Assessment of the Commercial Fishery of Saba Bank

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Executive Summary

The commercial fishery of Saba Bank, Netherlands Antilles, was assessed for six months from June 1 through November 30, 2007, by conducting port sampling interviews with Saban commercial fishermen to obtain information on fishing effort, gear usage, landings and species composition of catches. Results from our survey are compared to previous studies to provide an updated assessment of the Saba Bank commercial fishery.

The fishery can be summarized as follows. A small fishing fleet of approximately ten vessels operates from Fort Bay, Saba Island, and conducts small-scale commercial fishing on Saba Bank. Saban commercial fishermen may participate in either or both of two distinct types of fisheries: a lobster trap fishery and a "redfish" trap fishery. The two trap fisheries account for almost all commercial landings while other fishing methods (e.g. hook & line) make only a minor contribution to total landings from Saba Bank. Specific patterns of effort, landings and catch composition are identified within each trap fishery.

Lobster trap fishing is the more prevalent and economically significant Saba Bank fishery. Lobster catch rate is 0.84 lobster per trap-haul and 184 pounds per trip. Catch rates vary significantly with season. Projected annual lobster landings are 184,000 lbs (83.6 mt) with an ex-vessel value of US $1.3 million per year. The lobster trap fishery also harvests a diversity of "mixed fish" (shallow water reef fishes). Average catch rate of mixed fish is 0.5 pounds per trap-haul and 37.8 pounds per trip, with projected annual mixed fish landings of 37,700 pounds (17.1 mt) at an ex-vessel value of US $68,700 per year.

The fish trap fishery targets "redfish" - an assortment of deepwater snapper species that is dominated by silk snapper, blackfin snapper, and vermilion snapper. These three lutjanid species comprise > 91 % of fish trap catch. Average catch rate of redfish in fish traps is 10 pounds per trap-haul, and 291 pounds per trip. Projected annual fish trap landings of redfish are 90,800 pounds (41.3 mt) with an ex-vessel value of US $289,000 per year. Fish trap landings also include a small quantity of mixed fish (< 9 % by weight of finfish in fish trap landings) comprised of a diversity of species but dominated by red hind and lane snapper. Catch rate of mixed fish in fish traps is 1 pound per trap haul and 27 pounds per trip.

Viewed as a whole, 2007 landings from Saba Bank by Saban commercial fishermen are projected to exceed 145 metric tons in 2007 with an ex-vessel value greater than US $1.6 million. Comparison to previous fisheries studies indicates that the Saba Bank commercial fishery is relatively stable in terms of total fishing effort, total landings, economic value, and

fishing methods. The following trends were identified. Compared to 1999-2000, lobster catch rate in 2007 was approximately 33 % lower in terms of weight per trap-day, but there was only a small (6.3 %) reduction in total landings of lobster. A shift to smaller lobster size was not indicated by length frequencies: average carapace length was larger in 2007 (11.2 cm) than in 1999-2000 (10.7 cm). However, lobster fishing effort as measured by trap haul rate was 31 % greater in 2007 (80.9 trap-hauls per trip) than in 1999-2000 (62.0 trap-hauls per trip). We estimate that the total number of lobster traps in use on Saba Bank increased from 1,426 traps in 1999-2000 to 1,862 traps in 2007. Collectively, these findings indicate that Saba Bank fishermen of 2007 exert a greater fishing effort in order to maintain lobster landings at year 2000 levels. An increase in fishing effort coupled with a decrease in observed catch rate could suggest that lobster harvests are now at or exceed the maximum sustainable yield for Saba Bank stocks. However, more definitive conclusions about trends in lobster stock abundance are not possible owing to the limited time frame of available fisheries data sets.

The importance of redfish, as a percentage of total annual landings, has increased by three-fold since 2000. Yet, the Saba Bank redfish fishery is characterized by a lack of information. Stock densities are either unknown, or may be based on very optimistic calculations. The commercial fishery now harvests redfish primarily with fish traps, in contrast to hook & line fishing methods that predominated in 2000. Given that stock size remains poorly known, the current practice of harvesting almost exclusively juvenile fishes is a risky fisheries strategy. If reproductive output by silk snapper stocks is sufficiently reduced by harvesting it may lead to abrupt population declines or even a stock crash.

We recommend that the following actions should be priorities for management of Saba Bank fisheries resources: establishment of a program for long-term commercial fisheries monitoring, elimination of anchoring by large vessels on Saba Bank, development of a framework for monitoring and regulating the harvest of deepwater snappers, implementation of conservation measures to protect a red hind spawning aggregation, and initiation of a study to evaluate ghost fishing by lost traps.

Saban fisherman with a Saba Bank Lobster

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I. Introduction

1) Description of Saba Bank

Saba Bank is a large, completely submerged carbonate platform located 5 km southwest of the island of Saba (Macintyre et al., 1975) in the Netherlands Antilles. Well developed, actively growing coral reefs are found on the platform's eastern and southern margins leading some authors to conclude that Saba Bank is a submerged coral reef atoll (Van der Land, 1977, Meesters et al., 1996). A small commercial fishery operating from Fort Bay, Saba Island, presently exploits the fisheries resources of Saba Bank. These resources are of considerable economic importance to the local island population (Framhein, 1995 cited in Meesters et al., 1996, Dilrosun, 2000).

From June 1 through November 30 of 2007, we conducted port sampling of Saban commercial fishermen who fish on the Saba Bank. The goal of our study was to compile an updated assessment of the Saba Bank commercial fishery. Specific study objectives were to: provide a descriptive account of commercial fishing gears and methods; to examine of the spatial distribution of fishing effort on Saba Bank; to estimate fishing effort, landings, and annual economic value; and to examine the species and size composition of landings. A description of port sampling methods is given in Toller and Lundvall (2007) and supplementary information is provided in Appendix 1.

2) Previous Studies

There have been a number of previous accounts of the Saba Bank fishery (Boeke, 1907, Giudicelli and Villegas, 1980, Van Buurt, 1988, Meesters et al., 1996). Although the reports vary in the level of detail provided, they were generally based on limited observations and were widely separated in time. The most comprehensive investigation of the Saba Bank fishery was the recent study by Dilrosun (2000), who also provided a review of the fisheries literature relating to Saba Bank. Dilrosun performed extensive sampling of commercial catches over a 13-month period during 1999-2000. His study provides a baseline against which we compare the 2007 commercial harvests from Saba Bank. Commercial fisheries information for Saba Bank was not collected in the seven intervening years since Dilrosun's study.

3) Existing Fisheries Management and Jurisdictional boundaries

Formal management of the Saba Bank commercial fishery is minimal owing to limitations of capacity, funding, and infrastructure (Dilrosun, 2000). In this respect, the Saba Bank fishery resembles other artisanal fisheries in the Caribbean. There are no fisheries officers on Saba and there is no program for continuous recording of commercial landings. As a consequence, there is a lack of time-series data for commercial fisheries statistics. Resource managers thus face a data-poor situation for making decisions about the status of fisheries stocks.

The legislative framework for management and regulation of Saba Bank commercial fishing originates from the National Fisheries Ordinance of the Netherlands Antilles. A legal counterpart, the Saba Island Fisheries Ordinance, applies to Saban territorial waters. Existing legislation specifies certain restrictions on gear construction. The regulations that are of greatest relevance to our assessment are restrictions that specify: minimum trap mesh size (1.5 inches), obligatory use of biodegradable escape panels on traps, minimum capture size for lobster (9.5 cm carapace length), and prohibition on landing of egg-bearing female lobster. Enforcement of fisheries regulations is the purview of the Netherlands Antilles Coast Guard. The issuance of commercial fishing permits is another mechanism that resource managers may utilize to regulate the Saba Bank fishery. Permitting is useful as a means for limiting entry into the fishery, thereby allowing authorities some measure of control over fleet size.

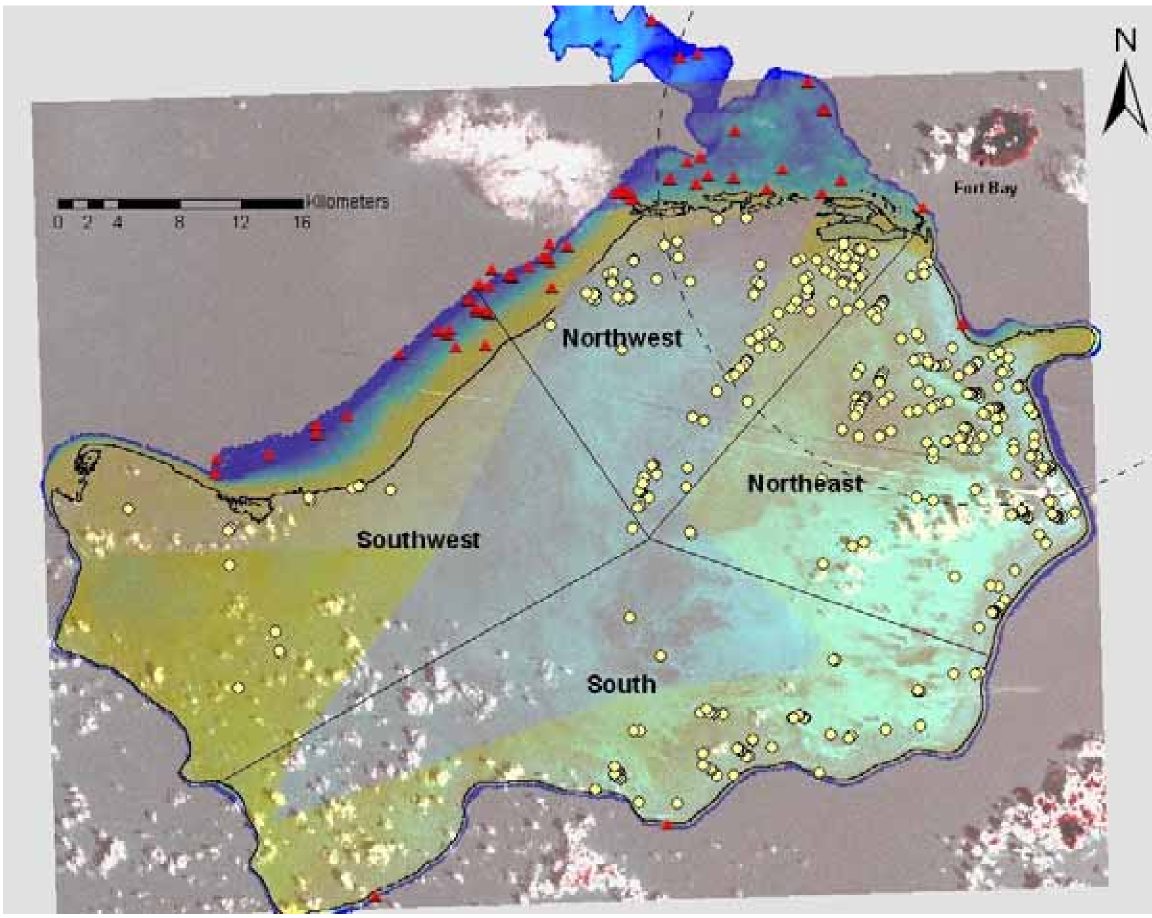


Figure 1. Commercial fishing grounds of Saba Bank. Reported fishing locations are shown on a composite map of bathymetry and satellite imagery (see Toller, 2008). This map shows the spatial distribution of fishing effort using two commercial gear types: lobster traps (yellow circles) and fish traps (red triangles). Also shown are Fort Bay, Saba Island (upper right), the 50-meter depth contour (black outline) and limit of Saban territorial seas (dotted line). Four fishing quadrants are recognized: northeast, northwest, southwest, and south with boundaries (black lines) radiating from the approximate center of Saba Bank.

Jurisdiction over the resources of Saba Bank is partitioned according to the UN Convention on the Law of the Sea (Meesters et al., 1996). The Saban local government is charged with authority for territorial seas that extend to 12 nautical miles from the island of Saba. The central government of the Netherlands Antilles has authority over the Exclusive Economic Zone (EEZ) that extends from the limit of territorial waters (12 nautical miles) to 200 nautical miles, and well beyond the farthest reaches of Saba Bank. At present, the Netherlands Antilles government lays claim to only a limited EEZ for the purpose of fisheries, and the claim is termed an EFZ or Economic Fisheries Zone (Meesters et al., 1996). The boundary between Saban (territorial) and EFZ (federal) waters is shown in Figure 1. Roughly three-quarters of Saba Bank lies within the EFZ and one-quarter falls within Saban territorial waters.

II. Description of Fisheries

1) Fleet Size and Composition

Twelve fishing vessels based in Fort Bay are permitted for commercial fishing in EFZ and/or Saban waters of Saba Bank. During our study, ten of these Saban vessels were active in the commercial fishery while two participated only in recreational fishing (e.g. trolling for pelagic species). The latter were excluded from our port sampling.

A typical Saban commercial fishing vessel is shown in Figure 2. Vessels are 30-40 foot length overall and powered by inboard diesel engines. Design is similar to New England-style lobster boats and construction is fiberglass or wood. Most vessels have live wells. All vessels are outfitted with hydraulic wench and davit for hauling traps (Figure 2). Vessels are also outfitted with modern electronics including radio, GPS, and depth sounder.

Figure 2. A typical commercial fishing vessel used for trap fishing on Saba Bank. Note the davit and hydraulic wench mounted to port side behind the wheelhouse.

Saban fishermen make single-day trips to fishing grounds on Saba Bank. Crew consists of vessel captain and usually one helper. Average trip duration is approximately 9 hours, but ranges from 5.3 to 14.5 hours, being strongly influenced by distance to fishing grounds and prevailing weather. Various fishing activities, such as deploying new traps or re-positioning existing traps, also influence the duration of fishing trips.

2) Primary Types of Fisheries

Traps or "pots" are the primary gear used by Saban commercial fishermen on Saba Bank. Saban commercial fishermen use traps to target two different fisheries stocks: lobster and "redfish." Lobster traps are set to capture the Caribbean spiny lobster, *Panulirus argus*, although additional finfish and invertebrate species are also taken incidentally in lobster traps. Fish traps are set to capture a number of snapper species or "redfish" that occur in moderate to deep waters – particularly silk snapper, *Lutjanus vivanus*, blackfin snapper, *L. buccanella*, and vermilion snapper, *Rhomboplites aurorubens*. The quantity and construction of trap gears used, as well as the specific methods to bait and set them, depend upon whether a fisherman is targeting lobster or redfish. The differences between trap methods for harvesting lobster and redfish are sufficiently large, and catch characteristics sufficiently distinctive, that we consider them two different types of fisheries. Therefore the lobster trap fishery (= lobster fishery) and fish trap fishery (= redfish fishery) of Saba Bank are treated separately in the following text.

3) Fishing Grounds

The area of Saba Bank that is potentially available to lobster and fish trap fisheries is defined, in the first instance, by suitable habitat depths for target species. As such, the areal extent of potential fishing grounds can be approximated from bathymetric maps (see Toller, 2008, for a discussion of Saba Bank mapping information). Saba Bank is reported to encompass an area of 2,200 km^2 above the 200-meter isobath (Meesters et al., 1996), and lobster traps are set in depths < 25 fathoms (45.7 m). Therefore, we used the 50-meter isobath to calculate the area of Saba Bank that is potentially available to the lobster trap fishery. Our analysis indicates that an area of 1,850 km^2 lies within suitable depths for lobster trap fishing, and it includes most of Saba Bank's shoal area.

In contrast to lobster fishing grounds, suitable depths for redfish (fish trap) fishing are generally restricted to a relatively narrow band around the periphery of Saba Bank. Detailed bathymetry of Saba Bank does not extend to the greatest depths fished by redfish trap fishermen, which may exceed 134 fathoms (245 m). Therefore, we calculated a minimum estimate for the area of Saba Bank that occupies suitable redfish depths. This was done by subtracting the area enclosed by the 50-meter isobath from that of the 200-meter isobath. Our analysis indicates that at least 350 km^2 of Saba Bank are potentially available as redfish trap fishing grounds. For comparison, Giudicelli and Villegas (1980) estimated that Saba Bank encompasses an area of 500 km^2 between 50 and 300 m depth.

