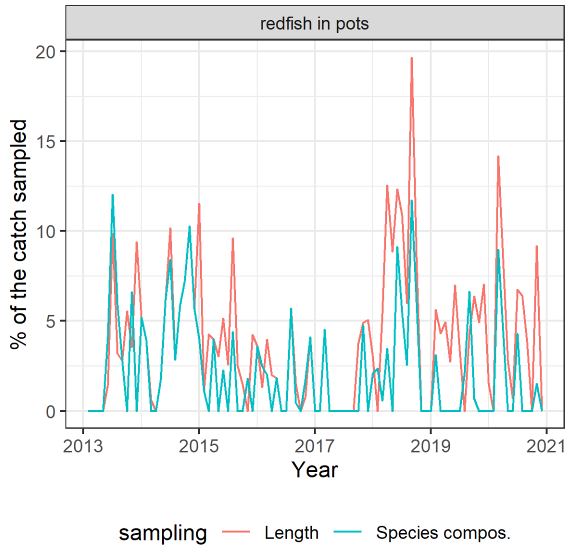


Figure 10: *Sampling intensity in the redfish fishery on Saba.*

3.4.3 Free diving and scuba diving fishery

The free diving and scuba diving fishery in St. Eustatius target lobster, reef fish and conch. This activity is often carried out in combination with another one (traps) in the same fishing day (occur for 22% and 26% of the fishing days, respectively). Diving accounts for 10% and 13%, for free diving and scuba diving respectively, of the total lobster landings, for 19% and 17% of the reef fish landings and all conch are taken by scuba diving. Information about the distribution of the landings between these three (groups of) species is available from the logbook data, in which they are reported separately. Analysis of these data shows that there are clear patterns in the activity, with trips targeting fish and lobsters and other trips targeting conchs (Amelot et al., 2021).

When estimating the landings of conch, it appeared that all the boats targeting conch were delivering logbooks, and that the third step of the raising (as described in table 1) was hence not needed. This could not be inferred from the data available to WMR, but was a conclusion made after discussions with the DMO's and the local fisheries managers who had the knowledge of the fishery and its activity. This is not per se indicative of any gap in data collection, but illustrates the necessity of a good communication between DMO's and WMR for a correct data analysis.

Although well-covered in the logbook (for the part of the fleet that fill them in), this métier is not used to derive abundance indices. The daily catch rates often show a large variability, which suggest that the activity (target species) is variable, and should be well described before any analysis of logbooks via modelling is attempted. Collecting information about the target species in the logbook would greatly facilitate this analysis.

Biological sampling is very low for the free diving activity (see figure 7). For scuba diving, there is a larger number of samples measured. As in St. Eustatius the information on fishing trip is not present in the length-sampling data for lobster and conch, sampling intensity is unknown. For reef fish the sampling intensity is very irregular, with many months without any sampling, and occasionally very high sampling rate (see Figure 11, occasional sampling rates higher than 100% are due to uncertainty in total landing estimates). There is currently no attempt to derive length-based indicators for these fisheries as it is not sure if these methods are applicable in the case of spearfishing activities. For this activity too, a higher sampling to estimate species composition, or alternatively a declaration of the landings by species (at least for the main species) by the fishers is necessary to make estimates of landings by species.

