An Assessment of Montserrat's Fisheries

November 2016

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*Definitions of terms highlighted in blue can be found in the Glossary (Appendix 1)

Executive Summary

- This assessment summarizes and analyzes data from the following: the Montserrat (MNI) Fisheries Division catch database from 1994 to 2015, fishery length data collected from June 2015 to August 2016 by the Waitt Institute and the Sustainable Fisheries Group, and fish length data from the Blue Halo Scientific Assessment surveys conducted in October 2015.

- Montserrat has a small, artisanal fishery that targets coral reef, demersal, coastal pelagic, and pelagic species with most effort concentrated within 3 miles from shore. The vast majority of boats are small, open pirogues and less than 10 meters in length. Fish pots are the most common fishing method used and account for the largest portion of total landings recorded in the Montserrat Fisheries Division's catch database. Fishers also use beach seines, hook and line, and spears.

- The MNI catch database includes 196 species from 62 families. The largest portion of the total annual catch by weight is composed of fish from the family Belonidae, mainly gar. Red hind and old wife form the next largest portions of catch by weight. Reef fishes from the families surgeonfish (Acanthuridae) and snapper (Lutjanidae) as well as longjaw squirrelfish and butterfish make up substantial portions of the total catch as well.

- On average, recorded catch in Montserrat has been 28,000 kg per year since 1994. Total catch recorded in 2015 was slightly below average. Fishing effort (based on number of fishing trips) has been relatively stable over the last 10 years. In 2015, the catch database identified 34 active fishers and 29 active vessels. Total catch per unit effort (CPUE) appears to have been relatively stable since 1994 with a high of 67 kg/trip in 2005 and a low of 37 kg/trip in 2013. In 2015, the average annual CPUE was 58 kg/trip.

- Length-frequency data show that most doctorfish, red hind, and silk snapper landed are being caught before they reach maturity, i.e. they are not able to reproduce.

- Our length-based fisheries assessments of five key coral reef fishery species suggest that overfishing of blue tang and doctorfish is likely occurring, overfishing of silk snapper may be occurring, and overfishing of old wife and red hind is likely not occurring (Figure 1). A catch-based assessment of gar suggests this species may be experiencing slight overfishing (Figure 1).

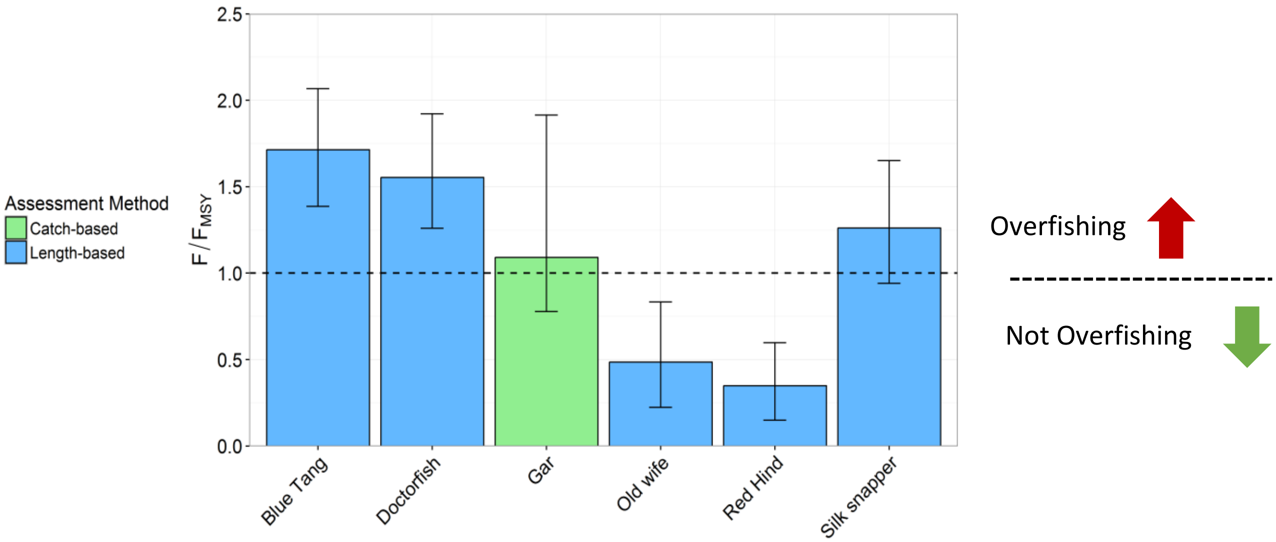


Figure 1. Estimated fishing mortality (*F*) relative to fishing mortality at maximum sustainable yield (F_{MSY}) from the LBAR length-based assessment for reef fish, and catch-based assessment for gar. Error bars indicate upper and lower 95% confidence intervals. The dotted line indicates F/F_{MSY} = 1.0 (> 1.0 indicates overfishing and < 1.0 indicates sustainable fishing pressure).

- The results of this assessment suggest that Montserrat's fisheries would benefit from management measures to help ensure sustainable harvests. Management regulations for the trap fishery to reduce the catch of juvenile fish could improve the sustainability of the fishery and result in higher long-term yields.

- To ensure Montserrat's fisheries are sustainably harvested and remain economically viable, it is recommended that fishery management objectives are clearly defined and that an adaptive approach to fisheries management is implemented that includes continued monitoring of fishery catch including length data, conducting annual data-limited assessments, and implementing appropriate harvest control rules to achieve management objectives.

Introduction

This report provides an assessment of Montserrat's fisheries, and includes an estimate of the status of six species targeted by the fishery.

Montserrat is a small volcanic island located in the northeastern Caribbean Sea, forming part of the Leeward Islands in the Lesser Antilles island chain (Cook et al. 1981). Montserrat has a small artisanal fishery comprised of small, open, wood or fiberglass boats from 3 to 10 m in length (Ponteen 2014). The fishery targets coral reef, demersal, coastal pelagic, and pelagic species. All catch is either sold at local markets or utilized for subsistence. Ninety percent of fishing in Montserrat occurs within 4.8 km (3 miles) of shore (Ponteen 2014).

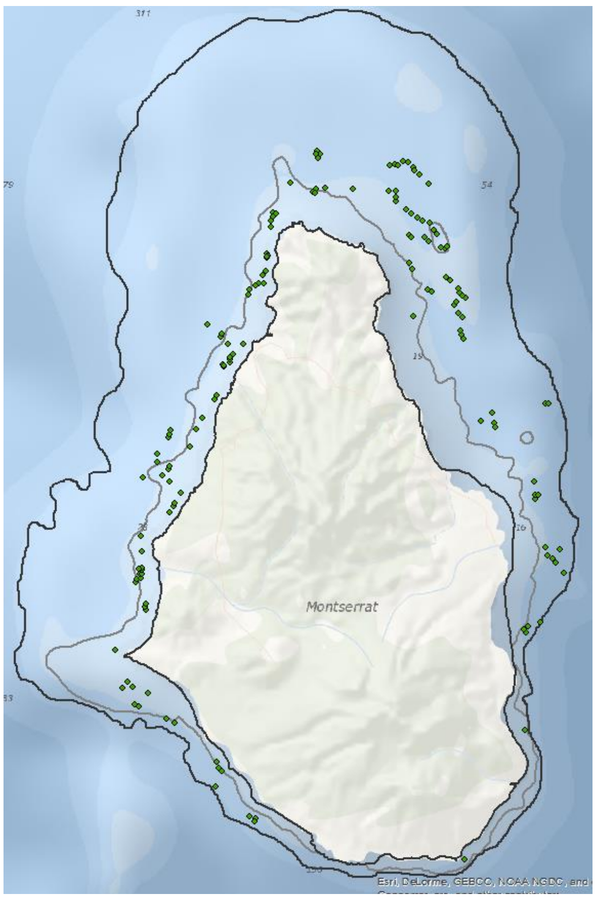


Figure 2. Location of fish pots (green points) observed around Montserrat during a Scientific Assessment conducted by the Waitt Institute in October 2015. 20 m (grey) and 100 m (black) contour lines are shown.

Pots (also called fishing traps) baited with coconut husks are the most common fishing gear used. Pots are set along the island's coast at depths of 15 to 100 m and marked with buoys (Figure 2). Blue Halo Montserrat conducted a Scientific Assessment in October 2015. During the assessment, the dive teams observed 157 pots (Figure 2). Pots are only fully removed from the ocean when repair is needed. Typically, pots soak for a minimum of 3 days before being pulled up to harvest the fish (Wild et al. 2007). Once the fish are removed, the trap is baited and returned to the sea. If ocean conditions are not favorable, pots may be left soaking in the ocean for several weeks.

Beach seines, lines, and spearguns are the other main fishing gears used in Montserrat's fisheries. Almost all fish are landed at Little Bay and are taken to King's Market in Carr's Bay to be sold fresh.

Four key components to fisheries management include monitoring, assessment, setting harvest control rules (i.e., fisheries regulations), and engaging in enforcement to ensure compliance with harvest control rules (Sainsbury *et al*. 2000, Punt *et al*. 2002, Dowling *et al*. 2015). The first step in managing any fishery is to define management objectives. Examples of objectives could be maximizing conservation of a certain species, maximizing economic yields over time, or balancing conservation and economic gains. Fisheries monitoring enables managers to obtain data and information that can be used to assess the sustainability of fishing pressure, evaluate the current health of the stock, and/or to predict future trends. Managers can then compare assessment results to management objectives in order to determine the most appropriate and efficient methods to regulate the fishery (Butterworth and Punt 2003). Ideally, monitoring and enforcement are ongoing, and assessments are repeated regularly (e.g., annually) to allow for adaptive management (Hartford et al. 2016) (Figure 3). An adaptive approach can enable the adjustment of allowable catch in response to stock recovery or decline, and can ultimately help ensure more sustainable use of marine resources.

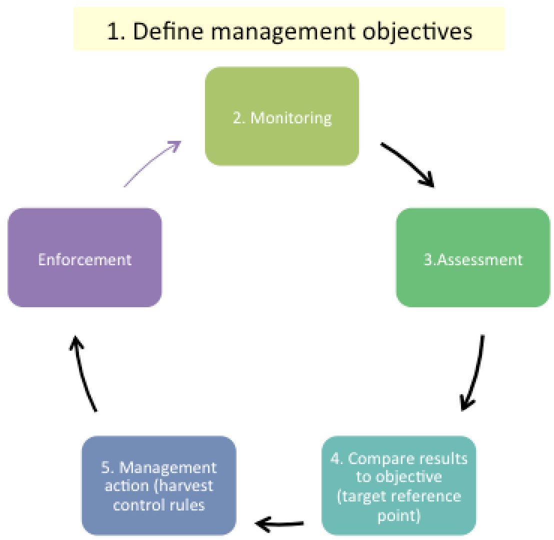


Figure 3. An adaptive fisheries management framework (adopted from Hartford et al. 2016).

Scientists have developed data-limited assessment methods in an effort to improve fisheries management in small-scale fisheries that lack sufficient resources for data collection and assessments (reviewed in Honey *et al*. 2010, Fujita *et al*. 2013). Data-limited stock assessments use information about a fishery as well as life history information about target species to estimate the sustainability of current fishing pressure or determine stock status at a given point in time.

There are a number of assessment techniques available for fisheries where full stock assessments are not feasible due to their data requirements and associated high costs (Carruthers et al. 2014). Data-limited assessment methods typically rely on either catch data from the fishery or length-frequency data of the population. Length-frequency data may be collected through measuring the size of individual fish landed in the fishery or through collecting data on fish lengths during dive surveys.

