BELIZE AQUARIUM FISH

AND SHELLFISH STUDY

Presented to
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The study team also spent a considerable amount of time gathering information from sources at the University of Miami, Hawaii Division of Aquatic Resources, Quality Marine (a U.S. based importer), and other government and private sources. Art Villanueva was the USAID project manager for this study. Mike Domeier of the University of Miami; Karl Bischof, James Beveridge and Thom Grimshaw of Belize; and Alton Miyasaka and Pete Hendricks of the Hawaii Division of Aquatic Resources supplied background data on previous and on-going studies. Jim Maloney of Quality Marine and Don Hemmes of the University of Hawaii generously donated their time and resources to assist in collection and marketing assessments.

This report is dedicated to the people of Belize, who have the primary responsibility in directing the future of their country.

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1.0 EXECUTIVE SUMMARY

The purpose of this project is to assist the country of Belize in diversifying its exports and to develop its import substitutes in an economically efficient manner. The United States Agency for International Development (USAID) has requested the execution of a number of feasibility studies designed to address the informational and analytical needs of specific sectors, including the agriculture industry, tourism, fisheries and mariculture, forest-based industries and light manufacturing sectors.

This project was requested by the Belize Department of Fisheries (DOF) to provide additional information on the status, management, economics, and impacts of the aquarium fish, shellfish, and shell trade in Belize.

Information for this project was developed during reconnaissance surveys and in-person interviews in Belize, Miami, Los Angeles and Hawaii; and from literature searches and reviews, and numerous telephone interviews.

Reef surveys completed for this project and by other workers suggested the overall abundance of reef fish and invertebrates in the country is at levels found on typical reef systems elsewhere where there is either a limited reef fishery, or the fishery appears to be within sustainable limits.

Aquarium fish exports from Belize in 1988 totaled 4,086 fish with a value of $28,000. Up to 600 specimens of fish and invertebrates per week with an annual estimated value of $90,000 to $100,000 were shipped in 1989. Only one collector is active: but several permit applications are pending.

Relatively small quantities of marine shells and corals are harvested in Belize for the production of jewelry and curios. Most Belize shellfish have limited value to the casual or novice collector; however, a number of species would be desired by the advanced hobbyist.

Measures suggested to manage the aquarium and shell collection industries were:

- Limiting the number of persons that can enter the fishery.
- Defining collection locations, especially areas that are "off-limits" to collection.
- Setting specific limits on the type and scale of harvest.
- Defining collection methods, for example including only those methods already in use in Belize and Hawaii.
- Setting minimum standards for collectors.
- Establishing reporting requirements and forms.

There were widely varied opinions regarding environmental and economic impacts of the collection and holding of aquarium animals and plants. On one hand, fish collection was viewed as a traditional wild capture fishery. In such a fishery, the economic value of the resource was realized only when it was harvested and sold. On the other hand, the organisms were considered to have environmental, aesthetic and economic values exceeding their harvest value. This was to many in the diving-related tourist industry of Belize, the most important issue in expansion of the collection trade.

The environmental impacts of the aquarium trade were judged to be slight to insignificant for the existing single collector/shipper. A significant expansion of the industry could increase the extent and intensity of site-specific impacts. If collecting is dispersed these impacts should be reversible. However, expansion of the fishery could increase the likelihood for conflicts with commercial dive guides and other fishermen. Some of the impacts to the reef resources could be avoided by artificial cultivation.

A "breakeven" cost-revenue worksheet was developed for a sample aquarium fish business. Similar detailed data for the shell and black coral jewelry and collection business were not available (nor were they requested in the scope of work). Estimated total annual costs per collection permit holder at a "breakeven" collection/shipping level of 450 pieces per week were about $138,000. Annual estimated foreign exchange revenues were $140,000 with employment of 2 to 3 per collector/shipper.

The worldwide market and demand for aquarium fish are excellent and with recent advances in equipment, artificial salt water and suitable foods for use in marine aquaria, marine fishkeeping is no longer a minor part of the aquarium trade. Improvements in the supply, diversity and health of the stocks have also contributed to the growth of the industry. Although expanded production in Belize is constrained by the relatively high level of sophistication and cost of entering the business, quality disease-free fish and invertebrates are in demand and command good prices, particularly in the European markets.

Marketing is a major constraint to expand shell and black coral jewelry production; particularly for export. The present marketing channels for jewelry produced in Belize are inefficient and do not provide a stable source of income for the manufacturers. These manufacturers should concentrate on the production of highly crafted and quality materials, and sales to the Belize tourist market.

We recommend the following areas of government involvement in the industries: 1) enhanced data collection and enforcement; 2) training and education; 3) coastal zone planning; 4) aquaculture studies; and 5) studies of diving, snorkeling and glass bottom boat impact on tourism revenues.

2.0 INTRODUCTION AND OBJECTIVES

This project is one of several recently completed by RDA International, Inc. (RDA) for the Government of Belize (GOB) under contract with the United States Agency for International Development (USAID). It was requested by the Belize Department of Fisheries (DOF) to provide additional information on the status, management, economics, and impacts of the aquarium fish and shellfish, and shell trade in Belize.

With an "overall goal of improving project development and planning procedures important for sustained economic growth in Belize, the objective of this study is to analyze the impact of harvesting reef fish for sale as aquarium stock and seashells for tourist and decorative items. The study results are also aimed at providing needed information for establishing policies on licensing, levels of harvest and resource management." (from Scope of Work)

The terms of reference for this project are to:

1) Determine the supply and location of reef fishes suitable for aquarium marketing, and seashells suitable for marketing.

2) Assess management practices to ensure a sustained yield of the existing stocks.

3) Estimate possible damage to the reef from harvest operations.

4) Discuss potential wider environmental impacts of harvest.

5) Prepare a cost-benefit analysis of aquarium fish harvest.

6) Recommend levels of government involvement to cover monitoring/ enforcement operations.

These tasks are addressed in the findings section of this report.

An additional element, for freshwater tropical aquarium fish, was added to the scope of work following a meeting with GOB on 30 August, 1989. Results for this task are in the Appendix to the report.

3.0 APPROACH

Information concerning the status of the marine tropical collection and export business was gathered from a wide range of sources in Belize and elsewhere. The approach consisted of the following tasks: 1) preliminary gathering of background data and contacts having expertise in the area; 2) initial coordination with GOB; 3) interviews in Belize with persons working in fisheries, marine ecology and tourism; 4) preliminary field surveys in Belize and development of a detailed workplan; 5) meetings and interviews with members of the marine tropical aquarium industry in Florida, Hawaii and California; 6) detailed field surveys in Belize with additional interviews and literature reviews; 7) preparation and presentation of draft recommendations and conclusions; 8) preparation and production of the draft and final reports. This work was carried out from August 27, 1989 through January 31, 1990. Dan Cheney of RDA International was primarily responsible for project management, field studies, and report preparation. Mike Domeier of the University Miami provided additional supporting material. Don Rivard of RDA International was the project administrator and provided editorial support.

3.1 Details of Work Completed or Scheduled

This is a list of the principal activities and persons contacted during field and office studies completed as part of this project. A detailed summary of the field observations is included in the Appendix.

August 21-25 -- Telephone interviews and reviews of available information: P. Glynn (U. of Miami); S. Strasdine (UBC); G. Jamieson (Canada Dept. Fish and Oceans); D. Sweat and D. Rivard (RDA)

August 27 -- Arrive in Belize

August 28 thru Sept 1 -- Introductions and meetings, interviews in Belize City and review of existing information.

Contacts: USAID -- A. Villanueva and S. Szadek; Government of Belize -- Y. Hyde, R. Neal, and V. Gillett; Others -- W. Miller (BEIPU), R. Bradley (Nat. Co-op), K. Bischof (St. Georges collector), J. Black (Blackline Marina), J. Gibson, B. Bowen, J. Aguilar (Belize Tourism Assoc.)

Sept. 2 - 3: Day trips to Caye Caulker and St. Georges Caye. Review collection methods and carry out qualitative field survey. Interviews with J. Beveridge, F. Bounting, B. Bowen and K. Bishoff.

Sept. 4: Early afternoon meetings with Peace Corps. Fly to San Pedro in late afternoon.

Sept. 5 to 9: San Pedro and Ambergris Caye. Meetings with dive/charter groups, and fishermen co-op. Visit with Holchan Reserve staff selected sites for possible fish population surveys. Interviews with J. Azueta, L. Reyes and E. Young of the Reserve Staff; R. Gonzales and M. Heredia from the co-op; R. Woods; and gift and dive shop operators. Review New York Zoology Society (NYZS) proposals, sample methodologies, and preliminary data (see Appendix).

Sept 10 and 11: Fly to Dangriga and visit freshwater culture site; also interview operators of the Pelican Beach Resort regarding shell collection on cayes, and Smithsonian Institution projects on Carrie Bow Caye. Interview T. Raft and A. Bowman.

Sept 13 thru 15: Continued interviews with fishermen co-ops, shipping (TACA and Tan Sahsa), tourist (J. Aguilar), freshwater fish farmer (T. Grimshaw) and environmental organizations (J. Grant, V. Gonzalaz). Review and summarize existing and relevant AID reports. Meet with Y. Hyde and R. Neal for a project update and critical assessment. Develop a work plan for the November and final phases of the study.

Sept. 17 - 19: Meet in Miami with U. of Miami biologists and fish wholesalers; gather and compile information on harvest, handling, and marketing of marine tropicals and shells.

Sept. 20 to Oct. 27: Complete workplan and finalize logistic and support requirements. Review and summarize available existing information.

Nov. 7 - 8: Meet with marine fish importer and inspect shipping and packing operations; interview J. Maloney regarding methods, costs and issues for the aquarium trade.

Nov. 9 - 10: Review progress with RDA staff and complete telephone interviews with Pete Hendricks, Richard Brock and Alton Miyasaka, State of Hawaii fisheries specialists. Also visit large retail aquarium supply store (Nippon Goldfish Co.).

Nov. 13: Arrive in Belize via Los Angeles to begin 2nd phase of workplan.

Nov. 15 to Dec. 2nd: Carry out field studies in the St. Georges and Sargeant Cayes area using both SCUBA and snorkel methods; work with Remi Marin, a local lobster fishermen to evaluate trapping methods and catch rates for marine tropicals and interview fish collector (Karl Bischof), Fred Good, operator of St. Georges Dive Resort, and Neal Roseman of Unicorn Charters

Dec. 3: Interview James Beveridge and Henny Fromm regarding dive guide concerns in region. Meet with Tom Grimshaw on freshwater fish farming.

Dec. 4 to 8: Dive survey in Carrie Bow Caye, and interviews at South Water Caye, Dangriga, Big Creek and Placencia. Contacts included Loren Coen and Nick Vrolijk, Smithsonian Institution; Earl Perez, Placencia Producers Cooperative; Andrew Fox, Independence Cooperative; George Cabral, local fishermen in Placencia; and Tony Raft, Pelican Beach Resort.

Dec. 9 to 11: Travel to San Pedro and meet with Holchan staff, and dive shop owners. Contacts with James Azweta, Linda Reyes, Richard Woods and David Guerrero.

Dec. 12 - 13: Complete preliminary conclusions and recommendations section of the report. Interviews with local shell jewelry manufacturers, Central Bank of Belize, and Taca Airlines.

Dec. 15 - Jan. 14: Complete draft report and give to RDA for review.

Jan. 15 - 19: Travel to Hawaii for field survey and interviews with Hawaii Island and Oahu collectors, state biologists and tour guide operators.

Jan 20 - 22: Add material to draft report, revise draft to reflect RDA comments. and submit final.

Jan 31: Final report to AID Belize.

3.2 Field Studies

Field surveys focused on those reef areas, and fish and invertebrate species of value to the collector and exporter. Approximately 12 comparative surveys inside and outside the barrier reef were completed at locations near Ambergris Caye, Caye Caulker, St. Georges Caye and Carrie Bow Caye. These surveys provided visual observations by species of fish and invertebrate, and descriptions of the associated habitats. Both collection and non-collection or "pristine" areas were sampled. Logistic support was provided by local fishermen and dive guides hired by the consultant, and by Belize Department of Fisheries and Smithsonian Institution staff.

3.3 Personal Contacts

Approximately 60 individuals or organizations were interviewed in person or in telephone surveys for this project. Most of those interviewed were in Belize and represented aquarium and capture fisheries, tourism, environmental and government interests in the country. The names and affiliations of principal personal contacts are listed in the Appendix.

3.4 Literature Surveys

Much of the literature used in compiling this study was obtained from personal interview sources. Additional published information was obtained using a computer-based (Dialog) search which scanned a number of data-bases for literature on the aquarium and shell-collection industries.

4.0 STUDY FINDINGS

This section presents the results of the field surveys, interviews and literature search for tropical marine aquarium species, shells and corals used for the manufacture of jewelry, curios and similar marine products. A summary report describing the market and production potential of freshwater tropical aquarium species (based on an RDA International El Salvador document) is included as an appendix to this report.

4.1 Description of Business

This is a summary of the major aspects of harvest, handling and processing, shipping and marketing of live marine tropicals, and dead shells and corals.

4.1.1 Live Marine Tropicals

Live marine tropicals include marine plants, invertebrates and finfish. The following is a summary of key aspects of the business. More detailed accounts can be found in Wood (1985), which discusses the collection methods in Sri Lanka and importation in the United Kingdom; and Albaladejo and Corpuz (1981), an assessment of the industry in the Philippines.

4.1.1.1 Extent and Value of Trade

The care and keeping of marine tropicals was, until a few years ago, an occupation confined to the advanced hobbyist and professional or public aquaria. However, with recent advances in equipment, artificial salt water and suitable foods for use in marine aquaria, marine fishkeeping is no longer a minor part of the aquarium trade. Improvements in the supply, diversity and health of the stocks have also contributed to the growth of the industry. The import value of world trade in tropical aquarium fish was estimated in 1985 at around U.S. $200,000,000 per year, and marine species were thought to constitute about 20% of this total, valued at $40,000,000. In the Philippines, marine aquarium fish exports increased 20 times in the ten year period 1970-79 and were within the top ten fishery products being exported (Albaladejo and Corpuz, 1981; Conroy, 1975; Wood, 1985).

In contrast to the situation in the Philippines, the Hawaiian collection business has exhibited relatively stable growth over the past 20 years. During the 1987/88 period 98 commercial and 133 amateur permit holders were collecting fish in the Hawaiian Islands; with 26 commercial full-time and part-time collectors on the Island of Hawaii, and 64 on the Island of Oahu. These fishermen collected a total of 250,000 fish with a landed value of U.S. $411,000 (Hawaii Department of Land and Natural Resources, 1988). Hawaii also imported U.S. $1,000,000 worth of aquarium fish into the state. Over 95% of all fish and invertebrates are exported (or re-exported) to the U.S. mainland (van Pooleen and Obara, 1984; Hendricks and Miyasaka, personal communications).

Within the last ten years, invertebrates and plants have become major elements in marine aquaria. Invertebrates and plants now account for up to 60% of the trade of many shippers. For example, finfish account for the majority of product sold in Hawaii, although increasingly greater numbers of invertebrates are being harvested (Hendricks and Miyasaka, personal communications).

4.1.1.2 Preferred Species

Of the thousands of different kinds of animals and plants occurring in marine waters, only a small fraction are suitable for the aquarium trade. The most popular species are those which are easy to maintain in aquaria, are colorful, and are compatible with other animals and plants in aquaria (Figure 1). For example, fish commonly used in marine aquaria include: damselfish, tangs or surgeonfish, angelfish, butterfly fish, batfish, wrasses, bassiets and gobies. Typical invertebrates include cleaner shrimp, sea urchins, featherduster worms, soft corals and anemones. The demand for very rare, larger and/or unusual animals is limited to the more advanced hobbyist and public display aquaria (Coniff, 1989; Quality Marine, 1989).

4.1.1.3 Principal Supplying Areas

Principal suppliers are the Philippines, Indonesia, Sri Lanka, Singapore, Florida, and Hawaii. Other suppliers include Costa Rica (only from the Pacific Coast), Puerto Rico, Haiti, Kenya and Fiji. Belize is a minor shipper. The United States is the largest importer followed by Japan, West Germany, United Kingdom and the Netherlands. Other importers include Hong Kong, Italy, Belgium, Canada, Australia and France (Maloney, personal communication; Wood, 1985).

4.1.1.4 Collection Methods

Most of the collection of marine animals is done from small boats, with the collectors using snorkel, hookah and/or SCUBA gear. Fish are taken with the aid of nets, traps, anesthetics and other devices.

- Nets -- various types of nets are used for fish catching. Most are small mesh (i.e. about 1/8 to 1/4 inch) which trap the fish but do not entangle them. Barrier nets about 3 to 6 ft high and 10 to 50 feet long are commonly used in Hawaii. These are set on the bottom, and fish are herded into the barrier and then picked off with hand nets (Randall, 1987). In the Philippines, a fine mesh hand seine about 3 ft long and 2 ft wide is used on the reef flats (Albaladejo and Corpuz, 1981). In some cases, such as in Hawaii, hand nets are used alone.

- Traps -- Traps are used primarily to capture food fish and invertebrates, but the catch often includes species commanding high prices as aquarium fish. Fishermen in the Philippines and Indonesia commonly sell them for aquarium stock rather than as food fish (Albaladejo and Corpuz, 1981). Traps are also commonly used to capture aquarium fish in Florida and Haiti (Mike

White, personal communication), and Belize (Figure 2) (Remi Marin, personal communication). Several problems were noted with wire trap caught fish from Hawaii, including fin damage and high mortalities. The experience in Florida with wire fish traps suggests they can cause extensive damage to reef fish. They are very effective, and when allowed on reefs 100 feet or deeper, result in embolism and death of many fish (Mike White, Bille Causey, and Jim Maloney, personal communications).

- Other mechanical methods -- slurp guns, which suck fish into an enclosed chamber, are used by some collectors, but are ineffective for all but the slowest swimming fish (Stan Ross, personal communications). In the Philippines some collectors use a small spear to take gobies and blennies. Invertebrates, such as hard and soft corals, are collected by breaking up pieces of larger colonies (Albaladejo and Corpuz, 1981). Other invertebrates are simply picked off by hand. The collection of corals, and coral rock is illegal in Hawaii and Florida, but remains a common practice elsewhere.

- Chemicals -- Collectors in many areas use a variety of chemicals to catch fish. Sodium cyanide (NaCN) is widely used in the Philippines, although supposedly it is illegal. Other common chemicals include quinaldine (an anaesthetic), sodium hypochlorite, rotenone and formalin. These are held in plastic bottles and squirted into holes on the reef where fish live or have been driven. The fish are narcotized and taken with hand nets or seines. The use of all chemicals is banned in Hawaii; however, quinaldine is allowed in Florida (Nelson, 1989).

4.1.1.5 Handling/Processing

Collectors have to supply good fish -- this requires good collection methods, proper holding conditions prior to shipment, and a good shipper.

Careful handling of fish or invertebrates immediately after capture requires keeping them in water (on or off the boat) and in some cases, decompression prior to transport to a shore-based holding facility (Maloney, personal communication).

The shore-based facility may consist of a simple aquarium system, but most collectors/shippers maintain their fish in relatively sophisticated systems (Wood, 1985).

The following is an example of a typical system that is used by larger shippers (Jim Maloney and Stan Ross, personal communications):

- Fish and invertebrate are held in tanks ranging from 100 gallon aquaria for collections of larger fish (such as tangs, sharks, tubesnouts, etc.) to 1 quart cubicles for individual fish (such as

clown fish, hamlets, etc.). Corals, live rock, anemones and algae are held in carpet-lined or grated bottom trays about 2 by 4 feet and 8 inches deep. The carpeting (indoor-outdoor w/o backing) keeps the anemones from creeping about and ending up in the drains. Shrimp and small crabs are held in individual 1 pint plastic containers.

- The sea water system is entirely self-contained and uses artificial salt water or a filtered open-water supply. Recirculating pumps, microfilters, biofilters and ultraviolet purifiers are used in the main sea water system. All tanks and small individual fish containers are plumbed into the main system. Separate systems are used for bagging and fish medication (Figures 3 and 4).

4.1.1.6 Shipping

Careful shipping and handling are essential elements in the aquarium trade, with packing being the first step in the chain to the consumer (Figure 5). Modern packing systems have a source of oxygen and water, and a scale to weigh the packed fish. The majority of fish, even juveniles and hardier species, are packed singly in individual bags. The volume of water in each bag varies with the size and type of animal shipped. Fish are packed to remain upright and turn around in the bag. Some anemones are shipped without water, wrapped in wet newspapers (Jim Maloney, personal communication).

The quality of packing varies with the shipper and country of origin. During our observations in Los Angeles, fish from the Philippines were packed in a minimum amount of water. Fish from Fiji and Hawaii were packed in larger bags with more water. Larger fish from the Philippines were often on their sides in a minimum amount of highly polluted water. Some had their fins out of the water, and a few (about 1%) arrived with no water in the bags.

Two clear plastic bags are always used for shipment. Sometimes newspaper or black plastic is used as a liner between the two bags to prevent spines from penetrating them or to reduce stress of aggressive species.

Fish and invertebrates are shipped in styrofoam containers or cardboard boxes w/styrofoam inserts. Boxes average 1/2 to 1 cubic foot and weigh up to 50 to 60 lbs when filled.

Usually an entire container is shipped, with 50 to 60 boxes to fill an entire container. While loose loads are usually acceptable, the best practice is to ship an entire container. Shipping costs to the United States range widely, for example, from a high of $3.43/lb for the Philippines to $0.20/lb for Hawaii (Maloney and Ross, personal communications).

Shippers strive for simplicity in shipping with little or no intermediate transfers from the point of shipment to destination. Air carriers

must guarantee the time of arrival and handling (i.e. controlling the temperature in the tropics); and the shipment time must be kept as short as possible. Fish held longer than 3 days may deteriorate rapidly after receipt or be more likely to die when sold to the retailers (Maloney, personal communication).

Shippers also have to allow for U. S. Fish and Wildlife Service inspection, which may mean the contalner remains unpacked on the ground for an additional 4 to 6 hours (Maloney, personal communication).

4.1.1.7 Importers/Repackers

These are the middlemen in the aquarium trade, importing and repacking fish and invertebrates for shipment to retailers. Most of the importers in the United States are located in Los Angeles and Miami; several are in Chicago and at least one operates out of Hawaii. One of the largest importer of marine tropicals (fish, invertebrates and plants) in the United States has been operating for 10 years and buys fish from suppliers throughout the world.

