A PRELIMINARY ASSESSMENT OF THE EXPORT TRADE IN MARINE AQUARIUM ORGANISMS IN PUERTO RICO

Report Submitted to the

CARIBBEAN FISHERY MANAGEMENT COUNCIL

by

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INTRODUCTION

There has been concern in Puerto Rico over the last 2-3 years regarding what is perceived to be a growing export trade in marine organisms marketed for the aquarium industry. This trade characteristically involves the collection and sale of a wide range of tropical marine vertebrate and invertebrate organisms, as well as plant species, to private and, to a lesser extent, public aquaria. Concern has been expressed both by those active within the aquarium trade and those familiar with Puerto Rico's marine resources over the potential negative impact that increasingly intensive collection could have on fish and invertebrate populations, and the habitat with which they are associated.

There is no published information or database currently available in Puerto Rico regarding either the volume or nature of this trade, the species and areas exploited, the gears employed, or the number of businesses involved. Such information is essential for issues to be addressed concerning the exploitation and preservation of marine resources marketed for the aquarium industry. The purpose of this report is 4-fold:

1. to summarize what is known from tropical areas worldwide regarding the growth and possible impact of the aquarium trade;
2. to provide a first assessment of the nature and extent of this trade in Puerto Rico by documenting the number of people involved islandwide, by determining the species involved and by identifying the principal areas and methods of collection;
3. to describe the biology of key exploited species, or species complexes;

4. to identify information required for monitoring and assessing the trade on a continual basis, with suggested actions for the compilation of the appropriate biological and socio-economic data;

5. to provide recommendations for regulating the industry to enable commercial exploitation commensurate with conservation of the resource base.

WORLD TRADE IN MARINE AQUARIUM ORGANISMS

Trade in ornamental marine fishes began in the early 1950's (Wood, 1985). Since 1965, there has been a steady increase in international trade in coral reef organisms for private aquaria (Lubbock and Polunin, 1975). By 1979, the world trade in marine and freshwater ornamental fishes had an annual wholesale value of $600 million, with a 10-15% estimated annual growth. Marine species had a relatively small share of the market (Wood, 1985) although this proportion is increasing. Growth in the marine side of the industry has come about because of a combination of the widespread use of biological filters, improvements in the treatment of disease, the development of silicone seals enabling easy construction of aquaria, and the manufacture and marketing of synthetic salts allowing salt water to be available countrywide (Hess and Stevely, no date).

Marine organisms are predominantly exported from the Philippines, Hawaii, Taiwan, Hong Kong, Thailand, Singapore, Java, Queensland, Sri Lanka, Ethiopia, Saudi Arabia, Kenya, Mauritius, Florida and some Caribbean Islands (Lubbock and Polunin, 1975),

although from a number of these locations fish are re-exported rather than actually collected (see below). The majority of marine organisms in world trade is exported from the Philippines, with 16% from Hawaii and Florida (this would include re-export from Caribbean countries). Major importers are the U. S. A., Hong Kong, western Europe, Japan, Canada and Australia. The cost, insurance, freight (c.i.f.) value of world trade in ornamental marine fish and invertebrates was estimated at $U.S. 24-40 million annually (Wood, 1985). This does not include international trade in dead coral and shells used for jewelry and ornamentation which may be substantial (Wells, 1981).

The majority of marine fish are tropical coral reef species which are largely collected from the wild, rather than cultivated, as is the case for 50-60% of freshwater ornamental species (Anon, 1979). All invertebrates are wild-caught (Wood, 1985). Imported animals are small species, or juveniles of larger species, usually less than 20 cm in length, although more commonly between 2-8 cm (Lubbock and Polunin, 1975). Since the mid-1980's, national and international trade has increasingly included "live rock". "Live rock" is a broad term used to describe several types of substrate colonized by marine organisms - four main types are distinguished; 1. rubble rock, 2. algae or plant rock, colonized by algae 3. false coral or anemone rock covered with anemones of the genera Ricordea and Rhodactis, and 4. sea mat or gravel rock colonized by anemone-like organisms, usually of the genus Zoanthus (Wheaton, 1989). The increased demand for

live invertebrates that comprise "live rock" has developed with the increasing popularity of "living reefs" or "mini-reefs", private aquarium systems which generally include few fish species.

There is considerable variation in the manner in which collectors and exporters of marine aquarium organisms operate, and regarding the licencing and regulation of harvest practices and trade (Conroy, 1975; Anon., 1979). Collectors may themselves be exporters, or may sell to exporting middlemen. The diverse nature of the marine aquarium industry worldwide, and perceptions regarding its potential impact in exploited areas, are best illustrated by the following individual country accounts.

Southeast Asia

Philippines

A major supplier of tropical fish worldwide. In 1975 more than 80% of U. S. imports originated in the Philippines (Randall, 1984). More than 90% of exported fish are marine species (Lubbock and Polunin, 1975). From 1970-1979 the export value increased 20-fold and today aquarium fishes are within the top ten fishery products being exported. More than 40 companies export fish (Albaladejo and Corpuz, 1981). The Philippines has a reputation for poor quality fish because of the collection techniques employed which include the use of sodium cyanide and explosives (Dawson-Shepherd, 1977; Albaladejo and Corpuz, 1981). The average volume and destination of fishes exported every month is monitored with the assistance of the Fisheries Unit Personnel,

National Export Coordinating Center (NECC). It was concluded that, without proper resource management, the supply of aquarium fishes would rapidly dwindle and extensive destruction of reefs would result (Albaladejo and Corpuz, 1981). There is high mortality of fishes between the time of collection and the time of export because of the limited experience of many people engaged in the industry, the collection methods used, fierce competition and low market prices.

Singapore

There is much re-export to the U. K. and other locations through Singapore from Thailand, Malayasia, Indonesia, Sri Lanka and the Philippines (Wood, 1985).

Indian Ocean

Kenya

Kenya is the largest supplier to the U. K. in East Africa. Collection is strictly regulated and demand exceeds supply (Wood, 1985).

Sudan

Export of native marine species for the ornamental trade is prohibited (Wood, 1985).

Red Sea

Little is exported because of strict regulations on collecting (Wood, 1985).

Sri Lanka

Between 25,000 and 30,000 boxes are exported annually containing approximately 200,000 fish and 400,000 invertebrates.

This is the largest exporter to the U. K. with 139 species appearing on exporters' trade lists. Many collectors believe that aquarium fish species are less abundant now than prior to the development of the aquarium trade. Fish from Sri Lanka are generally considered to be of acceptable quality (Wood, 1985). There is concern for the vulnerability of certain endemic or rare species to overcollection. Also, nothing is known of the secondary consequences of removing large numbers of fish or invertebrates from an ecosystem. It has been suggested, for example, that population explosions of coral-eating starfish, Acanthaster planci, in Sri Lanka, could have been caused by removal of fish that eat its larvae (Wood, 1985).

Maldives

Export of aquarium fish from the Maldives began in about 1980, and by 1988 exports had doubled (Edwards, 1988). The Maldives is now considered to be an attractive base for this industry because of an international airport with direct flights to Europe and abundant reefs. Two business are involved with 25 people. Holding facilities are good with central filtration, protein skimmer and sterilization capacity. Packaging techniques and practices are good. One hundred species are exported, although just 20% of species contribute to 70% of exports. Quality of fish is perceived to be good because of sound collection practices.

