DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES

Final Report

to

National Marine Fisheries Service
NOAA

Entitled

Caribbean/NMFS Cooperative SEAMAP Program Whelk and Finfish Assessment

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Submitted by

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Shallow-water Reef Fish Monitoring

SEAMAP-Caribbean Fisheries Independent Monitoring

Final Report

April 1, 2003 –September 30, 2006

A. Grantee: Puerto Rico Department of Natural and Environmental Resources, Fisheries Research Laboratory.

B. Project Budget Period No.: 1-3

C. Grant No.: **NA03NMF4350102**

D. Project Title: **Caribbean/NMFS Cooperative SEAMAP Program**

E. Amount of Grant:

Year	03-04	04-05	05-06
Federal	$59,350.00	$59,350.00	$59,350.00
Match	$ 0.00	$ 0.00	$ 0.00
Total	$59,350.00	$59,350.00	$59,350.00

F. Budget Period 0: April 1, 2003 – September 30, 2006

G. Period Covered by this Report: April 1, 2003 to September 30, 2006.

H. Summary of Progress and Expenditures to September 30, 2006.

I. Work Accomplishments

1. Description of the activities scheduled for this project

   Whelk surveys around Puerto Rico
   Finish the reef fish monitoring on the west coast of the Island.
   Boat refurbishing for which a six month, non cost extension was requested

2. Activities accomplished during the project period
   Whelk surveys around Puerto Rico
   Finish the reef fish monitoring on the west coast of the Island.
   Boat refurbishing

3. Activities non-accomplished during this year:

   All scheduled activities for the period covered by this report were accomplished.

J. Expenditures

Copy of the financial status report will be sent separately.

TABLE OF CONTENT

REEF FISH SURVEY

INTRODUCTION 1

OBJECTIVES 2

METHODOLOGY

- **Location** 2
- **Sampling** 2
- **Histology** 3

RESULTS 4

DISCUSSION 4

RECOMMENDATIONS 7

REFERENCES 8

FIGURES AND TABLES

- Figure 1. West coast platform divided in stations for the shallow-water reef fish monitoring 14
- Figure 2. Boundaries of the stations used for the reef fish monitoring 15
- Figure 3. Available seafloor information for Station 26 (Shallow depth) 16
- Figure 4. Available seafloor information for Station 32 (Shallow depth) 17
- Figure 5. Available seafloor information for Station 46 (Shallow depth) 18
- Figure 6. Available seafloor information for Station 49 (Shallow depth) 19
- Figure 7. Available seafloor information for Station 54 (Medium depth) 20
- Figure 8. Available seafloor information for Station 59 (Medium depth) 21
- Figure 9. Available seafloor information for Station 61 (Shallow depth) 22
- Figure 10. Available seafloor information for Station 66 (Medium depth) 23
- Figure 11. Available seafloor information for Station 68 (Medium depth) 24
- Figure 12. Available seafloor information for Station 73 (Deep depth) 25
- Figure 13. Available seafloor information for Station 78 (Shallow depth) 26
- Figure 14. Available seafloor information for Station 79 (Medium depth) 27
- Figure 15. Available seafloor information for Station 84 (Deep depth) 27
- Figure 16. Available seafloor information for Station 86 (Deep depth) 28
- Figure 17. Available seafloor information for Station 89 (Deep depth) 29
- Figure 18. Available seafloor information for Station 95 (Deep depth) 29
- Figure 19. Available seafloor information for Station 96 (Deep depth) 30
- Table 1. Point identification and coordinates that define the stations on the west coast platform 31
- Table 2. Summary by date of the surveys conducted at each station with the total catch in kilograms. 33
- Table 3. Fish species caught, by weight, at each station divided by fishing gear 34

Table 4. Summary by number of fish species caught by station 40
Table 5. Diversity index by station and average fish caught by trip per station 42
Table 6. Number of individuals caught of each species by fishing gear 43
Table 7. Fish species caught by only one fishing method 44
Table 8. Summary of Catch per Unit Effort for fishermen and the comparison with the CUE of the sampling period April 1, 2000 to March 31, 2001 45
Table 9. Summary of catch per unit effort by station 46
Table 9a. Summary of catch per unit effort by depth category 46
Table 10. Catch per unit effort for the three main species caught by hook and line compared with the results of 2001 46
Table 11. Information on histology samples taken from several fish caught during the sampling period. 47
Graph 1. Length-weight relation for *H. plumieri* 50
Graph 2. Length-weight relation for *C. pennatula* 50
Graph 3. Length-weight relation for *H. adscensionis* 51
Graph 4. Length-weight relation for *M. plumieri* 51
Graph 5. Length-weight relation for E. *guttatus* 52
Graph 6. Length-weight relation for *C. fulva* 52
Graph 7. Length frequency distribution for *Haemulon plumieri* 53
Graph 8. Length frequency distribution for *Calamus pennatula* 53
Graph 9. Length frequency distribution for *Holocenthrus adscencionis* 54
Graph 10. Length frequency distribution for *Malacanthus plumieri* 54
Graph 11. Length frequency distribution for *Epinephelus guttatus* 55
Graph 12. Length frequency distribution for *Cephalopholis fulva* 55

APPENDIX 1. Identification of reproductive stage of certain fish species – Histology 56

WHELK (*Cittarium pica*) SURVEY
INTRODUCTION 60

OBJECTIVES 60

METHODOLOGY
Site Selection 61
Sites information 61
Survey Methodology 62
Table 1. Site location of the whelk survey 62
Map 1. Whelk survey sites around Puerto Rico 63

RESULTS 63
Table 2. Data summary of the whelk surveys around Puerto Rico 64

DISCUSSION 65

REFERENCES 66

GRAPHS

Graph 1. Size distribution of *Cittarium pica* on transects along the north coast of Puerto Rico 67
Graph 2. Size distribution of *Cittarium pica* on transects along the east coast of Puerto Rico 68
Graph 3. Size distribution of *Cittarium pica* on transects along the south coast of Puerto Rico 69
Graph 4. Size distribution of *Cittarium pica* on transects along the west coast of Puerto Rico 70

REEF FISH SURVEYS

INTRODUCTION

For part of the population in Puerto Rico fisheries is their main family income. As the agency with the responsibility of preserve these resources the Puerto Rico Department of Natural and Environmental Resources (PRDNER) is always in the process of collecting information on fisheries trends, species biology and studying the fisheries status. As part of this effort the agency has been conducting fisheries independent studies since 1967 (Appeldoorn 1996, 2002; Appeldoorn et al., 1992; Bannerot et al., 1991; Boardman, 1982; Boardman and Weiler, 1979a, 1979b; Bonilla, 1982; Cardosa, 1982, 1984; Cardosa and Cardosa–Battistini, 1984; Chanley, 1982; Cole, 1976; Collazo, 1982, 1984; Collazo and Calderón, 1988; Erdman, 1976, 1983, 1987; Figuerola, 1991; Figuerola et al., 1995, 2001; González de Irrizary, 1981; Iñigo et al., 1970; Jiménez, 2004, 2005; Johnston et al., 2002; Juhl, 1969, 1970, 1972; Juhl et al., 1970; Juhl and Suarez-Caabro, 1970, 1972a, 1972b, 1972c, 1973; Kimmel, 1999; Musa et al., 1983; Omni Research Incorporated, 1973; Rosario, 1988, 1989, 1992a, 1993, 1994, 1996a, 1996b, 1998, 2002a, 2002b, 2004; Rosario and Figuerola, 1998, 2001, 2004; Rosario and Kimmel, 1986; Rosario and Sadovy, 1991, 1996; Sadovy, 1993; Sadovy and Figuerola, 1992; Sadovy et al., 1989, 1992, 1994a, 1994b; Smith and Ault, 1993; Ward et al., 2002; Watters and Acosta, 1976; Weiler, 1979; Weiler and Suarez-Caabro, 1980).

In 1988, the Caribbean region was included in a collaborative program between state and federal agencies and universities, which main goal is the collection, management and dissemination of fishery-independent data in the southeastern United States. This program is called the Southeast Area Monitoring and Assessment Program (SEAMAP). The Fisheries Research Laboratory of Puerto Rico Department of Natural and Environmental Resources has been managing this program since its implementation.

A SEAMAP-Caribbean Committee determines the priorities for the program in the Caribbean. The SEAMAP-Caribbean Committee is formed by members from the PRDNER, the Virgin Islands Division of Fish and Wildlife, the Puerto Rico Sea Grant College Program, the National Marine Fisheries Service-SERO, the U.S. Fish and Wildlife Service, and the Caribbean Fishery Management Council. Due to funding constrains they established a three year monitoring cycle as standard, in which the priorities are studies on Spiny lobster (*Panulirus argus*), Queen conch (*Strombus gigas*) and reef fishes. For the 2003-06 funding cycle, the last two years were corresponded to monitoring shallow-water reef fish resources. This report presents the data collected for this particular study.

OBJECTIVES

- Collect and disseminate fisheries independent data on shallow water reef fish resources.

- Enable Puerto Rico to identify, implement and measure the effectiveness of fishery management measures for their Territorial Waters.

- Enable Puerto Rico to take full advantage of an integrated, coordinated, and cost effective approach to fishery-independent data collection to fulfil priority data needs.

- Provide information to support the Caribbean Fishery Management Council's effort to implement and monitor the effectiveness of fishery management plans for fisheries in the U.S. Economic Exclusive Zone.

- Enhance the usefulness of the data, minimize the costs, and increase the accessibility of information to fishery managers through the Caribbean region.

- Serve as information and coordination effort to support plans to conserve and manage the fisheries that are Caribbean scope.

METHODOLOGY

Location

Following the methodology established previously for similar studies (Rosario, 2004), the western platform area of Puerto Rico, up to the 50 fathoms contour, was divided into two squared nautical miles sampling stations (Figure 1). Mona Island and Desecheo Island were included and their surrounding platform was divided in stations as well. Each sampling station was defined by four GPS coordinates and identified with a number (Figure 1 and 2; Table 1). Each station was classified according to the following depth ranges:

- Shallow- 1 to 10 fathoms
- Medium- 11 to 20 fathoms
- Deep- 21 to 50 fathoms

According to the station bathymetry it could have been classified under the three categories. Five stations from each category were randomly chosen (Figure 1). Some stations were added to cover off-shore marine protected areas on the west that has been traditionally sampled (Bajo de Cico, Tourmaline, Abrir la Sierra and Mona Island). This decision was made after the sampling was begun, reason for which the amount of sampled stations is greater than 15.

Sampling

The aim of the study was to sample each station ten times. The sampled area within a station was only that within the depth range for which the station was chosen (Figures 3-19). Sampling order was randomly chosen. Weather conditions, vessel condition and gear and personnel availability determined the sampling dates.

Two methods were used to sample the shallow-water reef fish at the stations, fish traps and hook and line. Fish traps were made of 1½" mesh size, with two doors, one of which was tied with a special rope that will deteriorate fast and allow fish to escape in case that the trap gets lost. Heavier steal rods were used for the trap bottom frame to assure the trap will place itself on the ground with the opening facing up. A total of fifteen traps were deployed during the sampling. The traps were divided in five sets of three. Each trap was identified, at the float, according to their respective set (e.g. 1-1, 1-2, 1-3, 2-1…). A small cage holding the bait (sardines) was placed at the same side of the trap opening to forbid fish access to the bait without entering the trap. At each station fish traps were deployed in sets, but individually, at least 150m apart. Soak time of the fish trap was five hours, from the time when the first fish trap was deployed to the time when the first fish trap was recovered.

Hook and line fishing was performed during fish traps soaking period for four hours. The vessel was kept adrift, moving it only when the vessel reached the station's boundaries or areas exceeding the depth range for which the station was chosen. The vessel was usually turned off while adrift. The area sampled was determined by recording the coordinates at the beginning and end of the fishing period. A minimum of three fisher, each using a line with three hooks (size #06 and #04), and using squid as bait.

Fish collected were placed in bags identified with the date, station number and origin (fish trap ID or fishermen ID). The fish were taken to the Fisheries Research Laboratory facility where they were placed on a freezer until processed. When processing the fish, it was weighted, measured (total and fork length), sexed and its reproductive stage determined by visual inspection. Five categories were used for the reproductive stage: undetermined (1), resting (2), enlarging (3), ripe (4) and spent (5).

SEAMAP standard data sheets for every fish trap and fisherman doing hook and line were completed. The data was entered and stored on SEAMAP software 3.0.

Histology

As a side study to this project the gonads from a sub-sample of the fish caught were collected and preserved for histological analysis. Pictures of the gonads were taken and identified with the gonad information. The slides were examined to determine sex and reproductive stage. The same categories used for the visual identification were used for female fishes. It was observed that for males, the reproductive stage were not as discrete as in females, for this reason the categories used were mature (M) or immature (I). The results were compared with the visual classification recorded when processing the fish. The purpose of this was to create a visual aid for the reproductive stage identification of gonads for the different fish species, and use it as a quality control for the visual identification of the fish gonads.

RESULTS

A total of 86 surveys were conducted, covering 17 stations (Table 2). Total catch was 1,625 fish that weighted 551.34 kg and included 55 fish species. Three species represent 56% of the total catch: *Epinephelus guttatus* (red hind), *Cephalopholis fulva* (coney) and *Malacanthus plumieri* (sandtile fish). Hook and line yielded 80 % of the total catch by weight, 443.12 kg (Table 3). Fish traps yielded 20% of the total catch, 108.24kg. Stations 79, 61, 46 and 73 showed the greatest fish diversity considering the amount of surveys conducted at each station (Table 4 and 5). Stations 49, 96, 66, 73, 59 and 68 were the stations with greatest amount of fish caught (Table 5). The coney (*C. fulva*), the white grunt, *Haemulon plumieri* and the longspine squirrelfish, *Holocenthrus adscensionis*, were the species caught more often in fish traps. The red hind (*E. guttatus*), the coney (*C. fulva*) and the sandtile fish (*M. plumieri*) were the species caught more often by hook and line (Table 6). Some fish species were caught only by one of the fishing methods used, hook and line or fish trap. Table 7 summarizes that information.

Since the sampling was done randomly, no correlation was made with months or moon phase. Given that the methodology used for the fish traps differ from that use usually by fishermen, no comparisons will be made with landing statistics. The amount of specimens per species in some cases was very small. For those species of which more than 50 individuals were caught, a relation of size and weight was made. The graphs for those species are shown in Graphs 1-6. Length frequency distribution was also calculated for those species (Graphs 7-12).

Catch per unit effort (CPUE) was calculated for fishermen and compare with that report for the sampling period of 2000-2001 (Table 8). Hook and line time effort was 274 line days and 3,356.05 hook hours. Only fishermen #6, #11, #13 and #16 were regular members. The other fishermen were people that were used as back up whenever the crew was short of personnel.

Catch per unit effort was also calculated for the different stations and by depth (Tables 9 and 9a). The fish caught by hook and line was the only one considered when calculating the CPUE. Table 10 summarizes the CPUE for the main species caught during the study period.

For the histology study a total of 84 gonads were collected. Table 11 summarizes the information of the samples collected. From the collected tissues, 61 were fixed adequately and gave good information. A selection was made of gonads pictures with their respective histology reading and presented in Appendix 1.

DISCUSSION

Hook and line yielded the majority of the total catch by weight (Table 3). It must be noticed that there was only one crew member (#13) with previous experienced fishing. This affects the results as it was mentioned in Rosario, 2004. Notwithstanding, observing the CPUE for the fishers in 2001 and 2006, in terms of g/ hook hours, the fishers experience does not seem to have been a major factor in the results (Table 8). Other analyses of CPUE are not considered since the number of trips and the stations covered were quite different from those in 2001.

There was little success with the fish traps, 20 % of the total catch. As mentioned in Rosario, 2004, there are many factors that could affect trap catch like moon phase, bait type, presence of conspecifics, trap design (including its entrance or the funnel and the mesh size, shape and flexibility), soak time and fish size and shape. The results are similar to those of Rosario, 2004. They also had little success with fish traps, yielding 11% of the total catch. On the other hand, fish trap gave information on other species that inhabit the area sampled, that was not obtained by hook and line (Table 7). Five fish species of commercial value were caught by fish traps only (*Lactophrys quadricornis, Lactophrys polygonius*, *Acanthurus bahianus*, *Sparisoma viride* and *Lutjanus jocu*). One fish species of commercial value in the ornamental fisheries industry was caught by fish traps only (*Chaetodon striatus*).

When analyzing this type of data, caution must be taken not to draw inadequate conclusions. Estimates of fish abundance or diversity from the data obtained could be inaccurate as there are several factors that were not standardized like moon phase, soak time and stage of reproductive cycle of target species (Miller, 1989). In addition the fishing gear selection used as part of the methodology prevents from obtaining information of the real fish population structure of the area (Dennis, 1987). Notwithstanding we will make some comments base on the obtained results. Information on bottom habitat for some of the sampled stations was obtained from the maps created by the USNOAA Biogeography Program (2001) (Figures 3 to 19). This maps only cover near shore waters, for which data for all stations was not available.

Stations 79 was the station with greatest species diversity, followed by stations 61, 46 and 73 (Table 5). There is no information on habitat type for station 79. The only available information is bathymetry (Fig. 14). Reef colonized pavement is the predominant habitat type in the sampled areas of stations 46, 61 and 73 (Fig. 5, 9 and 12 respectively). Two of these stations, 46 and 61, were classified as shallow depth stations, while station 79 was of medium depth and 73 of deep depth. The area sampled in this quadrant was greatly reduced due to the bathymetry within the quadrant. On the other hand there were stations in which the whole quadrant was sampled, like station 26 and 32 (Fig 3 and 4), which did not show as much species diversity. Although the habitat type for station 78 is not complete (Fig. 13), it shows that must of the sampled area was reef/colonized pavement. Notwithstanding, this station yielded low species diversity. These results suggest that the habitat type or the size of the sampled area might not be the only factors affecting the species diversity at certain areas. It must be noticed that there are many quadrants for which there is no information on habitat, eight out of seventeen (47% of the sampled stations). From the quadrants for which there is habitat information, there area three of which approximately half of the area is classified as unknown. For this reason no conclusions could be reached regarding habitat and species diversity relationship.

Stations 61 and 73 were the ones with highest average number of fish caught by trip (Table 5). These stations were also among the ones with highest CPUE (Table 9). Both stations are part of the Mona Island Reserve. They were also among the stations with high fish diversity. Although Mona Island Reserve has fishing regulations, these do not cover the area sampled. The Island is a remote site, for which it might not be under the same fishing pressure as the quadrants surveyed on the insular platform, on the west coast of the main island. Another possibility is that the surrounding protected areas could be replenishing the areas open to the public for fishing, maintaining fish abundance and diversity on the site.

The species caught more often in fish traps were the coney (*C. fulva*), the white grunt (*H. plumieri*) and the longspine squirrelfish (*H. adscensionis*). There is a little bit of difference on species dominating the fish trap catch from 2001 to 2006. On 2001 the predominant fish species caught by fish trap were the coney (*C. fulva*), the blue tang (*A. bahianus*) and the red hind (*E. guttatus*). Both results are remarkably different from landing reports (Matos, 2004). The fishes that predominated in landing reports using fish trap during 2001-2003 were the grunts, trunkfishes and the snappers.

The species caught more often by hook and line were the red hind (*E. guttatus*), the coney (*C. fulva*) and the sandtile fish (*M. plumieri*) (Table 6). These results are similar to what was reported on 2001 (Rosario, 2004). The fishes that predominated landing reports using bottom line during 2001-2003 were the snappers, the King mackerel and the red hind. The difference resides in the fishing methodology used. Snappers are usually caught at deep depth, over 50 fathoms, and the fishermen target that particular species. The present study does not target fish species and devoted only part of the time to deep depth sampling. King mackerel are mostly fished trolling at night, which was not the methodology used in this study.

The red hind (*E. guttatus*) had a higher CPUE in terms of g/ hook hours than those reported during 2001 (Rosario, 2004), but a lower CPUE in terms of line days for deep and medium depth stations (Table 10). For shallow depth stations it had a general CPUE lower than the one reported during 2001 (Rosario, 2004). Since the season was not considered in the study, these results could be reflecting sampling during aggregation times at medium and deep depth. That will yield higher CPUE in terms of hook hours than line days. Must of the individuals were caught on Bajo de Cico, stations 95 and 96, which has been previously known as an aggregation site for the species. The lower CPUE at shallow depth stations could be an indication of overfishing given the great difference in the results. We are assuming that the impact on the results due to fisher experience is not responsible for it given that the CPUE calculated for fishers (Table 8) does not indicate so. Size-weight relation calculated during this study period is similar to the one reported during 2001 (Graph 5). The length frequency distribution is also similar to that reported during 2001 (Graph 11).

The coney (*C. fulva*) had a higher CPUE in terms of g/ hook hours than those reported during 2001 (Rosario, 2004), but a lower CPUE in terms of line days for all stations (Table 10). These results might be suggesting a patchy distribution of the species, since the decline and the increase was similar at all depths. These results will need more analysis of the habitat type, but that information is limited. Size-weight relation calculated during this study period is similar to the one reported during 2001 (Graph 6). The length frequency distribution is also similar to that reported during 2001 (Graph 12).

The sandtile fish (*M. plumieri*) had a higher CPUE, when compared to the results of 2001, for deep depth stations, a lower CPUE for shallow depth stations and a higher CPUE, in terms of g/hook hours, but lower CPUE, in terms of g/ line days for medium depth stations (Table 10). These results could suggest a shift on habitat preference of the species towards the deeper areas. Size-weight relation calculated during this study period is similar to the one reported during 2001 (Graph 4). The length frequency distribution is also similar to that reported during 2001 (Graph 10).

The deep stations had the highest CPUE (3159 g/line day) (Table 9a.). The medium depth stations had the lowest CPUE with 899 g/line day. The deep depth stations had the highest CPUE of hook hours (249.5 g/ hook hours), followed by the shallow stations with 79.8 g/ hook hours. The results differed to those reported for 2001 (Rosario, 2004) in which the greatest CPUE in terms of g/ hook hours was for the shallow depth stations. The stations with highest CPUE were the ones farther from the coast, stations 95, 96, 73, 84 and 61 (Table 9). These stations are the ones around Mona Island and the ones located in the area called Bajo de Cico (Figs. 1, 2, 9, 12, 15, 18 and 19).

The sub-sample of fish caught that was used for histology shows that the visual identification of sex and reproductive stage is inaccurate. On 20 % of the sub-sample the sex was identified incorrectly and on 46 % the reproductive stage was classified incorrectly.

RECOMMENDATIONS

We recommend on a future study to change the stratification from depth to habitat type. The stations were defined by coordinates making a quadrant of 2 squared nautical miles. These quadrants could have an array of habitat types and depths. The sampling was done only on the area that met the characteristics for which the quadrant was chosen. This causes at the end that the sampling area is smaller than proposed. In addition habitat could be a key factor in determining the abundance of fish at certain areas, a relation that could be assess if all the information is available. The constrain will be that the areas will be limited to those for which the habitat type is known. Notwithstanding, there are many areas around the insular platform of Puerto Rico for which habitat type is known and that has never been study.

Considering the small amount of information obtained from fish traps, and the time and amount of resources needed to maintain this gear, it is suggested to concentrate efforts on hook and line gear.

Landing data report 31% of the total catch for the south coast and 37% for the west coast (Matos, 2004). For this reason it is recommended to start sampling the south coast as well as the west coast.

Knowing that some fish species aggregate at certain time of the year, it is suggested to determine sampling dates according to moon phase, aggregation period and considering the target species for the period.

The visual aid that was started should be expanded to cover at least the main fish species caught, at their different sexual stages. To improve the gonad preservation it is suggested that the gonad removal and preservation is done at the moment of collecting the fish. In case that this might interfere with the methodology, the fish or the gonad could be put in ice to avoid further deterioration of the tissue.

To better understand the reproductive cycle and collect better information on the fish caught, it is suggested to collect gonads from all the fish caught and do histology analysis to better determine the sex and reproductive stage of the specimen, especially those with immature gonads. The visual aid that was partially created should be continue to cover at least the main fish species caught, at their different stages.

