A Plan to Reduce Ciguatera in the Tropical Western Atlantic Region

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RESUMEN

La Ciguatera (envenenamiento por peces tropicales) es un envenenamiento gastro-intestinal y neurológico adquirido por el ser humano al ingerir ciertos peces que habitan los ecosistemas de arrecifes coralinos. Anualmente ocurren varios miles de casos en el Océano Atlántico occidental tropical y en el Océano Pacífico, asi como en algunas islas del Océano Indico. No existe método simple y poco costoso para identificar a un pez ciguato, y no existe curación médica para esta intoxicación, la que puede durar de unos pocos meses a 25 años. La ciguatera se supone se origina de uno o más organismos tóxicos que habitan los arrecifes coralinos, tales como los dinoflagelados, cuyas toxinas son transmitidas por las cadenas alimenticias via peces pequeños a peces predadores mayores, y, en ultima instancia, al hombre.

Los peces ciguatos están generalmente limitados a determinadas regiones, y frecuentemente a islas y arrecifes individuales, y aun a sectores de un arrecife coralino. Basado en bibliografía científica, peces seguros a ser ingeridos en un lado de una isla, a menudo pueden ser tóxicos en el otro lado. Se estima que este fenómeno está asociado con los vientos y corrientes que afectan al ecosistema y a los microorganismos tóxicos.

Una forma simple y barata de reducir la incidencia de intoxicación por la ciguatera en el ser humano sería la determinación de areas que habitualmente producen peces ciguatóxicos. Esto pudiera realizarse mediante un análisis crítico de la bibliografía científica, combinado con numerosas entrevistas con pescadores comerciales y autoridades de salud pública. Nosotros proponemos tal solución a fin de reducir la incidencia de la ciguatera en al Atlántico occidental tropical. Se pueden prepara listas y cartas de regiones ciguatóxicas a ser distribuidas a comerciantes mayoristas y al detalle de productos marinos, a oficiales pesqueros, personal de salud pública y a investigadores potenciales en nuevas areas pesqueras. Esta información sería valiosa al tomar decisiones relativas a en cuales arrecifes la pesca debe estar restringida para disminuir la incidencia de la ciguatera.

INTRODUCTION

Ciguatera is a strange illness caused by eating the flesh or viscera of any one of over 400 species of fishes and some invertebrates (Bagnis et al., 1970). Of the approximately 70 species of ciguatoxic fishes in the tropical western Atlantic, those most commonly reported as toxic are some species of groupers, snappers, tropical mackerels, barracudas, jacks, dolphin, and hogfish. All are important commercial and sport fishes, and most are non-migratory and are associated with coral reefs (see Appendix I). Ciguatoxic fishes occur in the shallow, tropical regions of the Atlantic and Pacific oceans and, to a lesser extent, the Indian Ocean (Halstead, 1967). Ciguatera in the tropical western Atlantic was first referred to by Martyr (1555), and has been reported from this Caribbean region by at least 132 authors. This information

is deduced from our ciguatera bibliography. Yasumoto et al. (1979b) estimated that several thousand victims annually suffer from ciguatera in the tropical western Atlantic and Pacific oceans.

The medical symptoms of ciguatera are both gastro-intestinal and neurological, with initial symptoms of nausea, diarrhea and abdominal cramps being followed some hours later by such neurological disturbances as reversal of hot and cold sensations, a peppery taste or numbness of the tongue and lips, aching jaws with a feeling of looseness of the teeth, severe pain in the joints, dizziness, severe itching and muscular fatigue (Russell, 1975; Deichmann et al., 1977). Victims are usually bedridden, with disability lasting from several days up to 25 years (Gudger, 1918; Randall, 1958). The average illness seems to be about 6 months. Treatment is purely symptomatic (Russell, 1975; Deichmann et al., 1977). Medical treatment of ciguatera intoxications has been largely unsuccessful, and long and complicated hospital treatments are expensive, uncertain, and sometimes cause unforeseen complications (Bagnis, 1968; Bagnis and Fevai, 1971; Bagnis et al., 1974; Banner, 1976; Banner et al., 1963; Barrau, 1957; Bouder and Cavallo, 1962; Halstead, 1964; Li, 1965; Loison, 1957; Cheng and Doorenbos, 1975; Russell, 1975; Deichmann et al., 1977). The mortality rate is estimated at about 7% (Halstead, 1967; Bagnis et al., 1970).