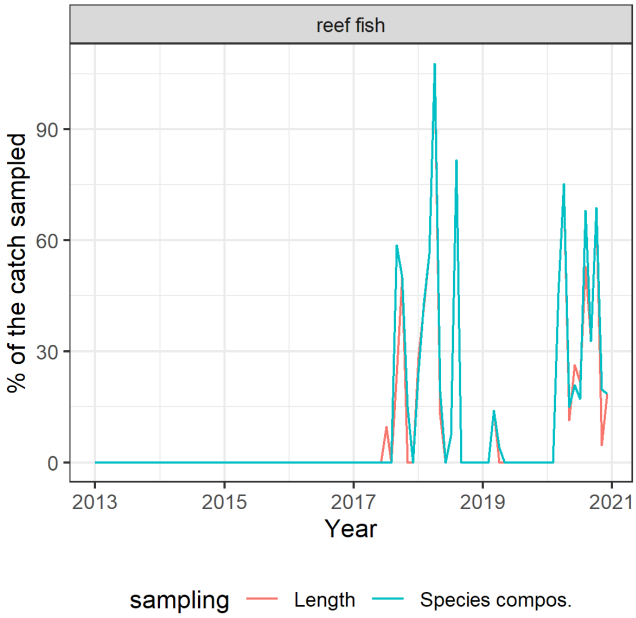


Figure 11: *Sampling intensity in the redfish fishery on St. Eustatius.*

Estimates of landings of conch in the scuba diving fishery were highly variable, ranging from an estimated 1,420 individuals in 2014 to 8257 in 2020. Although consultation with local experts affirmed that all vessels involved in this fishery were delivering logbooks, these estimates are also likely to be fairly uncertain, due to the lack of information from logbooks in some years. The particularly low value in 2014 is explained by the fact that landings of conch were only registered in the logbook data for four months of the year, and it is unknown whether it was because there were no trips targeting conch during the rest of the year, or because no logbooks from conch trips were available.

The Saba Bank monitoring does not cover conch as there is no current fishery for this species on the bank. Due to the *de facto* closure of the conch fishery on the Saba Bank in the mid-1990s the queen conch population has recovered and De Graaf et al. (2017) concludes that that at present a controlled limited fishery should well be possible, if judiciously controlled and regulated.

3.4.4 Pelagic fishery

A pelagic fishery is also developing both at Saba and St. Eustatius whereas most fishery activity in the past has traditionally targeted demersal species using traps. Whereas the catch of the lobster fishery is practically all exported, the pelagic fishery provides some of the key species for local consumption, namely wahoo (*Acanthocybium solandri*), dolphinfish (*Coryphaena hippurus*) and tuna. Tropical pelagic fisheries overall are able to sustain a higher yield than (the limited) coral reef fisheries and represent a major potential for fisheries transformation and expansion for Caribbean Netherlands (Debrot and van der Burg, 2019; Lotz et al., 2020). Current data collection on this métier is low and a proper assessment of developments or potential are almost impossible. Data collection needs to be greatly improved.
Boats returning from pelagic fishing trips arrive after office hours, which makes it difficult to conduct logbook interviews or sample the landings when adhering strictly to office hours. Due to the scarcity of data, catch per unit effort estimates in the recorded number of trips in Saba by Brunel *et al.* (2021) are highly variable from year to year, between and within months, and landings per trip estimates also showed a high uncertainty. As a result, interannual variations in the landings per trip could not indicate any specific trend. Intensification of sampling of these developing and expanding fisheries is essential and will require a more flexible approach to the distribution of daily working hours.

Species composition in Saba mainly consists of dolphinfish and wahoo, while tuna species represent only 3% of the landings in number and no length measurement were available for the tunas. This fishery needs more targeted sampling effort to achieve a better data collection. For example, since the landings are composed of mainly three groups of species, logbooks for trolling trips could be adapted to have the landings report by species. Information on the species composition is often provided as "comments" in the logbooks, which makes them difficult to use quantitatively. Formal sampling for species and length composition is very anecdotal (Figure 12). There has been no sampling since 2017. In St. Eustatius, pelagic fish are also mainly caught by trolling, although there is also some catches from handlines and droplines on Fish Attracting Devices anchored off-shore (FADs). The sampling for species composition is very variable, but with occasionally a high coverage of the total catches (Figure 13). There is very little sampling for length measurements, although this improved markedly in 2020 and 2021.

