Saba Bank Fisheries Resources Study, Report II:
Methods to Assess the Saba Bank Commercial Fishery and Preliminary Results

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Introduction

In June of 2007, the Saba Conservation Foundation initiated a fisheries-dependent investigation of the commercial fishery of Saba Bank, Netherlands Antilles as part of the Saba Bank Project funded by USONA. The goal of the present document is to outline the specific objectives of the Saba Bank Fisheries Assessment Project, to provide an account of the methods used to collect fisheries-dependent information, and to present preliminary results and observations.

Saba Bank is a large submerged coral atoll located 5 km southwest of the island of Saba (Macintyre et al., 1975, Van der Land, 1977). A small commercial fishery operating from Saba presently exploits fisheries resources of Saba Bank. Commercial fisheries harvests from Saba Bank are of considerable economic importance to the local population of Saba (Framhein, 1995 cited in Meesters et al., 1996).

Recently, Faisal Dilrosun (2000) completed a comprehensive examination of the Saba Bank commercial fishery. Dilrosun performed extensive sampling of commercial catches – particularly for lobster size. His study provides us with robust baseline data to compare to current harvest patterns and stock condition. Therefore, in the present study, we have relied on sub-sampling as a more practical means to compile fisheries statistics for the Saba Bank commercial fishery. We place greater emphasis on characterizing fishing methods, understanding the distribution of fishing activities, estimating total fishing effort, and calculating commercial landings from bulk reporting categories. This dataset should lay the foundation for establishing a long-term commercial fisher reporting system. In addition, several focused data collection efforts were made to address specific questions relating to biological attributes of harvested stocks including size-frequency relationships and species composition.

Specific Objectives

The specific objectives of the Saba Bank Fisheries Assessment Project are to:

1) Describe of the primary fishing methods used in the Saban commercial fishery
2) Examine the depth distribution of commercial fishing activities on Saba Bank
3) Examine the spatial distribution of commercial fishing activities on Saba Bank
4) Estimate fishing effort, landings, and annual economic value
5) Identify and estimate appropriate measures of catch per unit effort (CPUE)

6) Examine biological attributes of harvested stocks, including:
    a. species composition of landings
    b. size-frequency distributions of commercially important species
    c. age-structure of potentially vulnerable stocks (silk snapper)
    d. diversity of bycatch species

Successful completion of these specific objectives will provide essential information to be used in formulating the forthcoming management plan for Saba Bank.

Methods for Assessing the Saba Bank Commercial Fishery

1) Port Sampling

The primary source of data for this report comes from contact interviews with Saban commercial fishermen. Each interview represents a single port sample that was typically obtained from the vessel captain at dockside in Fort Bay at the time of landing. It is emphasized that the success of port sampling depends critically upon sharing by fishermen. Saban commercial fishermen have been exceptionally cooperative with Saba Bank Project staff thus far.

Port sampling was initiated on 5-Jun-2007 using an old data form. Data collection was sporadic and incomplete during the first three weeks, in part due to poorly defined data collection goals. In late June, the authors refined the specific objectives (listed above) and revised the port sampling form accordingly. A standardized Saba Bank Port Sampling Form (Appendix 1) was implemented on 28-June-2007.

The first section of the standardized port sampling form consists of general trip information. Completion of this section is the "short form" interview. Information collected using the short form includes: sample date, boat name, departure and arrival time, transit time, gear type, number of gears, soak time, fishing depth, number of crew, number of lost gears, and GPS location of fishing activities. Fishermen estimated the weight of their finfish landings (in pounds) into the following bulk categories: redfish, hinds, moonfish, grunts, other potfish, and total finfish (Appendix 1). Fishermen reported their lobster landings as total number of individuals. The short form was designed to be an abbreviated interview that is completed in < 10 minutes, thereby causing a minimum of disruption to the fishermen. Short form information was obtained from all port sampling interviews. Fishermen were selected for interviews on a haphazard but opportunistic basis. Our sampling target was to interview 30 % of all fishing trips.

The standardized port-sampling form also contains a second section termed "biostatistical sample." Biostatistical samples involved collection of detailed information on species composition and sizes. Interviews that involved biostatistical samples were longer and more disruptive to a fisherman's work in port (e.g. transferring catch, re-fueling the vessel), and therefore required a greater level of cooperation. For this reason, biostatistical sampling was done less frequently. Our sampling target was to obtain biostatistical samples from 10 % of all port sampling interviews. Fishermen were selected on a haphazard but opportunistic basis, and biostatistical sampling included partial or complete workups of landings.

2) Fishing Trip Log

A separate source of information was used to estimate the fishing effort of the Saban commercial fishing fleet - the Fishing Trip Log (FTL). Each day, project staff logged the vessels that had left port. In cases where fishermen used their vessels for purposes other than fishing, such trips were generally clarified by close of the same day. It is believed that the FTL provides the most reliable means to estimate the actual number of fishing trips made by the Saban commercial fishing fleet.

Does the FTL represent *all* commercial fishing effort expended on Saba Bank? Presently, all Saban commercial fishermen land their catches from Saba Bank at Fort Bay. However, fishing trips made by non-Saban fishermen to Saba Bank could not be quantified in the present study. We have observed only one incident of a non-Saban vessel (from St. Kitts) actively fishing on Saba Bank. Dilrosun (2000) reported that it was common for fishermen from St. Martin (Netherlands Antilles) to fish Saba Bank and land their catches at their home port. Meesters et al. (1996) indicated that much of Saba Bank catches were taken by foreign vessels, although these intrusions may have ceased since the Netherlands Antilles commenced patrolling of the Saba Bank Economic Fisheries Zone (EFZ) during the late 1990s (Dilrosun, 2000). Thus, the magnitude of fishing effort made by non-Saban vessels on Saba Bank remains an important but unanswered question.

3) Biostatistical Measurements

Lobster size was determined by measuring carapace length (CL) to the nearest 0.1 cm with plastic machinist calipers. Sex was determined by inspection of external dimorphic features. Females were categorized as either egg-bearing (F/B), tarred (F/T) or untarred & unberried (F). Fish size was determined on a measuring board. Fork length (FL) or total length (TL) was measured to the nearest 5 mm.

Weights were difficult to obtain during biostatistical sampling due to logistical and environmental circumstances. A small subsampling of individual lobsters and fish was weighed. Weights were determined using an Ultrasport 30 hanging digital scale fitted with a 2.2 kg soft rubber bucket. Accuracy of the scale+bucket was 10 g (0.01 kg). Specimens less than 200 g were weighed using a Scout Pro SP202 toploading balance (Ohaus Corp.). For the majority of finfish specimens, weight was calculated from FL (or TL) using established length-weight relationships (Froese and Pauley, 2007).