The importers purchase from selected shippers, most of whom ship at least weekly. Examples of purchase prices (U.S.$ per fish/invertebrate) are as follows:

	Puerto Rico	Virgin Islands
Royal gramma	2.00	
Longnose butterfly	6.00	
Blue tang	3.50	
Blue tang, tiny	1.00	
Blue head wrasse	1.50	
Red tall trigger	6.00	
Queen trigger	4.00	
Black angel, small		7.00
Blue angel, small		7.00
Blue angel, medium		9.00
French angel, small	5.00	8.00
French angel, medium	7.00	10.00
French angel, large	9.00	
Rock beauty	4.00	
Pygmy angel		5.00
Queen angel, medium		15.00
Queen angel, large		20.00
Hybrid queen, large		18.00
Longnose butterfly		7.00
Jack knives		7.50
Spotted drum		8.00
Flame cardinal		1.50
Pistol shrimp	2.00	
Tubeworms, giant		1.50

(from Maloney, personal communication)

Some importers allow their buyers to select the areas where fish are imported from. For example, if no chemicals are permitted in collection, the fish can be obtained from Fiji or Hawaii.

Fish are removed from the bags and placed in water of the same pH as that in the bags (the pH drops during long shipment times). Some fish always exhibit signs of shock upon receipt. For example, during our observations, a significant number of the acanthurids (see list on page 4-20) from Hawaii were immobile and lying on their sides up to 8 hours after receipt. Most of these fish appeared to have recovered (i.e. were swimming normally) the next day. A few (less than 1 to 2%) still had not recovered and were kept in floating pans isolated from the rest of the collection. Larger fish from the Philippines had higher, but unmeasured, mortalities. The principal problem with these fish is the high shipping cost -- shippers attempt to reduce the weight to the minimum extent possible, as the actual price of the fish is a fraction of the shipping cost (Maloney and Ross, personal communications).

4.1.1.8 Retailers / End Users

The primary market for marine fish and invertebrates is the private hobbyist. Public and private display aquariums may also purchase larger animals from importers and collectors. Marine aquarium fish and invertebrates are sold at the retail level at aquarium supply stores and pet shops. Aquarium supply stores usually market freshwater fish and aquarium supplies (tanks, pumps, etc.) as well as marine products. Some have on display a variety and number of fish rivaling small public display aquariums (Wood, 1985).

Retailers usually purchase their product from wholesalers, but a few import direct from the collector/shipper. There is a substantial markup in price between the importer and retailer; therefore, a collector can obtain a better price with direct sales. This advantage is offset by the small individual sales volumes and greater risk in dealing with the retailer.

We surveyed one large retail outlet in San Francisco, the Nippon Goldfish Company to obtain the following costs for fish and invertebrates:

Fish (price each, in U.S. dollars)	
Trigger fish (rectangular)	$21 Med; $30 Large
Squirrel fish	$14 Med
Blue Damsel	$3
4-spot butterfly	$16
Spot banded butterfly	$17
Moorish idol	$19
Brown tang	$26
Blue angel	$45 Med
Rainbow wrasse	$10
French angel (show, large)	$140

Tinker's butterfly	$200
Invertebrates (price each)	
Mantis shrimp	$10
Linkia starfish (6 to 8 inch width)	$6
Spiny oyster (3 inch dia)	$34
Brain coral (col 6 inch dia)	$35
Gonipora coral (col 6 inch dia)	$25
Octopus (2 ft spread)	$30
Moon coral (col 6 inch dia)	$30
Gorgonian coral (1 foot high)	$30
Feather duster worms (large)	$9
Sea urchins (2 to 3 inch dia)	$8 to $18

"Live Rock" -- Limestone with or without attached plants or animals (price per pound)

Rock with algae cover	$8
Rock with coral and hydroid cover (Hawaii)	$5 (Florida) to $8
Base rock (no live cover)	$1.50

4.1.1.9 Quality and Mortalities of Collected Species

While the average value of any single species is determined by availability and consumer demand, high quality and disease-free products always command the best prices. The principal measure of quality fish or invertebrate (without regards to type) is their appearance and behavior. They cannot be deformed, diseased or injured. In the case of fish, their fins and eyes must be in good conditions and they must arrive swimming. Poor quality fish are more likely to die within a short time of being introduced into aquarist's tanks (Maloney, personal communication).

Proper collection and handling methods play a key role in the survival of all aquarium animals. Mortalities from the point of collection to retail sale should be less than 5%. Mortalities occurring during collection are primarily the result of inappropriate collection methods and bad handling. For example, fish are easily cut and bruised, especially in the hands of inexperienced collectors who try to extract fish from holes and crevices in the coral. Additional mortalities after collection and prior to export are inevitable, as a result of further stresses. It is also important to recognize that mortalities that occur after export may stem from poor treatment in the exporting country. For example, fish collected with cyanide will generally die a few weeks later as a result of gross damage to the liver and other ailments (Wood, 1985). The cost of higher mortalities is often borne by the collector/shipper.

4.1.1.10 Present Status in Belize

Aquarium fish were added to Belize's export list in 1979, when about $1,400 of business was transacted. A total of about 25,200 lbs fish in water (< 1,000 lbs of fish) were exported in 1980. Figures in actual numbers of fish for 1988 show a total of 4,086 with a value of $28,000. Up to 600 specimens of fish and invertebrates per week with an annual estimated value of $90,000 to 100,000 were shipped in 1989. As many as 6 collectors, located in San Pedro, Caye Caulker, and St. Georges Caye, possessed a license to capture and export salt water aquarium fish in 1979 (Miller, personal communication; Perkins, 1983). Now only one collector is active; but several permit applications are pending (Vincent Gillett and Wayne Blackburn, personal communications).

The present collector began as a fish importer in Europe, and moved to Belize 10 years ago specifically to set up a collection business. His collection/shipping methods are similar to those discussed above and combine the use of hand nets and barrier nets in shallow water to hookah (surface-supplied compressed air) depths (less than 60 feet). He operates exclusively alone, and collects on Turneffe Island as well as the main Belize barrier reef, generally within a 10 to 15 mile radius of St. Georges. During calm water conditions he will collect on the reef face using hookah. If the waters are rough, he will work lagoon areas or rely on fish and invertebrates taken in traps by fishermen (see Impact section). No animals are taken with hooks, poisons or anesthetics. Fish and invertebrates are held in aquaria on St. Georges until they recover from capture stresses. They are then packed and shipped as described above (Bischof, personal communication).

This collector exports only a limited range of high quality fish to European buyers who are able to pay higher prices than U. S. buyers. His perception of the U. S. market is that it is aimed at quantity, not quality, and directed at attractive but not necessarily interesting fish. In addition to fish, he exports small gorgonians, crabs, tubeworms and other invertebrates. His price list is oriented to those fish which are abundant, but most suitable for the European market. All shipments are routed through Miami, where they are transferred to flights to Germany.

4.1.2 Shells and the Shell Trade

"Shells" as used in this study include bivalves (clams, scallops), gastropods (marine snails), and cephalopods (nautilus) taken from beach litter or after the animal or "meat" has been removed for food), and black corals. All are either traded between amateur shell collectors, or fabricated into various jewelry, craft and novelty items. The following is a summary of key aspects of the business.

4.1.2.1 Extent and Value of Trade

Shells

Generally the volume of shell trade is large, with the majority of shells being relatively inexpensive and used for the production of souvenir and craft items. A large segment of the trade has been in the amateur shell collection business. This ranges from the collection and sale of common souvenir items to a specialized market for the rarest and most expensive shells.

In recent years there has been a decline in the number of active participants in amateur shell collection, especially in Hawaii and the west coast U. S., and an increase in the average age of the participants. This appears to be a reflection in the trend to ecological conservation and desire not to remove live animals from the reef. Shell collection always requires the taking of live animals (Hemmes, personal communication).

Black Corals

Black corals all belong to the family Antipatharia. They have horny and flexible skeletons, which when properly cured and processed, can be manufactured into jewelry and craft items. Historically, the corals were marketed in the Far East and North Africa, where they were used as scepters and amulets to ward off evil and injury. Two general types, the black tree corals *Antipathes* spp., and the black whip corals *Cirrhipathes* spp. dominate the black coral trade. They are usually taken from relatively shallow waters (Carleton and Philipson, 1988; Grigg, 1976). Also important in the jewelry industry are the so-called "precious" corals, which are deep-water slow-growing species (Grigg, 1983). These are not covered in this report.

4.1.2.2 Criteria for Collected Species

Shells

Shells are valued on the basis of size, color, appearance, and rarity. Rare and/or colorful shells generally demand the best prices. The highest quality are live taken, i.e. cones with opercula are most valuable. All must be cleaned properly (see below). The most popular are cowries, cones, and miters. Many of the bivalves, such as the *Pecten* and *Spondylus* are also important. Some collectors concentrate on certain families or groups. In Hawaii, for example, the most sought-after shells are the endemic species, especially the cowries. Also of interest are the small and cryptic gastropods and unusual bivalves taken from caves, wrecks and other hard-to-access places (Hemmes, personal communication).

The average collector is often wealthy, older and retired; professionals make up the greatest proportion of amateur collectors. Many can SCUBA dive, although there is another segment that never collects from the field but buys and trades shells. Some pursue their hobby via special collection tours in Australia, Philippines, etc., but the preponderance purchase the shells (Hemmes, personal communication).

Black Coral

The factors that define the quality of black coral are: 1) color, 2) hardness, 3) parasitization, 4) seasoning/calcareous rings, 5) diameter, 6) length, and 7) blemishes and imperfections. In general, the material should produce a jet black, highly polished surface when worked (Carleton and Philipson, 1988). The depth of collection can have a strong influence on coral quality. Colonies taken from shallow waters (i.e. less than 100 ft (33 m)) are frequently small, soft, have imperfections and visible annular rings, and are difficult to carve and polish (Slater, Maui Divers of Hawaii, personal communication).

4.1.2.3 Principal Supplying Areas

Shells

Most of the shells traded in the international marketplace originate from the Indo-Pacific region. Principal supplying countries are Taiwan (has a trawling fleet that travels widely), Indonesia, and the Philippines. Australia used to be a major source but now restricts collection from the Great Barrier Reef. South Africa has a special fauna especially for cowries. Other supplying areas are the Red Sea, California, Hawaii and Florida (Hemmes, personal communication).

Black Coral

Black corals are found throughout the world but are harvested commercially only in tropical regions. There is very little data on the extent of black coral production worldwide. The annual (1987) harvest is estimated at 60 to 100 metric tons, with about 50% whip coral from the Philippines. Most of the present supply originates from the Indo-Pacific region (Carleton and Philipson, 1988; Rutka, personal communication).

4.1.2.4 Collection Methods

Shells

As with the aquarium fish collection business, shell and precious coral collection methods vary widely in intensity and potential impact to the reef.

Most modern amateur and semi-professional shell collectors use passive methods, i.e. they dive at night when shells are roaming over the reef. Some amateur and commercial collectors use dredges to harvest shells from the sediments at the base of cliffs and

ledges. Many of the smaller shells harvested this way are dead when they are taken.

The typical night-time shell collection takes place in tidepools and shallow water (less than 30 to 40 feet deep). Small caves are searched for cowries which are almost impossible to find during the day. Augers and other sand-dwelling species are found from the trails they leave in the sand. Dead coral rubble, on hard-substrate bottom, is a source of mitres and sand pockets are fanned for cones and terebrids.

In some locations in Hawaii and elsewhere, collectors use crowbars and hammers to breakup coral and coral rock and remove the shells from the broken debris. This type of activity must be strictly forbidden.

Dredging with a small sled dredge has been very successful in Hawaii, especially for smaller mollusks. These animals are harvested dead, and this method should have little impact to the reef.

Large numbers of shells are harvested in the Philippines with tangle nets which are dropped to the bottom and anchored with coral heads. Rare shells are often taken with these nets. A similar method is used by a commercial collector in the Turks and Caicos (Hemmes, personal communication).

Black Coral

Harvesting is usually by hand using SCUBA gear to access the deeper colonies. The corals are harvested by sawing colonies from the base or by removing branches (Carleton and Phillpson, 1988).

4.1.2.5 Processing / Manufacturing

Shells

The only processing required for shells is cleaning. Cowries are simply frozen (not put into water, or buried in sand, and then thawed so the animal can be picked out. Other shells are often put into a dilute bleach solution and the softened animal tissue is removed with a water jet. They are then placed in 100% bleach to loosen up the algae and calcium deposits. Very small shells are merely allowed to dry (Hemmes, personal communication).

Manufacturing steps to produce shell jewelry and novelty items are similar to those for black coral, described below (Cano, personal communication).

Black Coral

Harvested coral is held in water to cause the death and decomposition, and removal of the outer layer of living tissue. The dry cleaned coral should then be cured for up to 12 months to prepare

it for manufacturing. Uncured black coral is more likely to separate into layers and is more difficult to work (Carleton and Philipson, 1988).

Black coral is processed into beads, shaped and carved jewelry components, and sculptured articles.

For the production of beads and shaped items, the basic form is cut from the raw coral, is preformed where necessary using a grinding stone, and then filed to the final shape. Delicate and decorative work is undertaken using a series of hand tools and high speed hand drills. The shape is then smoothed and polished in tumblers or by hand using a range of finishing compounds and waxes (Carleton and Philipson, 1988).

These products are mounted using a variety of jewelry settings of precious, semi-precious or base metal; or used in necklaces and bracelets. Increasing, however, black coral is being used as a component of a jewelry item designed to display a mix of precious metal and gem stones. These processes require a high level of manipulative skills, craft and artistic talent (Slater, Maui Divers of Hawaii, personal communication).

4.1.2.6 Marketing

Shells

While huge numbers of shells are sold in curio, souvenir and craft shops there is no summary of the worldwide market in marine shells nor are records kept of the dealer trade for amateur collectors. Information on shell prices is available from shell club newsletters and dealer lists. Commercial shell collectors sell to dealers or directly to the consumer through ads in shell magazines, such as the Concologists of America Quarterly or regional publications. Most established dealers broker very rare and expensive shells. Prices to the hobbyist range from $1 -- $1000+, with most in the $30 to $50 range. Pectens such as lions claw *Pecten* are very desirable and sell in the $20 to $30 range (Hemmes, personal communication).

Black Coral

The market for coral jewelry is mainly in tourist areas with highly visible presentations in jewelry and souvenir shops. This market can be divided into low value, basic jewelry and carvings; high value, basic jewelry and carvings, and high value designer jewelry and sculptures (Carleton and Philipson, 1988). In the jewelry market, the higher the value of the item, there will be less black coral material used and a greater quantity of precious metals and stones (Slater, Maui Divers and Hawaii, personal communication).

Indo-Pacific and Hawaiian black coral sells at between $2 and $25 per pound for seasoned and trimmed pieces. The lower prices are for poor grade whip coral. Tree coral ranges from about $10 per pound

for jewelry to $25 or more per pound for large carving coral. Wholesale/export prices (1987) for strings of beads (16 inches long) ranged from $8 for 3 mm beads to $26 for 14 mm beads (Carleton and Philipson, 1988).

4.1.2.7 Present Status in Belize

There appears to be no information regarding the quantities of raw shells, corals, etc. that are extracted for gift shop sales or independent vendors, or the amount of income they procure. Shells are collected both for local jewelry makers and gift shops and by tourists. These are mostly tritons, helmet shells, cowries, murex, conch and top shells. This represents a fraction of the approximately 350 species of mollusks described in Belize for a range of reef zones (Morris, 1975; Opresko, et al., 1976; Perkins, 1983). Shells and shell products are uncommon in the gift shops of San Pedro and Belize City; black coral jewelry is a much more important part of their sales.

Jewelry production --

Jewelry production is based mainly on black coral (*Antipathes* spp.) and the west Indian top shell, "whelk" or "magpie" (*Livona pica*). Another coral type, a brownish species called "angel coral" is occasionally used, but is softer and does not work as well as black coral. Also, some jewelry is made from queen or pink conch (*Strombus gigas*) , the triton trumpet (*Charonia tritonis*), and a large nerite, the "bleeding tooth" (*Nerita peloronta*). Other gastropod types are rarely used, and there is little jewelry production from bivalves (the shells are too thin and fragile). However, bivalves are used for a wide range of shell curios and novelty items (see below). Other marine products used include marine turtle shell (esp. hawksbill), and on rare occasions, sea urchin spines (Cano, personal communication; Opresko, et al., 1976).

Most of the manufacturers buy their raw materials from fishermen. One or two collect their own shells. For example, one manufacturer travels to Glovers Reef or Turneff Island, making a 7 to 12 day trip once or twice a year to gather 3 to 5 buckets of whelks (at 400 to 600 pieces per bucket). He said he was very selective about his harvest, taking only clean and worm-hole free animals, and replacing rocks etc. to prevent reef damage. Lobster are usually taken during these trips, and are sold to partially offset the collection costs. This person occasionally sells the whelks to other manufacturers at $.50 each. After harvest, the whelks are boiled and the meats removed (and eaten!). This type of collection probably is a small fraction of the total number of whelks taken, since most are harvested to eat, with the meats selling for $6/pound in San Pedro and elsewhere for use in soups and ceviche (Cano, personal communication).

All black coral is taken by professional collectors (licensed by the DOF). Most is harvested by free divers from depths of 40 to 60 feet within a few miles of Belize City. It is sold for $50/pound (figures at about $60/lb when fully dried). Most of the manufacturers prefer smaller pieces (less than 1/2 inch diameter); larger pieces are more difficult to work. The supply and price per pound or piece of coral and shells have remained steady (Cano, personal communication).

The manufacturers produce a variety of jewelry items, ranging from necklaces, bracelets, earrings, pendants and pins. All are produced by the piece using a combination of small power tools -- disc sanders and polishers, and high-speed "hobby tools;" hand-held sand paper, and cutting and engraving tools. For example, the steps to create a simple earring involve 1) cutting the shell (1 - 2 min); shaping (5 min); fine sanding (2 min); water sanding (2 min); polishing (1 min); drilling and adding a hook. The use of simple manual methods increases the time and effort needed to prepare the finished product, in relation to manufacturers using more mechanical processing (Cano, personal communication).

Sales are made by in-house store-front retailing; direct sales (by street and airport vendors); and retailers in hotels, jewelry shops and boutiques. Most the sales are seasonal and peak during Christmas and Easter.

At least one manufacturer attempted to sell through a dealer in the United States; however, he found he could not compete effectively (considering the high local production cost) with shell and coral jewelry products imported from Mexico, and Asian suppliers (Cano, personal communication).

Craft or Novelty Products --

Several persons in Belize are producing craft works, novelty items, keepsakes and souvenirs, using in part, native marine products. Some of the items used, or have been used, include clam, mussel and marine snail shells, old coral rock, pieces of calcified algae, and drift wood. All of this material, with the exception of the marine snail shells, is taken from the drift line. The snail shells are almost exclusively shells used by hermit crabs, and are mostly apple murexes (*Phyllonotus pomum*). The use of coral rock was recently discontinued following a Department of Fisheries investigation -- it is illegal to take or harvest live or dead coral in Belize.

The various media are combined into a variety of forms, with one or more of the marine products used in each. These are sold in small boutiques and curio shops, or directly by the producer. Total sales are small, and in the case of one producer on St. Georges, probably no more than 1 item, worth $20 to $40 per week (Gillett and Roseman, personal communications; Opresko, et al., 1976).

4.2 Supply and Location

4.2.1 General Features of Reefs In Belize

As was noted earlier, almost all of the animals and plants harvested for the marine aquarium and shell trade come from tropical waters. Most are taken from mangrove-lined channels, coral patch reefs, and other areas at depths of less than 60 feet. These areas occur commonly on the Belize barrier reef.

The Bellze coastline is bordered for most of its length by a broad barrier and fringing reef. Numerous patch reefs, coral knolls, seagrass beds and mangrove communities occupy the fringing and barrier reef lagoons. Outside the barrier reef, but still relatively close to Belize, are three large coral reef complexes, separated by deep submarine canyons.

The shellfish and fish fauna of the Belize reef habitats has been described in several reports, including reports by Smithsonian scientists (i.e. Rutzler and Macintyre, 1982), a barrier reef survey (J. Perkins, 1983), and a environmental profile (Hartshorn, 1984). Marine shells have been described for about 350 species for a range of reef zones, and there is increasing evidence that the fish fauna in Belize are more diverse than in the eastern Caribbean (Perkins, 1983). More recently, the Smithsonian research program has been focusing on mangroves, at or near Carrie Bow Caye (Coen, personal communication; Dahl, et al., 1974). To the north, the New York Zoological Society (NYZS) is working through the Holchan marine reserve to monitor coral and fish populations at several locations on the reef (Carter, 1987).

While these studies were not intended to address the specific fish or shellfish types, and collection areas used in the aquarium trade, the NYZS work in progress, should provide some useful data on reef fish and corals -- especially when all the sampling data are compiled (early 1990) (Sedberry, personal communication; Belize, Government of, 1989).

The major geographic features of the Belize reef system is described as follows (from Perkins, 1983):

- Chetumal Bay, located between mainland Belize and Ambergris Caye and extending north into Mexico, is a semi-enclosed body of shallow water less than 15 feet (5 m) in depth.

- The Northern Shelf extends from Bulkhead Shoal to the Belize River delta. The reef ranges between 1/3 to 1 mile (0.5-1.5 km) in width, and contains segments of barrier reef broken by inlets. A linear chain of cayes, include Caye Caulker, Caye Chapel and Long Caye occur here.

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- The Southern Shelf runs roughly parallel to the coastline between the Belize River delta and the Sapodilla Cayes at the southern end of the barrier reef. The reef is widest between the Belize river delta and South Water Caye and narrows to a fringing reef, less than 300 ft wide in the Gulf of Honduras. The lagoon floor is smooth to the north and 30 to 100 ft (9-27 m) in depth, and becomes rugged and complicated to the south, with a maze of patch reefs, faroes (shelf atolls) and pinnacles. The faroes are angular islets on the continental shelf. Their distribution in Belize is confined to the area between Carrie Bow Caye and Round Caye.

- The Coastal Strip is a shallow zone of sediments, bordered on the landward side by mangrove swamps or narrow sand beaches created by longshore currents. Offshore in the an area between Placencia and Punta Ycacos at the northern entrance to Port Honduras it is bordered by a fringing reef. Relatively few corals are found on this reef.

- Atolls -- Glover's Reef, Lighthouse Reef and Turneffe Islands -- lie approximately 4, 30, and 12 miles (7, 45 and 20 km) east of the Belize barrier reef, respectively. Glover's Reef possesses the best developed reef growth and the greatest variety of reef types in the Carlbbean. Approximately 700 patch reefs are found in the central lagoon. Lighthouse reef is similar to Glover's Reef but its lagoon is shallower and contains fewer patch reefs. Turneffe Islands has a more segmented reef rim. Its central lagoon is shallow and dotted with mangrove cayes.

The most important of features in terms of aquarium fish and shellfish resources are the reef structures on the barrier reef and the offshore atolls. These complex structures can typically be divided into five major unlts: lagoon, back reef, reef crest, inner fore reef, and outer fore reef (from Rutzler and Macintyre, 1982).