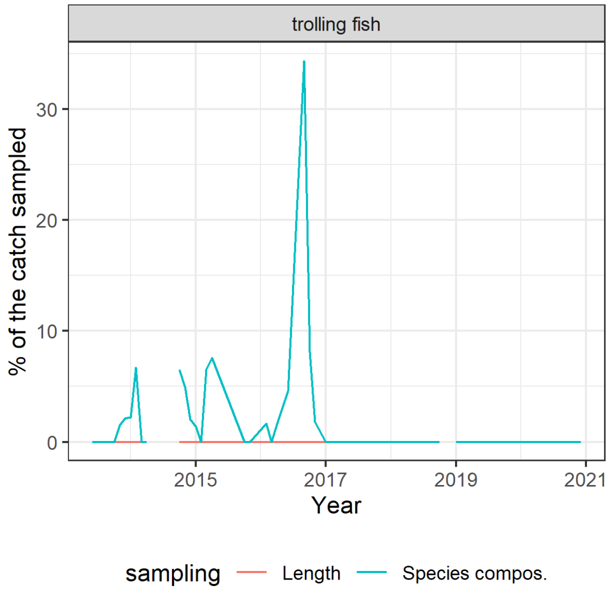


Figure 12: *Sampling intensity in the trolling fishery on Saba.*

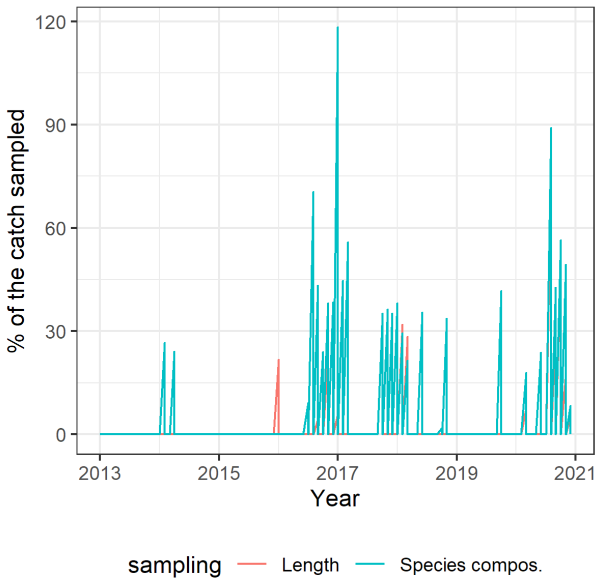


Figure 13: *Sampling intensity in the trolling fishery on St. Eustatius.*

3.4.5 Bottom-drop longline fishery

Bottom-drop longline fishery at Saba represents only 0.5 to 4% of the trips sampled at the harbor. The estimated number of bottom-drop longline fishery trips has ranged from 36 annual trips in 2015 to only

3 in 2019, but considering that, overall, only 30 to 50% of the trips were covered by a landing survey, there is a reasonable chance that none of the few trips using longline carried out in a given month were actually covered by the landing surveys. Because of the data scarcity, it is difficult to quantitatively analyze the data and make reliable stock assessments and predictions.

Also species composition data is lacking, with only 10 sampled trips over the period 2012-2020. With such little data being collected it is impossible to do meaningful estimations. The longline fishery targets mainly snappers, with the Wenchman snapper, *Pristipomoides aquilonaris*, and the Queen snapper, *Etelis oculatus*, being dominant in the catches.