Results of both catch- and length-based data-limited assessments are typically expressed in terms of fishing mortality (F) relative to the fishing mortality at maximum sustainable yield (F_{MSY}). MSY for a given fish stock is the highest possible annual catch that can be sustained over time by keeping the stock at a level that is producing maximum growth. Harvesting a stock at or below MSY ensures that fishing can continue into the future without causing negative impacts to the population, though there may still be negative impacts on the ecosystem, economy, and society. Catch-based methods also provide estimates of the stock's biomass (B) relative to the stock's biomass at maximum sustainable yield (B_{MSY}).

Catch-based and length-based assessment methods each require different data inputs, and rely on different assumptions. The most appropriate assessment method will depend on characteristics of the fishery, species being assessed, and data collection methods. Both catch-based and length-based methods are used in this report to assess the status of Montserrat's fisheries. The data requirements and major assumptions of each assessment approach are described below.

Length-based assessments: Length-based assessments require at least one year of species length composition data that are representative of the population in addition to information on the species' life history such as growth, maximum age, and age or size at which sexual maturity is reached. Length-based assessments assume that the length data from the fisheries catch or dive surveys are representative of the stock's length distribution. A major advantage of length-based assessments is that they do not require a long time series of data or samples from each day. To ensure that the length data are representative of the length structure of the stock, length data should be collected from all gear types, all areas exploited by the fishery, and across all seasons/months. Randomly measuring lengths of fish across these different sampling strata will reduce bias in length data associated with factors such as gear selectivity, recruitment pulses, and length- or age-based movement (Pauly and Morgan 1987).

Length-based assessment methods are ideal for species with growth patterns that allow length classes to be categorized as juvenile, adult, or mega-spawner. However, they are not appropriate for species that that show little difference in size between age classes (Cope and Punt 2009). Length-based assessment methods have frequently been applied to coral reef fish to estimate the sustainability of fishing pressure (Ault et al. 2008; Nadon et al. 2015).

Catch-based assessments: Catch-based assessments require a time series of at least 10 years of catch data from the fishery, the species resilience score (based on life history characteristics) (Musik 1999), and estimates of relative stock size in the first and final years of catch data. Catch-based methods assume that the catch data represent all individuals that were removed from the population by fishing, and that the population growth rate (r), and ecosystem carrying capacity (K) has not changed over time (Martell and Froese 2012).

Catch-based assessments are only appropriate for fisheries that are fully developed (i.e., have not experienced a continuous increase in catch). A catch-based assessment approach may be preferred over a length-based approach when a time series of over 10 years of catch is available, limited information is known about the species' life history, and/or if differences in lengths between age classes are small (e.g., for fast growing species).

Methods

Data Description

Montserrat Fisheries Division Catch Database

The Montserrat Fisheries Division has had a catch monitoring program to collect fisheries catch data since at least 1976 (Jeffers 1984). Since 1994, the Division has collected data that includes information on estimates of landed weight by species, fishing gear used, trip date, and vessel name, stored in an electronic database. Data collectors meet fishers at Carr's Bay Monday-Friday from 8 am-4 pm to record data as catch is being sold. Fishers who sell their catch typically land their catch in Little Bay and then sell it in Carr's Bay. Some fish landed at Little Bay may be sold along the road on the way to Carr's Bay and, thus, not captured by the catch monitoring program. Additionally, subsistence and recreational fishing, which occurs in other locations around the island, and fishing that occurs on the weekends and evenings, is not captured by the catch monitoring program. Overall, an estimated 75% of the total landed volume of catch in Montserrat is captured by the monitoring program (Ponteen 2014).

This report summarizes the data in the Montserrat Fisheries Division catch database from 1994-2015. It presents an inventory of all species landed in the fishery and summarizes the relative contribution to total landings of each species and family. We also summarize data to examine annual and seasonal trends in the number of fishers, catch, effort, and catch per unit effort (CPUE).

Fishery Length Data

In June 2015, in collaboration with the Waitt Institute and Montserrat Fisheries Division, SFG identified twelve fish species present on Montserrat's coral reefs to focus on for a one-year length-monitoring program. We identified species based on historical abundance in landings and availability of life history information. The purpose of the program was to obtain an accurate representation of the size structure of the stock being targeted by the fishery. We collected length data of coral reef fishes landed at Little Bay for several days each month (in addition to the Fisheries Division catch monitoring) from June 2015 to August 2016. We measured the lengths of individual fish using a measuring board and recorded all lengths to the nearest 0.5 cm. We took measurements of total length for all parrotfish (Scaridae) and grouper (Serranidae) species and fork length measurements for all other species.

Dive Survey Length Data

During the October 2015 Blue Halo Scientific Assessment (SA) surveys, scientific divers conducted fishery-independent surveys. Using Global Coral Reef Monitoring Network survey methods, divers collected data on fish species abundance and length. This report incorporates the length data from the SA with fisheries monitoring data described above to conduct length-based assessments. For more information on dive survey methods see the Blue Halo Montserrat Scientific Assessment Report.

Life History Information

We created a life history database in Excel for the target coral reef fishes included in the length-based analyses. The database includes information from published and grey (unpublished or not published in a scientific journal) literature. We conducted the literature search using FishBase, Google, and Google Scholar. We compiled data on the species' growth, longevity, and depth range, using the species name and the parameter name as search terms. We prioritized studies for inclusion based on proximity to Montserrat and reliability of the source.

Natural mortality (M) for each species was calculated based on longevity (t_λ) and assuming 5% of the population survives to the maximum age (Alagaraja 1984; Hewitt and Hoenig 2005):

$$M = \frac{-\ln(0.05)}{t_\lambda} \tag{1}$$

Length-Based Assessment of Coral Reef Fishes

We conducted the length-based assessment for species that had a minimum of 180 fishery length observations by the end of August 2016.

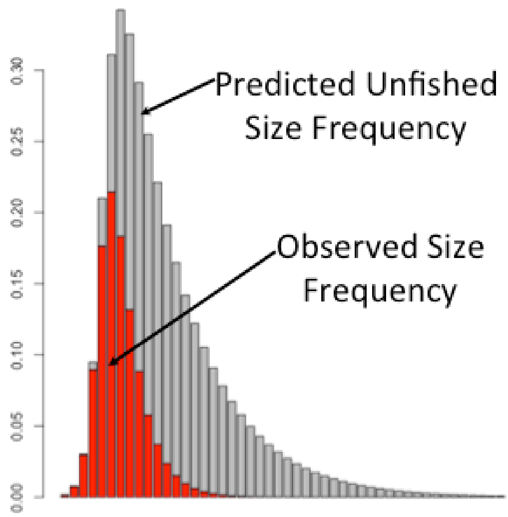


Figure 4. Hypothetical example of a population's simulated unfished size frequency distribution and observed size frequency

We used the length and life history data of each species as inputs to the 'LBAR' method (Ehrhardt and Ault 1992; Ault 2008; Nadon et al. 2016). The LBAR method uses life history parameters to simulate the length and age structure of an unfished population. The observed length frequency distribution of the population experiencing fishing pressure is then compared to the simulated population experiencing no fishing pressure in order to estimate the current level of fishing mortality (*F*), relative to the estimated fishing mortality at maximum sustainable yield (F_{MSY}) (Figure 4). The major assumptions of this method are that the stock is at equilibrium (i.e., not experiencing large variations in natural mortality or recruitment), and the length data represent the full size structure of the exploited population.

Catch-Based Assessment of Gar

The most abundant species by weight landed in Montserrat's fisheries is the gar *(Tylosurus crocodilus*), which the Montserrat Fisheries Division identified as a species of interest. Gar are found in waters over lagoons and seaward reefs in depths up to 13 m (Polunin and Roberts 1993). No published information is available on the species growth rates or longevity; however, other species in this family grow rapidly, reaching maximum size within the first 2-3 years of life, with an estimated life span of four years (Kalayci and Yesilicieck 2012).

We applied a data-limited catch-based assessment (Catch-MSY) (Martell and Froese, 2012) to estimate a sustainable yield for gar. This method uses a species resilience score (FishBase, Musick 1999), general life history characteristics of a species, and historical catch data to estimate a range of potential intrinsic growth rate (*r*) and ecosystem carrying capacity (*K*) values for the stock. These values are used in a Schaefer surplus production model together with the historical catch to estimate the stock's sustainable yield, fish biomass at MSY, and fishing mortality (*F*) at MSY. Catch levels are compared to the estimated MSY to determine if the stock has been overfished (Froese and Pauly 2016).

Catch Projections of Silk Snapper

We employed a spatial, age-structured fisheries model (Lester et al. 2016) to evaluate and compare how management actions would impact population biomass and fishery yield of silk snapper over time. Management scenarios evaluated included creation of a marine reserve, a minimum size limit, and/or a catch limit. Results from these scenarios were compared to no management intervention, or a "Business as Usual (BAU)" scenario. The age-structured model includes population growth, reproduction, dispersal, movement, and natural mortality of silk snapper. Fishing mortality is applied to the population, and under the BAU scenario, the total *F* is distributed equally across size classes in the population that are fully selected to the fishery. Under each management scenario, a portion of the fishing mortality is removed from the population, resulting in an overall lower total *F*. The portion of *F* that is removed depends on the management scenario (Table 1). Our model is able to project relative biomass and yield under any management scenario or combination of management scenarios listed in Table 1.

Table 1. List of potential management scenarios that can be modeled using the catch projection model. The parameter value that is changed, and the change in the distribution of F associated with each management change is listed.

Potential Management Scenarios	Parameter Value Change	Change in *F* Under Management Scenario
Business As Usual (BAU)	None	None
Minimum Size	L_c size is set to model the impact of a specified minimimum size	*F* = 0 is assigned to individuals equal to and less than the specified minimum size
Minimum Mesh Size	L_c is recalculated based on a different specified mesh size. The new L_c is calculated using assumed species-specific length to width ratios	Similar to the minimum size scenario, *F*= 0 will be applied to all sizes below the minimum size the species is fully selected for that mesh size (L_c). L_c for a specified mesh size is calculated using average length to width ratios of specific species
Seasonal Closure	Months for a fishery closure are specified	*F* = 0 for months during the seasonal closure
Marine Reserve	% of total habitat for the species that will be closed to fishing is specified	*F* is set to 0 for the specified % of total area of reserve size
Catch Scenario	% reduction from F under BAU is speciried	A % decrease from the current annual *F* (or catch) is specified, and the total *F* is reduced to that level and evenly distributed across sizes, months and areas

As illustrative examples, we modeled the following management scenarios: 1) BAU, 2) A catch limit that is 20% lower than the current catch level, 3) A minimum size limit of 38 cm, which is above the size at which 100% of individuals have reached maturity, 4) 20% of silk snapper habitat in a marine reserve, 5) 30% of silk snapper habitat in a marine reserve, and 6) 20% marine reserve size and minimum size regulation.

The model includes several assumptions about fish population dynamics, fishery fleet dynamics, and spatial interactions. One of the major assumptions is that if F is set to zero for a specific size, season, or place through a management intervention, this fishing pressure is removed, not redistributed to other size classes, time periods, or areas of the fishery. This essentially says that total fishing effort will be reduced, e.g. some fishers will leave the fishery or there will be an overall reduction in catch in the short-term. The purpose of this model is to provide a relative comparison of potential performance across model measures, and not to predict absolute changes in biomass and yield.

Results

Catch Database Summary

The Montserrat Fisheries Division catch database contains catch (kg by species) and effort (# fishing trips) data from 83 vessels across 13,224 fishing trips from 1994–2015, with the days of monitoring increasing over time (Figure 5).