In Florida, most medical doctors are unfamiliar with the symptoms of ciguatera intoxication or its symptomatic treatment to reduce the patient's discomfort. In addition to the debilitation suffered by the patient, expenses to the victim may be staggering. In one case in South Florida, a man (H.A.) was poisoned in May 1978 from eating a "red snapper" in a restaurant (pers. commun.). During the early stages of intoxication he visited his family doctor, who gave him a complete physical examination and administered vitamin shots. Finding no relief, he was referred to another doctor, who ran another series of tests, with no diagnostic results. Still suffering from the disease, he was admitted to a hospital for 15 days, where he was observed and tested by seven doctors who initially diagnosed his disease either as Addison's disease or acromegaly, then attributed his condition to "nerves." He returned to his family doctor who referred him to an endocrinologist. He was then hospitalized for 3 days, when three doctors diagnosed his case as diabetes. He was sent to another hospital for 3 more days for more tests, all of which were negative. It was recommended that he go to the Mayo Clinic or to National Institutes of Health in Bethesda, or take a month's vacation. It was not until June 1979, 13 months after he was poisoned, that he realized what illness he had contracted after he and his wife watched a local television program on ciguatera. His total medical costs, as of June 1979, approximated $15,000.

Clearly, some affluent inhabitants of Florida can afford the financial burden of ciguatera, but people afflicted elsewhere in the tropical western Atlantic are much less fortunate. This situation is made worse where protein other than fish is scarce, and seafood is a necessity. In parts of the U.S. Virgin Islands, it is reported that all families have been poisoned at least once (the Mayor of St. Thomas, V.I., pers. commun.).

Ciguatera differs in its origin and symptoms from other kinds of fish poisoning such as tetraodon (puffer) poisoning, scombroid (tuna) poisoning,

and food poisoning caused by bacterial contamination (Halstead, 1967). Because the unique set of symptoms of ciguatera poisoning is so distinctive from other kinds of disease, including bacterial intoxications, public health authorities, physicians, and scientists knowledgeable of ciguatera are readily able to identify cases of ciguatera poisoning.

Ciguatera poisoning is not inherent in the fishes themselves but is obtained from the environment (Randall, 1958; de Sylva, 1963; Banner et al., 1966; Bagnis and Denizot, 1978). The toxin or toxins apparently originate in reef-dwelling microorganisms which are ingested by small, herbivorous fishes, and the toxins are transferred through the food chain via predator-prey interactions (Yasumoto et al., 1977; de Sylva and Deichmann, 1979; Doorenbos, 1979). They are further magnified at each trophic level and reach their highest concentration in the large reef predators such as groupers, snappers, jacks and barracudas (de Sylva, 1979). Because the toxins accumulate in the body tissues, large fish are more poisonous when eaten than smaller fish of the same species (Randall, 1958).

There is no simple method of identifying a toxic fish or of detecting the toxins (Scheuer et al., 1967; Bagnis and Denizot, 1978).

DISTRIBUTION OF CIGUATOXIC FISHES

Ciguatoxic fishes may be present in one location, while even a few thousand meters away the same species may be non-toxic (Mowbray, 1916; Brown, 1945; Randall, 1958; de Sylva, 1963). Toxicity, once acquired by a fish, can be retained for at least 30 months (Banner et al., 1966). Ciguatera in the tropical Atlantic and Pacific oceans may be cyclic, ranging from seasonal or annual cycles to periods of many years. In some areas of the Atlantic and Pacific oceans, toxicity may occur gradually or abruptly, with a subsequent reversion to non-toxicity (Randall, 1958; Cooper, 1964).