Mapping of fishing activities on Saba Bank based upon 532 reported GPS locations of trap sets shows clear spatial separation of lobster trap and fish trap activities (Figure 1) as predicted from bathymetry. The number of reported trap fishing locations generally decreases with increasing distance from the island of Saba. For example, southwestern Saba Bank is the most distant fishing area from Fort Bay and it has the fewest reported fishing locations. Lobster trap fishing is concentrated towards the periphery of the shoal area of Saba Bank (Figure 1). Meesters et al. (1996) showed a similar distribution. Fish trap fishing effort is concentrated along the west, northwest, and northern margin of Saba Bank. The seafloor slopes gently in this region of Saba Bank (Macintyre et al., 1975, Van der Land, 1977). Little or no trap fishing is reported from the central reaches of Saba Bank – an area we call the "central void." Fishermen report that this area is a sand bottom habitat where sets of traps catch few lobster but large numbers of "white crabs." Specimens of white crab were examined and identified as the blotched swimming crab, *Portunus spinomanus* (T. Shirley, pers. com.). The central void is estimated to occupy 468 km^2, or roughly one quarter of the shoal area of Saba Bank.

Table 1. Distribution of Saba Bank Trap Fishing Effort by Area and Jurisdiction

		Quadrant				Jurisdiction			
Effort / Gear Type		NE	NW	SW	S	Saba	EFZ	Both	Total
Effort I. Number of Fishing Trips									
Lobster Trap	No.	73	46	7	18	71	60	13	144
	%	50.7%	31.9%	4.9%	12.5%	49.3%	41.7%	9.0%	100.0%
Fish Trap	No.	3	26	17	1	10	21	16	47
	%	6.4%	55.3%	36.2%	2.1%	21.3%	44.7%	34.0%	100.0%
All Traps	No.	76	72	24	19	81	81	29	191
	%	39.8%	37.7%	12.6%	9.9%	42.4%	42.4%	15.2%	100.0%
Effort II. Number of Trap-Hauls									
Lobster Trap	No.	6,264	2,788	357	2,269	5,665	6,013	-	11,678
	%	53.6%	23.9%	3.1%	19.4%	48.5%	51.5%	-	100.0%
Fish Trap	No.	34	1,514	301	21	701	1,169	-	1,870
	%	1.8%	81.0%	16.1%	1.1%	37.5%	62.5%	-	100.0%
All Traps	No.	6,298	4,302	658	2,290	6,366	7,182	-	13,548
	%	46.5%	31.8%	4.9%	16.9%	47.0%	53.0%	-	100.0%

The spatial distribution of fishing locations was collapsed onto a four-quadrant grid system (Figure 1), with quadrants of approximately equal size dividing Saba Bank into northeast, northwest, southwest and south fishing areas [the quadrant system was developed as a simplified means for determining fishing grounds in a commercial reporting system (see Recommendations, Toller and Lundvall, 2007)]. The spatial distribution of fishing effort among quadrants and between jurisdictions is shown in Table 1. Most fishing effort occurs in NE or NW quadrants, with more than 80 % of the lobster trap fishing effort recorded from either of these two quadrants. Lobster trap fishing effort is most intensive in the NE quadrant, while fish trap effort is concentrated in the NW quadrant. Collectively, commercial trap fishing effort is almost equally divided between territorial and federal waters of Saba Bank. However, fish trap effort is greater within the EFZ than within Saban waters of Saba Bank.

4) Gears Used

According to Dilrosun (2000), Saba Bank fisherman used 100 - 300 lobster traps and approximately 20 fish traps in 1999-2000. Applying Dilrosun's values to the fishery in year 2000 (14 fishermen), it can be calculated that there were a total of 3,080 traps (2,800 lobster traps and 280 fish traps) set on Saba Bank at that time. Since 2000, the number of active, permitted Saban commercial fishermen has declined to ten individuals in 2007. Assuming trap number per individual remained unchanged (i.e. using the above values from Dilrosun) it can be calculated that in 2007 there were a total of 2,200 traps (2,000 lobster traps and 200 fish traps) set on Saba Bank.

We did not census to determine the total number of traps used by each fisherman in this study. However, the information generated during our study allows us to estimate total trap number. Our results indicate that: 1) the total number of traps on Saba Bank has increased since Dilrosun's study, and 2) that previous calculations for total trap number were likely to be greatly over estimated.

Our data for trap-haul rate indicate that Saban commercial fishers haul 80.9 trap-hauls per trip. Data from Table I in Dilrosun indicate that the average lobster trap-haul rate was 62.0 trap-hauls per lobster trip in 1999-2000. Therefore, in 2007 fishermen are making approximately 31 % more trap-hauls per trip than was reported previously. Because trip frequency has not increased and reported trap soak time has remained unchanged (approximately seven days) we conclude that there are approximately 31 % more traps in use by the commercial fishery in 2007.

The total number of traps used by the Saba Bank commercial fishery in 2007 can be calculated using average fleet statistics for soak time, trip frequency, and trap-haul rate. This calculation yields an estimate of 1,958 traps (1,862 lobster traps and 96 redfish traps). By extension, it can be calculated that in 1999-2000 the Saban commercial fishery utilized 1,426 lobster traps on Saba Bank.

5) Total Fishing Effort

The Saban commercial fishing fleet makes an average of 3.7 fishing trips per day (stdev: 2.0, range: 0 - 9). It is projected that the fleet makes 1,310 fishing trips per year. Most of this fishing effort (76.2 %) is directed towards lobster (an estimated 998 lobster trips per year). The remaining effort (23.8 %) is directed towards redfish (312 redfish trips per year).

Fishing effort shows seasonality, with more fishing trips occurring in fall than in summer (Figure 3). Fishermen remarked that summer is typically a slow season for lobster. Saban fishermen will often schedule boat repairs and maintenance, or take time off from fishing for other reasons. Dilrosun (2000) noted that hurricanes also affect the fishing effort of the Saban commercial fleet. However, the low levels of commercial fishing effort that we observed in July-August of 2007 did not coincide with pronounced hurricane activity.

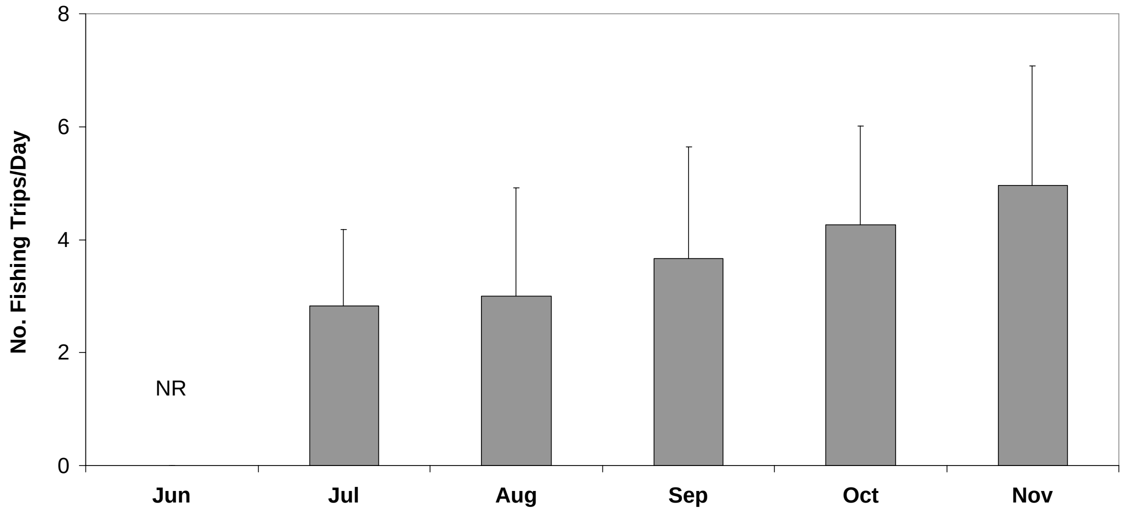


Figure 3. Saban commercial fishing effort by month. The average number of fishing trips to Saba Bank per day is shown. Error bars show standard deviation. Data are from the Fishing Trip Log from July 1 to November 30, 2007. Data was not recorded in June.

III. Lobster Fishery

1) Lobster Trap Soak Time and Haul Frequency

Saban commercial fishermen generally construct their own lobster traps. The predominant design for lobster traps is the chevron or West Indian arrowhead shape with a single funnel entrance. Traps are typically constructed from vinyl-coated wire mesh with welded rebar frame. According to Dilrosun (2000), the most common trap size is 4 feet wide x 4 feet long x 2 feet high (range: 3 - 5 feet) with a funnel size of 8.9 inches wide by 7.9 inches cm high. Trap mesh size varies among fishermen. We observed that the most frequent mesh size for lobster traps is 1.5 x 1.5 inch mesh although 2 x 2 inch mesh is also used. Some fishermen use 1 x 2 inch mesh for the side panels of lobster traps. Zinc anodes are affixed to traps to reduce corrosion and extend the working lifetime of traps. Biodegradable panels are rarely utilized. Trap doors are generally fastened closed with long-lasting materials such as vinyl-coated wire.

Fishermen bait their lobster traps with cow hides. Lobster traps are set in relatively shallow waters of Saba Bank, averaging between 12 and 14 fathoms and ranging from 6 to 25 fathoms. Lobster are harvested live (whole) and primarily transported onboard vessels in live wells. In port, fishermen transfer lobster to holding cages (fish traps without funnels) in Fort Bay. Lobster are kept in the holding cages at dockside (Figure 4) until they are sold.

Figure 4. Lobster harvest from Saba Bank. Saban commercial fishermen sell their lobster live. Lobster caught from Saba Bank are landed at Fort Bay and placed into holding cages, such as the one pictured here, until they are sent to market.

2) Lobster Effort

During a lobster trip, fishermen haul approximately 81 traps [average and stdev: 80.9 ± 29.2 trap-hauls per trip, median: 75, mode: 75, range: 18 - 213, n = 153 fishing trips]. Soak time of lobster traps is approximately one week [average and stdev: 8.4 ± 3.8 days, median and mode: 7 days, range: 5 - 31 days, n = 137 fishing trips]. Average lobster trap haul rates in 2007 are 31 % greater than reported in 1999-2000 (62.0 trap-hauls per lobster trip; see Table I in Dilrosun, 2000).

3) Lobster Catch Rate

A summary of lobster trap catch rate is presented in Table 2. Based upon our port sampling interviews collected over six months, Saban commercial fishermen land an average of 64.4 lobster per trip. Catch rate is approximately 8.4 lobster for every ten trap-hauls. By weight, lobster catch rate is 184 pounds per trip and 2.4 pounds per trap-haul.

Lobster catch rate is highly variable among individual fishing trips. Catch rates were significantly different among the months sampled (Kruskal-Wallis one-way analysis of variance, KW statistic = 34.1, $p < 0.001$, n =149, df = 5). The minimum observed CPUE occurred in June, and maxima occurred in August and September (Figure 5). Saban commercial fishermen report that summer is a "slow season" for lobster, and that lobster catch rate is partially influenced by lunar cycle. Lobster landings are also strongly influenced by water motion. Fishermen report that they experience a sharp increase in lobster catch rate with the arrival on Saba Bank of northern groundswells emanating from winter systems in the western Atlantic Ocean or during swells generated by passing hurricanes.

Table 2. Lobster CPUE

	No. Lobster		Wt. Per Trip		Wt. Per Trap-Haul		Wt. Per Trap-Day	
	Per Trip	Trap-Haul	(lbs)	(kg)	(lbs)	(kg)	(lbs)	(kg)
Average	64.4	0.84	184.2	83.6	2.40	1.09	0.32	143.6
St.Dev.	37.7	0.45	107.9	48.9	1.28	0.58	0.20	90.4
Max.	210	2.24	602.7	273.4	6.64	3.01	1.06	480.9
Min.	12	0.17	34.6	15.7	0.49	0.22	0.06	27.2
Count*	152	152	152	152	152	152	137	137

* Count is the number of port sampling interviews used for CPUE calculation.

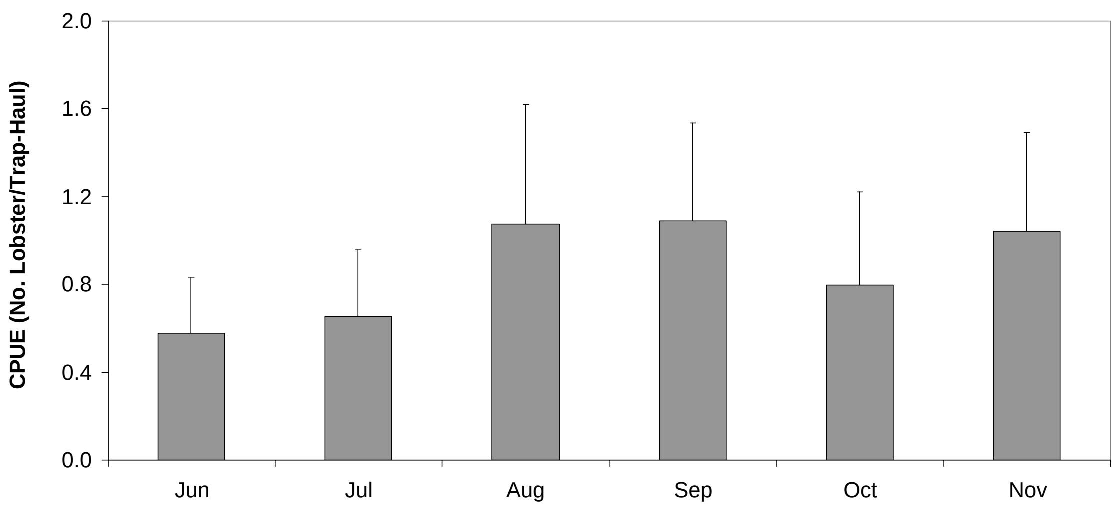


Figure 5. Lobster CPUE by month. Average monthly catch rates (number of lobster per trap-haul) for lobster traps on Saba Bank in 2007. Error bars show standard deviation.

4) Lobster Length-Frequency Distribution

The length-frequency distribution of harvested lobster (Figure 6) was compiled from all measurements collected during the six-month study period. The average carapace length (CL) of harvested lobster is 11.2 cm [average and stdev: 11.18 ± 1.84 cm, range: 7.8 – 19.9 cm, n = 1,518 lobster]. Harvest size of males (11.32 ± 1.93 cm) is slightly larger than that of females (10.96 ± 1.60 cm). In 2000, Dilrosun reported that average harvest size of lobsters was 10.7 cm CL (n = 29,802 lobster), and that males were larger than females (11.03 cm and 9.88 cm average

CL, respectively). Thus average lobster harvest size in 2007 was 0.5 cm larger than that reported in 1999-2000. The increase in average size appears to be a consequence of greater compliance with minimum harvest size regulations for lobster (9.5 cm CL) as discussed below.

Males comprise a greater percentage (61.2 %, 929 individuals) of lobster landings than females (38.8 %, 589 individuals). Dilrosun also observed that males dominated lobster landings, with males accounting for roughly 60 % and females 40 %. He calculated that female lobster experience a higher mortality rate (Z) than males which was attributed to a higher fishing mortality rate (F) for females than for males. However, females also display reduced growth rates compared to males, which means females recruit to the fishery at a relatively older age. In addition, it is prohibited to retain egg-bearing females, which may further reduce the contribution of females to total lobster landings.