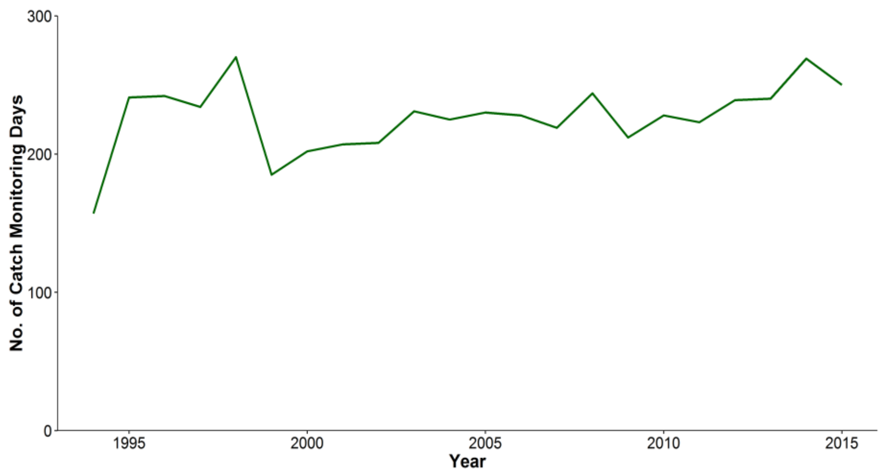


Figure 5. Total number of days per year of catch monitoring effort in Montserrat from 1994-2015. *Source*: Montserrat Fisheries Division Catch Database

On average, catch monitoring has been conducted 217 days a year since 1994. From 1994-1996 approximately half of the catch was reported as landed in Plymouth, and the other half was landed in Carr's Bay. Following 1996, the majority of reported catch was landed at Carr's Bay or Little Bay, with a small portion of catch landed at Old Road, Isles Bay, and Bunkum Bay (Figure 6).

Following a peak of 48 vessels in 1995, the number of active vessels in the fishery declined dramatically until 2006 when only 15 vessels were active in the fishery (Figure 7). The decline in active vessels starting in 1995 coincides with the eruption of the Soufriere Hills volcano, which caused extensive damage to the island. Additionally, in 1995, Hurricane Luis caused an estimated 20 million USD in damage to Montserrat (IDD 2008). A decline in catch and fishing effort beginning in 1995 has been attributed to the Soufriere Hills eruption (Ramdeen 2012), but it is not clear if this may be attributed to damage associated with the hurricane as well. Over the last 10 years, the number of participants in the fishery has gradually increased, while the population on the island has remained relatively stable, and in 2015, there were 34 active fishers recorded in the catch database.

Figure 6. Fisheries landing sites on Montserrat. Plymouth has been off limits since the Soufriere Hill volcano eruption.

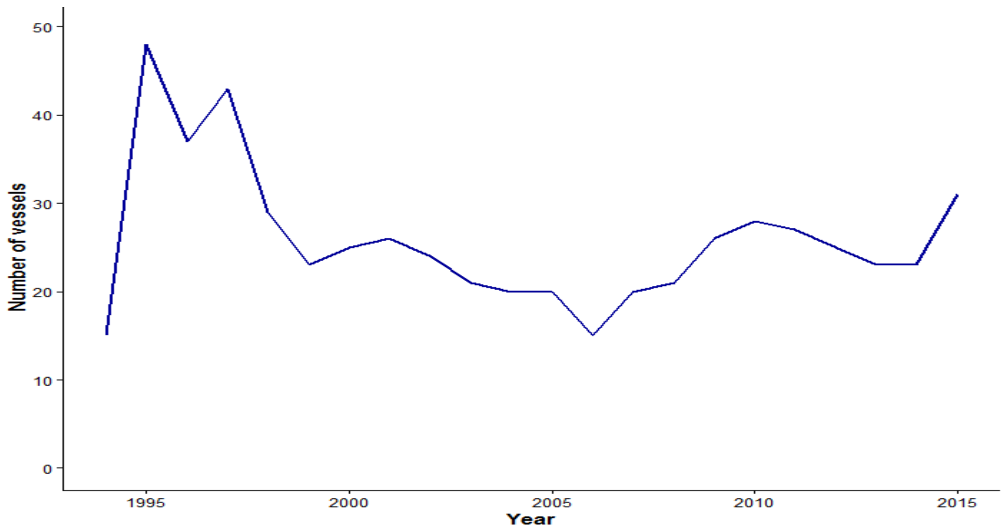
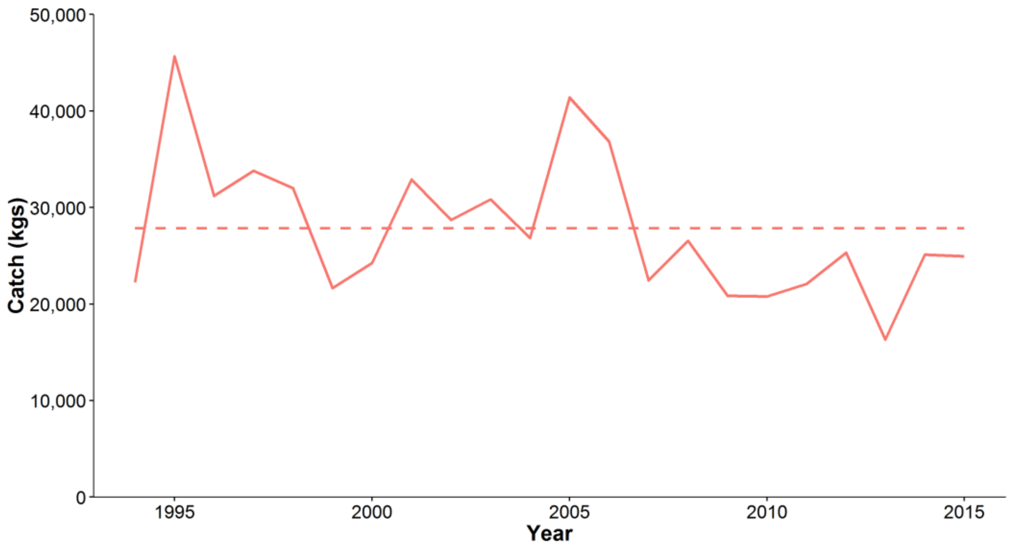


Figure 7. Total number of vessels per year active in Montserrat's fishery from 1994-2015. *Source*: Montserrat Fisheries Division Catch Database

An average of 27,864 kg of catch, and 575 fishing trips have been recorded each year in Montserrat from 1994-2015. Total annual catch and effort both peaked in 1995 at 45,633 kg and 1209 trips (Figures 8a and 8b). We calculated catch per unit effort (CPUE) as total catch (kg) per fishing trip. On average, CPUE in Montserrat's fisheries has remained relatively stable over time and the average over the period 1994-2015 was 47 kg/trip (Figure 8c). CPUE peaked in 2005 at 67 kg/trip, and hit a low in 2013 at 37 kg/trip. It has increased to 58 kg/trip in recent years.

(a)



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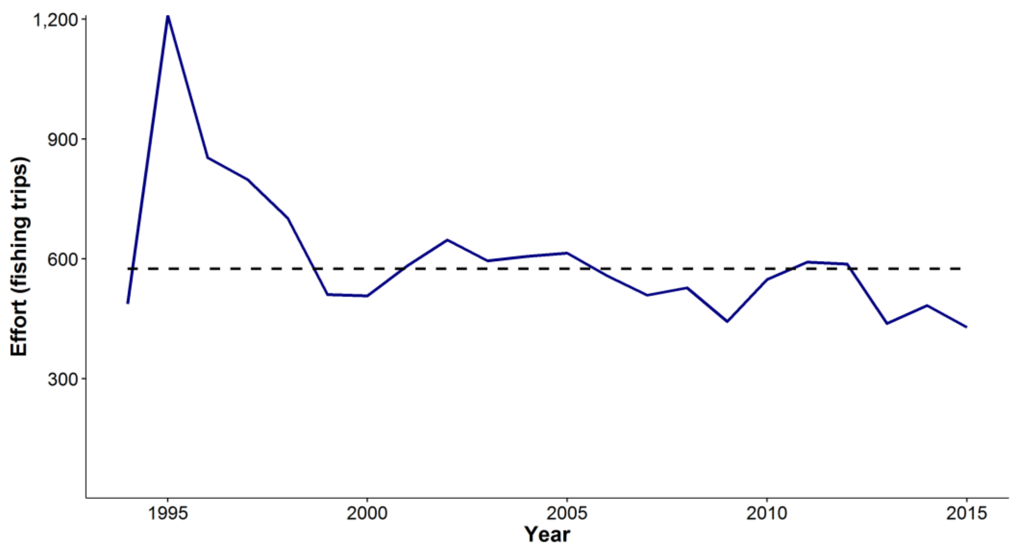

(c)

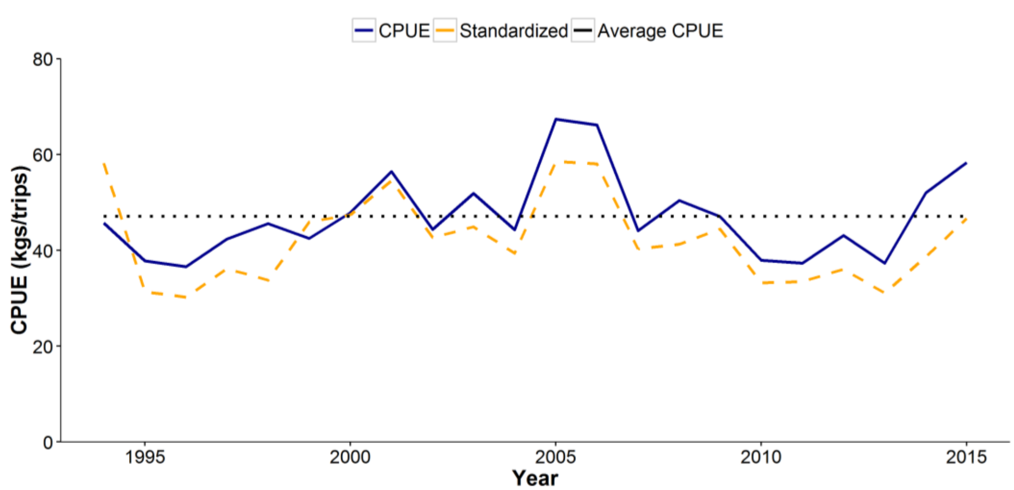

Figure 8a-c. (a) Total annual catch (kg), (b) effort (fishing days), and (c) CPUE recorded in Montserrat's fisheries from 1994-2015. CPUE was standardized using the total number of monitoring days. The dashed line in panel a and b, and dotted line in panel c represent the 1994-2015 average values. *Source*: Montserrat Fisheries Division Catch Database.

To ensure that trends in CPUE were not biased by the number of days of catch monitoring, annual average CPUE was standardized by monitoring days. The CPUE and standardized CPUE showed similar trends (Figure 8c). We were not able to calculate CPUE for individual species because of the non-selective nature of fishing with pots, the dominant fishing method used in Montserrat.

Fishers in Montserrat will often use multiple gear types on a single trip. For example, hand lines may be used while transiting from port to fishing pots, or a beach seine may be set if schools of ballyhoo or gar are observed while trolling. Historically, pots and nets have accounted for 47% and 45% of total landings, respectively (Figure 9).