In the previous study (Dilrosun, 2000), silk snapper, *Lutjanus vivanus*, was identified as the most important finfish in Saban commercial landings. Dilrosun raised concerns about the small average size of capture of silk snapper. To address the issue of stock structure, it was recommended that we investigate age-size relationships using otoliths (A. Debrot, pers. comm.).

4) Data Analysis

Dilrosun prepared a fisheries database using MS Access. In the present study, this relational database was modified to reflect the specific project goals and revised port sampling form. Each interview was assigned a unique number (SB001, SB002, etc…) for cross-referencing and archiving purposes. Database query results were exported from MS Access for further analysis using MS Excel. Spatial data (e.g. GPS locations) were analyzed using ArcGIS 9.2 (ESRI).

Preliminary Results and Observations

For the purposes of this report, an interim data analysis was performed to verify that data collection efforts were appropriate to address the specific objectives of the Saba Bank Fisheries Assessment Project. Results from the interim analysis are based on port sampling results obtained from 5-Jun-2007 to 3-Aug-2007 and represent a total of 76 interviews. Biostatistical samples were collected from 25 interviews during this period. The Fishing Trip Log (FTL) was initiated on 30-Jun-2007 and covered 36 days as of 3-Aug-2007 (there were two days where no data was collected). Thirty-two port sampling interviews were conducted during the FTL observation period.

1) Description of the Primary Fishing Methods

<u>Predominant Methods Used</u>

At present, traps or "pots" are the primary gear used by Saban commercial fishermen on Saba Bank. All interviews obtained to date (76) were from trap fishing trips. Saban fishermen also commonly use line fishing (Dilrosun, 2000) although no line-fishing trips were observed during the recent two month period. Diver-based harvesting methods (i.e. the use of scuba for capturing lobster and conch or spearing finfish) are not commonly used by Saban commercial fishermen. Currently, there is no commercial harvest of queen conch, *Strombus gigas*, from Saba Bank. Apparently, nets are also an uncommon gear type for fishing on Saba Bank. Thus, the Saban commercial fishery uses a relatively limited number of gear types and employs a small number of fishing methods. In this report, all landings from a single fishing trip could be ascribed to a single reported gear type and fishing method.

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 a number of additional finfish and invertebrate species are also taken incidentally in lobster traps. Redfish traps are set to capture a number of different snapper species that occur in moderate to deep waters. Redfish landings by Saban trap fishermen are dominated by three species: 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 fisher is targeting lobster or redfish. Therefore, differences between the gears/methods are emphasized in the following text.

<u>Soak Time</u>

Fishermen deploy lobster traps and redfish traps for differing periods of time before hauling. Soak time of lobster traps is ~ 1 week [average and stdev: 7.3 ± 1.7 days, median and mode: 7 days, range: 5-14 days, n = 50 fishing trips]. Soak time for redfish traps is 2-3 days [average and stdev: 2.9 ± 1.7 days, median and mode: 2 days, range: 1-6 days, n = 11 fishing trips]. These results are in general agreement with the findings of Dilrosun (2000).

<u>Trap Number and Trap Haul Rate</u>

In our assessment, we have not attempted to determine total number of traps used in the Saban commercial fishery. Dilrosun reported that each fisher used 100-300 lobster traps and ~ 20 fish traps. Extrapolation to the entire fishery (14 vessels in 1999-2000) gives an estimated total of 3,080 traps set on Saba Bank (2,800 lobster traps and 280 fish traps) in that year. Assuming trap number per fisherman has remained constant, it is estimated that the nine currently active Saban fishermen set a total of 1,980 traps (1,800 lobster traps and 180 fish traps) on Saba Bank.

Results from port sampling interviews indicate that the number of trap-hauls per trip differs between lobster and redfish trips. During a lobster trip, fishermen haul 81 traps [average and stdev: 81.0 ± 31.7 trap-hauls/trip, median: 74, mode: 75, range: 33-213, n = 64 fishing trips]. During a redfish trip, fishermen haul 30 traps [average and stdev: 29.6 traps ± 12.2, median and mode: 36, range: 9-41, n = 11 fishing trips]. These results are also in agreement with the findings of Dilrosun (2000).

<u>Trip Duration</u>

Trip duration statistics for typical lobster and redfish trips are presented in Table 1. Lobster trap trips and redfish trap trips were similar in terms of the average total duration, average transit time, and average fishing time. Statistics for trip duration were variable within and among fishermen. Duration was strongly influenced by distance to fishing grounds, prevailing weather, and various fishing activities such as re-positioning traps. As such, trip duration statistics were not particularly informative as a measure of fishing effort.

Table 1. Fishing Hours and Trip Hours by Gear Type.

	Lobster Trips (n = 38)			Redfish Trips (n = 12)		
	Transit Time (Hrs)	Fishing Time (Hrs)	Total Trip Duration (Hrs)	Transit Time (Hrs)	Fishing Time (Hrs)	Total Trip Duration (Hrs)
Average	2.3	6.8	9.0	2.2	5.5	8.8
St.Dev.	1.4	1.7	2.3	1.4	1.4	3.0
Max.	6.0	10.5	14.5	5.3	8.0	14.5
Min.	0.8	3.8	4.5	1.3	3.8	5.3
Count	26	26	38	8	8	12

2) Depth Distribution of Fishing Activities

Port sampling data from 32 interviews were used to examine the depth distribution of reported trap fishing activities. Fishing depth was separated on the basis of gear type (lobster traps vs. redfish traps) for analysis. Results are shown in Table 2. Note that depth is reported in fathoms to be consistent with depth units used by most Saban fishermen (1 fathom = 1.83 m).

Table 2. Reported Depth of Trap Fishing.