Fish are either exported directly from the Maldives or via Sri Lanka. Collection is regulated and the trade carefully

monitored (Edwards, 1988). There is concern over possible conflicts between the collection of fish and the tourist industry, as well as the potential for negative environmental and ecological impacts resulting from overexploitation. No collecting is permitted within approximately 1000 m of tourist islands (Wood, 1985). Quotas of 100,000 (fish plus invertebrates) have been introduced to prevent expansion of the trade and these are strictly enforced (Edwards, 1988). However, it is considered to be difficult to select which species should be subject to export quota. Some species are believed to be more likely to experience high levels of mortality if removed from the reef and thus need specific protection. For example, certain butterflyfishes do not feed well in captivity and their mortality is high. Other species are rare or live in limited or specialized habitats and are considered to be vulnerable to overcollection (e.g. Amphiprion spp.), or are important for reef health such as 'cleaners' (species of fish or invertebrate, commonly shrimp, that clean the ectoparasites from the bodies of other fishes).

Djibouti

The potential for developing an export trade in marine aquarium fishes in Djibouti was recently investigated to draft a preliminary management policy for the exploitation of marine ornamental fish. Evaluated were the nature of the resource base, the potential impact of collecting on the ecology of the area and on the artesenal fishery. If this trade were to be developed it would likely represent a major export. Djibouti has no national

product or export and relies largely on foreign aid (Barratt and Medley, 1990). Recommendations developed from initial assessments recognized that exploitation should be based on resource availability and that there could be successful trade provided there is sufficient management and protection of resources from overexploitation. Certain species such as Amphiprion spp. were perceived to be particularly vulnerable to heavy exploitation because of easy capture and specialized habitat i.e. association with anemones.

Pacific

Australia

Australia's principal export trade is with the U. S. A. where some species may be held temporarily before re-export (Wood, 1985). Trade to the U. K. is limited largely because of long travel times. The size and nature of the aquarium fish industry is economically and ecologically important, and is expanding fast. However, little information is available on target species involved or on acceptable collection levels (Whitehead et al., 1986). Collectors must have prior written permission from the Government to use chemicals or explosives for collection. Permits and licences exist depending on whether collection is recreational or commercial, or whether it takes place in zoned (protected) or unprotected areas, to ensure reasonable collecting, to reduce user conflict, and to conserve reefs (Whitehead et al., 1986).

Hawaii

Hawaii is an important exporter of marine ornamental species. The fish are reputed to be of high quality and mortality is low because collection with chemicals and explosives is prohibited (Poollen and Obara, 1984; Wood, 1985). The trade is of economic importance but considered to be of potential damage to reef ecosystems. Collection is prohibited in marine conservation areas. Collectors need permits to use nets and are required to maintain fish, prior to export, in reasonable health and in adequate holding facilities, which are periodically inspected (Wood, 1985). They must also submit monthly catch reports (Walsh, 1978). Businesses are small and the collector is usually the exporter. More than 60 licenced collectors were involved in the early 1980's (Randall, 1984), with an estimated total of 89 people participating in the industry at all stages, including packing and shipping (Poollen and Obara, 1984). The most important single fish species exported is the yellow tang (Zebrasoma flavescens) followed by a number of butterflyfish, angelfish and other tang (acanthurids). Some of these species were noted to have declined in collections between 1976-1982 (Poollen and Obara, 1984) and many fish collectors recognize the need for management of the industry to prevent overexploitation.

Western Atlantic

Florida

Attention was focused on the aquarium trade in Florida in 1975 (Robins, 1976) when it was recognized that information on

the biology and socio-economics, as well as possible user conflicts, was needed to characterize the industry. Florida exports both wild-caught as well as a small proportion of tank-bred species (mainly anemonefish). Mandatory landings figures have been collected from 1989 onwards from wholesalers. For April 1990 - March 1991, approximately 200 species, or species groups, were reported in landings data collected on trip tickets (Florida Marine Research Institute, Florida Department of Natural Resources (FDNR) data). Nearly two-thirds of the marine life fishermen live in Florida Keys (Januzzi, 1991). Because of many problems in the business, fishermen throughout Florida consider that some form of limited entry arrangement into the fishery is necessary (Januzzi, 1991).

The most frequently collected species reported were invertebrates (Condylactis gigantea - 316,000 organisms; sand dollars (several genera) - 211,000; various crabs - 120,000; turbinellid snails - 76,000; Lima scabra - 60,000, and substantial quantities of "live rock", recorded in pounds). The most frequently collected fish species were angelfish, wrasses, and damselfish (Holacanthus bermudensis - 28,000; Holacanthus tricolor - 27,000; Pomacanthus arcuatus - 17,000; Thalassoma bifasciatum - 16,000; Chromis cyaneus - 14,000). Considerably more invertebrates than fish were reported and there is concern particularly over the substantial numbers of anemones and volume of "live rock" being taken. Collection of "live rock" is to be phased out over the next three years. The economic importance of aquarium fishes has

been reported to be high. For example, the U. S. dollar value from FDNR landings statistics in 1976, prior to the recent growth in the industry, indicated that aquarium fishes ranked eighth in economic importance in Florida (following grouper and king mackerel).

The taking of organisms for the aquarium trade is regulated in Florida State and Federal waters. As of January 1st, 1991, regulations (Chapter 46-42 - Marine Life) were in effect to protect and conserve Florida's tropical marine life resources and assure use of non-lethal methods of harvest. The taking of several species of vertebrate, invertebrate and plant is restricted. Longspine urchin, Diadema antillarum cannot be harvested. Some species are subject to maximum or minimum size limits. Bag limits or quotas are in force and there are permitting requirements for collection of plants and animals, or the use of certain collection methods. Quinaldine use requires a permit which allows up to a 2% quinaldine concentration in solution in seawater, mixed with isopropyl alcohol or ethyl alcohol (acetone may not be used as a solvent).

Curaçao

In 1970, four licenced exporters were known to be exporting marine ornamental fish and invertebrates, including "live rock", for the aquarium trade. Data on the export of fishes and invertebrates from Curaçao between 1972 and 1977 indicate that all fish were collected using quinaldine (Kruijf, 1978). After 1976 the taking of stony corals was prohibited. Principal species exported

to the U. S. and Europe over this period were Gramma loreto - 48,185; Condylactis giganteus - 41,530; Sabella spp. - 34,586; Centropyge argi - 24,751; Opistognathus aurifrons - 24,244; Holacanthus tricolor - 14,272; Myripristis jacobus - 13,219; Pomacanthus paru - 10,693). Exports after 1975 declined for two reasons; collectors around Miami came to supply an increasingly large proportion of the U. S. market, and the opening of reef areas in Haiti produced supplies of organisms for the U. S. market at very low prices. Concern was expressed that two of the most commonly collected species, H. tricolor and P. paru, might require collecting limits because of their relatively low abundance (Kruijf, 1978). Holacanthus ciliaris - the queen angel - is a rare species which cannot be collected (Lubbock and Polunin, 1975).

Barbados

This is the principal Caribbean source of aquarium trade fishes to the U. K. and accounts for 2% of total U. K. imports (Wood, 1985). Use of quinaldine is not permitted.

U. S. Virgin Islands

Some export of marine organisms occurs. Licensing is required for the export of indigenous and endangered species (Jim Beets, pers. comm.) and a 10% export tax is in effect. Principal species exported are Gramma loreto, Opistognathus aurifrons, angelfish species and a number of invertebrates.