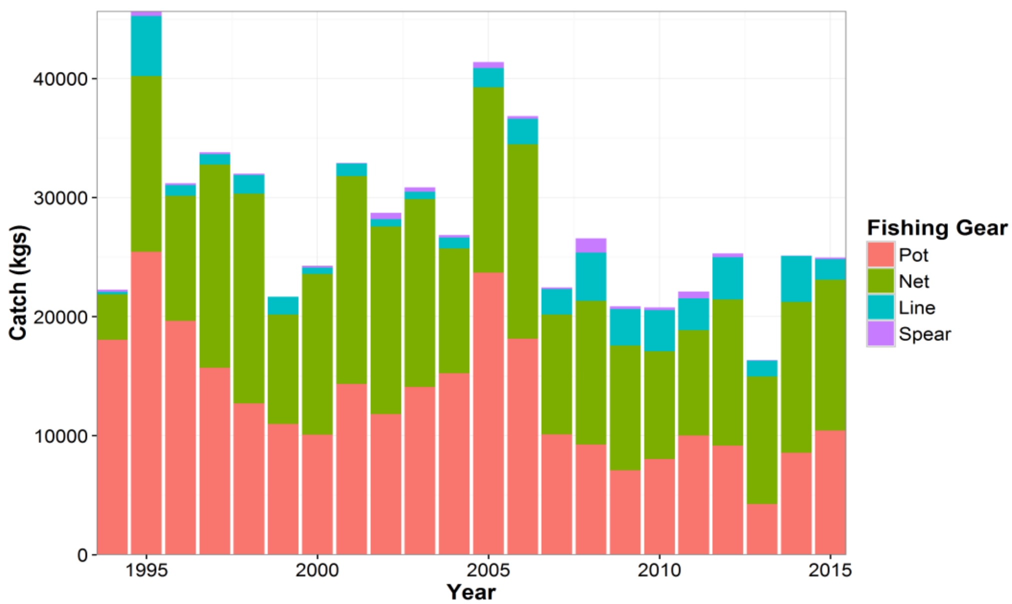

Figure 9. Total annual catch by gear type in Montserrat's Fisheries from 1994-2015. *Source*: Montserrat Fisheries Division Catch Database.

Line fishing has accounted for 7% of total landings, and spearfishing accounts for less than 1% of total landings (Figure 9). Over the last 10 years, pots have accounted for a smaller portion of the total catch. It is not clear if the low number of trips recorded in the database from line and spear fishers is because few trips are made using these gear types or if fish landed using these gear types are more spatially dispersed around the island and, therefore, not recorded by the catch monitoring program, and less likely to be sold at the market. Generally, there have not been any major changes in gear types used in the fishery over the past 20 years (Figure 9). The catch database lists 196 species as landed in Montserrat's fisheries, representing 62 families that are listed in Appendix 1,Table A1.

Seven families account for over 75% of Montserrat's total historic fisheries landings (Figure 10). The relative contribution of landings from each family has remained relatively constant over time. The Belonidae family accounts for the largest portion of catch and is comprised of mostly gar caught in beach seine nets. In 1995, a large volume of ballyhoo (Hemiramphidae) were landed in the fishery resulting in a peak in catch. The grouper family (Serranidae) accounts for the second largest portion of catch, and is dominated by red hind (*Epinephelus guttatus*) and coney (*Cephalopholis fulva*) groupers.

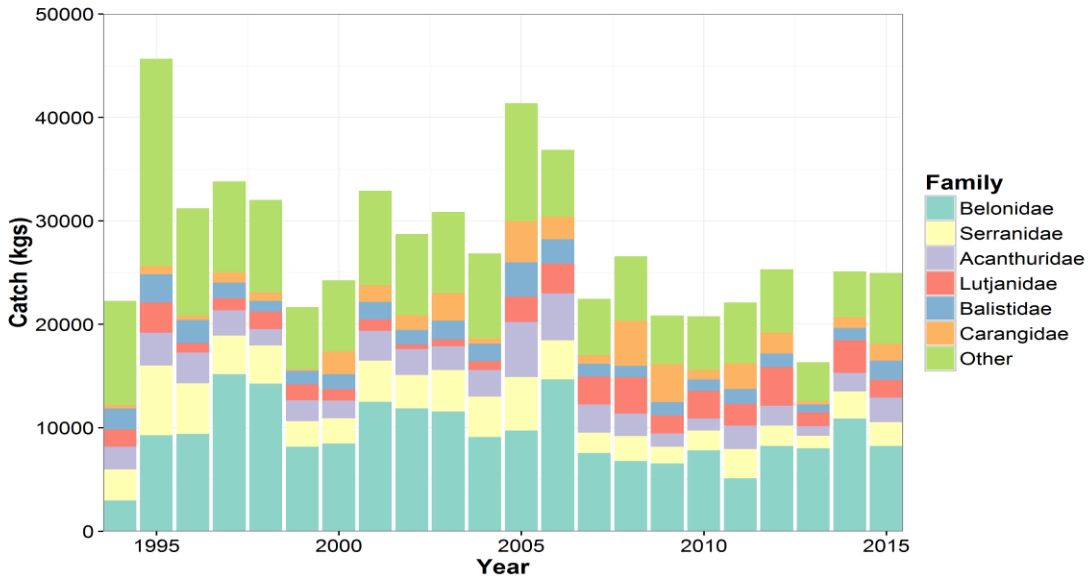

Figure 10. Total annual catch by family in Montserrat's Fisheries from 1994-2015. *Source*: Montserrat Fisheries Division Catch Database.

Average catch, effort, and CPUE (Figure 11a-c) in the fishery are relatively stable across months. On average, total monthly catch was highest in March (2,689 kg) and lowest in July (2,059 kg). Fishing effort was highest in May (57 trips) and lowest in December (42 trips), but the highest average CPUE values were in December (52 kg/trip), with the lowest in May (43 kg/trip).

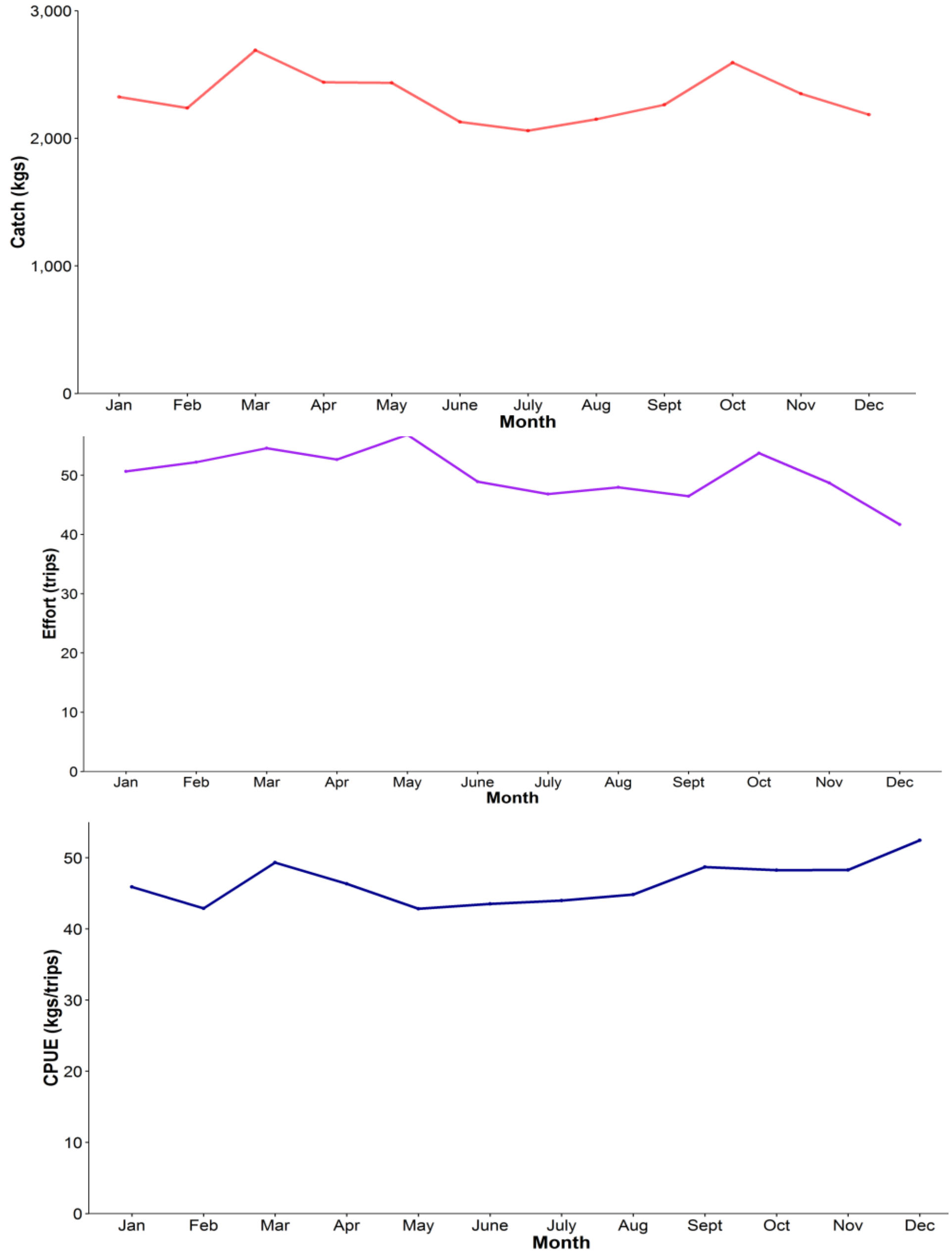

Figure 11a-c. Long-term average monthly (a) catch (kg), (b) effort (fishing days), and (c) nominal CPUE recorded in Montserrat's fisheries from 1994-2015. *Source*: Montserrat Fisheries Division Catch Database.

Length-Based Assessment of Coral Reef Fishes

Data Summary

We had sufficient fish length samples and life history information to conduct length-based analysis for five species: doctorfish (Acanthurus chirurgus), blue tang (Acanthurus coeruleus), old wife (Balistes vetula), silk snapper (Lutjanus vivanus), and red hind (Epinephelus guttatus). Life history parameters used for each species in the length-based assessment, and depth distributions for these species found in FishBase are presented in Table 2. Age, growth, and maturity of a fish species may vary by region depending on environmental factors such as temperature, food and habitat availability, and predation rates, and thus we used parameters based on studies conducted as close to Montserrat as possible.

Both doctorfish and blue tang are reef-associated species from the surgeonfish family (Acanthuridae). Surgeonfish are mainly herbivores that graze on algae. Some also feed on zooplankton or detritus (Froese and Pauly 2016). Doctorfish are found in depths ranging from 2 to 25 m, and have a maximum length of 27 cm FL (Kishore and Chin 2001). In Montserrat, doctorfish are known to live up to 27 years and begin to reach sexual maturity at an average length of 24 cm FL. Blue tang are found in depths between 2 and 40 m and have a maximum recorded length of 39 cm FL. In the San Blas Islands, off the Caribbean coast of Panama, blue tang are known to live up to 16 years and reach maturity at an average length of 16 cm FL.

Old wife, also known as queen triggerfish in other regions, belong to the triggerfish family (Balistidae). Most triggerfishes are solitary diurnal carnivores and feed on a wide variety of invertebrates, algae, and zooplankton (Pauly and Frose 2016). Old wife are associated with reefs, found in depths from 2 -275 m, and have a maximum reported length of 60 cm FL (Pauly and Froese 2016). A life history study on old wife conducted in Puerto Rico and the U.S. Virgin Islands found it to have a maximum age of 7 years, reaching maturity at an average length of 27 cm FL (Manooch and Drennan 1987).