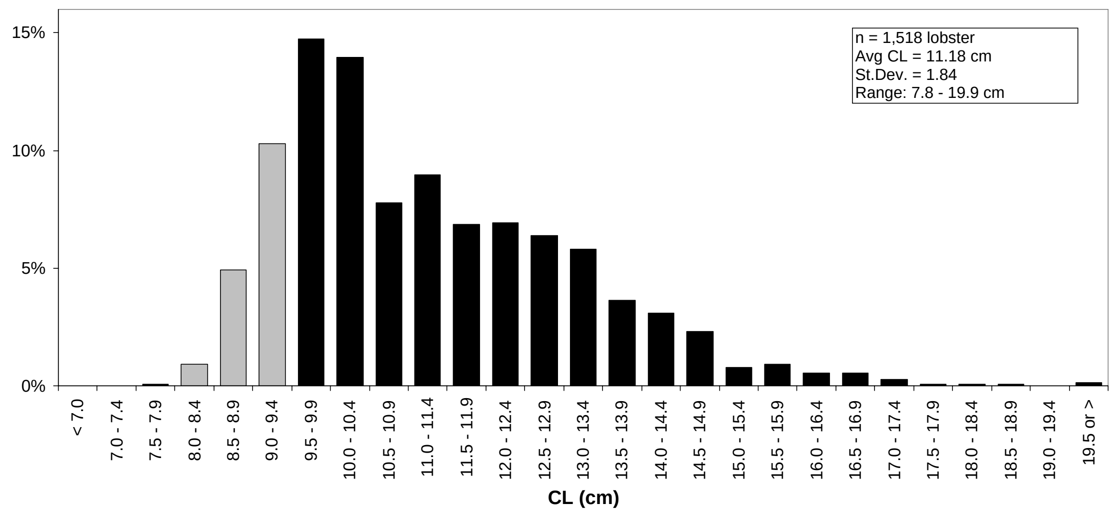


Figure 6. Length-frequency distribution of lobster harvested from Saba Bank, 2007. Data for lobster carapace length (CL) are from 1,518 individuals measured during port sampling. The legal minimum harvest size in the Netherlands Antilles is 9.5 cm CL. Harvested lobster that fall below the minimum CL are shown in gray and those above are shown in black.

Undersized individuals (CL < 9.5 cm) account for 16.2 % by number of all lobster landings (Figure 6). A greater percentage of harvested female lobster are undersized (22.2 % of females) than male lobster (12.4 % of males). For comparison, Dilrosun (2000) reported that undersized lobster accounted for 28.0 % of Saba Bank lobster landings in 1999-2000 (19.5 % of males and 40.1 % of females were undersized). This suggests that there is greater compliance in 2007 by the Saban commercial fishery for minimum harvest size. The observed 11.8 % decrease (from year 2000 to 2007) in the percentage of retained undersized lobsters is equivalent to the fishery discarding at sea 7,584 lobster from year 2007 catches.

Egg-bearing female lobster are rarely landed. Such "berried" female lobster account for 0.8 % of all harvested female lobster. For comparison, in Dilrosun (2000) reported that berried females comprised 4.1 % of female lobster landings. This suggests that there is greater compliance in 2007 by the Saban commercial fishery with regulations that prohibit retention of egg-bearing female lobster. The observed 3.3 % decrease (from year 2000 to 2007) in the percentage of retained berried female lobsters is equivalent to the fishery discarding at sea 823 berried lobster from year 2007 catches.

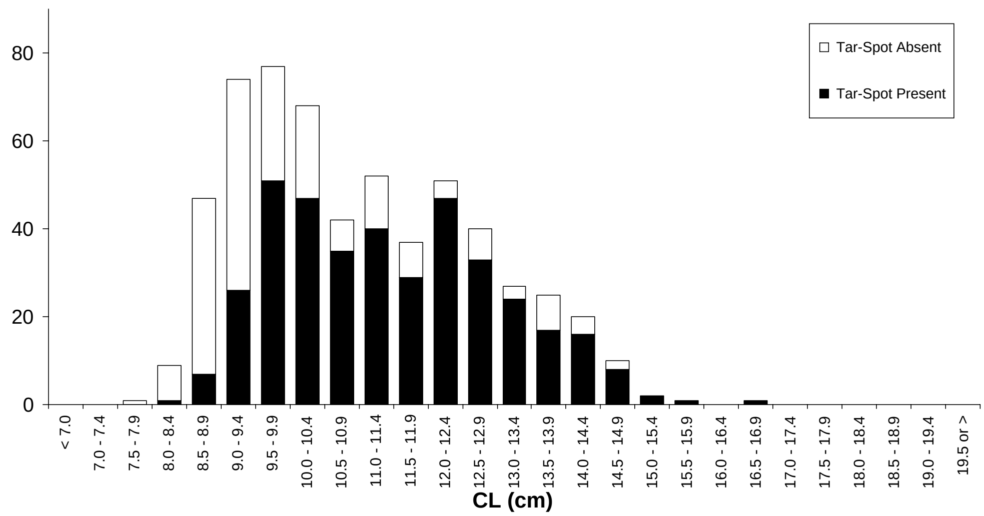


Figure 7. Occurrence of tar-spots on female lobster harvested from Saba Bank. The presence or absence of tar-spots (a black spermatophoric mass deposited by the male lobster onto the sternal plates of a female lobster) is shown in relation to body size (carapace length, CL).

Seasonal patterns of lobster reproductive activity were not detected in the present study. It was not possible to examine the frequency of egg-bearing females due to their low abundance in landings. However, we obtained information on frequency of spermatophoric masses or "tar-spots" on female lobster. The hard, black spermatophoric masses are deposited by male lobster onto the sternal plates of females during copulation (MacDiarmid and Kittaka, 2000), and thus may be indicative of sexual maturity and reproductive activity. Most of the female lobster harvested from Saba Bank have tar-spots (65.4 %). The proportion of tarred females increases with size (Figure 7). Frequency of tar-spots is low (0 – 14.9 %) in small size classes (< 9.0 cm CL). The proportion of females with tar-spots rises rapidly with size up to 9.5 – 10.0 cm CL and thereafter females have tar-spots at an average frequency of 82.0 % (average value for size classes $\geq$ 9.5 cm). There was no relation between season and proportion of females with tar-spots: occurrence of tar-spots varied between 51.4 % and 75.4 % of sampled female lobster during the study period without any clear trend (not shown).

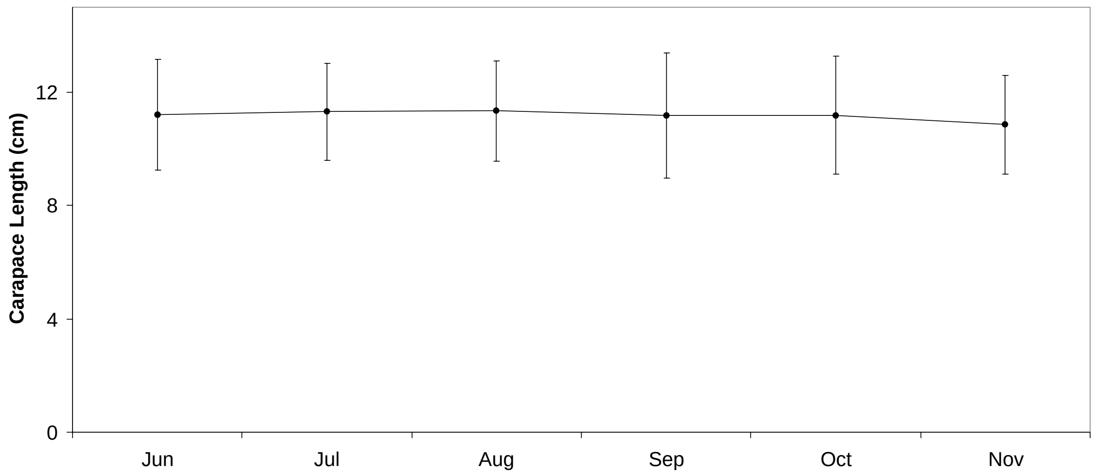


Figure 8. Average size of lobster harvested from Saba Bank by month. Average carapace length is shown for each month. Error bars show standard deviation.

Lobster harvest size did not vary by month (Figure 8). Average carapace length ranged from 10.96 cm (November) to 11.34 cm (August). The percentage of male lobster in landings exceeded that of females for each month of sampling. We did not detect any obvious seasonal trends in the proportions of male to female lobster during the six-month period.

5) Mixed Fish from Lobster Traps

CPUE of mixed fish in lobster traps is presented in Table 3. Landings of mixed fish from lobster traps averages approximately 38 pounds per trip. CPUE of mixed fish in lobster traps is approximately 0.5 pounds per trap-haul.

Table 3. CPUE of Mixed Fish in Lobster Traps

	Wt. Per Trip		Wt. Per Trap-Haul		Wt. Per Trap-Day	
	(lbs)	(kg)	(lbs)	(kg)	(lbs)	(kg)
Average	37.8	17.1	0.52	0.24	0.072	32.5
St.Dev.	34.2	15.5	0.47	0.21	0.073	32.9
Max.	150	68.0	2.14	0.97	0.414	187.8
Min.	0	0	0	0	0	0
Count*	112	112	112	112	111	111

Mixed fish landings from lobster traps are dominated by four species (Figure 9). The white grunt, *Haemulon plumierii*, accounts for almost half (43.0 %) of mixed fish landings by weight. Red hind (or "hinds"), *Epinephelus gutattus*, and queen triggerfish (or "moonfish"), *Balistes vetula*, are also important components of mixed fish landings from lobster traps, accounting for 16.7 % and 12.6 % respectively of finfish landings by weight (Figure 9). The cottonwick, *Haemulon melanurum*, is also abundant in mixed fish landings (3.7 % by weight). Collectively, these four species comprise > 76 % by weight of the finfish landings from lobster traps. Length-frequency distributions are shown in Figure 10.

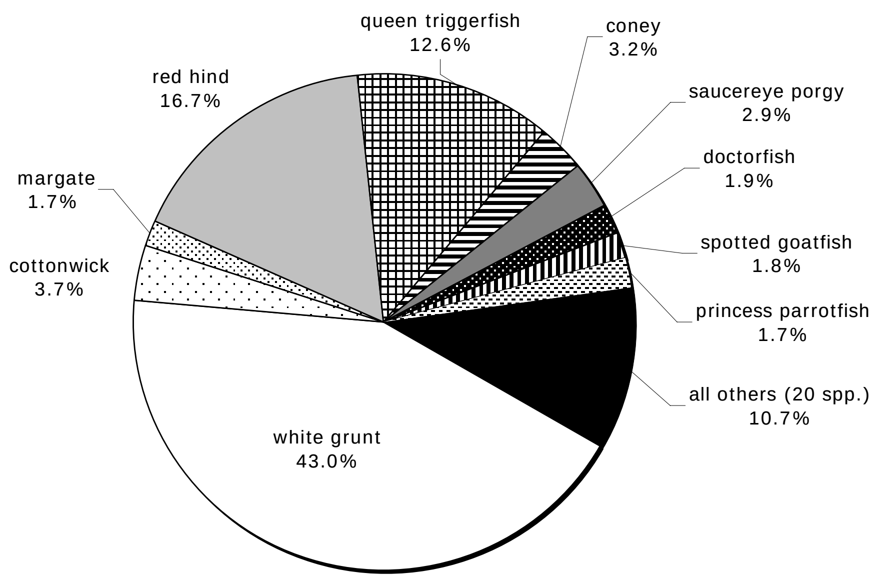


Figure 9. Composition of mixed fish landings from lobster traps.

Aside from white grunt, red hind, queen triggerfish and cottonwick, the incidental catch of other reef fishes in lobster traps contribute 24 % by weight to Saba Bank lobster trap landings (Figure 9). Species-level information from port sampling indicates that at least 30 finfish taxa are retained from lobster trap catches (Appendix 5). However, the diversity of species that occur in low numbers in the landings, as well as the variation in species composition among catches, precludes adequate sampling. Length-frequency analysis is possible only for the most abundant species. This situation applies equally to mixed fish taken in the fish trap fishery (see below). Length-frequency distributions are shown in Figure 11 for three of the more commonly harvested "mixed fish" species: coney (*Cephalopholis fulva*), lane snapper (*Lutjanus synagris*), and saucereye porgy (*Calamus calamus*). All three species are captured in both the lobster trap and fish trap fisheries and histograms represent pooled data. Coney and saucereye porgy are more common in lobster trap catches while lane snapper is more common in fish trap catches (Appendix 5).

Figure 10. Length-frequency distribution of mixed fish from Saba Bank lobster traps. Shown are the four most common finfish in lobster trap landings: white grunt, red hind, queen triggerfish, and cottonwick. Histograms for the latter three species include data from redfish traps.