		Reported Fishing Depth (fathoms)			
Gear Type	No. of Trips	Minimum Depth		Maximum Depth	
		Avg	Range	Avg	Max
Lobster Trap	23	12.3	6 - 25	13.9	10 - 25
Redfish Trap	9	58.1	31 - 110	112.2	43 - 134

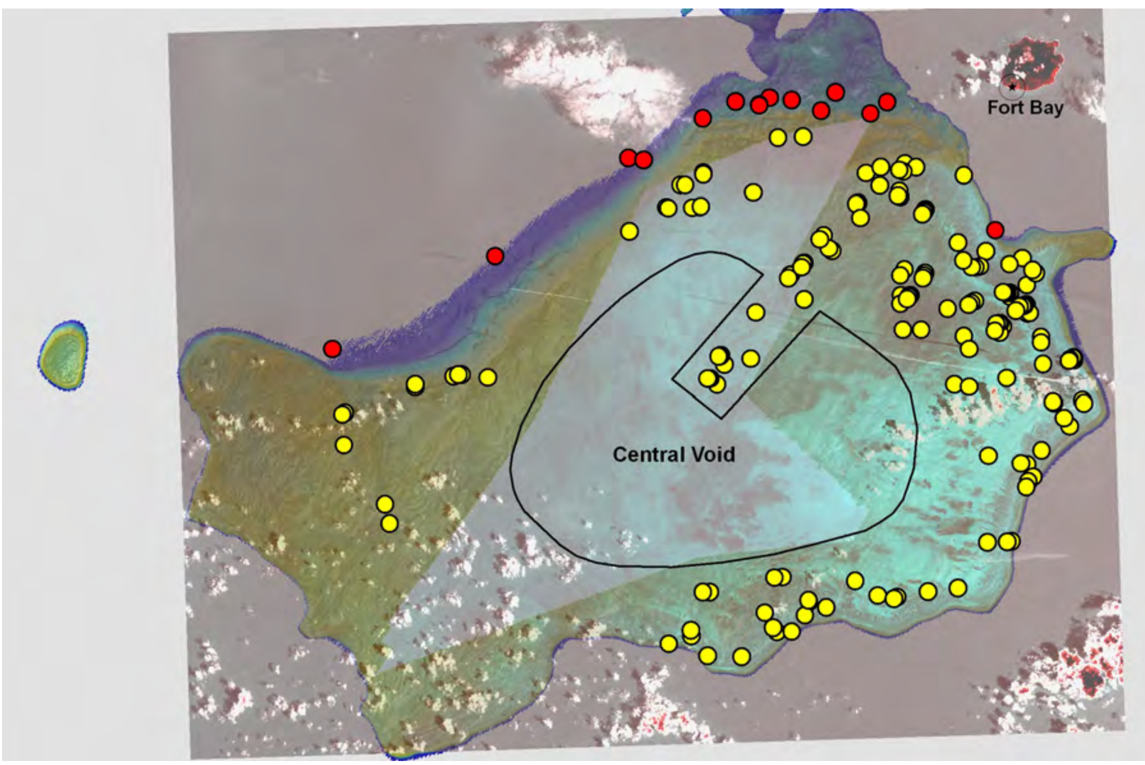
The results indicate that fishermen who target lobster set their traps in relatively shallow waters of Saba Bank. On average, lobster traps were set between 12 and 14 fathoms (range: 6 to 25 fathoms). In contrast, redfish traps were set at greater depths, averaging from 58 to 112 fathoms (range: 31 to 134 fathoms). There appears to be little or no overlap between lobster traps and redfish traps in terms of the depth range selected by fishermen. It is noted, however, that at some fishermen routinely catch lobster in their shallow-set redfish traps, at depths > 35 fathoms (64 m).

Saba Bank is a very large submerged island, encompassing an area of ~2,200 km^2 above the 200 meter isobath (Meesters et al., 1996). In principle, suitable fishing grounds for lobster include the entire shoal area of Saba Bank and suitable fishing grounds for redfish include a band of habitat around the periphery of Saba Bank. Assuming that lobster traps are set only in depths < 25 fathoms (45.7 m), the area of Saba Bank available as lobster trapping grounds can be approximated using the 50 meter isobath. This calculation gave an area of 1,850 km^2 (excluding Small Bank at ~ 3 km^2). For redfish, we presently lack sufficient information about Saba Bank bathymetry to define the spatial extent at redfish lower depth limits, which extend to > 134 fathoms (245 m). A preliminary estimate can be obtained by subtracting the area enclosed by the 50 meter isobath from that of the 200 meter isobath. This calculation gave a minimum estimate of 350 km^2 of available redfish grounds on Saba Bank.

3) *Spatial Distribution of Fishing Activities*

The spatial distribution of fishing activities on Saba Bank was mapped in ArcGIS (Figure 1) based upon 204 reported GPS locations of trap sets. As predicted from fishing depth ranges, lobster and redfish trap activities are spatially separated. This map of fishing activity suggests two additional patterns. The first pattern is that the number of reported trap fishing locations generally decreases with increasing distance from the island of Saba. The southwestern portion of Saba Bank had the fewest reported fishing locations.

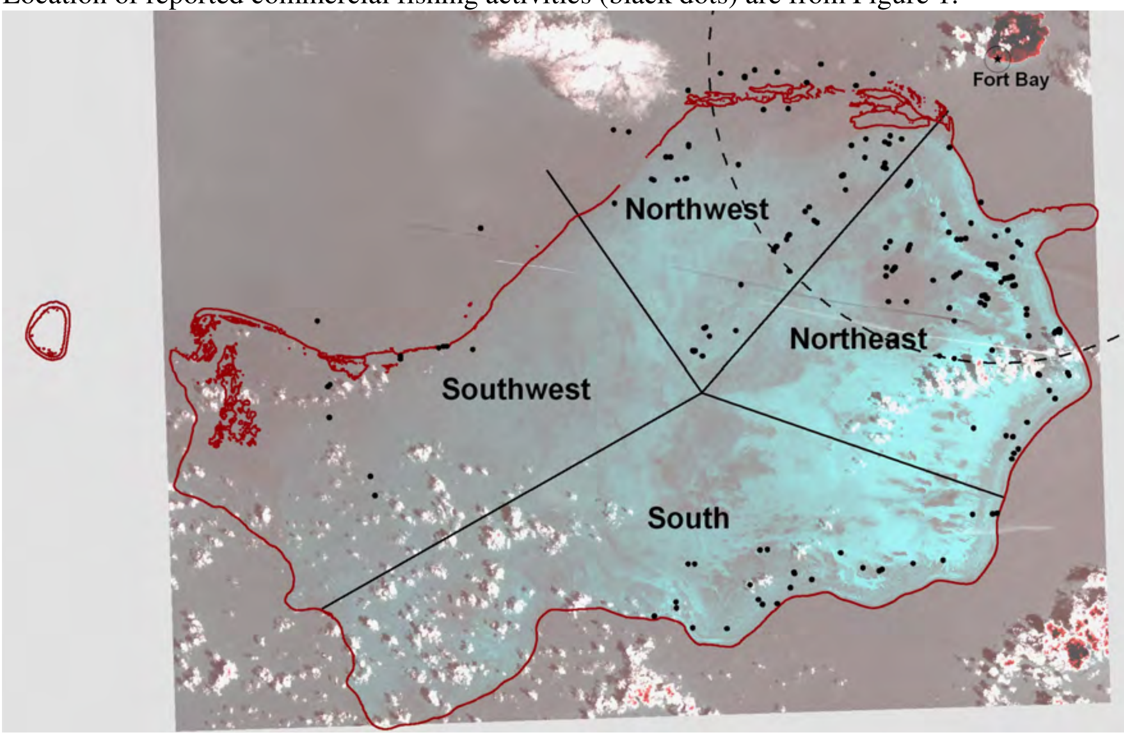
Figure 1. Spatial distribution of commercial fishing effort on Saba Bank. Location of 181 lobster trap sets (yellow circles) and 23 redfish trap sets (red circles) are shown on a Landsat/Bathymetry composite GIS map. Fort Bay, Saba, appears at upper right (unfilled circle). An unfished area called the "central void" is shown in the middle of Saba Bank (black polygon).