Hispaniola

Exports from Haiti increased in the mid 1970's (Kruijf,

1978). Fish prices were low and labor was cheap. Haiti is believed to be a principal shipper to the U. S. A. (Mark Derr, pers. comm.). Reports indicate that alcohol and quinaldine are used extensively to capture fish and that the resulting fish quality is poor. Substantial export activity has also been reported to occur from the Dominican Republic although specific information was unavailable.

Bahamas

Use of bleach for fish capture has been reported from the Bahamas (Hess and Stevely, no date).

Puerto Rico

Export of organisms for the aquarium trade began in about 1970. In the early 1970's, Lubbock and Polunin found Puerto Rico listing 49 species available for export (Lubbock and Polunin, 1975). In 1983, Puerto Rico supplied 0.1% of total U. K. imports, representing approximately 123,000 kg in weight. The U. S. is the principal import market. Until recently the number of collector/exporters has been small but over the last 2-3 years there has been an increase in collecting and export activity on the Island. Possible reasons for this are the excellent air transport facilities, the increased restrictions on Florida-based collectors, and increased demand for marine aquarium organisms in general. Listings of exported species are provided to Puerto Rico's Department of Natural Resources personnel at the Luis Muñoz Marín airport where shipments must be inspected. Summaries of these data are not compiled. The aquarium fish trade is not

specifically regulated, although collection of a number of marine species (e.g. lobster with carapace length less than 3.5" and removal of corals including sea fan/gorgonian) is prohibited, as is the use of poisonous substances in Puerto Rico waters (regulated under Law No. 83, May 13, 1936, known as the "Ley de Pesca", and amendments), and the taking of "live rock" (Law No. 132, June 25, 1968, amended). The treatment of animals maintained in captivity is also regulated (Ley, 67 May, 1973, known as the "Ley para Protección de Animales"). Exporters do not have to be licenced and collectors are not legally recognized as commercial fishermen.

THE MARINE AQUARIUM TRADE IN PUERTO RICO (1990-1991)

Collection of Data

Information on the aquarium trade in Puerto Rico was obtained from conversations with knowledgeable contacts both within and outside the aquarium trade in Puerto Rico and in Florida, as well as officials of the Florida and Puerto Rico Departments of Natural Resources. All individuals known to be active in the export trade for a number of years were either visited at their business facilities or interviewed by telephone. Information was summarized on species, or species complexes, indicated on company trade lists as available in Puerto Rico, species, or species complexes, actually exported (by number of organisms), and numbers of boxes of organisms imported and exported per month, for 1990-1991. Export information was obtained from export packing lists of individual shipments (shipping lists) from a

total of 92 (species composition of exports data) and 81 (boxes exported data) shipping lists, respectively (11 shipping lists had species composition data but did not show numbers of boxes exported). The shipping lists utilized do not constitute a random subset of all island exporters as some, not necessarily the biggest shippers, are more frequently represented than others.

Collectors/Exporters

Most collectors are exporters, although some collectors also sell their catch to an exporting middleman, or, less frequently, to Island pet shops. There are at least 6 export businesses on the Island. These are based in western and southern Puerto Rico and also out of San Juan. Three of these businesses have been established in the export trade for a number of years, others are relatively recent: several collectors started by selling locally and then later began to export. One recently established business is reportedly initiating a breeding program for Indo-West Pacific anemonefish (clownfish). Combined, the businesses depend on about 40 regular collectors working on a full- or part-time basis, with additional individuals collecting on a more casual basis. I would estimate that less than 100 people are involved in all phases of the aquarium trade, from collectors and their assistants, to biologists, packers and shippers. Most exporters depend for the majority of their income on the export trade, but often have other means of income outside of the aquarium industry.

Methods Used for the Harvest of Marine Organisms

Major collectors have their own boats, diving and collecting

gear. Boats are in the order of 7 m in length. Collecting trips may be made 7 days a week if weather permits and demand is high, otherwise collecting trips may be made 3-4 days weekly. Demand tends to be highest in the winter and lowest in the summer months (Wood, 1985; pers. comm.). Collectors visit specific collecting areas depending on species being sought and indicate that they are careful to rotate the area of collection to avoid fishing too heavily in any one location. Collection is predominantly by SCUBA, generally down to 20 m but occasionally to 40 m for certain species. Mask and snorkel are commonly used in shallow-water areas.

Collection is by net (barrier, gill, drop or cast, and hand or dip nets), fish trap (1/4 - 1/2" mesh, and specialized traps - for example to catch Gramma loreto), chemicals such as 'Quinaldine', and slurp gun (not common). Cast nets are small circular nets with weights attached along the outer edge, and hand or dip nets are generally comprised of 1/8" monofilament mesh and may incorporate plastic panels. There are also reports that bleach, formalin and gasoline have been used on occasion, especially in the area of La Parguera. Quinaldine (2-methyl-quinoline) is mixed with isopropyl or ethyl alcohol or acetone, diluted with seawater and dispensed from bags, small plastic bottles or pressure sprayers. It is derived from coal tar and used in the manufacture of dyes and explosives (Hess and Stevely, no date). There is considerable debate regarding the short- and long-term effects of this chemical on fishes and invertebrates, although it is clear

that it is toxic to certain species (see below). Many wholesalers are reluctant or refuse to purchase fish collected with quinaldine because they believe that mortality rates are higher than with net-caught fishes. Some collectors interviewed indicated that quinaldine-caught fish may be detected visually by damage to gills which come to look "burned" or pinker than the gills of fish not exposed to this chemical. Many locations prohibit the unpermitted use of quinaldine because of its perceived detrimental effects on marine organisms (e.g. Hawaii and Florida).

Areas Collected

Collection areas are north and south of the Rincón peninsula, Punta Arenas in Cabo Rojo (for sea mat - Zoanthus), and along the northwest coast to Arecibo for certain species such as angelfish and blennies (Fig. 1). The island of Desecheo 20 km west of Rincón is especially suitable for yellowhead jawfish (Opistognathus aurifrons), royal gramma (Gramma loreto) and pygmy angelfish (Centropyge argi). Collecting is also carried out extensively around the reefs and mangrove islands of La Parguera, especially for invertebrates and queen angelfish, as well as southeast of Ponce, especially off the island of Caja de Muertos, 8 km offshore, for angelfish and triggerfish, and between Ponce and Salinas. No collection sites could be confirmed off eastern Puerto Rico although collection has recently been proposed for Fajardo and Isla Cabra, and has been reported to occur sporadically in Culebra.

Species Collected

Species composition, as determined from trade lists and exporters' shipping lists, of 5 different shippers between 1990 and 1991, is shown in Table 1. A total of 155 species (plus a few "miscellaneous" invertebrate species which could not be identified to genus), or species groups, appeared on traders' lists, as available in Puerto Rico, 104 fish species and 51 (+ miscellaneous) invertebrates. Of these, 83 fish species and 23 (+ miscellaneous) invertebrates were noted as exported. Examination of a subsample of 92 shipping lists from 4 different shippers indicated that 6 species, or families, made up 70% of the total fish export: Gramma loreto; Opistognathus aurifrons; Holacanthus tricolor; Pomacanthus paru; Balistes vetula, and assorted blennies. Principal fish families exported were Grammidae, Opistognathidae, Pomacanthidae, Chaetodontidae, Pomacentridae, Holocentridae, Blenniidae, Labridae, and Balistidae. Individuals are taken between 3.5 - 13 cm depending on the species.