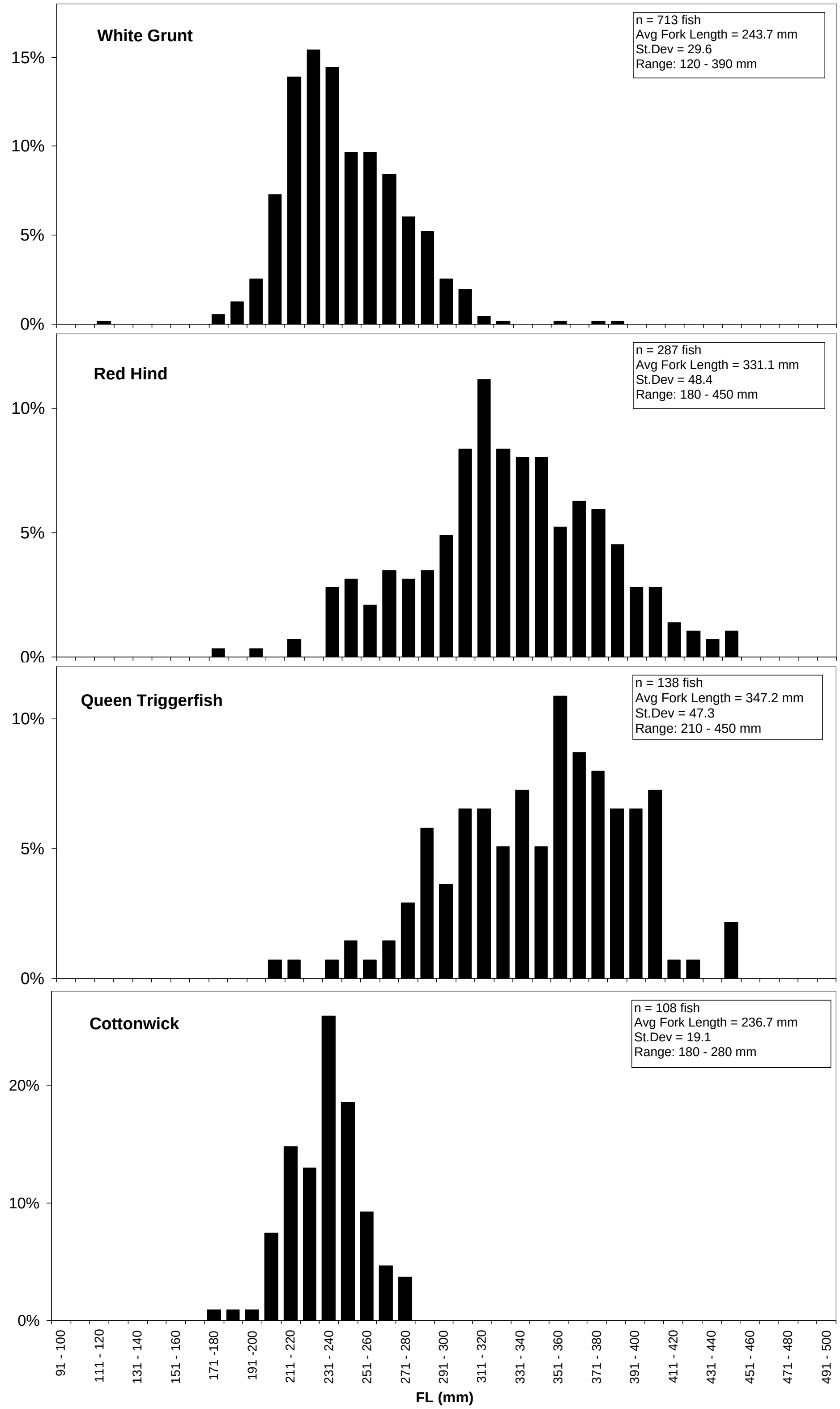
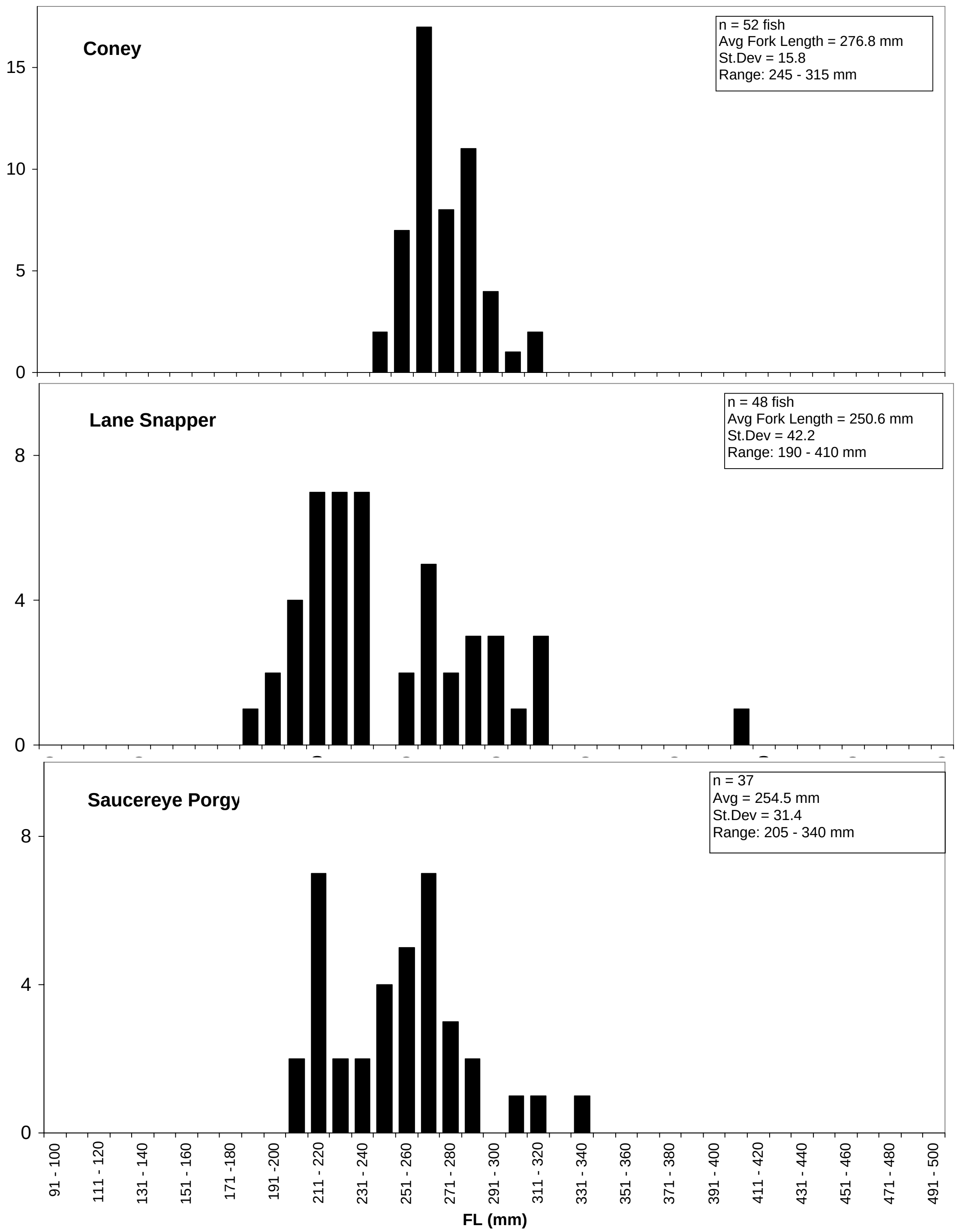


Figure 11. Length-frequency distribution of additional mixed fish species from Saba Bank trap landings. Shown are coney, lane snapper, and saucereye porgy. Histograms include pooled data from lobster trap and redfish trap landings.



Lobster traps also interact with a variety of non-target reef fishes and invertebrates that fishermen either discard at sea as bycatch or use for other purposes (e.g. as bait in traps). The prevalence of bycatch in the Saba Bank lobster trap fishery remains largely unquantified. We note the following observations. The nurse shark, *Ginglymostoma cirratum*, is a common bycatch species in the lobster trap fishery. Saban fishermen consider the nurse shark to be a nuisance because the sharks consume catch and bait, and because they damage trap gear. Although nurse sharks are generally not marketed, they are moved, killed, or retained for personal consumption. It is also common practice for fishermen to retain a small quantity (3 to 6 pounds) of reef fishes to feed to lobster in holding cages in Fort Bay. Finfishes retained as lobster forage includes small-bodied or inedible species. Typical species are the ocean surgeon, blue tang, striped and foureye butterflyfishes, and rock beauty.

In addition to lobster and finfish landings, a small quantity of invertebrates (< 1 % of total landings by weight) is also retained from lobster trap catches for sale or for personal consumption. The most common invertebrates in lobster trap landings (Appendix 3) include the Spanish slipper lobster (*Scyllarides aequinoctialis*), batwing coral crab (*Carpilius corallinus*), common octopus (*Octopus* cf. *vulgaris*), and spider crab (*Mithrax spinosissimus*).

IV. Redfish Fishery

1) Redfish Trap Soak Time and Haul Frequency

Among Saban commercial fishermen, the preferred design for fish traps is the chevron or West Indian arrowhead shape with a single funnel entrance. We observed that fishermen build their fish traps according to two basic designs. Lightweight and relatively inexpensive fish traps are constructed from galvanized chicken wire (1.5 inch hexagonal mesh) with wooden frame. Heavier, longer-lasting, and more expensive fish traps are constructed from vinyl-coated wire mesh with rebar frame. Mesh size for the latter type of fish trap is either 1.5 x 1.5 inch square, or 1 x 2 inch rectangular mesh. Dilrosun (2000) did not report the use of 1 x 2 inch mesh in year 2000. We observed that it was used commonly and may well be “industry standard” among Saban fish trap fishermen in 2007. This mesh size is smaller than the minimum allowable mesh size (1.5 inch) as specified in the National Fisheries Ordinance. Compared to lobster traps, the funnel entrance of fish traps is narrower and has an elliptical shape. Biodegradable panels are rarely utilized and trap doors are generally fastened closed with long-lasting materials such as vinyl-coated wire.

During the study period, all Saban commercial fishermen who were setting fish traps were specifically targeting deepwater snappers or “redfish.” No fishermen were using fish traps to target shallow-water assemblages of reef fishes. For this reason, our use of the term “fish trap” in the following sections is synonymous with the fishing method that targets deepwater snappers.

Saban fishermen usually bait their redfish traps with fish. The most common bait is "Japanese Bait" (Pacific saury, *Cololabis saira*) although salted mackerel, herring or ballyhoo may be used. Fish traps are set at greater depths than lobster traps, averaging from 58 to 112 fathoms, and ranging from 31 to 134 fathoms. Although there is little or no overlap between lobster traps and fish trap depths, it is noted that at fishermen routinely catch small numbers of lobster in their shallower-set redfish traps (~ 35 fathoms depth, or 64 m). Redfish are gutted at sea and immediately placed on ice in coolers (Figure 12) to preserve the quality of flesh, which will reportedly otherwise deteriorate rapidly. At Fort Bay, the fish are transferred to chest freezers where they are thoroughly packed in ice and maintained at ~ 0° C until sale.

Figure 12. Deepwater snapper harvest from Saba Bank. Saban fishermen use the name "redfish" for this assortment of snappers that are captured with fish traps between 50 m and 250 m depths. Redfish are gutted at sea and kept on ice in coolers to preserve freshness.

2) Redfish Effort

The Saban commercial fishing fleet makes an average of 3.7 fishing trips per day (stdev: 2.0, range: 0 - 9) and the fleet is projected to make 1,310 fishing trips per year. A proportion of this fishing effort (23.8 %) is directed towards redfish (312 redfish trips per year). The remaining effort is directed towards lobster. The difference between redfish and lobster fishing effort is a consequence of extent to which individual fishermen choose to target redfish: we observed that all Saban commercial fishermen participate in the lobster fishery while less than half of the fishermen participate in the redfish fishery.

During a redfish trip, fishermen haul about 30 traps [average and stdev: 30.4 traps ± 11.2, median and mode: 34, range: 5 - 44, n = 48 fishing trips]. Soak time for redfish traps is 2 to 4 days [average and stdev: 3.7 ± 2.9 days, median: 3 days, mode: 2 days, range: 1 - 14 days, n =47 fishing trips].

Table 4. Fish Trap CPUE

	Wt. Per Trip		Wt. Per Trap-Haul		Wt. Per Trap-Day	
	(lbs)	(kg)	(lbs)	(kg)	(lbs)	(kg)
Redfish						
Average	291.1	132.1	9.7	4.4	3.92	1.78
St.Dev.	148.6	67.4	3.7	1.7	2.59	1.18
Max.	600.0	272.2	18.3	8.3	9.47	4.30
Min.	70.0	31.8	2.9	1.3	0.45	0.21
Count	41	41	40	40	40	40
Other finfish						
Average	27.3	12.4	1.0	0.5	0.40	0.18
St.Dev.	32.4	14.7	1.4	0.6	0.56	0.25
Max.	120.0	54.4	5.9	2.7	2.07	0.94
Min.	0.0	0.0	0.0	0.0	0.00	0.00
Count	41	41	40	40	40	40
Total Finfish						
Average	318.4	144.4	10.8	4.9	4.32	1.96
St.Dev.	147.7	67.0	3.6	1.7	2.76	1.25
Max.	615.0	279.0	18.4	8.3	11.25	5.10
Min.	88.0	39.9	4.1	1.9	0.57	0.26
Count	41	41	40	40	40	40

3) Catch Rate of Redfish Traps

A summary of catch rate from fish traps is presented in Table 4. The total finfish catch in redfish traps consist of two types of landings: redfish and “other finfish.” Redfish are the target of the fishery, and comprise the bulk of landings. Other finfish comprise the remainder of fish trap landings. This incidental catch component is analogous to mixed fish from lobster traps, and it is marketed as such, although the species composition differs. Total finfish landings from redfish traps average approximately 320 pounds per trip. The catch rate (total finfish) in redfish traps is approximately 11 pounds per trap-haul. Of the reported catch, more than 90 % by weight consists of redfish (silk, blackfin and vermilion snappers). The redfish-specific catch rate of redfish traps is 9.7 pounds per trap-haul. The remaining 9 % of finfish landings (Table 4, Figure 13) is composed of a variety of species as discussed below.

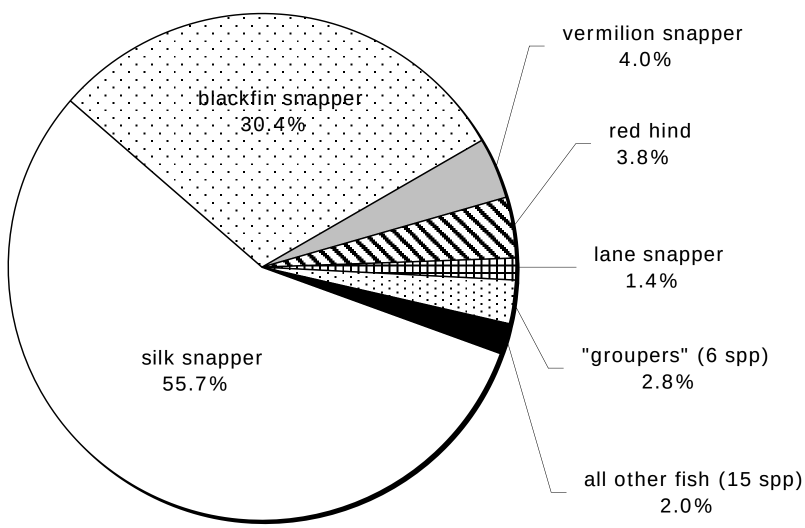


Figure 13. Composition of finfish landings from redfish traps.

Our sample size of redfish trips was not large enough to allow for examination of seasonal trends in catch rates. Fishermen did not make reports to us of any seasonality for redfish abundance or catch rate. They did, however, identify two factors that substantially influence redfish catches: currents and lunar phase. Lunar phase appears to influence depth of capture. Fishermen report that silk snapper make monthly cross-shelf migrations, moving from deeper water to shallower water with a waning moon, and in the reverse direction with a waxing moon. Currents may influence redfish catches in a number of ways. Currents may influence the movements of redfish or their likelihood of encountering and entering traps. Fishermen did not report a consistent pattern in this regard. From time to time, periods of strong currents also make it difficult for fishermen to relocate their redfish traps. Sufficiently strong currents will drag the marker buoys underwater due to the extensive lengths of float lines (often > 200 fathoms). This can force an unintentional extension of redfish trap soak time until currents subside.

4) Redfish Length-Frequency Distributions

The three most abundant species in fish trap landings are silk snapper, blackfin snapper, and vermilion snapper (Figure 13). Length-frequency distributions for these species are shown in Figure 14. Silk snapper or “yelloweye silk” is the most commercially important species, accounting for over half of fish trap landings by weight. Harvest size of silk snapper is small (Figure 14), with an average fork length of 287.1 mm (± 59.5 mm ± stdev). These results are similar to Dilrosun’s (2000) findings for silk snapper length, where the average FL was 294.3 mm (± 57.9 mm stdev). Assuming that silk snapper reach reproductive maturity at 370 to 500 mm FL (Cummungs, 2003), it is estimated that between 90.1 % and 98.9 % of silk snapper harvested in the Saba Bank fishery are taken prior to attainment of sexual maturity.

Blackfin snapper is the next most commercially important type of redfish, accounting for 30.4 % of fish trap landings (Figure 13). Harvest size of blackfin snapper is small (Figure 14), with an average fork length of 290.4 mm (± 57.4 mm ± stdev). These data are comparable to Dilrosun’s (2000) observations for blackfin snapper from fish traps, where the average length was observed to be 286 mm. However it should be noted that Dilrosun presented evidence of size-selectivity between gear types for blackfin snapper: line fishing captured individuals of larger average size (352 mm) than did fish traps (286 mm). Blackfin snapper from Jamaica reach sexual maturity at 230 to 250 mm FL (Froese and Pauley, 2007). Using these values for length at maturity, it is estimated that between 14.3 % and 32.1 % of blackfin snapper harvested in the Saba Bank fishery are taken prior to sexual maturity.

Vermilion snapper ranks third among species harvested in the fish trap fishery. Landings of vermilion snapper or “roundhead” are much less (3.9 % of total landings by weight) than those of silk and blackfin snappers (Figure 13). Harvested vermilion snapper were small in size (Figure 14), with an average fork length of 258.6 mm (± 40.0 mm ± stdev). This size is substantially smaller than observed by Dilrosun (2000) who reported an average fork length of 286 mm for vermilion snapper. However, direct comparisons to Dilrosun’s results are difficult because of the small sample sizes involved (in both studies) and the likelihood that gear selectivity has introduced a size-bias into the observations (in the earlier study). Vermilion snapper from Puerto Rico reach sexual maturity at 200 to 230 mm FL (Froese and Pauley, 2007). Using these values for length at maturity, it is estimated that 1.6 % to 28.4 % of vermilion snapper harvested in the Saba Bank fishery are taken prior to reaching sexual maturity.