Lagoon -- thls is made up of a variety of coral, algal, seagrass and mangrove communities. Near the margin of the barrier and atoll reef it consists of sand and coral rubble; the remainder of the lagoon is largely covered with sand, algae and seagrass (*Thalassia*), with scattered patch reefs and mangrove islands. Much of the lagoon near the reef is shallow (less than 20 feet (3 m) in depth) and easy to access with snorkel or hookah gear. Patch reefs are lagoon reefs of low relief 15 to 200 feet (5 to 60 m) In diameter found in areas of good water circulation, containing an exceptional diversity of marine plants and animals, not unlike the barrier reef itself. The mangroves (dominated by the red mangrove *Rhizophora mangle*) range from small plants a few feet in diameter to large islets containing numerous channels. They support a variety of plants and animals adapted to more turbid waters and muddy substrate conditions.

Back Reef -- here the bottom rises steadily from the lagoon floor to the reef crest. There is usually a patch reef zone seaward of the lagoon grading to rubble and pavement. The patch reef is typically a living and dead coral framework, with massive flattened and branching staghorn colonies 1 to 4 feet (.5 to 1.5 m) in height. The more seaward pavement is often a hardened and smooth coralline material of low relief, with scattered and robust coral colonies.

Reef Crest -- separates the fore and back-reef areas. In areas of high surf energy it is a shallow 3 to 6 foot depth (1 to 2 m) 20 to 100 foot (6 to 30 m) wide rampart built of coral rubble, *Millepora* and *Acropora*, interspersed with other corals and coralline algae, esp. seaward. On more protected barrier or atoll reefs (i.e. the west side of Turneffe Island) the reef crest is absent.

Inner fore-reef -- ranges from coral pinnacles near the surface to a spur and groove structure (interdigitating buttresses and sand troughs), extending to a depth of 45 to 60 feet (15 to 20 m). Hard corals (*Acropora, Agaricia, Montastrea*), and *Millepora* and gorgonian fan corals dominate the area.

Outer fore-reef -- a deeper water, steeper gradient zone grading downward beyond the continental shelf. There may be vertical structures, with overhanging surfaces, dropping vertically from about 200 ft (60 m) to 300 ft (100 m) in depth. This grades in a less-steeply sloping talus slope at greater depths.

4.2.2 Types Suitable for Export

Below is a selected list of approximately 100 types of fish and shellfish which either are exported from Belize, or occur in the area and have a known market in the United States and Europe. Some on the list have a limited or specialized market, and there may be a future demand for the many other animals (and plant forms) found in region (from BelaCarib, 1989; Bohlke and Chaplin, 1975; Quality Marine, 1989; Randall, 1987; Rehder, 1981; Scullinn and Littler, 1989; Stokes, 1980; and Steerer, 1986)

Fish --

Sharks and Rays (Chondrichthyes) -- examples
- Nurse Shark (*Ginglymostoma cirratum*)
- Yellowspotted stingray (*Urolophus jamaicensis*)

Eels

Moray eels (Muraenidae)

- Spotted moray (*Gymnothorax moringa*)
- Purplemouth moray (*Gymnothorax vicinus*)
- Green moray (*Gymnothorax funebris*)

Snake eels (Ophichthidae)

Spotted snake eel (*Ophichthus ophis*)

Trumpetfishes (Aulostomidae)

Trumpetfish (*Aulostomus maculatus*)

Pipefishes and sea horses (Syngnathidae) -- examples

Pipefish (*Syngnathus spp.*)
Sea horse (*Hippocampus spp.*)

Squirrel or soldier fish (Holocentridae) -- examples

Black bar (*Myripristis jacobus*)
Cardinal (*Plectrypops retrospinus*)
Reef (*Adioryx [Sargocentron] coruscum*)

Groupers (Serranidae)

Coney, gold or colored (*Cephalopholis fulva*)

Hamlets -- examples

Barred hamlet (*Hypoplectrus puella*)
Indigo hamlet (*Hypoplectrus indigo*)
Shy hamlet (*Hypoplectrus guttavarius*)

Basslets -- examples

Black cap (*Gramma melacara*)
Harlequin (*Serranus tigrinus*)
Lantern (*Serranus baldwini*)
Royal gramma or fairy basslet (*Gramma loreto*)
Swissguard (*Liopropoma rubre*)
Tobacco fish (*Serranus tabacarius*)

Cardinal fishes (Apogonidae)

Flame (*Apogon maculatus*)
Barred (*Apogon binotatus*)
Punctate or freckled (*Phaeoptyx conklini*)

Sand tilefishes (Malacanthidae)

Sand tilefish (*Malacanthus plumieri*)

Hawkfishes (Cirrhitidae)

Redspotted hawkfish (*Amblycirrhitus pinos*)

Grunts (Haemulidae)

Striped (*Haemulon striatum*)
Porkfish (*Anisotremus virginicus*)

Drums (Sciaenidae)

Jackknife fish or high hat (*Equetus lanceolatus*)

Goatfish (Mullidae)

Flounder or flatfish (Bothidae)

Peacock flounder (*Bothus lunatus*)

Jawfishes (Opistognathidae)

Yellowhead jawfish (*Opistognathus aurifrons*)

Scorpion fish (Scorpaenidae)

Flying Gurnards (Dactylopteridae)

Flying gurnard (*Dactylopterus volitans*)

Butterfly fishes (Chaetodontidae)

Foureye (*Chaetodon capistratus*)
Banded (*Chaetodon striatus*)
Spotfin (*Chaetodon ocellatus*)

Angel fishes (Pomacanthidae)

French (*Pomacanthus paru*)
Gray (*Pomacanthus arcuatus*)
Rock beauty (*Holacanthus tricolor*)
Queen (*Holacanthus ciliaris*)

Damsel fishes (Pomacentridae) -- examples

Beau gregory (*Stegastes [Pomacentrus] leucostictus*)
Bicolor (*Stegastes [Pomacentrus] partitus*)
Scarlet back (*Stegastes [Pomacentrus] fuscus*)
Longfin (*Stegastes [Pomacentrus] diencaeus*)
Three spot or Yellow (*Stegastes [Pomacentrus] planifrons*)
Cocoa or Honey gregory (*Stegastes [Pomacentrus] variabilis*)
Sergeant major (*Abudefduf saxatilis*)
Blue chromis (*Chromis cyanea*)
Yellowtail or Jewelfish (*Microspathodon chrysurus*)

Wrasses and hogfish (Labridae) -- examples

Spanish hogfish (*Bodianus rufus*)
Bluehead wrasse (*Thalassoma bifasciatum*)
Green or black-ear wrasse (*Halichoeres poeyi*)
Clown wrasse (*Halichoeres maculipinna*)
Yellow head, neon or rainbow wrasse (*Halichoeres garnoti*)
Pudding wife (*Halichoeres radiatus*)
Creole wrasse (*Clepticus parra*)

Parrot fish (Scaridae) -- example

Blue (*Scarus coeruleus*)

Blennies (Blennidae) -- example

Redlip blenny (*Ophioblennius atlanticus*)

Gobies (Gobiidae) -- examples

Neon (*Gobiosoma oceanops*)
Goldspot or sand (*Gnatholepis thompsoni*)

Surgeon fish (Acanthuridae)

Blue tang (*Acanthurus coeruleus*)
Doctorfish (*Acanthurus chirurgus*)

Triggerfish (Balistidae)

Grey (*Balistes capriscus*)
Queen (*Balistes vetula*)

Filefish (Monacanthidae)

Fringed (*Monacanthus ciliatus*)
Taillight (*Cantherhines pullus*)
Whitespotted (*Cantherhines macrocerus*)
Pygmy (*Monacanthus sp.*)

Trunkfish (Ostraciidae)

Cowfish (*Acanthostracion spp.*)
Spotted (*Lactophrys bicaudalis*)

Puffers (Tetraodontidae) -- example

Sharpnose (*Canthigaster rostrata*)

Frogfishes (Antennariidae)

Sargassumfish (*Histrio histrio*)

Batfishes (Ogcocephalidae)

Redbellied batfish (*Ogcocephalus nasutus*)

Invertebrates --

Sponges (unid. species)

Anemones

Condylactis (*Condylactis sp.*)
Curleycue (*Bartholomea annulata*)
Carpet (*Stoichactis helianthus*)
Warty (*Burdiosoma sp.*)
Crucifer (*Pymanthus crucifer*)
Seamat (*Zoanthus sociatu*)

Corals, Gorgonian

Plexaura and others

Polyps or hydroids (unid. species)

Shellfish, Bivalves

Flame scallop (*Lima scabra*)

Shellfish, Snails

Ribbon nudibranch (*Triolachia crispata*)
Flamingo tongue (*Cyphoma gibbosum*)
Cowry (*Cypraea spp.*)

Shellfish, Cephalopods

Octopus (*Octopus briareus*)

Crabs

Mangrove hermit (*Pagarus sp.*)
Red reef hermit (*Petrochirus diogenes*)
Porcelain crab (*Pisidia longicornis*)
Emerald or sculpted spider crab (*Mithrax sculptus*)
Anemone crab (*Mithrax cinctimanus*)
Arrow crab (*Stenorhynchus seticornis*)
Decorator crab (*Majidae sp.*)

Shrimp

Peppermint (*Lysmata wurdemanni*)
Scarlet lady (*Lysmata grabhami*)
Sargassum (*Leander tenuicornis*)
Pistol or brown snapping shrimp (*Alpheus armatus*)

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Peterson cleaning (*Periclimenes pedderson*i)

Polychaetes

Featherduster worms (*Sabella melanostigma and Sabellastarte magnifica*)
Christmas tree worms (*Spirobranchus giganteus*)

Starfish

Belize red (*Echinaster spinasus*)
West Indian (*Oreaster reticulatus*)
Serpent (*Ophiaderma sp.*)
Brittle (*Ophiomitrella glabra*)
Basket (*Astrophyton muricatum*)

Sea cucumbers (unid. species)

Sea urchins

West Indian sea egg (*Tripneustes ventricosus*)
Pencil (*Eucidaris tribuloides*)
Pin cushion (*Lytechinus variegatus*)
Long spine (*Diadema antillarum*)

Sea squirts - tunicates

Mangrove tunicate (*Ecteinascidia turbinata*)

Common animals for the shell/coral trade --

Corals, Black

Antipathes spp.
Cirrhipathes spp.

Conch and Helmets

Queen helmet (*Cassis madagasscariensis*)
Flame helmet (*Cassis flammea*)
Reticulated cowry helmet or baby bonnet (*Cypraecassis testiculus*)
Queen or pink conch (*Strombus gigas*)
Fighting conch (*Strombus pugilis*)
Hawkwing conch (*Strombus raninus*)

Tritons

Triton trumpet (*Charonia tritonis*)

Murexes

Apple murex (*Phyllonotus pomum*)
Florida lace murex (*Chicoreus florifer dilectus*)

Top shell

West Indian Top-shell -- Whelk or magpie in Belize (*Livona [Cittarium] pica*)
Carved star-shell (*Astraea caelata*)
Green top-shell (*Astraea tuber*)

Nerite, Bleeding tooth (*Nerita peloronta*)

Moon shell (*Natica canrena*)

Cowries and tongue shells

Measled cowry (*Cypraea zebra*)
Atlantic yellow cowry (*Cypraea spurca*)
Deer cowry (*Cypraea cervus*)
Flamingo tongue (*Cyphoma gibbosum*)

Cones

Carrot cone
Alphabet cone (*Conus spurius*)

Bivalves

Sentry scallop (*Chlamys sentis*)
Little knobby scallop (*Pectin laurenti*)
File shell (*Lima scabra*)

4.2.3 Summary of Habitat/Survey Sites

The following summarizes field information gathered during August-September and November-December 1989 surveys. A more detailed account of the survey is provided in the Appendix.

4.2.3.1 Lagoon

Patch Reefs -- These interesting and productive features dominated the landscape in areas, such as between Sargeant and English Caye. They contained a variety of often larger marine tropicals including fourspot and banded butterfly, painted and yellowhead wrasse, and many grunts and snappers. Many damselfish juveniles were living in small coral heads growing in the seagrass meadows surrounding the reefs. Patch reefs are productive and accessible collection areas.

Seagrass -- Many lagoon areas are seagrass meadows made up of an unconsolidated mixed algal sand with a good cover of *Halimeda*, other green algae and sea grasses. While the seagrass meadows were

good lobster habitat (frequently taken in traps), fish abundance varied widely. For example, on the lagoon seaward of St. Georges Caye, no fish were seen in brief spot check, nor were fish captured in traps. However, seagrass stands on the landward side of the island supported populations of juvenile marine tropicals and certain commercially important marine aquarium invertebrates, such as anemones, are common in all locations.

Mangroves -- Prop roots and branches of the mangrove plants extended several feet into the channel, shading the underlying waters and supporting a dense benthic community on the submerged portions of the plants. Benthic organisms are dominated by mangrove oysters within the upper 1/2 foot of the water column; and the green algae *Caulurpa*, feather duster worms, anemones and tunicates below. Reef fish ranged from rare to moderately common, and consisted largely of cocoa damsels, fourspot butterflies, and sergeant majors. The mangroves were good areas for invertebrates, suited for the marine aquarium trade.

Traps -- Lobster traps were found to be very effective fish attractant devices. These were surveyed on the lagoon and barrier reef sides of St. Georges Caye.

Both wooden and plastic lobster traps were observed, but marine tropicals were only seen in the wooden traps. In all cases, most of the fish and invertebrates fell out, or swam out of the traps as they were being pulled.

On traps pulled from the seaward lagoon area, one small (1 1/2 inch test diameter) "pencil" urchin was recovered. Usually there are few tropical aquarium species taken in traps on the barrier reef side of the island.

Traps from the landward lagoon side of St. Georges contained, when pulled, one small queen angel, two small foureye butterfly fish, and 3 arrow crabs. Some of the traps also contained one or more each of non-marketable crabs.

In general, few reef fish would be taken with existing trap designs; and those fish saved would only be those of highest value to the fisherman.

Piling and Docks -- Piling and dock structures were, like traps, very attractive to small reef animals. We found, in addition to a substantial number of invertebrate species, small reef fish, such as juvenile French and gray angelfish, gobies, several basslet types, and cocoa, dusky and sergeant major damselfish. These could be good collection sites provided older piling sites were selected.

4.2.3.2 Back Reef

Back reef areas often consisted of individual coral colonies and small patch reefs from 3 to 60 feet in diameter and 3 to 10 feet in

height. Surrounding bottom areas were usually sand and coral rubble. At Carrie Bow Caye, corals were mainly *Porites* and *Acropora cervicornis* in the seagrasses, grading to the massive *Diploria* and *A. palmata* near the edge of the flat. Back reef areas are relatively shallow in the northern barrier reef flat and outer lagoons. In the southern regions of Belize they are generally deeper.

A high diversity of reef fish were seen on these reefs, but their number often varied widely from region to region. For example, in the Gallows Point reef few (in relation to Key Caulker) marine tropicals were seen. Most common throughout this reef type were wrasses (esp. the bluehead) and parrotfishes. Also seen were all known butterfly, angelfish and tang species from the region; cleaner gobies; and several basslet species. Both juvenile and adult forms were seen of several types. The back reef can be an important and accessible collecting area.

4.2.3.3 Reef Crest

The structure of the reef crest was usually typical of a high wave energy area. Gorgonians and robust or massive hard corals were most abundant. At some locations (eg. Sergeant and Carrie Bow Cayes) zoanthids and fire corals were common, and elkhorn and staghorn *Acropora* were abundant. Marine tropicals consisted mainly of blue tangs (often in large schools), hogfish, mixed parrot fish, wrasses and damselfish. Juvenile yellow (*Stegastes planiforns*) and cocoa damselfish were abundant.

The reef crest is a difficult area to work except during the calmest sea conditions, but some of the fauna (i.e. zoanthids) are valuable marine aquarium species.

4.2.3.4 Inner Fore Reef

The inner fore reef was often a complex reef structure with a diverse coral community of massive, foliaceous and branching corals. The massive and foliaceous colonies were huge, up to 10 ft in diameter. Also common and well developed were fire corals, gorgonians and soft corals. Reef fish were abundant, particularly small damsel fish (mixed species), butterfly fish and wrasses. They were most abundant around the branching and foliaceous corals.

For example, off Carrie Bow Caye at -50 feet the bottom had a 50% sand cover with coral pavement. Massive coral heads 2 feet in diameter, and gorgonians were scattered throughout. Blue chromis and queen angels were common. Coral cover and diversity increased at -20 feet, and sand cover decreased. *Acropora palmata* colonies were beginning to grow at this elevation, and massive *Agaricia* and other species with relief to 6 feet were common. Fish included the rock beauty, banded butterfly, bicolor damsels, and yellow head wrasse.

Some of the more productive portions of the inner fore reef was found near the edges of channels. South of St. Georges Caye the bottom consisted of a flat sandy and pavement-like floor grading upward rather abruptly to an extensive and well-developed coral community made up primarily of elkhorn coral (*Acropora palmata*). Small numbers of jewelfish and yellow damsels were seen, as well as schools of larger blue tangs and sergeant major damsel fish. The long spine *Diadema* urchin was common.

Patchy and low-relief coral features in deeper waters of the same channel were dominated by several species of grunts, which swam in large aggregations. The most unusual aspect of one site was the extremely high density of moray eels. Marine tropicals included several juvenile French angels (in with the moray eels), a juvenile queen angel, and a number of juvenile jewelfish (yellowtail damselfish).

This was an interesting area in terms of the complexity of the coral structure. Where the spur and groove system was poorly developed, such as semi-protected reef areas opposite Turneffe Island, there was easy access to the reef face from the lagoon.

4.2.3.5 Outer Fore Reef

A wide range of habitat types were encountered on the outer fore reef area surveyed off St. Georges Caye and the Holchan reserve. They ranged from a steep and cliff-like reef slope, to a gently sloping sand platform; and large coral and rock patches. The royal gramma basslet was abundant in the lower portions of the reef slope from -50 to -80 feet. Small communities of garden eels and large hermit crabs were abundant on the sand platforms, and razorfish (caught when they dove into the sand) were common. Also seen over these sandy areas were rays, goatfish and hogfish.

Bottom areas from -40 to -50 feet contained a wide diversity of fish; and corals, sea fans and other invertebrates. Common were the blue chromis, sergeant major, painted and bluehead wrasse, and moray eels. Also seen were harlequin and lantern basslets and the sharpnose puffer; and other reef fish such as the tangs and parrotfish.

These are excellent collecting areas; however, they are exposed to open-ocean wave and sea conditions, and usually require the use of SCUBA or at least, hookah.

4.3 Collection Management Practices

4.3.1 Present Methods in Belize

Management practices to control or regulate the harvest of marine aquarium fish and shells in Belize include limitations on the number of permits issued; prohibition against the removal and sale of live and dead hard corals, and of the use of SCUBA; allowing no chemical use for

collection; and the development of marine reserve or sanctuary areas. Black coral harvesters must also be licensed. Harvest of the queen conch is regulated by the DOF during the normal fishery for this species (Strasdine, 1988). There are no regulations controlling the harvest of other invertebrate types (Gillett, DOF, personal communication).

These practices and economic constraints have effectively limited the intensity and scale of collection activities in Belize. Other practices suggested by a local collector include (Bischof, personal communication):

- Limit collectors to major collection stations outside of high tourist use areas.
- Insure the highest possible price -- don't attempt to compete with collectors in regions which have historically allowed uncontrolled harvest.
- Evaluate opportunities for rearing and culture of freshwater fish, especially in using indigenous stocks.
- Assess the potential effects of imported species on local stocks and habitats, especially the release of exotics and introduction of diseases.
- Don't allow shell collection -- or the assembly of shell jewelry and souvenirs.

The potential application of these suggested measures is discussed in the conclusions section of this report.

4.3.2 Approaches Elsewhere

Few regions have developed management approaches directed specifically to marine aquarium fish and shell collection. The discussion below reviews actions by three regions, Florida, Hawaii and Fiji to manage this fishery.

4.3.2.1 Florida

Other than informal testimony from commercial harvesters, Florida has no data on how many fish are collected, or of their standing stocks. Information is available on the species collected and market value (Russ Nelson, FMFC, personal communication).

By mid-1990 the FMFC will present to the state a report recommending certain actions to be taken in management of the fishery. A preliminary staff report suggested the following recommended actions (from Nelson, 1989):

- A minimum size of 1-1/2 to 2 inches and a maximum size limit of 8 to 10 inches for angelfish. This is to reduce the impact of a localized harvest for both aquarium and foodfish.

- o Consider possible closed seasons, closed areas or maximum size limits for other fish. No specific recommendations were given but species limitations were suggested, for example for mouth brooders. Additional reviews were to be carried out for marine reserves.

- o Limit recreational collection to a bag limit of 5 to 20 fish per day, with no minimum size limit.

- o Encourage mariculture as an alternative to the harvest of wild stocks.

- o Continue to ban harvest of living and dead coral in Florida and the South Atlantic. Study approaches for "artificial" cultivation of "live rock."

- o Possibly recommend continued restriction on "live rock" collection, which was banned by the state in early 1989. May evaluate enhancement or seeding on reef areas by non-native rock to "create" live rock.

- o Allow the use of the anesthetic quinaldine only in collection of marine tropicals, and review net mesh and length guidelines.

Presently there are no restrictions on the number of permitted collectors in the state. Anyone can buy a commercial saltwater fishing license. However, most marine tropicals are restricted species and cannot be harvested without a permit endorsement on the permit indicating the financial status of the collector. This endorsement prevents part-time or informal collection and is a modest form of limited entry (Russ Nelson, FMFC, personal communication).

Additional management tools were provided by Causey (Looe Key National Marine Sanctuary, personal communication). He noted:

- o The use of wire fish traps is banned in State waters; however, they can be used in federal waters. Many reef fish continue to be trapped as by-catch by lobster fishermen and sold in the aquarium markets (similar to the present situation in Belize).

- o There is no shell collection or any consumptive research allowed in refuges or sanctuaries.

4.3.2.2 Hawaii

The marine aquarium fishery in Hawaii is managed by the Division of Aquatic Resources, a state agency under the Department of Land and Natural Resources.

The only permit required in Hawaii for the taking of aquarium fish is to allow use of nets of less than 1 1/2 inch mesh. This permit can be obtained by any fisherman, and there are no experience,

training, equipment or fishing location limitations, other than those noted below. Traps are not prohibited, but as noted earlier, fish taken this way are of poorer quality than those taken with nets. No chemicals of any kind are allowed.

No permit is required for any animal that can be taken without use of nets. Therefore most invertebrates and some fish can be harvested without a permit.

Collectors are not allowed to collect or take any kind of live hard coral or coral-containing material ("live rock") from marine waters. The sale of coral is still allowed, and much is imported from the Philippines and Indonesia; however, a sales ban is expected. Federal action was recently noted against a collector who was openly shipping "live rock" to the U. S. mainland. Although this case was subsequently shifted to the State, if it had remained in Federal hands, the shipper could have been fined a minimum of $10,000.

Collection is prohibited by statute in designated sanctuaries (there are nine in Hawaii). An informal agreement between collectors and tour guide operators excludes collection from four areas on the west side of the island of Hawaii (see below) (Pete Hendricks, Alton Miyasaka, and Stan Ross, personal communications).

