

By-catch Study of the Puerto Rico's Marine Commercial Fisheries

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ABSTRACT

A "by-catch" study of Puerto Rico's marine commercial fisheries" was conducted in Puerto Rico from February 2004-May 2005. This is the first by-catch study of Puerto Rico's fishery. Non-commercial species, commercial species of small size, individuals with no market value (economic discards), and individual discarded due to illegal sizes (regulation discarded) were considered as by-catch. The by-catch data was obtained from common fishing gears as beach seines, trammel nets, fish traps, and hand lines. A total of 71 commercial fishing trips were interviewed to collect the by-catch data. Six trips of beach seine were interviewed, 27 trips for trammel nets, 13 trips for fish traps and 25 trips for hand lines. Biostatistics data was collected for most of the by catch caught. In Puerto Rico during 2003-05, a total of 10 shellfish species and 95 fish species were considered by catch. This paper reports a description of Puerto Rico's by-catch species composition by gear and recommendations to decrease the by-catch capture.

KEY WORDS: By-catch, Puerto Rico's fisheries

Estudio de Captura Incidental de las Pesquerías Comerciales Marinas de Puerto Rico

El "Estudio de captura incidental de las pesquerías comerciales marinas de Puerto Rico" fue realizado entre febrero de 2004-mayo de 2005. Este es el primer estudio de captura incidental de la pesquería de Puerto Rico. Especies no comerciales, especies comerciales pero capturadas a un tamaño muy pequeño sin valor comercial (descartes económicos) y especies comerciales devueltas al mar por ser capturadas antes de tener el tamaño mínimo legal (descartes reglamentados) fueron consideradas pesca incidental. El estudio obtuvo datos de captura incidental realizadas por las artes de pesca mayormente usadas como chinchorro de arrastre, mallorquines, nasas y líneas de mano. Un total de 71 viajes de pesca comercial fueron entrevistados por el proyecto para obtener datos de captura incidental. Seis viajes de chinchorro de arrastre fueron entrevistados, 27 viajes de mallorquín, 13 viajes de nasas y 25 viajes de línea de mano. En Puerto Rico durante 2004-05, un total de 10 especies de mariscos y 95 especies de peces fueron consideradas capturas incidentales. Este estudio describe la composición de especies de captura incidental por arte de pesca y contiene recomendaciones para disminuir la captura incidental.

PALABRAS CLAVES: Pesca incidental, pesquerías de Puerto Rico

INTRODUCTION

The Fisheries Research Laboratory (FRL) of the Puerto Rico Department of Natural and Environmental Resources (DNER) monitors the commercial landings of fish and shellfish in Puerto Rico. The FRL's Commercial Fisheries Statistics Program (CFSP) maintains reporting services on the landings on the commercial finfish and shellfish resources of Puerto Rico. CFSP reaches its mission by collecting landings data, determining total weight of principal finfish and shellfish landed, collecting CPUE data, and collection and analysis of biostatistics data of Puerto Rico's commercial fishery. The data collected by the CFSP shows that Puerto Rico's fishery resources has been overexploited (Matos-Caraballo 2004).

Most of the fish landed are sold or kept for personal use; consequently there is no action to minimize by-catch. However, the CFSP data only reflects the commercial landings reported, so by-catch information is not obtained. Puerto Rico needs to know the amount of by-catch in order to do a wise management of the commercial fisheries resources. By-catch is defined by the Magnuson-Stevens

Act (MSA) Section 3(2) (1996) as "fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. This term does not include fish released alive under a recreational catch and release fishery management program". On the other hand, in the report entitled "Managing the Nation's By-catch" (NMFS 1998) expanded the MSA by-catch definition to "discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear". The mentioned definition was used in this project, thus, all the non-commercial species, commercial species of small size, individuals with no market value (economic discards), and individuals discarded due to illegal sizes (regulation discarded) were considered as by-catch.

By-catch is a great issue in fisheries management. The Federal Government is issuing regulations to reduce by-catch mortality. Under the Magnuson Act 1996 National Standards it is emphasized that "conservation and manage-

ment measures shall, to the extent practicable, (a) minimize by-catch, and (b) to extend by-catch cannot be avoided, minimize the mortality of such by-catch". The NOAA/NMFS Caribbean Fisheries Management Council (CFMC) mentioned in his "Sustainable Fisheries Act", that the US Caribbean needs to collect and analyzed by-catch data. The results and conclusions of this project will help NOAA/NMFS/CFMC and DNER in their mission to identify, protect and conserve the species that constitutes by-catch in the US Caribbean.

This is the first by-catch study of Puerto Rico's commercial fishery. It will serve to identify the by-catch and how to diminish and/or eliminate this practice. The biological impact from the information collected by this project will improve significantly the data needed for fishery resources managers to take measures that will minimize by-catch. Fishing mortality on juveniles should be reduced, which will help managers to maintain the fishery resources in a healthy state.

The objective of this project is to describe Puerto Rico's commercial fishery by-catch in their biological aspects. The commercial fishing gears of the Island don't discriminate between target species and those that live in close association with them. The goals of this project are to:

- i) Determine the magnitude of by-catch and by-catch mortality,
- ii) Identify by-catch composition by most used fishing gears,
- iii) Direct participation of commercial fishers in this project,
- iv) Obtain by-catch independent data from commercial fishers that collaborated with this project, The independent data included biological fish and shellfish at species level, biostatistics data and habitat related (e.g. invertebrates),
- v) Evaluate all different fishing gears in order to reduce the impacts of by-catch, and
- vi) Recommend conservation and management measures to minimize by-catch.