A second pattern which is evident from the map (Figure 1) is that trap fishing activities are decidedly not uniformly distributed across the available area (i.e. suitable depth range). Activity is concentrated around the Bank's periphery [Meesters et al. (1996) showed a similar distribution]. There is little trap fishing activity 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 crabs (*Callinectes* sp.?). At a minimum estimate, the central void occupies 468 km^2, or roughly one quarter of the shoal area of Saba Bank (Figure 1). By extension, this map of fishing activities implies that the distribution of productive fisheries habitat is also non-uniform. The ability to identify productive habitats for fisheries resources and to quantify the spatial distribution of such habitats will undoubtedly play an important role in management of Saba Bank fisheries resources.

In order to further analyze the spatial distribution of fishing activities, it was desirable to collapse reported GPS locations into a limited number of fishing areas. Dilrosun proposed a delineation using 12 quadrants (each cell 12 x 12 nautical miles) following lines of latitude and longitude. That system was rejected because it did not adequately reflect spatial patterns of fishing activity, the divisions were independent of natural features of Saba Bank, and the quadrant boundaries were counter-intuitive. Here, we propose a revised system with four fishing area quadrants of approximately equal size: the northeast, northwest, southwest and south fishing areas (Figure 2). Eastern and western quadrants are distinguished by a heading from Fort Bay to the approximate center of Saba Bank (bearing 220°). Northern and southern quadrants are distinguished by distance from Fort Bay (greater than or less than 20 miles).

Figure 2. Fishing areas shown on a Landsat image of Saba Bank. Four quadrants are proposed: northeast, northwest, southwest, and south with boundaries (black lines) radiating from the approximate center of Saba Bank. The 50 meter depth contour (red lines) and limit of territorial seas (dotted line) are shown. Location of reported commercial fishing activities (black dots) are from Figure 1.



Based upon the number of reported trips to fishing areas, most fishing occurs in NE or NW (Table 3). Almost 80 % of lobster trap trips occur in one of these two areas. Redfish trips are more common in NW. Based upon trap-haul frequency (Table 4), most fishing effort occurs in NE, although the majority of redfish trap-hauls are reported from NW.

The spatial distribution of fishing activities was also analyzed based upon jurisdictional boundaries of Saba Bank [the Saban local government is charged with seas within 12 nautical miles of Saba, the central government of the Netherlands Antilles is responsible for the economic fisheries zone (EFZ) extending beyond 12 nautical miles to the sovereign end]. Jurisdictional limits are shown in Figure 2.

Table 3. Number and Percentage of Trips by Area.

Area	No. Trips to Area			% of Trips		
	Lobster	Redfish	All Types	Lobster	Redfish	All Types
Fishing Area						
NE	32	1	33	47.1%	10.0%	42.3%
NW	22	7	29	32.4%	70.0%	37.2%
SW	7	2	9	10.3%	20.0%	11.5%
S	7	0	7	10.3%	0.0%	9.0%
Total	68	10	78	100.0%	100.0%	100.0%
Jurisdiction						
Saban	34	5	39	54.8%	50.0%	54.2%
EFZ	25	2	27	40.3%	20.0%	37.5%
Both	3	3	6	4.8%	30.0%	8.3%
Total	62	10	72	100.0%	100.0%	100.0%

The number of fishing trips relative to jurisdictional boundaries is shown in Table 3. Most commercial fishing trips to Saba Bank (54.2 %) fall within Saban territorial waters (< 12 nautical miles from shore). This observation applies equally to lobster trap trips (54.8%) and redfish trap trips (50 %). The remaining fishing trips take place either within the EFZ (37.5 %) or occur within both jurisdictions (8.3 %).

Table 4. Number and Percentage of Trap-Hauls by Area.

Area	No. of Trap-Hauls			% of Trap-Hauls		
	Lobster	Redfish	All Types	Lobster	Redfish	All Types
Fishing Area						
NE	2556	25	2581	51.8%	7.9%	49.2%
NW	1164	219	1383	23.6%	69.3%	26.3%
SW	297	72	369	6.0%	22.8%	7.0%
S	916	0	916	18.6%	0.0%	17.5%
Total	4933	316	5249	100.0%	100.0%	100.0%
Jurisdiction						
Saban	2558	230	2788	51.9%	72.8%	53.1%
EFZ	2375	86	2461	48.1%	27.2%	46.9%
Total	4933	316	5249	100.0%	100.0%	100.0%

4) Total Fishing Effort, Total Landings, and Economic Value

<u>Total Fishing Effort</u>

During the 36 days of FTL observation, a total of 101 fishing trips were recorded. The average number of trips per day was 2.8 (stdev: 1.5, range: 1 - 6). The greatest fishing effort occurred during the middle of the week. Distribution of effort by day of week (as a percentage of all recorded trips) was: Wednesday (21.5 %), Thursday (17.2 %), Tuesday (16.1%), Monday (15.1 %), and Friday (12.9 %). The least fishing effort occurred on weekends: Saturday (8.6 %) and Sunday (8.6 %).

At the time of this writing, nine Saban commercial fishing vessels were based in Fort Bay. Of these, eight were active during the FTL observation period. Fishing effort was not uniformly distributed among the eight vessels. Three vessels made > 3 trips/week on average (max = 3.9 trips/week) and these vessels collectively accounted for 57 % of recorded trips. The remaining five vessels made 1-2 trips/week on average. It was remarked that summer is typically a slow season when Saban commercial fishermen often schedule boat repairs/maintenance or take vacations. Therefore, the total fishing effort calculated for July is considered a minimum value for extrapolation to annual fishing effort.