Previous studies on ciguatera in the tropical western Atlantic have been limited to reports of its occurrence and the species implicated. No research had been done comparable in scope or depth to that which has been done in the Pacific (Bagnis and Denizot, 1978; Banner, 1976).

The first intensive attempt toward a comprehensive study of ciguatera resulted in a series of papers from the College of the Virgin Islands Ecological Research Station (Dammann, 1969; Dammann et al., 1970; Brody, 1970, 1972; Brownell, 1971; Teytaud and Brody, 1971). These studies evaluated the distribution of ciguatera intoxications in the Virgin Islands, attempted to develop a bioassay, and sought, especially, to locate non-poisonous fishes in deeper waters, where poisonous fishes were not expected to occur on the *a priori* reasoning that ciguatera only occurs in shallow-water reef fishes. This did not, however, prove to be true, as a number of species were found to be toxic in deep waters as well, thus casting further mystery on the complex ecology of ciguatera.

The IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, held at Fort-de-France, Martinique, 28 November - 2 December, 1977, devoted special attention to recommendations for ciguatera research in the tropical western Atlantic. Participants discussed the importance of determining whether ciguatoxins in the Atlantic and Pacific

were similar, and of determining the role that algae may play in transmitting toxins through the food chain, both of which were aimed at improving the living conditions of fishing communities. Unfortunately, the formal recommendations of IOCARIBE did not include priority assignment or recommendations for financial support from the Food and Agricultural Organization (FAO) of the United Nations.

Supported by the U.S. Sea Grant program, Granade et al. (1976), working in the British Virgin Islands, evaluated the occurence of ciguatoxic fishes and modified a brine shrimp bioassay to determine ciguatoxin in fishes. Results of this program helped to focus on future research areas (Doorenbos, 1979).

The studies we have referred to have attempted to determine the cause, methods of transmission, symptomatology of victims, identification of the toxin or toxins responsible for ciguatera poisoning and treatment of victims. Their goals have been too idealistic because of the exciting problems posed by this highly complex enigma. Yet considerable funds have been expended on ciguatera since it was initially studied in 1953 on a comprehensive basis by Halstead (1967 and contained references). The literature reveals an increasing understanding of the mechanisms of ciguatera, but few applied methods of coping with the problem. Suggestions to attempt to "prevent the occurrence of ciguatera" (Doorenbos, 1974) seem presumptive and impractical (Yasumoto et al., 1977a).

Throughout the tropical western Atlantic, ciguatera intoxications are well known. Numerous authors allude to the peculiar, spotty distribution of ciguatoxic fishes in which specific reefs are "poisonous" and other are not (Fig. 1). It is not practical to identify whether an individual fish is toxic or not, except by eating it or feeding it to a cat, which is not a reliable method. Methods of identifying toxic flesh using coins or ants are not reliable. Thus, the simplest, most inexpensive method to avoid ciguatera intoxications is to know *which* reefs traditionally harbor ciguatoxic fishes. It is our belief that when such reefs are identified, ciguatera intoxications could be greatly reduced by providing this information to fishermen, consumers, and appropriate managerial and regulatory agencies, thereby embargoing the catches of fish from toxic reefs. Similarly, the wide dissemination of this information could be used to encourage wholesalers not to purchase fish for sale unless they know from exactly which location the fish originated.