The State of Hawaii has also considered aquaculture of marine aquarium species as a means of offsetting the wild fishery. Generally, the emphasis is placed on native or indigenous species -- the importation of non-native marine fish and invertebrates would be prohibited; however, importation for re-export would still be allowed on a restricted basis (Bill Denick, personal communications; Hawaii Department of Agriculture, 1989).

As noted above, Hawaii has no restrictions on the harvest of marine shells, but there are management controls on the black coral fishery. The principal control is a minimum size limit of 4 feet (1.2 m) in height, which corresponds to a base stem diameter of 1 inch and 20 years of age (Grigg, 1976 and 1983; Olsen and Wood, 1980). This minimum size allows a good proportion of the population to reach reproductive maturity, limits the collection of "display" specimens, and produces an optimum sustainable yield (Grigg, 1976). It also, as was found out, is the minimum size for "high quality" black coral (Slater, Maui Divers of Hawaii, personal communication).

4.3.2.3 Fiji

Fiji supports a rich fish fauna (> 700 species) including many valued by the aquarium industry. It has, therefore, attracted the attention of aquarium fish traders. Under the Fisheries Regulations (Cap. 136) the export of live fish "or any kind whatsoever" is prohibited, without an exemption by the Director of Agriculture. Presently there is one local company, Aquarium Fish (Fiji) Ltd., licensed to operate in the country.

The collection of reef fish in Fiji is managed with a set of informal guidelines adopted by the Fisheries Division in 1982, and codified by the Cabinet in 1984. These guidelines were as follows:

- Operators exporting live fish should be licensed and limited to a single operator, at least till July 1985, giving the sole operator a 12-month period of grace.
- Future operators should be of high international repute with a proven record in the trade.
- Involvement of resource custodians (traditional fishing rights owners) in the collection process should be to the maximum extent practicable. There should be a training component in this process.
- The use of chemicals or poisons for collection is prohibited.
- Export permits are required for each shipment, with quantities and species to be noted.
- Conservation guidelines were to be formulated by the Fisheries Division in consultation with the operator. A ceiling on the total number of fish exported per year may be set, taking into account the area to be fished.
- Efforts should be made to ensure that collection activities do not conflict with other uses, eg. tourist diving.
- With a single moderate-level operator it is not necessary at this stage to consider reserves, closed seasons and other conservation measures. The Fisheries Division should, however, closely monitor the development of this trade.

The marine aquarium fishery of Fiji was judged to be successful with good socio-economic benefits and no observed adverse ecological effects (Lewis, 1988).

4.4 The Aquaculture Alternative to Wild Harvest

Aquaculture or the captive breeding and raising of marine tropical fish and invertebrates is an alternative to exploitation of the oceans' reefs. Tank or pond rearing of fish and invertebrates would help to relieve pressure on wild populations, and would reduce disturbance and incidental damage to coral reefs. Another positive feature of tank-bred fish is that they can be transported when very small, and so are easier and cheaper to handle, and offer the hobbyist fish that are preconditioned to aquarium life (Dewey, 1989). Both the importers and suppliers interviewed believe culture may be the best bet in the long run to sustain the industry (Maloney and Hendricks, personal communication).

This potential, however, is yet to be realized. There are currently and readily available only a few varieties of Indo-Pacific anemonefish or clownfish, the

neon goby *Gobiosoma oceanops*, and the California red abalone. Anemonefish, *Amphiprion* spp. and *Premnas biaculeatus* were the first marine aquarium fish to be reared successfully on a commercial scale. They still constitute the bulk of tank-bred fish in the trade. Culture of other species is still largely experimental, or has proven uneconomical in initial attempts. Several commercial firms are now cultivating marine tropicals -- these include Dynasty Marine in Florida and Aqualife Research Corp. in the Bahamas. These firms have created an impression of the difficulty of rearing marine fish via highly proprietary methods. Nevertheless, with careful selection of cultured species, use of low-cost and efficient rearing and growout systems, and applying experienced and capable personnel, it should be possible for other farms to at least meet the harvest price of the more valuable marine species (Domeier, personal communication).

4.4.1 Species with Good Culture Potential and Value

There are several groups of marine fish and shellfish which have good potential for commercial and experimental culture. We reviewed, in association with a fish culture specialist from the University of Miami (Mike Domeier, personal communication) the culture potential of the following:

- Groupers -- hamlets and basslets: most of these are rearable.
- Angelfish -- French and gray angelfish were reared commercially, but the farmer just barely broke even. Queen angels could probably also be cultivated and the broodstock would be very valuable.
- Jawfish -- these are mouth brooders, and may be easily reared.
- Gobies and blennies -- very easy to rear, however, none of the Caribbean blennies (i.e. red-lip) are especially valuable; however, the neon goby, an attractive species, is easy to rear.
- Wrasses, parrotfish and most damselfish (except clownfish) -- generally not suitable for culture. Parrotfish, for example, have long early life histories.

4.4.2 Culture Approaches and Facilities -- Two Scenarios

The experience in Belize with the culture of marine animals has been confined to penaeid shrimp and the queen conch. Shrimp are produced commercially, although not yet at a great profit (RDA report), and a conch hatchery is now being reoutfitted for a pilot-scale enhancement project. Grimshaw (personal communication) estimated earnings per acre of $37,000 for freshwater tropical fish, $4,500 for shrimp, and $2,000 for citrus (orange) at full development. Similar earnings should be realized in the future culture of marine aquarium fish and invertebrates in Belize. The following scenarios present two differing approaches to this culture concept. The first a government supported and staff research and development facility; and the second a private commercial production farm.

4.4.2.1 A Research and Development Facility

In general, a commercial research and development or pilot-scale facility can be similar to an existing facility at the University of Miami Rosenstiel School of Marine and Atmospheric Sciences, as follows:

- Seawater system -- a flow-through filtered seawater or highly controlled recirculating system. Probably will need controlled temperatures and some shading during first week of rearing. The salinity has to be precisely controlled -- many fish are stenohaline (unable to withstand wide variation of salinity) during spawning phases.

- Aquarium types -- consisting of a large number of small tanks used for hatching and rearing, and larger tanks for culture of larger juveniles and holding adults.

- Other major equipment items -- including pumps for the water system, particle filters, lighting (for algal cultures), an air blower, and backup generation.

- Feed requirements -- algae, rotifers and brine shrimp. These can be augmented by plankton taken in tows or drawn through the system (if unfiltered). Wild plankton produces hardier larvae and better survival than artificial or culture feeds.

- Labor requirements -- a specialist trainer with a background in algae/rotifer/fish culture and two technicians.

4.4.2.2 A Commercial Production Facility

In this example the marine reef fish and invertebrate culture facility is developed as a subsidiary or independent firm affiliated with an existing freshwater ornamental fish farm and nursery.

The facility would occupy about 20 acres of coastal land. Its development would require the following:

- Lined earthen growout and broodstock ponds and storage reservoir -- 20 ponds at 800 sq. ft each ($30,000);
- Hatchery building and rearing tanks -- 7,500 square ft ($50,000);
- Residence building -- ($30,000);
- Pump station -- diesel pump/generator/seawater pump, sand filters and supply pipe ($50,000);
- Aeration system -- ($15,000);
- Boat -- ($25,000);
- Truck -- ($25,000); and
- Other equipment and startup supplies -- ($75,000).

The total estimated startup cost would be $300,000. The facility would be staffed with a plant manager/biologist who would divide

his/her time between the freshwater and marine operations, an on-site technician/collector, and two technicians who would rotate between the two facilities. A consultant would be brought in initially, and as required during development (Grimshaw, personal communication).

The farm could be initially capitalized by a stock offering to private investors and by a reinvestment of revenues from the parent organization. The first 3 to 5 years operating costs would be met with proceeds from the sales of freshwater tropicals, by a draw from the capital account, and/or from the sale of wild caught marine tropicals. The farm could break even and begins to show a profit in 3 to 5 years. All wild capture then would cease, with the exception of stocking required to offset broodstock losses.

4.5 Direct Impacts Due to Harvest

This section describes the potential impacts of marine fish and shellfish harvest.

4.5.1 Aquarium Fish and Shell Collection

The collection of reef and invertebrate species for commercial sale has attracted a sizable group of proponents and opponents. As a renewable reef resource, aquarium fish are the basis of a sizable fishery in countries where most conventional reef resources are heavily exploited, or economic alternatives are limited. Albaladejo and Corpuz (1981) note aquarium fish were within the top ten fisheries exports in value for the Philippines and De Silva (in Sale, 1985) reported 50,000 persons were employed in the Sri Lanka fishery. On the other hand, depletion through commercial collection at aesthetic and ecological cost is a valid concern, particularly when it impacts tourism or ecological interests. In general, very few of the species collected are juveniles of commercially important food fishes (Lewis, 1988; Lubbock and Polunin, 1975).

Recruitment dynamics of the species harvested and the methods of collection are the key issues. Recruitment dynamics of planktonic reef fish larvae are complex (Richards and Lindeman, 1987) and poorly understood for many species. It is generally argued, in the absence of hard data, that mortality due to collection activities is a small fraction of the natural mortality of reef fish juveniles between settlement and adulthood (Lewis, 1988). While Doherty (1987) expressed the view that larval supply will limit the population density of adults, the empirical observations of collectors tend to support the former view.

Much of the opposition to the commercial collection of marine species is fueled by the methods employed by some collectors. Randall (1987) and Fairfield (1989) gave a detailed account of the widespread and harmful use of sodium cyanide (NaCN) as a anesthetic in the Philippines and Indonesia, as well as the less common use of rotenone, quinaldine, insecticides and dynamite. Poor survival in aquaria and possible environmental damage are the consequences of chemical collection and the use of chemicals and

explosives to catch fish is banned (but not rigorously enforced) in most countries.

It is also argued, that in hurricane-prone tropical areas, episodic storm events do more damage to aquarium fish populations through habitat destruction than do collection activities. Pfeffer and Tribble (1985) for example, describe the collapse of an aquarium fishery on Oahu, Hawaii following hurricane damage, and predicted complete recovery would take several decades.

4.5.2 Impacts of Aquarium Species Collection

4.5.2.1 Fiji

The collection of fish in Fiji has been judged to be a management success. Local collectors account for over 90% of the fish taken, only approved methods are used, and fish survival at all stages is very high. Good information on the catch have been provided, local reef owners are receiving a fair resource rental and are involved in collection, and no significant user conflicts have developed. The value of exports now exceeds $200,000 per year (Lewis, 1988).

In ecological terms, the impact of the fishery proved difficult to quantify. The total catch (about 80,000 fish per year) has stabilized while the area of collection has increased (Lewis, 1988). Less than 0.5% mortality has been experienced from arrival in the onshore holding tanks to delivery at the wholesale outlet overseas (Lewis, 1988). This compares with the 23.5% mortality estimated for Sri Lankan fish (Wood, 1985).

4.5.2.2 Florida

At this time, there is little information available from the State of Florida on basic life history or population parameters for any of the targeted marine aquarium species (Nelson, 1989). Fisheries data that is available suggests, while collection may change community structure (i.e. different types of fish may occupy a harvested coral head), there is no alteration of species diversity or abundance (Russ Nelson, FMFC, personal communication).

Causey (Looe Key National Marine Sanctuary, personal communication) believed fish traps cause the most damage to reef fish. They are very effective, and when allowed on reefs 100 feet or deeper, result in embolism and death of most fish. Causey stated the use of traps to collect marine tropicals should be sharply restricted.

4.5.2.3 Curacao

A study conducted in Curacao (deKruijf. 1978 report in Nelson, 1989) found small, schooling reef fish populations recovered rather quickly to removals, with new recruits replacing harvested fish in a matter of weeks. It was suggested that the more solitary fishes, such as angelfish, might be more vulnerable to high levels of harvest.

4.5.2.4 Hawaii

Information from collector-supplied data in the State of Hawaii suggests there is no significant effect due to collection of marine aquarium species (Hendricks, personal communication). Although several problems, such as fin damage and high mortalities, were noted with trap caught fish from Hawaii (Maloney, personal communication).

There are no comparative quantitative data on this fishery. A long-term study on reef fish populations in collected and uncollected regions carried out by the State in the mid-1970's was found to be flawed, and the study was never published (Pete Hendricks, Alton Miyasaka, and Stan Ross, personal communications).

The existing reporting data are for relatively large statistical areas, and there is concern that some depletion may be occurring in specific areas. Catch and effort information obtained from collectors may not accurately represent the actual abundance of fish on the reef. For example, an inexperienced collector may report a very low catch per unit of effort because he must expend a great deal of effort attempting to catch fish using poor techniques in the wrong locations. Presently, catch data are combined and larger-scale trends in fish abundance are monitored in conjunction with field surveys. Hopefully, this problem will be resolved by the end of 1990 with more comprehensive reporting (see the Government Involvement section) and more detailed cooperative evaluations of size and frequency of catch processed through the shippers (Pete Hendricks, personal communication).

4.5.2.5 Belize

There is no information for Belize reefs regarding the existing or potential impacts of marine aquarium fish and invertebrate collection activities. No catch statistics or detailed shipping records are available.

In light of the minimal impacts observed with much greater collection intensity in Hawaii and Florida, the impacts of the single collector on St. Georges Island should be insignificant. However, many individuals interviewed for this study believed the industry could have marked detrimental impacts, especially to the reef ecosystem and to other reef users. Their comments are summarized in the following section.

Several individuals believed the GOB should be very careful in allowing additional exploitation of fisheries resources, at least until there is a better understanding of their extent. Seen as a key issue was the need for a coordinated management plan for the barrier reef ecosystem particularly in light of significant increases in fishing pressure and apparent reductions in fish abundance (Tony Rath and Janet Gibson, personal communications; Katz, 1989).

The single marine tropical collector in Belize stated his collection methods had a strong conservation ethic. He felt those individuals most critical of fish collection in Belize were unaware of the actual impacts on fish fauna, and believed far more fish were killed by lobster traps and shrimp trawlers than could be taken by a collector using the proper methods (Karl Bischof, personal communication).

4.5.3 Impacts of Shell and Black Coral Collection

Shell Collection --

The impacts of shell collection vary with the intensity of harvest and methods used. Shell collection using passive methods does not appear to have any effect on the composition and abundance of marine shells. In Hawaii, for example, there were probably never large numbers of shells, and one can still readily find tiger cowries, triton shells, and other valuable species. The actual extent of collecting activity and number of collectors is relatively limited (Hemmes, personal communication). The shell harvests in Belize are restricted to an intensive fishery for a few species (Strasdine, 1988), and quantities used for shell collection and jewelry are relatively minor.

However, at some locations in Hawaii and elsewhere, collectors continue to use highly destructive methods to take shells. The mollusks live on and in old coral rock, and during the day are frequently hidden from view. Collectors use crowbars and hammers to breakup the reef material, either to produce rubble to attract shells or to collect hidden shells. The heaviest damage appears to be on intertidal species (Hemmes, personal communication). A similar observation was made by Alice Bowman (Pelican Beach Resort, personal communication) reporting on an excessive and damaging "research" harvest of shellfish at Carrie Bow Caye.

Finally, regarding shell collection, most collectors want to have the shells in hand and are not interested in simply observing them in the field. Some are not particularly good ecologists and see the supply as inexhaustible. Probably this attitude will change, although we can expect there will always be collectors.

Black Coral --

Black coral in Hawaii and elsewhere in the tropics has proven to very sensitive to overfishing. All species are slow growing, long-lived and reach peak reproductive maturity only after 10 to 20 years. Also, all are sessile and are readily exposed to fishing pressure (Olsen and Wood, 1980). Diver harvests have had a substantial impact on standing stocks in Hawaii, and most now occur only in deeper waters.

There is no information on the distribution and abundance of black coral in Belize; and it is possible that a substantial increase in harvest rate will exceed the maximum sustained yield (Grigg, 1976).

4.6 Effects on Other User Groups

4.6.1 Commercial Fisheries

The commercial fishing industries have generally not expressed great concern about aquarium reef fish and shell collection, mainly because of the lack of competition between the two fisheries. However reef fish collection, in both Florida and Belize, and elsewhere in the Caribbean, does have an impact on the commercial fishery. For example, in Hawaii reef fish and some marine invertebrates are harvested for food fish as well as for the aquarium trade and their is a potential conflict between these two harvesting groups.

The following are comments from commercial fisheries organizations and fishermen in Belize concerning the potential impacts of marine tropical collection. Both positive and negative impacts were noted, although generally, the comments were relatively neutral.

- National and Caribena Fishermen Producers Cooperatives -- the executive director of the National Cooperative expressed concern mainly about increased development on cayes and large-scale diving charters. He did not believe the cooperative would be interested in the collection business. but stated it was suitable for indivldual fishermen (Bradley, Raymond, personal communications). A similar statement was made by the president of the Caribena Cooperative (Heredia, Manuel, personal communication).

- Independence Cooperative -- the cooperative manager stated they were beginning a deep-water trap fishery for lobster. The approach to this fishery was to be radically different from lobster fishing as now practiced in Belize. All lobster would be held live in a recirculating cooled seawater system, using a ozone and filtered treatment system. Some would be shipped by air, vla Houston and Seattle to Japan. He expressed great interest in the collection business, thought one or two fishermen might be interested in the business, and that the Cooperative may wish to consider it as further diversification. The experience gained with closed sea-water systems would be of value. The manager had no understanding of the collection methods, handling, shipping or marketing; all of this information would have to be provided to the coop before any decision could be made. They also did not wish to become involved in possible controversies between fishermen, and other groups (Fox, Andrew, personal communication).

- Placencia Producers Cooperative -- The cooperative manager was concerned about a large increase in the collection business. He thought the link to the tourist industry was too close, did not expect the industry to self-regulate, and could see a potential for an uncontrolled increase in fishing pressure. However, at the same time, he agreed there may be room for a few dedicated fishermen/collectors. and that a moderate level of harvest should not have an impact on the resource. The manager expressed the

greatest concern over the direct impact of tourism to the fishing industry. He acknowledged the often greater revenues of the fishermen from guiding snorkeling or SCUBA divers rather than fishing was having a detrimental effect on the Cooperative's supply of fish. More intensive use by tourists and sport fishermen of commercial fishing grounds is likely to result in user group conflicts (Perez, Earl, personal communication).

- St. Georges Caye Fisherman - One fisherman on St. Georges Caye was interviewed regarding his involvement as a supplier of marine tropicals. His principal income was from trapping spiny lobster and handlining for fish. He works about 300 traps during the 8 month lobster season. As was noted earlier, marine tropicals were caught incidentally in the wooden traps used for lobster. Fish taken included flame cardinal fish (*Apogon*); French angels; high hat and spider crabs. Numbers of most desired fish (French angels) were small, one or two per day at the most. These were retained because of their high value to the fisherman (i.e. $2-3), other fish were of lower value ($.25 to $.50). He removed the fish from the traps and held them in a bucket of water for up to 4 hours before transferring them to the shipper's tanks. He appears to be one of maybe two or three fishermen supplying fish to the shipper (Remi Marin, personal communications).

4.6.2 Recreational Diving/Tourism

Basic conflicts have developed in Florida and Hawaii between harvesters of reef animals who desire to make the species available to the public for aquaria display purposes and the non-consumptive users of the reef resources who prefer a pristine setting with large standing stocks of animals available for viewing and photography. The marine aquarium industry in both states points out that many areas are closed to harvest (for example, the Key Largo Marine Looe Key Sanctuaries in Florida, and the Kealakekua Bay and Lapakahi Marine Reserves in Hawaii) and provide the best opportunity for non-consumptive use. Environmental groups and the tourism industry have argued that harvests should be carefully managed to avoid declines in stocks on reefs available to the snorkeling and diving public and that further no-harvest areas should be designated.

During the 1988-89 period, the State of Hawaii was mandated by legislative action to assess and mediate conflicts between dive tour and glass-bottom boat operators and fish collector. Within the past year, Hawaii collectors and shippers collaborated with tour guide operators to set aside dive only areas, where collectors would not fish. Four areas were located in the most heavily fished regions, but not in preferred collection areas. An extension agent acted as a facilitator -- to stand between these two opposing groups and mediate the agreement. The State may follow through with formal proceedings (including the possibility of establishing marine reserves to prohibit aquarium fish collecting) should the informal agreement prove ineffective (Pete Hendricks, personal communication; Hawaii Department of Land and Natural Resources, 1988).

Similar concerns regarding potential problems of marine fish and invertebrate collection were expressed by the diving and tourism industry in Belize. Comments from industry members are summarized as follows:

- San Pedro Tourist Guides Association -- this association sponsors a decompression chamber at San Pedro, and monitors the training and procedures used by the dive guides. It has about 70 members. The president of the association believed his members would object strongly to any plans for reef fish collection off Ambergris Caye. The guides would be opposed to any type of activity impacting the reef resource, particularly in the Caye Caulker to Ambergris Caye region. Their clients are requested to avoid touching or breaking corals (i.e. no gloves are allowed) and not to remove anything from the reef except photographs (Guerrero, David, personal communication).

- Sea-ing is Belizing -- this Caye Caulker based tour guide and photographer stated the introduction of a large scale tropical marine aquarium fish industry into Belize will have a negative effect on the presently established reef eco-tourism oriented businesses. He noted there are now approximately 30 firms which cater mainly or solely to the SCUBA diver (Table 1). Both snorkelers and SCUBA divers are attracted to Belize by the unspoiled virgin reefs and colorful reef fish. Except in areas where the local community fishes with spear-gun, the marine life is unafraid and easy to approach. This makes it attractive and relatively simple for underwater photographers to photograph, and ecology-minded divers to identify marine life. He believed any area in which persons capture reef fish will have a reduced reef fish population, and those remaining fish will be more difficult for the dive tourist and underwater photographer to approach (Beveridge, James, personal communication).

- St Georges Diving Resort -- this resort has been in operation for 17 years and is a successful dive tour business. The operator of the resort suggested fish collection may be a factor in the recent decline of French angelfish abundance around the island. He was opposed to any expansion of the collection business in Belize and felt this opinion would be shared by others in the business (Good, Fred, personal communication).

- Great Reef -- this is one of several live-aboard dive boats operating in Belize. The operator noted his clients have a wide range of skills and interests ranging from novices wanting to see a variety of reef areas, to photographers with very specific goals. He thought the impact would be minimal to his business provided the total number of fishermen was controlled, but would not rule out potential conflicts between other dive operators and collectors (Fromm, Henny, personal communication).

Table 1. Partial list of dive and fishing resorts in Belize (from Fromm, Henny, personal communication).

- Ambergris Caye -- numerous facilities ranging from individual chartered skiffs (usually taking snorkeling tours) to larger first-class resorts (i.e. Journey's End).
- Caye Caulker -- Belize Diving Services, Sea-ing is Belizing and several smaller facilities (for snorkeling).
- Caye Chapal -- Pyramid Resort
- Long Caye -- resort planned
- St. Georges Caye -- Saint Georges Lodge and the British Recreation Training Centre.
- Gallows Point, Drowned Caye -- Belcove Hotel
- Spanish Lookout Caye -- resort planned
- Bluefield Range -- Richardo's Huts
- Turneffe Islands -- Turneffe Lodge and Turneffe Flats (snorkeling only).
- Lighthouse Reef -- dive lodge with airstrip.
- Belize City -- Blackline Dive Shop.
- Glovers Reef -- Manta Resort
- South Water Caye -- Blue Marlin Lodge
- Live-aboard vessels

- Blackline Marina -- this is a diving and fishing charter service, and boat repair yard. The operator once had plans for a marine fish collecting service on Caye Caulker, but never carried them out because of an expected poor dollar return. He believed the reef to be in good condition, with the exception of corals damaged by storms; and noted the special natural resource value of reef areas south of Dangriga (Black, Jim, personal communication).