PROCEDURES

Personnel from the DNER/FSL/CFSP were responsible to realize this study. To reach the project goals they followed the following procedures:

- i) Interview experienced commercial fishers and collect data to estimate the by catch for the last 30 years and if any changes have been occurred.
- ii) Select commercial fishers to be contracted to collaborate with the project. This participation helped to obtain independent data. These commercial fishers were contracted to work with DNER.
- iii) Investigate the following gears to obtain the by-catch collected: fish traps, trammel nets, beach seines and hand lines.

- iv) Sample 30 trips per gear, with commercial fishers collaborators to collect the independent data.

The following data were collected for every single fishing trip for discarded fish, shellfish, or invertebrates:

- i) Identify fishing by-catch at species level and obtain length of all individuals (fish in fork length in mm; crustaceans in carapace length).
- ii) Account the by-catch by number of species caught and total catch weight.
Collect the biostatistics data from the commercial total landings by species and if possible collect individual weight.
- iii) Collect the following fishing gear information by trip:
Fish trap – number of crew, trap size, depths, mesh size, # of traps hauled, soak time (days), fishing time (hours), catch per unit effort (CPUE).
Trammel net – number of crew, gear length in fathoms, height, mesh sizes, soak time (hours), and CPUE data.
Beach seine – number of crew, gear length in fathoms height, mesh sizes, soak time (hours), fishing time (hours) and CPUE data.
Hand line – number of crew, fishing time, line resistance number and size of hooks, fish time (hours), depth and CPUE.
- iv) All data was entered on computers using Microsoft Access and Microsoft Excel.
- v) Data was analyzed and the analysis include by-catch composition by gear, and recommendations to reduce or eliminate the by-catch.

This study collected quantitative and qualitative information to describe the by catch in Puerto Rico and the biological consequences that it could have. Federal and local agencies that work as fishery managers are able to use this report as a useful tool.

RESULTS

Survey to Interview Experienced Commercial Fishers and Collect Data to Estimate the By-catch for the Last 30 Years and If Any Changes Have Been Observed

Biologist assistants visited the fishing villages of Puerto Real, Cabo Rojo; Corozo, Cabo Rojo; El Seco, Mayagüez; El Maní, Mayagüez; Tres Hermanos, Añasco; Barrero, Rincón; Estela, Rincón; Espinar, Aguada; Higuey, Aguadilla and Playuela, Aguadilla. Three experienced fishers (ten years or more as active commercial fishers) per fishing village were interviewed with the assistant biologists assistances about what was their perception about by-catch composition in the past and what is the present by-catch composition. It was amazing that all the interviewed commercial fishers mentioned that most of the

by-catch is used. The non-saleable products were used by the fishers for their own consumption or as bait. If the fishers did not have use for the by-catch, they would give it to a friend. The fishers mentioned that some species considered as by catch 30 or more years ago are easily sold today as food, for example coral crabs (*Mythrax sp.*), marine crabs (*Brachiura*), squirrelfishes (*Holocentridae*) and sharks (*Hexanchidae*). Others are sold as bait, for example, sandtilefish (*Malacanthus plumieri*), skipjack tuna (*Euthynnus pelamis*), and starfishes as *Oreaster reticulatus*. Juvenile commercial fishes caught and considered by-catch because of the size sometimes are used to bait hooks or traps.

Select Commercial Fishers to Cooperate with Project

From February – March 2004, the project personnel identified 12 commercial fishers that were willing to cooperate with the CFSP and filled all the government requirements to be contracted. On March 12th, 2004, Hon. Luis E. Rodríguez-Rivera, then Secretary of the DNER, announced the implementation of the Puerto Rico's Fishing Regulation #6768. The regulations included legal minimum size for several species, closed seasons for other species, and other management measures to protect the overfished resources. As a result of the fishing regulations, commercial fishers became angry with the DNER. Immediately, 50% of the commercial fishers that were working to complete their contracts with this project quit. The other 50% never completed the documents and never cooperated with this project. Project personnel started to find ten other commercial fishers willing to participate in the project. Finally five fishers completed the documents to cooperate with the project. However, only one helped the project, with only four trip interviews. Then, the project personnel, with the help of CFSP's port samplers and DNER rangers, collected data from other fishers that had not received financial aid from the project.

By-catch Composition

A total of 71 commercial fishing trips were interviewed to collect by-catch data. The number of interviews was lower than expected due to the fact that commercial fishers did not cooperate with the project as was mentioned in the previous paragraph. Project personnel were able to interview six trips of beach seines, 13 trips for fish traps, 27 trips for trammel nets and 25 trips for hand lines. Biostatistics data was collected for most of the by-catch caught.

Table 1 shows the species caught by commercial fishers that were defined as by-catch by commercial fishers in Puerto Rico during 2003-2005. A total of 10 shellfish species and 95 fish species were considered by-catch. This list includes many species that are considered an important part of the commercial fishery, but due to their small size or illegal size, they were discarded and considered by catch. No reptiles, birds, or marine mammals were caught

as by-catch during the project.