Red hind belong to the grouper family (Serranidae). Groupers are bottom dwelling predators that feed on zooplankton, crustaceans, fish, and octopus (Pauly and Froese). Red hind are found in both shallow reefs and rocky bottoms and have a maximum recorded length of 76 cm TL. Although FishBase has not quantified their depth range, they have been reported in depths of over 100 m. In a life history study on red hind conducted in Puerto Rico and St. Thomas, red hind were found to live up to 17.5 years and to reach maturity at an average length of 35 cm TL.

Silk snapper belong to the snapper family (Lutjanidae) and are a predatory species that feed on fish and crustaceans. Silk snapper are a reef associated species, found in depths between 90 and 242 m, and have a maximum recorded length of 83 cm TL. In Puerto Rico, silk snapper were found to live up to 7 years and reach sexual maturity on average at 30 cm FL.

Table 2. Life history parameters used in length-based assessments. Depth range for each species is also listed if available. Location refers to location of the study site.

Species	Parameter	Value	Units	Reference	Location
Doctorfish *(Acanthurus chirurgus)*	L_{inf}	36.69	cm (FL)		Montserrat
	k	0.08	$year^{-1}$		
	t_0	-4.31	-		
	Longeveity (t_λ)	27.00	year		
	Length at maturity (L_{mat})	24.18	cm (FL)	Kishore and Chin 2001	
	Natural mortality (*M*)	0.11	$year^{-1}$	calculated, see equation 1	
	Depth range	2 -25	m	FishBase	
Blue tang *(Acanthurus coeruleus)*	L_{inf}	23.10	cm (FL)	Mutz 2006	San Blas Islands, Panama
	k	0.42	$year^{-1}$		
	t_0	-0.25	-		
	Longevity (t_λ)	16.00	year		
	Length at maturity (L_{mat})	15.96	cm (FL)		
	Natural mortality (*M*)	0.19	$year^{-1}$	calculated, see equation 1	
	Depth range	2 -40	m	FishBase	
Old wife *(Balistes vetula)*	L_{inf}	41.50	cm (FL)	Manooch and Drennon 1987	Puerto Rico and US Virgin Islands
	k	0.30	$year^{-1}$		
	t_0	-0.60	-		
	Longevity (t_λ)	7	year		
	Length at maturity (L_{mat})	27.01	cm (FL)		
	Natural mortality (*M*)	0.43	$year^{-1}$	calculated, see equation 1	
	Depth range	2 -275	m	FishBase	
Red hind *(Cephalopholis guttatus)*	L_{inf}	55.78	cm (FL)	Sadovy et al. 1992	Puerto Rico and St. Thomas
	k	0.09	$year^{-1}$		
	t_0	-3.82	-		
	Longevity (t_λ)	17.50	year		
	Length at maturity (L_{mat})	35.22	cm (FL)		
	Natural mortality (*M*)	0.17	$year^{-1}$	calculated, see equation 1	
	Depth range	NA	m	FishBase	
Silk snapper *(Lutjanus vivanus)*	L_{inf}	78.10	cm (FL)	Ault et al. 1998	South Florida
	k	0.09	$year^{-1}$		
	t_0	-2.31	-		
	Longevity (t_λ)	9.00	year		
	Length at maturity (L_{mat})	30.40	cm (FL)		
	Natural mortality (*M*)	0.23	$year^{-1}$	calculated, see equation 1	
	Depth Range	9 -242	m	FishBase	

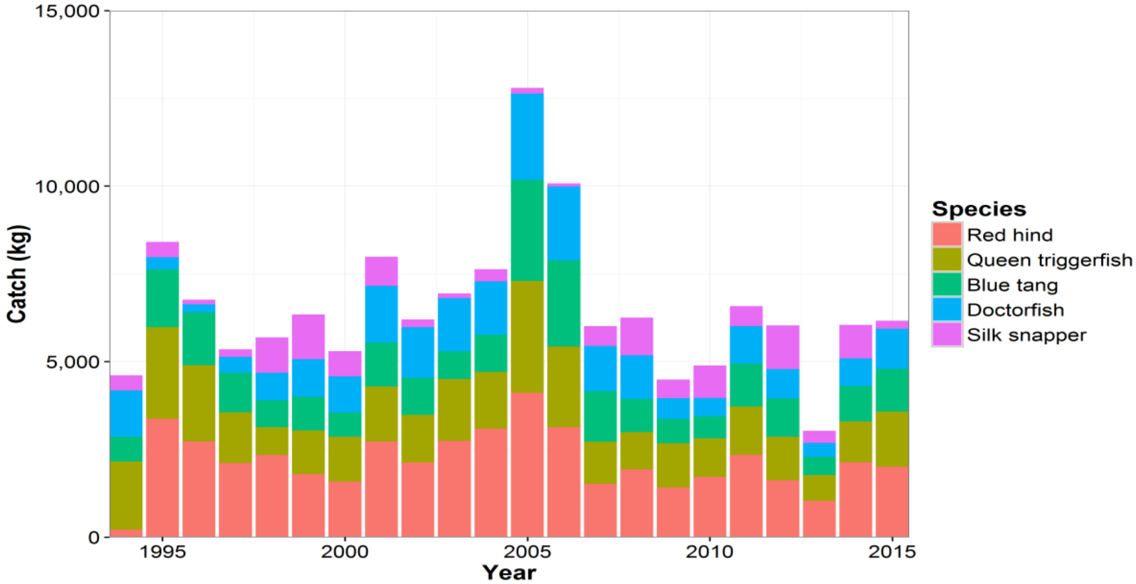

Figure 12. Total annual catch for target species of length-based assessment. *Source*: Montserrat Fisheries Division Catch Database.

Recorded catch for all target species except silk snapper peaked in 2005, declined in 2006, and has been relatively stable over the last 9 years (Figure 12). Silk snapper recorded catch peaked in 1999 and 2012 and has decreased over the last 3 years (Figure 12). Length frequency distributions for each species as observed in our fisheries-dependent surveys and in the Scientific Assessment (SA) are presented in Figure 13 with the length at maturity and theoretical maximum length (L_{inf}) indicated on each species' plot with vertical dashed and solid lines respectively. The red bars represents the number of individuals observed in the fishery catch at each length. These data were collected through random length sampling of fishers' catch between June 2015 and August 2016. The fishery data includes individuals that were landed mainly using pots, with some line and spear catch at a variety of depths. The blue bars represent the number of individuals at each length that were observed during the Blue Halo Scientific Assessment dive surveys that were conducted in October 2015 in depths < 20 m. The differences in the number of species observed in the survey and fishery data sets may be due to the species' associated depth ranges. For example, silk snappers were not observed during the dive surveys, but this is likely because they are found in depths deeper than the dive surveys were conducted.

Over 50% of the individual lengths observed in the fisheries-dependent length data for doctorfish, silk snapper, and red hind were below the minimum size at which the species reaches reproductive maturity. Silk snapper had the largest portion of observed fishery-dependent lengths below the reproductive size. Although seasonal recruitment patterns for silk snapper in Montserrat are not known, the samples for silk snapper were taken in July and August, which could potentially coincide with the season juvenile silk snapper begin recruiting to the fishery. This could mean our samples are biased towards a single, smaller age class that was most abundant during those 2 months, which could result in an overestimation of fishing mortality (F). Having length samples more evenly distributed across months will help reduce potential bias. No silk snapper were observed in the fishery-independent data. This is likely because the maximum depth of the surveys was 20 m, and the preferred depth range of this species is between 90 and 140 m.

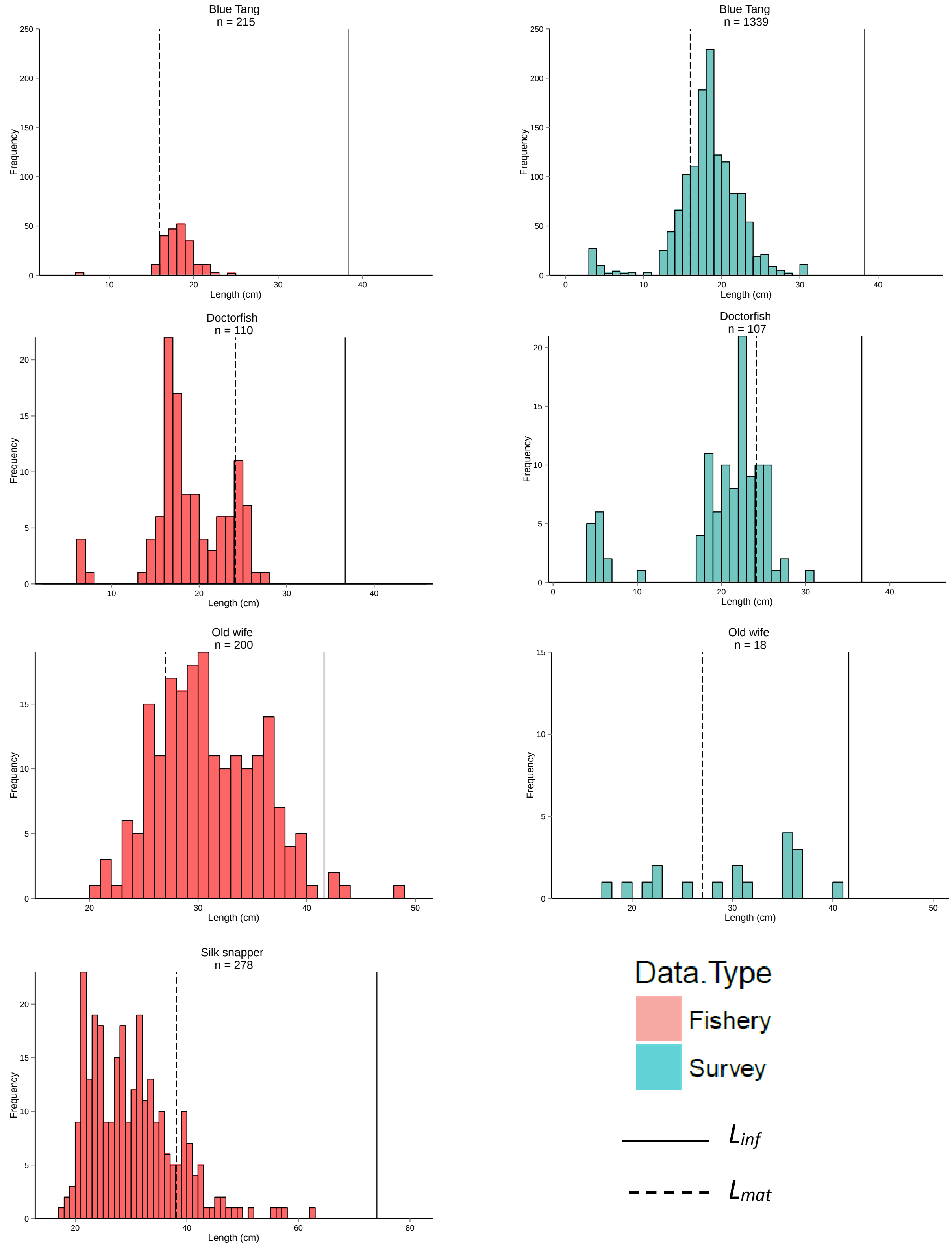

Figure 13. Length frequency distributions used in the length-based assessment of each species. Red represents length observations from the fishery and blue represents length observations from the scientific assessment survey. Darker green indicates overlap of the 2 length observations from both data sets. The solid line indicates the species' theoretical maximum size (L_{inf}) and the dotted line indicates the species size at maturity (L_{mat}).

Length-based Assessment

Results of the LBAR length-based assessment are presented in Table 3 and Figure 14. Length at capture (L_c) is the length at which the species is fully selected, meaning the probability of being captured by the fishery at that length is 1. L_c was calculated using methods described in Sparre 1998. L_{BAR} is the average length of the population that is exploited by the fishery. Results of the assessment indicate that blue tang and doctorfish are currently experiencing moderate overfishing, silk snapper may be experiencing mild overfishing, and old wife and red hind are not currently experiencing overfishing.