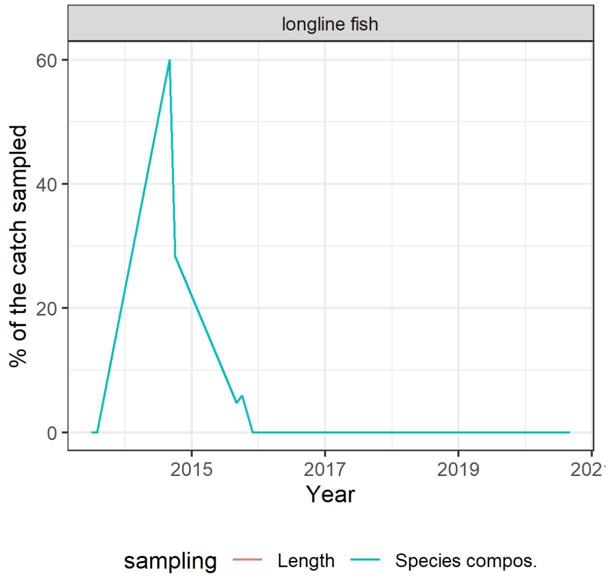


Figure 14 : *Sampling intensity in the longline fishery on Saba.*

3.4.6 Shark bycatch

Since 2016, shark bycatch and release has also been recorded in the landing survey of the Saba Bank, which forms a key part of the Yarari Marine Mammal and Shark Sanctuary. Bycatch of nurse sharks seems to have increased in the lobster fishery from an average of less than 3 sharks per trip (or an estimated 0.035 per trap) until 2018, to 6 individuals per trip (estimated 0.084 per trap) in 2019 and 2020 (Brunel et al. 2021). So far, only a crude estimate of the annual number of nurse sharks caught and released can be calculated, by multiplying the annual mean catch rates by the estimates of the annual number of traps lifted. A more accurate assessment of shark catches is needed on a per trap basis, and for different areas of the bank, in order to address questions of actual catch frequencies and associations between sharks and lobsters. Additionally, a formal analysis of data from current tagging/recapture programs (Winter and de Graaf 2019, Stoffers et al. 2021) is necessary to understand if the frequency in recapture rates could potentially be an alternative explanation for the increase in observed CPUE. In St. Eustatius shark bycatch does appear in the logbooks but not frequently.

3.4.7 Fish Attracting Devices (FADs)

Finally, of particular concern is the unofficial FAD fishery, in which buoys are anchored offshore and used to concentrate pelagic fish (Figs. 15 and 16). These fisheries exists in St. Eustatius and Saba, but data for this type of pelagic fishing are not yet available. This fishery targets pelagic fish species that are also caught in the small-scale trolling fishery. This fishery is rarely recorded by the DMO’s as the fishers leave early morning and come back only after 5pm, while officers quit work at 4pm.

FAD fisheries have proven very problematic elsewhere, leading to cases of severe overfishing and serious disputes between fishers (Samples and Sproul 1985, CRFM 2015, Sadusky et al. 2018). There is an urgent need to obtain data from this new fishery. While FAD fishing likely presents valuable opportunities for fisheries (Debrot and van den Burg 2019; Lotz et al 2020), it should be monitored and sampled, to allow sustainable development and avoid the many pitfalls associated with this form of fishing.

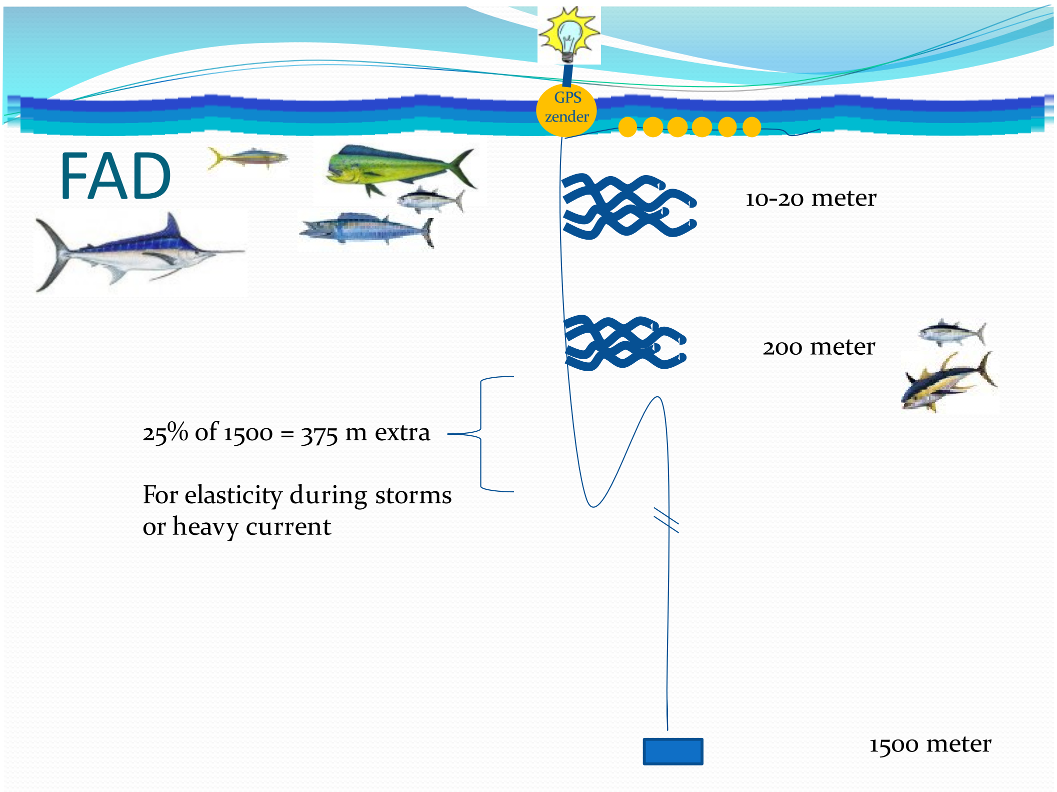


Figure 15: *Diagrammatic representation of a Fish Attracting device (FAD) anchored in deep waters and serving to attract schooling pelagic species (courtesy of Larry Gerharts).*