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FIGURES AND TABLES

Figure 1. West coast platform divided in stations for the shallow-water reef fish monitoring

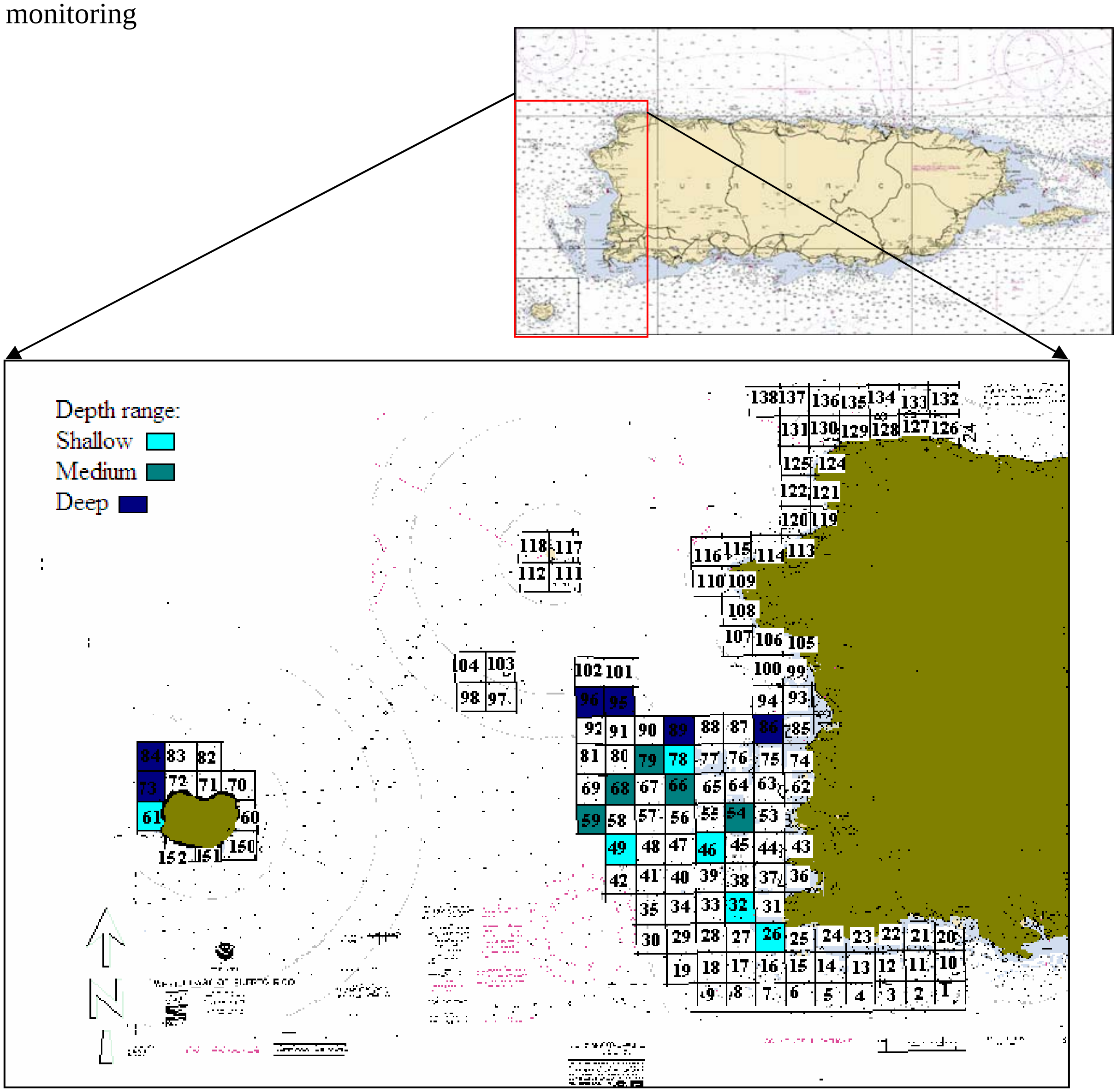


Fig 2. Boundaries of the stations used for the reef fish monitoring

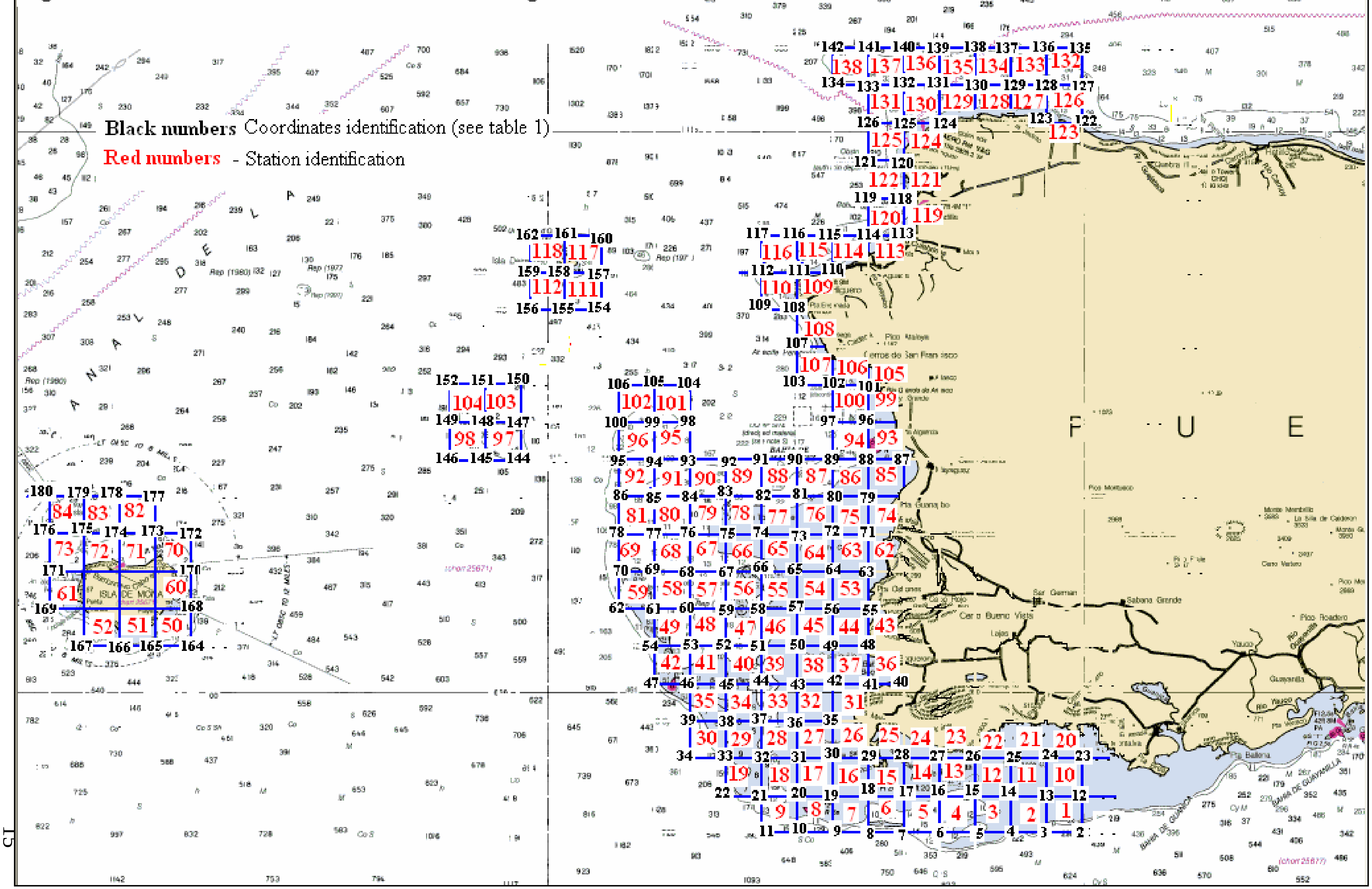
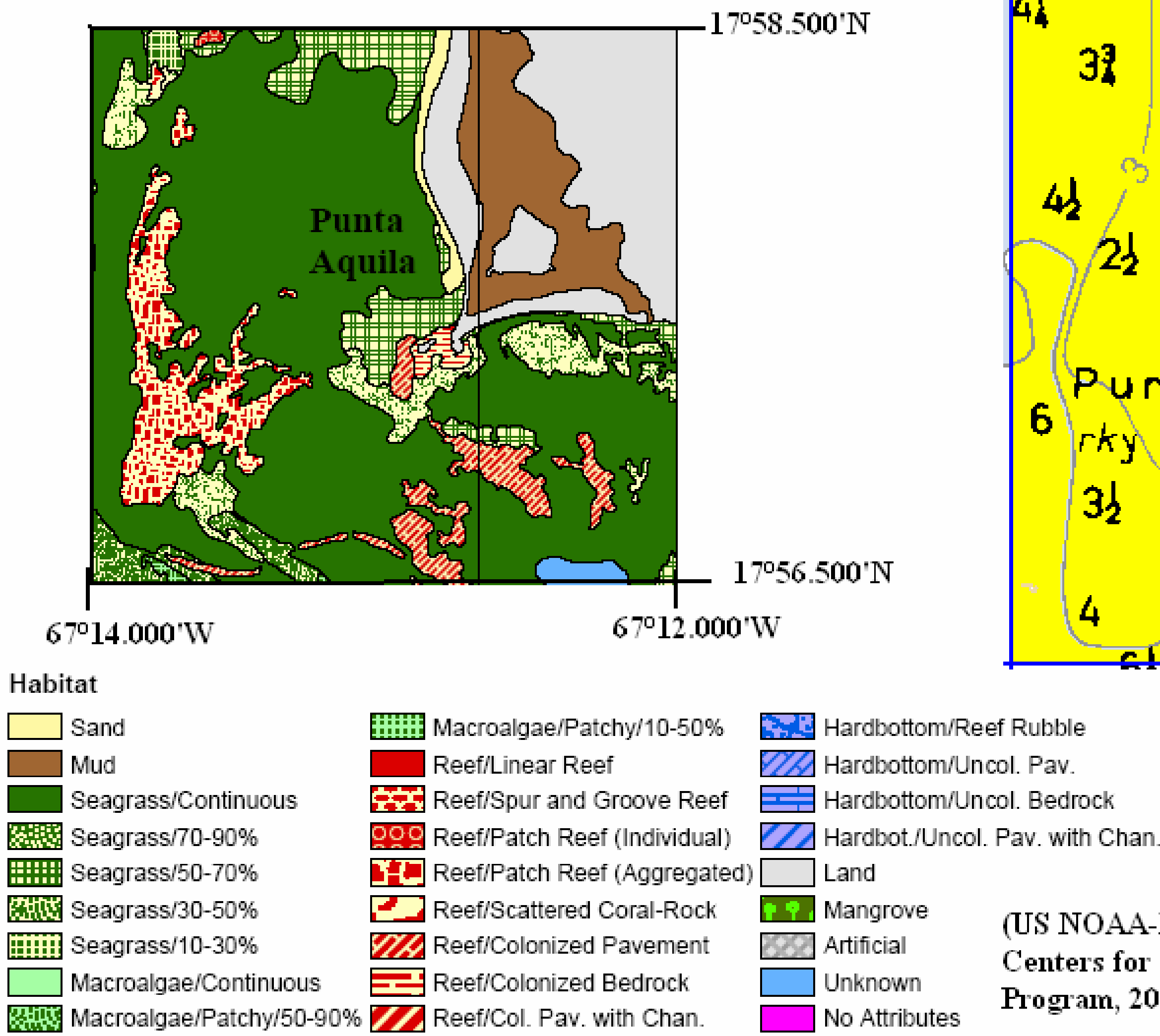
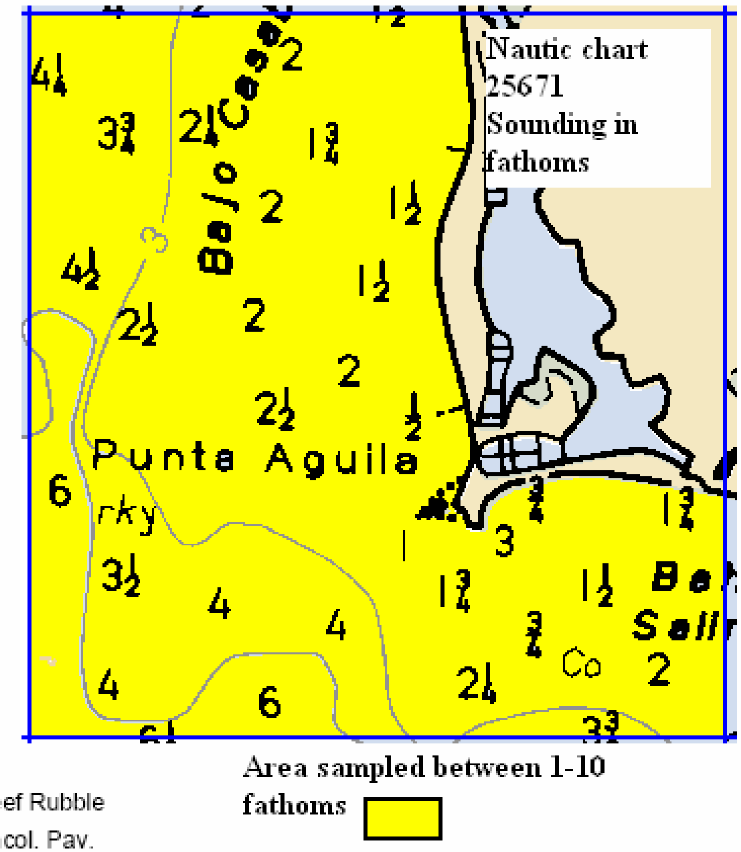


Fig 3. Available seafloor information for Station 26 (Shallow depth)





(US NOAA-National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program, 2001)

Fig 4. Available seafloor information for Station 32 (Shallow depth)

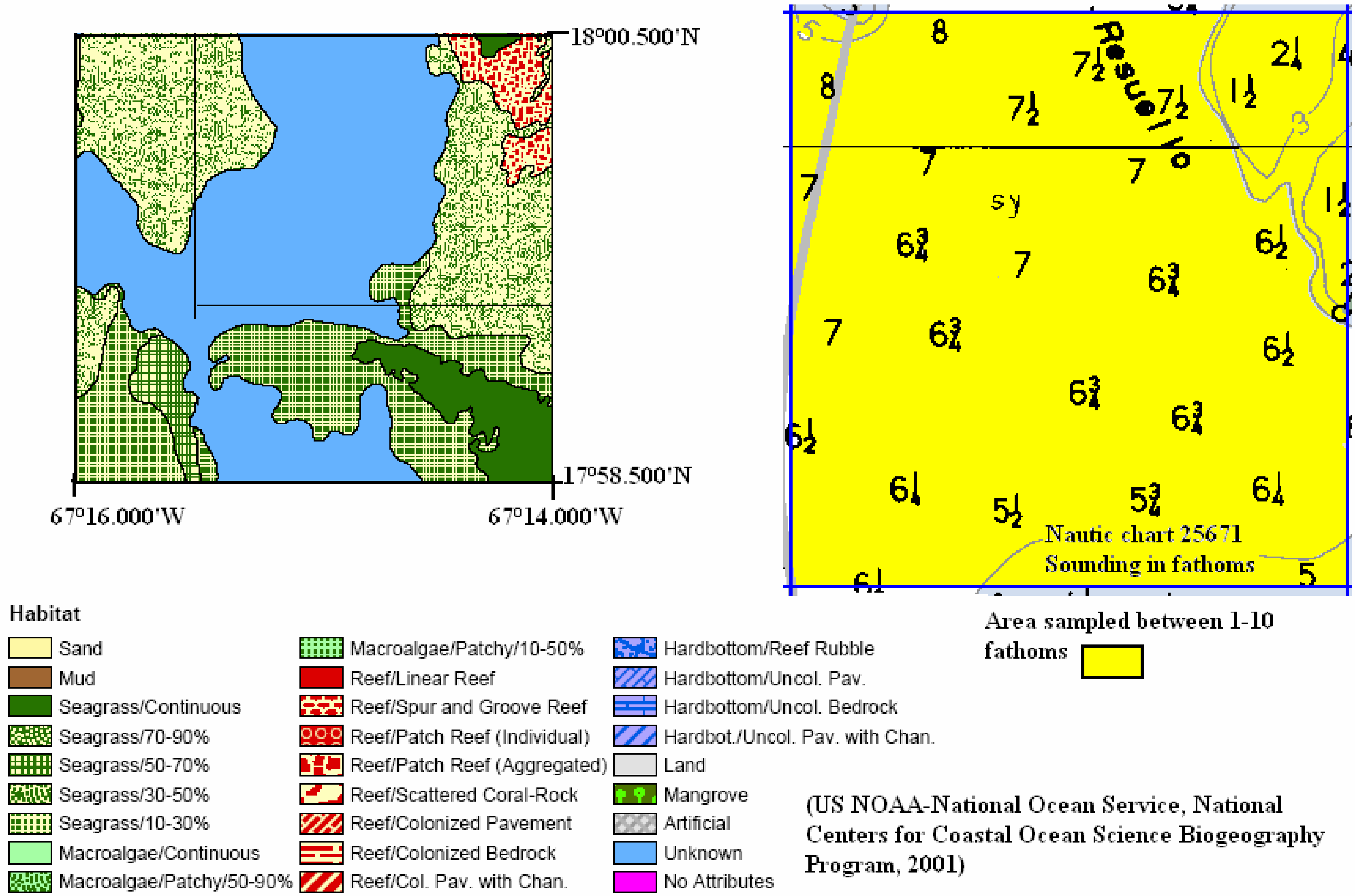


Fig 5. Available seafloor information for Station 46 (Shallow depth)

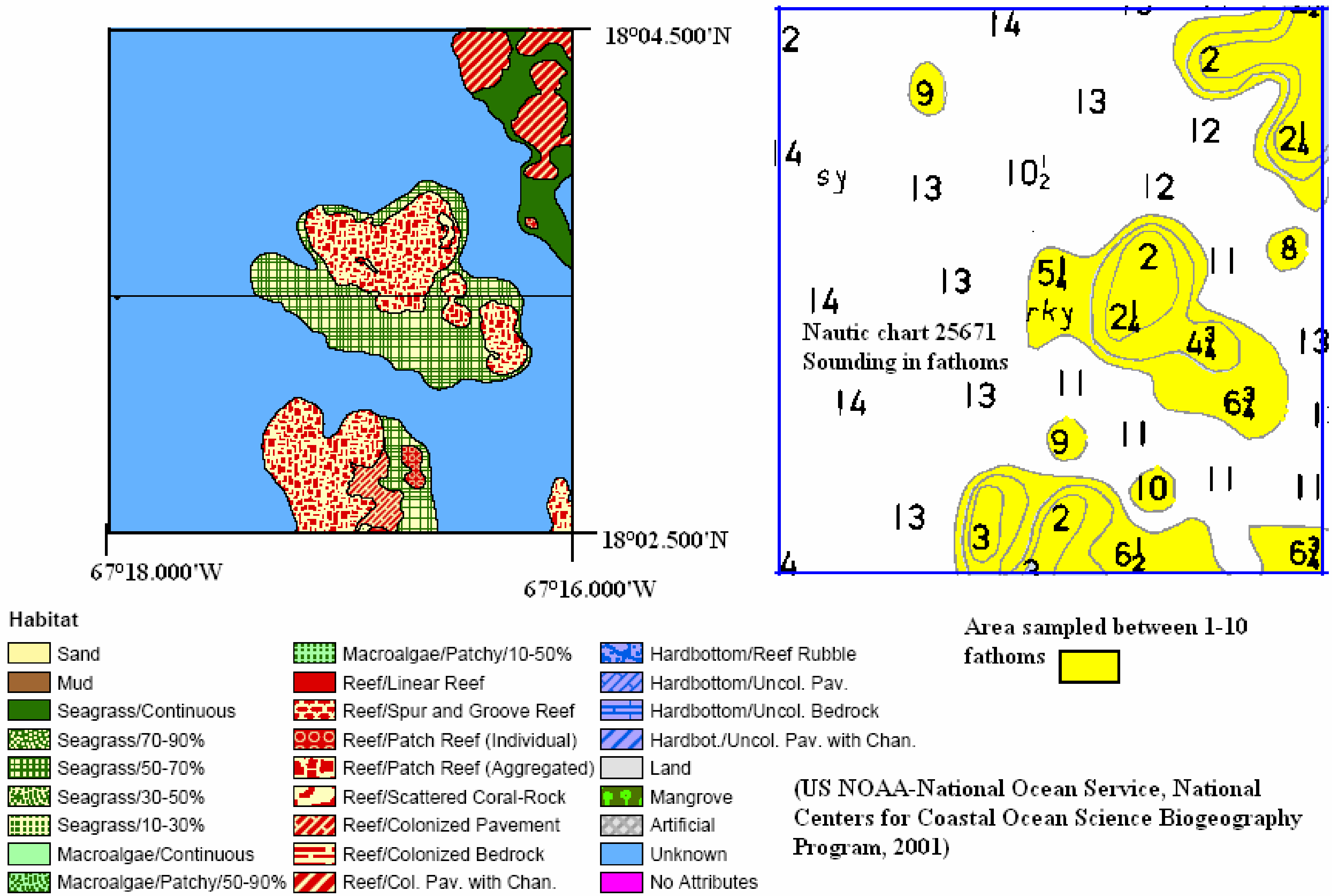


Fig. 6 Available seafloor information for station 49 (Shallow depth)

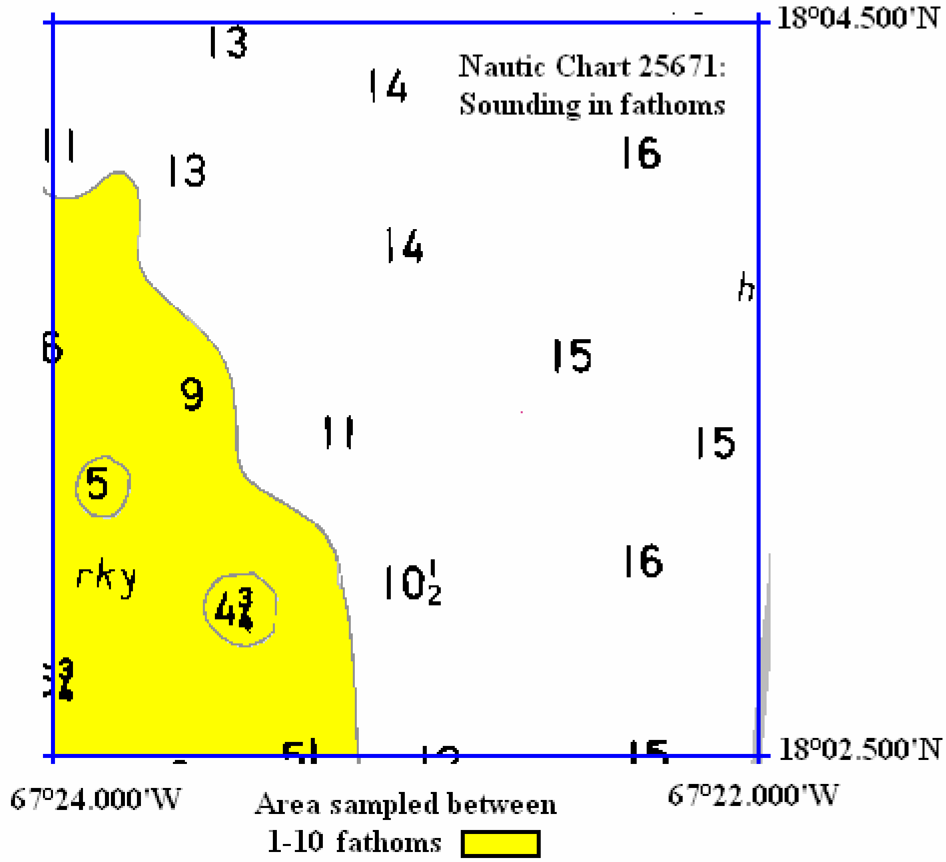
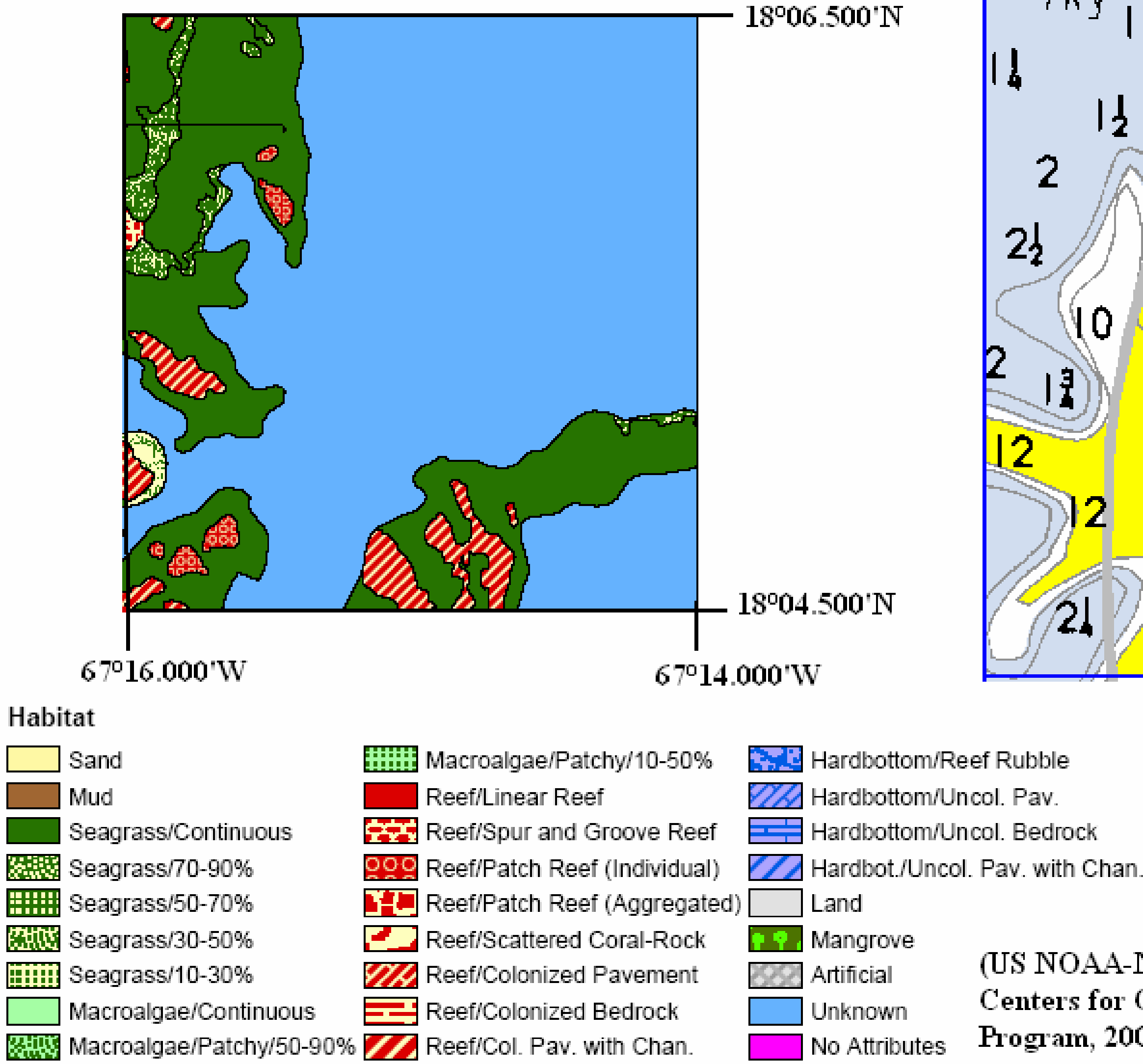
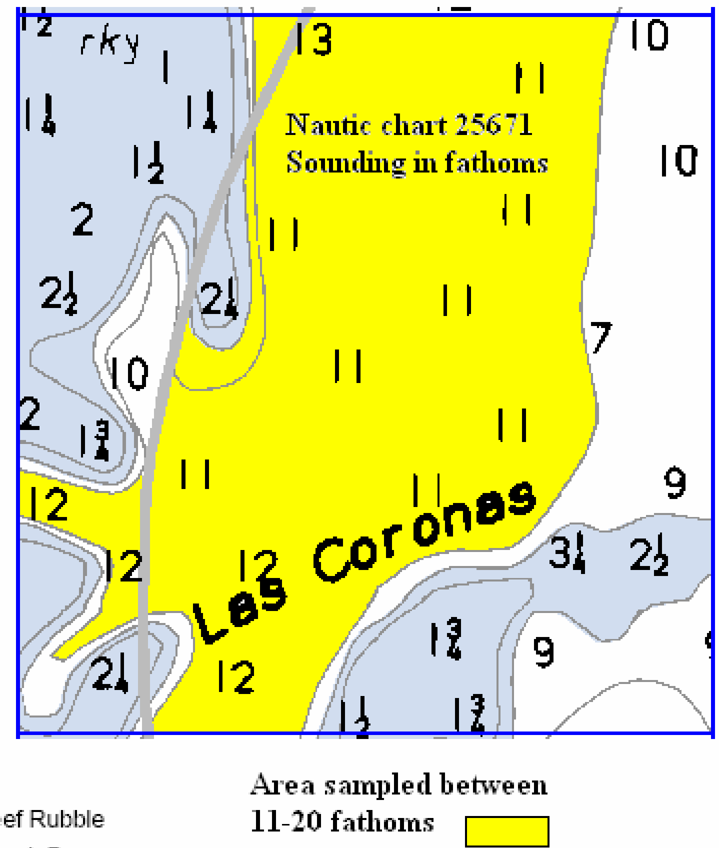