Overfishing means that the level of fishing pressure is not sustainable, and that more fish are caught from fishing than the population can replace through reproduction. A population that has experienced overfishing may reach an overfished state, meaning the population size is below sustainable levels due to fishing activity.

Table 3. Results of LBAR length based assessment.

Species	L_c	L_{BAR}	F/F_{MSY}	lower 95% C.I.	upper 95% C.I.
Blue tang	18.00	20.24	1.71	1.39	2.07
Doctorfish	18.00	22.21	1.55	1.26	1.92
Old wife	30.00	32.32	0.49	0.22	0.83
Red hind	32.00	35.57	0.35	0.15	0.60
Silk snapper	27.50	34.55	1.26	0.94	1.64

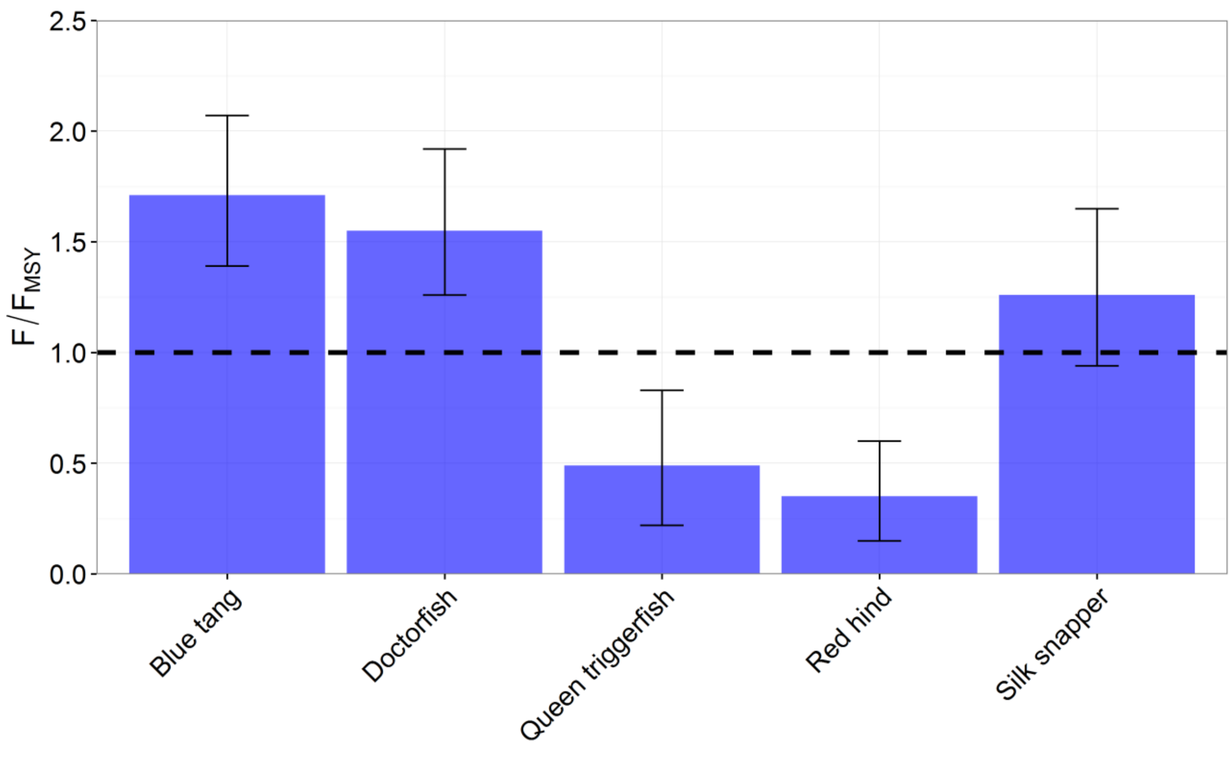

Figure 14. Estimated F/F_{MSY} from the LBAR length-based assessment. Error bars indicate upper and lower 95% confidence intervals. The dotted line indicates F/F_{MSY}=1 (> 1.0 indicates overfishing and < 1.0 indicates sustainable fishing pressure).

The results of the Catch MSY analysis of gar estimated the stock's median MSY as 8,111 kg per year. Gar catch from 1994-2015 relative to the estimated MSY are presented in Figure 15.

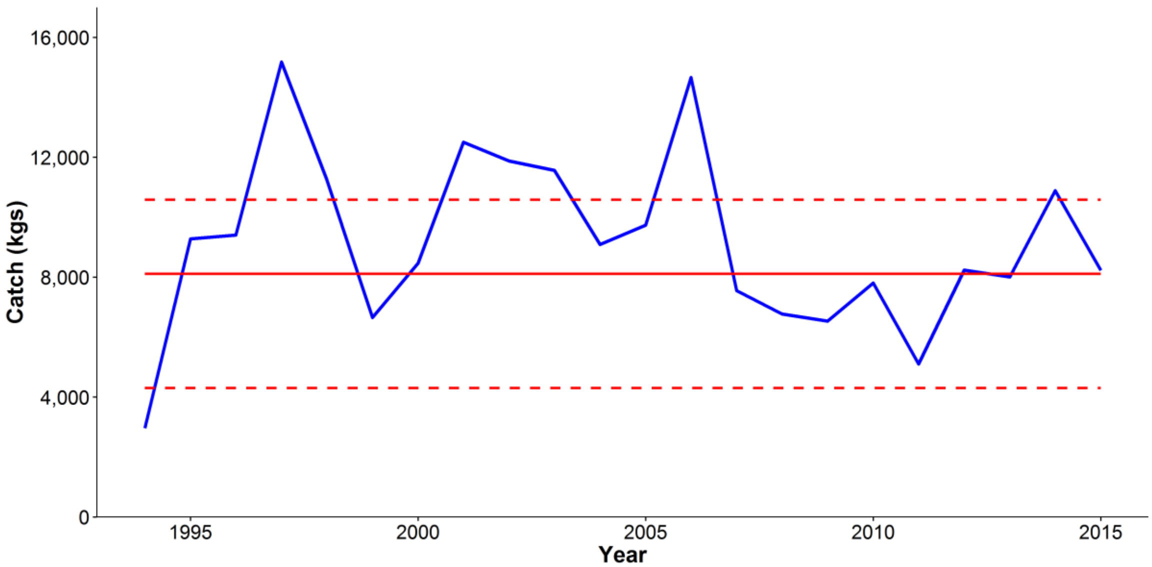

Figure 15. Total annual catch of gar (solid blue line) and the estimated maximum sustainable yield (solid red line) with upper and lower 95% confidence intervals

These results suggest that historical catch levels may have exceeded the estimated sustainable yield, meaning the stock has likely experienced overfishing. The model also estimated fishing mortality (*F*) levels and stock biomass for each year from 1994-2015 (Figure 16a and b). Figure 16a presents the estimated fishing mortality (*F*) of gar for each year relative to the estimated fishing mortality at F_{MSY}. Overfishing is assumed to be occurring when the value of F/F_{MSY} is greater than 1. Overfishing of the gar stock likely began in 1997 (Figure 16a). Figure 16b presents the estimate of stock biomass (B) relative to the biomass at maximum sustainable yield (B_{MSY}) for each year. The stock is considered overfished for B/B_{MSY} values that are less than 1. Although overfishing may have begun as early as 1997 (Figure 16a), the biomass of the stock did not reach a potentially overfished state until 2007 (Figure 16b). Since 2007, our estimates for stock status have been below, or very near 1, indicating that the stock may have reached or be close to an overfished state (Figure 16b).

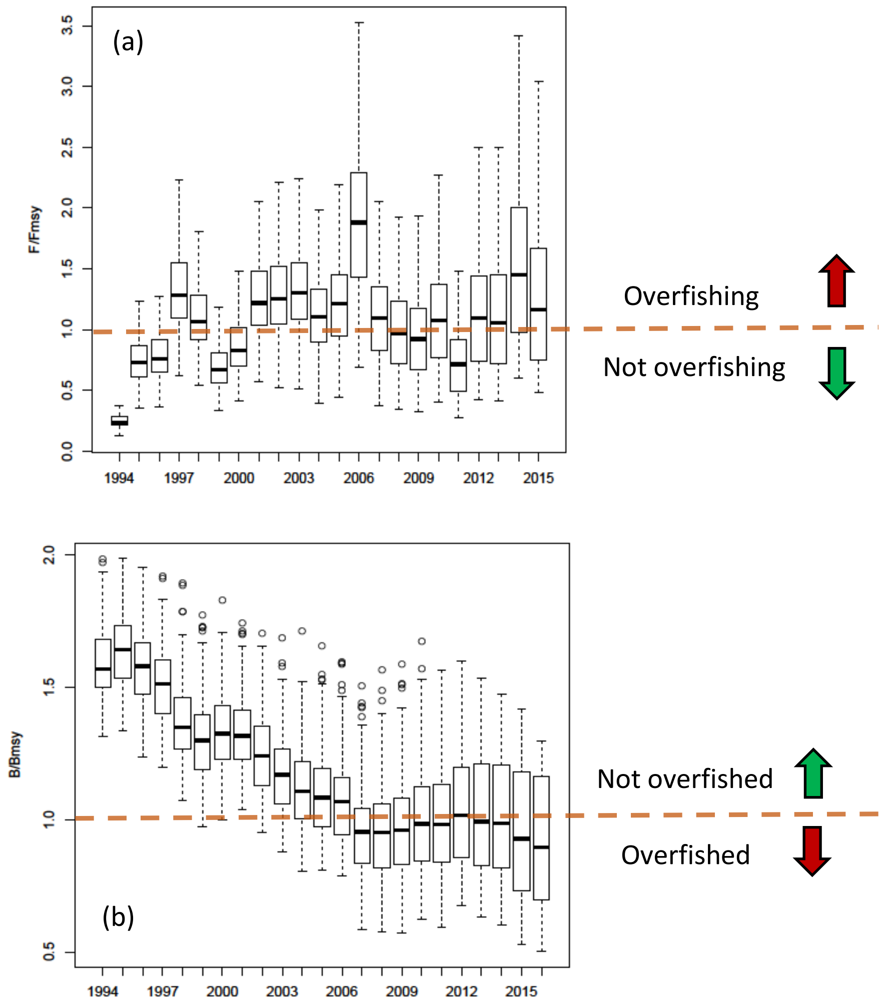

Figure 16. Results of the catch-based assessment on gar showing the annual median and associated error for estimated (a) F/F_{MSY} and (b) B/B_{MSY}. Overfishing (unsustainable fishing pressure) occurs when $F/F_{MSY} > 1$ (top) and the stock is considered overfished (low population biomass) when $B/B_{MSY} < 1$.

Catch Projections of Silk Snapper

The projection model estimated annual fishery yields and population biomass of silk snapper for 30 years under six example management scenarios. Input parameters used for the model are presented in Table 4. Parameters that varied for each management scenario are also presented in Table 4. These management scenarios were chosen for illustrative purposes only, to show that this model can be used to help evaluate management scenarios that may be of interest to Montserrat.