Beach Seine — Biologist assistants visited approximately 25 times the fishing villages of Espinar, Aguada and El Combate, and Cabo Rojo to intercept the beach seine fishers to collect the by-catch data. Only six trips were intercepted, although one commercial fisher had a contract, and he was supposed to inform project personnel when he was going out to fish, but he never did. The beach seines used by commercial fishers were 100-150 fathoms length and the seine mesh size was 0.5-2.0 inches. The beach seine operation takes approximately two hours. The crew was 3-4 fishers. However some neighbors helped to haul the beach seine just to take some fishes. This data was obtained with high difficulty. Biologist assistants observed that approximately 30% of the discarded individuals caught by beach seines were returned alive to the sea. Due to the fact that this fishery occurred on the shore a bunch of neighbors were close to the beach seine and collected the other 70% of the by-catch to consume at their homes. The CFSP collected data from beach seines that confirmed that individuals of *Scomberomorus cavalla*, *Scomberomorus regalis* and *Caranx latus* were sold at juvenile stages.

Table 2 shows the 35 species that composed the by-catch in the beach seine activity. From the total of 401 individuals caught by beach seine, the most common were *Vomer setipinnis* with 15%, *Ocyurus chrysurus* with 14%, *Gerres cinereus* with 13%, *Scomberomorus cavalla* with 12% and *Harengula jaguana* with 10%. Table 2 also shows the mean average size by species when $n \geq 10$. The Beach seine was sampled at estuary ecosystem area (Espinar) and at sea grass beds and coral reef area (El Combate). Both places were hatchery areas that contain many species at juvenile stages. Both areas are frequently fished by beach seine. Beach seine caught an average of 65.8 by-catch individuals per trip. The DNER Fishing Regulations will proscribe the use of beach seine after 2007. The catch per unit effort (CPUE) for beach seines was 0.07 pounds/fathom/hour.

Trammel Nets — Project personnel visited approximately 40 times the fishing villages of Corozo, Cabo Rojo to intercept the trammel nets fishers to collect the by catch data. They were able to do 27 interviews of this gear. The trammel net fishers cooperate with the program but did not permit the presence of the project personnel during their fishing trips. On the other hand, they brought the whole catch (by catch included) to the landings area where the data was collected. Approximately five trammel net fishing trips were interviewed by the DNER Rangers that were intercepted at open sea (8-10 miles from Cabo Rojo's coast). Trammel nets used by commercial fishers during the data collection was 200 - 600 fathoms length; mesh sizes were six, four in and two inches. Trammel nets were fished at depths between 15 - 20 fathoms. Trammel net fishers have different target species, parrotfishes

(Scaridae), trunkfishes (Ostracidae), and spiny lobsters (*Panulirus argus*). Parrotfishes trammel net fishers were hostile to project personnel. Project personnel were able to intercept parrotfish trammel net only once at the sea with the help of DNER Rangers. Each target species change a little with the fishing depth and the period of gear soak time. However, the three target groups are fished around coral reefs and sea grass beds. Fishers mentioned that the trammel nets operation started around 1:00 AM and finished one hour after the sunrise, approximately 5 - 6 hours. Spiny lobster and trunkfishes trammel nets soak the trammel nets during 12 hours, starting one our before sunset and finished one hour after sunrise. Most times crew size was two fishers. Project personnel observed one fisher that worked alone.

Table 3 shows by-catch composition of trammel nets that includes 30 species during this project. A total of 131 individuals were counted as by-catch. The most common species in he bycat8ch composition were *Haemulon plumieri* (13%), *Dasyatis americana* (13%), *Carpilus coralinus* (11%), *Diodon hystrix* (8%) and *Mythrax spinosissimus* (6%). Trammel net caught an average of 4.9 by-catch individuals per trip. The project data shows that by-catch individuals caught by trammel nets is low, although the parrotfish trammel net fishers were interviewed only once. In the near future CFSP must continue the monitory of the parrotfishes trammel nets by-catch. The catch per unit effort for trammel net was 0.05 pounds/fathom/hour.

Fish Traps — The Puerto Rico commercial fishery census of 2002, mentioned that since 1996 - 2002, the fish traps number were reduced in 2,385 units, by approximately 15% (Matos-Caraballo, 2004). However, the same census mentioned that 13,146 traps were active in Puerto Rico's fishery. Fish traps are expensive and frequently stolen by other fishers. Principal Investigator talked with various fish trap fishers whom make criminal accusations thru Puerto Rico's Justice Department to other peers due to the fish trap robbery. However, fish trap continue to be a very important gear in Puerto Rico's fishery. Fish trap fishers target mainly two objectives, first lobsters and trunkfishes (90% of active fish traps) and second deep water snappers (10% of active fish traps). The lobsters and trunkfishes traps fished around coral reefs and sea grasses areas. The depth range of this activity is 10 - 30 fathoms. The deep water snappers category is fishing at top of sea mountains at open sea, at depth range of 90 - 150 fathoms. In this project only lobster and trunkfish category were studied. The deep water snappers fishers did not cooperate with the project. The Puerto Rico fishing census 2002 shows that fish traps are expensive, young fishers can not afford this gear, resulting that most owners are over 50 years old (Matos-Caraballo 2004). On the other hand fish trap fishers mentioned that many SCUBA divers stole their lobster catch underwater. The fish traps commercial

fishers lift between 30-60 traps per trip. Assistant biologists, CFSP's port samplers, and DNER Rangers interviewed 13 trips to collect by-catch data. Fish trap's crew sizes were two fishers.