Total Landings

Reported Landings were obtained from port sampling interviews and results were compiled as weekly averages (Table 5). Thirty-two port sampling interviews were collected during the Fishing Trip Log period (38 days) where 101 fishing trips were logged. Thus, port sampling interviews captured 32 % of all fishing trips. Reported landings were subsequently expanded by a factor of 3.13. Note that fishermen reported number of lobster rather than weight. To convert to lobster weight, a factor of 2.75 (average weight of lobster in pounds; Dilrosun, 2000) was used.

Table 5. Reported Landings by Saban Commercial Fishermen.

Category of Landings	Reported Landings (Avg lbs/Week)	Expanded Landings (Avg lbs/Week)	Annual Landings (lbs/Yr)
Lobster Wt.	606.4	1,898.0	98,697.7
(Lobster Number)	(220.8)	(691.1)	(35,937.4)
Redfish	210.9	660.1	34,326.1
Hind	41.3	129.3	6,722.0
Moonfish	24.5	76.7	3,987.6
Grunts	78.6	246.0	12,792.9
Other Finfish	33.9	106.1	5,517.2
Total Finfish	389.2	1,218.2	63,346.2
Total landings	995.6	3,116.2	162,043.9

Estimated Value

Total landings were broken down into the three primary marketing categories identified by Saban commercial fishermen (Table 6). Preparation for marketing is also shown.

Table 6. Market Prices of Saban Commercial Landings.

	Preparation	Price/Unit	US$/kg	US$/lb	ANG$/lb*
Lobster	Live	US$/lb	15.40	7.00	12.46
Redfish	Gutted	US$/kg	7.00	3.18	5.66
Potfish (mixed)**	Whole or Gutted	US$/kg	4.00	1.82	3.24

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

** Reporting categories Hind, Moonfish, Grunts, and Other were combined into one "Potfish" market category.

The expanded estimates for reported landings (Table 5) were used to calculate economic value of landings by multiplying landings by market prices (Table 6). The resulting calculation for economic value of total 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. Estimated Economic Value of Total Landings Based on Ex-Vessel Prices.

	Avg. Landings (lbs/Wk)	Ex-Vessel Price (US$/Wk)	Ex-Vessel Price (US$/Yr)	Ex-Vessel Price (ANG$/Yr)
Lobster	1,898.0	$13,286.22	$690,883.65	$1,229,772.89
Redfish	660.1	$2,099.17	$109,156.95	$194,299.37
Potfish (mixed)	558.1	$1,015.70	$52,816.60	$94,013.54
Total	3,116.2	$16,401.10	$852,857.19	$1,518,085.80

The calculations presented above were based upon a limited number of interviews (32) and should be viewed as preliminary results. Nonetheless, findings are generally consistent with previous reports. Lobster represents the most economically significant component of Saban commercial landings, accounting for almost 81 % of ex-vessel value. Redfish are the second most economically significant component of Saban commercial landings. However, the results also suggest that while finfish collectively account for a modest portion of economic value (19.0 %), the weight of finfish landings is substantial (39.1 % of total landings by weight) and greater than previously reported [data from Dilrosun (2000) indicated that finfish accounted for only ~ 17 % of total landings by weight in 1999-2000].

5) Catch Per Unit Effort

In order to evaluate of the status of exploited fisheries resources, fisheries managers rely heavily on the familiar parameter of catch-per-unit-effort (CPUE). Ideally, a long-term series of CPUE data is available to make inferences about the status of the stocks themselves and the fishing effort directed towards those stocks. For the purposes of assessing commercially harvested stocks of Saba Bank, a long-term CPUE dataset is not available. We consider it a priority to establish a longer-term dataset for CPUE for Saba Bank fisheries (see Discussion). It is therefore worthwhile to consider the utility and practicality of input parameters for computing CPUE the Saba Bank fishery.

The two primary inputs to CPUE (catch, effort) can be reported using a variety of unit measures. Previous investigators of Saba Bank fisheries (e.g. Meesters et al., 1996, Dilrosun, 2000) reviewed landings statistics but did not provided a consistent approach to estimation of CPUE. For small-scale Caribbean trap fisheries, resource managers have estimated CPUE using a measure of catch weight per gear per unit of time fished. Dilrosun expressed Saba Bank lobster trap CPUE in terms of g/trap/day. However he also observed that Saban fishermen generally used defined trap soak times, that extended soak times did not appreciably increase the catch weight, and that extended soaks were generally accidental (caused by weather, breakdowns, etc.) rather than deliberate. We propose to use two simpler parameters for CPUE: weight/trap-haul (for redfish) and number/trap-haul (for lobsters). These parameters reflect the manner in which Saban commercial fishermen estimate their own landings at dockside: lobsters are counted as they are transferred to holding cages; redfish are aggregated into coolers where bulk weight is known from experience. These CPUE parameters are intuitive and readily communicated without error. More importantly, we believe that fishermen could record this information faithfully as part of a long-term fisher logbook program or some similar reporting system.

Based upon port sampling interviews conducted from June through July, Saban commercial fishermen landed approximately six lobster for every ten traps hauled [average and stdev: 0.61 ± 0.27 lobster/trap-haul, range: 0.17 – 1.49, n = 63 interviews]. Fishermen reported that this catch rate (CPUE) was very poor. Data in Dilrosun (2000) confirm that average lobster CPUE was > 1 lobster/trap-haul during 1999-2000.

CPUE of redfish traps was calculated from a limited number of port samples (8) obtained from June through July. Approximately 90 % by weight of the reported catch from redfish traps consisted of redfish (average and stdev: 89.9 % ± 0.15.4 %) with the remaining 10% comprising a variety of species (e.g. lane snapper, cottonwick, red hind, graysby, groupers). CPUE of redfish traps was calculated on the basis of total finfish weight per trap-haul. Fishermen landed > 7 pounds of finfish for every redfish trap-haul [average and stdev: 7.42 ± 2.77 lbs/trap-haul, range: 2.93 – 11.11, n = 8 interviews].

6) Biological Characteristics of Harvested Stocks

<u>Species Composition of Landings</u>
At present, the biostatistical database has 1,298 individual species-size records. The species composition of landings based upon frequency in 25 port samples is shown in Table 8. A total of 31 species (27 finfish and 4 invertebrates) were recorded from commercial landings. Number of individuals and sizes (average, maximum, minimum) are also shown. These preliminary results indicate that only about eight finfish species and one invertebrate are captured in sufficient quantities to merit length-frequency distribution analyses.