Table 4. Input parameters for spatial age-structured model of silk snapper

Model Component	Parameter	Description	Value	Units
Growth	L_{inf}	Asymtopic length	78.1	cm FL
	k	von Bertlanffy growth coefficient	0.09	yr^{-1}
	t_0	Theortical age at size 0	-2.309	
	t_{max}	Maximum age	9	years
	a	Length to weight conversion	1.00 E-05	
	b	Length to weight conversion	3.1	
Reproduction	L_{mat}	Length at maturity	41.8	cm FL
	Age_{mat}	Age at maturity	3	years
	FecundEgg	Average number of eggs once mature	108,000	
	h	Steepness	0.5	-
Movement	PLD	Pelagic larval duration	36	days
	A	Adult movement	241686.95	m
Mortality	M	Natural Mortality	0.23	yr^{-1}
	F	Relative Total Fishing mortaltiy	see Table 5	
Management	F_{BAU}	Relative Total Fishing Mortality under Business as usual	1	yr^{-1}
	$F_{Scenario2}$	Fishing Mortality for Management Scenario 2	0.8	yr^{-1}
	L_{cBAU}	Length at capture under Business as usual	27.5	cm FL
	$L_{cScenario5,6}$	Minimum size under management scenaios 5 and 6	38	cm FL
	$MR_{Scenario3,4,and 6}$	Marine reserve size	20-30	% of total area

All of the management scenarios modeled for silk snapper resulted in a steady increase in stock biomass relative to the no management intervention scenario (Figure 17). In general, fishery yields decline for the first one to two years after any of the management interventions relative to no management intervention. However, 5-10 years after a management intervention, fishery yields in all management scenarios surpass the no management intervention scenario, and by the end of the projection (30 years) are approximately 1.3 to 3.3 times greater (Figure 17).

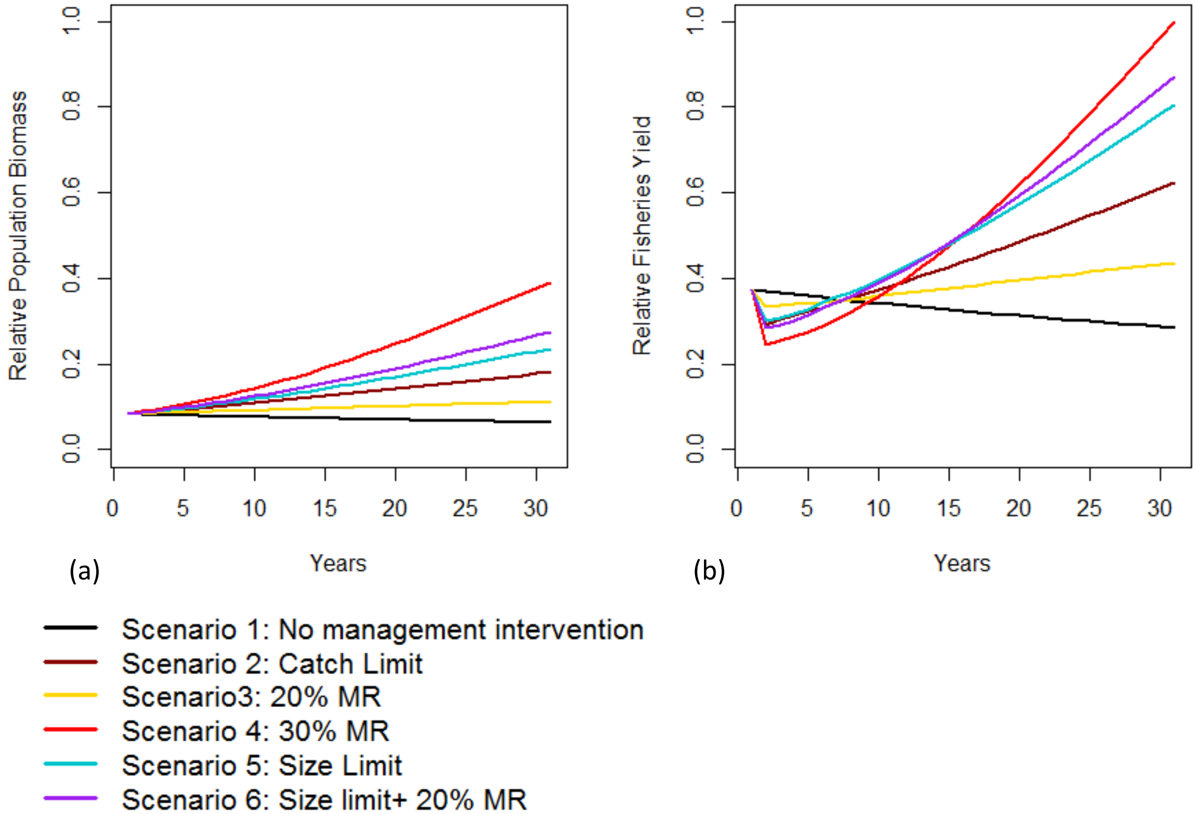

Figure 17. Projected (a) relative biomass, and (b) relative yield of silk snapper in Montserrat under various management scenarios. Year 0 is the current status of the population in 2016.

Of the management scenarios that were tested, a no-take marine reserve that covers 30% of silk snapper's habitat results in the largest long-term benefit to yield and biomass for silk snapper (Figure 17). The 20% no take marine reserve scenario, on the other hand, resulted in the smallest short-term impacts on relative yield, and the smallest increase in long term yield and biomass (Figure 17). However, these predictions are sensitive to the adult movement rate we assume for silk snapper. Adult movement was calculated using the relationship described in Kramer and Chapman (1999) between maximum size and home range. If this assumed rate is too low, the benefits of the marine reserve may be overestimated (and vice versa) as fish with higher movement rates are more likely to swim outside of a reserve and be caught. In general, the effectiveness of a marine reserve will largely depend on the size of the reserve relative to the home range, or movement, of the species, and larval dispersal distance (PISCO 2007; Gaines et al. 2010).

A minimum size limit would allow fish to reproduce and contribute to the population before being caught by the fishery. To be effective, minimum sizes should be set above the length at which the fish reaches maturity to account for some measurement error by fishers. For this example, the minimum size for silk snapper was set 5 cm above the size at maturity.

Conclusions

Our length-based and catch-based assessment results suggest that several of the top landed species in Montserrat's fisheries may currently be experiencing mild to moderate overfishing. The high abundance of species that are considered highly trappable (easily caught in pots), such as old wife, may indicate that Montserrat's pot fishery has not been severely overexploited. Low abundance of old wife in Jamaica and the US Virgin Islands has been correlated with high pot fishing pressure (Hawkins et al. 2007).

Currently, most traps are set in deep waters (>20 m), and the fisheries-independent dive surveys were conducted in shallower waters (< 20 m). Species that were not abundant in the fisheries catch may have been more abundant in the survey data due to depth distributions or vice versa. For example, no silk snappers were observed in the dive surveys because their preferred depth range is > 20 m. We do not know how deep traps have been set historically, and it is possible that they have gradually been set deeper over time in response to stock depletion. However, the species composition of catch has not shifted over time as would be expected if fishing depth had changed significantly.

Montserrat's fisheries are an important marine resource that have a long history of providing the island's fishers a source of steady income and the island's residents an essential source of protein. Identifying management objectives now and determining appropriate harvest strategies before the biomass of stocks drop to levels from which it may be hard to recover is crucial to ensure Montserrat's fisheries continue to provide economically viable catches. Monthly length data could be collected for 2017, or any future year, analyzed to provide an estimate of the stock's status, and compared to results presented here to determine trends over time.

We hope that this report will serve as the first step in adopting an adaptive approach for monitoring and managing Montserrat's fisheries. The high proportion of juvenile doctorfish, silk snapper, and blue tang recorded in the catch- and length-based assessment results shows that these species are experiencing overfishing and strongly suggests the trap fishery should be regulated. A summary of potential management approaches for traps and other gears used in Montserrat's fisheries is presented in the separate Gear-based Management Literature Review Report. If Montserrat's Fisheries Division were able to include length measurements in their catch monitoring, future assessments would be able to determine the impact of any new fisheries regulations and better assess the stock status. These suggestions and the results presented here may be used as a guide to help managers identify the most efficient way to continue monitoring the fisheries, to develop regulations to ensure the sustainability of future fish catches, and to serve as a baseline against which to compare future assessments.

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Appendix 1: Glossary

Biomass at maximum sustainable yield (B_{MSY}): The biomass (total weight of fish) that can support harvest of the maximum sustainable yield. A population below B_{MSY} is considered overfished.

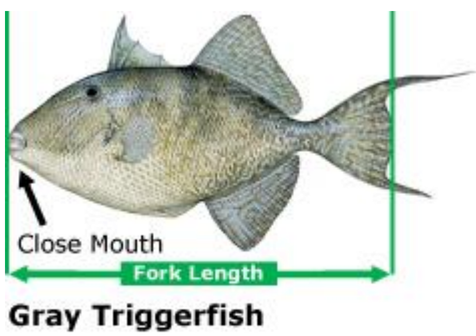
Carrying capacity (*K*): Maximum population size (or biomass) of a single species that the environment can support.

Catch per unit effort (CPUE): The amount of catch per unit of fishing effort. This can be calculated in numerous different ways such as weight of fish caught per fishing trip, weight of fish in each trap haul. In the context of Montserrat's fisheries, effort is defined as number of fishing trips and catch is defined as weight (kg) landed.

Fishing mortality (*F*) : Death or removal of fish from a population due to fishing. The fraction of the fish stock that are caught at a point in time (often each year).

Fishing mortality at maximum sustainable yield (F_{MSY}): Fishing mortality rate that would yield the MSY when the population level is at B_{MSY}.

Fork length (FL): Length measurement of fish from front of the jaw or tip of snout to center of the tail fork (see figure below).



Fully selected: Fully selected means that the probability of a fish being captured by the fishing gear is 100%. Fish below this size may have a chance of not being caught by the gear because of their smaller size. For example, some fish of a smaller size may not be caught by a trap because they can squeeze between the trap mesh.

Intrinsic growth rate (*r*): The rate of population increase in the absence of density-dependent forces; the maximum population growth rate.

Length at capture (L_c): Length at which an individual becomes fully selected by a fishery.

Length frequency distribution: a histogram of length measurements. Normally plotted with size classes on the x-axis and the frequency fish (or organisms) within those size classes were recorded on the y-axis.

Maximum sustainable yield (MSY): Maximum catch that can be taken from a population over an indefinite period of time without causing the population to decrease.

Natural Mortality (*M*): The removal of fish the a population due to causes not associated with fishing. Such causes may include disease, competition, cannibalism, old age, predation, or any other natural factor that causes the death of fish.

Overfishing: A level of fishing pressure is not sustainable, and that more fish are caught from fishing than the population can replace through reproduction. A fishing mortality (*F*) that exceeds $F_{MSY.}$

Overfished: The population biomass is below B_{MSY} as a result of overfishing.

Sustainable yield: Catch that can be taken from a population over an indefinite period of time without causing the population to decrease.

Schaefer surplus production model: A common model applied by fishery scientists to estimate the sustainable yield of a population, and the population biomass required to obtain the maximum sustainable yield of a population (B_{MSY}) and the fishing mortality rate (F_{MSY}) required for MSY. The basic Schaefer curve equation expresses the change in biomass of the populations with time:

$$g(B) = rB\left[1 - \frac{B}{K}\right]$$

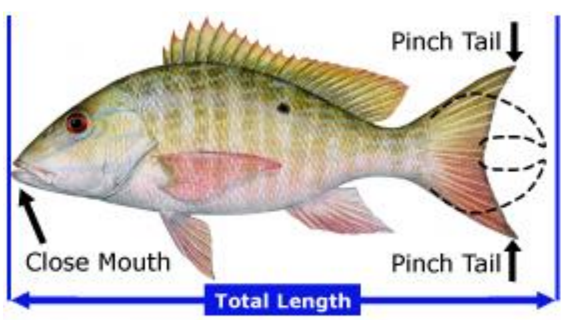
Where *B* is the exploitable biomass at time t; g(B) is the surplus production as a function of biomass; K is the population's carrying capacity (maximum biomass); and r is the intrinsic growth rate

Species resilience: A classification of a fish population's capacity to withstand exploitation based on several life history parameters. Fishbase gives each species a high, medium, low, or very low resilience score based on life history classification by Musick 1999.