Fig.7 Available seafloor information for Station 54 (Medium depth)





(US NOAA-National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program, 2001)

Fig. 8 Available seafloor information for station 59 (Medium depth)

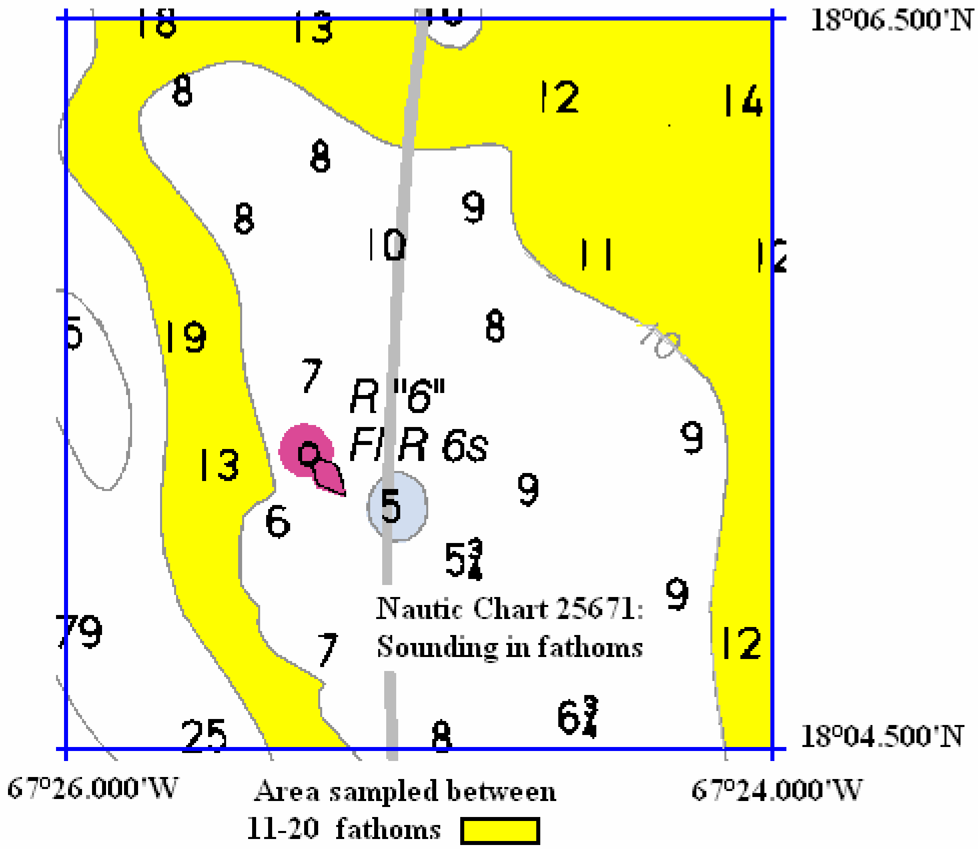
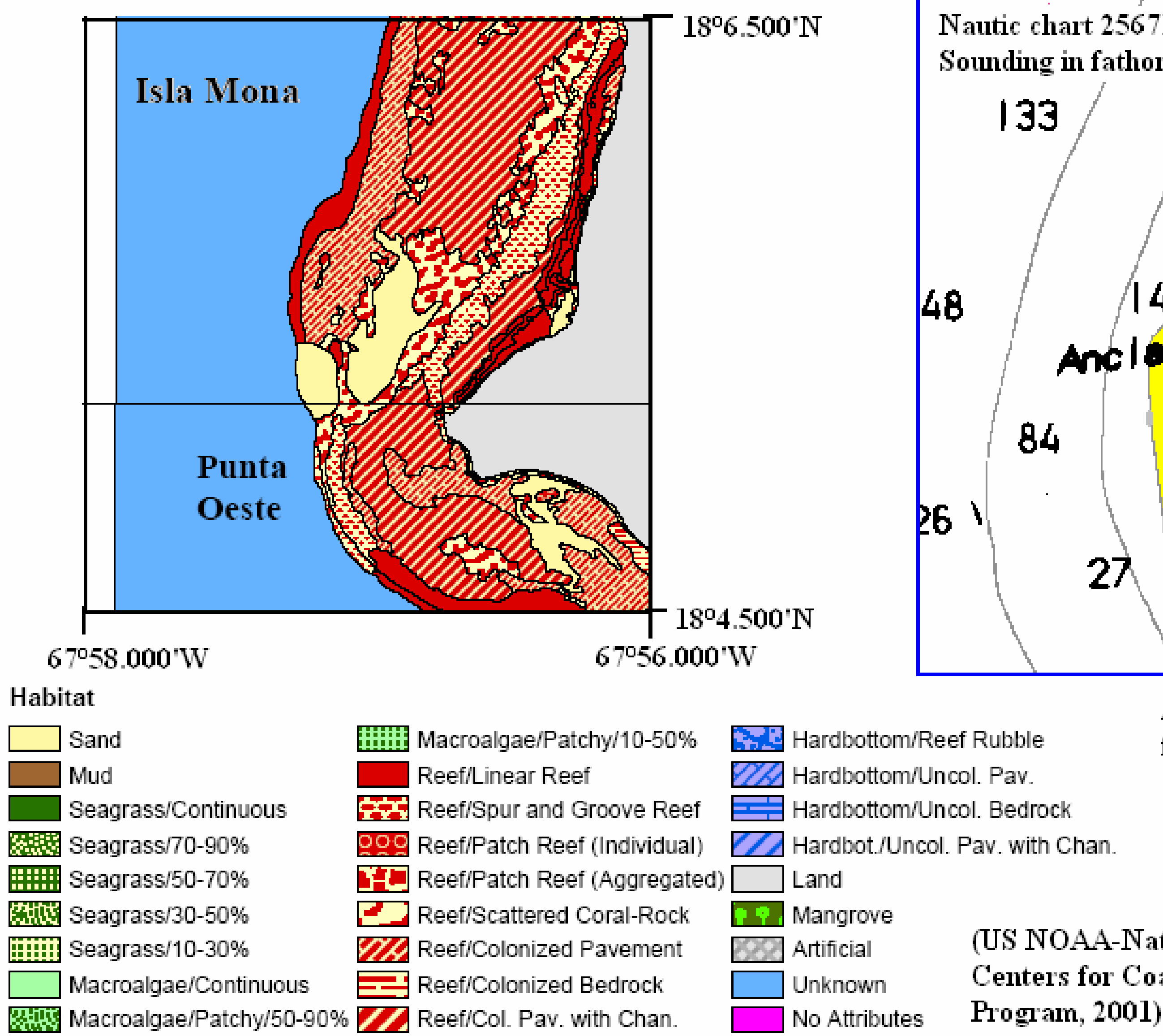
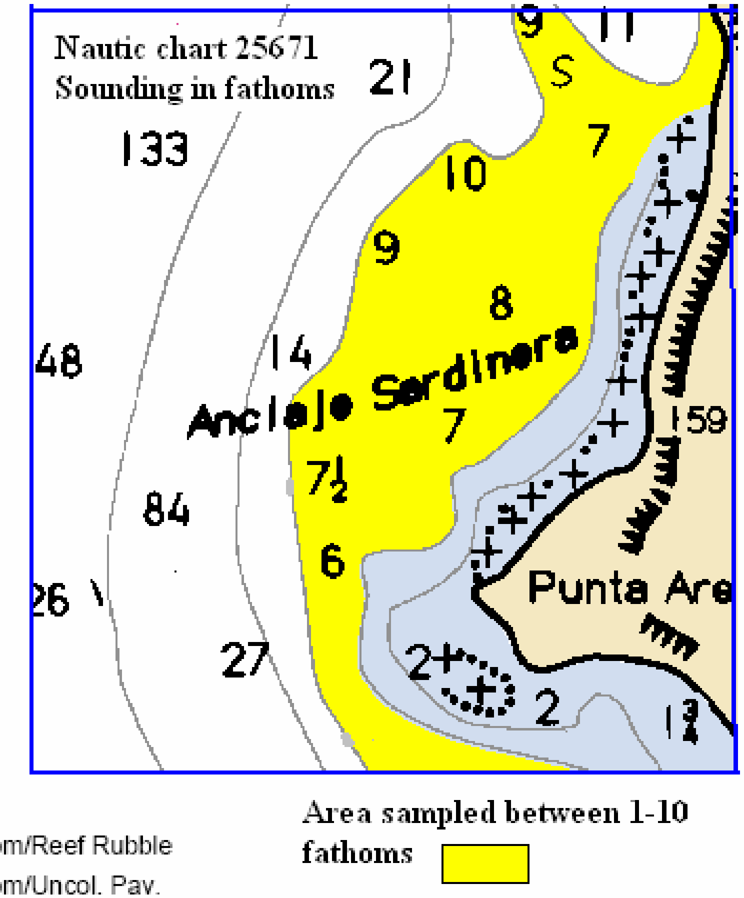


Fig. 9 Available seafloor information for Station 61 (Shallow depth)





(US NOAA-National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program, 2001)

Fig.10 Available seafloor information for Station 66 (Medium depth)

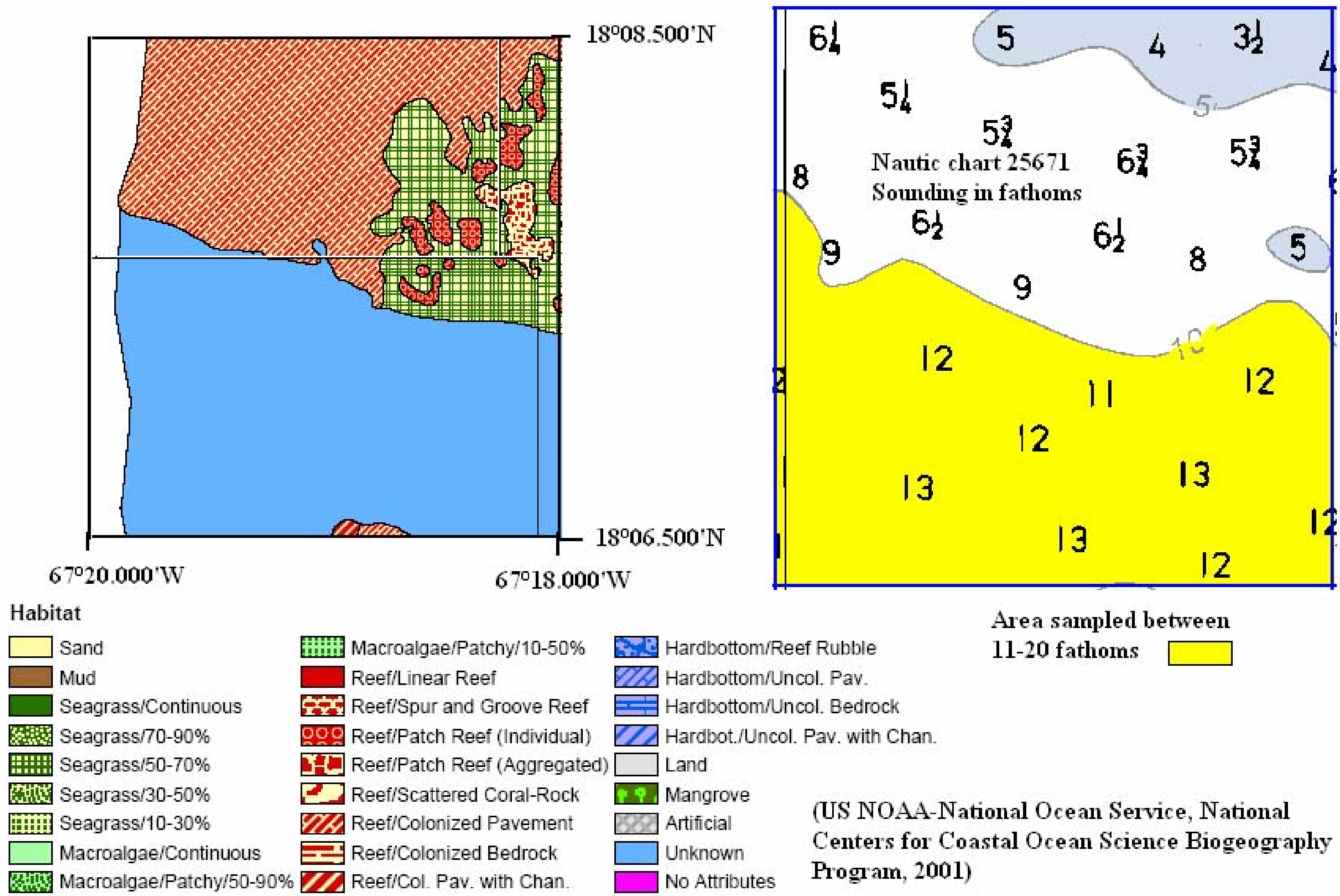
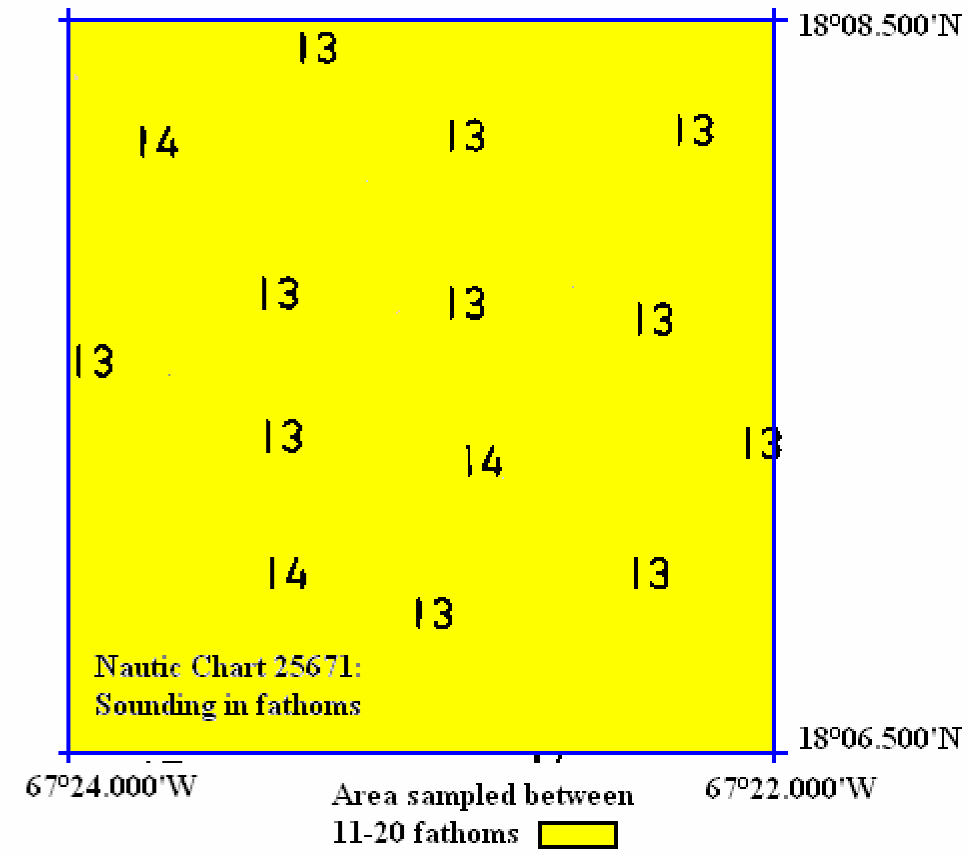


Fig. 11 Available seafloor information for station 68 (Medium depth)



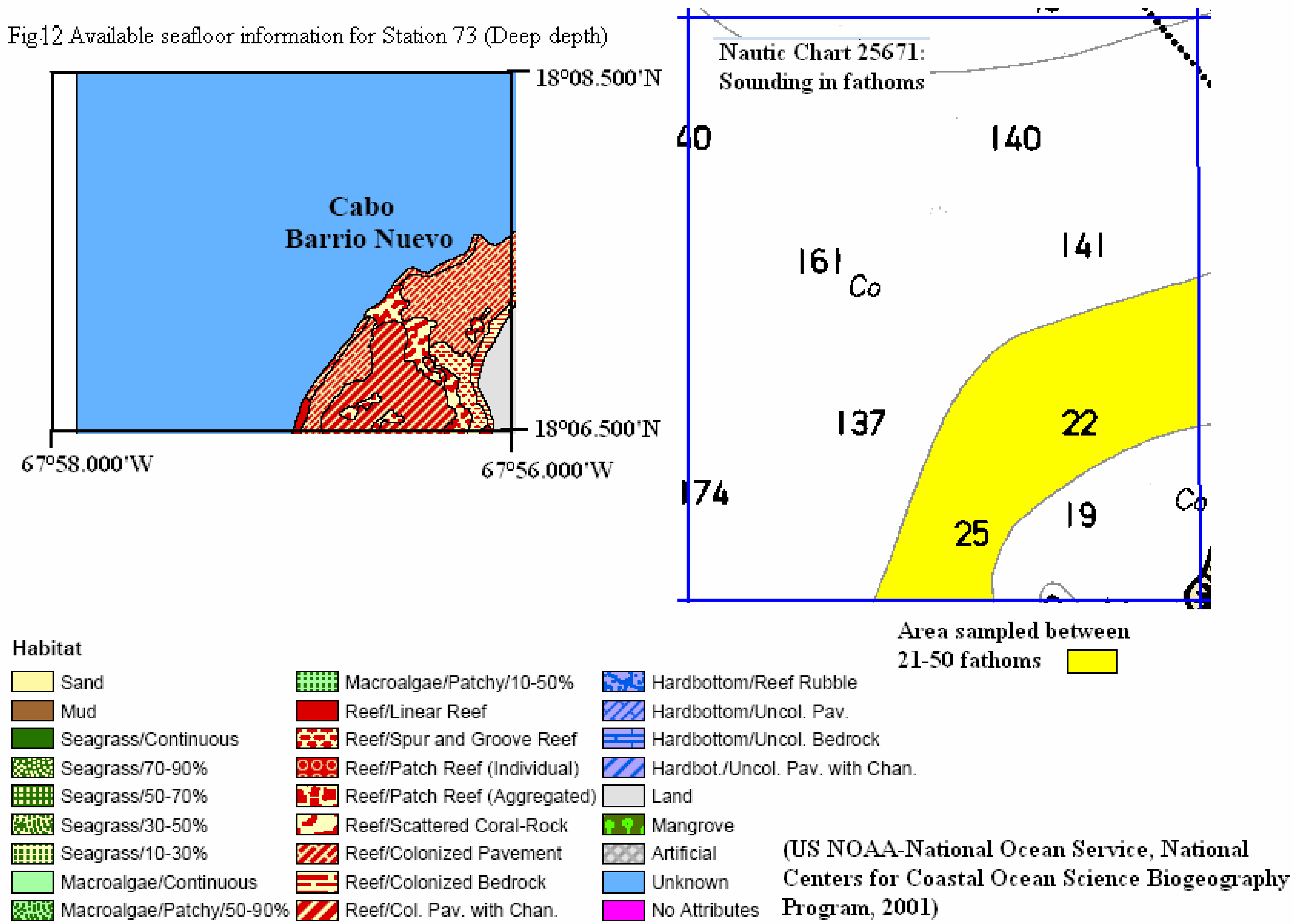


Fig.12 Available seafloor information for Station 73 (Deep depth)

(US NOAA-National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program, 2001)

Fig. 13 Available seafloor information for Station 78 (Shallow depth)

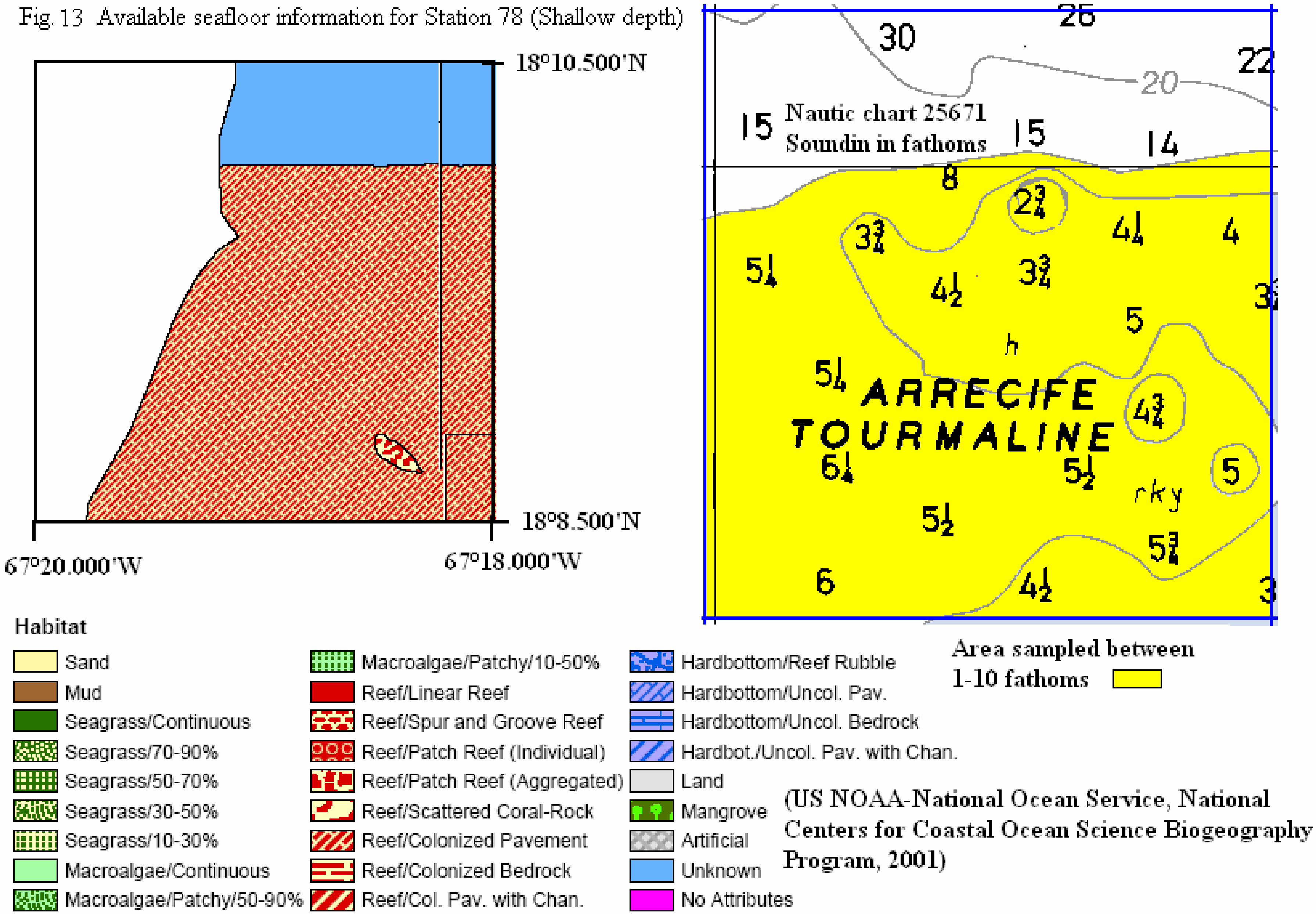


Fig. 14 Available seafloor information for station 79 (Medium depth)