A wide variety of invertebrates was exported, in particular anemones, shrimps, crabs, flame scallop, and various echinoderms, e.g. brittlestars. There were difficulties in identifying to species a variety of species. Often, common names were used which are not species-specific or names of species not present in Puerto Rico, or even in tropical waters, were applied. Several species were listed as available on company trade lists (although not recorded as shipped) the taking of which is not permitted (e.g. lobster, gorgonian/sea fan). Removal of certain species

would require removal of substrate and hence come under the definition of "live rock" (e.g. Ricordea florida). I believe that the volume of invertebrates exported is grossly under-represented in shipping lists. It has been reported, for example, that in a single day collectors take many hundreds of anemones from La Parguera.

Handling and Shipping of Marine Organisms

Animals are taken to holding facilities and generally retained for a few days prior to packing and export. Facilities vary from a small number of plastic "paddling pools" fed by a simple flow-through water system, to a series of glass and concrete tanks, under-gravel and ultra-violet filters, and protein skimmers. On several occasions I observed small numbers of unhealthy fish (pale in color, fins torn, listless) in holding facilities. Some collectors report that fish considered to be in less than good health are returned to the sea.

For shipping, animals are packed in single or double plastic bags. These are filled with oxygen by some shippers, and the bags closed and placed in boxes for shipping. Boxes vary in dimension from 30 x 43 x 43 cm (12 x 17 x 17") to 53 x 53 x 53 cm (21 x 21 x 21") and may or may not be lined with insulating material for stabilization of temperature, depending on shipper, destination and season. The majority of marine organisms is currently shipped out of San Juan (Luis Muñoz Marín airport) to the east and west coasts of the U. S. A., Canada, and to Europe, particularly to the U. K. and Germany. However, some export also occurs out of

Aguadilla, and reportedly on occasion through the postal system (Federal Express) and United Parcel Service (U.P.S.).

Listings of exported species are provided to Department of Natural Resources personnel at the Luis Muñoz Marín airport where shipments are inspected. Shipments must also be checked by the U. S. Division of Fish and Wildlife, who charge a $25 inspection fee, if for export outside U. S. territory

Estimates of mortality from the time of capture to the time of export reportedly varies between 10% and 20% depending on capture and handling methods, the level of skill of collectors and conditions of holding facilities. This estimate of mortality is high compared to mortality rates reported for net-caught fish in Hawaii (Poollen and Obara, 1984) and relative to the most commonly cited level in the industry of 10% (Wood, 1985). Some fish importers consider that mortality rates of more than a few percent are unacceptable (pers. comm. Richard Sankey).

Estimated Export/Import Volume (1990-1991)

From the shipping lists, it was determined that an average shipment of fish and invertebrates comprised 12 boxes (range 2 - 29) and that each box on average contained 31 organisms (range 7 - 100, depending on the species involved and their size). It was estimated from interviews with exporters that an average of at least 9 shipments a week leave Puerto Rico. This provides a monthly estimate of 432 boxes exported per month (9 x 12 x 4), and 5184 boxes per year, containing an annual total of 160,704 organisms (9 x 12 x 4 x 12 x 31). This does not include U. S.

mail or U. P. S. shipments. Exporters vary in the number of shipments from 1-3 per week. Boxes were estimated to weigh between 8-14 kg, if not containing coral or "live rock". To put into perspective the current volume involved in this trade, the estimated number of organisms exported is approximately equivalent to the total number of grouper reported landed annually by the comemrcial fishery of Puerto Rico (Fisheries Research Laboratory, PRDNR, unpubl. data). Grouper are among the most frequently landed fish categories on the Island.

The number of boxes exported appearing in Department of Natural Resources records (2448 for 10 months) (Table 2) is clearly a gross underestimate of true exports. This conclusion is supported in part by reports of zero boxes in June, July and August, 1991, during which months export shipments were made according to interviews with collectors/exporters. Furthermore, Department figures did not include shipments out of the Aguadilla airport where airport inspection activity is reported to be minimal. Substantial imports of marine organisms were also noted (Table 2).

SPECIES DESCRIPTIONS OF COMMONLY EXPLOITED MARINE ORGANISMS

Fish Species

For the majority of species exploited, there is little life history information available. Only data on the most commonly exported species, as determined from shipping lists, are summarized. However, other species of importance for the industry are damselfish, such as blue chromis, Chromis cyanea, the pygmy

angelfish, Centropyge argi, and a number of squirrelfish species and blennies, in particular the red-lipped blenny, Ophioblennius atlanticus.

Gramma loreto - royal gramma, fairy basslet (Grammidae)

A violet/yellow colored fish commonly found in groups of 2-3 to dozens or more in clear waters down to about 60 m although generally in shallower water (Böhlke and Chaplin, 1968; Randall, 1983). Its range extends from Bermuda and the Bahamas throughout the Antilles to islands off Venezuela. It is apparently absent from Florida (Böhlke and Chaplin, 1968). It is found in high vertical relief habitat, in caves and under ledges in restricted home ranges where residency has been reported up to 76 weeks (Luckhurst and Luckhurst, 1978). It is mainly planktivorous (Luckhurst and Luckhurst, 1978), although it has been reported to feed on the ectoparasites of other fish (Eibl-Eibesfeldt, 1955). It attains just over 8 cm in total length and shows little sexual dimorphism other than a somewhat larger male mean size (Thresher, 1984). Reproduction in Puerto Rico occurs between January and June (Amador, 1982), and in Curaçao recruitment was noted through much of the year, with peaks in September and May (Luckhurst and Luckhurst, 1978). Information on the biology of this species is scattered and fragmented and there is some debate over its sexual pattern, which has been proposed to be hermaphroditic (Corsten and Corsten, 1974). This is considered to be a common western Atlantic species (Randall, 1983). It is captured predominantly using quinaldine with which 300-500 individuals may be captured

in a day. Occasionally a specially designed hand trap may be used but catch rates are reported to be substantially lower than with quinaldine. Several aggregations of this species were monitored after partial or total removal (Kruijf, 1978). Replacement occurred within 1-4 weeks and was dependent on levels of recruitment into the area.

Holacanthus tricolor - rock beauty (Pomacanthidae)

A pomacanthid (angelfish) found in the western Atlantic from Georgia, Bermuda and the Bahamas to Brazil and in the Gulf of Mexico (Böhlke and Chaplin, 1968; Randall, 1983). It occurs to depths of approximately 10 m and forages solitarily during the day, feeding on algae and sponges, and occasionally ascidians, fish eggs, gorgonians and zooantharians (Neudecker and Lobel, 1982). It has been reported to attain 34 cm in length (Munro, 1983), although it is not generally of value to the aquarium trade at lengths greater than 13 cm. The young up to about 2.5 cm are yellow in color with a black spot on the upper side of the body posterior to the mid-point. This spot later grows to become the large dark area covering most of the body, and dorsal and anal fins (Randall, 1983). Juveniles may feed on the cutaneous mucus of larger cave-dwelling fishes (Thresher, 1984). Spawning has been observed at dusk in triplets or small groups of one male and several females, throughout much of the year (Moyer et al., 1983; Munro, 1983). The smallest mature female was recorded at 10 cm total length (Munro, 1983), and the eggs are planktonic. Individuals are relatively sedentary. Females have overlapping

home ranges and males defend large territories with a mean area of approximately 1,000 m^2 which encompass a number of female home ranges (Hourigan and Kelley, 1985). The sexual pattern of this species is unclear and protogynous hermaphroditism has been proposed (Hourigan and Kelley, 1985). The species is sexually monomorphic. Rock beauty are caught using large hand nets, and with quinaldine.