Table 4 shows by-catch composition of fish traps that includes 48 species during this project. Assistant biologists counted 340 individuals as by-catch. The most common species in the fish traps by-catch composition were *Acanthurus coeruleus* (21%), *Holocentrus adscensionis* (13%), *Calamus pennatula* (6%), *Holocentrus rufus* (5%) and *Haemulon plumieri* (4%). It was curious the catch of juvenile nurse shark *Giglymostoma cirratum*, when his head become stocked in the fish trap's door, then fishers were able to return alive to the sea. Other fish trap fishers mentioned to the principal investigator that this incident rarely occurred since most times the shark is able to break the fish trap door and eat the catch. Fish trap fishers reported that many of the by-catch is used as bait inside the traps. Fish traps fishers mentioned that when they catch *Panulirus argus* before reaching minimum legal size (3.5 in carapace length) or females with eggs, they keep them in the trap, because females with eggs attract larger males. Few fish trap fishers catch some fishes alive, for example butterflyfishes (Chaetodontidae) and angelfishes (Pomacanthidae) to sell in the ornamental fish trade. Fish trap caught an average of 27.6 by-catch individuals per trip. The catch per unit effort for fish trap was 1.5 pounds/trap/day.

Hand Lines — In the Puerto Rico commercial fishery census of 2002, it was reported a total of 9,306 units, increased 2,579 more units that 1996 (Matos-Caraballo, 2004). Compared with nets, traps and SCUBA gear, hand lines have the lowest cost. The target species for hand lines are coral reef fishes mainly Serranidae (mostly *Epinephelus guttatus* and *Cephalopholis fulvus*) and Lutjanidae (mostly *Ocyurus chrysurus* and *Lutjanus analis*). This fishery occurred at a depth range of 10 - 30 fathoms), deep water snappers Lutjanidae (80 - 250 fathoms), coastal pelagic species Scombridae and Coryphaenidae (2 - 20 fathoms). Project personnel with the helpof CFSP's port samplers and DNER Rangers were able to interviewed 25 fishing trips to collect by-catch data.

Table 5 shows by-catch composition of hand lines that includes 31 species during 2004 - 2005. Assistant biologists counted 161 individuals as by-catch. The most common species in the hand lines by-catch composition were *Malacanthus plumieri* (22%), *Caranx crysos* (20%), *Melichthys niger* (8%), *Tylosurus crocodilus* (4%), *Mustelus norrisi* (4%), and *Caranx latus* (4%). The mentioned species were used as bait or for the fisher consumption. The project results show that 6.3 by-catch individuals were caught by trip. The number of species and individuals caught by hand lines is considered low. The catch per unit effort for hand lines was 0.8 pounds/hook/hour.

Table 1. List of species considered by-catch in Puerto Rico's commercial fishery during 2004 - 2005.

Shellfish				
	Genus	Species	Family	Common Names
1	<i>Carpilius</i>	<i>coralinus</i>	Xanthidae	Coral crab
2	<i>Mithrax</i>	<i>spinosissimus</i>	Majidae	King crab
3	<i>Oreaster</i>	<i>reticulatus</i>	Asteroidea	Cushion sea star
4	<i>Panulirus</i>	<i>argus</i>	Panuliridae	Spiny lobster
5	<i>Scyllarides</i>	<i>aequinoctialis</i>	Scyllaridae	Spanish lobster
6	<i>Strombus</i>	<i>gallus</i>	Strombidae	
7	<i>Strombus</i>	<i>gigas</i>	Strombidae	Queen conch
8			Brachiura	Marine crabs
9			Demospongiae	Sponges
10			Penaeidae	Shrimp
Fish				
	Genus	Species	Family	Common Names
1	<i>Abudefduf</i>	<i>saxatilis</i>	Pomacentridae	Sergeant major
2	<i>Acanthostracion</i>	<i>polygonius</i>	Ostraciidae	Honeycomb cowfish
3	<i>Acanthurus</i>	<i>bahianus</i>	Acanthuridae	Ocean surgeon
4	<i>Acanthurus</i>	<i>coeruleus</i>	Acanthuridae	Blue tang
5	<i>Aetobatus</i>	<i>narinari</i>	Myliobatidae	Spotted eagle ray
6	<i>Aluterus</i>	<i>scriptus</i>	Monacanthidae	Scrawled filefish
7	<i>Ancylopsetta</i>	<i>antillarum</i>	Bothidae	Antillean three-eye flounder
8	<i>Anguilla</i>	<i>rostrata</i>	Congridae	American eel
9	<i>Anisotremus</i>	<i>virginicus</i>	Haemulidae	Porkfish
10	<i>Archosargus</i>	<i>rhomboidalis</i>	Sparidae	Sea bream
11	<i>Ballistes</i>	<i>capriscus</i>	Ballistidae	Gray Triggerfish
12	<i>Ballistes</i>	<i>vetula</i>	Ballistidae	Queen triggerfish
13	<i>Bardiella</i>	<i>rhonchus</i>	Scianidae	Ground croacker
14	<i>Bellator</i>	<i>sp.</i>	Triglidae	Searobins
15	<i>Calamus</i>	<i>pennatula</i>	Sparidae	Pluma
16	<i>Calamus</i>	<i>sp.</i>	Sparidae	Porgies
17	<i>Cantherhines</i>	<i>macrocerus</i>	Monacanthidae	Whitespotted filefish
18	<i>Canthidermis</i>	<i>maculata</i>	Balistidae	Triggerfish
19	<i>Canthidermis</i>	<i>sufflamen</i>	Balistidae	Ocean triggerfish
20	<i>Caranx</i>	<i>bartholomaei</i>	Carangidae	Jackfish
21	<i>Caranx</i>	<i>latus</i>	Carangidae	Horse-eye jack
22	<i>Caranx</i>	<i>lugubris</i>	Carangidae	Black jack
23	<i>Caranx</i>	<i>crysos</i>	Carangidae	Blue runner
24	<i>Caranx</i>	<i>ruber</i>	Carangidae	Bar jack