In January 1979, we received a small grant from United Way of Dade County, Florida, in partial support of a study entitled, "Distribution and Significance of Ciguatera in Florida." This has since been supplemented by funds from the Lerner Foundation for Marine Research and from the Pompano Beach (Florida) Fishing Rodeo. Questionnaires have been sent to 10,000 medical doctors in Florida requesting the names and addresses of ciguatera victims. Hospital records are being examined to identify the distinctive symptoms of ciguatera intoxications. Television and radio appearances, press releases and numerous newspaper articles have given the project wide coverage. As the news of this program reaches northern communities through national publications, calls are being received from all over the country from victims who have contracted the disease in Florida, the Bahamas and the Caribbean. Calls also are received from physicians who are

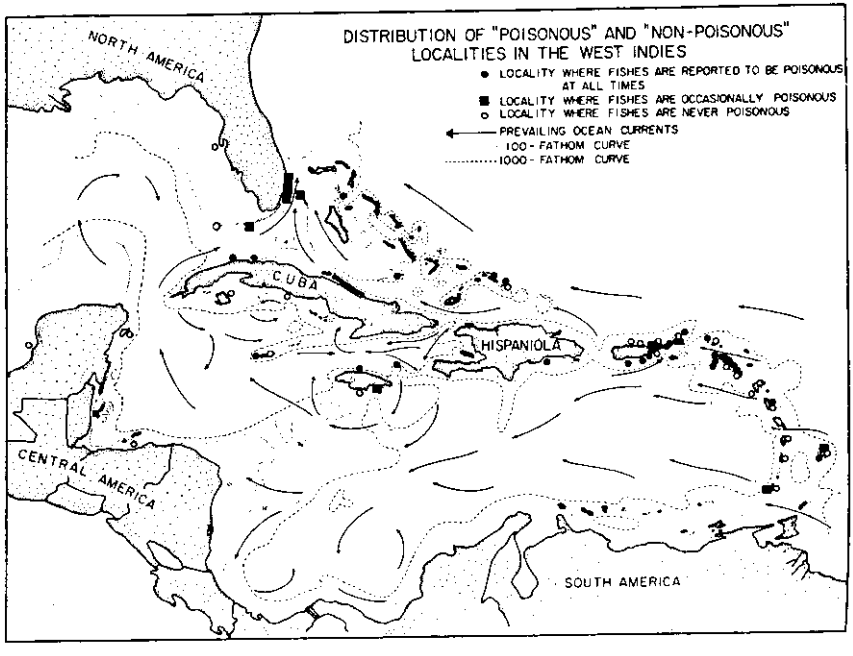

Figure 1. Distribution of localities in the tropical western Atlantic based on literature reports and personal communications where fishes are reputed to be "poisonous" or "non-poisonous." Current patterns are based on Whiteleather and Brown (1945).

at a loss to make diagnoses and prescribe symptomatic treatment.

From February to December 1979, we have received approximately 400 phone calls about ciguatera. Based on preliminary interviews with medical doctors, public health authorities and victims, we now estimate that there are at least 300 cases per year in Florida. Many persons in Florida have been poisoned from eating fish which they caught on Florida's reefs, but approximately 80% of the cases reported to us have resulted from persons eating fish in restaurants. Some of these can be traced to Florida waters, but a presently unknown percentage is caught in the Bahamas, the Caribbean Sea or the Gulf of Mexico. Approximately 90% of the grouper and snapper (the principal fishes causing ciguatera in Florida victims) sold in Dade County, Florida, originate in the Bahamas (Ernest Snell, National Marine Fisheries Service, pers. commun.). The source of most fish sold to Florida restaurants and seafood dealers may be traced through the assistance of dealers and wholesalers, most of whom have offered to cooperate because of the implications of liability from ciguatera victims. Continued cooperation can be expected because of the increasingly bad publicity that seafood dealers and restaurants are receiving. In a recent decision, a Florida court awarded damages to a ciguatera victim in a suit brought against a local merchant who had sold a ciguatoxic fish to the complainant. Now that this precedent has

been established, hundreds of seafood establishments could face similar or worse financial consequences arising from claims filed by ciguatera victims against restaurants, merchants, distributors, fishermen and others. The outcome seems to be a greater distrust by the public of the seafood merchant and restaurant, and a tendency to avoid eating all seafood, thus depressing the market and resulting in a loss of a valuable source of protein.