Holacanthus ciliaris - queen angelfish (Pomacanthidae)

This angelfish is colored blue/green and yellow. There is no sexual dichromatism. It is distributed in the tropical western Atlantic from the Gulf coast of Florida and the southern Gulf of Mexico, through the Bahamas down to Brazil (Böhlke and Chaplin, 1968; Randall, 1983). It has been collected to a maximum length of 43 cm (Randall, 1983), and is often found in triplets or small groups (Thresher, 1984). Ripe fish have been reported in all months of the year except November and December (Munro et al., 1983). Individuals tend to stay in the same general area (Randall, 1962). This species is taken with nets and quinaldine. Its capture is banned in Curaçao because of its rarity (Lubbock and Polunin, 1975).

Pomacanthus paru - french angelfish (Pomacanthidae)

The adults of this species are grey and the juveniles are black with vertical yellow bands. Juveniles are known to pick the skin of various fish species and have been observed cleaning the teeth of large needlefish (Böhlke and Chaplin, 1968). It is distributed in the western Atlantic from the Bahamas and Florida

to Brazil. Ripe individuals were collected from May to November in Jamaica (Munro, 1983). French angelfish have been reported to reach 41 cm (Randall, 1983), although only individuals up to about 13 cm are used for the aquarium trade. They are taken with hand nets and quinaldine.

Bodianus rufus - spanish hogfish (Labridae)

A red/violet/yellow fish with a black spot on the anterior portion of the spinous dorsal fin. It is recorded in the western Atlantic from Bermuda, the Bahamas and Florida to Brazil, including the Gulf of Mexico, the coast of Central America and Venezuela (Böhlke and Chaplin, 1968; Randall, 1983). This is a reef-associated species found down to about 40 m. The young pick parasites from larger fishes. Individuals have been reported to reach about 40 cm (Randall, 1983) and feed on crabs, sea urchins, brittlestars and mollusks. The social structure is characterized by stable dominance hierarchies that are linearly organized according to sex and relative size. Males are generally larger and dominate groups of up to 12 females in permanent territories (Hoffman, 1985). Females mature at about 10 cm and spawning occurs daily at sunset through much of the year. Eggs are planktonic and the species is protogynous (Hoffman, 1985). Individuals are predominantly caught by hand net and quinaldine.

Thalassoma bifasciatum - bluehead wrasse (Labridae)

This is one of the most abundant West Indian reef fishes and is distributed from Bermuda and the Bahamas, southern Florida, southern Gulf of Mexico, throughout the Caribbean Sea to the

islands of the north coast of South and Central America (Böhlke and Chaplin, 1968; Randall, 1983). The species has several different color phases, exhibiting marked sexual dichromatism, and its name derives from the largest phase, that of the adult male. It feeds on small benthic animals and zooplankton, and the juveniles feed on the ectoparasites of other fishes (Randall, 1983). It spawns through much of the year in pairs or groups at about midday, is a diandric protogynous hermaphrodite, and produces planktonic eggs (Thresher, 1984). Some males defend territories and females have home-ranges. It is reported to reach about 15 cm (Randall, 1983). Only blueheads are caught for the aquarium trade in Puerto Rico resulting in differential male removal from exploited populations. Individuals are generally taken by hand nets to which they are attracted by bait such as crushed sea urchin.

Halichoeres radiatus - puddingwife wrasse (Labridae)

The puddingwife wrasse is known from Bermuda and North Carolina to Brazil (Böhlke and Chaplin, 1969), and is recorded to reach a length of 46 cm (Randall, 1983). It is found in areas of coral cover where individuals are often seen singly, and is somewhat secretive. The species exhibits sexual dichromatism and is reported to be hermaphroditic. The smallest mature female recorded was 16 cm in standard length (Warner and Robertson, 1978).

Opistognathus aurifrons - yellowhead jawfish (Opistognathidae)

A yellow/white colored jawfish which is found in the

Florida Keys and throughout the West Indies (Randall, 1983). It usually lives in sandy areas in vertical burrows lined with small stones or shell fragments above which it is most commonly seen to hover as it feeds on zooplankton (Randall, 1983; Thresher, 1984). It occurs in relatively shallow water and attains a length of about 10 cm (Randall, 1983). Its abundance has been reported to vary seasonally and it is often found in large groupings (Kruijf, 1978). Spawning occurs in the burrow and males incubate eggs in their mouth. Eggs hatch within 7-10 days and settlement occurs at about 10-15 mm (Thresher, 1984). The species is sexually monomorphic and is a popular aquarium fish (Thresher, 1984). It is caught predominantly by using quinaldine, although this species is reported to be particularly sensitive to quinaldine and is easily killed by overdosing (Colin, 1975).

Balistes vetula - queen triggerfish (Balistidae)

Distributed from Massachusetts to Brazil, this is a common species on reef or rocky areas, but ventures to adjacent sand rubble or seagrass areas (Randall, 1983). Adults are solitary diurnal feeders on a great variety of invertebrates but particularly on sea urchins, such as Diadema (Randall, 1983). It may also be found in schools and has been reported to occur down to 100 m (Munro, 1983), although smaller individuals are generally found in shallow water. The queen triggerfish is reported to attain a fork length of 57 cm (Randall, 1983) and to mature sexually at about 17 cm (Munro, 1983). Ripe individuals have been collected between January and August in Puerto Rico (Erdman,

1976). This species is commercially exploited and rated number 16 of the 33 most economically-important fish groups in Puerto Rico in 1990 (Matos and Sadovy, 1991). Individuals are taken with quinaldine at about 5 - 7 cm length - only juveniles of this species are apparently exploited for the aquarium trade.

Invertebrate Species

A wide range of invertebrate species are taken, in particular brittlestars, cleaner shrimps, flame scallops and anemones (Table 1). Reports indicate that several hundred individuals of the anemone Condylactis may be taken in a single day from La Parguera, a location particularly popular for collection of invertebrate species. A number of species reported as being available on traders' lists are in reality what should most accurately be described as "live rock". For example, Ricordea florida must be removed with its rocky substrate and is considered one type of "live rock" in Florida. Certain species such as the flame scallop, some feather dusters and the christmas tree worm are typically removed with accompanying substrate and should likewise be considered "live rock". Collection of brittlestars and some tube worms may necessitate the lifting or displacement of rock or coral substrate. Some organisms are extracted individually from sandy substrates. Cleaner shrimp are removed from host anemones. The effect of the removal of cleaners (fish or shrimp species) on the general health of reef fish is unknown. The long- and short- term effects of using quinaldine both on individuals captured, or impacted when other species are being taken, or on

associated habitat at time of capture are not clear. However, its effect is clearly toxic in some cases. This chemical has been shown to cause no damage to certain scleractinian corals during preliminary studies but was found to have a detrimental effect on two coral species, Agaricia agaricites and Meandrina meandrites (Jaap and Wheaton, 1975). Jellyfish may be killed instantly by quinaldine (Ireland and Robertson, 1974), and crustaceans and cephalopods showed signs of irritation at quinaldine concentrations used to anesthetize fishes, although it is unclear if it was the alcohol associated with the quinaldine or the quinaldine which causes the reaction (Hess and Stevely, no date). This chemical has also been shown to induce significant histopathological changes in the thyroids of mice, and thyroid abnormalities have also been encountered in people exposed to quinaldine (Dr. F. Khafagi, Director of Nuclear Medicine, Royal Brisbane Hospital, Herston, Brisbane, 4029, Australia).