Figure 16: *Example of yellowfin tuna and dorado's aggregating by flotsam over deep water (image courtesy of Larry Gerharts).*

4 Conclusions and recommendations to improve port sampling

After a first decade of activity, the fisheries monitoring programs in Saba and St. Eustatius have collected a large amount of data, that substantially improved our knowledge of the fisheries and the resources they exploit, and allowed for the development of a first set of stock assessment indicators. However, this report identified a number of gaps in the current program, that greatly limit the precision and the level of detail of the assessments that are possible for these fisheries.

The main gaps identified in the data are:

- Limited coverage by the logbook data, especially the case in St. Eustatius. This implies that large raising factors are applied when estimating total effort and landing estimates, which leads to more uncertain estimates
- Landings not reported by species (at least for the main species) and port sampling for species composition not frequent enough to be able to produce landing estimates and abundance indices at the species level (instead of species groups).
- While some species are over-sampled for landing length composition, others are not sampled enough to be able to compute reliable length-based indicators.

Based on the above, a list of points on which data collection could be improved is proposed:

For both Islands :

- Discuss with fishers to see if they could provide details on the landings composition in weight, at least for the main species in each métier. For instance,
  - For redfish, differentiate the four main species (silk, vermillion, blackfin, lane) and “other”.
  - For Saba reef fish, differentiate queen triggerfish, red hind, white grunt and “other”.
  - For St. Eustatius reef fish :

    Traps : blue tang, coney, honeycomb cowfish, squirrelfish, other

    Scuba : red hind, coney, stoplight parrotfish, other

    Trolling : wahoo, dolphinfish, tuna (this information is probably available because it is often provided as “comments” in the xls sheets)
- Increase logbook coverage, especially for boats that are known for conducting multiple métiers and for boats that land the most.
- Intensify catch sampling (at present around 40 trips per year are sampled for species composition, taken representatively from the different fishing methods). This should be increased to at least 1 trip sampled per week for both the snapper and the lobster fishery. This will allow length-frequency assessments for individual species instead of pooled species.
- Arrange to collect more detailed biometric data coming from a full range of target fish of different fish sizes in order to make possible to derive local biometric parameters for modelling purposes. These include length-weight curves, size at age curves, size fecundity curves and seasonal gonad indices. This will involve dissection of fish, collection of otoliths and weighing and preserving of gonads. Depending on the willingness of fishers, fish might need to be purchased from the fishers for resale to cooperating parties.
- Pelagic fisheries :
  - Reinforce logbook coverage
  - Directed sampling of developing pelagic fisheries by shifting the office hours
  - Develop data collection on the fisheries on FAD

For Saba :

- Maintain current level for the activity survey
- Obtaining more accurate positions for the positions of traps lifted and longlines set, keeping in mind that this information should be treated in a confidential way vis-a-vis other (competing) fishers.

- Sampling of the lobster trap fishery :
    - Species composition: if not possible to have fishers reporting per species in the logbooks, the ideal would be to cover each boat (6 boats), each month (or every second month).
    - Size sampling : if that allows to cover a higher % of the landings : set a limit to the monthly number of lobster measured (e.g. 100 p. month from September to February and 50 p. month from March to August) and when reached, focus on measuring more reef fish (try to reach at least 200 measurements per year for queen triggerfish, red hind and white grunt.
- Sampling of the redfish fishery :
    - Size : if that allows to cover a higher % of the landings: set a max number of silk snappers to measure (e.g. 100 per month), and when reached, measure only the other species (trying to reach at least 200 per year for vermillion, land and blackfin).
    - Species comp : if not possible to have fishers reporting per species in the logbooks, the ideal would be to cover the main boats (6 boats), each month (or every second month).
- Shark bycatch rates and size data collected via on-board sampling.