Table 1 continued.
Fish

	Genus	Species	Family	Common Names
25	<i>Carcharhinus</i>	<i>perezii</i>	Carcharhinidae	Sand shark
26	<i>Caulolatilus</i>	<i>cyanops</i>	Malacanthidae	Blackline tilefishes
27	<i>Cephalopholis</i>	<i>fulva</i>	Serranidae	Coney
28	<i>Chaetodon</i>	<i>capistratus</i>	Chaetodontidae	Foureye butterflyfish
29	<i>Chaetodon</i>	<i>ocellatus</i>	Chaetodontidae	Spotfin butterflyfish
30	<i>Chaetodon</i>	<i>striatus</i>	Chaetodontidae	Banded Butterflyfish
31	<i>Conodon</i>	<i>nobilis</i>	Haemulidae	Barred grunt
32	<i>Coryphaena</i>	<i>hippurus</i>	Coryphaenidae	Dolphinfish
33	<i>Dasyatis</i>	<i>americana</i>	Dasyatidae	Southern stingray
34	<i>Diodon</i>	<i>holocanthus</i>	Diodontidae	Spiny puffer
35	<i>Diodon</i>	<i>hystrix</i>	Diodontidae	Porcupinefish
36	<i>Epinephelus</i>	<i>cruentatus</i>	Serranidae	Graysby
37	<i>Cephalopholis</i>	<i>fulvus</i>	Serranidae	Coney
38	<i>Epinephelus</i>	<i>guttatus</i>	Serranidae	Red hind
39	<i>Epinephelus</i>	<i>mystacinus</i>	Serranidae	Misty grouper
40	<i>Gerres</i>	<i>cinereus</i>	Gerreidae	Yellowfin mojarra
41	<i>Gymnothorax</i>	<i>funnebris</i>	Muraenidae	Green moray
42	<i>Ginglymostoma</i>	<i>cirratum</i>	Orectolobidae	Nurse shark
43	<i>Haemulon</i>	<i>album</i>	Haemulidae	Margate
44	<i>Haemulon</i>	<i>aurolineatum</i>	Haemulidae	Tomtate
45	<i>Haemulon</i>	<i>macrostomum</i>	Haemulidae	Spanish grunt
46	<i>Haemulon</i>	<i>parra</i>	Haemulidae	Sailor choice
47	<i>Haemulon</i>	<i>plumieri</i>	Haemulidae	White grunt
48	<i>Haemulon</i>	<i>sciurus</i>	Haemulidae	Bluestriped grunt
49	<i>Harengula</i>	<i>jaguana</i>	Clupeidae	Scaled Sardine
50	<i>Hemiramphus</i>	<i>brasiliensis</i>	Hemiramphidae	Ballyhoo
51	<i>Holacanthus</i>	<i>ciliaris</i>	Pomacanthidae	Queen angelfish
52	<i>Holacanthus</i>	<i>tricolor</i>	Pomacanthidae	Rock beauty
53	<i>Holocentrus</i>	<i>adscensionis</i>	Holocentrinae	Squirrelfish
54	<i>Holocentrus</i>	<i>rufus</i>	Holocentrinae	Squirrelfish
55	<i>Lactophrys</i>	<i>bicaudalis</i>	Ostraciidae	Spotted trunkfish

Table 2. By-catch composition by species and by number of individuals caught by beach seines in Puerto Rico during 2004 - 2005 (six fishing trips interviewed).