The small average size of redfish harvested from Saba Bank may be driven to some degree by market forces. Saban fishermen report that their buyers, who often represent restaurants from neighboring islands, prefer to purchase “plate-sized” snappers (fish of approximately one-half pound) that can be prepared and served whole to consumers.

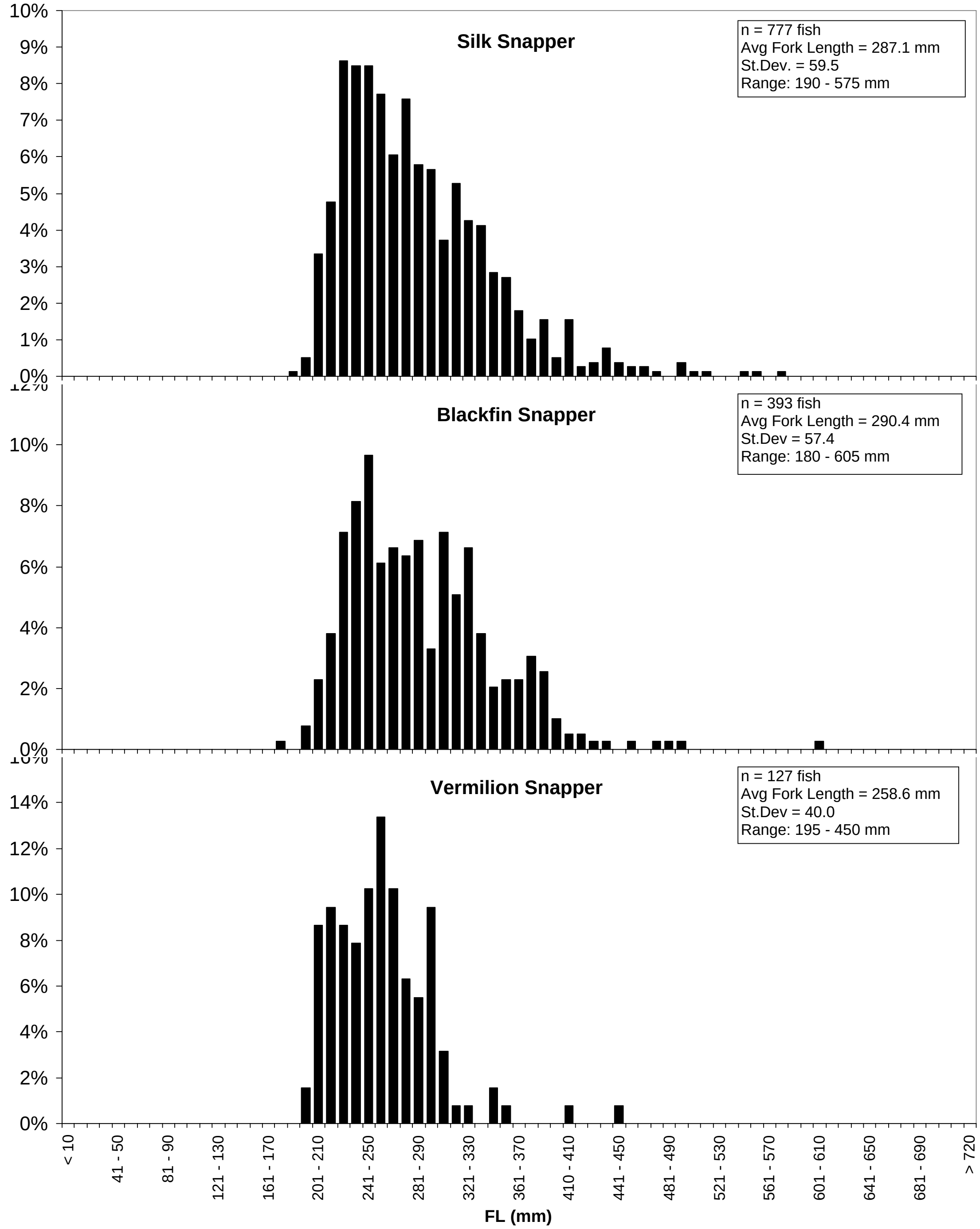


Figure 14. Length-frequency distribution of redfish landings from Saba Bank. Histograms are shown for the three most common species in fish trap catches: silk snapper, blackfin snapper, and vermilion snapper.

5) Species Composition

In addition to redfish (silk, blackfin and vermilion snappers), species-level information from port sampling indicates that at least 23 other finfish taxa are retained from Saba Bank fish trap catches (Appendix 5). The most common of these species are red hind and lane snapper (Figure 13). Length-frequency distributions for red hind and lane snapper are shown in Figure 10. Fish trap landings also include at least six taxa of large-bodied groupers (Serranidae), although all are caught infrequently. The yellowfin grouper, *Mycteroperca venenosa*, is the most common of these large serranids in fish trap landings and its length-frequency distribution is shown in Figure 15. Additional information is presented elsewhere on the species composition of redfish trap catch (Appendix 5) and bycatch (Toller, 2007) from Saba Bank.

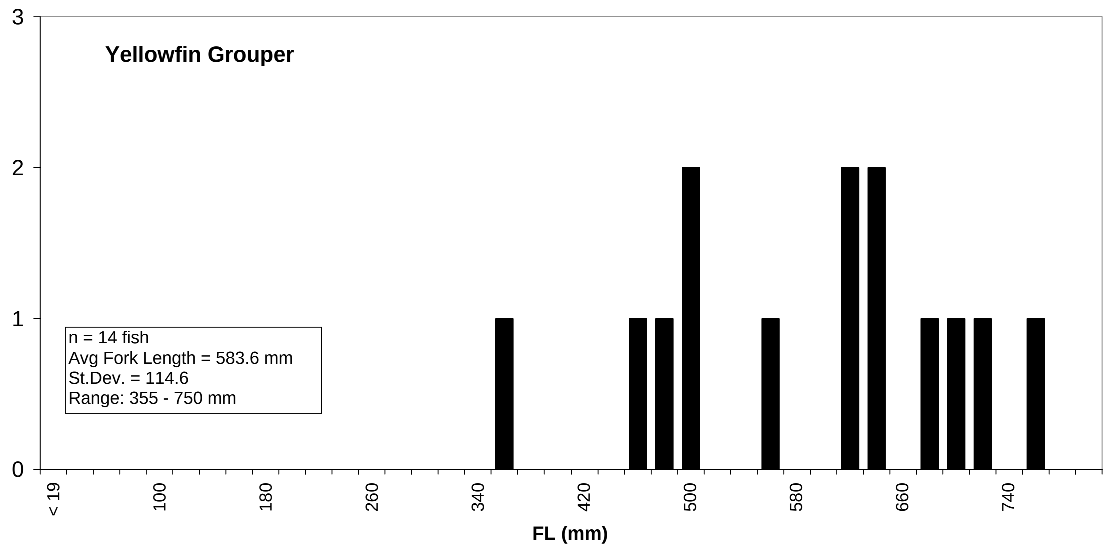


Figure 15. Length-frequency distribution of yellowfin grouper from Saba Bank fish trap landings.

V. Associated Landings and Lost Gears

1) Line Fishing

The Saba Bank commercial fishery operating from Fort Bay uses traps to the near exclusion of other gear types. Saban fishermen do not utilize alternate methods and gears that are common elsewhere in the Caribbean. For example, diver-based harvesting methods, such as the use of scuba for capturing lobster and conch or spearing finfish, are absent and there is currently no commercial harvest of queen conch, *Strombus gigas*, from Saba Bank. Similarly, Saban fishermen do not use nets for fishing on Saba Bank.

Hook & line fishing is practiced on an infrequent basis by Saban commercial fishermen. Our data indicate that this method may produce 87 pounds of fish per trip. However due to its infrequent usage, hook & line does not contribute substantially to annual landings of finfish (Table 7, Appendix 4). The limited port sampling information we obtained suggests the following. Hook & line fishing with handline or with rod and reel is done opportunistically during a subset of routine trap fishing trips. Some fishermen also troll with rod and reel to and from their trap fishing grounds. The frequency of trolling fishing trips generally follows seasonal abundance patterns of migratory pelagic species such as wahoo, tuna, and dolphinfish. Fish Attraction Devices (FADs) are also deployed by some Saban fishermen to increase catch rates for pelagic species. In several respects, these hook & line fishing activities resemble recreational fishing.

In 1999-2000, Dilrosun (2000) observed that deepwater snappers were harvested from Saba Bank using a wide variety of gear. In addition to traps, fishermen used snapper reels, bottom long lines and hand lines. In 2007, use of hook & line methods for deepwater snapper was uncommon. We did not record these methods during port sampling of Saban commercial fishermen. Outside of port sampling, we did observe the following: a limited number of fishing trips (10 -15) using vertical long line sets for deep water snapper that took place in waters of Saba Island or at nearby offshore seamounts that are isolated from Saba Bank (e.g. John Green's Bank, New Bank [see map in Figure V of Dilrosun (2000) for locations]); fish trap fishing for redfish in waters of Saba Island; and hand line fishing for deepwater snapper on Grapplers Bank (3 trips). Although hook & line methods for redfish are still used by Saban fishermen, it is evident that the Saba Bank long-line fishery of 2000 has been largely replaced by a fish trap fishery in 2007.

2) Lost Traps

Lost fishing gear may be a serious management concern for a number of reasons. In the Saba Bank fishery, the foremost management concern is the potential for lost traps to continue "ghost fishing" (Dilrosun, 2000), which may potentially result in negative impacts to stocks and wasted fisheries resources. Additionally, lost traps represent an economic loss to fishermen, which translates into reduced profits by the commercial fishing industry. Traps may become lost for a number of reasons including: storms, groundswells or exceptionally strong currents that sweep traps into deep waters, vandals that remove marker buoys (or steal the gear altogether), and passing vessels that run across and cut marker buoy lines.

In this study we recorded the number of traps lost during port sampling interviews. Reported losses were used to estimate trap loss frequency and trap loss rate (Table 5). Owing to inconsistencies in interpreting the fishermen's reports, a measure of uncertainty was introduced into the dataset. Therefore, reported trap loss data were expanded using both a minimum (conservative) and maximum (liberal) estimate. By either estimate, our results indicate that trap loss is common and occurs in 5 to 20% of all fishing trips. Trap loss rate is slightly higher for lobster traps than for redfish traps. Loss rate may be as high as 0.8 traps lost per fishing trip. Reported loss rates imply that between 260 and 988 traps are lost on an annual basis. Assuming that there are a total of 2,000 traps on Saba Bank, this equates to an annual loss rate of 13.0 % to 49.4 % of traps lost per year.

Table 5. Summary of Lost Trap Information

	Fishing Gear			
	Lobster Trap	Fish Trap	Mixed	Total
Trips Reporting Trap Loss				
1 or more Lost Traps	22	9	0	31
No Lost Traps	81	33	3	117
Total Number of Trips	103	42	3	148
% of Trips with Trap Loss	21.4%	21.4%	0.0%	20.9%
Trap Loss Frequency (% of Trips with Trap Loss)				
Minimum Estimate (572 Trips)	5.5%	5.5%	0.0%	5.4%
Maximum Estimate (148 Trips)	21.4%	21.4%	0.0%	20.9%
Quantity of Traps Lost Per Trip				
Trips reporting 1 Lost Trap	6	2	-	8
Trips reporting 2 Lost Traps	3	3	-	6
Trips reporting 3 Lost Traps	5	1	-	6
Trips reporting 4 Lost Traps	3	1	-	4
Trips reporting 5 Lost Traps	2	1	-	3
Trips reporting > 5 Lost Traps	3	1	-	4
Total	22	9	0	31
Total Number of Traps Reported Lost	82	26	0	108
Trap Loss Rate (Number of Traps Lost per Trip)				
Minimum Estimate (572 Trips)	0.21	0.16	-	0.19
Maximum Estimate (148 Trips)	0.80	0.62	-	0.73
Calculated Annual Trap Losses				
Projected Annual Number of Fishing Trips	998	312	na	1310
Minimum Estimate for Number of Lost Traps	209.6	49.9	na	259.5
Maximum Estimate for Number of Lost Traps	794.5	193.1	na	987.7

VI. Total Annual Landings and Ex-Vessel Value

Saban commercial fishermen sell their commercial landings according to three primary marketing categories: lobster, redfish, or mixed fish. Pelagic species are also marketed separately on a seasonal basis. The 2007 market prices, as well as method of preparation for marketing, are shown in Table 6. Lobster, at $7 per pound, fetches a much higher market price than any finfish category. Mixed fish are sold at the relatively low market price of $1.82 per pound.

Table 6. Market Prices of Saban Commercial Landings

Landings	Preparation	Sales Unit	Price per Unit US $/kg	US $/lb	ANG/lb*
Lobster	Live	US $ per lb	15.40	7.00	12.46
Redfish	Gutted	US $ per kg	7.00	3.18	5.66
Mixed Fish	Whole / Gutted	US $ per kg	4.00	1.82	3.24
Pelagics	Fillet / Steak	US $ per kg	7.50	3.41	6.07

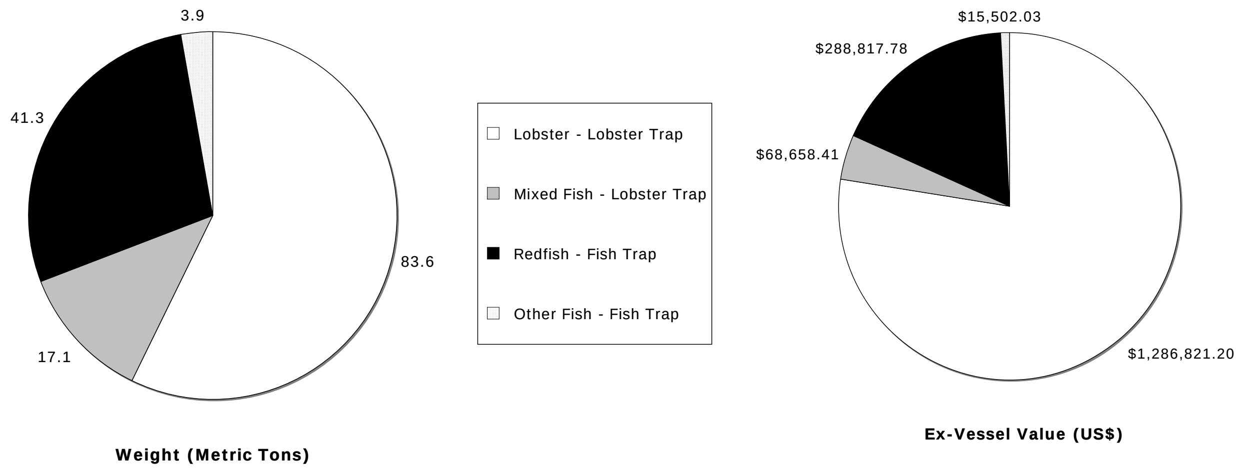
* Calculated using an exchange rate of 1.78 Netherlands Antilles Guilder (ANG) = 1 U.S. dollar.

Observed catch rates were expanded by estimated total annual fishing effort in order to project total annual landings. The projected annual harvest and economic value of Saban commercial landings based on ex-vessel prices is shown in Table 7. Note that the ex-vessel value of landings does not include fishermen's capital investments, operational costs, and other economic variables. Therefore, these figures should not be construed as an estimate of economic profit generated by the commercial fishery.