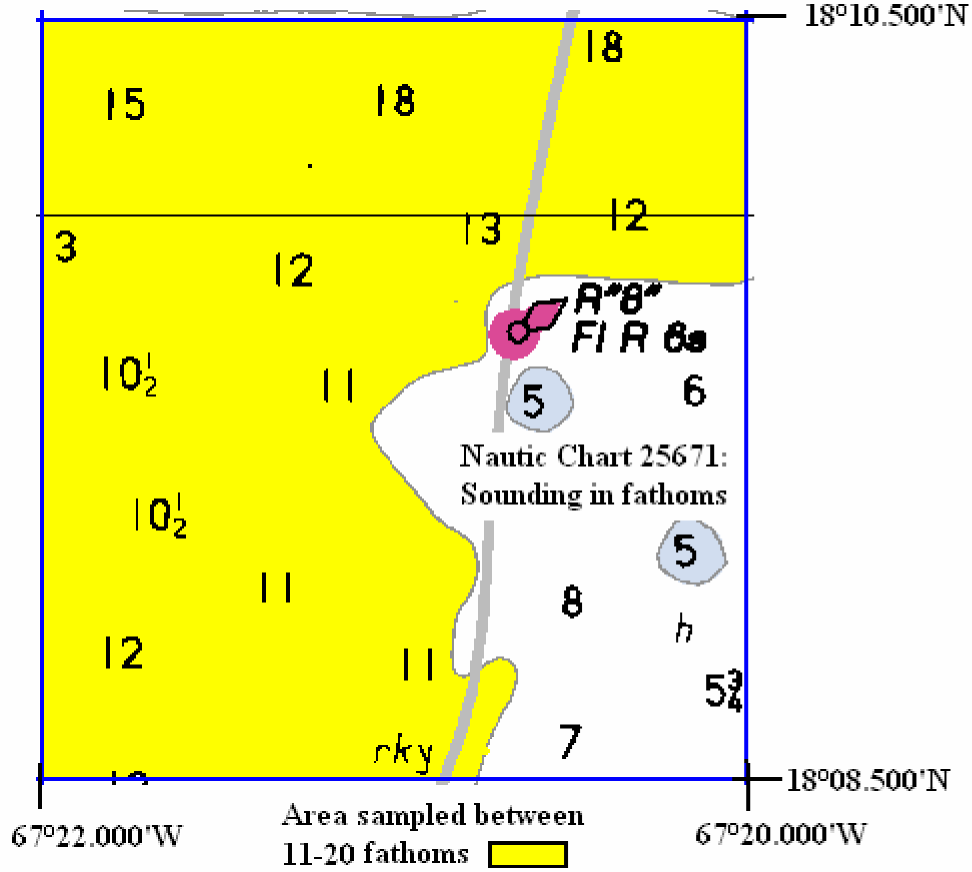


Fig. 15 Available seafloor information for station 84 (Deep depth)

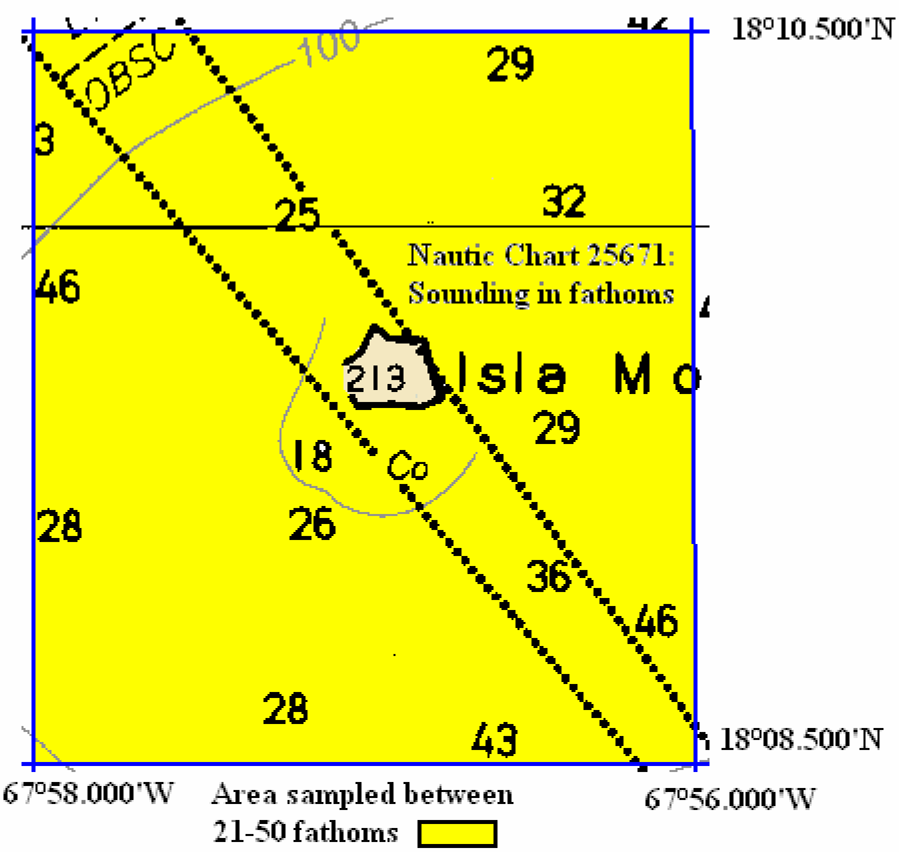


Fig. 16 Available seafloor information for Station 86 (Deep depth)

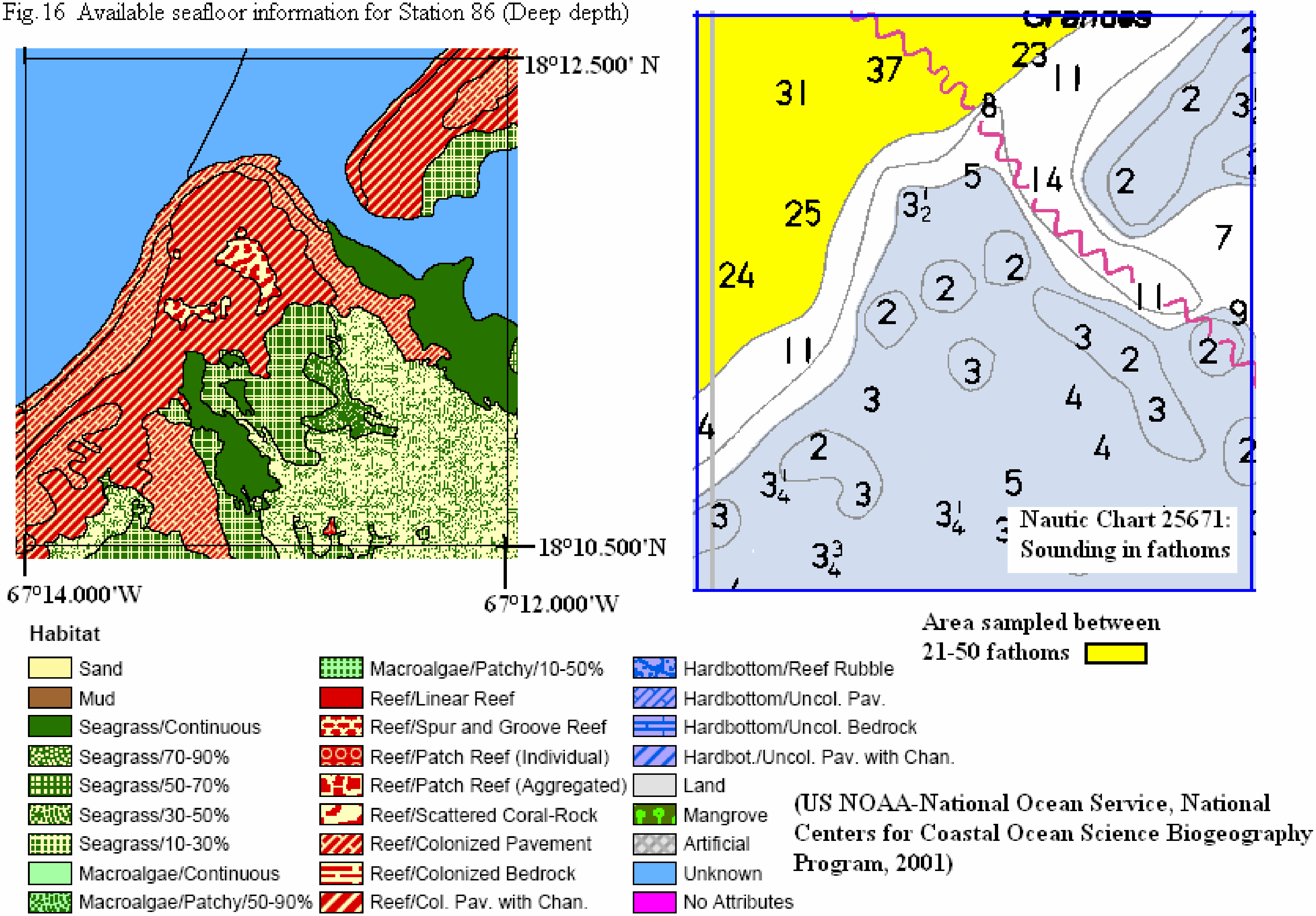


Fig. 17 Available seafloor information for station 89 (Deep depth)

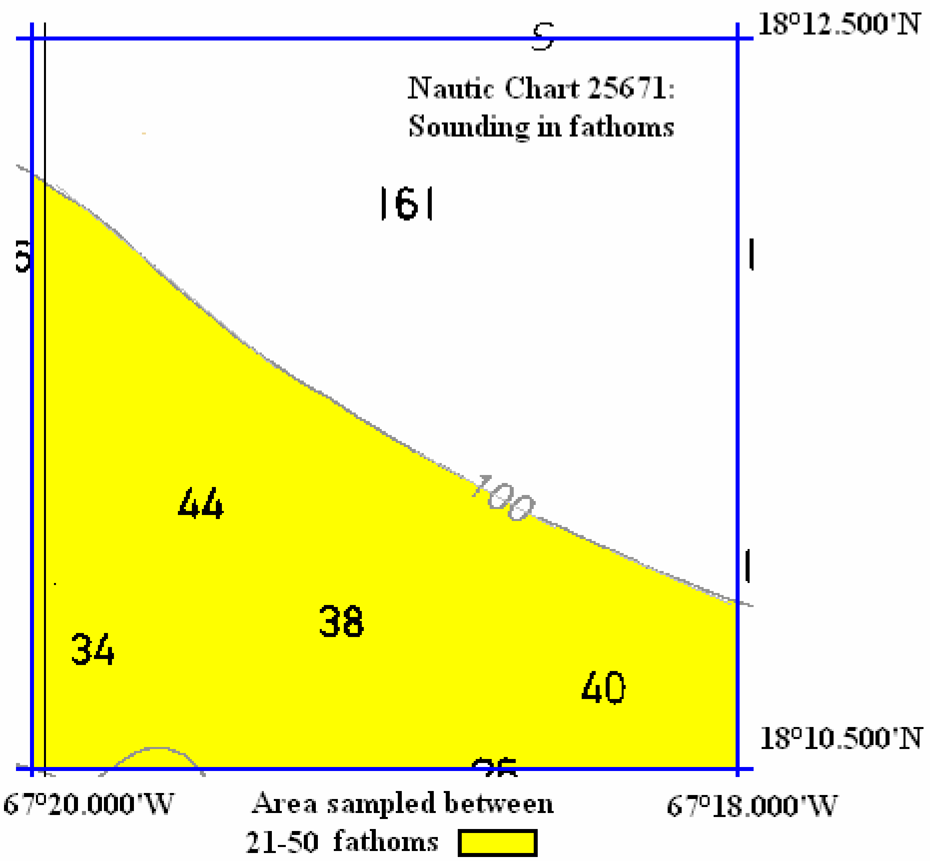


Fig. 18 Available seafloor information of station 95 (Deep depth)

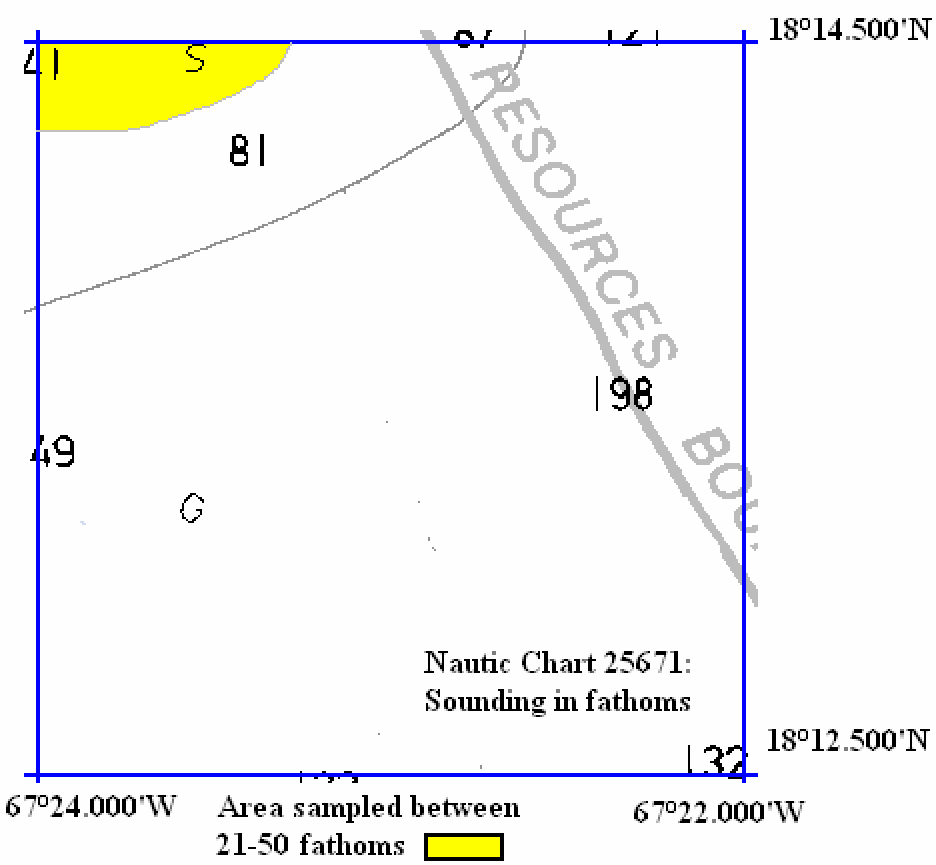


Fig. 19 Available seafloor information for station 96 (Deep depth)

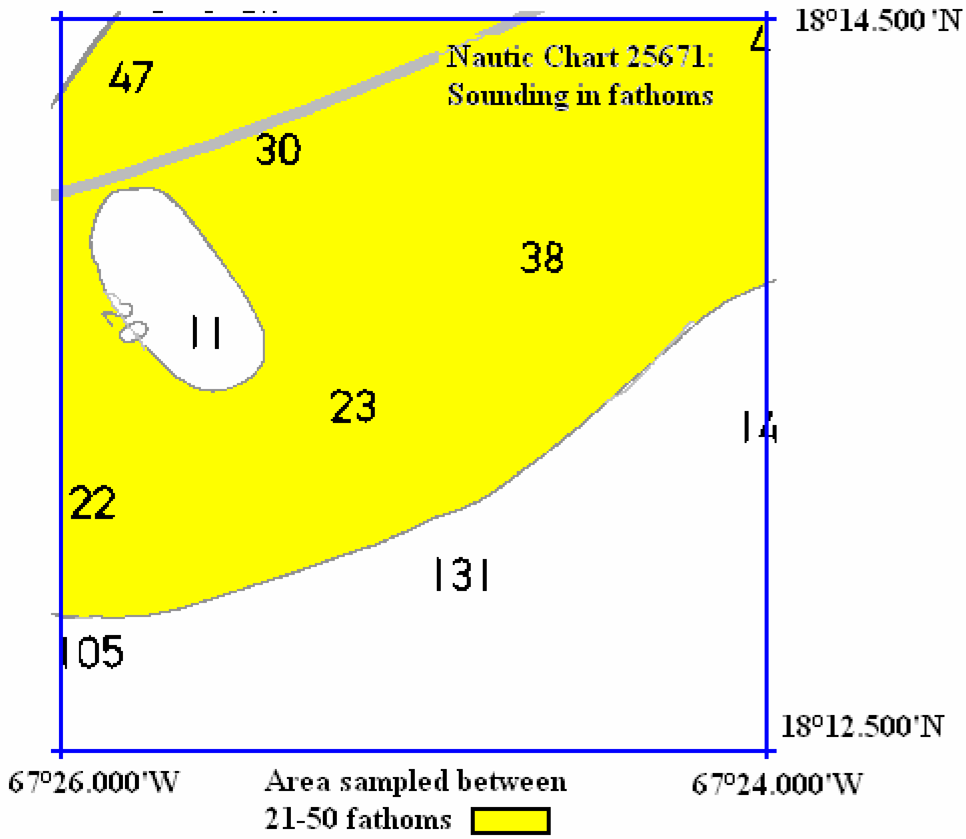


Table 1. Point identification and coordinates that define the stations on the west coast platform.

Point ID	North	West	Point ID	North	West
2	17°52.500	067°00.000	**90**	18°12.500	067°16.000
3	17°52.500	067°02.000	**91**	18°12.500	067°18.000
4	17°52.500	067°04.000	**92**	18°12.500	067°20.000
5	17°52.500	067°06.000	**93**	18°12.500	067°22.000
6	17°52.500	067°08.000	**94**	18°12.500	067°24.000
7	17°52.500	067°10.000	**95**	18°12.500	067°26.000
8	17°52.500	067°12.000	**96**	18°14.500	067°12.000
9	17°52.500	067°14.000	**97**	18°14.500	067°14.000
10	17°52.500	067°16.000	**98**	18°14.500	067°22.000
11	17°52.500	067°18.000	**99**	18°14.500	067°24.000
12	17°54.500	067°00.000	**100**	18°14.500	067°26.000
13	17°54.500	067°02.000	**101**	18°16.500	067°12.000
14	17°54.500	067°04.000	**102**	18°16.500	067°14.000
15	17°54.500	067°06.000	**103**	18°16.500	067°16.000
16	17°54.500	067°08.000	**104**	18°16.500	067°22.000
17	17°54.500	067°10.000	**105**	18°16.500	067°24.000
18	17°54.500	067°12.000	**106**	18°16.500	067°26.000
19	17°54.500	067°14.000	**107**	18°18.500	067°16.000
20	17°54.500	067°16.000	**108**	18°20.500	067°16.000
21	17°54.500	067°18.000	**109**	18°20.500	067°18.000
22	17°54.500	067°20.000	**110**	18°22.500	067°14.000
23	17°56.500	067°00.000	**111**	18°22.500	067°16.000
24	17°56.500	067°02.000	**112**	18°22.500	067°18.000
25	17°56.500	067°04.000	**113**	18°24.500	067°10.000
26	17°56.500	067°06.000	**114**	18°24.500	067°12.000
27	17°56.500	067°08.000	**115**	18°24.500	067°14.000
28	17°56.500	067°10.000	**116**	18°24.500	067°16.000
29	17°56.500	067°12.000	**117**	18°24.500	067°18.000
30	17°56.500	067°14.000	**118**	18°26.500	067°10.000
31	17°56.500	067°16.000	**119**	18°26.500	067°12.000
32	17°56.500	067°18.000	**120**	18°28.500	067°10.000
33	17°56.500	067°20.000	**121**	18°28.500	067°12.000
34	17°56.500	067°22.000	**122**	18°30.500	067°00.000
35	17°58.500	067°14.000	**123**	18°30.500	067°02.000
36	17°58.500	067°16.000	**124**	18°30.500	067°08.000
37	17°58.500	067°18.000	**125**	18°30.500	067°10.000
38	17°58.500	067°20.000	**126**	18°30.500	067°12.000
39	17°58.500	067°22.000	**127**	18°32.500	067°00.000
40	18°00.500	067°10.000	**128**	18°32.500	067°02.000
41	18°00.500	067°12.000	**129**	18°32.500	067°04.000
42	18°00.500	067°14.000	**130**	18°32.500	067°06.000

Point ID	North	West	Point ID	North	West
43	18°00.500	067°16.000	**131**	18°32.500	067°08.000
44	18°00.500	067°18.000	**132**	18°32.500	067°10.000
45	18°00.500	067°20.000	**133**	18°32.500	067°12.000
46	18°00.500	067°22.000	**134**	18°32.500	067°14.000
47	18°00.500	067°24.000	**135**	18°34.500	067°00.000
48	18°02.500	067°12.000	**136**	18°34.500	067°02.000
49	18°02.500	067°14.000	**137**	18°34.500	067°04.000
50	18°02.500	067°16.000	**138**	18°34.500	067°06.000
51	18°02.500	067°18.000	**139**	18°34.500	067°08.000
52	18°02.500	067°20.000	**140**	18°34.500	067°10.000
53	18°02.500	067°22.000	**141**	18°34.500	067°12.000
54	18°02.500	067°24.000	**142**	18°34.500	067°14.000
55	18°04.500	067°12.000	**144**	18°12.500	067°31.500
56	18°04.500	067°14.000	**145**	18°12.500	067°33.500
57	18°04.500	067°16.000	**146**	18°12.500	067°35.500
58	18°04.500	067°18.000	**147**	18°14.500	067°31.500
59	18°04.500	067°20.000	**148**	18°14.500	067°33.500
60	18°04.500	067°22.000	**149**	18°14.500	067°35.500
61	18°04.500	067°24.000	**150**	18°16.500	067°31.500
62	18°04.500	067°26.000	**151**	18°16.500	067°33.500
63	18°06.500	067°12.000	**152**	18°16.500	067°35.500
64	18°06.500	067°14.000	**154**	18°20.500	067°27.000
65	18°06.500	067°16.000	**155**	18°20.500	067°29.000
66	18°06.500	067°18.000	**156**	18°20.500	067°31.000
67	18°06.500	067°20.000	**157**	18°22.500	067°27.000
68	18°06.500	067°22.000	**158**	18°22.500	067°29.000
69	18°06.500	067°24.000	**159**	18°22.500	067°31.000
70	18°06.500	067°26.000	**160**	18°24.500	067°27.000
71	18°08.500	067°12.000	**161**	18°24.500	067°29.000
72	18°08.500	067°14.000	**162**	18°24.500	067°31.000
73	18°08.500	067°16.000	**164**	18°02.500	067°50.000
74	18°08.500	067°18.000	**165**	18°02.500	067°52.000
75	18°08.500	067°20.000	**166**	18°02.500	067°54.000
76	18°08.500	067°22.000	**167**	18°02.500	067°56.000
77	18°08.500	067°24.000	**168**	18°04.500	067°50.000
78	18°08.500	067°26.000	**169**	18°04.500	067°58.000
79	18°10.500	067°12.000	**170**	18°06.500	067°50.000
80	18°10.500	067°14.000	**171**	18°06.500	067°58.000
81	18°10.500	067°16.000	**172**	18°08.500	067°50.000
82	18°10.500	067°18.000	**173**	18°08.500	067°52.000
83	18°10.500	067°20.000	**174**	18°08.500	067°54.000
84	18°10.500	067°22.000	**175**	18°08.500	067°56.000
85	18°10.500	067°24.000	**176**	18°08.500	067°58.000
86	18°10.500	067°26.000	**177**	18°10.500	067°52.000

Point ID	North	West	Point ID	North	West
87	18°12.500	067°10.000	**178**	18°10.500	067°54.000
88	18°12.500	067°12.000	**179**	18°10.500	067°56.000
89	18°12.500	067°14.000	**180**	18°10.500	067°58.000

Table 2. Summary by date of the surveys conducted at each station with the total catch in kilograms.