For St. Eustatius :
- Improve logbook coverage, with, as first priority, getting a full coverage of the fleet
- Maintain the current high level of activity survey.
- Sampling of the trap fishery : make sure there are at least 250 individuals measured per year
- Scuba and free diving : Not necessarily more sampling needed, but make sure it is evenly distributed, and avoid years like 2019 when only three trips were sampled.

The recommendations listed above should be achievable by a team of two DMOs on each island, for which fisheries monitoring would be the main activity. This would therefore require that one additional DMO be hired in St. Eustatius and that the focus of the DMO work be set on collecting the required fisheries data. Also, in order to reach a larger coverage of the fleets activity, working in morning/midday/evening shifts should be facilitated. This enables data collection after regular working hours, e.g. when fishers come home late in the day (5-6pm). Finally, DMOs need to use a workspace with a clear view of the harbor where fishers arrive with their catches, so they can immediately act when ships arrive with their catches. This is especially an issue for the St. Eustatius DMO. Closer and preferably structural coordination of port sampling progress with WMR is advisable.

For a successful fisheries data monitoring program it is also essential to increase willingness of fishers to participate to the data collection. Unfortunately our DMOs experience that most fishers do not see the value of the work they do. Improvement of the relationship and understanding between fishers and DMOs can be achieved by getting the fishers more involved in the research/monitoring by:
- Incentivizing fishers to participate possibly by organizing regular (6-monthly?) get-togethers where the DMOs update fishers on monitoring results (analysed by WMR), providing some food and drinks during this reoccurring event.
- Providing dedicated freezer storage space for fishers at the harbor, enabling DMOs more time for the port sampling. Fishers work hard for their catch and when arriving at the harbor, willingness to wait for port sampling is understandable limited. By providing dedicated freezer storage facility, we enable DMOs/students to take the time needed for sufficient biological sampling (i.e. species composition, length, sex) while the catch of the fishers stays fresh. For bycatch measurements photographing the fish on a cm grid surface can save measuring time in port or on vessels (e.g. Debrot et al. 2022; Fig. 17)). An alternative solution could be to use electronic measuring boards.
- Providing modern technologies to the fishers and/or DMOs, e.g. Electronic Reporting Systems (ERS) such as electronic logbooks, and GPS systems such as the Vessel Monitoring System (VMS).

Figure 17: *A fish catch (Indonesia) spread out on a grid to take a picture so that identification and size estimation can take place later in the office (Photo: A. O. Debrot).*

5 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

Report C053/22
Project Number: 4318100256, 4318100260

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Ralf van Hal
researcher

Signature:

Date: 13-09-2022

Approved: Drs. J. Asjes
Manager Integration

Signature:

Date: 09-09-2022

Annex 1 Logbook forms used in data collection

STATIA FISHERIES RESEARCH LOGBOOK

Date:	Boat:	No. Crew:

Fishing gear:	Pot	Diving	
		Free Diving ☐	Scuba Diving ☐
No. of pots hauled:			:Speargun (Yes/No)
Soak time (days):			:Dive time (hours)
Depth max/min (ft):	/	/	:Depth max/min (ft)
			:Divers (No.)
Fishing zone:			:Fishing zone
Reef Fish (lbs):			:Reef Fish (lbs)
Red fish (lbs):			:Red fish (lbs)
Lobster (No.):			:Lobster (No.)
Short lobsters (No.):			:Short lobsters (No.)
Berried Females (No.):			:Berried Females (No.)
Other________(No/lbs):			:Other________(No/lbs)

STATIA FISHERIES RESEARCH LOGBOOK

Date:	Boat:	No. Crew:

Fishing gear:	Handline	Longline
No. of lines:		
Duration (hours):		
Depth (ft):		
Quadrat:		
Reef Fish (lbs):		
Red fish (lbs):		
Pelagics (lbs):		
Other______________(No/lbs):		

Finshing gear:Trolling		Species	No.	Lbs
No. Lines:				
Duration (hr):				
Quadrat:				

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With knowledge, independent scientific research and advice, **Wageningen Marine Research** substantially contributes to more sustainable and more careful management, use and protection of natural riches in marine, coastal and freshwater areas.

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