There is a general perception that tropical aquarium fish and shellfish collection poises a significant economic as well as environmental hazard to the reef resources in Belize. While no data were collected on the economic impacts of diving related tourism in Belize, the revenue return undoubtedly exceeds the return from the existing marine aquarium fish harvest. Azueta (Holchan Reserve, personal communication) estimated that about 100,000 tourists visited the country in 1989, with nearly 50% involved in some type of diving-related activity lasting a minimum of two days. With diving charters costing at least $50 per day, or $100 per tourist visit, total annual diving-related expenditures (and foreign exchange revenues) may exceed $7,500,000. However, in light of the absence of observed environmental impacts for relatively intense collection efforts, such as in Hawaii, it would seem a well-managed modest marine tropical fishery could function without jeopardizing the greater economic status fo the tourist diving industry.

4.7 Cost-Benefit Analysis

A breakeven cost-revenue worksheet was developed for a sample aquarium fish business in Table 2. Similar detailed data for the shell and black coral jewelry and collection business were not available (nor were they requested in the scope of work). Individual cost and revenue considerations are discussed below.

4.7.1 Costs

Costs for aquarium fish and invertebrate collection, and shell and black coral jewelry manufacture are high. This is labor intensive work, and the inexperienced or untrained collectors will probably operate at a loss. For example, labor and expense requirements for collection of marine tropicals are as follows, assuming a shipment of 900 pieces every two weeks, with 25 fifty pound boxes containing an average of 36 fish each (from Grimshaw, Bischof, and Maloney, personal communications).

4.7.1.1 Labor requirements

One and preferably 2 collectors working 4 to 8 hours/day for 10 days; 2 - 4 hours/day for one person to tend the fish; 6 - 8 hours for two persons to prepare fish for shipping; and 10 hours per week for administration.

4.7.1.2 Operational Costs

The majority of operational expenses are for labor. Collecting costs include fuel, air and supplies (nets, bags and buckets); boxes, bags, oxygen, etc.; inland freight (if required); and a 5% export duty. International freight is usually paid by the importer, but would be about $31 per box.

4.7.1.3 Fixed Costs

Fixed expenses are principally for equipment and administrative costs. They can be substantial. Required equipment items include: skiff and motor (two may be needed); truck; hookah and diving equipment; sea water system; aquaria, filters and air supply; oxygen regulator; and a telephone and/or access to a fax machine.

4.7.2 Benefits

4.7.2.1 Revenues

4.7.2.1.1 Collector/Shipper

Revenues to the collector/shipper will depend on the mix of fish and invertebrates shipped. We used an average value of $6 per piece. Total estimated revenues would be based on the number of fish shipped for month or year.

Table 2. Belize Aquarium Fish -- Financial Prospectus for Collection/Sales. (All figures are in Belize Dollars)

		Amt./Month	Amt./Year
I. Production Economics			
Assume --	450 pieces per week		
selling for	$6 per piece		
with	25 box shipments every two weeks		
worth	$216 per box		
Gross value --		$11,700	$140,400
II. Production Costs			
Labor (in 40 hr workweek units)			
Collectors --	1.5 @$10 /hour	$2,600	$31,200
Packers --	0.5 @ $6 /hour	$520	$6,240
Total labor		$3,120	$37,440
Fuel		$480	$5,760
Diving supplies		$100	$1,200
Feed		$25	$300
Subsistence		$300	$3,600
TOTAL		$7,145	$85,740
III. Shipping Costs			
Boxes, Bags, Oxygen, etc.	$5 /box	$271	$3,250
Inland Freight/Handling	$6 /box	$325	$3,900
Export Tax (5% of sales $)	$11 /box	$585	$7,020
TOTAL	$22 /box	$1,181	$14,170
IV. Management/Fixed Costs			
Administration labor	0.25 @$12 /hour	$520	$6,240
Depreciation on equip.*		$792	$9,500
Estimated Loan Costs **		$1,130	$13,560
Administration costs		$200	$2,400
Lease on land and dock		$500	$6,000
TOTAL		$3,142	$37,700
TOTAL COSTS		$11,468	$137,610
GROSS PROFIT		$232	$2,790

* Figured at 5 year straight line with no salvage value.
** Payment for 5 year commercial loan at 15% annual interest

V. Capital Costs

Skiff (2)	$8,000
Outboard motor (2)	$6,000
Pickup truck (used)	$10,000
Hookah equipment	$2,000
Snorkeling equipment	$500
Sea water system (constructed by shipper)	$15,000
Aquariums (constructed by shipper)	$3,000
Air supply for aquariums	$500
Packing equipment	$1,000
Telephone/fax machine	$1,500
TOTAL	$47,500

Some financing will probably be needed to fund a startup collection business of the type described above. Traditional bank loans usually cannot be secured for such funds mainly because of the high investment risk and lack of a long-term business history. Business loans have a 16 to 19% interest, and is difficult, if not impossible, to obtain a line of credit from banks. Collectors who are members of fisheries cooperatives may be able to borrow money at lower interest rates (Heredia, personal communications).

4.7.2.1.2 Government

The principal revenue to the government would be the duty amount received upon export of the live or manufactured product.

4.7.2.2 Other Benefits

A total of about three full time workers would be employed by each collection shipping operation. In addition there would be secondary employment in the transportation, supply and government sectors indirectly affected by the development of the business.

4.8 Governmental Involvement

The level of government involvement in the marine aquarium and shell collection industries varies widely from region to region. There is very limited international involvement, but a number of individual countries and states have developed regulatory and management authority over these fisheries. Few areas (e.g. Sudan) prohiblt export of their native marine animals. Others control it (e.g. Kenya, Hawaii), but many allow it to continue unrestricted. Most require the collector/shipper to be licensed, but there are few license conditions (Wood, 1985).

4.8.1 Present Status in Belize

The GOB has little direct involvement in either the aquarium fish or jewelry businesses. Enforcement actions have been taken against persons or organizations selling shell/coral curios and the DOF is the primary agency responsible for permitting and licensing aquarium fish collectors/fishermen and black coral fishermen. Also, DOF is responsible for administration and operation of the Holchan marine reserve. As was noted earlier, GOB has enacted a comprehensive set of management regulations to control the method of harvesting aquarium products.

4.8.2 Examples Elsewhere

International -- International control of the trade in aquarium products is through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Of the marine aquarium species, only the black corals and some of the hard corals come under CITES regulation. Import of these species into countries (including the U. S. and most European countries) which are parties to CITES is allowed if accompanied by a valid export or re-export document issued by the country of export (Wood, 1985; Carleton and Philipson, 1988). Belize is a party to the CITIES regulations (Hartshorn, 1984).

Although these regulations exist, they are generally poorly enforced and there are many loopholes. Probably a large amount of illegal trade still continues (Carleton and Philipson, 1988).

National -- National involvement in importation of marine tropicals may have a greater impact on the shipper. In the United States, both the National Marine Fisheries Service (NMFS) and the U. S. Fish and Wildlife Service (FWS) regulate marine tropical importation. Federal personnel directly involved in regulation, management or research related to marine tropicals include the inspection staff (U.S. Customs and FWS), and employees of NMFS, the National Marine Sanctuaries, and the regional Fisheries Management Councils (Kyle, NMFS, personal communication).

NMFS administers the Lacey Act (U.S. Code 16-3371, Section 3372). The Lacey Act applies to all marine tropicals taken using methods or involving species or forms which are illegal in the U. S. Or if the state to which product is imported prohibits capture by a particular gear type or a particular species (i.e. walking catfish), then transport and interstate commerce into that state would be a violation of the Act. Also, if the product was illegally exported (violated foreign nation regulations), it would be illegal to import that product into the U. S. Civil penalties for violation are $20,000; and criminal penalties are $40,000. Imports are allowed into the U.S. provided the correct foreign permits are obtained (Kyle, NMFS, personal communication).

Two other federal laws that may apply are the Endangered Species Act, and an Act Prohibiting the Import of Dangerous, and Non-Indigenous Species (Title 18, Sec. 42, U.S. Code), both administered by FWS under the Secretary of the Interior. The latter may limit the shipment of non-in-

digenous invertebrates, fish, amphibia, reptiles, birds and mammals (Kyle, NMFS, personal communication).

FWS levies an inspection charge of $50 to $75 per shipment, usually borne by the importer. Currently the inspection procedure appears to serve little function except to prevent shippers from importing species on the CITES list, where a special permit is needed (Maloney, Quality Marine, personal communication).

State -- The State of Hawaii expends a considerable amount of effort in the management of the marine tropical business. There is one person directly responsible for management on each of two islands. At least two extension agents from related agencies, and enforcement personnel also participate in the fishery. State staff are responsible for data analysis and reporting, fishermen education and coordination with other agencies. They contribute 1/3 to 1/2 full time employees.

Hawaii requires collectors to complete a monthly catch log and shippers/exporters file a similar report. This form is geared to commercial food fish and does not provide detailed data on how many fish are being sold. More detailed sales information will be required on State reporting forms beginning mid-1990. Also, an attempt will be made to design a new form which duplicates the typical collector/shipper invoice, thereby simplifying filing and hopefully increasing compliance (Hendricks and Miyasaka, personal communications).

The State of Hawaii also monitors the importation of marine and freshwater aquarium fish and shellfish. The Plant Quarantine Inspection Office of the State Department of Agriculture is responsible for enforcing import restrictions set by other government agencies who, in theory, have the expertise to determine the reasons for restrictions. The inspection procedure has proven to be time consuming and somewhat ineffective, in that several harmful freshwater fish and shellfish species have been inadvertently introduced in State waters (van Poollen and Obara, 1984; Bill Denick, personal communications).

The State of Florida has only recently begun to take an active role in the management of the aquarium reef fish and shellfish collection. This is in response to 1) increased public concern over environmental impacts on nearshore resources; 2) expanded harvest of previously unexploited reef animals, such as "live rock"; 3) more intense recreational fisheries; and 4) development of reef sanctuaries and refuges (Russ Nelson, Florida Marine Fisheries Commission (FMFC), personal communication).

A reporting form similar to the one used in Hawaii is required in the State of Florida, however, it is only within the past year that requested information focused specifically on the aquarium fish industry (Nelson, FMFC, personal communication).

5.0 CONCLUSIONS/RECOMMENDATIONS

5.1 The Aquarium Business

Private and public aquaria are a major element in the pet and wildlife display industries. The trade in aquarium fish and invertebrates is a multi-million dollar business, and is based on both wild capture fisheries and aquaculture.

The collection and sale of marine plants, invertebrates and finfish, is becoming increasingly important in the aquarium trade. While appearing to consist of relatively simple tasks of capture, processing, shipping and marketing, this sector of the industry is probably the most complex of the entire trade. This is due to a combination of the following:

- There are hundreds of species and size categories traded on a multinational level, requiring collecting and handling methods often specifically tailored to each species and supplying region.

- The most valuable species are usually rare and difficult to collect; and/or require extraordinary care in handling and shipping; thus the collective experience of all parties involved in the trade play an important part in the supply and quality of the products.

- The varying reproductive strategies and life histories of the plants and animals make them particularly challenging and sometimes nearly impossible to culture artificially, and almost all species are still wild captured.

- Most of the organisms are harvested from tropical ecosystems which are often poorly understood or described at the local or regional level; and the individual and cumulative impacts of harvest are incompletely assessed.

- Differing, and sometimes destructive collection methods, coupled with heightened public concern and awareness of the tropical resources have resulted in increased controversy and user conflicts over wild capture harvest.

- Government agencies have only recently recognized the economic benefits and the environmental impacts of the business. They by-and-large still lack effective monitoring and enforcement tools to manage the industry. Nor has significant long-term research on the impacts, management tools and artificial culture of aquarium species been funded or carried out by those agencies.

The widely ranging positions regarding the collection and holding of aquarium animals and plants involve trade-offs between the benefits of the reef community to the whole population vs a captive aquarium community to a few individuals. On one hand, fish collection is viewed as a traditional wild capture fishery. The species taken, and harvest level and intensity are determined by the carrying capacity of the habitat and recruitment. In such a fishery, the economic value of the resource is realized only when it is harvested and sold. On the other hand, the organisms are considered to have environmental, aesthetic and economic values exceeding their harvest value. For example, the

ecological and tourist values of a marine park are predicated on the presence of a substantial aquatic wildlife community. Tourists come to the sanctuaries to see fish and will not visit a biological desert.

Other issues affecting the industry include the research and public education values of captive species; the trade of endangered, threatened, or dangerous species; and, recently, the collection of living coral rocks.

All of these issues relate closely to the present situation in Belize. Presently, the extent and value of the marine aquarium business is very small; however, there is no consensus on approaches for the future of the industry among fisheries, environmental and tourist interests.

5.2 Shells and the Shell Trade

The harvest of marine plants and animals for the purpose of manufacturing jewelry, curios, and other items has a long history. For example, queen conch shells were popular decorative pieces in 19th century English homes, and many shells and corals were put to very practical uses in the Caribbean. Today, shells and corals are highly visible curio items, and are often crafted into novelty pieces, such as painted shells and sea urchin spine wind chimes. Smaller amounts of, usually higher quality material is used to make jewelry, and the rarest shells are purchased at great cost by professional and amateur shell collectors. There are, of course, a wide range of specialized uses for certain products ranging from pharmaceutical applications and biological experimentation (i.e. some algas) to building construction (i.e. some hard corals). These uses are out of the range of this study.

Relatively small quantities of marine shells and corals are harvested in Belize for the production of jewelry and curios. There is no legal harvest of hard corals. The fishery for black coral provides product for a domestic jewelry industry. A few species of marine snails are also used by this industry; the same snails (such as the "whelk" or top shell) are also heavily harvested for their meats. Most Belize shellfish have limited value to the casual or novice collector; however, a number of species would be desired by the advanced hobbyist. There are issues affecting the taking and handling of shells and corals, which are similar to those listed above for living marine tropicals (such as insuring a sustained and low impact harvest); but, in general, the intensity of the controversy has been much lower.

5.3 The Supply and Location of Fish and Shellfish

Reef surveys completed during this study, and as part of the longer term quantitative evaluations for DOF, indicate the types of aquarium reef fish and invertebrate found in Belize are relatively uniform within similar habitat types, i.e., in protected mangrove channels or reef walls. There are significant differences in abundance between those habitats, i.e. mangroves from St. Georges Caye, vs those from Water Caye. The overall abundance of these animals in the country is at levels found on typical reef systems elsewhere where there is either a limited reef fishery, or the fishery appears to be within sustainable limits.

5.4 Management of Wild Harvest

The management of the wild harvest of aquarium fish and invertebrates from Belize waters is, in general, more strictly controlled than in other collection areas. Limitations on the number of permits issued: regulations against the harvest and sale of live and dead hard corals, and the use of SCUBA: and the creation of marine protected areas are the main management approaches. These approaches recognize the need to avoid the uncontrolled and destructive harvest methods that are practiced elsewhere.

As was discussed earlier, there are a wide range of options in the management of the aquarium and shell fishery. These options are reviewed below for a range of development conditions:

5.4.1 Limiting Numbers of Collectors

What is a practical upper level to allow for expansion of the industry without adversely impacting the reef resources? This number can range from none, one (the existing condition), to dozens. Our findings suggest the total number of collectors in other collecting regions is limited by economic and market factors and not by supply. Experience, ability and motivation play a big role in economic success. Nevertheless, unrestricted collection will result in conflicts with other user groups, and, in extreme cases, environmental damage. This is true for aquarium and shell collection.

Recommendations for a limited entry fishery include:

- Issue permits only to the most qualified individual collector/shipper ("permit holder"). Permit holders must meet minimum training and business requirements.

- Harvest for each permit may be allowed only 1) within selected areas (see below) with a maximum of two permit holders per area; or 2) be rotated between the same areas or smaller areas according to a schedule set after DOF monitoring, with no restriction on the number of permit holders per area (but not to exceed the total number noted below).

- Limit the number of collectors that can be licensed under each permit. Experience in Hawaii suggests that 2 full-time collectors per permit holder makes an efficient and controllable team.

- Limit the number of permit holders allowed to operate in the country to no more than 8.

- Require the permit holder to be a Belize-based firm or cooperative, with the principals being Belize nationals. This guideline is similar to the limited entry provisions for the State of Alaska.

- o Allow exceptions to these guidelines only for limited cases by established public aquaria or marine facilities where it can be demonstrated the principal purposes of collection are for education or scientific research.

5.4.2 Defining Collection Locations

What are merits of supply driven collection -- i.e., collect until the resource is exhausted and then move on; vs sustained yield production within given locations? Unfortunately, data is lacking on the sustained yield for Belize's reefs. The present aquarium fish collector in Belize, and collectors in Hawaii generally harvest within a 15 mile radius of their processing base. Harvest area zoning is a practical aspect of physical and logistic settings, and not necessarily on the quality of the resource. In addition, there are a number of reef areas in Belize which are protected, are likely to be protected, or are heavily used by dive groups and research scientists.

There are two suggested options.

Option 1 -- Each permit specifies non-overlapping collection areas with a maximum radius of 15 miles and excluding any protected or prohibited regions. The recommended bases of operations for marine aquarium species would be limited to the following:

- o St. Georges Caye
- o Dangriga
- o Big Creek/Placencia
- o Punta Gorda

These operation or staging areas address practical considerations of logistics and access to suitable fishing areas and marketing channels. Collection, with the exception of scientific collection, would be prohibited from Ambergris Caye, Lighthouse Reef, Glovers Reef, and the barrier and lagoon complex from Tobacco Caye to Wee Wee Caye. With the exception of marine reserves on Ambergris Caye and Lighthouse Reef and research sites in the Tobacco Caye to Wee Wee Caye areas, no special collection zoning is recommended for marine shells. Prohibited/restricted collection areas are shown in Figure 6.

This option disperses the collection effort and reduces the likely adverse impacts. However, it is also restrictive and may place some fishermen, for example, in Punta Gorda, at a cost disadvantage versus their colleagues on St. Georges.

Option 2 -- Each permit allows collection in all areas, with the exception of the prohibited or reserve areas noted above. The number of permits would be limited by the maximum country total. Regional or area-wide closures would be the principal management tool to allow fishing area populations to regenerate. Closure requirements and timing would be determined after DOF monitoring and sampling.

This approach relies on normal competitive factors to control harvest, and is similar to a management method used in Hawaii and Florida. It is likely, initially, at least to result in a concentration of fishing pressure in the most accessible locations, and therefore greater local impact on the resource. This has not proven to be a problem, as yet, in Hawaii and Florida. A principal difficulty is the increased DOF management burden and monitoring cost.

5.4.3 Limiting Species/Number of Fish

What harvest limitations should be imposed on the taking of individual species of fish and shellfish? The diversity of aquarium fish and shellfish in Belize is relatively low, in relation to western Pacific or Hawaiian reef. However, some of the popular aquarium species (such as gorgonian corals, anemones, and fairy basslets (royal gramma) are abundant. Also, several of the shells typically used in the curio and jewelry trade are still relatively common in Belize.

Recommended harvest limits include the following:

- Continue prohibition for the harvest and sale of live and dead hard coral.

- Prohibit the collection of any marine animal or plant on the CITES list, and leave the option open for additional species prohibitions in Belize.

- Prohibit the harvest for sale of any shells for the curio, hobby or collector trade unless there is substantial processing to produce a souvenir, craft or jewelry item.

- Allow amateur or hobby collection for personal use only.

5.4.4 Identifying Collection Methods

What collection methods should be used in Belize? Of the wide variety of collection methods used to harvest marine aquarium animals and shells throughout the world, only a few are both practical and have low environmental impact. Some procedures, such as the use of sodium cyanide to take fish, affect both the reef and the marketability of the product.

In general we recommend only those methods already used in Belize and Hawaii. Specific recommendations include:

- Permit harvesting with hand-held nets and barrier nets with a mesh size of no more than 1/4 inch square.

- Allow the use of surface supplied air for harvesting; prohibit SCUBA.

- Prohibit the use of drugs, anesthetics, or poisons for any purpose to take fish or invertebrates, or any shell.

- o Prohibit the use of specialized fishing gear including trawls, dredges, seines, gill nets, spears or spear guns or wire-mesh fish traps to take aquarium fish or invertebrates, or any shell.
- o Allow the use of lobster traps only for the incidental capture of aquarium animals and prohibit modification of the traps (i.e. adding wire or plastic mesh to the bottom) for the purpose of improving the capture rate.

- o Allow the use of artificial reefs and other "fish attractant structures" only in conjunction with commercial food fish harvest.

5.4.5 Minimum Standards/Capabilities

The experience, training and capabilities of the collector/shipper determine the quality and value of the exported product, and, eventually, the level of impact to the environment.

Minimum qualifications for aquarium species permit holders should include the following:

- o Documented experience and/or training in tropical aquarium fish collection.

- o A business plan describing the method of collection, desired collection location, numbers of collectors, design and operation of the handling and shipping facility, and marketing channels.

- o A cost pro forma covering at least a three year period.

5.4.6 Reporting Requirements/Form

Effective management of reef fisheries and shell collection requires catch, catch location and effort data. A comprehensive and reliable database is the keystone to good fisheries management. This is a critical element, especially to guide future decisions regarding the industry.

We recommend application of the reporting procedures used in Hawaii for the aquarium collectors. Monitoring of the shell collectors will be more difficult and will probably require personal interviews to obtain meaningful data. These inventory procedures can be built into the permit conditions so information is gathered at little or no cost to the government. Sample forms are shown in Figures 7 and 8.

5.5 The Aquaculture Alternative

Commercial cultivation of all but a few marine species of aquarium fish and invertebrates has proven to be difficult. Nevertheless, with careful selection of cultured species, use of low-cost and efficient rearing and growout systems, and applying experienced and capable personnel, it is possible to at least meet the harvest price of the more valuable marine species.

There are at least two differing approaches to this option. The first is a government supported and staffed research and development facility; and the second a private commercial production farm.

The research and development facility could be patterned after the small research facility constructed at the University of Miami Rosenstiel School of Marine and Atmospheric Science Center. It would be best to link it with the conch hatchery or the proposed grouper hatchery at San Pedro.

A commercial production facility could be developed, for example, as a subsidiary or independent firm affiliated with an existing freshwater ornamental fish farm and nursery. The first few years of operating costs may be met in part, with proceeds from the sales of wild caught marine tropicals.