BIOLOGICAL AND SOCIO-ECONOMIC DATA NEEDS

In order to monitor and evaluate the volume, nature and potential impact of the marine aquarium trade in Puerto Rico, information is needed, on an annual basis, on the number of individuals collecting and exporting organisms, the numbers and types of animals collected and exported, and the extent of trade in aquarium organisms within Puerto Rico i.e. non-export trade. Also, some means of measuring catch per unit effort (perhaps on a per trip basis) should be established.

Species identification of a number of invertebrate organisms

needs clarification by direct examination of specimens, if possible, and the principal collection areas should be assessed regarding their significance, if any, as critical habitats. The capture methods employed need to be evaluated to ascertain to what extent these may impact detrimentally either targeted or non-targeted species and associated habitat. In particular, the short- and long-term impact of using quinaldine to collect vertebrate and invertebrate species must be addressed if limited use of this chemical is to be permitted.

The potential for user conflict between aquarium industry collectors, commercial fishermen and the tourist/recreational industry needs evaluation. Stock analyses of species exploited by more than one user group (such as the queen triggerfish, Balistes yetula) should be made to determine the combined impact of removal of individuals at distinct life history phases, by different user groups, on the overall condition of the stock. The impact of collection activities on areas programmed for tourist development, such as Caja de Muertos, should be evaluated.

Biological data on the life history of principal species exploited is inadequate, particularly with respect to reproductive biology, and special habitat requirements, vulnerability to collecting methods, if any, and abundance on a local and island-wide level. Assessment of commonly collected organisms regarding their suitability as aquarium species would enable formulation of recommendations concerning species considered appropriate for exploitation by the industry. For example, if mortality in

aquaria is high (such as determined for certain butterflyfishes, see above), exploitation for the aquarium industry should be discouraged. It is necessary to assess the holding and shipping techniques utilized by collector/ exporters to ensure that mortality is minimized, the animals treated humanely, and hence that best use is made of exploited resources.

The time required for recolonization of an area following heavy collection should be assessed. For example, areas heavily collected in the Bahamas using rotenone and subsequently monitored were found to exhibit disturbances in population balance for at least 4 months following collection. Between 4-9 months were required to re-establish the pre-collection population equilibrium (Smith, 1973). The time required for recolonization by Gramma loreto was found to be dependent upon availability of recruits (Kruijf, 1978). A study by Taylor and Nolan carried out over 2.5 years in Hawaii on the 5 most frequently exploited fish species indicated that more heavily collected areas did not show greater reductions when compared to non-collected areas but did indicate population fluctuations in certain species for both collected and uncollected areas (Taylor and Nolan, 1978). Populations of heavily fished species (e.g. royal gramma, yellowhead jawfish, angelfish species, and a number of invertebrates) should be monitored to determine the impact of heavy collection, and how this may vary seasonally. Recommendations regarding appropriate periods for collection, or for protection of collected areas or species, based on biological knowledge of population responses to

collection, could be made to reduce the possibility of over-exploitation.

MANAGEMENT OPTIONS AND CONSIDERATIONS

1. Collectors and exporters of marine organisms for the aquarium trade should be licenced to collect and export marine organisms, and the number of licences limited according to availability and suitability for exploitation of fish and invertebrate resources. To prevent further expansion of the industry until the necessary studies and evaluations are available, licences could be restricted to those individuals who can clearly demonstrate current and substantial activity in the industry in Puerto Rico. Licence applications should include socio-economic details of applicants.
2. Licenced collectors/exporters should be required to submit monthly reports on numbers of each species captured, as well as exported or sold in Puerto Rico, and location and method of capture. Listings should include both common and latin names.
3. Holding facilities and packing materials and techniques used for shipment should meet certain specified standards to minimize mortality and to ensure the good health and welfare of live organisms. Exporters should demonstrate knowledge of Commonwealth and Federal laws pertaining to the capture, treatment and shipping of marine organisms.
4. The use of quinaldine to capture fishes should be unequivocally prohibited on the basis of its proven toxicity to certain fish and coral species, pending further study of its effects, if this should be determined as necessary. The use of any other

capture method determined to be damaging to organisms harvested, or to the coral reef environment, should be prohibited, or carefully regulated.

5. Inspections of export shipments should be thorough and made on all shipments from both San Juan and Aguadilla (or others as necessary) airports, or any other shipment points. Inspectors need to be trained to recognize marine species of fish and invertebrates. Any box weighing over approximately 14 kg should be carefully inspected for coral or "live rock". Shipment weights should be noted, and monthly figures showing export volume (by number of boxes and by weight should be made available in summarized form.

6. Consideration should be given to the possibility of introducing annual quotas for the capture of certain vulnerable or uncommon species (possible candidates are sea horses and swissguard basslets), species which do not survive well in captivity, or species which may be of particular importance to the reef ecosystem, such as fish and invertebrates which clean ectoparasites off other species. Global annual catch quotas, in addition to limited entry (item 1), should be introduced to prevent expansion of collection activity while the resource base and other biological questions are being assessed.

7. Consideration should be given to the imposition of size limits (minimum and/or maximum) to protect life history phases deemed to be particularly vulnerable to overexploitation.

8. A summary of laws which relate to all phases of the collec-

tion, handling, maintenance, and sale and export of organisms for the aquarium trade should be developed and pertinent regulations clarified and communicated to the industry.

9. Collectors and exporters of marine organisms marketed for the aquarium trade should be encouraged to participate fully in the development of a management policy for the fishery.

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TABLE 1:

Fish and invertebrate species, or species groups, exported from Puerto Rico, or indicated on company trade lists available for export, according to trade lists and shipping lists for 1990/1

FISHES:

Elasmobranchs	SHARKS, SKATES, RAYS	
Gymnothorax miliaris	GOLDENTAIL MORAY	44
Gymnothorax funebris	GREEN MORAY	
Myrichthys oculatus	GOLDSPOTTED SNAKE EEL	4
Echidna catenata	CHAIN MORAY	
Muraenids	MORAY "EELS"	8
Plectrypops retrospinis	CARDINAL SOLDIER	183
Holocentrus ascensionis	LONGJAW SQUIRRELFISH	5
Myripristis jacobus	BLACKBAR SOLDIERFISH	242
Holocentrids	SQUIRRELFISH	3
Apogon maculatus	FLAME/FISH/CARDINAL	98
Astrapogon stellatus	CONCHFISH	1
Priacanthus arenatus	BIGEYE	24
Priacanthus cruentatus	GLASSEYE	26
Chromis cyanea	BLUE CHROMIS	439
Chromis insolatus	SUNSHINE DAMSELFISH	20
Abudefduf saxatilis	SERGEANT MAJOR	12
Stegastes partitus	BICOLOR DAMSELFISH	
Stegastes leucostictus	BEAUGREGORY	49
Stegastes planifrons	YELLOW DAMSELFISH	20
Stegastes dorsopunicans	DUSKY DAMSELFISH	
Microspathodon chrysurus	YELLOWTAIL/JEWEL DAMSEL	299
Pomacentrids	DAMSELFISH	8
Thalassoma bifasciatum	BLUEHEAD WRASSE	612
Clepticus parrae	CREOLE WRASSE	43
Halichoeres cyanocephalus	LIGHTNING WRASSE	20
Halichoeres radiatus	PUDDING WIFE	587
Halichoeres maculipinna	CLOWN WRASSE	34
Halichoeres garnoti	YELLOWHEAD/NEON WRASSE	122
Xyrichtys splendens	RAZORFISH/GREEN WRASSE	26
Bodianus rufus	SPANISH HOGFISH	462
Labrids	WRASSES	
Sparisoma chrysopterum	REDTAIL PARROTFISH	
Scarus taeniopterus	PRINCESS PARROTFISH	
Scarids	PARROTFISH	20
Centropyge argi	PYGMY ANGELFISH	345
Pomacanthus paru	FRENCH ANGELFISH	882
Pomacanthus arcuatus	GRAY ANGELFISH	7
Holacanthus ciliaris	QUEEN ANGELFISH	114
Holacanthus tricolor	ROCK BEAUTY	1552
Pomacanthids	ANGELFISH	7
Chaetodon capistratus	4-EYE BUTTERFLYFISH	133
Chaetodon ocellatus	SPOTFIN BUTTERFLYFISH	
Chaetodon striatus	BANDED BUTTERFLYFISH	338

FISHES continued:

Chaetodon aculeatus	LONGSNOUT/NOSE BUTTERFLY	111
Chaetodontids	BUTTERFLYFISH	98
Gramma loreto	ROYAL GRAMMA	11124
Serranus tabacarius	TOBACCO FISH	57
Serranus tigrinus	HARLEQUIN BASS	76
Serranus annularis	ORANGEBACK BASS	1
Serranus baldwini	LANTERN BASS	13
Serranus tortugarum	CHALK BASS	54
Serranids	BASSES	14
Liopropoma rubre	SWISSGUARD BASSLET	6
Hypoplectrus nigricans	BLACK HAMLET	
Hypoplectrus indigo	INDIGO HAMLET	
Hypoplectrus unicolor	BUTTER HAMLET	
Hypoplectrus puella	BARRED HAMLET	
Hypoplectrus guttavarius	SHY HAMLET	1
Hypoplectrus gummigutta	GOLDEN HAMLET	
Hypoplectrus aberrans	YELLOWBELLIED HAMLET	
Serranids	HAMLETS	12
Paranthias furcifer	CREOLE FISH/ANTHIAS	135
Epinephelus fulvus	CONEY/GOLD CONEY	53
Epinephelus guttatus	RED HIND	12
Serranids	GROUPER	47
Rypticus saponaceus	SOAPFISH	1
Equetus punctatus	SPOTTED DRUM	21
Equetus lanceolatus	JACKKNIFE FISH	22
Pareques acuminatus	CUBBYU/HIGH-HAT	205
Chaetodipterus faber	SPADEFISH	6
Amblycirrhitus pinos	REDSPOTTED HAWKFISH	31
Anisotremus virginicus	PORKFISH	17
Ophioblennius atlanticus	REDLIP BLENNY	451
Blenniids	BLENNIES	948
Gobiosoma spp.	NEON GOBY	
Quisquilius hipoliti	RUSTY GOBY	
Gobiids	GOBIES	
Opistognathus aurifrons	YELLOWHEAD JAWFISH	2631
Opistognathus whitehurstii	DUSKY JAWFISH	126
Scorpaenids	SCORPIONFISH (STONEFISH)	8
Bothus lunatus	PEACOCK FLOUNDER	
	FLOUNDER	23
Symphurus arawak	CARIBBEAN TONGUEFISH	
Dactylopterus volitans	FLYING GURNARD/SEA ROBIN	437
Hippocampus spp.	SEA HORSE	24
Sygnathids	PIPEFISH	3
Acanthurus coeruleus	BLUE/YELLOW TANG	367
Acanthurus chirurgus	SURGEON TANG/DOCTORFISH	50
Balistes vetula	QUEEN TRIGGERFISH	920
Xanthichthys ringens	SARGASSUM/REDTAIL TRIGGERFISH	74
Canthidermes sufflamen	OCEAN TRIGGERFISH	1
Melichthys niger	BLACK TRIGGERFISH	76

FISHES continued:

Aluterus scriptus	SCRAWLED FILEFISH	
Cantherhines macrocerus	WHITESPOTTED FILEFISH	22
Monacanthids	FILEFISH	28
Lactophrys, Acanthostracion	TRUNKFISH, COWFISH	
Canthigaster rostrata	SHARPNOSE PUFFER	36
Diodon hystrix	PORCUPINEFISH	2
Antennarius spp.	FROGFISH	70
Ogcocephalus spp.	BATFISH	6
Synodus intermedius	LIZARDFISH	1
Mullids	GOATFISH	9
Aulostomids	TRUMPETFISH	60

INVERTEBRATES:

Haliclona spp.	ORANGE TREE SPONGE	45
	RED SPONGE	146
	ELEPHANT EAR SPONGE	50
	GORGONIANS/SEA FANS	
Tubastrea aurea	ORANGE POLYP (CORAL)	
Condylactis	CLUSTER ANEMONE/PINKTIP	382
Bartolomea annulata	CURLIQUE ANEMONE	150
	COLONY ANEMONE	45
Stoichactis helianthus	CARPET ANEMONE	105
Ricordea florida	GREEN ANEMONE	
Phymanthus crucifer	ROCK ANEMONE	10
Heteractis lucida	STINGING ANEMONE	
Aiptasia tagetes	ANEMONE	
Zoanthus spp.	ORANGE TUNICATE(?)/SEA MAT	
Sabellastarte magnifica	SOLO FEATHER DUSTER	75
Sabellastarte spp.	COLONIAL/CLUSTER DUSTER	61
Spirobranchus giganteus	CHRISTMAS TREE WORM	
Panulirus argus	SPINY LOBSTER	
Periclimenes spp.	ANEMONE SHRIMP	
Stenopus hispidus	RED-BANDED CORAL SHRIMP	102
Stenopus scutellatus	GOLD SHRIMP	2
Alpheus armatus	PISTOL SHRIMP	162
Lysmata spp.	PEPPERMINT SHRIMP/ SCARLET/LADY	15
Thor amboinensis	BUMBLEBEE SHRIMP	
Pseudosquilla	MANTIS SHRIMP	
Other hermits		10
Paguristes cadenati	RED LEG HERMIT	
Mithrax sculptus	GREEN/EMERALD CRAB	20
Percnon gibbesi	SALLYLIGHT/URCHIN CRAB	
	DECORATOR/SPONGE CRAB	
Stenorhynchus seticornis	ARROW CRAB	78
Mithrax cinctimanus	ANEMONE CRAB	

INVERTEBRATES continued:

Cyphoma gibbosum	FLAMINGO TONGUE	
Lima scabra	FLAME SCALLOP	280
	SPINY OYSTER	
Charonia variegata	TRITON	
Oliva reticularis	MEASLE COWRIE/OLIVE SHELL	
Tridachia crispata	NUDIBRANCH	
	OCTOPUS	
Astropecten	SAND STAR	76
Oreaster reticulatus	RED BAHAMA/WEST INDIES STARFISH	83
Subclass OPHIUROIDEA	BRITTLESTAR	180
Ophioderma	RED/SERPENT/BURGUNDY BRITTLESTAR	481
Astrophyton	BASKET STAR	
	CRINOID	
Diadema antillarum	LONG SPINE URCHIN	
Lytechinus spp.	PIN CUSHION URCHIN	
Eucidaris tribuloides	PENCIL URCHIN	103
Echinometra spp.	PURPLE/ROCK URCHIN	
Valonia ventricosa	SINGLE CELL	
Pencillus capitatus	NEPTUNE SHAVING BRUSH	

MISCELLANEOUS INVERTEBRATES 135

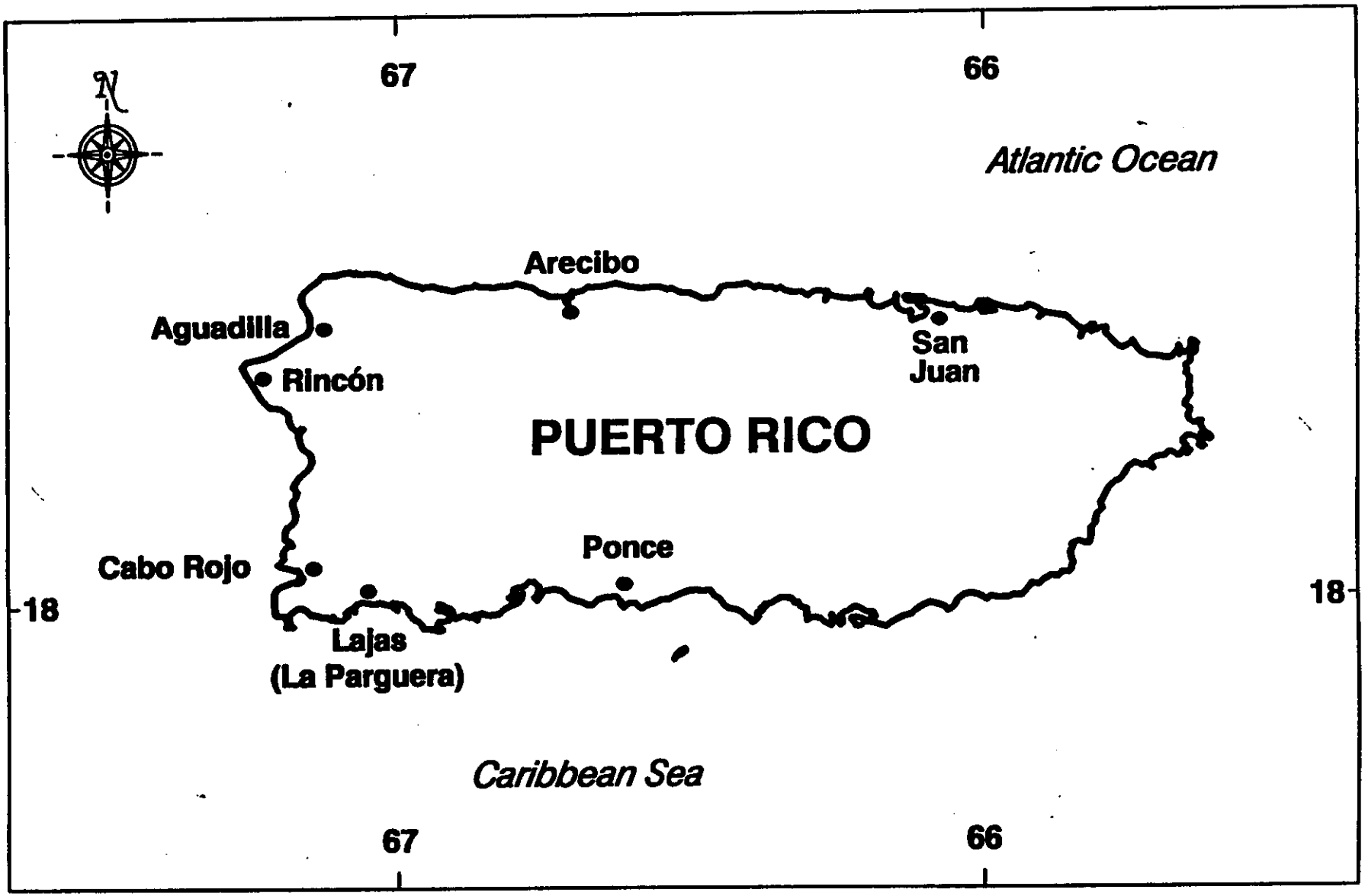
TABLE 2:

Numbers of boxes of marine fish and invertebrate species exported from and imported to Puerto Rico through the Luis Muñoz Marín airport by month for 1990 and 1991 (Source: Puerto Rico Department of Natural Resources)

	1990		1991	
MONTH	EXPORT	IMPORT	EXPORT	IMPORT
JANUARY	11	359	218	172
FEBRUARY	36	453	218	145
MARCH	0	0	98	192
APRIL	0	470	243	108
MAY	86	701	1,291	213
JUNE	332	637	0	154
JULY	239	726	0	149
AUGUST	146	0	0	87
SEPTEMBER	125	153	145	N/A*
OCTOBER	177	177	235	N/A
NOVEMBER	135	124	N/A	N/A
DECEMBER	114	167	N/A	N/A
TOTALS	1,401	3,967	2,448	1,220

* N/A - information not available

FIGURE 1: Collection areas discussed in text



Bycatch Study of the Puerto Rico's Marine Commercial Fisheries
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Study Objective: The objective of this project is to describe the Puerto Rico's commercial fishery bycatch in their biological, economical and social aspects. The commercial fishing gears don't discriminate between target species and those that live in close association with it. Puerto Rico did not have any study of the bycatch, thus this study it is needed urgently. The goals of this project are: determine the magnitude of bycatch, obtain information about most used fishing gears in Puerto Rico where bycatch occurs at any scale, commercial fishers will participate directly in this project, for bycatch fisheries species biostatistics data will collected, determine the catch mortality by gear of any fishery resource in the bycatch, evaluate all different fishing gears in order to reduce the impacts of bycatch and recommend conservation and management measures to minimize bycatch.

Methods and Materials: Select commercial fishers of different type of fishing gears (fish traps, trammel nets, beach seine and hand lines) to be contracted to collaborate with the project and work with the DNER. Personnel of the project will travel 30 trips per gear to collect independent data. This includes identifying fishing bycatch by species level, obtain length (fork length in mm) and weight (g) and account the bycatch number by species caught. Collect the biostatistics data from the commercial total landing by species and by weight. For every trip collect the following fishing gear information: size of the gear, soak time, fishing time, depth and CPUE . All data will be enter using Microsoft Access and data analysis will include bycatch composition by gear in order to make recommendations to reduce or eliminate bycatch.

Conclusions and Recommendations: The data collected shows that every gear have their own bycatch characteristics. Fish traps that target spiny lobsters and trunkfishes shows approximately 33% of their total catch weight was bycatch. However, 13 of 35 bycatch species reported (37%) were commercial and easily marketed. The others bycatch individuals were used as bait to attract lobsters. On the other hand, trammel nets that targeted lobsters and trunkfishes, approximately 50% of the total catch were bycatch. A total of 16 species composed the bycatch for this gear, 43% of the mentioned species were commercial and easily marketed. Beach seine reported only 17% of the total weight