Table 7. Projected Saba Bank Annual Commercial Landings and Ex-Vessel Value

Landings by Gear	Catch Rate (lbs/Trip)	Total Effort (No. Trips/Yr)	Projected Total Landings (lbs/Yr)	(mt/Yr)	Ex-Vessel Value (US$)
Lobster Trap					
Lobster	184.2	998	183,831.6	83.6	$1,286,821.20
Mixed Fish	37.8	998	37,724.4	17.1	$68,658.41
Fish Trap					
Redfish	291.1	312	90,823.2	41.3	$288,817.78
Other Finfish	27.3	312	8,517.6	3.9	$15,502.03
Hook & Line					
Pelagics	87.30	11	960.3	0.4	$3,274.62
Subtotal - All Finfish	-	-	138,025.5	62.7	$376,252.84
Total Annual Landings		1310	321,857.1	146.3	$1,663,074.04

Relative contribution of lobster and finfish to total annual landings and annual ex-vessel value is shown diagrammatically in Figure 16. Lobster represents the most economically significant component of Saban commercial landings, accounting for almost 77 % of ex-vessel value. Redfish are the second most economically significant component of Saban commercial landings.



A. **B.**

Figure 16. Projected annual Saba Bank commercial landings. Landings are subdivided by type of fishery (lobster trap fishery or fish trap fishery) and further broken down based upon primary market categories of landings. ***A.*** *Contribution to projected annual landings based upon weight.* ***B.*** *Contribution to annual economic value of commercial landings based upon ex-vessel prices.*

Table 8 presents a comparison of our estimates for 2007 Saban commercial landings with those reported by Dilrosun for 1999-2000. In general, landings estimates are similar in terms of the proportional value of components. Annual landings of lobster are comparable in magnitude (89 mt versus 83.5 mt). The comparison indicates that lobster landings have decreased slightly (6.3 %) since Dilrosun's study.

Estimates presented in Table 8 also identify large differences in calculated finfish landings between years. Year 2007 finfish landings are estimated to be 3-fold larger than those reported for 2000. The largest increase in landings has occurred within the "redfish/snapper" category. Increases were also observed in each of the mixed fish categories except for queen triggerfish. Finfish landings in 2007 contribute substantially (43.7 % by weight) to total annual landings (Figure 16). Data from Dilrosun (2000) indicate that finfish accounted for a smaller component of total annual landings (approximately 17 % by weight) in 1999-2000. Thus, comparison of 2007 to 2000 landings indicates that finfish have grown in importance to the Saban commercial fishery based upon weight and economic value.

Table 8. Total Saba Bank Commercial Landings: Comparison of 2007 to 2000

	Total Annual Landings (kg)		
Landings	Year 2000	Year 2007	% Change
Lobster	89,149	83,560	-6.3%
Finfish			
Snappers/Redfish	11,398	41,283	262.2%
Red Hind	1,510	4,565	202.4%
Moonfish/Queen Triggerfish	2,464	2,265	-8.1%
Grunts	2,096	8,385	300.1%
Other Finfish	1,890	5,869	210.6%
Subtotal - All Finfish	19,357	62,367	222.2%
Total Annual Landings	108,506	145,927	34.5%

* Landings data from 2000 spanned 13.2 months (403 days). The data were adjusted by a factor of 0.896 to obtain annual landings for year 2000.

VII. Discussion

1) Overview

The results of this assessment indicate that the Saban commercial fishing industry has expanded little since 2000. Fishermen use modern and productive methods that are similar to year 2000. Landings from Saba Bank continue to make an important contribution to the local island economy, as observed previously (Dilrosun, 2000). The Caribbean spiny lobster remains the most important component of Saba Bank harvests and the economic productivity of the commercial fishery is largely dependent on this species. Annual lobster landings have remained relatively stable.

Nonetheless, there are indications of change in the Saban commercial fishery since 2000. Some of these changes have direct implications for fisheries management and sustainable use of the Saba Bank. Additionally, many of the fisheries management concerns identified by Dilrosun in 2000 are seen to persist in 2007. In the following discussion, we emphasize the findings from our assessment that we feel are of greatest relevance to sustainable use of Saba Bank resources. To conclude, we propose a set of five recommendations as priorities for fisheries and resource management of Saba Bank.

2) Lobster Landings and Catch Rate

Lobster catch rate was highly variable among months. This short-term variation is not reflective of stock abundance. Such variability may lead to a misinterpretation of trends if datasets represent very short periods of time, as illustrated by the following account. During the initial two months of our assessment (June and July, 2007), we observed that the average lobster catch rate was less than half that reported for 1999-2000 (Dilrosun, 2000). At this time, some Saban fishermen were reporting that lobster stocks had declined drastically. In subsequent months (August and September, 2007), lobster catch rate doubled (…and fishermen had quieted). Dilrosun also observed comparably large swings in monthly lobster CPUE over time, although the highs and lows occurred during different months than we observed in 2007. These observations suggest that short-term (i.e. monthly) temporal variation in CPUE is a reproducible characteristic of the Saba Bank lobster fishery and the findings should underscore the need for longer-term datasets.

The basis for month-to-month variability in Saba Bank lobster catch rate is not understood at present. Clearly, a number of factors influence the rate at which lobster may enter traps including: foraging movements, reproductive behavior, lunar cycles, and migratory patterns. Regardless of cause, efforts to identify long-term trends in lobster stock abundance from commercial landings data must also grapple with fine-scale temporal variation. Accordingly, an important management objective should be to perform trend analyses of lobster landings using data collected over appropriate time frame. We suggest that a minimum time frame requirement is semi-annual or annual lobster landings.

Comparison of our results to year 2000 data indicates that Saba Bank lobster landings are relatively stable, at roughly 80 to 90 metric tons annually. Lobster catch rates are also similar between years 2000 and 2007 when compared on the basis lobster weight landed per trip (Figure 17A). However, data from 2007 show a decrease of approximately 33 % in the average trap soak-specific CPUE for lobster when compared to 2000 - a decrease that is persistent across all months compared (Figure 17B). These results imply that lobster stock abundance in 2007 is reduced compared to 2000. They also indicate that Saba Bank fishermen of 2007 exert more fishing effort, via increased number of trap-hauls per trip, to maintain lobster landings at year 2000 levels. In other words, individual fishermen now use more traps at lowered catch efficiency to effectively harvest the same quantity of lobster as they did seven years ago.

The observed decline in lobster CPUE between 2000 and 2007 suggests that current harvest levels are at, or now exceed, the maximum sustainable yield (MSY). A further increase in lobster fishing effort is likely to lead to a further decrease in CPUE, with only a small increase in total annual landings. However, reliable estimation of MSY requires a sufficient time-series of catch and effort data (e.g. Hoggarth et al., 2006). The limited time span covered by available data for Saba Bank makes it difficult to provide definitive conclusions on this point. Nonetheless, the available data suggest that spiny lobster resources of Saba Bank are fully exploited and it would be imprudent to further expand fishing effort.

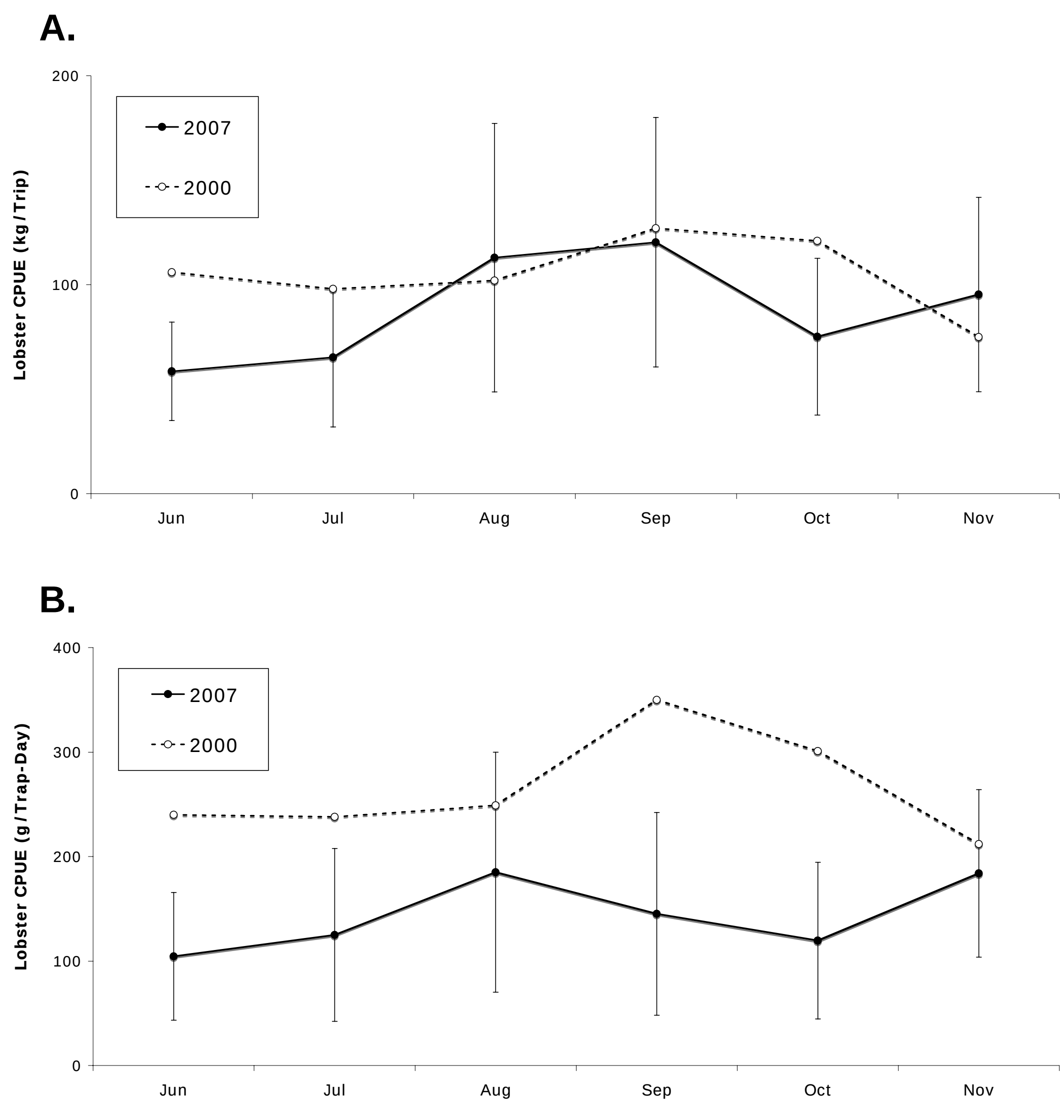


Figure 17. Comparison of monthly lobster CPUE estimates between the years 2007 and 2000. Average values are presented. Error bars show standard deviation for 2007 data only. ***A.*** *Lobster catch rates compared in terms of total weight of lobster per fishing trip.* ***B.*** *Lobster catch rates compared in terms of trap-soak efficiency (weight of lobster per trap per day). Year 2000 CPUE data are from Dilrosun (2000).*

A central concern for sustainable management of Saba Bank lobster is to determine whether a reduction in stock abundance is attributable to over-harvesting. Inter-annual fluctuations in lobster stocks may occur naturally due to variable recruitment rates among years or other environmental factors. For example, cyclic patterns of lobster abundance over periods of 4 to 5 years are known from Florida (Hunt, 2000) and Nicaragua-Honduras Shelf (Ehrhardt, 2000).

Our results give a clear indication that total trap number has increased since 2000. We estimate that lobster trap number has increased from 1,426 in 1999-2000 to 1,862 in 2007. Our values for trap number are far below the estimates derived from Dilrosun's study in 2000, implying that some uncertainty still remains regarding the actual number of traps employed by the lobster and redfish fisheries on Saba Bank. A more detailed knowledge of trap number could be obtained by conducting a complete census of traps as recommended by Dilrosun (2000). This information would be useful to resource managers for monitoring trends in fishing effort and also for formulating management measures to control fishing effort through restrictions on gear quantity.

Dilrosun (2000) noted poor compliance among Saban commercial fishermen for regulations relating to lobster minimum harvest size and prohibition on landing egg-bearing females. During 1999-2000 he observed that 28 % of harvested lobster were < 9.5 cm CL and that 4.1 % of harvested females were egg-bearing. During our assessment, we observed that 16 % of harvested lobster were under-sized and that 0.8 % of harvested females were bearing eggs. Both measures indicate an improvement in regulatory compliance by the Saban commercial fishery since 2000. Thus, Saban commercial fishers may have more willingness than previously appreciated to adopt practices that are protective of fisheries stocks. However, enforcement of existing regulations remains minimal (Dilrosun, 2000). The enforcement issue is likely to be a significant obstacle for implementation of new fisheries management policies for Saba Bank.

3) Redfish

Since 2000, redfish have grown in economic importance to the Saba Bank commercial fishery. Among the redfish, silk snapper is of rather singular commercial importance. We consider this species to be of particular management concern. Dilrosun reported a fish trap catch rate of 1.85 kg per trap-day (4.1 pounds per trap-day) in 1999-2000. In 2007, we observed a fish trap catch rate of 1.96 kg per trap-day (4.3 pounds per trap-day). These values are comparable to the CPUE observed in 2000 and they do not indicate a further decline in CPUE for deepwater snappers over the most recent seven-year period.

Dilrosun expressed concern that year 2000 redfish catch rates were very low in comparison to results from experimental fishing during the research cruise of the *M/V Calamar* in 1971 (FAO, 1971) where average catch rates of 22.5 kg per trap-day were obtained. These experimental trapping studies were conducted on the northwestern slope of Saba Bank in the area where most contemporary redfish trap effort is exerted (Table 1). Their catches were "overwhelmingly" dominated by silk snapper. Due to the small mesh size employed (1.25 inch) in the 1971 study, though, it is not clear whether the experimental trapping results are directly comparable to contemporary redfish catch rates. Nonetheless, results from the *M/V Calamar* study do provide a qualitative indication of the potential productivity of a "really underexploited" stock (i.e. a virgin stock) of silk snapper from Saba Bank (Giudicelli and Villegas, 1981).

Dilrosun also commented on the small average size at capture for *L. vivanus* from Saba Bank. Our data confirm that most of the harvested silk snapper (> 90 %) are taken before they reach reproductive maturity. Dilrosun also demonstrated that *L. vivanus* recruits to the trap fishery at a smaller size than to the line fishery. Size selectivity of fish traps is inversely related to mesh size, and mesh sizes used for redfish traps are small. Small redfish are reportedly more easily marketed, which encourages fishermen to continue the use of small-meshed traps. With the decline in hook & line methods and growth of traps for snapper harvests, fishing pressure has been further focused on silk snapper stocks. This concern is addressed further in the recommendations (below).

4) Mixed Fish

In addition to lobster, Saban commercial fishermen harvest a substantial quantity of finfish or "mixed fish" from lobster traps. In comparison to year 2000, mixed fish landing from lobster traps in 2007 are considerably larger. Dilrosun reported a "by-catch" of demersal finfish from lobster traps that amounted to approximately 8,000 kg annually. We estimate that the 2007 mixed fish landings are more than twice this large (17,000 kg annually). These results suggest that mixed fish have grown in importance to the Saban fishery. However, it is also possible that Dilrosun underestimated mixed fish landings due to differences in port sampling methods. Further data collection, spanning multiple years, will be required to better evaluate trends in mixed fish landings.

5) Groupers

Intensive fishing is known to selectively remove piscivores and large predatory fishes (Russ, 1991). Our port sampling indicates that species of large-bodied groupers (*Mycteroperca* sp., *Epinephelus* sp.) form only a minor component of present-day commercial landings. Dilrosun (2000) concluded that Saba Bank stocks of large grouper species were "practically non-existent, presumably due to over-fishing." Long-time fishermen of Saba Bank have witnessed the decline in grouper abundance over more than two decades and they unequivocally attribute grouper declines to trap fishing. Thus, grouper fish stocks should be considered depleted. It may be assumed that the intensive fishing effort on Saba Bank during the 1980's and early 1990's by international fishing fleets (Meesters et al., 1996) contributed significantly to reduction of grouper stocks.

The management of multi-species stocks of groupers will pose some special challenges for resource managers. An important approach for grouper stock management is the protection of spawning aggregations (Levin and Grimes, 2002). Unfortunately little is known about grouper spawning aggregations from Saba Bank at present. This should be an area for further research in the future. Information is currently available for only one grouper species – the red hind (Nemeth et al., 2006). Recommendations for management of red hind spawning aggregations are presented below.