Date	Station	Kg.	Date	Station	Kg.	Date	Station	Kg.
19-Jan-04	66	5.534	23-May-05	59	5.984	16-Sep-05	49	5.778
29-May-04	84	26.928	24-May-05	89	2.369	19-Sep-05	26	0
30-May-04	84	14.802	25-May-05	59	8.085	20-Sep-05	49	16.459
9-Jun-04	59	9.016	9-Jun-05	61	26.353	22-Sep-05	78	1.544
21-Jun-04	78	1.782	10-Jun-05	84	19.281	30-Sep-05	68	6.403
23-Jun-04	49	6.472	10-Jun-05	73	47.113	3-Oct-05	26	0.214
21-Jul-04	95	10.404	14-Jun-05	49	7.761	5-Oct-05	78	2.927
23-Jul-04	89	11.031	15-Jun-05	78	0.421	6-Oct-05	68	3.756
29-Nov-04	66	2.322	21-Jun-05	96	17.55	10-Oct-05	49	20.379
2-Dec-04	68	5.952	23-Jun-05	59	3.195	24-Jan-06	54	1.423
6-Dec-04	86	2.368	27-Jun-05	95	12.147	25-Jan-06	66	0.94
7-Dec-04	89	2.494	28-Jun-05	96	8.807	27-Jan-06	26	0
9-Dec-04	54	2.292	11-Jul-05	54	0.799	31-Jan-06	66	6.44
13-Dec-04	26	0.284	12-Jul-05	79	3.938	1-Feb-06	68	3.826
14-Dec-04	66	2.619	19-Jul-05	32	1.061	2-Feb-06	96	9.273
16-Dec-04	32	2.812	28-Jul-05	26	0.369	8-Feb-06	54	4.214
9-Mar-05	79	8.705	2-Aug-05	89	1.446	9-Feb-06	66	0.579
10-Mar-05	68	2.191	3-Aug-05	54	0.962	13-Feb-06	78	0.253
15-Mar-05	54	1.742	5-Aug-05	96	14.974	17-Feb-06	26	0.159
16-Mar-05	46	1.861	18-Aug-05	73	15.837	21-Feb-06	49	4.453
17-Mar-05	59	7.624	22-Aug-05	66	0.976	22-Feb-06	26	0
29-Mar-05	96	11.997	23-Aug-05	78	2.509	24-Feb-06	66	1.237
12-Apr-05	84	15.975	26-Aug-05	68	6.931	27-Feb-06	32	0.701
13-Apr-05	73	10.069	30-Aug-05	49	8.327	2-Mar-06	46	1.609
14-Apr-05	61	19.884	1-Sep-05	68	2.544	7-Mar-06	86	1.205
25-Apr-05	78	1.911	6-Sep-05	66	0	8-Mar-06	89	0.837
26-Apr-05	95	10.465	8-Sep-05	95	4.548	14-Mar-06	78	1.478
28-Apr-05	89	10.024	13-Sep-05	26	0.864	15-Mar-06	59	6.902
3-May-05	96	13.267	14-Sep-05	32	0.379			

Table 3. Fish species caught, by weight, at each station divided by fishing gear

Species	Station												Total
	26		32		46		49		54		59		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Acanthurus bahianus								1.03				0.33	1.36
A. chirurgus								1.06					1.06
A. coerulus								1.88				0.14	2.03
Alectis ciliaris													0.00
Aluterus monocerus				0.20									0.20
Anisotremus virginicus								0.36					0.36
Apsilus dentatus													0.00
Balistes capriscus										2.33			2.33
Balistes vetula							1.11				0.76		1.88
Bothus lunatus													0.00
Calamus calamus													0.00
Calamus pennatula	1.36	0.27	1.93		0.27		2.10			1.16	1.10		8.19
Cantherbines macrocerus													0.00
C. pullus													0.00
Canthidermis sufflamen													0.00
Caranx bartholomaei		0.11											0.11
Caranx crysos			0.45		0.78					2.08			3.30
C. lugubris													0.00
C. ruber				0.88				0.72					1.60
Cephalopholis cruentatus			0.18			0.98	0.21		0.13		0.05		1.54
C. fulva							11.57	9.78			6.66	1.51	29.53
Chaetodon striatus													0.00
Diodon hystrix							0.70						0.70
Echeneis naucrates													0.00
Elegatis bipinnulata													0.00
Epinephelus guttatus						0.22	5.22	2.37			14.51	1.05	23.37
Epinephelus striatus													0.00
Haemulon aurolineatum									0.15				0.15
H. flavolineatum								0.76					0.76
H. plumieri							1.04	9.49				0.28	10.81
Halichoeres garnoti							0.25				0.24		0.49
Holocentrus adscensionis	0.15						1.03	0.19			1.12	0.16	2.65
H. rufus							1.65	0.24			0.62		2.51
Lactophrys polygonius													0.00
L. quadricornis										0.46		0.11	0.57
L. trigonus			1.06		0.82				0.63				2.51
Lutjanus buccanella													0.00
L. jocu													0.00
L. synagris					0.23	0.19			0.51	3.98			4.91
L. vivanus													0.00
Malacantus plumieri							8.06				3.99		12.05
Melichthys niger							1.18				5.38		6.55
Ocyurus chrysurus							0.90	3.90				2.04	6.84

Species	Station												Total
	26		32		46		49		54		59		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Panulirus argus								0.81					0.81
Rhombhoplites aurorubens													0.00
Scarus taeniopterus												0.15	0.15
Scorpaena brasiliensis											0.38		0.38
S. plumieri													0.00
Seriola rivoliana													0.00
Serranus tabacarius													0.00
Sparisoma viride													0.00
Sphyraena barracuda							2.03						2.03
Synodus foetens			0.17										0.17
S. intermedius													0.00
Trachinocephalus myops			0.09										0.09
Xanthichthys ringen												0.24	0.24
Grand Total	1.51	0.38	3.88	1.08	2.09	1.38	37.05	32.58	1.43	10.01	34.80	6.01	132.18

Table 3. Cont. Fish species caught, by weight, at each station divided by fishing gear

Species	Station												Total
	61		66		68		73		78		79		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Acanthurus bahianus		0.29				1.354						0.38	2.02
A. chirurgus													
A. coerulus		0.51				0.961		0.19		0.19			1.84
Alectis ciliaris													
Aluterus monocerus													
Anisotremus virginicus													
Apsilus dentatus							0.49						0.49
Balistes capriscus													
Balistes vetula	2.81					0.988	0.89						4.70
Bothus lunatus										0.19			0.19
Calamus calamus											0.27	0.28	0.55
Calamus pennatula			1.584	1.29	4.08	0.231			1.82		2.78		11.78
Cantherbines macrocerus												0.58	0.58
C. pullus										0.08			0.08
Canthidermis sufflamen	1.01												1.01
Caranx bartholomaei													
Caranx crysos			5.384		0.66						0.29		6.33
C. lugubris	1.86						5.71						7.57
C. ruber										0.20			0.20
Cephalopholis cruentatus													
C. fulva	14.3	2.73	1.096		5.4	1.533	13.81	0.66	3.11	0.26	2.02	0.26	45.16
Chaetodon striatus													
Diodon hystrix													
Echeneis naucrates					0.7								0.70
Elegatis bipinnulata													
Epinephelus guttatus	3.43	0.46	1.234	0.61	3.87	2.016	15.86	0.98	0.29	1.21	2.27	0.25	32.49
Epinephelus striatus													
Haemulon aurolineatum			0.09										0.09
H. flavolineatum													
H. plumieri				0.59		0.245						0.37	1.20
Halichoeres garnoti													
Holocentrus adscensionis			1.735	0.7	4.48	2.568	0.32		1.61		0.66		12.07
H. rufus		0.16	0.122		0.2		0.11		1.25				1.84
Lactophrys polygonius				0.41				0.26					0.67
L. quadricornis						0.101		0.37				0.09	0.56
L. trigonus			0.886		0.76								1.64
Lutjanus buccanella							2.00						2.00
L. jocu													
L. synagris			2.014	0.59									2.61
L. vivanus													
Malacantus plumieri	7.19		0.204		0.63		16.59		0.13		0.94		25.68
Melichthys niger	9.82						1.73						11.55

Species	Station												Total
	61		66		68		73		78		79		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Ocyurus chrysurus			0.973		0.21					2.06		0.19	3.43
Panulirus argus												1.02	1.02
Rhombhoplites aurorubens			0.351		0.19	0.179							0.72
Scarus taeniopterus		0.21											0.21
Scorpaena brasiliensis													
S. plumieri					0.25		0.35		0.43				1.02
Seriola rivoliana													
Serranus tabacarius													
Sparisoma viride				0.58									0.58
Sphyraena barracuda	1.48						12.70						14.18
Synodus foetens													
S. intermedius			0.204										0.20
Trachinocephalus myops													
Xanthichthys ringen													
Grand Total	41.9	4.36	15.88	4.77	21.4	10.18	70.57	2.45	8.64	4.18	9.22	3.42	196.97

Table 3. Cont. Fish species caught, by weight, at each station divided by fishing gear

Species	Station										Total
	84		86		89		95		96		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Acanthurus bahianus										0.38	0.38
A. chirurgus											0.00
A. coerulus										0.32	0.32
Alectis ciliaris					4.65						4.65
Aluterus monocerus											0.00
Anisotremus virginicus											0.00
Apsilus dentatus											0.00
Balistes capriscus											0.00
Balistes vetula	2.26								2.76		5.03
Bothus lunatus											0.00
Calamus calamus											0.00
Calamus pennatula			0.19	0.45		0.21					0.84
Cantherbines macrocerus											0.00
C. pullus											0.00
Canthidermis sufflamen									2.14		2.14
Caranx bartholomaei							1.04				1.04
Caranx crysos			0.44		14.25						14.69
C. lugubris	2.15								11.57		13.72
C. ruber	1.23				2.10						3.33
Cephalopholis cruentatus							0.05		0.30		0.35
C. fulva	6.93	0.48	0.05	0.40			2.44	1.05	6.17	3.09	20.61
Chaetodon striatus										0.08	0.08
Diodon hystrix											0.00
Echeneis naucrates											0.00
Elegatis bipinnulata	1.89								2.58		4.47
Epinephelus guttatus	47.17						24.63	2.20	14.92	6.38	95.30
Epinephelus striatus									4.94		4.94
Haemulon aurolineatum											0.00
H. flavolineatum											0.00
H. plumieri				0.30						0.46	0.76
Halichoeres garnoti									0.25		0.25
Holocentrus adscensionis					0.22		1.11		1.01	4.06	6.39
H. rufus	0.45								0.59		1.04
Lactophrys polygonius											0.00
L. quadricornis				0.24		0.51					0.75
L. trigonus											0.00
Lutjanus buccanella						0.15	1.42		0.42	0.42	2.40
L. jocu										0.75	0.75
L. synagris			0.10								0.10
L. vivanus					0.48	1.63					2.12
Malacantus plumieri	14.42				1.28		3.64		3.30		22.63
Melichthys niger									4.18		4.18
Ocyurus chrysurus						0.28				1.98	2.25

Species	Station										Total
	84		86		89		95		96		
	HL	TR	HL	TR	HL	TR	HL	TR	HL	TR	
Panulirus argus											0.00
Rhombhoplites aurorubens			0.18	1.24	0.57	0.18					2.16
Scarus taeniopterus											0.00
Scorpaena brasiliensis											0.00
S. plumieri										0.23	0.23
Seriola rivoliana					1.65				2.60		4.25
Serranus tabacarius					0.05						0.05
Sparisoma viride											0.00
Sphyraena barracuda					0.00						0.00
Synodus foetens											0.00
S. intermedius											0.00
Trachinocephalus myops											0.00
Xanthichthys ringen											0.00
Grand Total	76.50	0.48	0.95	2.62	25.25	2.95	34.32	3.25	57.73	18.14	222.19

Table 4. Summary by number of fish species caught by station

↓Species Station→	26	32	46	49	54	59	61	66	68	73	78	79	84	86	89	95	96	Total
Acanthurus bahianus				9		2	3		11			2					4	31
A. chirurgus				4														4
A. coerulus				7		1	5		4	1	1						2	21
Alectis ciliaris															2			2
Aluterus monocerus		1																1
Anisotremus virginicus				1														1
Apsilus dentatus										1								1
Balistes capriscus					4													4
Balistes vetula				2		1	3		3	1			2				2	14
Bothus lunatus											2							2
Calamus calamus												3						3
Calamus pennatula	9	6	1	6	5	3		13	14		6	9		3	1			76
Cantherbines macrocerus												1						1
C. pullus											1							1
Canthidermis sufflamen							1										1	2
Caranx bartholomaei	1															2		3
Caranx crysos		1	1		4			10	1			1		1	23			42
C. lugubris							1			2			1				6	10
C. ruber		2		2							1		1		1			7
Cephalopholis cruentatus		2	4	2	1	1										1	3	14
C. fulva				87		53	79	4	40	61	19	17	32	2		17	52	463
Chaetodon striatus																	2	2
Diodon hystrix				1														1
Echeneis naucrates									2									2
Elegatis bipinnulata													1				1	2
Epinephelus guttatus			1	18		41	5	4	18	27	4	8	70			62	49	307
Epinephelus striatus																	1	1
Haemulon aurolineatum					2			1										3
H. flavolineatum				5														5
H. plumieri				46		1		2	1			1		1			1	53
Halichoeres garnoti				1		1											1	3
Holocentrus adscensionis	1			5		7		13	45	2	10	4			1	6	31	125
H. rufus				16		7	1	1	2	1	11		2				6	47
Lactophrys polygonius								3		1								4
L. quadricornis					3	1			1	2		1		1	1			10
L. trigonus		1	1		1			1	1									5
Lutjanus buccanella										3					1	1	2	7
L. jocu																	1	1
L. synagris			2		19			10						1				32
L. vivanus															6			6
Malacantus plumieri				31		14	20	1	3	48	1	5	34		5	14	10	186
Melichthys niger				2		10	19			3							7	41
Ocyurus chrysurus				18		7		2	1		6	1			1		3	39
Panulirus argus				1								1						2
Rhombhoplites aurorubens								2	2					8	4			16
Scarus taeniopterus						1	1											2

↓**Species Station→**	**26**	**32**	**46**	**49**	**54**	**59**	**61**	**66**	**68**	**73**	**78**	**79**	**84**	**86**	**89**	**95**	**96**	**Total**
Scorpaena brasiliensis						1												1
S. plumieri									1	1	1						1	4
Seriola rivoliana															2		1	3
Serranus tabacarius															1			1
Sparisoma viride								2										2
Sphyraena barracuda				1			1			1					1			4
Synodus foetens		1																1
S. intermedius								1										1
Trachinocephalus myops		1																1
Xanthichthys ringen						2												2
Total	11	15	10	265	39	154	139	70	150	155	63	54	143	17	50	103	187	1625

Table 5. Diversity index by station and average fish caught by trip per station

Station	# Trips	# Species	Diversity/Effort index	Station	# Fish caught	Fish caught/ Trips
79	2	13	6.50	61	139	69.5
61	2	12	6.00	73	155	51.7
46	2	10	5.00	49	265	37.9
73	3	15	5.00	84	143	35.8
32	4	15	3.75	96	187	31.2
96	6	22	3.67	79	54	27.0
86	2	7	3.50	95	103	25.8
49	7	21	3.00	59	154	25.7
59	6	18	3.00	68	150	21.4
68	7	17	2.43	66	170	18.9
89	6	14	2.33	86	17	8.5
84	4	8	2.00	89	50	8.3
66	9	16	1.78	78	63	7.9
95	4	7	1.75	54	39	6.5
78	8	12	1.50	46	10	5.0
54	6	8	1.33	32	15	3.8
26	8	3	0.38	26	11	1.4

Table 6. Number of individuals caught of each species by fishing gear

Species	HL	FT	Total
Acanthurus bahianus		31	31
Acanthurus chirurgus		4	4
Acanthurus coerulus		21	21
Alectis ciliaris	2		2
Aluterus monocerus		1	1
Anisotremus virginicus		1	1
Apsilus dentatus	1		1
Balistes capriscus		4	4
Balistes vetula	11	3	14
Bothus lunatus		2	2
Calamus calamus	1	2	3
Calamus pennatula	55	21	76
Cantherbines macrocerus		1	1
Cantherbines pullus		1	1
Canthidermis sufflamen	2		2
Caranx bartholomaei	2	1	3
Caranx crysos	38	4	42
Caranx lugubris	10		10
Caranx ruber	2	5	7
Cephalopholis cruentatus	10	4	14
Cephalopholis fulva	382	81	463
Chaetodon striatus		2	2
Diodon hystrix	1		1
Echeneis naucrate	2		2
Elegatis bipinnulata	2		2
Epinephelus guttatus	273	34	307
Epinephelus striatus	1		1
Haemulos aurolineatum	3		3
Haemulon flavolineatum		5	5
Haemulos plumieri	3	50	53
Halichoeres garnoti	3		3
Holocenthrus adscensionis	76	49	125
Holocentrus rufus	44	3	47
Lactophrys polygonius		4	4
Lactophrys quadricornis		10	10
Lactophrys trigonus	5		5
Lutjanus buccanella	5	2	7
Lutjanus jocu		1	1
Lutjanus synagris	14	18	32
Lutjanus vivanus	2	4	6
Malacabtus plumieri	186		186
Melichthys niger	41		41
Ocyurus chrysurus	6	33	39
Panulirus argus		2	2

Species	HL	FT	Total
Rhombhoplites aurorubens	7	9	16
Scarus taeniopterus		2	2
Scorpaena brasiliensis	1		1
Scorpaena plumieri	3	1	4
Seriola rivoliana	3		3
Serranus tabacarius	1		1
Sparisoma viride		2	2
Sphyraena barracuda	4		4
Synodus foetens	1		1
Synodus intermedius	1		1
Trachinocephalus myops	1		1
Xanthichthys ringen		2	2
Grand Total	1205	420	1625

Table 7. Fish species caught by only one fishing method

Caught by fish trap only	Caught by hook and line only
Acanthurus bahianus	*Malacanthus plumieri*
Acanthurus coerulus	*Melichthys niger*
Lactophrys quadricornis	*Caranx lugubris*
Haemulon flavolineatum	*Lactophrys trigonus*
Acanthurus chirurgus	*Sphyraena barracuda*
Balistes capriscus	*Haemulon aurolineatum*
Lactophrys polygonius	*Halichoeres garnoti*
Bothus lunatus	*Seriola rivoliana*
Chaetodon striatus	*Alectis ciliaris*
Panulirus argus	*Canthidermis sufflamen*
Scarus taeniopterus	*Echeneis naucrate*
Sparisoma viride	*Elegatis bipinnulata*
Xanthichthys ringen	*Apsilus dentatus*
Aluterus monocerus	*Diodon hystrix*
Anisotremus virginicus	*Epinephelus striatus*
Cantherbines macrocerus	*Scorpaena brasiliensis*
Cantherbines pullus	*Serranus tabacarius*
Lutjanus jocu	*Synodus foetens*
	Synodus intermedius
	Trachinocephalus myops

Table 8. Summary of Catch per Unit Effort for fishermen and the comparison with the CUE of the sampling period April 1, 2000 to March 31, 2001

Fisher ID	Trips	Hrs fish	Weight (g)	g/hk hrs		g/hk hrs/trip		g/trip	
				2006	2001*	2006	2001*	2006	2001*
1	3	12.4	710	57.18	1.34	19.06	17	236.7	655
4	9	36.2	14792	408.6	4.16	45.40	65.3	1644	1605.6
6	51	204.7	25245	123.3	21.51	2.42	178.9	495	3097
9	3	13.9	14716	1057	5.78	352.48	84.4	4905	1788
11	68	275.8	95797	347.3	10.19	5.11	88.03	1409	1525
12	3	16.1	23160	1433	0.35	477.53	995.1	7720	9157
13	78	323.1	118467	366.6	64.9	4.70	216	1519	3861
16	41	164.2	71050	432.6	4.49	10.55	19.47	1733	1000
22	4	20	9700	485		121.25		2425	
26	5	20.5	21024	1024		204.78		4205	
28	10	40.5	48449	1195		119.53		4845	
			Avg	630	14.09	123.89	208	2831	2836.08

* Not the same fishers

Red numbers- Regular fishers crew

Table 9. Summary of catch per unit effort by station

Station	Grams	g/line days	g/ hook hours
26	1510	62.9	5.2
54	1430	79.4	6.5
86	950	158.3	13.2
32	3880	323.3	26.9
78	8640	345.6	27.9
46	2090	348.3	27.9
66	15880	588.1	49.0
68	21400	1019.0	85.3
89	25250	1402.8	112.2
79	9220	1536.7	124.7
59	34800	1740.0	149.1
49	37050	1764.3	147.0
95	34320	2640.0	208.9
96	57730	2886.5	240.5
61	41900	4190.0	344.1
84	76500	5100.0	354.2
73	70570	5880.8	483.4

Table 9a. Summary of catch per unit effort by depth category

Depth	grams	g/ hook hours	g/ line days
Shallow	95070	79.78	970.1
Medium	82730	75.13	899.2
Deep	265320	249.5	3159

Grams include only those caught by hook and l line

Table 10. Catch per unit effort for the three main species caught by hook and line compared with the results of 2001

	Shallow				Medium				Deep			
	2006	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006	2001
	g/l d	g/l d	g/hk hrs	g/hk hrs	g/l d	g/l d	g/hk hrs	g/hk hrs	g/l d	g/l d	g/hk hrs	g/hk hrs
E. guttatus	91.1	183.8	7.5	237.8	19.9	99.9	1221.2	96.5	289.4	460.6	96.5	8.5
C. fulva	295.5	612.7	24.3	164.9	13.8	363.9	350.0	27.7	83.0	403.3	27.7	1.1
M. plumieri	157.1	824.6	12.9	62.0	5.2	113.9	466.7	36.9	110.6	27.7	36.9	0.5

g/l d= g/line days g/hk hrs= g/ hook hours
blue numbers= decrease when compared with 2001
red numbers= increase when compared with 2001

Table 11. Information on histology samples taken from several fish caught during the sampling period.