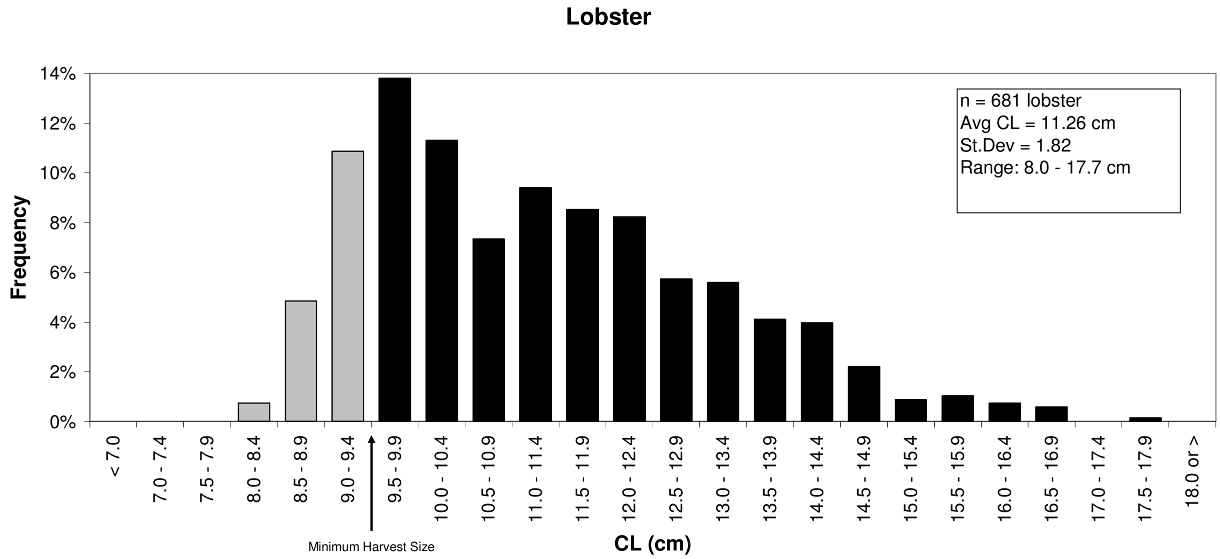
Table 8. Species Composition of Landings by Rank Order of Abundance in Port Samples.

Common Name	Species	Count	Length (mm) Avg	Min	Max
Finfish					
white grunt	*Haemulon plumierii* (Lacepède, 1802)	164	232.0	185	310
silk snapper	*Lutjanus vivanus* (Cuvier, 1828)	128	288.0	190	575
red hind	*Epinephelus guttatus* (Linnaeus, 1758)	96	330.3	180	450
blackfin snapper	*Lutjanus buccanella* (Cuvier, 1828)	42	296.9	200	500
vermilion snapper	*Rhomboplites aurorubens* (Cuvier, 1829)	36	275.6	220	410
cottonwick	*Haemulon melanurum* (Linnaeus, 1758)	31	240.3	190	280
coney	*Cephalopholis fulva* (Linnaeus, 1758)	25	272.2	245	315
queen triggerfish	*Balistes vetula* Linnaeus, 1758	23	336.7	275	395
lane snapper	*Lutjanus synagris* (Linnaeus, 1758)	10	250.5	190	315
redband parrotfish	*Sparisoma aurofrenatum* (Valenciennes, 1840)	9	230.0	220	245
princess parrotfish	*Scarus taeniopterus* Desmarest, 1831	7	223.6	190	255
redtail parrotfish	*Sparisoma chrysopterum* (Bloch and Schneider, 1801)	6	285.8	250	320
mutton hamlet	*Alphestes afer* (Bloch, 1793)	4	245.0	215	270
yellowfin grouper	*Mycteroperca venenosa* (Linnaeus, 1758)	4	667.5	560	750
honeycomb cowfish	*Acanthostracion polygonius* Poey, 1876	3	228.3	220	235
saucereye porgy	*Calamus calamus* (Valenciennes, 1830)	3	250.0	230	270
snowy grouper	*Epinephelus niveatus* Valenciennes, 1828	3	228.3	220	235
spotted goatfish	*Pseudupeneus maculatus* (Bloch, 1793)	3	243.3	235	255
almaco jack	*Seriola rivoliana* Valenciennes, 1833	2	540.0	510	570
blue runner	*Caranx crysos* (Mitchill, 1815)	2	325.0	320	330
blue tang	*Acanthurus coeruleus* Bloch and Schneider, 1801	1	220.0	220	220
doctorfish	*Acanthurus chirurgus* (Bloch, 1787)	1	230.0	230	230
gray angelfish	*Pomacanthus arcuatus* (Linnaeus, 1758)	1	260.0	260	260
graysby	*Cephalopholis cruentata* (Lacepède, 1802)	1	295.0	295	295
margate, white margate	*Haemulon album* Cuvier, 1829	1	535.0	535	535
queen parrotfish	*Scarus vetula* Bloch and Schneider, 1801	1	280.0	280	280
yellowmouth grouper	*Mycteroperca interstitialis* (Poey, 1860)	1	475.0	475	475
Invertebrates					
Caribbean spiny lobster	*Panulirus argus* (Latreille, 1804)	681	11.3	8	17.7
batwing coral crab	*Carpilius corallinus*	4	12.7	12.3	13
Spanish slipper lobster	*Scyllarides aequinoctialis* (Lund, 1793)	4	10.3	9.4	11.2
common octopus	*Octopus vulgaris*	1	120.0	120	120