5.6 Impacts of the Industry

5.6.1 Environmental Impacts

The adverse environmental impacts of the aquarium trade are slight to insignificant for the existing single collector/shipper. There is depletion of fish and invertebrates from individual rocks and coral heads. As long as there is no hard structure impact to the reef, this type of site-specific harvest impact should be reversible.

A significant expansion of the industry (to the upper limit of 16 collectors) will increase the extent and intensity of site-specific impacts and an estimated "breakeven" harvest of 3,000 to 3,500 pieces per week or 160,000 to 180,000 per year. If collecting is dispersed as discussed above, these impacts will be reversible; however, continuous collection within a limited area is likely to result in long-term reductions of some reef fish and invertebrate species. Analysis of information soon to be available from the State of Hawaii is needed before considering permits for an expanded fishery under the Option 2 strategy noted above.

Expansion of the fishery will also increase the likelihood for conflicts with commercial dive guides and other fishermen. Few, if any dive guides will approve of increased collection effort (especially within their favorite dive spots) unless there is clear evidence the reef resource will not be affected.

Shell collection impacts are still relatively minor in terms of shells and other marine materials used for the jewelry and curio trade. While shell collection, i.e, the conch fishery, can result in significant and long-term depressions in abundance, most species will not be subjected to intensive and wide-ranging fishing pressure.

Some, and potentially all of the impacts to the reef resources could be avoided by artificial cultivation (see above).

We recommend that a more detailed inventory and reef management plan be prepared before collection is allowed at the highest levels (i.e. 8 permits), and also to gather more information on shell collection impacts. This plan concept is briefly outlined below.

5.6.2 Costs and Benefits

Aquarium trade --

Costs for aquarium fish and invertebrates, and shell collection are high, and in the case of jewelry manufacture, the markets are very competitive. We estimated total annual costs at a nearly breakeven collection/shipping level of 400 pieces per week to be about $123,000.

A minimum of about $40,000 to $80,000 investment may be required to start the business per permit holder -- required for equipment and supply purchases and an initial period of reduced cash-flow.

Annual estimated foreign exchange revenues are $125,000 ($63,000 US), with employment of 2 to 3 per collector/shipper. Estimated total revenues at maximum development are about $1,000,000.

Shell and coral jewelry and handicrafts --

While the market and demand for aquarium fish is excellent, the jewelry trade is highly competitive. The present marketing channels for jewelry are inefficient and do not provide a stable source of income for the manufacturers. Marketing is a major constraint to expanded production; particularly for export. Also, because the present manufacturers have no long-term production history, it has proven impossible for them to obtain commercial and government assisted loans, even for relatively small amounts (less than $5,000).

Product availability and cost are not at the present time, limiting any of the jewelry manufacturers. Equipment and working conditions are rudimentary, and constrain the production potential of the local producers. There are a variety of commercially available specialized jewelry tools. Many are probably too expensive for the individual, single producer.

The shell and black coral jewelry manufacturers in Belize should concentrate on the production of highly crafted and quality materials. The labor costs remain too high for them to compete either locally or with the export market with typical mass-produced items from Asia or Mexico -- some of which sells locally for less than the Belize products.

5.7 Government Involvement

The interactions between the DOF and the marine aquarium and shell collection business can take a wide range of forms. Several key questions remain. Do we have enough information to allow increased harvest of reef fish stocks in Belize? Detailed surveys in limited areas suggest a great deal of spatial heterogeneity in fish stocks and abundance. Should we impose a moratorium on any further fisheries development, as some have suggested, until a comprehensive coastal zone management plan can be completed, encompassing the entire reef? These questions apply not only to the aquarium fishery, but also to other activities impacting the reef resource.

DOF staff can work with the private sector in responding to these key issues. The interactions between the DOF and the marine aquarium and shell collection business can take a wide range of forms. We recommend the following:

Enhanced data collection and enforcement -- DOF will monitor collection stations and shipments to insure compliance with the permit conditions, and compile and interpret statistical data obtained from required reporting forms (discussed above). DOF could also train and monitor customs inspectors and BDF personnel to assist the enforcement effort. Up to a full time employee equivalent (FTE) position would be needed for an expanded fishery.

Training and education -- the strong commitment by DOF to environmental and fisheries education greatly improves regulatory compliance and lessens the need and cost of enforcement actions. DOF can insure there is uniformly high quality in training both the private and public sectors, for example, for divers and boaters, in the marine sciences and natural history. This could require up to a 1/2 FTE.

Coastal Zone Planning -- both the public and private sectors will play a role in coastal zone planning for Belize, and the aquarium fish and shell collection business should be integrated in this process. A typical approach for such planning is: 1) creation of a steering committee; 2) initiation of coastal and reef planning study groups and workshops; 3) setting of goals; 4) development of a workplan: 5) inventory, mapping and analyses of information; 6) plan formulation and 7) plan implementation. These are long-term processes, requiring 2+ years and a strong support staff to produce a product that can be accepted and used by all parties.

Aquaculture studies -- A government-funded research station, attached to the existing conch hatchery would require an estimated 2 additional FTEs.

5.8 Sample Strategy for Marine Fish and Shell Collection

While there is no single "best" approach to guide the future of marine tropicals and shell/coral collection industries in Belize, the following example illustrates the potential consequences of a conservative development strategy.

o The Approach --

1) Allow permits for up to four marine tropical collectors/shippers to operate at specific locations, exclusive of reserves and other protected areas determined by DOF.

2) Condition collection and shipping permits according to the guidelines noted above.

3) Impose no special conditions on the collection of marine shells/precious corals except as stipulated in DOF regulations and as noted above.

4) Actively investigate and promote artificial cultivation of marine fish and invertebrates, with the eventual objective of, at least, a partial phase out of the wild-capture fishery.

5) Assist shell/coral jewelry manufacturers, and producers of curios in the production of high-quality and unique items that will compete effectively in the local and international marketplace.

6) Initiate long-term evaluations of reef fish and shellfish harvesting coordinated with other reef management and assessment projects in Belize; and other locations (i.e. Puerto Rico, Florida and Hawaii).

7) Develop and carry out an aggressive education and enforcement effort as part of a general program covering all sectors of the fishing industry.

8) Provide limited "seed money" assistance, for example, in the form of low-interest guaranteed loans, for these non-traditional industries.

o Environmental Trade-Offs --

1) The increased collection effort is unlikely to have an adverse effect on the reef habitat, or the total abundance of reef fish or shellfish providing the collecting effort remains dispersed, and follows procedures outlined above.

2) Impacts on reef fish and shellfish abundance and diversity are likely within the immediate collection area (i.e. coral head, patch reef, or mangrove clump). These impacts should be temporary and reversible provided guidelines and enforcement provisions are followed.

3) No impact is expected in marine protected areas, or other regions set aside by DOF as long as there is compliance with their sanctuary status.

4) The development of aquaculture practices to replace at least a portion of the wild capture fishery with cultivated species would lower the harvest pressure on reef fish stocks and reduce the overall impact on the reef community.

o Economic Trade-Offs --

1) There would be increased employment and revenues coming into Belize from the harvest and export of reef fish and other living marine plants and animals. Annual estimated foreign exchange revenues are about $500,000 ($250,000 US), with employment of about 3 full-time employee equivalents (FTE) per collector/shipper.

2) Economic gains for the marine shell and coral trade will depend on the success in developing improved manufacturing methods and marketing channels. Little or no change is expected under existing conditions; but considerable "value added" gains can be achieved be relatively simple and low-cost enhancements.

2) Marine tropical collection would have a minor positive impact on those fishermen selling incidental trap catches; however, this is not a recommended practice. Black coral and to a lesser extent, shell collection, will continue to provide a modest income to fishermen; and no change in production value is likely unless there is a significant improvement in the market for these products.

3) The modest increase in fishing pressure, coupled with a segregation of collection and diving areas, and development of artificial cultivation should avoid adverse economic impacts to the tourist industry.

4) The GOB would have to add up to 1 FTE for monitoring/training; and additional staffing as needed to support culture and/or impact assessments. A portion of the added costs could be funded from the duty (estimated between $20,000 and $24,000) on the exported product.

6.0 FIGURES

Figure 1. Marine tropical fish of Belize. Top, porkfish Anisotremus virginicus near St. Georges Caye. Bottom, doctorfish Acanthurus chirurgus at Mexican Rocks, Ambergris Caye. Smaller individuals of these fish are harvested for the aquarium market.

Figure 2. Lobster traps or pots. Top, left traditional wooden trap; right, steel drum trap. Bottom, center, juvenile queen angel fish Holacanthus ciliaris, a species commonly seen in traps placed in seagrass meadows.

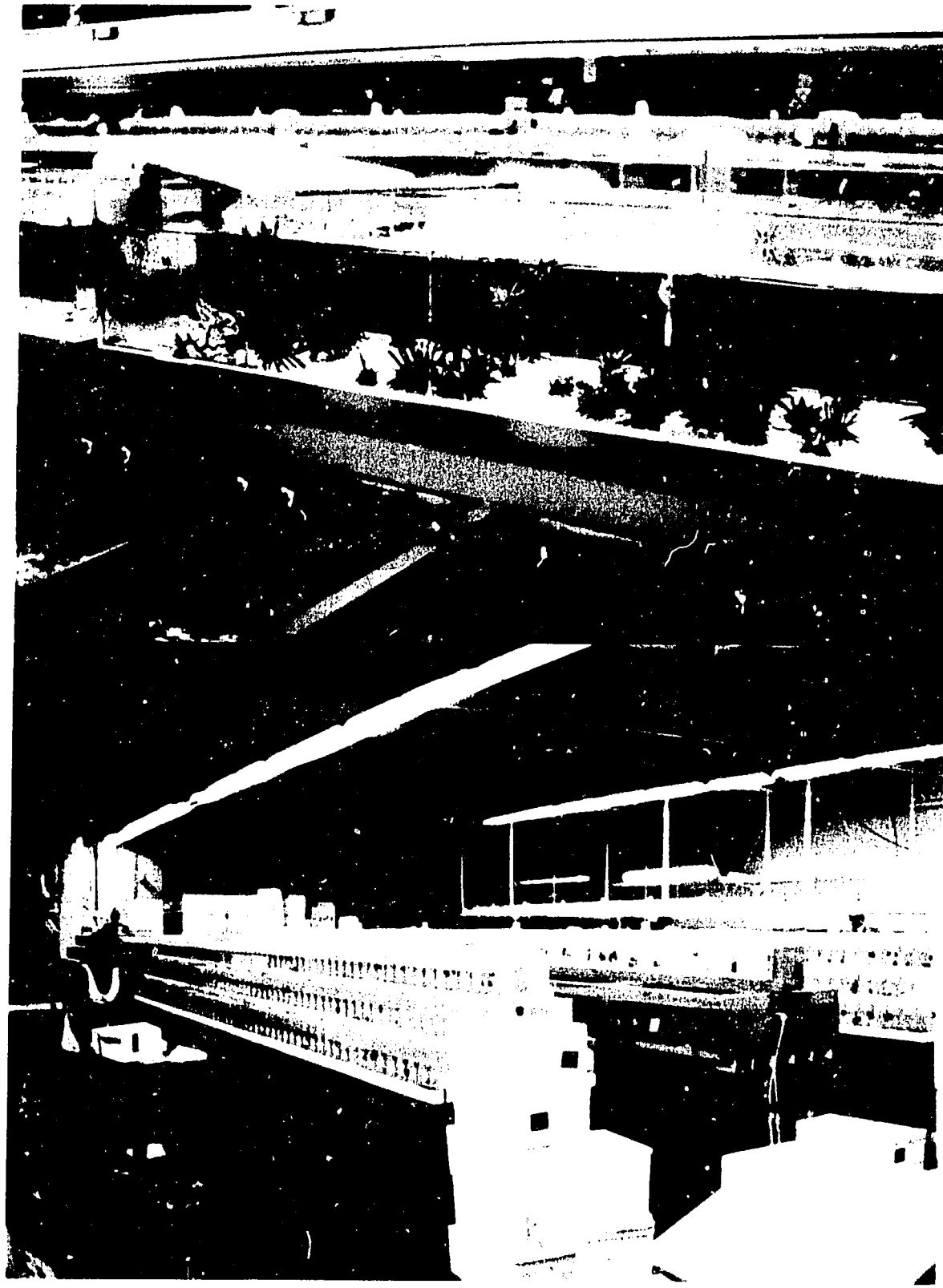

Figure 3. Aquaria and trays used for holding marine tropicals prior to shipment. Top, sea urchins and brittle starfish; the trays are also used for soft corals and anemones. Bottom, arrays of aquarium cubicles; each small (1 liter) cubicle holds a single fish and has is individually plumbed with flowing seawater.

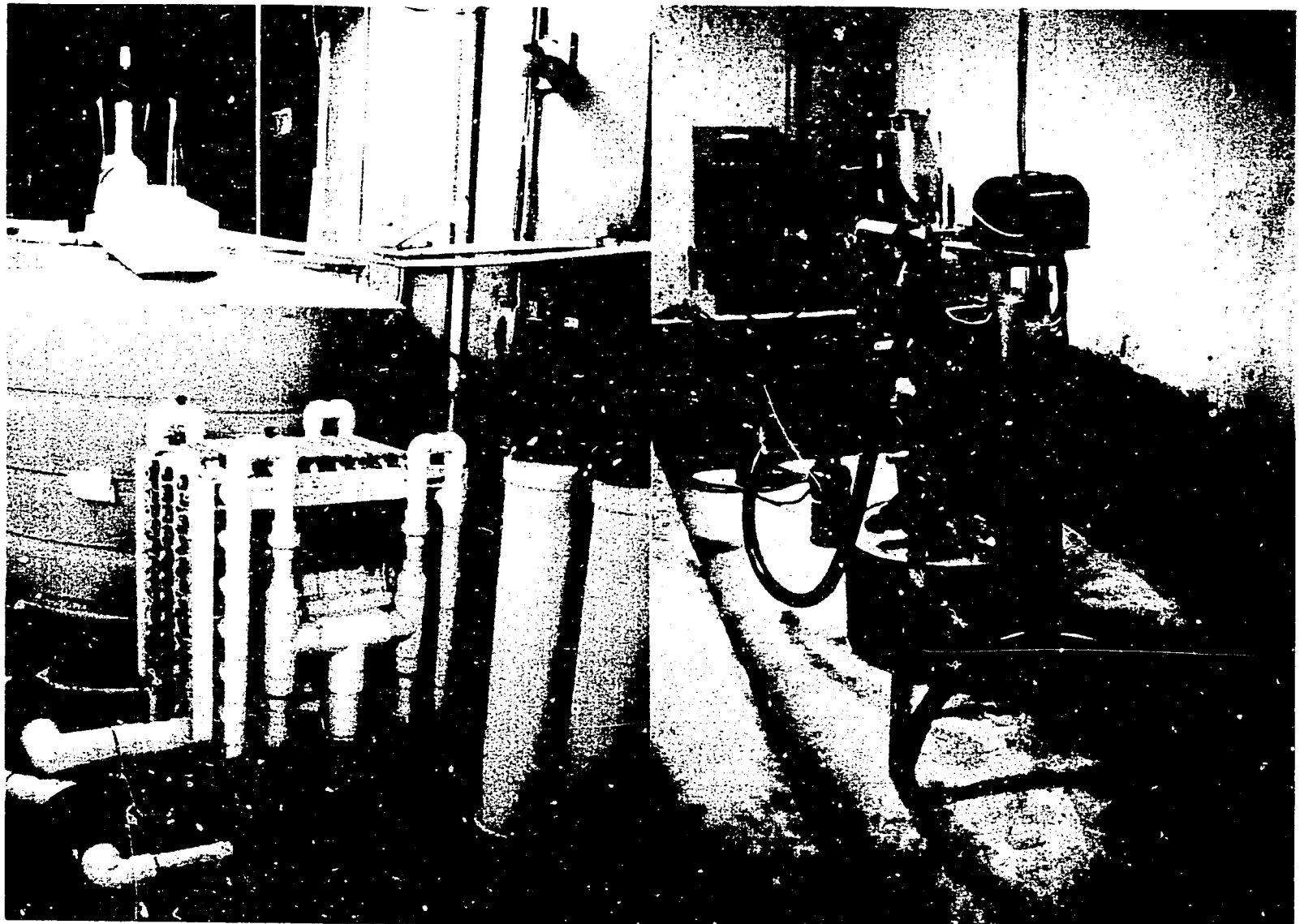

Figure 4. Seawater filtration and treatment systems. Left, system used by a large-scale importer in Los Angeles with a storage tank, filters, treatment columns (rear) and ultra-violet sterilizers (front, center). Right, prototype stand-alone system at the Independence Copperative, Big Creek; it is used to process water for live storage of lobsters, and could probably be adapted for keeping of marine tropicals.

Figure 5. Packing and shipping of marine tropicals. Top, sorting and filling area, equipment to inject oxygen and clip the bags can be seen to the right, rear. Bottom, packing lines; the double wrapped bags are packed in single or double layers in styrofoam-lined boxes.

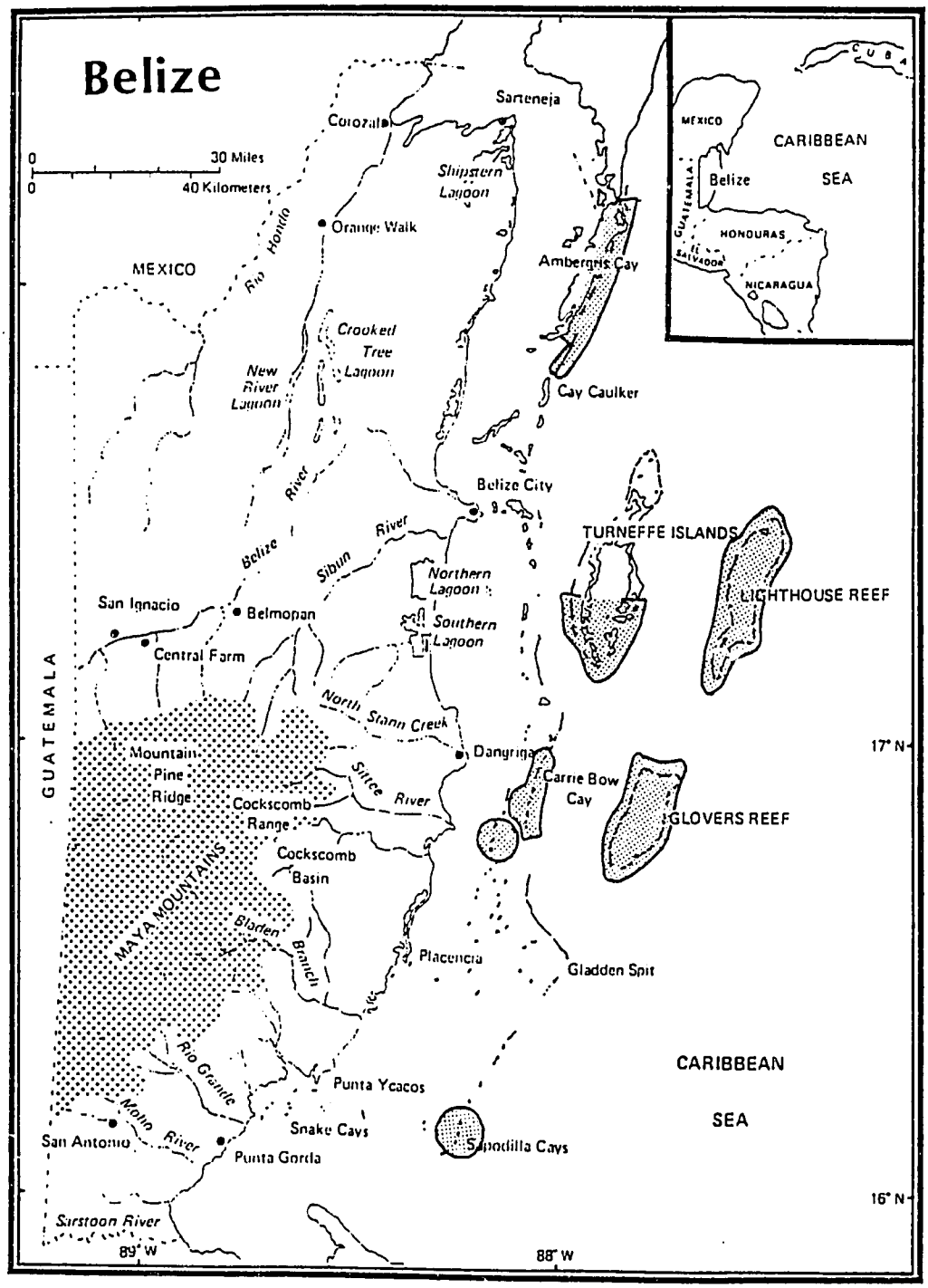

Figure 6. Prohibited/restricted aquarium fishing regions of Belize. Waters and reefs shown in the shaded areas are regions where some level of protection is recommended.

RGA International, Inc.

STATE OF HAWAII
DEPARTMENT OF LAND
AND NATURAL RESOURCES

Division of Aquatic Resources
1151 Punchbowl Street, Rm. 330
Honolulu, Hawaii 96813

See Instructions on Inside of Cover

AQUARIUM FISH CATCH REPORT

Name _____ (LAST) (FIRST) (M.I.)

Aquarium Permit No. _____

Zone Fished _____ Month Fished _____, 19 ____

Commercial Fisherman Yes ____ No ____

Total No. of Days Fished _____

Total No. of Hours Fished _____
(includes actual dive time, snorkel time, shoreline time, etc.)

Totals are for all persons included on this form.