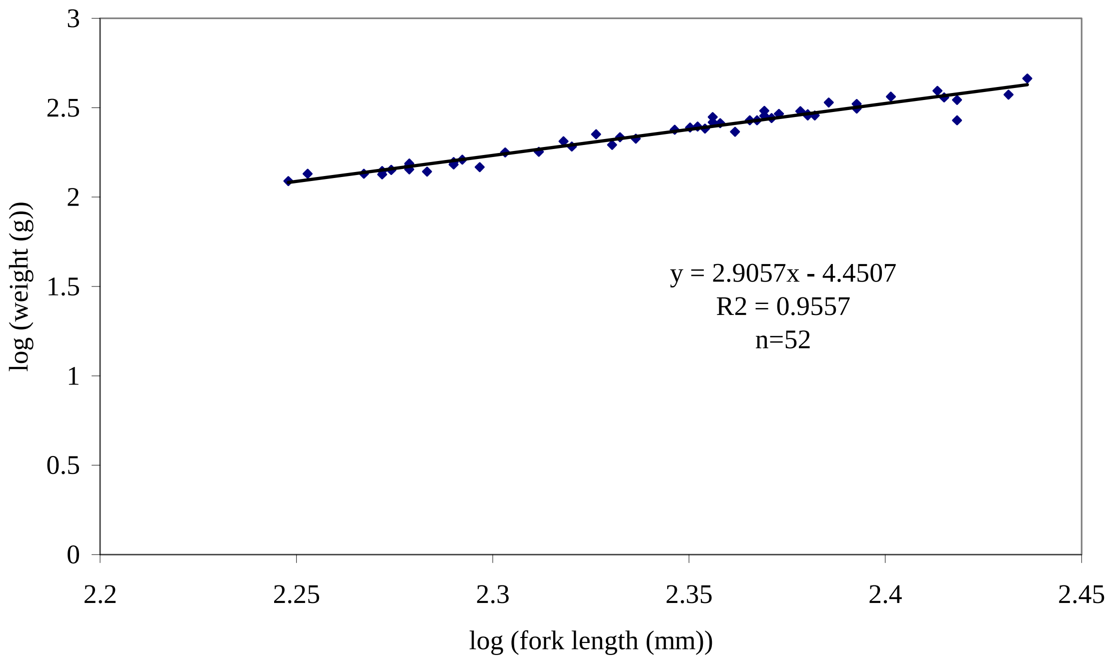
			Visual Identification		Histology results	
Date	**Gonad ID**	**Species**	**Sex**	**Stage**	**Sex**	**Stage**
23-ago-05	1	C. fulva	F	2	NG	
23-ago-05	2	C. fulva	F	2	NG	
23-ago-05	3	O. chrysurus	M	4	M	M
18-ago-05	4	E. guttatus	F	3	F	2
18-ago-05	5	E. guttatus	F	3	NG	
18-ago-05	6	E. guttatus	F	3	F	2
18-ago-05	7	E. guttatus	F	3	F	2
18-ago-05	8	E. guttatus	F	2	D	
18-ago-05	9	E. guttatus	F	3	F	2
18-ago-05	10	E. guttatus	F	3	F	2
18-ago-05	11	C. fulva	F	3	F	2
18-ago-05	12	L. buccanella	F	2	M	M
18-ago-05	13	L. buccanella	M	2	NG	
18-ago-05	14	M. plumieri	F	4	F	3
18-ago-05	15	M. plumieri	M	3	M	M
18-ago-05	16	M. plumieri	F	2	NG	
18-ago-05	17	M. plumieri	F	2	M	M
18-ago-05	18	M. plumieri	NS			
18-ago-05	19	M. plumieri	F	2	NG	
18-ago-05	20	M. plumieri	F	2	F	
18-ago-05	21	M. plumieri	F	3	F	5
18-ago-05	22	M. plumieri	F	2	M	
23-ago-05	23	O. chrysurus	M	4	M	M
22-ago-05	24	C. pennatula	M	2	NG	
23-ago-05	25	O. chrysurus	F	4	F	4
23-ago-05	26	O. chrysurus	M	4	M	M
23-ago-05	27	O. chrysurus	NS			
23-ago-05	28	O. chrysurus	NS			
22-ago-05	29	C. chrysos	NS			
18-ago-05	30	L. buccanella	NS			
18-ago-05	31	C. fulva	F	3	NG	
18-ago-05	32	C. fulva	F	2	F	2
18-ago-05	33	M. plumieri	F	3	F	3
18-ago-05	34	M. plumieri	F	2	M	M
18-ago-05	35	A. dentatus	M	2	NG	
13-Sep-05	1	C. pennatula	M	2	M	M
13-Sep-05	2	C. pennatula	F	5	H	
13-Sep-05	3	C. pennatula	F	2	F	
13-Sep-05	4	C. pennatula	M	5	NG	

			Visual Identification		Histology results	
Date	**Gonad ID**	**Species**	**Sex**	**Stage**	**Sex**	**Stage**
14-Sep-05	5	C. cruentatus	F	2	NG	
14-Sep-05	6	C. cruentatus	F	2	NG	
8-Sep-05	7	E. guttatus	F	3	H	
8-Sep-05	8	E. guttatus	F	3	F	2
8-Sep-05	9	E. guttatus	F	3	F	2
8-Sep-05	10	C. fulva	F	2	M	M
8-Sep-05	11	H. adscensionis	F	3	F	2
8-Sep-05	12	E. guttatus	F	5	M	M
8-Sep-05	13	E. guttatus	F	3	F	2
16-Sep-05	1	H. rufus	M	4	F	2
16-Sep-05	2	H. rufus	F	4	F	4
16-Sep-05	3	H. rufus	F	4	F	4
16-Sep-05	4	C. fulva	F	5	D	
16-Sep-05	5	C. fulva	F	2	F	2
16-Sep-05	6	C. cruentatus	F	2	M	M
16-Sep-05	7	C. pennatula	M	5	M	M
16-Sep-05	8	M. plumieri	F	2	M	M
16-Sep-05	9	C. fulva	NS			
20-Sep-05	10	H. plumieri	F	3	H	
20-Sep-05	11	E. guttatus	F	2	H	
16-Sep-05	12	O. chrysurus	M	5	M	M
16-Sep-05	13	C. fulva	F	2	F	2
16-Sep-05	14	M. plumieri	M	2	M	2
16-Sep-05	15	M. plumieri	M	2	NG	
20-Sep-05	16	C. fulva	F	5	F	
20-Sep-05	17	C. fulva	F	5	H	
20-Sep-05	18	C. fulva	F	5	NG	
16-Sep-05	19	C. ruber	F	2	M	M
16-Sep-05	20	C. ruber	F	3	F	2
16-Sep-05	21		NS			
20-Sep-05	22	H. plumieri	M	2	M	M
20-Sep-05	23	H. plumieri	F	4	F	4
20-Sep-05	24	O. chrysurus	F	3	F	2
20-Sep-05	25	C. fulva	F	5	H	
20-Sep-05	26	O. chrysurus	M	3	M	M
20-Sep-05	27	O. chrysurus	M	3	M	M
20-Sep-05	28	H. plumieri	F	4	F	4
20-Sep-05	29	C. pennatula				
20-Sep-05	30	C. pennatula	F	5	H	
20-Sep-05	31	C. pennatula	F	3	F	2
20-Sep-05	32	E. guttatus	F	3	NG	
20-Sep-05	33	O. chrysurus	F	3	F	2

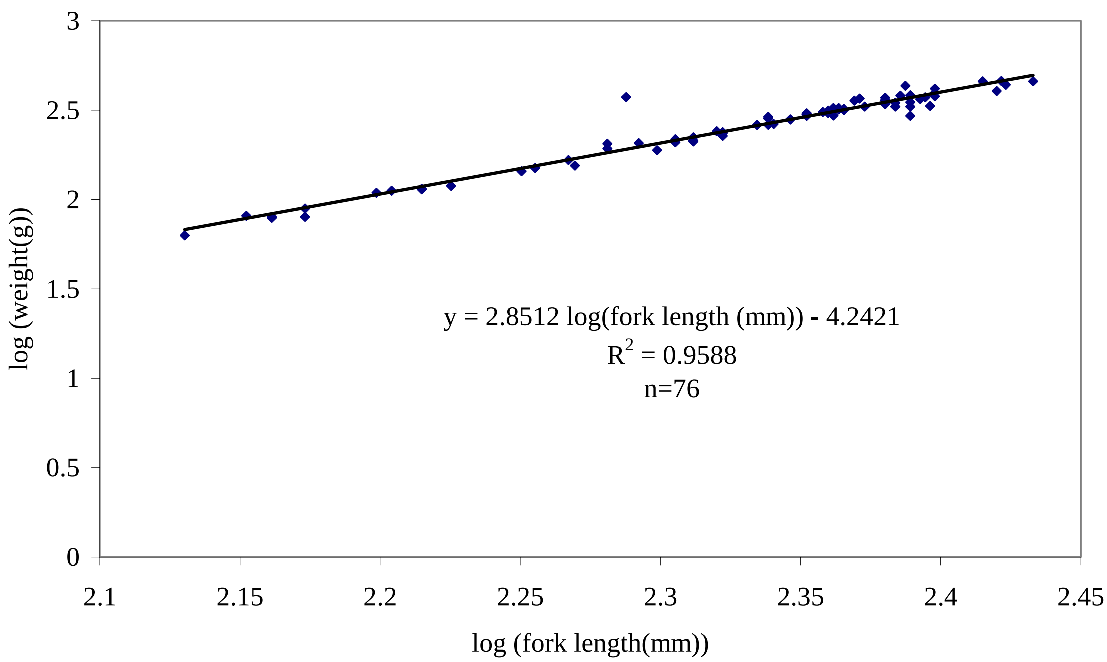
			Visual Identification		Histology results	
Date	**Gonad ID**	**Species**	**Sex**	**Stage**	**Sex**	**Stage**
20-Sep-05	34	H. adscensionis	M	2	M	M
6-Oct-05		C. fulva	M	3	F	2
6-Oct-05		E. guttatus	M	3	F	2
6-Oct-05		R. aurorubens	M	3	M	M

D- Decomposed gonad- Bad slide   1- Undetermined   3- Enlarging
NG- Tissue in the slide is not gonad   2- Resting   4- Running ripe
NS- No slide prepared   5- Spent
H- Hermaphrodite   M- Male   F-Female
For Histology in males stage were M- Mature   I- Inmature

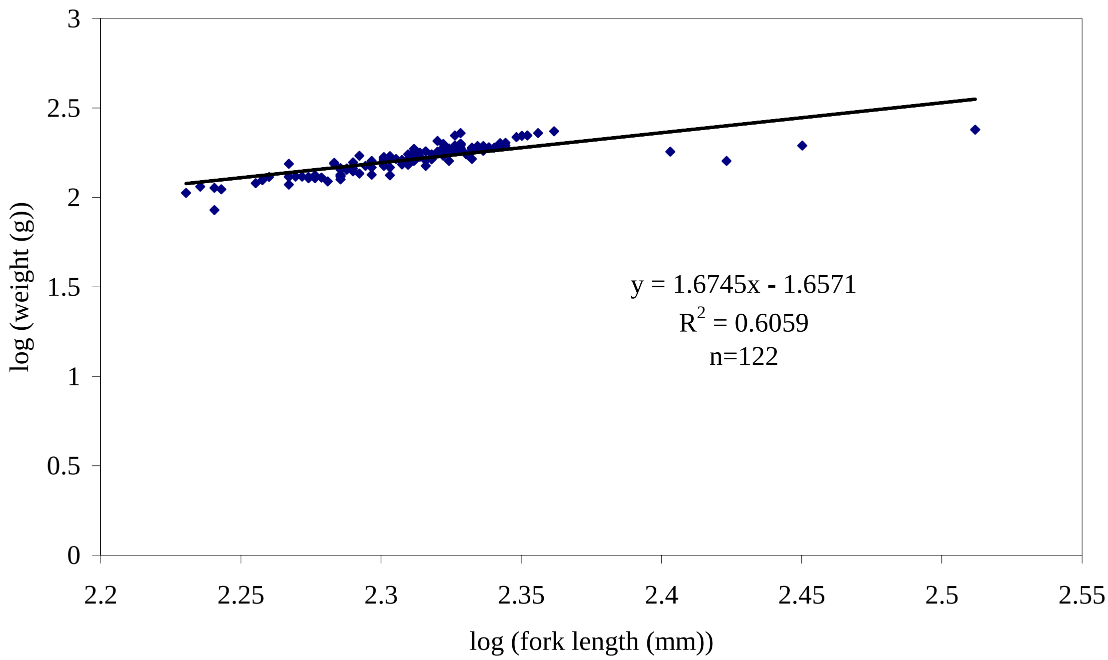
Graph 1. Length-weight relation for H. plumieri



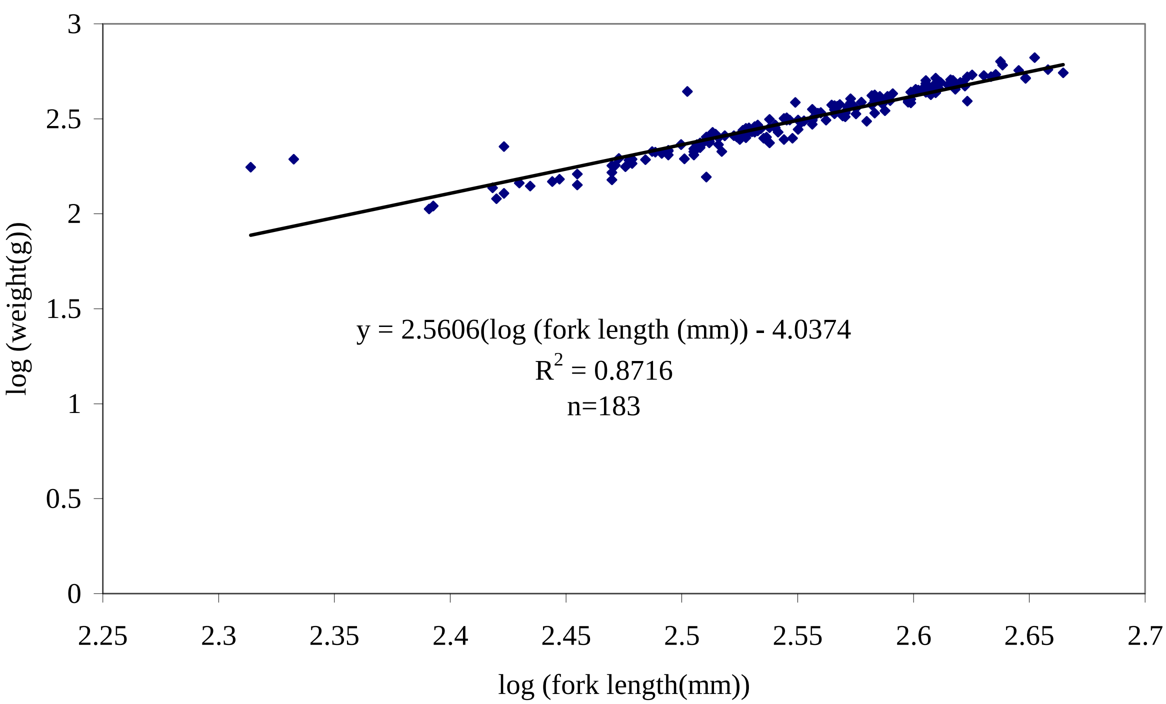
Graph 2. Length-weight relation for *C. pennatula*



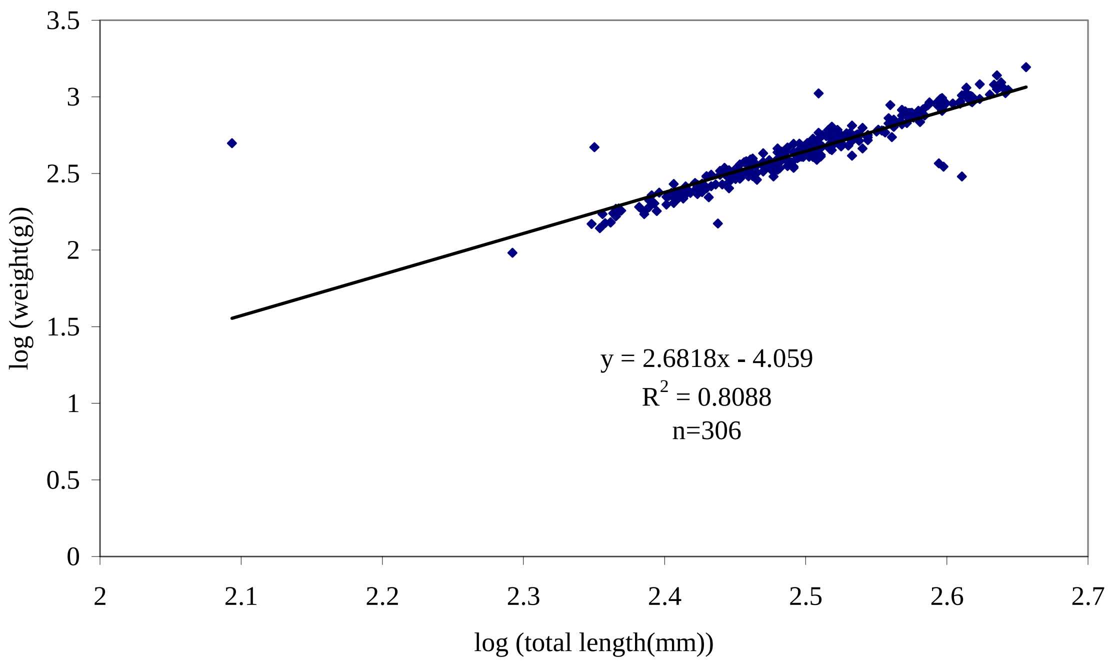
Graph 3. Length-weight relation for *H. adscensionis*



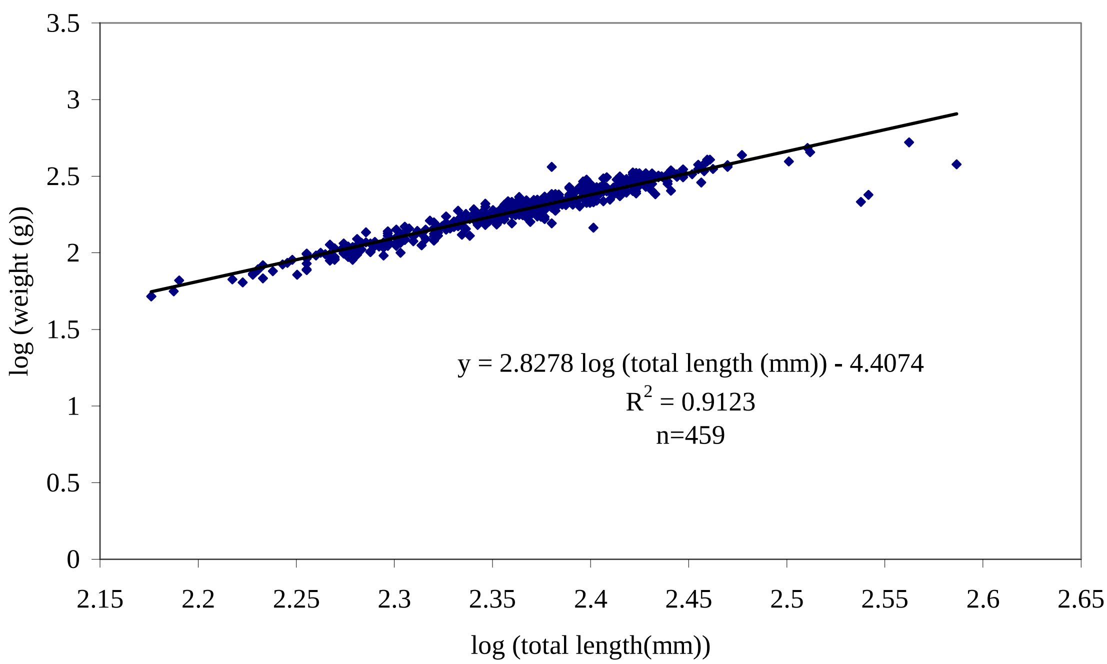
Graph 4. Length-weight relation for *M. plumieri*



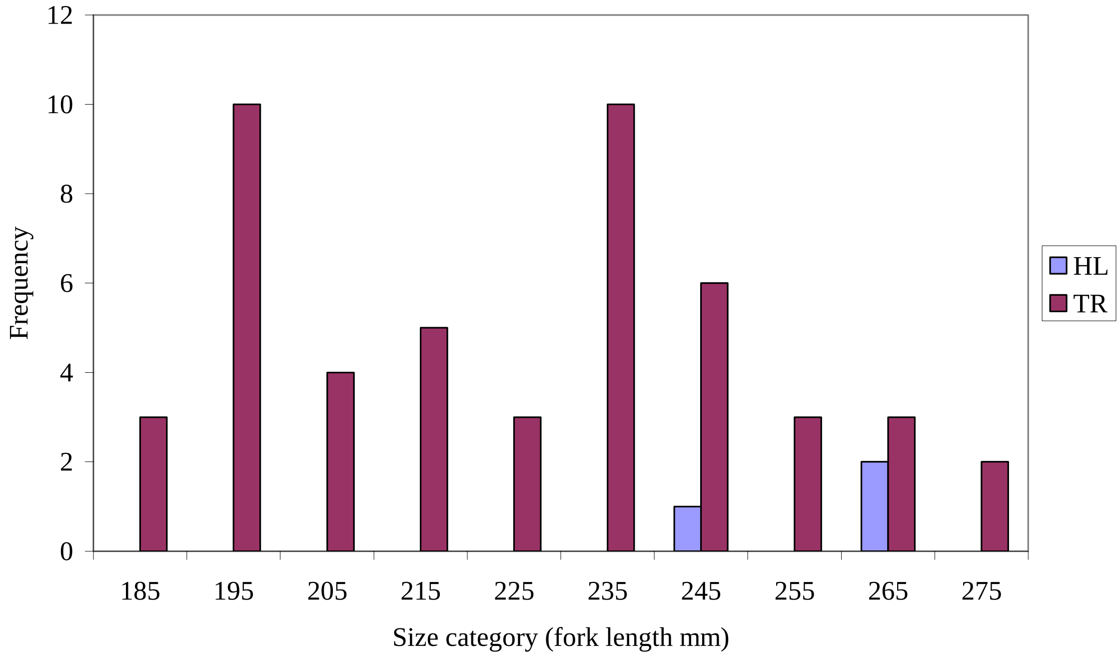
Graph 5. Length-weight relation for *E. guttatus*



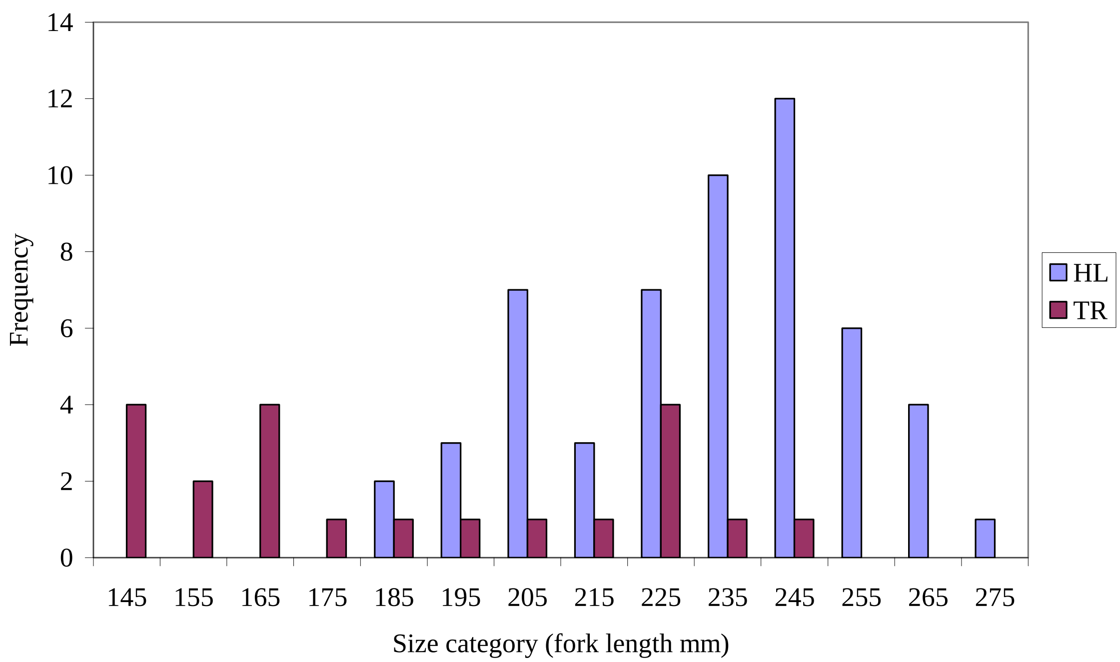
Graph 6. Length-weight relation for *C. fulva*



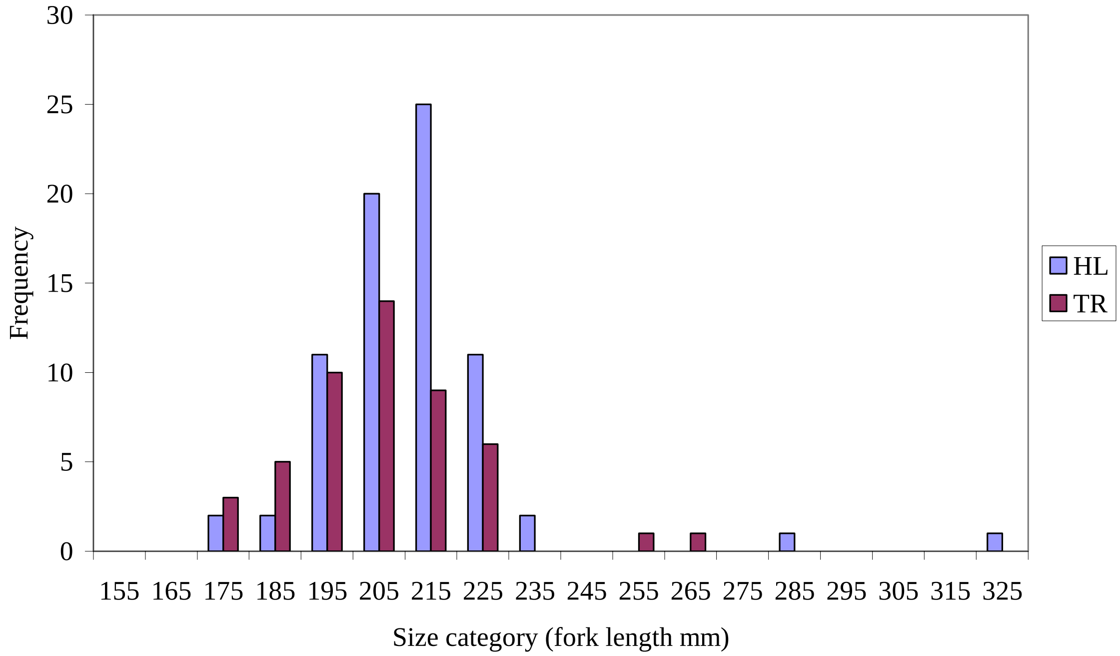
Graph 7. Length frequency distribution for *Haemulon plumieri*