6) Habitat

The distribution of commercial fishing effort across Saba Bank is not uniform. Our results indicate that traps are set at high densities in localized areas of Saba Bank, while other areas are largely avoided fishermen. This non-uniform distribution of fishing effort is at least partially reflective of the underlying distribution of fisheries resources. In turn, it can be expected that the distribution and abundance of fishes and invertebrates are strongly influenced by habitat type.

More detailed information on the composition and distribution of benthic habitats of Saba Bank is needed in order to understand stock abundance patterns. Recent studies to develop benthic habitat maps for Saba Bank (MINA, 2007, Toller, 2008) are especially promising in this regard. Habitat maps will provide a much-needed spatial framework for conducting fisheries-independent investigations. Critical fisheries habitats of Saba Bank, such as recruitment areas or nursery habitats, may be identified in the near future using this approach. Thus, habitat-mapping studies hold the potential to contribute substantially to management of Saba Bank fisheries resources.

VIII. Recommendations

1) Implement Reporting System

We strongly recommend that management authorities establish a program for long-term monitoring of commercial fisheries landings from Saba Bank. These data are essential for tracking trends in fisheries landings and catch rates over an appropriate time frame (i.e. years). We suggest that the reporting system be developed and implemented to fulfill explicit fisheries data needs. Reports may consist of monthly log sheets submitted by fishermen. Data requirements should be minimal, intuitive, and accurately estimated by fishermen. At a minimum, the reporting system should provide for calculation of CPUE on a monthly basis for lobster (e.g. number per trap-haul), redfish (e.g. weight per trap-haul), total finfish (e.g. weight per trap-haul), and fishing area (four quadrants as proposed here). The costs associated with obtaining this information are small, and analysis of the resulting dataset would be straightforward. However, managers and fishermen alike must recognize at the outset that such a time-series will require at least five years of data collection in order to be useful for identifying trends (T. Shirley, pers. com.). Thus, the program will require a sustained commitment. Success will likely depend upon levels of agency commitment and the provision of infrastructure and funding to insure implementation.

The proposed landings dataset will be useful for management of all Saba Bank commercial stocks, but we view this information as essential for sustainable management of lobster stocks. Lobster landings are presently the most economically significant component of the Saba Bank commercial fishery (77 % of ex-vessel value of total annual landings) and lobster stocks should therefore be considered the first priority for fisheries management. Caribbean spiny lobster populations are known to exhibit natural fluctuations in stock abundance over multi-year time scales (see above). Therefore, the effective management of Saba Bank lobster stocks will require a perspective towards long-term trends in stock abundance – trends which can only be detected in time-series data sets.

2) Eliminate Anchoring

Saba Bank is used by oil tankers and other large vessels for passage and for anchoring (Meesters et al., 1996). Anchoring by large ships, particularly oil tankers using the St. Eustatius trans-shipment terminal, results in the destruction of habitat on Saba Bank (Meesters et al., 1996). Vessel traffic across Saba Bank also causes the loss of traps, thereby creating economic losses for fishermen and potentially increasing rates of ghost trap fishing (see below). Thus, large vessel traffic represents a doubly negative impact on Saba Bank fisheries and it must be considered a major issue for fisheries and natural resource management.

A number of previous authors have identified anchoring by large vessels as a major impact to the natural resources of the Saba Bank (Meesters et al. 1996, Dilrosun, 2000). More recent investigations have focused greater attention on this issue (e.g. Conservation International, 2006). Saba Bank resource managers are currently seeking means to reduce or eliminate impacts caused by anchoring. One promising initiative is a push to have the International Maritime Organization designate Saba Bank as a Particularly Sensitive Sea Area (MINA, 2007). Attainment of PSSA status would effectively eliminate the practice of anchoring by large vessels on Saba Bank.

In recent years, fisheries scientists have recognized the need for an ecosystem-based approach to marine resource management (Garcia et al., 2003). In this view, protection of fisheries habitat is an essential component of fisheries stock management. Although quantitative data on anchor impacts to Saba Bank are presently scant, it must be assumed that dragging 10-ton anchors across the seafloor does not improve the habitat quality for fisheries species. We recommend an ecosystem-based approach for Saba Bank fisheries management, and assert that the first step must be to address the habitat impacts caused by anchoring.

3) Redfish Management

At present, the Saba Bank redfish fishery is characterized by a lack of information. Stock densities are either unknown, or may be based on very optimistic calculations. For example, Giudicelli and Villegas (1980) estimated that the “potential yield” of silk snapper from Saba Bank was 1,600 metric tons. Their value was derived assuming stock densities of silk snapper on Saba Bank were equivalent to those of Cuba. We urge caution in interpreting such estimates as they may not accurately portray sustainable harvest levels from Saba Bank.

Critical information is lacking for monitoring long-term trends in redfish total landings and catch rates. The few existing regulations that are of direct relevance to this fishery, such as mesh size restriction, appear to be ineffective. Furthermore, the results of our assessment and that of Dilrosun (2000) raise serious concerns about the average harvest sizes of redfish from Saba Bank. In particular, the silk snapper that dominate landings are composed primarily (> 90% by number) of pre-reproductive size individuals. Given that stock size remains poorly know, the current practice of harvesting almost exclusively juvenile fishes is a risky fisheries strategy. If reproductive output by silk snapper stocks is sufficiently reduced by harvesting it may lead to abrupt population declines or even a stock crash.

We recommend that a fisheries management framework should be developed in order to manage Saba Bank redfish stocks. This policy framework must set forth specific goals and objectives for sustainable use of redfish resources (FAO, 1995) and it should be developed in parallel with a commercial fishery reporting system (see above) for collection of catch and effort data. Initial focus should be placed on silk snapper with a goal of estimating stock size. There are undoubtedly a wide variety of management actions available to resource managers, such as seasonal closures or annual catch quotas (e.g. Hoggarth et al. 2006). However, selecting from among such options will require a clearly defined policy with stated goals and objectives, and determining the effectiveness of such measures will require a commitment to long-term data collection.

4) Red Hind Spawning Aggregation

Spawning aggregations represent a critical phase in the life history of many commercially important fishes such as groupers and snappers. Stocks may become exceptionally vulnerable to overfishing during their spawning aggregation period. For this reason the spawning phase of some species (e.g. groupers) requires particular attention from fisheries resource managers (Levin and Grimes, 2002). Saban fishermen have long known of the annual formation of spawning aggregations on Saba Bank. For example, it is a long-standing tradition among Sabans to fish the Saba Bank "moonfish" (queen triggerfish) aggregation during November (Boeke, 1907, Meesters et al., 1996, Dilrosun, 2000). Recently, Nemeth et al. (2006) conducted a detailed study of the red hind spawning aggregation located on the northern Saba Bank. They emphasized the importance of this aggregation as a primary source for red hind recruitment to Saba Bank. Nemeth et al. (2006) recommended "… swift action by the biologists and managers of the Saba Bank fisheries to enact some type of proactive protective management…" of the red hind aggregation area.

During the time of our study, a discussion was initiated with the Saban commercial fishery and local governmental authorities to consider alternative management measures for conserving the Saba Bank red hind spawning aggregation. Consultations were still ongoing at the close of our study and a clear course for management action had not been identified. We strongly recommend that this issue does not get set aside. Results from our study indicate that red hind is of substantial economic importance to the local fishery. Red hind was ranked as the fourth most important finfish species in terms of commercial landings in 2007 (Appendix 5) and was ranked fifth in 2000 (Dilrosun, 2000). Thus, the commercial value of this species cannot be ignored and management action is warranted on economic grounds alone. Careful management of red hind aggregations was a successful strategy in the U.S. Virgin Islands, where area closures led to the recovery of a red hind aggregation and subsequently contributed to elevated landings of red hind by the commercial fishery (Nemeth, 2005). There is reason to believe that comparable measures to protect Saba Bank red hind aggregations would be equally successful and would directly benefit the Saban commercial fishery in the long-term.

5) Lost Fishing Gear

Dilrosun (2000) asserted that lost traps are a central issue for the management of Saba Bank's fisheries resources. He reported that close to 1,000 traps were lost during the 1999 hurricane season alone, and that tanker vessel traffic over Saba Bank was also responsible for the loss of a considerable number of additional traps. Results from our study indicate that lost traps continue to be an issue for management of the Saba Bank fishery in 2007.

Lost traps have the potential to negatively impact fisheries resources through continued unattended fishing or "ghost fishing " (e.g. Parrish and Kazama, 1992). The potential impact of ghost trap fishing is extended when traps are fabricated from long-lasting, corrosion-resistant materials. To reduce the longevity of lost gears, Netherlands Antilles fisheries regulations specify that all traps must be fitted with a biodegradable escape panel. However, the Saban commercial fishing industry has not embraced the practice of installing escape panels in traps. Compliance with this regulation was poor in 2000 (Dilrosun, 2000) and remains low in 2007.

In order to address the issue of lost traps, the first requirement will be to get a better understanding of ghost fishing in the context of the Saba Bank trap fisheries. The second requirement will be for resource managers to work directly with the Saban fishing industry to identify realistic solutions to reduce ghost fishing by lost traps. At present, there seems to be a "disconnect" between scientists and resource managers on the one hand, and the fishing industry on the other. There is general disagreement about the magnitude of impacts caused by lost traps and about the efficacy of the legally mandated management solution (biodegradable escape panels). The issue has been debated without resolution for at least seven years. In that time, no quantitative information was gathered on ghost trap fishing to substantiate the position of either side. This impasse has blocked progress towards identifying and implementing solutions.

Assuming that levels of enforcement and compliance are unlikely to change in the immediate future, we suggest that a different approach be taken to address the issue of lost traps in the Saba Bank fishery. We recommend that the scientific method be used to collect quantitative information relevant to this issue. We envision a detailed study to quantify the parameters of ghost trap fishing (magnitude, duration, species impacts) in the context of local fishing practices on Saba Bank. Investigators would enlist participation by the commercial fishery to conduct this study. Results from the study would provide a means to objectively assess impacts of ghost fishing and to evaluate alternatives for reducing those impacts (i.e. through modified trap construction). Direct involvement of the fishing industry in this research would insure dissemination of the results. Such a study could also provide much needed information on bycatch rates and mortality rates associated with trap fishing on Saba Bank.

IX. Acknowledgments

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Appendix 1. Methods Addendum.

Our methods to collect Saba Bank fisheries data are described elsewhere (Toller and Lundvall, 2007). This addendum provides a brief synopsis of the dataset and derivation of fisheries statistics.

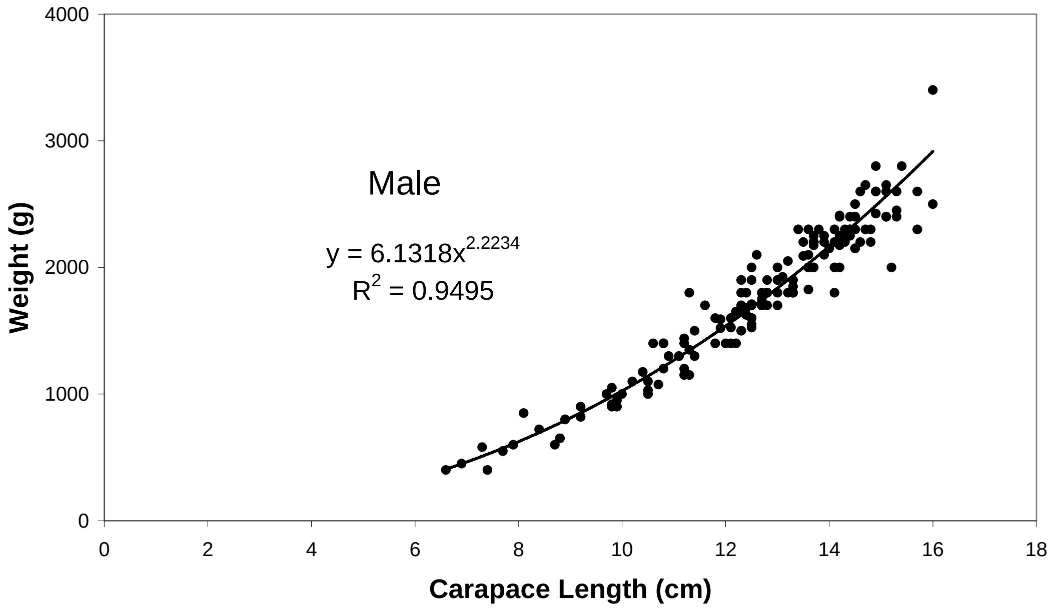
Total Fishing Effort: Fleet effort (total number of fishing trips) was derived from a daily log of fishing trips to Saba Bank as observed from Fort Bay. The log ran from July 1 to November 30. Data were not recorded in June and July averages were applied. During the six-month assessment period (183 days) there were a total of 657 fishing trips, which corresponds to a projected 1,310 fishing trips per year by the Saban commercial fleet.

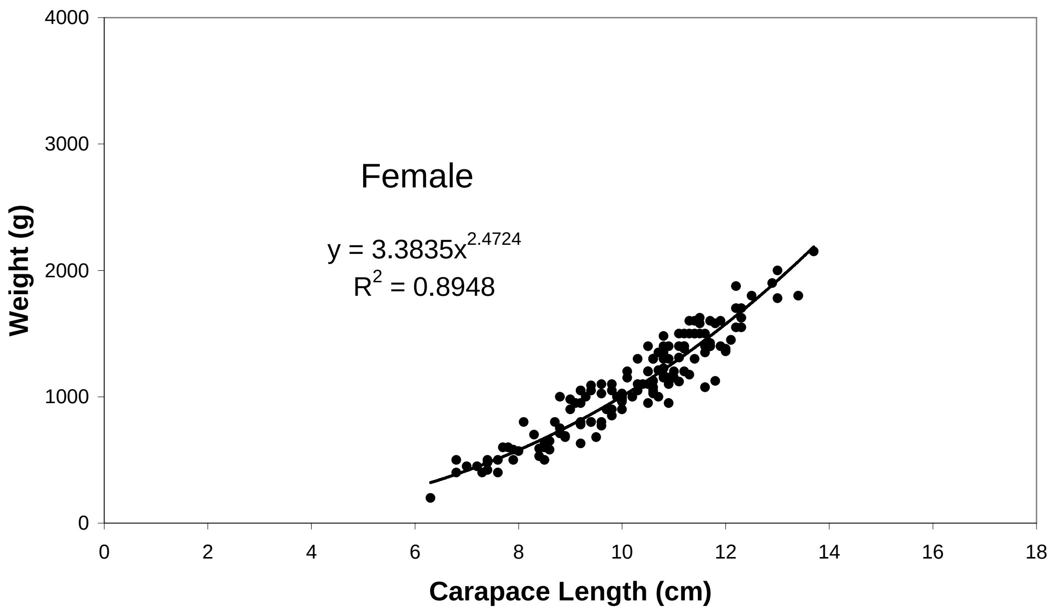
Trip Type and Landings: Fishing trip information was collected in 203 port sampling interviews with Saban commercial fishermen (30.1% of all fishing trips). Trip type was assigned based upon fishing gear used: lobster trap (155 trips, 76.2 %) or fish trap (48 trips, 23.8 %). Reported landings were recorded in bulk categories (e.g. hinds, moonfish, grunts, redfish) and were summarized by gear type to calculate total landings and catch per unit effort (CPUE).