	Genus	Species	Family	# of Individuals caught	Mean Fork Length (mm) (n>=10)	Standard Deviation Fork Length (mm) (n>=10)
1	<i>Vomer</i>	<i>setipinnis</i>	Carangidae	59	79	15
2	<i>Ocyurus</i>	<i>chrysurus</i>	Lutjanidae	54	186	16
3	<i>Gerres</i>	<i>cinereus</i>	Gerreidae	50	100	28
4	<i>Scomberomorus</i>	<i>cavalla</i>	Scombridae	46	125	15
5	<i>Harengula</i>	<i>jaguana</i>	Clupeidae	42	112	12
6	<i>Caranx</i>	<i>latus</i>	Carangidae	34	95	18
7	<i>Scomberomorus</i>	<i>regalis</i>	Scombridae	17	149	12
8	<i>Caranx</i>	<i>ruber</i>	Carangidae	17	146	23
9	<i>Bairdiella</i>	<i>rhonchus</i>	Sciaenidae	11	135	14
10	<i>Calamus</i>	<i>pennatula</i>	Sparidae	10	157	17
11	<i>Trachinocephalus</i>	<i>myops</i>	Eleotridae	6		
12	<i>Ogcocephalus</i>	<i>nasutus</i>	Ogcocephalidae	6		
13	<i>Haemulon</i>	<i>plumieri</i>	Haemulidae	6		
14	<i>Sphyaena</i>	<i>barracuda</i>	Sphyaenidae	5		
15	<i>Opisthonema</i>	<i>oglinum</i>	Clupeidae	5		
16	<i>Conodon</i>	<i>nobilis</i>	Haemulidae	4		
17	<i>Ancylopsetta</i>	<i>antillarum</i>	Bothidae	4		
18	<i>Trachinotus</i>	<i>goodei</i>	Carangidae	3		
19	<i>Odontoscion</i>	<i>dentex</i>	Sciaenidae	3		
20	<i>Sphoeroides</i>	<i>spengleri</i>	Tetraodontidae	2		
21	<i>Sparisoma</i>	<i>chrysopterum</i>	Scaridae	2		
22	<i>Hemiramphus</i>	<i>brasiliensis</i>	Hemiramphidae	2		
23	<i>Tylosurus</i>	<i>crocodilus</i>	Belonidae	1		
24	<i>Anguilla</i>	<i>rostrata</i>	Anguillidae	1		
25	<i>Haemulon</i>	<i>sciurus</i>	Haemulidae	1		
26	<i>Lutjanus</i>	<i>synagris</i>	Lutjanidae	1		
27	<i>Lutjanus</i>	<i>jocu</i>	Lutjanidae	1		
28	<i>Lutjanus</i>	<i>apodus</i>	Lutjanidae	1		
29	Marine crabs		Brachiura	1		
30	<i>Oligoplites</i>	<i>saurus</i>	Carangidae	1		
31	Shrimp		Peneidae	1		
32	<i>Oreaster</i>	<i>reticulatis</i>	Asteroidea	1		
33	<i>Strombus</i>	<i>gallus</i>	Strombidae	1		
34	<i>Strombus</i>	<i>gigas</i>	Srombidae	1		
35			Demospongiae	1		
Total of individuals caught by this gear				401		

Table 3. By-catch composition by species and by number of individuals caught by trammel nets in Puerto Rico during 2004 - 2005 (27 fishing trips interviewed).

	Genus	Species	Family	# of Individuals caught	Mean Fork Length (mm) (n>=10)
1	<i>Haemulon</i>	<i>plumieri</i>	Haemulidae	17	231
2	<i>Dasyatis</i>	<i>americana</i>	Dasyatidae	17	297
3	<i>Carpilius</i>	<i>coralinus</i>	Xanthidae	15	123 mm (Carapace Length)
4	<i>Diodon</i>	<i>hystrix</i>	Diodontidae	10	Only 6 individuals were measured
5	<i>Mithrax</i>	<i>spinosissimus</i>	Majidae	8	112
6	<i>Holocentrus</i>	<i>ascensionis</i>	Holocentrinae	7	
7	<i>Melichthys</i>	<i>niger</i>	Balistidae	7	
8	<i>Negaprion</i>	<i>brevirostris</i>	Chondrichthyes	5	
9	<i>Acanthurus</i>	<i>bahianus</i>	Acanthuridae	5	
10	<i>Holocentrus</i>	<i>rufus</i>	Holocentrinae	4	
11	<i>Lutjanus</i>	<i>apodus</i>	Lutjanidae	4	
12	<i>Trachinotus</i>	<i>goodei</i>	Carangidae	4	
13	<i>Caranx</i>	<i>crysos</i>	Carangidae	3	
14	<i>Cantherhines</i>	<i>macrocerus</i>	Monacanthidae	3	
15	<i>Trachinotus</i>	<i>falcatus</i>	Carangidae	2	
16	<i>Lutjanus</i>	<i>nalis</i>	Lutjanidae	2	
17	<i>Haemulon</i>	<i>macrostomus</i>	Haemulidae	2	
18	<i>Aetobatus</i>	<i>narinari</i>	Myliobatidae	2	
19	<i>Chaetodon</i>	<i>striatus</i>	Chaetodontidae	2	
20	<i>Acanthurus</i>	<i>coeruleus</i>	Acanthuridae	2	
21	<i>Ginglymostoma</i>	<i>cirratum</i>	Orectolobidae	1	
22	<i>Sparisoma</i>	<i>viride</i>	Scaridae	1	
23	<i>Archosargus</i>	<i>rhomboidalis</i>	Sparidae	1	
24	<i>Haemulon</i>	<i>album</i>	Haemulidae	1	
25	<i>Ogcocephalus</i>	<i>nasutus</i>	Ogcocephalidae	1	
26	<i>Mulloidichthys</i>	<i>martinicus</i>	Mullidae	1	
27	<i>Synodus</i>	<i>intermedius</i>	Synodontidae	1	
28	<i>Calamus</i>	<i>pennatula</i>	Sparidae	1	
29	<i>Haemulon</i>	<i>sciurus</i>	Haemulidae	1	
30	<i>Holocanthus</i>	<i>sp</i>	Pomacanthidae	1	
Total of individuals caught by this gear				131	

Table 4. By-catch composition by species and by number of individuals caught by fish traps in Puerto Rico during 2004 - 2005 (13 fishing trips interviewed).