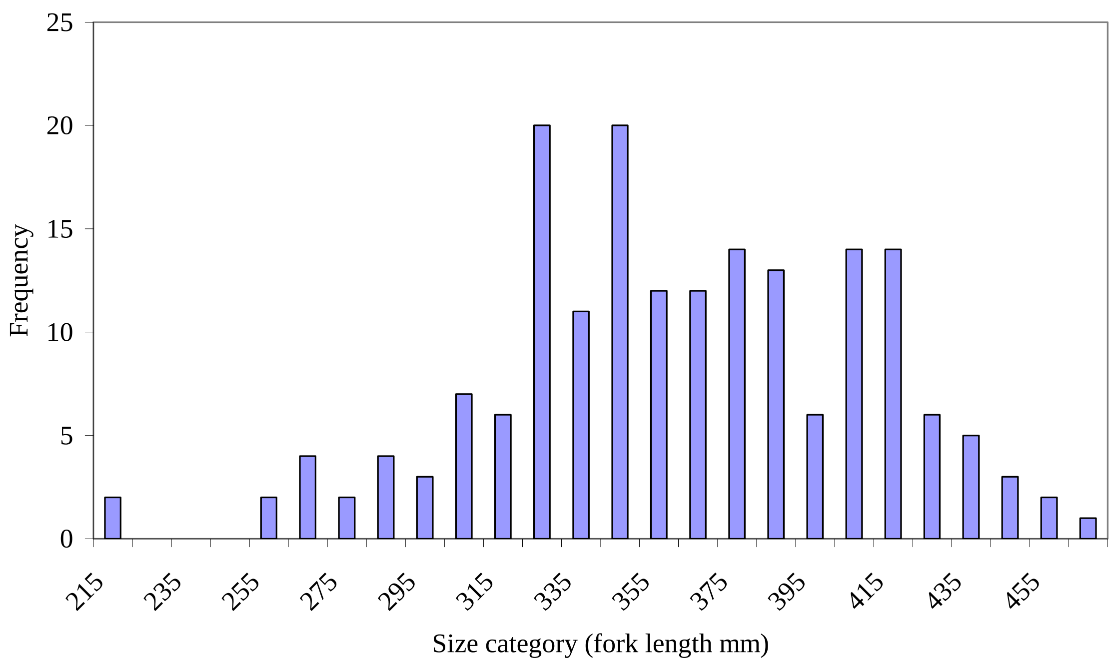
Graph 8. Length frequency distribution for *Calamus pennatula*



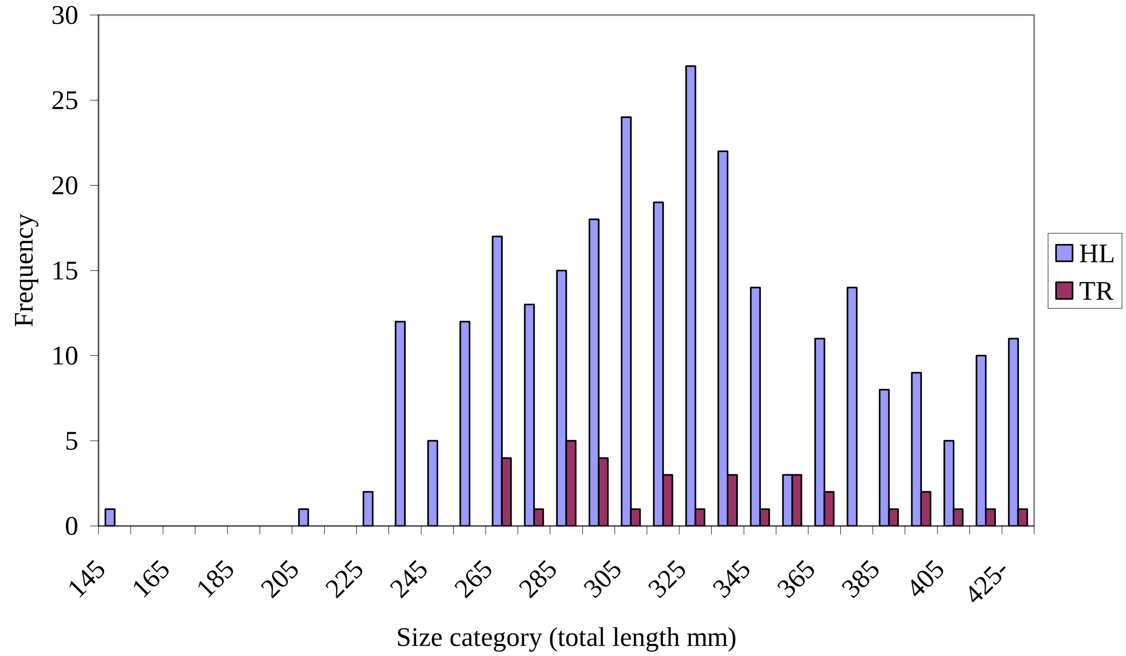
Graph 9. Length frequency distribution for *Holocenthrus adscencionis*



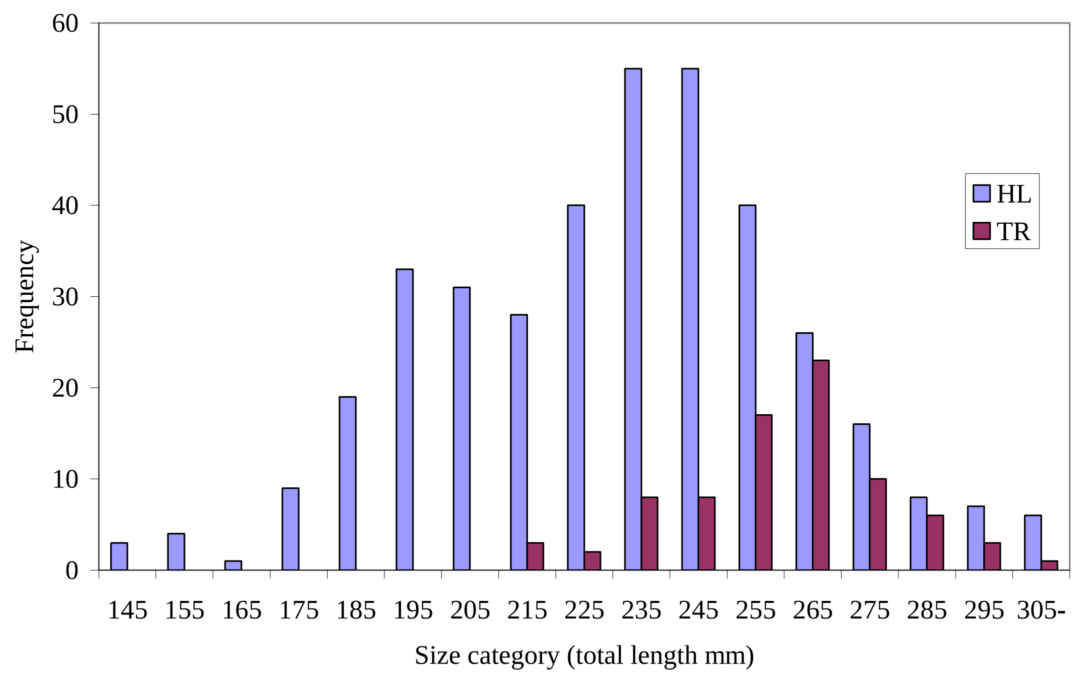
Graph 10. Length frequency distribution for *Malacanthus plumieri*



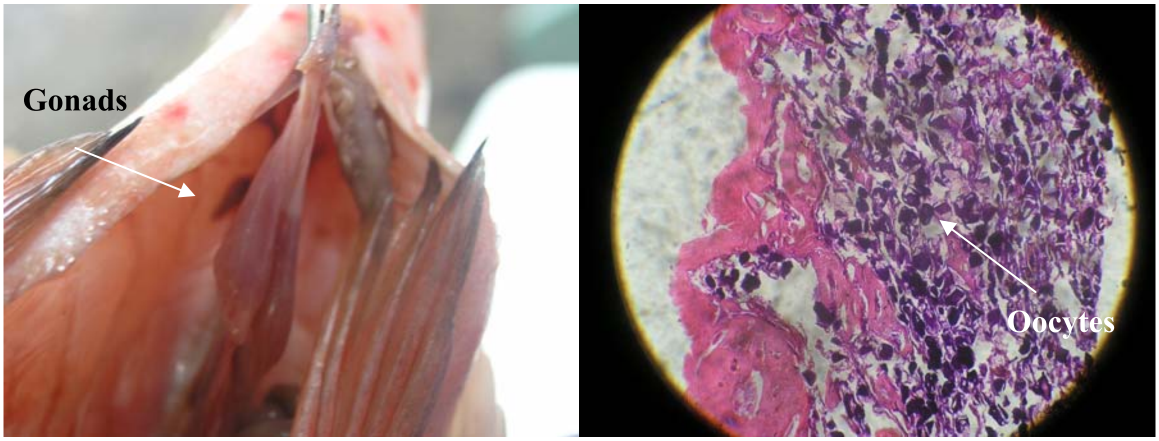
Graph 11. Length frequency distribution for *Epinephelus guttatus*



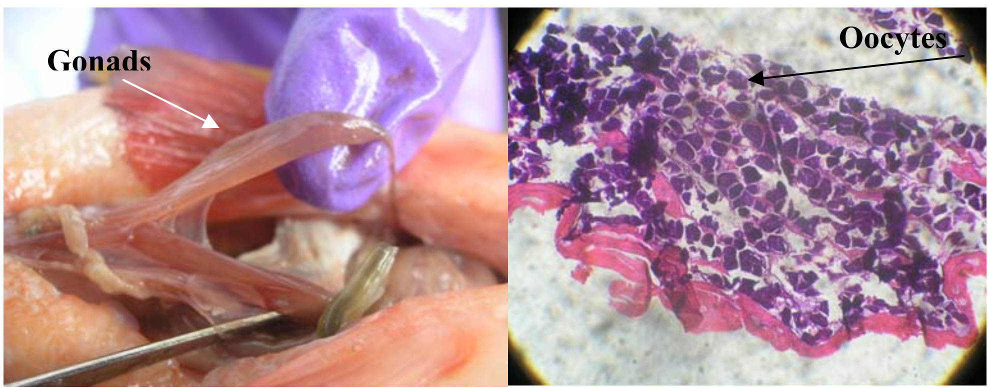
Graph 12. Length frequency distribution for *Cephalopholis fulva*



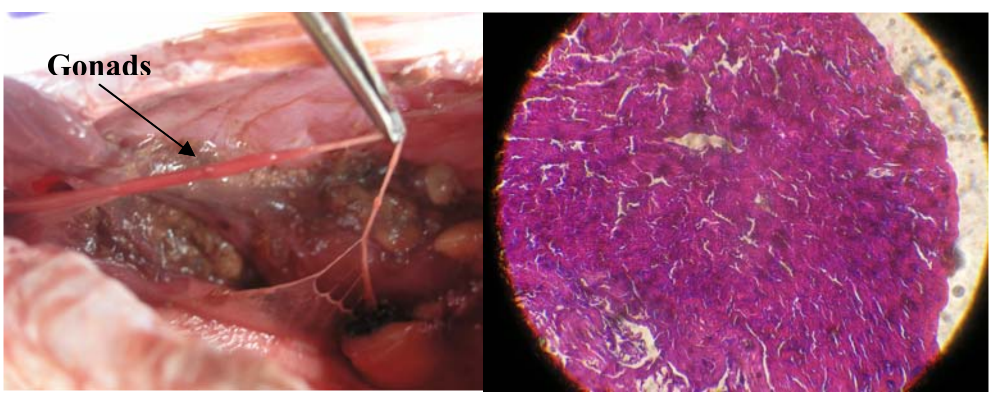
APPENDIX 1. Identification of reproductive stage of certain fish species - Histology



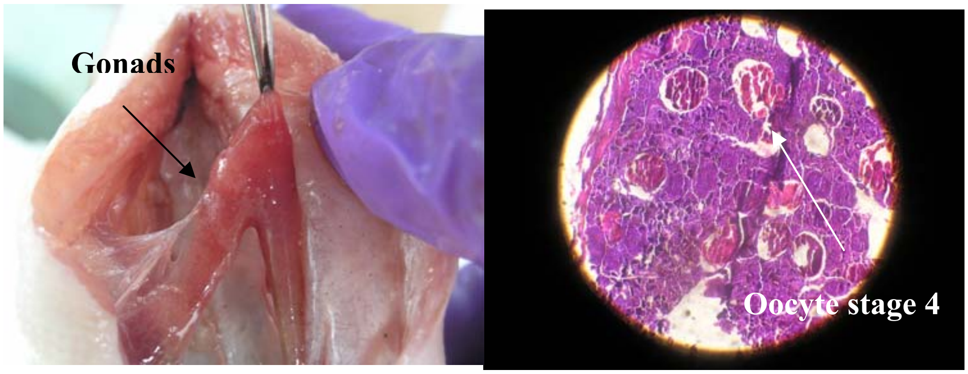
E. guttatus Female Stage 2- Inactive, Mature, Resting, Oocytes in stage 1 and 2. Thick and convoluted tunica indicates is not inmature



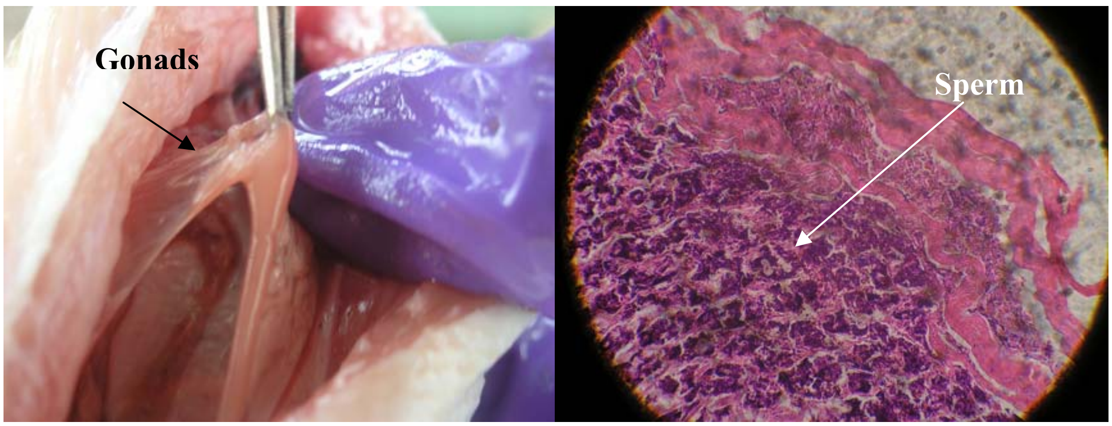
C. fulva Female Stage 2- Inactive, Mature, Resting, Oocytes in stage 1 and 2



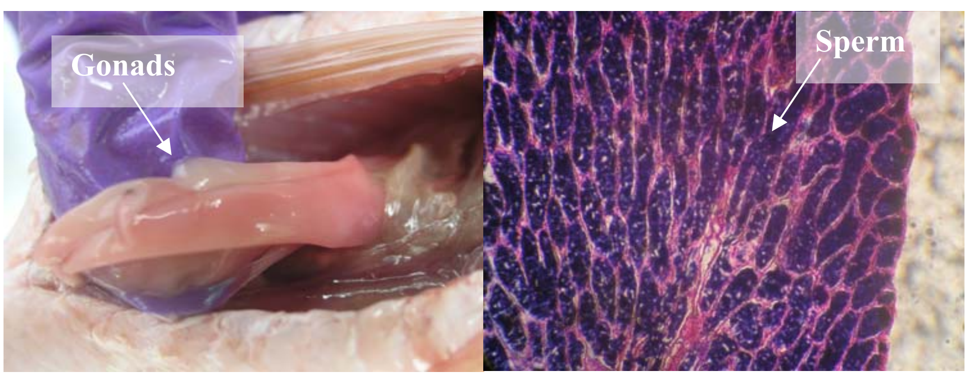
L. buccanella Male Undetermined stage



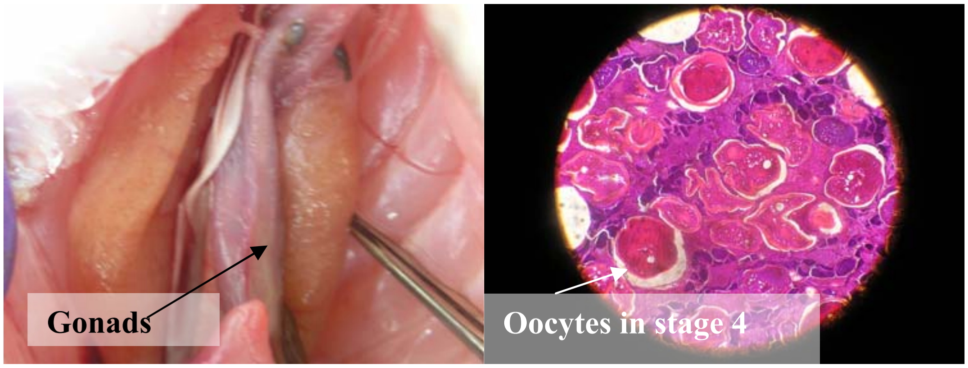
M. plumieri Female Stage 3- Mature, Active, Enlarging, Some oocytes in stage 4



M. plumieri Male- Mature

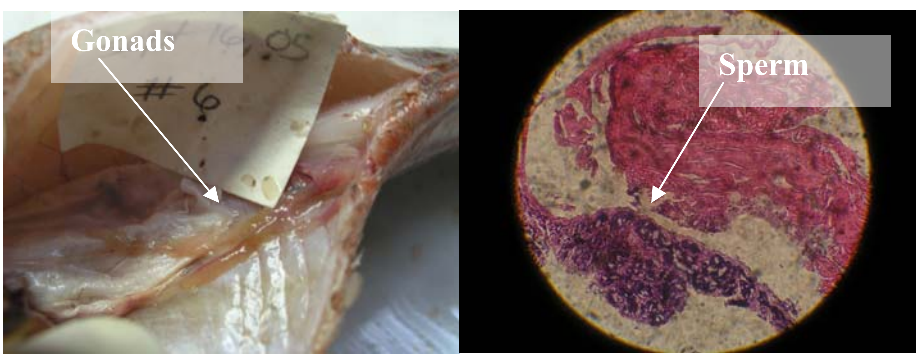


O. chrysurus Male- Mature



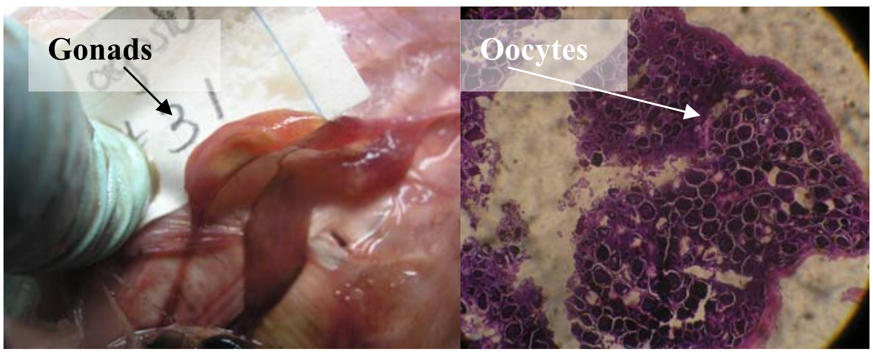
O. chrysurus Female Stage 4- Ripe, Many oocytes in stage

H. rufus Female Stage 4- Ripe, Oocytes in stage 4, almost 5

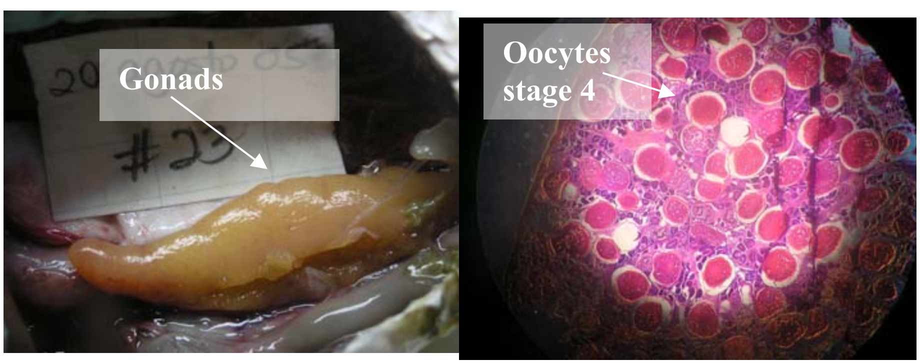


C. cruentatus Male- Mature

C. pennatula Male- Mature



C. pennatula Female Stage 2- Mature inactive, Resting. Oocytes in stage 1 and 2



H. plumieri Female Stage 4- Ripe, oocytes stage 4

WHELK (*Cittarium pica*) SURVEYS

INTRODUCTION

The West Indian topshell, *Cittarium pica*, is among the Caribbean gastropods, one of the most valuable as food item (Bell, 1992; Randall, 1964). It lives on the rocky intertidal area, presenting zonation between larger and smaller individuals (Debrot, 1990b). It feeds nocturnally on algae. The West Indian topshell is fished throughout its range, and in many cases overexploited (Bell, 1992). In Puerto Rico, based on preliminary commercial landing statistics, the landings appeared to be diminishing; from 1270 pounds in 2001 to 906 pounds in 2003 (Fisheries Research Laboratory unpublished data). A regulation has been proposed to establish a minimum capture size for this species in an effort to attain sustainable management of it. But, to determine the correct minimum capture size we must know detail information on the reproduction of the species.

A study conducted in the Virgin Islands reported that females reach sexual maturity at a shell width of 33.7mm and males earlier (Schmidt, 2001). Studying the West Indian topshell in the Bahamas, Debrot (1987) suggested a minimum capture size of 70mm to maximize the yield at the targeted sites. In Bermudas the minimum capture size is 45 mm, and the monitoring conducted in the region determined that the mollusk become reproductively mature during their third year (Coates et al., 2004). Ambiguity on this matter makes it difficult to established or support the proposed regulation. The lack of biological and ecological information of this resource is one of the main problems in terms of management.

Before trying to pull out such a regulation there is a need to gathered information on the biology of the species. A regulation not based on this could be worst than no regulation at all. In Puerto Rico no study addressing the population status, biology or ecology of this species has been conducted. A start point is to determine the distribution of the West Indian topshell around the island, collect general information on the populations found and corroborate the fishing pressure over this resource.

OBJECTIVE

The main goal is to collect baseline data on the size, distribution, and density of the whelk populations around the coasts of Puerto Rico. Information collected will be part of the foundation for making management decisions. Results of this survey will also provide the basis for future time series studies on the whelk stocks in Puerto Rico.

METHODOLOGY

Sites selection

Commercial catch reports data files were reviewed to identified whelk fishermen. These were interviewed about fishing methodology, sites and general knowledge on the West Indian topshell. Sites for the study were selected randomly from the fishing sites noted by the fishermen, choosing only ten transects per coastline (north, south, east and west). Table 1 and Map 1 summarize the location of the sites.

Sites information

On the north coast, prevailing high seas and bad weather prevented the access to the high wave-stress areas identified as fished sites. On these localities an area close to the main area of interest was used. These areas were usually protected areas in which the weather was not a risk for the persons performing the survey. The amount of small size shell snails found at these sites was remarkable. The observation contradicts what has been report for Bahamas (Debrot, 1986; 1990a) where the greater amount of larger shell size snails found on protected areas was related to a minor predator density. The average shell size found on the Puerto Rico north coast was 20mm.

Transects on the east coast were on the keys called La Cordillera. The keys are characterized for having a wave-stress side and a protected side. Transects were done on the wave-stress side avoiding risky or life-threatening areas. The average shell size found on the east coast was 46mm. One of the reasons for which average shell size on the east coast is greater than in other coastal sides might be a reduction on fishing pressure because of the sites inaccessibility and the prevailing high waves. The general weather conditions under which the surveys were done could be considered life-threatening for the general public, including fishermen.

Survey conditions on the south varied. Two transects on the south east were on keys. The snails were found under the rocks at the reef crest of the key. At this locations the back reef was not surveyed to keep fidelity to the transect size (1m from the line) used as part of the methodology. Because of their size-specific zonation (Debrot, 1990b), larger individuals were probably on this unsurveyed area. Three transects were on Caja de Muerto Island on the south. The area surveyed was the windward. The other five transects were on the mainland rocky shore. The average shell size on the south coast was 32mm.

Six of the ten transects on the west coast were on offshore islands, Mona Island and Desecheo Island. Both are renowned fished sites, but not of easy access. Trips to these islands could take from two to eight hours. The other four were on the mainland rocky shore. Average shell size on the west coast was 38mm.