Size-Frequency Distributions of Commercially Important Species

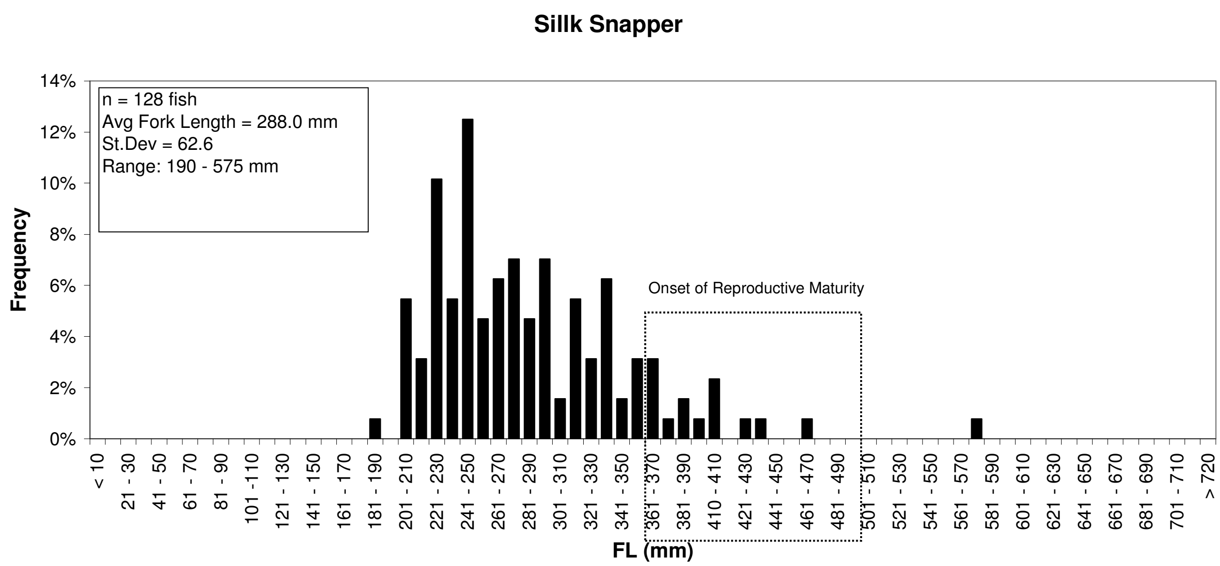
A total of 681 lobsters were measured for CL. Lobster length-frequency distribution is presented in Figure 3. Average carapace length was > 11.2 cm [CL average and stdev: 11.26 ± 1.82 cm, range: 8.0 – 17.7 cm, n = 681 lobster]. Males were slightly larger than females (11.4 cm vs. 11.0 cm) and comprised a greater percentage (58.0 %) of lobster landings than females (42.0 %). Undersized lobsters (CL < 9.5 cm) accounted for 16.4 % of all lobster landings. Most female lobster (66.8 %) had tar spots. Berried females were rarely encountered (0.3 % of female lobster landings).

Figure 3. Length-frequency distribution of lobster, *Panulirus argus*, from biostatistical samples.



Sufficient information has been collected for several finfish species (Table 7) to examine length-frequency distribution. Only information for silk snapper is presented here (Figure 4). Silk snapper were small in size [FL average and stdev: 288.0 ± 62.6 mm, range: 190 – 575, n = 128 fish]. These results are similar to Dilrosun's findings for silk snapper length [FL average and stdev: 294.3 ± 57.9 mm, range: 170 – 720 mm, n = 1,514 fish].

Figure 4. Length-frequency distribution of silk snapper, *Lutjanus vivanus*, from biostatistical samples.



Age-Structure of Silk Snapper Stocks

We have begun collecting otoliths from a size range of silk snapper on an opportunistic basis. Progress has been slow - only fourteen pairs of sagittal otoliths collected to date - because of the manner in which fishermen prepare/maintain silk snapper for market. Fishermen gut silk snapper at sea (also making it difficult to obtain measurements of total weight) and keep them iced continuously. They do not remove the head or gills because consumers inspect eyes and gills to determine the quality of the fish and because most restaurants prefer to serve whole fish (head intact). The procedure to remove otoliths defaces the fish, effectively rendering it unmarketable.

At the present rate of otolith collection, we will not have a sufficiently large sample size at the termination of the study in December 2007 to draw statistically sound conclusions. We will also lack data to relate whole body weight to length and to age. If a detailed understanding of silk snapper age-structure is viewed as a priority concern, then we recommend that a study be initiated soon to insure we obtain adequate samples of silk snapper material. Such a study will invariably require compensation to fishermen for access to (and probably purchase of) portions of their silk snapper catches.

Biodiversity of Catch and Non-Target Species

Recent scientific investigations of Saba Bank have focused on quantifying biodiversity of flora and fauna (Conservation International, 2006). These expeditions have relied on intensive sampling over short time intervals at safe scuba diving depths across Saba Bank. The Saban commercial fishery exerts a substantially greater “sampling effort” towards the harvest of fisheries resources from Saba Bank. On a daily basis Sabas fishermen observe a diversity of finfish and invertebrates which may include targeted, non-targeted, and unwanted bycatch species. Some of this sampling effort occurs at depths well beyond safe diving limits (e.g. redfish traps). Although the spatial and depth distribution of the commercial fishery sampling effort is dictated by economic objectives, it nonetheless represents an opportunity to identify patterns of species distribution and occurrence.

We have made a deliberate effort to identify unusual or rare species in Saban commercial landings. This information will provide an adjunct to existing and forthcoming biodiversity surveys. So far, Saban fishermen have been interested and willing participants, often retaining unusual bycatch specimens for the authors to examine.

Unusual fish specimens retained by commercial fishermen were identified using taxonomic keys provided in Carter (2002). In some cases, voucher specimens were prepared by fixing in seawater-buffered formalin. Vouchers will be deposited in the Smithsonian Museum of Natural History. In other cases, photographs were taken of specimens or they have been stored in a freezer. A preliminary list of new finfish species records for Saba Bank is shown in Table 9.

Table 9. New Fish Species Records for Saba Bank from Commercial Catches.

	Common Name	Species	Family
Retained in Finfish Catch			
	yellowedge grouper	*Epinephelus flavolimbatus* Poey, 1865	Serranidae
	snowy grouper	*Epinephelus niveatus* (Valenciennes, 1828)	Serranidae
	greater amberjack	*Seriola dumerili* (Risso, 1810)	Carangidae
	almaco jack	*Seriola rivoliana* Valenciennes, 1833	Carangidae
	rainbow parrotfish	*Scarus guacamaia* Cuvier, 1829	Scaridae
Discarded Bycatch			
	Cuban dogfish	*Squalus cubensis* Howell Rivero, 1936	Squalidae
	polygon moray	*Gymnothorax polygonius* Poey, 1876	Muraenidae
	saddle bass	*Serranus notospilus* Longley, 1934	Serranidae
	blackline tilefish	*Caulolatilus cyanops* Poey, 1866	Branchiostegidae

Discussion

The foregoing observations are preliminary in nature. Therefore, only a cursory discussion is presented here. We use this discussion to identify some of the general or important questions surrounding the commercial fishery of Saba Bank.

Fishermen report that their landings of lobsters have declined since the study conducted seven years ago (Dilrosun, 2000). Dilrosun monitored Saba Bank commercial landings for 13 months and observed that average lobster catch rate by commercial fishermen of Saba Bank was 1.32 lobsters per trap-haul. Our preliminary estimates confirm the assertions of Saban fishermen that current lobster catch rates have declined. We observed an average lobster catch rate of 0.61 lobster/trap-haul, which is less than half the catch rate of 1999-2000.