	Genus	Species	Family	# of Individuals caught	Mean Fork Length (mm) (n>=10)	Standard Deviation Fork Length (mm) (n>=10)
1	<i>Acanthurus</i>	<i>coeruleus</i>	Acanthuridae	77	203	34
2	<i>Holocentrus</i>	<i>ascensionis</i>	Holocentrinae	46	218	21
3	<i>Calamus</i>	<i>pennatula</i>	Sparidae	22	228	43
4	<i>Holocentrus</i>	<i>rufus</i>	Holocentrinae	17	213	20
5	<i>Haemulon</i>	<i>plumieri</i>	Haemulidae	14	217	27
6	<i>Chaetodon</i>	<i>striatus</i>	Chaetodontidae	13	121	9
7	<i>Pomacanthus</i>	<i>paru</i>	Pomacanthidae	13	350	91
8	<i>Lactophrys</i>	<i>quadricornis</i>	Ostraciidae	12	206	35
9	<i>Acanthurus</i>	<i>bahianus</i>	Acanthuridae	11	153	24
10	<i>Canthidermis</i>	<i>maculata</i>	Balistidae	10	329	75
11	<i>Ballistes</i>	<i>vetula</i>	Ballistidae	9		
12	<i>Pomacanthus</i>	<i>sp</i>	Pomacanthidae	8		
13	<i>Scorpaena</i>	<i>plumieri</i>	Scorpaenidae	8		
14	<i>Haemulon</i>	<i>album</i>	Haemulidae	7		
15	<i>Ballistes</i>	<i>sp</i>	Ballistidae	6		
16	<i>Diodon</i>	<i>hystrix</i>	Diodontidae	6		
17	<i>Panulirus</i>	<i>argus</i>	Panuliridae	6		
18	<i>Holacanthus</i>	<i>ciliaris</i>	Pomacanthidae	5		
19	<i>Lutjanus</i>	<i>synagris</i>	Lutjanidae	4		
20	<i>Chaetodon</i>	<i>ocellatus</i>	Chaetodontidae	3		
21	<i>Haemulon</i>	<i>aurolineatum</i>	Haemulidae	3		
22	<i>Haemulon</i>	<i>parra</i>	Haemulidae	3		
23	<i>Scyllarides</i>	<i>aequinoctalis</i>	Scyllaridae	3		
24	<i>Caranx</i>	<i>bartholomaei</i>	Carangidae	2		
25	<i>Caranx</i>	<i>crysos</i>	Carangidae	2		
26	<i>Epinephelus</i>	<i>cruentatus</i>	Serranidae	2		
27	<i>Epinephelus</i>	<i>guttatus</i>	Epinephelinae	2		
28	<i>Holacanthus</i>	<i>tricolor</i>	Pomacanthidae	2		
29	<i>Lactophrys</i>	<i>bicaudalis</i>	Ostraciidae	2		
30	<i>Malacanthus</i>	<i>plumieri</i>	Malacanthidae	2		
31	<i>Seriola</i>	<i>dumerili</i>	Carangidae	2		
32	<i>Sparisoma</i>	<i>chrysopterum</i>	Scaridae	2		
33	<i>Abudefduf</i>	<i>saxatilis</i>	Pomacentridae	1		
34	<i>Acanthostracion</i>	<i>polygonius</i>	Ostraciidae	1		
35	<i>Aluterus</i>	<i>scriptus</i>	Monacanthidae	1		
36	<i>Anisotremus</i>	<i>virginicus</i>	Haemulidae	1		
37	<i>Caranx</i>	<i>ruber</i>	Carangidae	1		
38	<i>Cephalopholis</i>	<i>fulva</i>	Serranidae	1		
39	<i>Chaetodon</i>	<i>capistratus</i>	Chaetodontidae	1		
40	<i>Dasyatis</i>	<i>americana</i>	Dasyatidae	1		
41	<i>Diodon</i>	<i>holacanthus</i>	Diodontidae	1		
42	<i>Ginglymostoma</i>	<i>cirratum</i>	Orectolobidae	1		
43	<i>Gymnothorax</i>	<i>funnebris</i>	Muraenidae	1		
44	<i>Lutjanus</i>	<i>analis</i>	Lutjanidae	1		
45	<i>Mycteroperca</i>	<i>venenosa</i>	Serranidae	1		
46	<i>Pomacanthus</i>	<i>arcuatus</i>	Pomacanthidae	1		
47	<i>Scarus</i>	<i>taeniopterus</i>	Scaridae	1		
48	<i>Aluterus</i>	<i>sp</i>	Monacanthidae	1		
Total of individuals caught by this gear				340		

Table 5. By-catch composition by species and by number of individuals caught by hand lines in Puerto Rico during 2004 - 2005 (25 fishing trips interviewed).