If yes, License No. 8 - [ ][ ][ ][ ]

SPECIES	COMMON NAME	CODE	Ave. Depth (ft.)	Total Caught	Commercial Fishermen Only			
					Export		Local	
					No. Sold	Total Value	No Sold	Total Value
FAMILY POMACANTHIDAE	Angelfishes							
Centropyge fisheri	Fisher's Angel	223						
C. loriculus	Flame Angel	221						
C. potteri	Potter's Angel	220						
Holacanthus arcuatus	Black-Branded Angel	219						
FAMILY CHAETODONTIDAE	Butterflyfishes							
Chaetodon auriga	Cross-Stripe Butterfly	209						
C. fremblii	Blue-Lined Butterfly	205						
C. kleini	Coralicola	207						
C. lunula	Raccoon Butterfly	211						
C. miliaris	Milletseed Butterfly	217						
C. multicinctus	Many-Branded Butterfly	215						
C. ornatissimus	Ornate Orange-Stripe Butterfly	213						
C. quadrimaculatus	Four-Spot Butterfly	214						
C. reticulatus	Reticulated Butterfly	208						
C. tinkeri	Tinker's Butterfly	224						
C. trifasciatus	Three-Banded Butterfly	212						
C. unimaculatus	One-Spot Butterfly	210						
Forcipiger flavissimus	Common Longnose Butterfly	200						
F. longirostris	Rare Longnose Butterfly	201						
Hemitaurichthys polylepis	Black-Face Pyramid Butterfly	204						
Heniochus acuminatus	False Moorish Idol	202						
FAMILY LABRIDAE	Wrasses Hinalea							
Anampses chrysocephalus	Redtail Psych-Head Wrasse	159						
A. cuvier	Flag Snowflake Wrasse	160						
Bodianus bilunulatus	Table Boss Hog Wrasse, Aawa	133						
Cirrhilabrus ornani	Flame Wrasse	162						
Coris bulleri	Sand Wrasse Malamalama	155						
C. flavovittata	Hilu	152						
C. gaimard	Clown Wrasse	154						
C. venusta	Red-Banded Hilu	153						
Gomphosus varius	Bird Wrasse	151						
Halichoeres ornatissimus	Ornate Pink-Face Wrasse	161						
Hemipteronotus pavoninus	Peacock Wrasse Nabeta	143						
H. taeniurus	Dragon Wrasse	144						
Labroides phthirophagus	Cleaner Wrasse	134						
Leptojulis cerasinus	Pencil Wrasse	156						
Macropharyngodon geoffroyi	Potter's Wrasse Akilolo	158						
Pseudocheilinus evanidus	Scarlet Wrasse	138						
P. octotaenia	Eight-Lined Wrasse	139						
Stethojulis balteata	Omaka	157						
Thalassoma ballieui	Hinalea Luahine	150						
T. duperrey	Saddleback Wrasse	148						
FAMILY POMACENTRIDAE	Damselfishes							
Abudefduf abdominalis	Mamo	182						
Dascyllus albisella	White-Spot Damsel-Alolilo	180						
Chromis ovalis	Blue Damselfish	188						
Plectroglyphidodon imparipennis	White-Eyed Cat-Eyed Damselfish	183						
FAMILY HOLOCENTRIDAE	Squirrelfishes							
Sargocentron Diadema	Black-Dorsal Squirrelfish	374						
S. xantherythrus	Red-White Banded Squirrelfish	375						
Myripristis amaenus	Menpachi U.U. Small-Scaled	377						
M. murdjan	Menpachi U.U. Large-Scaled	376						
FAMILY ACANTHURIDAE	Surgeonfishes/Tangs							
Acanthurus achilles	Achilles Tang/Pakuikui	103						
A. dussumieri	Palani	110						
A. glaucopareius	Gold-Rim Tang	104						
A. olivaceus	Na ona e	109						
A. triostegus	Manini	101						
Ctenochaetus hawaiiensis	Hawaiian Surgeonfish	114						
C. strigosus	Kole	113						
Naso lituratus	Clown Tang	118						
N. unicornis	Unicorn Tang/Kala	121						
Zebrasoma flavescens	Yellow Tang	115						
Z. veliferum	Sailfin Tang	116						
FAMILY ZANCLIDAE	Moorish Idol							
Zanclus cornutus	Moorish Idol/Kihikihi	122						
FAMILY BALISTIDAE	Triggerfishes/Humu humus	307						
Melichthys niger	Black Trigger/Humu humu Ele ele	303						
M. vidua	Pink-Tail Triggerfish	304						
Rhinecanthus aculeatus	Black Spinelets on Caudal Peduncle	302						
R. rectangulus	Black Wedge on Tail	301						

Figure 7. Marine aquarium fish catch reporting form, State of Hawaii. This sample form is filled out and turned in monthly by collectors and processed by Division biologists.

1°

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

DIVISION OF CONSERVATION AND RESOURCES ENFORCEMENT

FISH DEALER'S REPORT ON PURCHASES OF FISH AND SHELLFISH

Fish Dealer_____ Phone_____

Business Address _____

19___ MONTH	DAY	FROM WHOM BOUGHT	COMMERCIAL LICENSE NO.	SPECIES	LBS. BOUGHT	NO. BOUGHT	AMOUNT PAID
				TOTAL			

The above report is true, correct, and complete to the best of my knowledge and belief.

Date _____ Signature _____
FISH DEALER OR AUTHORIZED AGENT

NOTE: The law requires this report to be filed on or before the tenth day of each month.
Mail Yellow Copy to: **DIVISION OF CONSERVATION AND RESOURCES ENFORCEMENT** office on your island.

Rev. 7/86

Figure 8. Marine aquarium fish shipper/buyer reporting form, State of Hawaii.

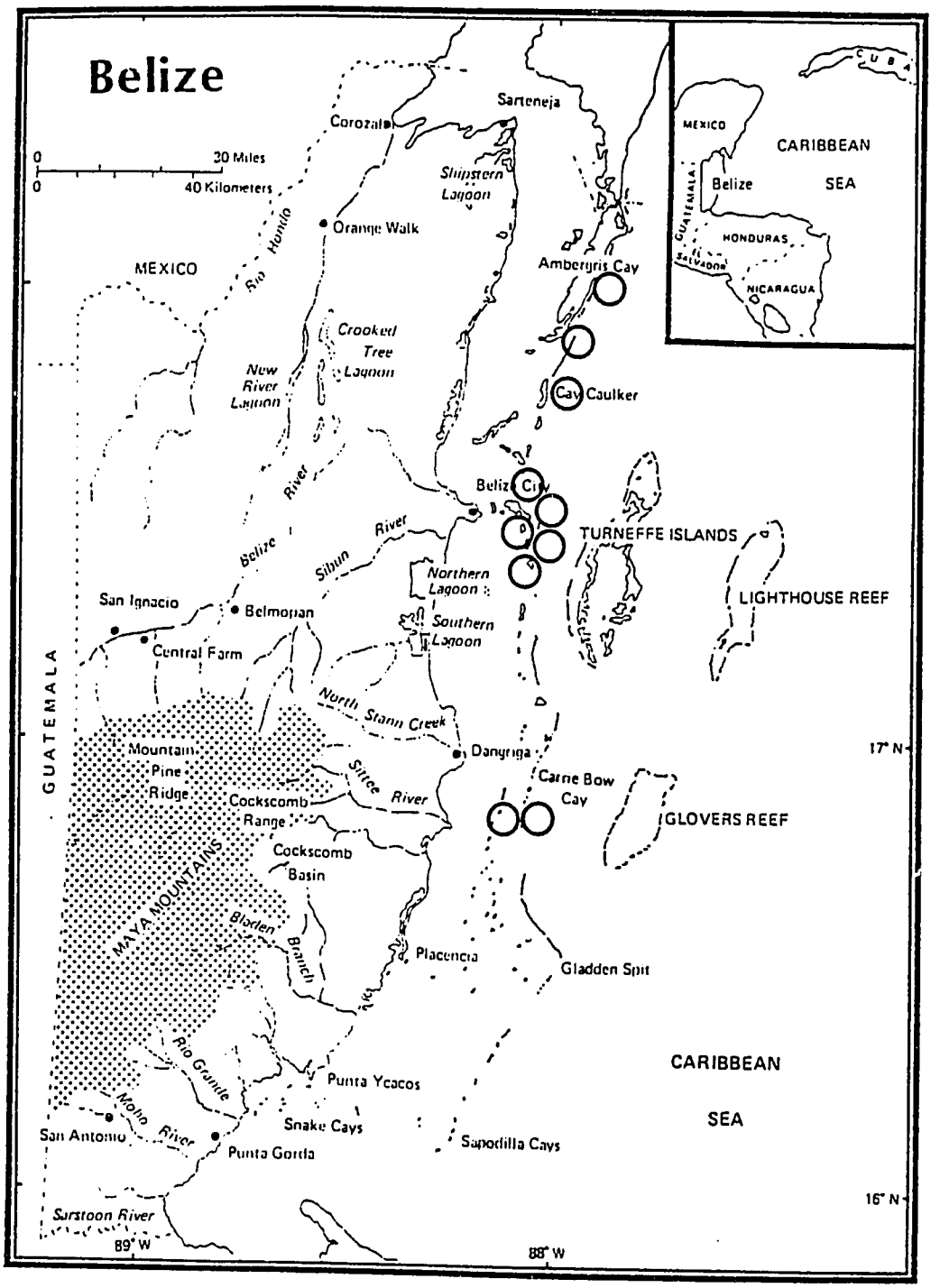

Figure 9. Locations of survey stations, Belize aquarium fish study, September - November, 1989. Each circle represents single or multiple qualitative assessments of reef fish and habitats.

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APPENDIX A

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APPENDIX B

Field Observations

Qualltative or visual surveys were made, augmented with 35 mm color slide photographs taken with a Nikonos camera. Most surveys consisted of spot checks at selected locations on the reef. Except where noted, all work was done by snorkel diving in depths ranging from 2 to 20 feet. Additional comments on survey locations are given in the approach section. Station locations are shown in Figure 9.

Ambergris Caye

Sept. 5 to 8, 1989

Holchan Marine Reserve
Survey of the reef face and reef flat lagoon.

The reef face dive was with SCUBA, beginning at about -70 feet, and ranging up to -30 feet. The barrier reef lagoon survey was a brief snorkel assessment of several coral patches occurring at about -6 feet. This is a marine reserve and no collection or capture of marine life is allowed.

Coral cover was relatively high on the reef slope, ranging from 25 to 50% live cover on the spurs. Gorgonians. hard corals and sponges were equally dominant, and some areas were characterized by dense patches of *Halimeda* spp, and other green and filamentous red algae. Reef fish were most abundant around the branching and foliaceous corals. Absolute reef fish abundance was low in relation to Pacific reefs. Several larger fish were seen, including a ray and groupers. Grunts were abundant and crowded around the divers.

The reef lagoon bottom was dominated by turtle grass, with occasional patches of hard coral and gorgonians. Reef fish were common around the reef patches, more so than in deeper waters and were made up of many aquarium species.

Mexico Rocks

A deep fringing reef lagoon about 8 miles north of San Pedro.

This area was surveyed with SCUBA, water depth was 6 to 12 feet (2 to 4 m) and there was a moderate current leading to a cut in the reef.

This site consisted of individual coral colonies and small patch reefs from 3 to 60 feet (1 to 20 m) in diameter and 3 to 10 feet (1 to 3 m) in height. Surrounding bottom areas were largely sand and coral rubble. Most corals were massive species and gorgonians, although some large branching *Acropora* colonies occur. Common alga were *Halimeda* spp., *Dictyota* spp., and algal turf species.

A fish census on two patch reefs identified a moderate diversity with medium abundance of reef fish as follows:

Twenty foot diameter by 4 foot high (6 by 2 m) head -- 1 each blue tang and doctorfish; 2 four-eye butterfly fish; 6 -- sergeant major damselfish; 10 bluehead wrasse; and 12 mixed parrotfish.

Forty-five foot diameter by 3 foot high (15 by 1 m) mixed *Acropora* and massive colonies -- 6 mixed parrotfish; 1 blue tang, 4 doctorfish; 2 bluehead wrasse males; 6 bluehead wrasse female; 2 yellowtail damsel; and 1 grey angelfish.

Caye Caulker

Sept. 2, 1989

Field survey at Caye Caulker

A snorkel dive on the reef flat and outer barrier reef lagoon offshore from the Caye.

The bottom was made up of coral blocks and smaller massive to branching colonies separated by sand channels grading to larger sand/sea grass covered bottom toward the Caye. The water depth was 3 to 6 feet (1 to 2 meters) over the sand channels, but often just a few inches above the reef flat.

There was moderate diversity of hard corals, and soft corals were common but not abundant.

Tube worms, such as the Christmas tree worm, and sponges were common. Also seen were tongue shells, top shells, queen conch, and an anemone with associated cleaner shrimp.

A high diversity of reef fish were seen, but none were abundant. Most common were wrasses (esp. the bluehead) and parrotfishes. Seen were all known butterfly, angelfish and tang species from the region; cleaner gobies; and several basslet species. Both juvenile and adult forms were seen of several types . There were limited numbers of fish of significant commercial importance.

This area was representative of habitats in the northern barrier reef flat and outer lagoon. Southern regions are reported to be generally deeper.

St. Georges Caye and Sergeant Caye Area

November 20, 1989

St. Georges Kev

Gallows Point Reef and mangrove cayes

Reef flat to outer lagoon, within 100 yards (90 m) north and south of a wrecked sailing vessel, and about 1/2 mile (800 m) south of the channel separating St. Georges reef from the Gallows Point Reef.

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Water conditions were rough and turbid. There were large quantities of dead *Acropora* in the outer lagoon, and coral cover in the limited area of reef flat that was accessible appeared low. Relatively few (in relation to Key Caulker) marine tropicals were seen -- grunts and wrasses were the most common fish.

Reef flat to outer lagoon, 300 yards (270 m) south of the wrecked sailing vessel.

Outer lagoon was shallow (less than 4 feet deep) with a good cover of *Porites* (low finger form), sea grasses and *Halimeda*. Scattered massive corals and some branching forms are found on the inner reef flat pavement. There were small numbers of tropicals, mostly blue tangs, cocoa damsels, banded butterfly, and hawkfish. None were at high densities and most were quite large.

Central barrier reef lagoon, immediately inshore from the wrecked sailing vessel.

This was about 1/3rd of the way to shore in 6 to 9 feet (2 to 3 m) of water. All of the bottom was an unconsolidated mixed algal sand with a good cover of *Halimeda*, other green algas and sea grasses. Ghost shrimp burrows were common.

Mangrove lined channel, in Drowned Caye, immediately south of Gallows Point.

This channel is one of two or three which bisect the mangrove caye. There was a swift current pouring into the narrow entrance of the channel. However, within the caye, the channel deepened and widened, and the flow became at best sluggish.

A dense mangrove forest lined the channel, and numerous side channels lead from the main stream. In most areas prop roots and branches of the mangrove plants extended several feet into the channel, shading the underlying waters.

There was a dense benthic community on the submerged portions of the plants, with very little large attached benthos on the more unconsolidated bottom sediments. Benthic organisms were dominated by mangrove oysters within the upper 1/2 foot (.5 m) of the water column; and the green algae *Caulurpa*, feather duster worms, anemones and tunicates below. Striped black grunts were common as well as small sergeant major damsel fish. This was a good area for invertebrates suited for the marine aquarium trade.

November 22, 1989

Gallows Point barrier reef

Morning dive on the northern channel margin from 20 to 30 feet (6 to 9 m) in depth.

On this survey I went with a small group of tourists who were staying at the St. Goeorge's Dive Resort. There were four divers plus a guide in our party.

This survey had two purposes. The first was to survey a deeper coral reef area within the St. George area in terms of reef fish and invertebrate abundance. The second was to assess the responses and comments of the diving group and the way in which the operator used the marine resources.

We dove over several small patch reefs or low coral communities. A line of markers along the bottom led the party to these sites from an anchorage in soft sand (this was good, no chance of coral damage). The divers were briefed on what they would see and how the dive should progress prior to the descent.

The patch reefs were 50 to 100 feet (17 to 33 m) in diameter with a vertical relief of 1 to 2 feet (.3 to .7 m). Corals consisted almost exclusively of massive hemispherical colonies (*Diploria, Montastrea*). Fire coral (*Millepora*), and encrusting sponges were common. Most of the colonies were 1 to 2 feet in diameter. The green algae *Halimeda* and *Valonia* were also common.

Fish were dominated by several species of grunts, which swam in large aggregations (individuals up to 8 inches in length) of 100 or more. Reef squirrel fish were also common, and were frequently swimming with the grunts. The most unusual aspect of this site was the extremely high density of moral eels. Up to six eels were seen beneath a single coral head, with each eel ranging from 1 to 4 feet (to 3.3 m) in length. Green, and purplemouth morays seemed to be the most common, and a few spotted morals were seen.

Marine tropicals included several juvenile French angels (in with the moray eels), a juvenile queen angel, and a number of juvenile jewelfish (yellowtail damselfish). Other fish/inverts seen included: a pygmy filefish; numerous cleaner shrimp, in amongst the morays; feather duster worms and several small anemones.

The divers seemed to be reasonably cautious and were not touching or resting on coral during any time I observed them. Most appeared to have acceptable depth compensation, All expressed great interest in their observations and were well managed by the guides, who often pointed out interesting or unusual features during the dive. No one removed any coral or shells. The dive lasted about 1--1/2 hours.

Afternoon snorkel survey

Three locations were surveyed on the reef face off the Gallows Point reef.

Southern margin of the entrance channel within a high wave energy coral community, and about 1500 feet (450 m) north of a wrecked sailboat.

This area consisted of a flat sandy and pavement-like channel bottom grading rather abruptly to an extensive and well-developed coral

community made up of primarily of elkhorn coral (*Acropora palmata*). These were very large colonies overlying a massive quantity of coral rubble. Living and dead coral extended up to the surface at several locations.

Most of the fish were not high value tropical species. Small numbers of jewelfish and yellow damsels were seen, as well as a school of larger blue tangs and sergeant major damsel fish. The long spined *Diadema* urchin was common. Blue head wrasse (adults and juveniles), and parrot fish were also common. This was an interesting area in terms of the complexity of the coral structure, and might provide a much different picture at night.

Reef face about 300 feet (90 m) north of the wrecked sail boat. This was near the same location on the reef flat surveyed on 11/20. Also, reef face 1000 feet (300 m) south of the wrecked sail boat.

The reef structure was typical of a high wave energy area. Gorgonians and robust or massive hard corals were most abundant, as were fire corals. Corals were widely spaced beyond the immediate surge zone (below 10 feet). Marine tropicals consists mainly of large specimens of blue tangs (a school of maybe 200 to 300 individuals), hogfish, mixed parrot fish, wrasses and damselfish. Juvenile yellow damselfish (*Stegastes planiforns*) were abundant. Not an important collecting area.

November 24, 1989

St. Georges Caye barrier reef and lagoon area:

Spot checks were made at several locations immediately seaward of St. Georges Caye; also dove over a small artificial reef and traps which were placed on the lagoon side of the key by Remi Marin, a local lobster fisherman.

Northern margin of the channel entrance immediately south of St. Georges key. This dive was in about 20 feet (6 m) of water at a site used as a practice SCUBA station by the British Recreation group. Visibility was only fair -- up to 30 feet (9 m).

Most of the corals were massive domed colonies up to 6 feet (2 m) in diameter. There were several extremely large soft coral colonies up to 6 ft in height. The bottom areas surrounding the larger colonies was either sand or a coral and algae covered pavement. Reef fish were uncommon and included several fourspot butterfly fish, rock beauties, and blue head wrasse.

St. Georges barrier reef, approx. 500 ft (150 m) north of the channel entrance. Outer edge of the surge zone to reef front at about -10 feet. Further offshore, the bottom features graded to a typical spur and groove system, with depths in the grooves of about 60 feet (18 m).

This area was similar to the Gallows Pt. reef except for a much gentler slope and much more barren sand cover. Corals were mostly low and encrusting, and gorgonians were common but widely scattered. Juvenile

damselfish were common, especially yellow and cocoa damsels; there were also a fair number of small blue tangs. This would be a difficult area to work except during the calmest sea conditions.

North end of St. Georges Caye, and on seagrass meadow inside the barrier reef. All of the bottom in this area, including the seaward portions of the reef are hard sand or a thin sand veneer overlying a limestone pavement. Seagrass covers much of the lagoon area between the island and the approximate edge of the reef.

While the seagrass meadows are good lobster habitat (frequently taken in traps); no fish were seen in a brief spot check, nor are fish captured in traps. Seagrass stands were made of mixed seagrass and green algae species.

Lagoon side of St. Georges Caye, about 1/2 mile (800 m) west of resort and British camp. This was one of Remi Marin's lobster trapping and fin-fishing areas.

We first looked at a small artificial reef constructed by Remi to attract snappers. This was made up of discarded lobster traps, old metal objects and appliances piled up in a depression about 3 ft high and 15 ft in diameter (1 by 5 m). Remi fishes it in the late afternoons when larger fish come to feed on smaller fish attracted to the reef.

Most of the fish on the reef were grunts and black snappers. Tropicals include a large queen angelfish, several small spotfin butterfly fish and a number of sergeant major damselfish.

Individual lobster traps were observed to have considerably larger numbers and more species of marine tropicals. These were, with one exception, standard wood lath lobster traps, with a single funnel and 1/2 to 3/4 inch (12 to 20 mm) spaces between the lath. Remi had also set at least one collapsible plastic lobster trap. The traps were set in lines, usually between stakes, at intervals of 100 to 200 feet (30 to 60 m). All were weighted with 50 to 75 pounds (23 to 34 kg) of rock.

I surveyed five traps with the following observations:

Trap	1	2	3	4	5*
Queen angel	0	4	1	2	0
Grey angel	0	2	2	0	0
French angel	0	2	0	0	0
4-eye butterfly	0	0	1	3	0
High hat	0	0	3	10	0
Doctor fish	0	2	0	2	0
Blue tang	0	3	0	1	0

* Plastic trap

November 25, 1989

I worked with Remi Marin while he picked lobster traps set on the lagoon and barrier reef sides of St. Georges Caye. Traps picked were in the north side of the channel between St. Georges and Gallows Point Reefs, and on the lagoon side of St. Georges, 1/4 to 1 mile (400 to 1,600 m) west of the island.

A total of 9 traps were picked in the entrance channel. All contained one or more lobsters and most had marketable lobsters. One small (1 1/2 inch test diameter) "pencil" urchin was recovered. This was the only tropical species seen. Usually there are few tropical aquarium species taken in traps on the barrier reef side of the island.

A total of 12 traps were pulled or checked on the lagoon side. These traps, before they were pulled, contained a number of tropical species. Nine traps were pulled -- these were only those having lobster signs (i.e. one or more large dark patches). One small (1 inch total length) queen angel, two small (1 1/2 inch total length) foureye butterfly fish, and 3 spider or arrow crabs were recovered. The fish and spider crabs were simply held in small plastic containers until he returned to the collector's shop. Some of the traps also contained one or more each of non-marketable crabs; however, most of the fish and invertebrates fell out, or swam out of the traps as they were being pulled.

This was, according to Remi a typical experience, he catches few if any of the fish that aggregate in the traps. Also, he stated fewer numbers are taken during overcast days and choppy sea conditions (as it was when we sampled) than during sunny and calm conditions. He thought he could increase retention of his catch by lining the traps with wire cloth; however, the low price paid for most collected species (except for queen angels) offered no incentive for extra measures to catch fish. Therefore, few reef fish would be taken with existing trap designs; and those fish saved would only be those of highest value to the fisherman.

November 27, 1989

Chartered Neal Roseman's boat, the "Unicorn" from St. Georges from 10 AM to 2 PM.

I made spot diving surveys at Sergeant Caye, and areas of mangrove cayes immediately west of Sergeant Caye. These were all made by snorkeling, and both written notes and photographic records were made of each area.

Sergeant Caye is a sand island 300 to 400 ft (90 to 120 m) in length, resting on the reef flat about 100 feet (30 m) from the reef margin. There are several small coconut trees on the island, a small amount of low vegetation; and the remains of a large concrete structure (now in ruins) constructed there many years ago.

Reef front, 100 yds (90 m) northeast of Sergeant Caye.