Survey methodology

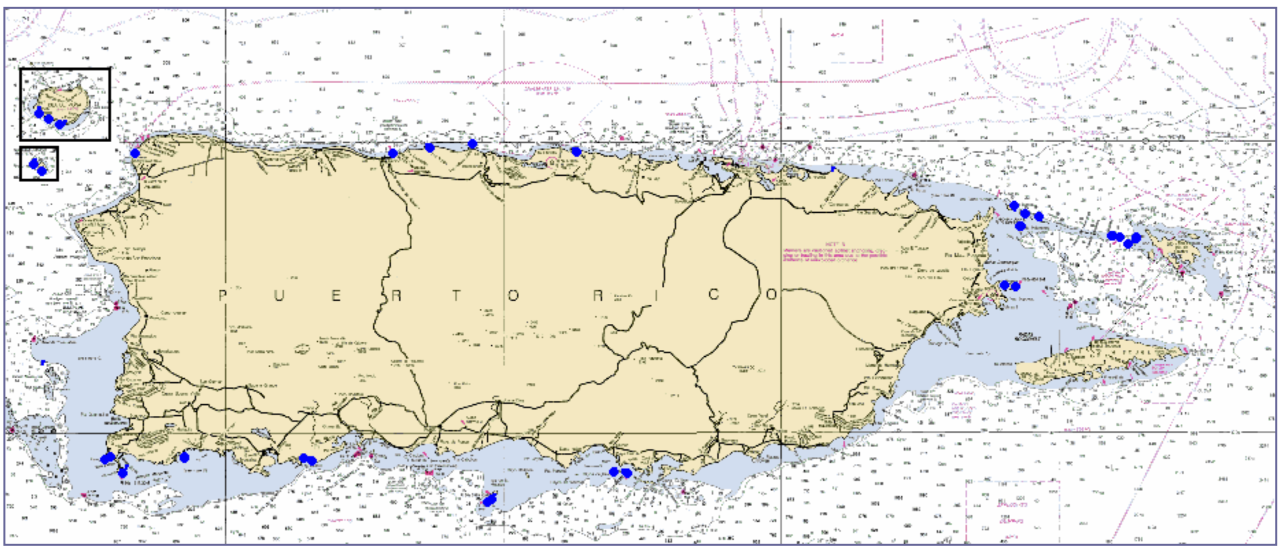
Knowing that *Cittarium pica* lives mostly in the cracks, fissures and under rocks on the surf zone during daylight, feeding usually at night (Robertson, 2003); the surveys were done at daytime, for safety reasons, but thoroughly searching on creeds and under rocks. At each site a 100 m line was deployed along the contour of the shore line. The line was marked with floats every 10 m which made ten transects. The line had weights on both ends for it to stay in place. Using snorkel gear when necessary, all the individuals found in each transect were collected up to a depth limit of 1m. The shell length and the base diameter of every individual collected were measured with a caliper. The collected individuals were returned to the area where they were found.

Table 1. Site location of the whelk surveys.

Survey	**Coast**	**Date**	**Locality**	**Latitude**	**Longitude**
1	South	7-Oct-03	Caja de Muertos, Morrillo	17°53.02'N	66°31.67'W
2	South	15-Oct-03	Caja de Muertos, Cayo	17°52.91'N	66°31.90'W
3	South	16-Oct-03	Caja de Muertos	17°53.48'N	66°31.05'W
4	South	25-Nov-03	Guánica- Atolladora	17°57.23'N	66°51.07'W
5	North	21-Jan-04	Barceloneta	18°29.25'N	66°33.47'W
6	South	23-Jan-04	Faro Cabo Rojo	17°55.58'N	67°11.27'W
7	South	3-Feb-04	Isla Cuevas, Lajas	17°56.30'N	67°04.38'W
8	South	25-Feb-04	Cayo Ratones, Salinas	17°56.00'N	66°16.59'W
9	South	26-Feb-04	Cayo Caracoles, Santa Isabel	17°56.24'N	66°17.98'W
10	West	6-Apr-04	Punta Aguila, Cabo Rojo	17°57.07'N	67°12.61'W
11	West	23-Apr-04	Punta Aguila, Cabo Rojo	17°57.07'N	67°12.51'W
12	West	28-May-04	Las Carmelitas, Mona	18°05.58'N	67°56.09'W
13	West	28-May-04	Sardinera, Mona	18°05.30'N	67°56.17'W
14	West	30-May-04	Carabinero, Mona	18°04.05'N	67°55.32'W
15	West	15-Jun-04	Punta Borinquen, Aguadilla	18°29.05'N	67°10.01'W
16	North	16-Jun-04	El Muelle, Barceloneta	18°29.17'N	66°33.45'W
17	East	22-Jun-04	Cayo Agua, Culebra	18°18.43'N	65°20.54'W
18	East	23-Jun-04	Cayo Yerba, Culebra	18°18.40'N	65°21.18'W
19	East	24-Jun-04	Cayo Lobo, Culebra	18°19.24'N	65°22.44'W
20	East	24-Jun-04	Cayo Lobito, Culebra	18°19.59'N	65°23.34'W
21	West	8-Jul-04	Puerto Los Botes, Desecheo	18°22.57'N	67°29.10'W
22	East	3-Aug-04	Cayo Piñero, Fajardo	18°15.24'N	65°36.02'W
23	East	3-Aug-04	Cayo Perro, Fajardo	18°14.57'N	65°34.43'W
24	North	11-Aug-04	La Cueva del Indio, Arecibo	18°29.32'N	66°38.30'W
25	West	17-Aug-04	Desecheo	18°22.50'N	67°29.01'W
26	South	19-Aug-04	Guanica	17°57.17'N	66°50.71'W
27	North	22-Aug-04	El Faro, Arecibo	18°28.55'N	66°42.05'W
28	East	24-Aug-04	Cayo ratones, Fajardo	18°22.50'N	65°34.46'W
29	East	25-Aug-04	Palomino	18°21.12'N	65°34.09'W
30	West	7-Sep-04	El Faro, Cabo Rojo	17°56.04'N	67°11.44'W
31	North	13-Sep-04	Vacía Talega, Loíza	18°27.02'N	65°54.20'W

Table 1. Site location of the whelk surveys.					
Survey	**Coast**	**Date**	**Locality**	**Latitude**	**Longitude**
32	North	13-Sep-04	Mar Bella, Vega Baja	18°29.31'N	66°22.38'W
33	North	21-Sep-04	Manatí	18°28.53'N	66°31.10'W
34	West	13-Oct-04	Uvero, Mona	18°03.24'N	67°54.03'W
35	West	13-Oct-04	Luego de Caigo, Mona	18°03.22'N	67°53.59'W
36	East	18-Oct-04	Lobo, Fajardo	18°22.52'N	65°34.14'W
37	East	18-Oct-04	Isla Blanquilla, Fajardo	18°22.09'N	65°32.52'W

Map 1. Whelk survey sites around Puerto Rico



RESULTS

A total of thirty-seven whelk surveys were conducted along the shoreline of Puerto Rico, ten on each coast except the north coast, in which only 7 were conducted because of prevailing bad weather conditions. The maximum shell width found was 124 mm. The average size was 35.3 mm. The average number of individuals found per site was 260. Table 2 summarizes the average size and number of individuals found per site. Graphs 1- 4 are the whelk size distribution found adding all transects on each coastal side.

Table 2. Data summary of the whelk surveys around Puerto Rico.

#	**Coast**	**Date**	**Lugar**	**Total**	**Max**	**Min**	**Avg**	**Ind/m**
1	South	7-Oct-03	Caja de Muertos, Morrillo	127	93	14	44.6	1.3
2	South	15-Oct-03	Caja de Muertos, Cayo	50	84	14	28.6	0.5
3	South	16-Oct-03	Caja de Muertos	200	97	14	47.1	2.0
4	South	25-Nov-03	Guánica- Atolladora	45	50	19	33.3	0.5
5	North	21-Jan-04	Barceloneta	7	63	18	33.9	0.1
6	South	23-Jan-04	Faro Cabo Rojo	115	49	17	26.0	1.2
7	South	3-Feb-04	Isla Cuevas, Lajas	173	82	18	25.9	1.7
8	South	25-Feb-04	Cayo Ratones, Salinas	721	54	18	33.7	7.2
9	South	25-Feb-04	Cayo Caracoles, Santa Isabel	745	55	18	36.5	7.5
10	West	6-Apr-04	Punta Aguila, Cabo Rojo	12	81	35	64.2	0.1
11	West	23-Apr-04	Punta Aguila, Cabo Rojo	35	90	29	57.2	0.4
12	West	28-May-04	Las Carmelitas, Mona	88	88.5	17	52.8	0.9
13	West	28-May-04	Sardinera, Mona	270	124	13	30.9	2.7
14	West	30-May-04	Carabinero, Mona	177	83	5.5	34.6	1.8
15	West	15-Jun-04	Punta Borinquen, Aguadilla	130	34	11	23.5	1.3
16	North	16-Jun-04	El Muelle, Barceloneta	372	32	7	19.7	3.7
17	East	22-Jun-04	Cayo Agua, Culebra	40	107.1	61.1	81.1	0.4
18	East	23-Jun-04	Cayo Yerba, Culebra	52	96.9	58.2	81.9	0.5
19	East	24-Jun-04	Cayo Lobo, Culebra	105	83.9	7.3	23.6	1.1
20	East	24-Jun-04	Cayo Lobito, Culebra	101	108.8	6.7	53.0	1.0
21	West	8-Jul-04	Puerto Los Botes, Desecheo	462	99.5	5	28.1	4.6
22	East	3-Aug-04	Cayo Piñero, Fajardo	453	80	6	34.0	4.5
23	East	3-Aug-04	Cayo Perro, Fajardo	111	89	13	50.7	1.1
24	North	11-Aug-04	La Cueva del Indio, Arecibo	149	56	8.5	19.6	1.5
25	West	17-Aug-04	Desecheo	199	102	7.5	35.1	2.0
26	South	19-Aug-04	Guánica	101	46	11	21.9	1.0
27	North	22-Aug-04	El Faro, Arecibo	27	32.5	10	16.9	0.3
28	East	24-Aug-04	Cayo Ratones, Fajardo	331	90	9	31.8	3.3
29	East	25-Aug-04	Palomino	289	94.5	6.5	44.8	2.9
30	South	7-Sep-04	El Faro, Cabo Rojo	833	89	6	25.4	8.3
31	North	13-Sep-04	Vacía Talega, Loíza	226	42.8	3	13.7	2.3
32	North	13-Sep-04	Mar Bella, Vega Baja	554	117.7	2	14.6	5.5
33	North	21-Sep-04	Manatí	131	64	5	22.7	1.3
34	West	13-Oct-04	Uvero, Mona	660	79	9	24.3	6.6
35	West	13-Oct-04	Luego de Caigo, Mona	1073	97	8	29.8	10.7
36	East	18-Oct-04	Lobo, Fajardo	244	100	9	32.6	2.4
37	East	18-Oct-04	Isla Blanquilla, Fajardo	199	88	7	26.6	2.0

DISCUSSION

Fisheries reports show that the West Indian topshell, *Cittarium pica*, is fished all along the coasts of Puerto Rico. Although not much was known about the population status of this mollusk in the Island, fishermen complain that it used to be very abundant along the rocky shores, and that now it is not. Based on this statements and the decline on landing reports, it could be concluded that the resource is certainly diminishing.

It was found during the study that the West Indian topshell is not fish with equal intensity or sale at the same scale throughout the Island. At some areas, like Cabo Rojo on the southwest coast, it is part of the food menu of some restaurants, on other areas it will be sale on a more local or informal scale. Sale prices ranged from $8.00 to $12.00 per pound. Variation on fishing pressure could be an effect of the resource availability.

There was great variety on the amount of snails found during the surveys. The range was from 7 to 1,073 individuals. The average of snails found was 259. Several factors could be responsible for the variation found. Some areas might be overfished while others might be fished occasionally. Difference on recruitment rate is another factor to consider. Debrot (1986) suggested that low population densities at calm sites could be due to poor recruitment. But, on places of high wave action, recruitment might be difficult because low capability of small snails to confront the wave dragging force. The majority of the high wave action areas surveyed showed small amount of small snails (18-24%). On the contrary low wave action areas showed great amount of small snails (65%). This suggests that the snail recruitment is better on quiet sites. The small amount of larger shell size snail on quiet sites could be due to overfishing, given that predation pressure is the same on both areas. It should be noted that on Bahamas a greater predation pressure was found on high energy sites, which will mean larger snails on quiet areas, contrary of what was found in this study.

Considering the data gathered the following behavioral pattern is suggested for the West Indian topshell in Puerto Rico. As stated by other studies, it was found that *Cittarium pica* showed a size-specific zonation (Debrot, 1990b). Larger snails use the creeds on the submerged rocky shore, while smaller snails use the pseudo-exposed rocky shore (it gets wet with the wave movement). Recruitment is better on low-energy sites because of less stress due to wave dragging forces. The West Indian topshell has been overfished at these low-energy sites, which explains the lack of larger snails. High energy sites are probably not overfished because the difficulties that weather imposes to the fishermen. Although, still fished, as declared by fishermen, during calm weather. Site of difficult access showed the same situation as the high energy sites.

In Puerto Rico no study has been conducted to collect information on recruitment and reproduction of the *Cittarium pica*. A study in Bahamas (Debrot, 1986) found that snails on quiet areas had a maturation size and fecundity greater than the ones in wave-stress areas. If that holds true for Puerto Rico, as well as the suggested behavioral pattern, it would mean that larger snails are especially important in the quiet areas. Therefore, in order to recover the overfished sites, snails should be allowed to reach their sexual maturity size. If the whole scenario is true, the snails in the exposed areas might be the ones responsible for most of the recruitment, and this are also being fish.

All that has been suggested is only a possibility that explain the data gathered and what has been reported by fishermen. But, the fact is that there is too much unknown. We need to study the reproduction and recruitment patterns of the species to be able to determine accurately what will be the right management measurements to take.

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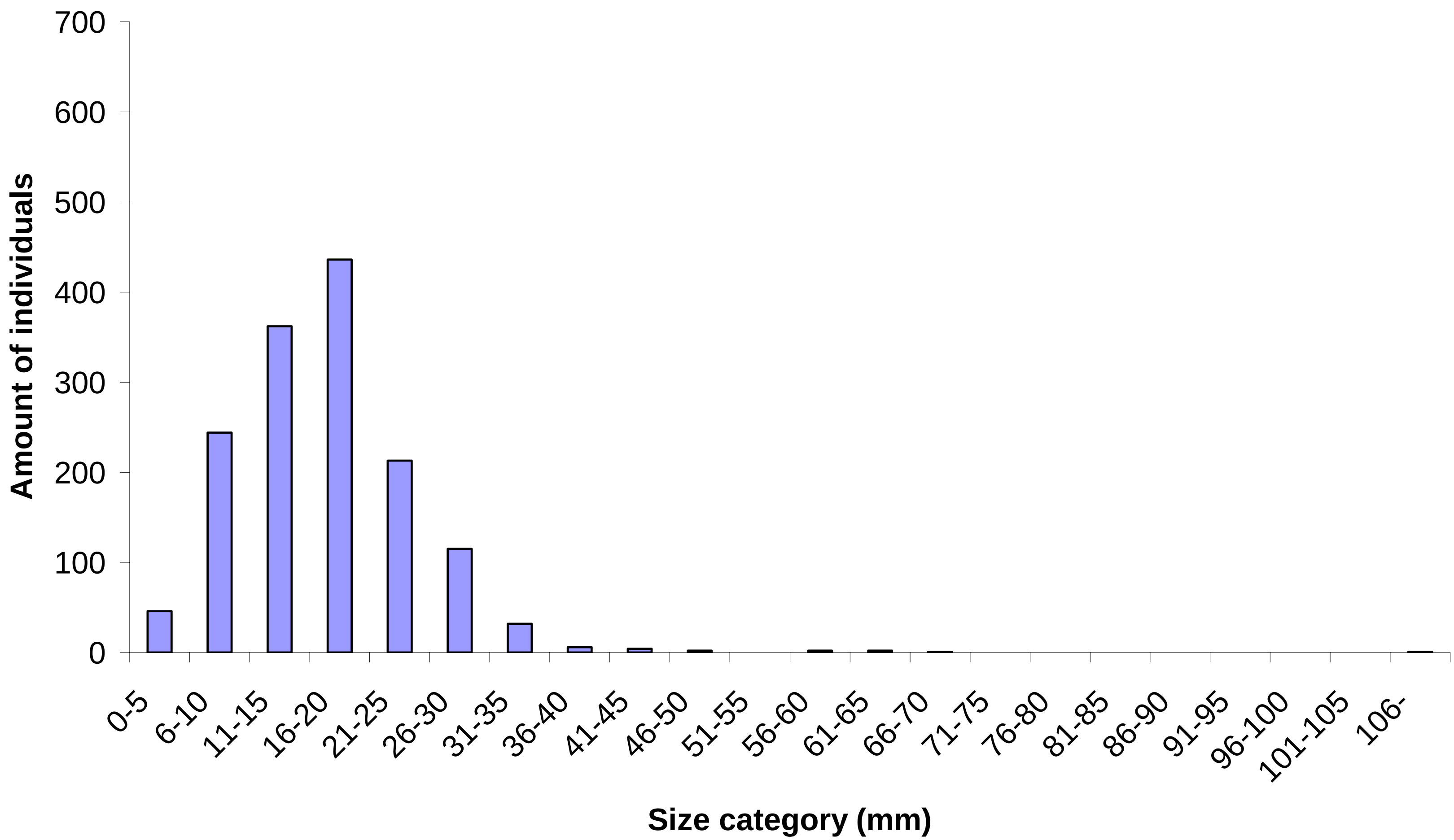
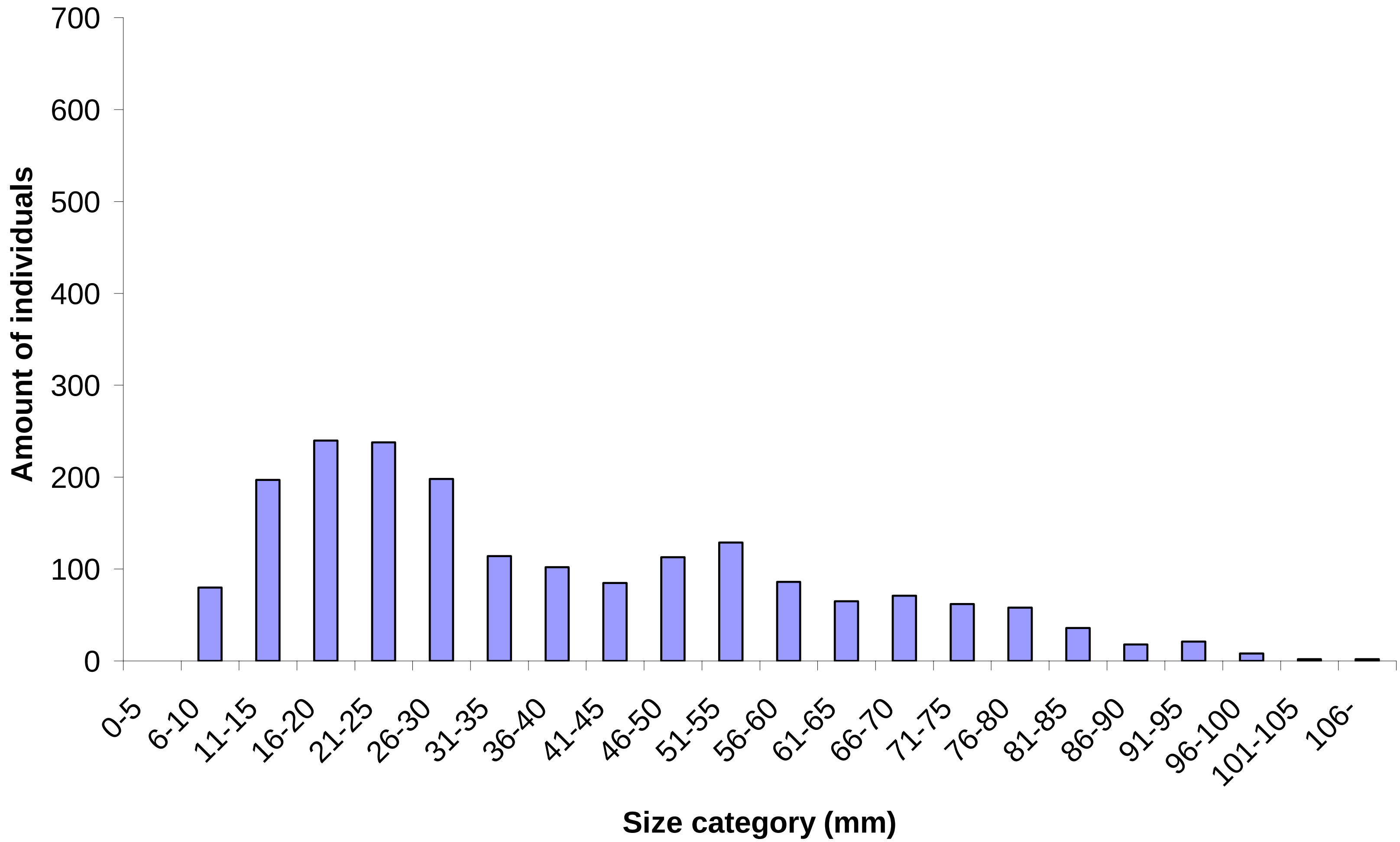
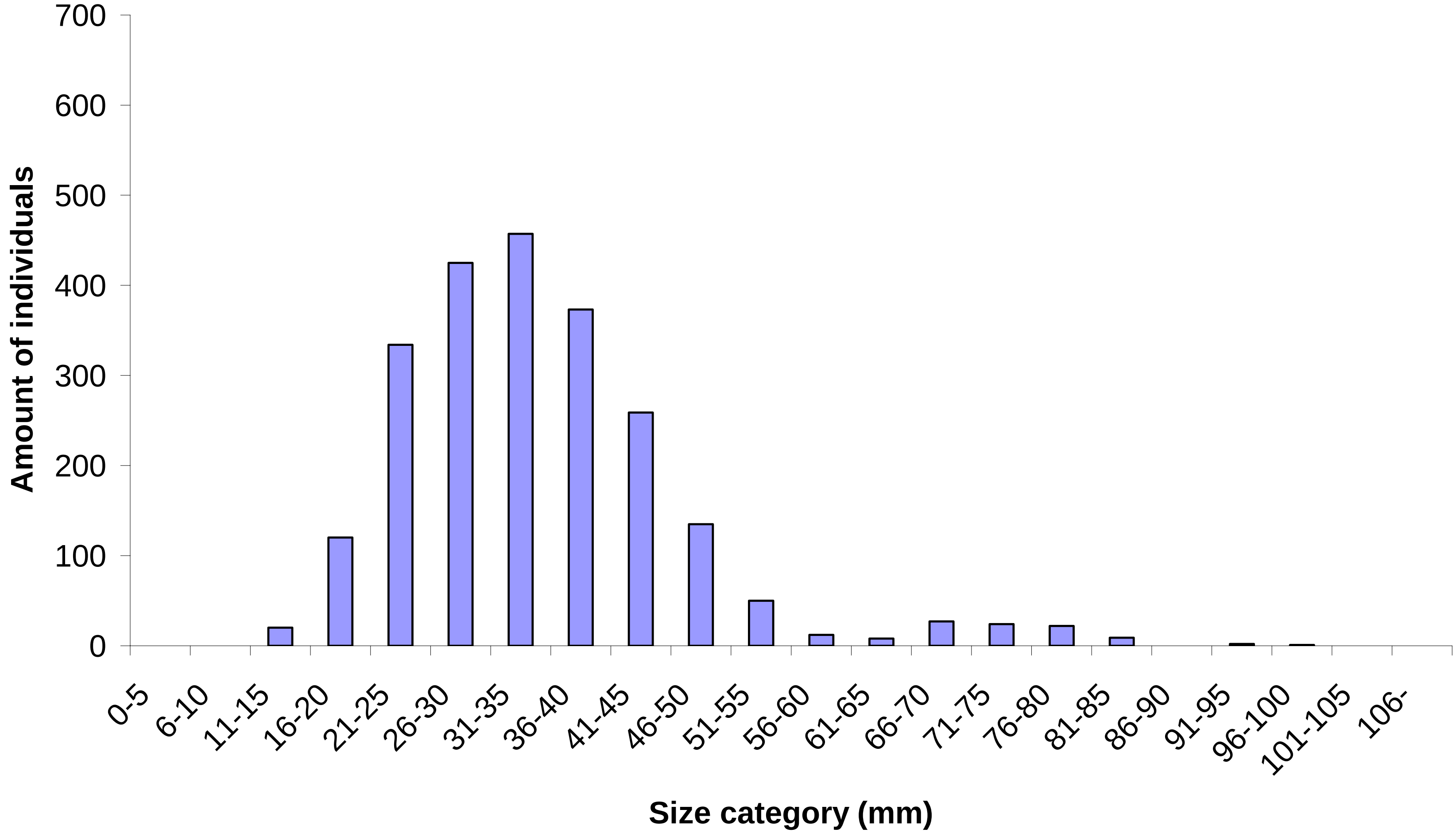
Graph 1. Size distribution of Cittarium pica on transects along the north coast of PR



Graph 2. Size distribution of Cittarium pica on transects along the east coast of PR



Graph 3. Size distribution of Cittarium pica on transects along the south coast of PR



Graph 4. Size distribution of Cittarium pica on transects along the west coast of PR