	Genus	Species	Family	# of Individuals caught	Mean Fork Length (mm) (n>=10)	Standard Deviation Fork Length (mm) (n>=10)
1	<i>Malacanthus</i>	<i>plumieri</i>	Malacanthidae	34	379	39
2	<i>Caranx</i>	<i>crysos</i>	Carangidae	31	419	79
3	<i>Melichthys</i>	<i>niger</i>	Balistidae	13	276	22
4	<i>Caranx</i>	<i>latus</i>	Carangidae	7		
5	<i>Mustelus</i>	<i>norrisi</i>	Carcharhidae	7		
6	<i>Tylosurus</i>	<i>crocodilus</i>	Belonidae	7		
7	<i>Holocentrus</i>	<i>rufus</i>	Holocentrinae	6		
8	<i>Balistes</i>	<i>vetula</i>	Balistidae	5		
9	<i>Coryphaena</i>	<i>hippurus</i>	Coryphaenidae	5		
10	<i>Holocentrus</i>	<i>ascensionis</i>	Holocentrinae	5		
11	<i>Rhoboplites</i>	<i>aurorubens</i>	Lutjanidae	5		
12	<i>Haemulon</i>	<i>plumieri</i>	Haemulidae	4		
13	<i>Sphyraena</i>	<i>barracuda</i>	Sphyraenidae	4		
14	<i>Epinephelus</i>	<i>mystacinus</i>	Serranidae	3		
15	<i>Priacanthus</i>	<i>arenatus</i>	Priacanthidae	3		
16	<i>Scombrops</i>	<i>oculatus</i>	Scombroptidae	3		
17	<i>Dasyatis</i>	<i>americana</i>	Dasyatidae	2		
18	<i>Gerres</i>	<i>cinereus</i>	Gerreidae	2		
19	<i>Negaprion</i>	<i>brevirostris</i>	Chondrichthyes	2		
20	<i>Ocyurus</i>	<i>chrysurus</i>	Lutjanidae	2		
21	<i>Acanthurus</i>	<i>bahianus</i>	Acanthuridae	1		
22	<i>Bellator</i>	<i>sp.</i>	Triglidae	1		
23	<i>Canthidermis</i>	<i>sufflamen</i>	Balistidae	1		
24	<i>Caranx</i>	<i>lugubris</i>	Carangidae	1		
25	<i>Cephalopholis</i>	<i>fulva</i>	Serranidae	1		
26	<i>Lutjanus</i>	<i>buccanella</i>	Lutjanidae	1		
27	<i>Lutjanus</i>	<i>synagris</i>	Lutjanidae	1		
28	<i>Polymixia</i>	<i>nobilis</i>	Polymixiidae	1		
29	<i>Seriola</i>	<i>rivoliana</i>	Carangidae	1		
30	<i>Synodus</i>	<i>intermedius</i>	Synodontidae	1		
Total of individuals caught by this gear				160		

DISCUSSION AND CONCLUSIONS

The project was negatively impacted due to the poor cooperation from commercial fishers that were angry and hostile with the project personnel for implementation of the DNER's Puerto Rico Fishing Regulation 6768. This poor cooperation reduced the proposed number of fishing trip interviews. Despite these difficulties, project personnel, CFSP's port samplers, the valuable help of the DNER's Rangers and a few cooperative commercial fishers, project personnel were able to intercept 71 fishing trips to collect the by catch data.

This project shows that Puerto Rico's by-catch can be considered low in species and number of individuals. However, due to the overfished resource in Puerto Rico the DNER should try to reduce the current by-catch.

The following recommendations would help to reduce the by-catch and improve the fishery resources resulting in better socioeconomics conditions to commercial fishers and will help in the recovery of fishery stocks:

- i) DNER and NMFS should educate all commercial fishers to return juveniles fishes caught by fishing gears alive to the sea when possible.
- ii) The Puerto Rico DNER Fishing Regulations 6,768 eliminates the beach seine gear in 2007. This action will contribute to conserve the small size individuals of many species and reduce the juveniles fishing mortality.
- iii) Educate trammel net fishers to reduce the soak time for this gear (frequently soak time reach 12 hours). This action will reduce the juveniles fishing mortality and by-catch and the probability of catching sea turtles.
- iv) Educate fish trap fishers to return the by-catch alive to the sea. Also educate them to use as bait only dead by-catch or adult individuals.
- v) The implementation of DNER Puerto Rico Fishing Regulations 6768 will reduce the by-catch with closed seasons for some species and minimum and maximum legal sizes for other species. Effective enforcement of these regulations is urgently needed to ensure the success of the management actions.

The project data collected and its analysis was enough to achieve the goals and objectives for this project. However, due to the fact that fishing activity is constantly changing, the CFSP should identify additional funds in the near future to continue the by catch data collection.

ACKNOWLEDGEMENTS

We want to express our gratitude to all the people that contribute in this study. CFSP port samplers Walter Irizarry, Jesús León, Héctor Y. López and Luis A. Rivera, who helped to contact commercial fishers and collect by-catch data; to Boqueron DNER Rangers Unit who helped project personnel to intercept and collect by-catch data; to

NOAA/NMFS MARFIN project NA04NMF433071, Caribbean Fisheries Management Council and DNER for providing funds to complete this project; and to Miguel figuerola, who edited the manuscript. Finally, we want to acknowledge all the commercial fishers who cooperated with this research, without whose contributions this study would not have been possible.

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