I swam out to a depth of about 20 feet (6 m). This is a complex reef structure with a diverse coral community of massive, foliaceous and branching corals. The massive and foliaceous colonies are huge, up to 10 ft (3 m) in diameter. Also common and well developed are fire corals, gorgonians and soft corals. Reef fish are abundant, particularly small damsel fish (mixed species), butterfly fish and wrasses. *Diadema* urchins are common. The spur and groove system is poorly developed, and there is easy access to the reef face through channels from the north side of the caye.

Surge zone, 100 yds (90 m) north, and immediately east of Sergeant Caye.

Corals were generally well developed with little true surge zone features. Zoanthids and fire corals were common, and elkhorn and staghorn *Acropora* were abundant in surge areas to the north of the caye. Reef fish were not abundant, and consisted mainly of damselfish (i.e. cocoa damsels), gobies and bluehead wrasse. The lantern basslet was common in deeper crevices of corals. There was little coral cover immediately east of the caye, and reef fish abundance was low there.

Reef Flat, south of Sergeant Caye

No more than 1 to 2 feet in depth, this area was made up of a coral pavement and small rubble with a heavy red algae cover. Small reef fish, including gobies and damselfish were common.

Outer lagoon reef, north and west of Sergeant Caye

This was a particularly interesting area, probably typical of the outer lagoon reef at least to English Caye. The depth was up to 10 feet and the bottom had a mixed coral and seagrass cover. Large coral patches to 15 feet (5 m) in diameter and 3 to 6 ft (1 to 2 m) high dominated the landscape north of the caye, and seagrass meadows and small coral colonies were more common to the west and north. Fish were a variety of mostly larger tropicals including fourspot and banded butterfly, painted and yellowhead wrasse, and many grunts and snappers. Many damselfish juveniles were living in small coral heads growing in the seagrass meadows.

Shallow subtidal to intertidal shoreline on west side of Sergeant Caye.

Mostly a sand and eelgrass covered bottom, with the main feature attractive to reef animals being the concrete rubble. Painted wrasse, small urchins and small damselfish were common.

Mangrove community in channel and seaward face of Water Caye, southwest of Sergeant Caye.

There were very few marine tropicals, except for occasional featherduster worms and anemones. The sergeant major damsel was the most common marine tropical; and grunts were abundant. In addition to mangrove oysters, the flat tree oyster *Isognomon alatus* was abundant.

Deep channel and mangroves on northern portions of Water Caye.

This was a seagrass covered channel about 15 feet (5 m) in depth, with sidewalls appearing to be made up of organic debris. There were no marine tropicals, with the exception of scattered *Diadema* urchins.

Mangrove and seagrass beds on the seaward side of an unidentified caye north of Water Caye.

Here the mangrove community was less well-developed and more open to the lagoon than other sites visited. Mangrove patches were surrounded by shallow seagrass beds and channels up to 10 feet in depth. Grunts and unidentified fish fry were abundant, the latter in schools of thousands. Reef fish were moderately common, and consisted largely of cocoa damsels, fourspot butterflies, and sergeant majors. Anemones, and featherduster worms were common -- the anemones were particularly attractive.

November 29, 1989

Shallow water morning survey of piers and piling and associated bottom communities, barrier reef side, immediately opposite Peyerfitte home on St. Georges Caye.

The pilings were all constructed of palm trunks, 4 to 6 inches (10 to 15 cm) in diameter. Plastic PVC pipe was also used for a fish corral. Piers were about 4 feet (1.2) wide and 1 to 2 feet (.3 to .6 m) off the surface of the water. Platforms varied in size from 10 by 20 to 15 by 30 feet (to 5 by 10 m). Both the piers and platforms were constructed of 2 by 6 inch planks with 1/2 to 1 inch spacing between each plank.

The amount of fouling growth appeared to vary with the age and placement of the piles. Older piles (time in the water wasn't known) were covered with a dense growth of hard corals, fire corals, tunicates, sponges and algae; with the corals and algae tending to be absent on piles under the platforms. Newer piles and the PVC pipe were covered with bryozoans, and an algal turf.

Small reef fish, such as juvenile French and gray angelfish, gobies, several basslet types, and cocoa, dusky and sergeant major damselfish were common, and grunts were abundant. These could be good collection sites provided older piling were selected.

Shading by pier and platform structures appeared to have a marked effect on the density of the submergent seagrass and algal community. The seagrass community was well developed around the piers and platforms. Seagrass density declined to 3/4 to 1/2 of open area densities beneath the piers, and was nearly absent beneath the platforms. Large anemones were

common on the bottom between seagrass turions and attached to the plants.

SCUBA diving survey, mid-afternoon. Dove with Fred Good and two guests on the reef face offshore the northern portion of St. Georges. The deepest point in the dive was -80 feet (24 m). This site is frequently used by Good and his guests, and is a preferred dive area.

A wide range of reef structures were encountered on this dive ranging from a steep and cliff-like reef slope, to a gently sloping sand platform; and large coral and rock patches. The royal gramma basslet was abundant in the lower portions of the reef slope from -50 to -80 feet (15 to 25 m). It occurred in small aggregations of 4 to 10 fish along the vertical faces of coral heads and boulders (often in areas occupied by large green moray eels). The grammas were absent above 50 feet. Other reef fish common in the more shallow waters of this site also were found (see below).

Small communities of garden eels and large hermit crabs were abundant on the sand platforms, and razorfish (caught when they dove into the sand) were common. Also seen over these sandy areas were rays, goatfish and hogfish.

Bottom areas from -40 to -50 feet (12 to 15 m) contained a greater diversity of fish; and corals, sea fans and other invertebrates. Common were the blue chromis, sergeant major, painted and bluehead wrasse, and moray eels. Also seen were harlequin and lantern basslets and the sharpnose puffer; and other reef fish such as the tangs and parrotfish.

Carrie Bow Caye

December 6, 1989

Carrie Bow Caye is the site of a Smithsonian Institution field station, a small facility dedicated to reef and mangrove research. I spent two days and one night at the station, made several shallow water snorkel surveys, and interviewed the research staff.

The reef flat and reef margin north and east of the Caye. A portion of this area was included in a detalled transect study made in the early 1970's (see Rutzler and Macintyre, 1982).

Patches of coral, sand and seagrass dominated the bottom landscape north of the caye. Corals were mainly *Porites* and *Acropora cervicornis* in the seagrasses, grading to the massive *Diploria* and *A. palmata* near the edge of the flat. Fish consisted largely of small to medium sized bluehead wrasse, juvenile blue tangs and doctorfish, small parrotfish and sergeant major damselfish and cocoa danselfish. There was excellent diversity in habitat and algae, and numerous urchins (esp. *Tripneustes*). Closer to the reef margin, sand and seagrass cover disappeared, and zoanthids, *A. palmata* and *A. cervicornis* were common.

Across the flat east of the caye, there was high algal cover on the inner flat, with a pronounced algal ridge on the reef margin. Storm damage,

especially to the *A. palmata* was considerable, but there was good re-growth. Small parrotfish were numerous, and filefish and damselfish were common, as well as large blue tangs. Several old experiments were in place -- such as a group of concrete blocks with cemented live coral. Reef flat conditions were typical throughout the eastern margin with mixed seagrass, *Porites* and *A. cervicornis*. Algal turf was the dominant cover toward the southeast, and very similar to Sergeant Caye.

In the evening, I made a night dive in the shallow seagrass and coral head covered bottom south of the caye. Fish diversity and abundance was generally low -- most abundant were blue tangs, and squirrel fish. Also seen were *Diadema* urchins and Peterson cleaning shrimp. Damselfish and other reef fish were absent or rare.

The next day (12/6/89) about 1300, I ran a transect from the south reef flat across the margin of the reef to a fore-reef depth of about -50 feet (15 m).

At -50 feet the bottom had a 50% sand cover with coral pavement. Massive coral heads 2 feet in diameter, and gorgonians were scattered throughout. Blue chromis and queen angels were common.

Coral cover and diversity increased at -20 feet (6 m), and sand cover decreased. *Acropora palmata* colonies were beginning to grow at this elevation, and massive *Agaricia* and other species with relief to 6 feet (2 m) were common. Fish included the rock beauty, banded butterfly, bicolor damsels, and yellow head wrasse.

Most of the bottom had a rock or coral pavement at -10 feet (3 m), and there was about a 10% sand cover. Corals were dominated by large (4 - 6 ft relief) *A. palmata* and massive colonies. There were numerous damselfish species, and small parrotfish.

Coral and coral pavement surface was 90 to 100% at -5 feet (2 m). Massive *Diploria*, *Agaricia*, and *Montastrea*, and zoanthids were common; and *A. palmata* was the dominate species. Danselfish (several mixed species, esp. juveniles), neon gobies and tangs were abundant.

Other Recent Observations of Fish Abundance

Holchan Marine Reserve 1989 Progress Report, 2nd year, 6 month

This is work underway at several locations on the barrier reefs and atolls. Stationary visual censuses are made for quantitatively assessing community structure of fishes in all zones of the reserve as well as other areas adjacent to Ambergris Caye. The data collected provide estimates of abundance, size, and species of fish found in different habitats and in different areas. The sampling method is described in detail in Carter (1987).

Data from these surveys are being compiled by George Sedberry (personal communication) in South Carolina. Preliminary data sheets list species by

location and strata (habitat) sampled. Noted are species code, species name, total number, % total number, weight, % weight, frequency of occurrence and % frequency of occurrence.

A total of 114 species from Ambergris Caye were listed in preliminary August 10, 1989 printouts. The most abundant (top 10) were *Haemulon sciurus, Thalassoma bifasciatum, H. plumieri, Pomacentrus partitus, Abudefduf saxatilis, Scarus croicensis, Chromis cyanea, Halichoeres bivittata, Acanthurus coereleus* and *A. bahianus.* Fish frequently targeted by the aquarium trade included *Acanthurus chirurgus* (no. 35); *Chaetodon capistratus* (no. 52); *C. ocellatus* (no. 36); *C. striatus* (no. 69); *Holacanthus tricolor* (no. 72). Most in the list are not species generally targeted by collectors.

from DeGeorges (1989):

Holchan Marine Reserve and Mexican Rocks, Ambergris Caye -- Fish abundance: Excellent fish abundance, especially tame and approachable reef fish.

Caye Caulker, behind the reef and in one cut, in front of and south of the town -- Fish abundance: Fish life diversity was very low.

Gladdens Cut, located approximately 21 miles (34 km) east of Placencia on the barrier reef. The dive started at 70 feet (21 m) on the outside of the reef, and then moved toward the reef flat -- Fish abundance: Fish life was varied and abundant.

Lighthouse Reef, located about 45 miles (70 km) east and southeast of Belize City -- Fish abundance: Ranged from "sparse" to plentiful and varied.

Rendezvous Point, northern tip of the Turneffe Islands, 25 miles (40 km) east of Belize City -- Fish abundance: Sparse.

Freshwater Fish Annex

There is relatively little information on the freshwater fish resources of Belize; however, one grower is producing fish for export (Grimshaw, personal communication).

Studies completed in the mid-1970's by Dr. David Greenfield (now at the University of Hawaii) lead to the description of several new or previously undescribed species from Belize. There has also been a commercial/subsistence harvest of indigenous species from the northern brackish lagoons, especially during extended periods of low rainfall, and centered in Crooked Tree Lagoon.

Recently culture and re-export of several exotic species of ornamental fish was begun by a farmer in the Dangriga area (Mr. Tom Grimshaw, Black Orchid Ornamentals). Fry and juveniles of these fish are held in a system of concrete tanks and earthen ponds until they are of suitable size for re-export. This farmer is spawning several of these species and spawning and cultivating indigenous fish for potential marketing in the U. S. and Europe. A discussion of the potential value and market for indigenous and high-value exotics was included in a report submitted by RDA to FUSADES in El Salvador and is copied as an attachment to this report.

APPENDIX C

ORNAMENTAL TROPICAL FISH

The following is an excerpt from the El Salvador Aquaculture Feasibility Study Final Report, presented by RDA International, Inc., to The Salvadoran Fund for Economic and Social development (FUSADES), April 1988.

APPENDIX C

ORNAMENTAL TROPICAL FISH

Current Demand and Trends

In the U.S. and Canada, the tropical fish industry is intimately tied to the pet industry. This industry is dependent upon an economy with disposable income. In the U.S., the pet industry as a whole is on a rebound with increased sales after having suffered from the interest in video and computer games (according to some buyers). There are also patterns evident to the experienced dealers, as when they see new generations of children buying ornamental fish, as their parents did.

The tropical fish sector of the pet industry, in particular, is on a positive upswing. Brokers caution that the market is very good in general, but has large fluctuations for particular species. They say that care and expertise is needed to stay current on marketing issues, because of the many types of fish available, but the market is viable and lucrative. There is a great demand in both the U.S. and Canada for tropical fish, with brokers saying that they cannot meet market demands.

The magazine, "Pet Dealer", said that annual retail sales in the U.S. for tropical fish totaled $535,797,930. Tropical fish have the largest sales of any type of animal sold in pet stores. Recently a market study was done by Burke Market Research. This study found that the number of aquariums owned in the U.S. has risen for the first time since 1977. The total estimate of aquariums in the U.S. is 10 million, with more people buying large size aquariums over 15 gallons.

The U.S. and Asia have active ornamental fish culture industries, while most fish from other areas are primarily wild caught. There is a problem with seasonal availability. As one buyer put it, "It depends upon what is running in the river that week." For particular species, there is already an oversupply, especially for animals grown both in the U.S. and Asia. The tropical fish for which there is enough technical information for successful commercial culture are naturally the easiest to grow. The market for these specific animals, such as Swords and Platies, is already glutted.

The constraints to supply, or selling a particular animal, are quality and price. Primarily, the animals must reach the market in good (almost perfect) condition. Cost is the second factor which governs the supply, or marketability, of a specific animal. It is interesting that Florida growers maintain they have kept the same cost levels for growing fish, for the last 10 to 20 years. This consistency is caused by improvements in culturing techniques, which keep costs down.

Freight is approximately 50% of the U.S. wholesale cost of imported ornamental fish. Although labor costs in El Salvador would probably be less expensive than U.S. labor costs, freight expenses from Central America could offset that advantage. In order to reach the interior of the U.S. and Canada, many small

buyers use transshippers. These transshippers are large brokers, who will reoxygenate the bags of fish, when the shipment reaches the coast. These transshippers are the biggest importers of tropical fish. Larger brokers handle their own import paperwork, and are used to working with their suppliers, offering advice on the quality and marketability of particular species.

Product Form

It is not unusual for an ornamental fish broker to offer a thousand different species for sale. One of the largest brokers in the U.S. has a catalog of 7,000 species. Brokers are continually interested in new species, but for these new fish they will have to develop markets. Brokers are reluctant to release price lists for fish which are not yet available, due to changing market conditions.

As a general rule, fish which are live bearers tend to come from South America, and fish which are egg layers are from the Far East. Live bearing species tend to be these four groups; guppies, swordtails, platies and mollies. Egg layers tend to be tetras, barbs, danios, rasboras, catfish such as *Corydoras*, rainbows, gouramis and some cichlids. These two groups have very different culturing, holding and shipping requirements.

Existing Sources and Competition

One third of the demand for tropical fish in North America is met by species which are cultured in the U.S., primarily in Florida. (Florida growers maintain that a retailer can order 80% of his fish needs from Florida growers.) The other two thirds is supplied by Asia (Taiwan and Singapore suppliers), South and Central America (Brazil, Costa Rica and Mexico, with a small supply from El Salvador), and West Africa.

There are literally hundreds of species being imported from the Americans alone. It rapidly proved unfeasible to provide lists of imported species from all the competing countries. Ornamental fish buyers can assist with that type of information if it is needed, once concrete arrangements are being made.

Florida Products

The following will provide a profile of U.S. ornamental fish production.

- More than 95% of the ornamental fish produced in the U.S. are raised in Florida.
- There are more than 200 full time and 100 part time tropical fish growers in Florida.
- Total retail value of Florida grown ornamentals, shipped out of state exceeds $75,000,000 annually.
- The value of the annual tropical fish crop to Florida growers is $10,000,000 annually.

- There are basically three types of Florida farms:

  a. Small family run businesses that sell in state to larger national distributors.

  - Large full service farms grow and buy additional product to supplement their lines and purchase "growouts" which are small sized fish, usually imported from other countries, and grown to maturity for sale. Some do direct importing of full size fish as well.

  - Distributors which grow a small amount of fish and do most of their business buying and selling other grower's products. These distributors rely on imported fish to a varying degree.

Asian Products

Asian culture technology is quite sophisticated. Some Asian growers can import cultured fish at less cost than Florida growers can produce them domestically. For example, a Beta may cost a Florida grower $3.50 to grow but the same Beta from Asia could be landed at the Miami airport for $.50. One Florida grower said in dismay that Asia could grow fish "over there" that U.S. growers had no idea how to grow. If Asian labor costs could be matched, El Salvador could have an advantage over Asia, with less freight expenses. Governments in Asia have offered freight subsidies to their ornamental fish culture industry, in order to offset the advantage to countries which are closer to North American markets.

Africa

Cichlids are being exported from both South and Central America and Africa. Some of the African countries exporting are: Tanzania, Tanganyika, Malawi, Burundi, Nigeria, Zambia, and Zaire.

South and Central America

The following is a list of species mentioned by the buyers contacted in this study. This list is quite short and buyers can provide extensive information when specific arrangements are being developed. These species vary and brokers often felt that complete lists of what they offered would be overwhelming, considering the number of species which they import from South and Central America. Local Salvadoran growers would have much more current and complete information.

Cichlids
Cortez, Passers, and Clarion Angel
Wrasses
Paddlefins
Hawk Fish
Eels

Catfish - Catfish species specific to El Salvador, which could be new species to the market, were considered very interesting. These would be wild caught, and not compete with domestic grown catfish, like *Plecostomus* and *Corydoras*.

Prices

Imported prices were reported as considerably lower than wholesale prices, but brokers were understandably reluctant to discuss those prices. In fact, not a single broker was willing to supply RDA with an illustrative list of their purchase prices, although many were asked. There were too many species to talk about and price arrangements between foreign producers and ornamental fish buyers are a matter of negotiation. Potential producers are urged to discuss their specific plans with the broker they anticipate working with, to develop specific commitments. The wholesale range of prices for tropical fish varies from $.05 to $500.00 per fish, depending on its rarity. As mentioned, 50% of the wholesale price of the fish is freight.

The U.S. industry standard for basic retail pricing of tropical fish is the wholesale price, (including freight), multiplied by two. If this retail price becomes too high, the fish simply cannot be sold. A responsible broker will often accept a shipment on a trial basis, particularly for a new species. After seeing the results of sales, the broker will have time to develop a market for the animal and continual sales may occur.

Impediments to El Salvador Product

The fact that so many species are marketable presents a problem in targeting which fish to consider. A tropical fish expert is really needed to advise the Salvadoran entrepreneur. Possibly this consultant could be a successful Salvadoran grower. Often big distributing companies have their own staff zoologist to keep track of the different species.

The climate in El Salvador lends itself to growing ornamental fish. Care should be taken in making the decision to grow what is already being grown elsewhere, especially growing fish already produced in both Florida and Asia. Costa Rica and Brazil are already developing markets. A cultured fish is usually more expensive to grow than a wild fish is to catch. Cultured species should command a higher price, or be sufficiently rare in order to be economically viable. Probably the biggest impediment to production in general is the existing industry in Florida, which in turn feels threatened by Asian imports.

Advantages for El Salvador Product

The greatest advantage for El Salvador lies in the fact that there are already two or three ornamental tropical fish farmers in the country. Therefore, the industry is not starting from the very beginning, and these growers have done much to see what animals are viable. Helping these growers, and encouraging more activity would build upon a knowledge base existing in the country already. The industry in El Salvador has already approached Florida farmers,

looking for possible funding or partnerships. Ornamental tropical fish are very marketable, and enhancing the existing industry may be very successful for El Salvador.

Florida growers maintain that almost all of the varieties of ornamental fish that a retail store would need are available from them. However, these growers are not supplying two thirds of the existing market demand. Even local Florida tropical fish farmers will admit that there will always be a need for imported farmed and wild caught species in addition to their locally produced animals.

These local growers, themselves, are also an available market. The second type of farmer, who purchases "growouts," is buying imported species such a red-tailed black shark, iridescent shark, bala shark, clown knife, clown loach, rainbow shark and tinfoil barbs. The third type of farmer, (who is actually more of a distributor), is also a potential buyer group.

The market for ornamental tropical fish is excellent, if sometimes fickle for particular species. More than four million pet fish are shipped weekly in the U.S., alone. Much information on the U.S. market is available from pet industry magazines, such as "PSM", "Pet Age", "Pet Dealer", and "Pet Business". These large magazines publish directories of shippers, the livestock that they carry, terms, etc. (Information on the Canadian industry is available from Canadian pet industry magazines, which have been difficult to obtain, within the time frame for this study).

Another advantage for El Salvador's imported tropical fish is that shipping in and out of the Miami and Tampa, Florida areas have been tailored to the live tropical fish market. The single largest air freight item from Florida is live tropical fish. Estimates for shipment are about 15 to 20 thousand boxes of live ornamental fish shipped from Florida, weekly. There is usually a minimum of 100 lbs. for live ornamental fish shipments (that is about eight boxes of fish).

Finally, one of the most positive aspects of this investigation into marketing ornamental fish was the attitude of the brokers, themselves. Large brokers were more than willing, (in fact, very interested), in developing markets for new species. Novelty and exclusivity of species were very attractive to buyers. Responsible buyers actually provide a very necessary marketing function for the tropical fish growing industry, keeping on top of current trends, which growers may not have time to do. These buyers were also providing feedback into the quality and customer acceptance of the particular grower's or importer's product.

Brokers

The following recommendations are suggestions from brokers:

- For a new species, send an experimental shipment, and wait for payment before sending more shipments.
- Educate the workers on the need for high quality, undamaged fish.

- o Make sure payment is timely for each shipment, when continually shipping product. (The U.S. courts do not provide as timely or complete protection for the foreign importer, as other countries often think).

- o Send shipments of a minimum of 100 - 200 kilos. A 100 kilo shipment is almost too small to be worth the expense of paperwork.

- o Responsible brokers can help consolidate shipments for importing.

Aquaculture, Inc.
P.O. Box 261623
Tampa, Fl 33685
1-813-920-3661 TLX 4971147

This company imports cichlids from South and Central America, and claims to be the world's largest cichlid breeder.

Dolphin International, Inc.
P.O. Box 91081
Los Angeles, CA 90009
1-213-776-2352 David or Steve

This is one of the largest, and most reliable brokers in the U.S. This company is willing to advise customers on species selection and quality of product. This company has a catalog of 7,000 species available.

Philip Gaudio Enterprises
P.O. Box 172
Ruskin, FL 33570
1-813-645-0421

This firm offers "growouts", and ships to Europe, as well as the U.S. and Canada. This firm also offers aquatic plants for sale.

Segrest Farms
P.O. Box 758
Gibsonton, FL 33534
1-800-237-9317, 1-813-677-9196 Mr. Jack Bramlett

This firm buys through a brokerage firm, already "well known" in South America, and ships out through a national distributor. Segrest works with fish from all over the world.