Catch Composition: Biostatistical information on catch composition was collected from a subsample of the interviews (approximately 10 % of all fishing trips). The resulting dataset was comprised of 4,552 observations (Appendix 3) that included 50 finfish species and 4 invertebrate taxa. Measurements were obtained as follows. Lobster size was determined by measuring carapace length (CL) to the nearest 1.0 mm with plastic machinist calipers. Sex was determined by inspection of external dimorphic features. Females were categorized as egg-bearing (F/B), tar-spot present (F/T) or no eggs and no tar-spot (F). “Tar-spot” refers to a black spermatophoric mass deposited on the sternum of the female lobster (MacDiarmid and Kittaka, 2000). Lobster weight was calculated from CL using length-weight relationships shown in Appendix 2 (Dilrosun, 2000). Finfish were identified using taxonomic keys provided in Carpenter (2002), as discussed elsewhere (Toller, 2007). Fish length was measured to the nearest 5 mm using fork length (FL) or total length (TL) as appropriate. Weight of finfish specimens was calculated using established length-weight relationships (Froese and Pauley, 2007). The values for *a* and *b* used in the growth equation are shown in Appendix 4.

Species composition of projected annual landings (Appendix 5) was derived by multiplying weight (as observed in biostatistical samples) by percent composition in landings category for each gear type (as derived from reported landings).

Appendix 2. Length-weight relationships for male and female lobster from Saba Bank. Data are from Dilrosun (2000).





Appendix 3. Saba Bank landings: Number of individuals and lengths for all species observed in port samples.

			Length (mm)*		
Common Name	Species	Count	Avg	Min	Max
Finfish					
silk snapper	*Lutjanus vivanus* (Cuvier, 1828)	777	287.1	190	575
white grunt	*Haemulon plumierii* (Lacep¸de, 1802)	713	243.7	120	390
blackfin snapper	*Lutjanus buccanella* (Cuvier, 1828)	393	290.4	180	605
red hind	*Epinephelus guttatus* (Linnaeus, 1758)	287	331.1	180	450
queen triggerfish	*Balistes vetula* Linnaeus, 1758	138	347.2	210	450
vermilion snapper	*Rhomboplites aurorubens* (Cuvier, 1829)	127	258.6	195	450
cottonwick	*Haemulon melanurum* (Linnaeus, 1758)	108	236.7	180	280
coney	*Cephalopholis fulva* (Linnaeus, 1758)	52	276.8	245	315
lane snapper	*Lutjanus synagris* (Linnaeus, 1758)	48	250.6	190	410
spotted goatfish	*Pseudupeneus maculatus* (Bloch, 1793)	46	219.6	190	265
saucereye porgy	*Calamus calamus* (Valenciennes, 1830)	37	254.5	205	340
doctorfish	*Acanthurus chirurgus* (Bloch, 1787)	37	224.3	180	295
princess parrotfish	*Scarus taeniopterus* Desmarest, 1831	34	261.8	190	365
honeycomb cowfish	*Acanthostracion polygonius* Poey, 1876	26	245.4	215	345
redtail parrotfish	*Sparisoma chrysopterum* (Bloch and Schneider, 1801)	20	276.3	230	330
French grunt	*Haemulon flavolineatum* (Desmarest, 1823)	18	210.3	180	260
redband parrotfish	*Sparisoma aurofrenatum* (Valenciennes, 1840)	16	225.3	200	245
yellowfin grouper	*Mycteroperca venenosa*(Linnaeus, 1758)	14	583.6	355	750
margate	*Haemulon album* Cuvier, 1829	12	457.3	370	535
blue runner	*Caranx crysos* (Mitchill, 1815)	12	369.2	300	420
ocean surgeon	*Acanthurus bahianus* Castelnau, 1855	11	202.3	170	230
wahoo	*Acanthocybium solandri* (Cuvier, 1832)	11	1306.8	1175	1430
squirrelfish	*Holocentrus adscensionis* (Osbeck, 1765)	11	238.6	220	255
blue tang	*Acanthurus coeruleus* Bloch and Schneider, 1801	8	196.3	175	220
spotted trunkfish	*Lactophrys bicaudalis* (Linnaeus, 1758)	7	280.0	180	380
mutton hamlet	*Alphestes afer* (Bloch, 1793)	6	245.0	215	270
almaco jack	*Seriola rivoliana* Valenciennes, 1833	5	541.0	455	620
snowy grouper	*Epinephelus niveatus* Valenciennes, 1828	5	254.0	220	345
Caribbean reef shark	*Carcharhinus perezi* (Poey, 1876)	4	1551.3	805	1850
yellow goatfish	*Mulloidichthys martinicus* (Cuvier, 1829)	4	272.5	260	290
yellowmouth grouper	*Mycteroperca interstitialis* (Poey, 1860)	4	500.0	410	605
schoolmaster	*Lutjanus apodus* (Walbaum, 1792)	3	283.3	275	295
red grouper	*Epinephelus morio* (Valenciennes, 1828)	3	585.0	460	660
scrawled cowfish	*Acanthostracion quadricornis* (Linnaeus, 1758)	3	213.3	200	230
graysby	*Cephalopholis cruentata* (Lacep¸de, 1802)	2	275.0	255	295
yellowedge grouper	*Epinephelus flavolimbatus* Poey, 1865	2	642.5	575	710
gray angelfish	*Pomacanthus arcuatus* (Linnaeus, 1758)	2	287.5	260	315
blacktip shark	*Carcharhinus limbatus* (M ller and Henle, 1839)	1	690.0	690	690
black snapper	*Apsilus dentatus* Guichenot, 1853	1	250.0	250	250
dolphinfish	*Coryphaena hippurus* Linnaeus, 1758	1	595.0	595	595
blackfin tuna	*Thunnus atlanticus* (Lesson, 1831)	1	475.0	475	475
Caesar grunt	*Haemulon carbonarium* Poey, 1860	1	220.0	220	220
Caribbean red snapper	*Lutjanus purpureus* (Poey, 1866)	1	240.0	240	240
Nassau grouper	*Epinephelus striatus* (Bloch, 1792)	1	745.0	745	745
tomtate	*Haemulon aurolineatum* Cuvier, 1830	1	180.0	180	180
little tunny	*Euthynnus alletteratus* (Rafinesque, 1810)	1	540.0	540	540
yellowtail snapper	*Ocyurus chrysurus* (Bloch, 1791)	1	320.0	320	320
queen parrotfish	*Scarus vetula* Bloch and Schneider, 1801	1	280.0	280	280
rainbow parrotfish	*Scarus guacamaia* Cuvier, 1829	1	685.0	685	685
trunkfish	*Lactophrys trigonus* (Linnaeus, 1758)	1	400.0	400	400
Invertebrates*					
Caribbean spiny lobster	*Panulirus argus* (Latreille, 1804)	1518	111.8	78	199
Spanish slipper lobster	*Scyllarides aequinoctialis* (Lund, 1793)	7	103.1	94	112
batwing coral crab	*Carpilius corallinus* (Herbst, 1783)	6	131.7	123	145
common octopus	*Octopus* cf. *vulgaris* group	2	120.0	120.0	120.0

* Finfish length reported as fork length or total length. Invertebrate size reported as carapace length (lobsters), carapace width (crab) or mantle length (octopus).

Appendix 4. Saba Bank landings: Length to weight conversions for finfish species observed in port samples.

	L-W Variables			Wt (lbs)				
Common Name	a	b	Count	Avg	StDev	Min	Max	Total
silk snapper	0.0617	2.78	777	1.71	1.17	0.49	10.58	1327.1
white grunt	0.0259	3.00	713	0.86	0.33	0.10	3.38	614.3
blackfin snapper	0.0747	2.74	393	1.84	1.16	0.45	12.52	723.0
red hind	0.0360	2.84	287	1.73	0.69	0.29	3.93	497.6
queen triggerfish	0.0657	2.83	138	3.46	1.25	0.80	6.90	478.2
vermilion snapper	0.0214	2.95	127	0.74	0.42	0.30	3.55	94.3
cottonwick	0.0226	2.95	108	0.58	0.14	0.25	0.93	62.5
coney	0.0175	3.00	52	0.82	0.14	0.57	1.20	42.9
lane snapper	0.0387	2.84	48	0.86	0.48	0.36	3.24	41.4
spotted goatfish	0.0159	3.03	46	0.41	0.12	0.26	0.71	19.0
saucereye porgy	0.0125	3.18	37	0.85	0.35	0.41	2.04	31.6
doctorfish	0.0040	3.53	37	0.54	0.20	0.24	1.37	20.1
princess parrotfish	0.0335	2.71	34	0.53	0.18	0.21	1.26	18.0
honeycomb cowfish	0.0179	3.00	26	0.60	0.24	0.39	1.62	15.6
redtail parrotfish	0.0099	3.17	20	0.84	0.26	0.45	1.42	16.7
French grunt	0.0127	3.16	18	0.43	0.15	0.26	0.82	7.8
redband parrotfish	0.0046	3.43	16	0.45	0.08	0.29	0.59	7.1
yellowfin grouper	0.0122	3.00	14	5.89	3.05	1.20	11.32	82.5
margate	0.0144	3.07	12	4.12	1.47	2.07	6.41	49.4
blue runner	0.0524	2.69	12	1.94	0.51	1.08	2.68	23.2
ocean surgeon	0.0237	2.98	11	0.41	0.09	0.24	0.59	4.5
wahoo	0.0025	3.19	11	31.41	6.50	22.07	41.29	345.5
squirrelfish	0.0208	3.00	11	0.63	0.11	0.49	0.76	6.9
blue tang	0.0415	2.83	8	0.43	0.09	0.30	0.58	3.42
spotted trunkfish	0.0294	3.00	7	1.65	1.17	0.38	3.55	11.5
mutton hamlet	0.0175	3.00	6	0.58	0.14	0.38	0.76	3.5
almaco jack	0.0064	3.17	5	4.55	1.60	2.54	6.77	22.8
snowy grouper	0.0214	2.93	5	0.67	0.46	0.40	1.49	3.3
Caribbean reef shark	0.0061	3.01	4	63.75	38.04	7.31	89.52	255.0
yellow goatfish	0.0207	3.00	4	0.93	0.13	0.80	1.11	3.7
yellowmouth grouper	0.0141	3.00	4	4.11	2.01	2.14	6.87	16.4
schoolmaster	0.0194	2.98	3	0.90	0.10	0.82	1.02	2.7
red grouper	0.0162	2.99	3	7.31	3.48	3.34	9.83	21.9
scrawled cowfish	0.0014	3.42	3	0.11	0.03	0.09	0.14	0.3
graysby	0.0135	3.04	2	0.73	0.22	0.57	0.88	1.5
yellowedge grouper	0.0500	2.80	2	13.04	5.29	9.30	16.78	26.1
gray angelfish	0.0345	2.97	2	1.66	0.65	1.20	2.12	3.3
blacktip shark	0.0061	3.01	1	4.60	-	4.60	4.60	4.6
black snapper	0.0150	3.00	1	0.52	-	0.52	0.52	0.5
dolphinfish	0.0380	2.78	1	7.17	-	7.17	7.17	7.2
blackfin tuna	0.0154	3.08	1	4.94	-	4.94	4.94	4.9
Caesar grunt	0.0404	2.74	1	0.42	-	0.42	0.42	0.4
Caribbean red snapper	0.0141	2.99	1	0.42	-	0.42	0.42	0.4
Nassau grouper	0.0065	3.23	1	15.87	-	15.87	15.87	15.9
tomtate	0.0100	3.21	1	0.23	-	0.23	0.23	0.2
little tunny	0.0163	3.00	1	5.65	-	5.65	5.65	5.6
yellowtail snapper	0.0405	2.72	1	1.10	-	1.10	1.10	1.1
queen parrotfish	0.0250	2.92	1	0.93	-	0.93	0.93	0.9
rainbow parrotfish	0.0155	3.06	1	14.30	-	14.30	14.30	14.3
trunkfish	0.0178	3.08	1	3.40	-	3.40	3.40	3.4

Appendix 5. Projected annual Saba Bank landings:
Rank abundance by weight of finfish species.

		Landings (lbs) by Gear Type						
		Lobster Trap		Fish Trap		Hook & Line		Total Annual
Rank	Common Name	%	Wt.	%	Wt.	%	Wt.	Landings (lbs)
1	silk snapper	-	-	55.72%	55,350.6	-	-	55,350.6
2	blackfin snapper	-	-	30.36%	30,154.8	-	-	30,154.8
3	white grunt	43.03%	16,234.5	-	-	-	-	16,234.5
4	red hind	16.70%	6,300.0	3.78%	3,764.6	-	-	10,064.6
5	queen triggerfish	12.60%	4,753.3	0.24%	239.6	-	-	4,992.9
6	vermilion snapper	-	-	3.96%	3,933.1	-	-	3,933.1
7	lane snapper	0.78%	295.0	1.39%	1,384.7	-	-	1,679.7
8	cottonwick	3.71%	1,398.2	0.16%	158.3	-	-	1,556.6
9	coney	3.24%	1,222.1	0.15%	149.7	-	-	1,371.8
10	yellowfin grouper	-	-	1.36%	1,358.1	-	-	1,358.1
11	saucereye porgy	2.89%	1,090.9	0.02%	23.8	-	-	1,114.7
12	margate	1.68%	634.2	0.42%	418.4	-	-	1,052.7
13	doctorfish	1.92%	726.2	-	-	-	-	726.2
14	spotted goatfish	1.82%	686.0	-	-	-	-	686.0
15	princess parrotfish	1.72%	649.4	-	-	-	-	649.4
16	redtail parrotfish	1.60%	605.3	-	-	-	-	605.3
17	honeycomb cowfish	1.50%	566.0	-	-	-	-	566.0
18	wahoo	-	-	-	-	56.6%	543.1	543.1
19	rainbow parrotfish	1.37%	517.5	-	-	-	-	517.5
20	Caribbean reef shark	-	-	0.12%	120.4	40.5%	389.4	509.8
21	yellowedge grouper	-	-	0.43%	429.4	-	-	429.4
22	spotted trunkfish	1.11%	417.8	-	-	-	-	417.8
23	blue runner	-	-	0.38%	382.4	-	-	382.4
24	almaco jack	-	-	0.38%	374.8	-	-	374.8
25	red grouper	-	-	0.36%	360.8	-	-	360.8
26	yellowmouth grouper	-	-	0.27%	270.8	-	-	270.8
27	Nassau grouper	-	-	0.26%	261.2	-	-	261.2
28	redband parrotfish	0.68%	258.0	-	-	-	-	258.0
29	French grunt	0.55%	206.9	-	-	-	-	206.9
30	squirrelfish	0.29%	108.7	0.06%	64.1	-	-	172.8
31	blacktip shark	0.44%	166.4	-	-	-	-	166.4
32	ocean surgeon	0.43%	162.0	-	-	-	-	162.0
33	mutton hamlet	0.33%	124.9	-	-	-	-	124.9
34	blue tang	0.33%	123.7	-	-	-	-	123.7
35	trunkfish	0.33%	123.1	-	-	-	-	123.1
36	gray angelfish	0.32%	120.3	-	-	-	-	120.3
37	yellow goatfish	0.27%	101.6	0.01%	14.8	-	-	116.3
38	schoolmaster	0.18%	68.3	0.01%	13.6	-	-	81.8
39	snowy grouper	-	-	0.06%	55.1	-	-	55.1
40	queen parrotfish	0.09%	33.6	-	-	-	-	33.6
41	graysby	-	-	0.02%	23.9	-	-	23.9
42	yellowtail snapper	-	-	0.02%	18.1	-	-	18.1
43	scrawled cowfish	0.03%	11.8	-	-	-	-	11.8
44	dolphinfish	-	-	-	-	1.2%	11.3	11.3
45	Caesar grunt	0.03%	11.2	-	-	-	-	11.2
46	little tunny	-	-	-	-	0.9%	8.9	8.9
47	black snapper	-	-	0.01%	8.5	-	-	8.5
48	tomtate	0.02%	8.5	-	-	-	-	8.5
49	blackfin tuna	-	-	-	-	0.8%	7.8	7.8
50	Caribbean red snapper	-	-	0.01%	6.8	-	-	6.8
	Total Wt. (lbs)		37,725.3		99,340.6		960.3	138,026.3