Stock biomass (*B*): the total weight of all fish or organisms in a stock.

Theoretical maximum length indicated (L_{inf}): The length that the fish of a population would reach if they were to growth indefinitely, or the asymptotic length. One of the three parameters included in the von Bertalanffy growth function.

Total length (TL) – length measurement of fish from the furthest forward point on head to farthest tip of the tail (see Figure below)



Appendix 2: Catch Database Species List

Table A1. List of species and families found in Montserrat's Fisheries Division catch database.

Family	Common name	Scientific name
Acanthuridae	ocean surgeon	*Acanthurus bahianus*
	doctorfish	*Acanthurus chirurgus*
	blue tang	*Acanthurus coeruleus*
Albulidae	bonefish	*Albula vulpes*
Ariidae	catfishes	*Aridae (g.arius)*
Atherinopsidae	silversides	*Atherinidae*
Aulostomidae	trumpetfishes	*Aulostomidae*
Balistidae	gray trigger	*Balistes capriscus*
	queen triggerfish	*Balistes vetula*
	ocean triggerfish	*Canthidermis sufflamen*
	black durgan	*Melichthys niger*
Belonidae	needlefishes	*Belonidae spp.*
	keeltail needlefish	*Platibelone argalus arga*
	gar	*Tylosurus crocodilus*
Carangidae	crevalle jack	*Caranx hippos*
	big eye scad	*Selar crumenophthalmus*
	african pompano	*Alectis ciliaris*
	yellow jack	*Carangoides bartholomaei*
	blue runner	*Caranx crysos*
	horseeye jack	*Caranx latus*
	horseeye jack	*Caranx latus*
	black jack	*Caranx lugubris*
	bar jack	*Caranx ruber*
	round scad	*Decapterus punctatus*
	rainbow runner	*Elagatis bipinnulata*
	bigeye	*Priacanthus arenatus*
	atlantic moonfish	*Selene setapinnis*
	greater amberjack	*Seriola dumerili*
	almaco jack	*Seriola rivoliana*
	permit	*Trachinotus falcatus*
	palometa	*Trachinotus goodei*
	cottonmouth jakc	*Uraspis secunda*
Carcharhinidae	blacktip shark	*Carcharhinus limbatus*
	oceanic whitetip shark	*Carcharhinus longimanus*
	sandbar shark	*Carcharhinus milberti*
	caribbean reef shark	*Carcharhinus perezi*
	tiger shark	*Galeocerdo cuvier*
	lemon shark	*Negaprion brevirostris*
	carib sharpnose shark	*Rhizonoprionodon porosus*
	sharks,unclassified	*Squalidade*
Centropomidae	snooks	*Centropomidae*
Chaetodontidae	foureye butterfly fish	*Chaetodon capistratus*
	spotfin butterflyfish	*Chaetodon ocellatus*
	banded butterfly fish	*Chaetodon striatus*
Cheloniidae	green sea turtle	*Chelonia mydas mydas*
	turtles	*Cheloniidae*
	hawksbill turtle	*Eretmochelys imbricata*
Cichlidae	peacock bass	*Cichla ocellaris*

Clupeidae	herrings	*Clupeidae*
Congridae	conger eel	*Conger oceanicus*
	manytooth conger	*Conger triporiceps*
Coryphaenidae	dolphinfish	*Coryphaena hippurus*
Cyprinidae	bream	*Abramis brama*
Dactylopteridae	flying gurnard	*Dactylopterus volitans*
Echeneidae	sharksucker	*Echeneis naucrates*
Ephippidae	atlantic spadefish	*Chaetodipterus faber*
Exocoetidae	flyingfishes	*Exocoetidae*
Gerreidae	silver jenny	*Eucinostomus gula*
Ginglymostomatidae	nurse shark	*Ginglymostoma cirratum*
Haemulidae	black margate	*Anisotremus surinamensis*
	porkfish	*Anisotremus virginicus*
	barred grunt	*Conodon nobilis*
	caesar grunt	*Haemulon carbonarium*
	smalltooth grunt	*Haemulon chrysargyreum*
	spanish grunt	*Haemulon macrostomum*
	cottonwick	*Haemulon melanurum*
	sailors choice	*Haemulon parrai*
	white grunt	*Haemulon plumieri*
	blue striped grunt	*Haemulon sciurus*
	striped grunt	*Haemulon striatum*
	french grunt	*Haemulon flavolineatum*
	black grunt	*Heamulon bonariense*
Hemiramphidae	ballyhoo	*Hemiramphus brasiliensis*
Holocentridae	squirrelfish	*Holocentrus adscensionis*
	longjaw squirrelfish	*Holocentrus marianus*
	longspine squirrelfish	*Holocentrus rufus*
	blackbar soldierfish	*Myripristis jacobus*
Istiophoridae	sailfish	*Istiophorus platypterus*
	blue marlin	*Makaira nigricans*
	white marlin	*Tetrapturus albidus*
Kyphosidae	bermuda chub	*Kyphosus sectatrix*
Labridae	spotfin hogfish	*Bodianus pulchellus*
	spanish hogfish	*Bodianus rufus*
	creole wrasse	*Clepticus parrae*
	puddingwife	*Halichoeres radiatus*
	hogfish	*Lachnolaimus maximus*
Loliginidae	squid	*Loliginidae*
Lutjanidae	uku	*Aprion viscerens*
	black snapper	*Apsilus dentatus*
	queen snapper	*Etelis oculatus*
	white margate	*Haemulon album*
	glass eye snapper	*Heteropriacanthus cruentatus*
	mutton snapper	*Lutjanus analis*
	schoolmaster	*Lutjanus apodus*
	blackfin snapper	*Lutjanus buccanella*
	red snapper	*Lutjanus campechanus*
	cubera snapper	*Lutjanus cyanopterus*
	gray snapper	*Lutjanus griseus*
	dog snapper	*Lutjanus jocu*
	mahogony snapper	*Lutjanus mahogoni*
	southern red snapper	*Lutjanus purpureus*

	lane snapper	*Lutjanus synagris*
	silk snapper	*Lutjanus vivanus*
	yellowtail snapper	*Ocyurus chrysurus*
	glasseye snapper	*Priacanthus cruentatus*
	wenchman	*Pristipomoides aquilonar*
	vermilion snapper	*Rhomboplites aurorubens*
Malacanthidae	sand tilefish	*Malacanthus plumieri*
Megalopidae	tarpon	*Megalops atlanticus*
Melongenidae	indian crown conch	*Melongena melongena*
Monacanthidae	orange filefish	*Aluterus schoepfi*
	scrawled filefish	*Aluterus scriptus*
	white spotted filefish	*Cantherhines macrocerus*
	orangespot filefish	*Cantherhines pullus*
Muglidae	white mullet	*Mugil curema*
Mullidae	yellow goatfish	*Mulloidichthys martinicu*
	spotted goatfish	*Pseudupeneus maculatus*
	dwarf goatfish	*Upeneus parvus*
Muraenidae	green moray	*Gymnothorax funebris*
	spotted moray	*Gymnothorax moringa*
	purplemouth moray	*Gymnothorax vicinus*
	staut moray	*Muraena robusta*
Octopodidae	carib. reef octopus	*Octopus briareus*
	common octopus	*Octopus vulgaris*
Odontaspididae	sand tiger shark	*Odontaspis taurus*
Ostraciidae	spotted trunkfish	*Lactophrys bicaudalis*
	spotted spiny lobster	*Panulirus guttatus*
	honeycomb cowfish	*Lactophrys poligonius*
	scrawled cowfish	*Lactophrys quadricornis*
	trunkfish	*Lactophrys trigonus*
	smooth trunkfish	*Lactophrys triqueter*
Palinuridae	Caribbean spiny lobster	*Panulirus argus*
Pomacanthidae	french angelfish	*Pomacanthus paru*
	blue angelfish	*Holacanthus bermudensis*
	rock beauty	*Holacanthus tricolor*
	batfishes	*Ogcocephalidae*
	sergeant major	*Abudefduf saxatilis*
	night sergeant	*Abudefduf taurus*
	queen angelfish	*Holacanthus ciliaris*
	yellowtail damselfish	*Microspathodon chrysurus*
	gray angelfish	*Pomacanthus arcuatus*
Portunidae	speckeled swimming crab	*Arenaeus cribrarius*
Scaridae	spotted parrotfish	*Cetoscarus ocellatus*
	midnight parrotfish	*Scarus coelestinus*
	blue parrotfish	*Scarus coeruleus*
	striped parrotfish	*Scarus croicensis*
	rainbow parrotfish	*Scarus guacamaia*
	princess parrotfish	*Scarus taeniopterus*
	queen parrotfish	*Scarus vetula*
	redband parrotfish	*Sparisoma aurofrenatum*
	redfin parrotfish	*Sparisoma rubripinne*
	stoplight parrotfish	*Sparisoma viride*
	redtail parrot	*Sparisoma chrysopterum*
Sciaenidae	striped croaker	*Bairdiella sanctaeluciae*

	jackknife-fish	*Equetus lanceolatus*
	spotted drum	*Equetus punctatus*
	gulf kingfish	*Menticirrhus littoralis*
	drums	*Sciaenidae*
	kingfish	*Scomberomorus cavalla*
Scombridae	wahoo	*Acanthocybium solandri*
	little tunny	*Euthynnus alletteratus*
	skipjack tuna	*Katsuwonus pelamis*
	atlantic bonito	*Sarda sarda*
	spanish mackerel	*Scomberomorus maculatus*
	cero mackeral	*Scomberomorus regalis*
	albacore	*Thunnus alalunga*
	yellowfin tuna	*Thunnus albacares*
	blackfin tuna	*Thunnus atlanticus*
	bluefin tuna	*Thunnus thynnus*
Scorpaenidae	lionfish	*Pterois volitans*
Scyllaridae	sculp slipper lobster	*Parribacus antarcticus*
	slipper lobster	*Scyllaridae*
Serranidae	rock hind	*Epinephelus adscensionis*
	graysby	*Epinephelus cruentatus*
	coney	*Epinephelus fulvus*
	red hind	*Epinephelus guttatus*
	honeycomb grouper	*Epinephelus merra*
	red grouper	*Epinephelus morio*
	naussau grouper	*Epinephelus striatus*
	soapfishes	*Grammistidae*
	black grouper	*Mycteroperca bonaci*
	yellowfin grouper	*Mycteroperca interstita*
	tiger grouper	*Mycteroperca tigris*
	yellowfin grouper	*Mycteroperca venenosa*
	butterfish	*Peprilus triacanthus*
Sparidae	sea bream	*Archosargus rhomboidalis*
	jolthead porgy	*Calamus bajonado*
	jolthead porgy	*Calamus bajonado*
	saucereye porgy	*Calamus calamus*
	pluma porgy	*Calamus pennatula*
	pinfish	*Lagodon rhomboides*
Sphyraenidae	great barracuda	*Sphyraena barracuda*
	southern sennet	*Sphyraena picudilla*
Sphyrnidae	shark,hammer.scaloped	*Sphyrna lewini*
	shark,great hammerhd	*Sphyrna mokarran*
Strombidae	queen conch	*Strombus gigas*
Synodontidae	lizardfishes	*Synodontidae*
Urotrygonidae	stingrays	*Dasyatidae*