A number of factors may contribute to a reduced lobster CPUE from Saba Bank. Foremost among them is the concern that there has been a reduction in stock abundance due to over-harvesting. However additional contributing factors may include: seasonal variation (e.g. migratory lobster movements), inter-annual variation in stock abundance (i.e. due to variable recruitment rates among years), and an increase in lobster regulatory discards (i.e. greater compliance with regulations [minimum harvest size, prohibition on landing of berried females] that result in fishermen releasing a greater proportion of lobster catches). With such a short period of observation, it is not possible to draw definitive conclusions. However, given the tremendous economic importance of Saba Bank lobsters to the Saban commercial fishery and the Saban economy, it is clearly important to first substantiate this trend and then to further investigate its cause(s).

In addition to lobster, Saban commercial fishermen harvest a substantial quantity of finfish. Multi-species landings of "potfish" from lobster traps are ~ 30 % of the total weight of lobster landings. Dilrosun reported a "by-catch" of demersal finfish from lobster traps which amounted to 8,883 kg over a 13-month period (or ~ 1,500 lbs/month). We estimate that current potfish harvests rates are about 60 % greater (2,400 lbs/month). This suggests that potfish have grown in importance to the Saban fishery. Fishermen would be expected to shift their harvesting by retaining more potfish in order to offset losses due to declining lobster catch rates. However, potfish harvestng may also exhibit seasonal patterns and the data are too preliminary to draw conclusions.

Silk snapper are clearly of economic importance to the Saban commercial fishery. Dilrosun commented on the small average size at capture for *L. vivanus* from Saba Bank (and other redfish species as well). Our data confirm that a large percentage of silk snapper are harvested before they reach reproductive maturity (37 to > 50 cm; Cummings, 2003). Dilrosun also demonstrated that *L. vivanus* recruits to the trap fishery at a smaller size than to the line fishery. Size selectivity of redfish traps is related to mesh size. Mesh size used by redfish trap fishers is small. Small redfish are reportedly more easily marketed, which encourages fishermen to continue the use of small-meshed traps. This practice is a concern for management of silk snapper stocks.

The very large size of Saba Bank and the relatively small size of the Saban commercial fishery that utilizes it, would suggest that over-exploitation of fisheries resources is unlikely. For example, if nine Saban fishermen fully utilize the entire area of Saba Bank, each fisherman has the equivalent of roughly 245 km^2 (24,500 hectares) at his disposal - a comparatively large area on a per-fisherman basis. If Saban fishermen set a total of 2,000 traps across Saba Bank, the average trap density is less than 1 trap per km^2 (< 1 trap per 100 hectares) - a comparatively low trap density. However, the distribution of fishing effort is not uniform and it is unlikely that productive habitats are either. Our results indicate that traps are set at high densities in localized areas of Saba Bank. These incongruities underscore the importance of understanding the distribution of both fishing effort and productive fisheries habitats across Saba Bank.

Shallow coralline shelves or "banks" are prominent in many Caribbean commercial fisheries, including the Pedro Bank of Jamaica and the Campeche Bank. Munro (Ref?) suggested that shallow coralline shelf water may yield 0.2 - 5 metric tons of finfish per km^2 per year. Using Munro's values for finfish yields, the sizeable area of Saba Bank (2,200 km^2) could produce on the order of 968,000 pounds (440 metric tons) per year. Harvests of this magnitude were reported from Saba Bank during the 1980's and 1990's (Meesters et al., 1996). Presently, annual total landings (lobster plus finfish) amount to 161,621 lbs/year (73,464 mt/year), or roughly one-sixth of calculated yields.

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, despite the moderate levels of current fishing effort now exerted by the Saban commercial fishery, some vulnerable fish stocks should be considered reduced or depleted. It must be assumed that the intensive fishing effort on Saba Bank during the 1980's and early 1990's contributed significantly to reduction of grouper stocks.

It is strongly recommended that regulatory authorities establish a long-term, commercial fishing reporting system that will enable monitoring of CPUE over time. The reporting system 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 data to enable 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). Although the costs associated with obtaining this information are trivial, the long-term continuity of the reporting system will likely depend critically upon levels of agency commitment and adequate provision of infrastructure to insure implementation.

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List of Tables and Figures

Appendix 1. Port Sampling Data Form

Saba Bank Port Sampling Form

Trip Information and Effort

Sample Date: ____________ Gear Type: ____________
Boat Name: ____________ Total No. of Traps/Gears Hauled: ____________
Arrival: ____________ Soak Time (days): ____________
Departure: ____________ Fishing Depth: ____________
Trip Duration: ____________ No. of Crew: ____________
Transit Time: ____________ No. Traps Lost ____________

Position (GPS):

Set 1: N 17°	Set 2: N 17°	Set 3: N 17°
W 63°	W 63°	W 63°
No. Traps:	No. Traps:	No. Traps:
No. Lobster:	No. Lobster:	No. Lobster:
Soak Time:	Soak Time:	Soak Time:
Comment:	Comment:	Comment:

Estimated Landings

Total Lobster (No.): ____________ Moonfish (lbs): ____________
Redfish (lbs): ____________ Grunts (lbs): ____________
Hinds (lbs): ____________ Other Potfish (lbs): ____________
Est. Total Finfish (lbs): ____________

Biostatistical Sample

Catch Type: Lobster Trap: ☐ Redfish Trap: ☐ Other: ☐

Sample Type: Complete Lobster: ☐ Complete Finfish: ☐ Partial Lobster: ☐ Partial Finfish: ☐

No.	Species	Length	Sex	Wt (g)	No.	Species	Length	Sex	Wt (g)
1					21				
2					22				
3					23				
4					24				
5					25				
6					26				
7					27				
8					28				
9					29				
10					30				
11					31				
12					32				
13					33				
14					34				
15					35				
16					36				
17					37				
18					38				
19					39				
20					40				

Appendix 1 continued. Port Sampling Data Form

Additional Position (GPS) Info:

	Set 4	Set 5	Set 6
	N 17°	N 17°	N 17°
	W 63°	W 63°	W 63°
No. Traps:			
No. Lobster:			
Soak Time:			
Comment:			

No.	Species	Length	Sex	Wt (g)	No.	Species	Length	Sex	Wt (g)
41					76				
42					77				
43					78				
44					79				
45					80				
46					81				
47					82				
48					83				
49					84				
50					85				
51					86				
52					87				
53					88				
54					89				
55					90				
56					91				
57					92				
58					93				
59					94				
60					95				
61					96				
62					97				
63					98				
64					99				
65					100				
66					101				
67					102				
68					103				
69					104				
70					105				
71					106				
72					107				
73					108				
74					109				
75					110				