More than purely medical in the degree of pain and suffering of its victims, ciguatera has significant socio-economic impacts in Florida. Here the problem exists because fish has long been a staple of the lower socio-economic group. Seafood also provides a substantial portion of the protein consumed by Black and Hispanic members of the community. As a consequence, those who can least afford a lengthy debilitation are most likely to be affected by ciguatera. Undoubtedly this is true for the entire tropical western Atlantic, where most of the populations of the developing nations are economically deprived.

In many parts of the tropical western Atlantic, ciguatera is well known but is merely treated as an occupational hazard by fishermen, because protein in any form is in short supply. In contrast, in regions such as the British Virgin Islands and parts of the U.S. Virgin Islands, ciguatera is so common that many people refuse to eat any kind of seafood, resulting in a loss of much-needed protein.

A related problem is that considerable fisheries expansion in the tropical western Atlantic cannot be realized because of the uncertainty by exploratory fishermen and fish wholesalers concerning which reefs are toxic. Our School receives numerous phone calls and letters from seafood producers asking for advice on which species and which reefs are toxic, as well as any methods to identify toxic fishes.

PROPOSED RESEARCH

We propose to: (1) Prepare a comprehensive initial report on the locations of islands and reefs in the tropical western Atlantic where ciguatoxic species have been found. This report will be prepared from our extensive bibliography on ciguatera. (2) Secure governmental cooperation, to establish and instruct a network of ciguatera-reporting teams of responsive fishery officers or biologists to identify and report current ciguatoxic and non-ciguatoxic locations for the tropical western Atlantic countries. This would be done initially for those countries presently exporting commercial quantities of snapper and grouper to the U.S.A., such as the Bahamas. Eventually, this reporting system would be expanded to all cooperating countries of the region. (3) Prepare and distribute to the concerned parties scale maps and lists of islands and reefs giving the reported findings. (4) Inform fishery and marketing officials of the importance of these findings to the welfare of the public and to local and export trade. (5) Recommend to fishery administrators possible management measures based on our results that could reduce the incidence of ciguatera poisoning.

Proposals have been submitted to several U.S. agencies for possible funding to investigate areas of the tropical western Atlantic which can feasibly be studied in one year. Funding will be requested in subsequent years

for geographic areas that will require future investigation.

The initial procedure would be to analyze in detail the historical distribution of ciguatera based on scientific, medical and historical literature in our bibliography, documenting locations where fishes have been traditionally poisonous.

Concurrent with this literature analysis, a field survey would be conducted to define current ciguatoxic and non-ciguatoxic areas with greater precision. We intend to obtain such information by asking the cooperative assistance of local fishery officers or fishery biologists on a paid consultant basis to interview fishermen, fish buyers and other knowledgeable members of the production and marketing system. The use of local personnel is essential; they know the language, the customs and, more importantly, they know the key members of the fisheries community, and how and where to contact them. Charts, questionnaires, and instructions in their use, and the accurate disclosure of ciguatoxic locations would be provided by the project staff.

Preliminary analysis indicates that at least 132 coastal communities and islands should be visited to obtain complete coverage of possible ciguatoxic fishing locations in the tropical western Atlantic. To reduce the scope of the survey to manageable proportions, we would use data on imports of fish in Florida as a basis for selecting countries for study. We further selected only imports of snapper and grouper because these fishes are most commonly indicated as ciguatoxic. Quantities of fish imported into Florida and countries of origin are given in Table 1. In addition to these 12 countries, efforts will include Puerto Rico and the U.S. and British Virgin Islands because these areas seem to have the highest incidence of ciguatera in the Caribbean. Subsequent studies would concentrate on the Windward Islands.

We would contact all countries in the tropical western Atlantic, inform them of our proposed studies, and request their cooperation in helping to supply information. Following project activation, letters formally inviting cooperative participation will be mailed to heads of official agencies of these countries. Letters will request nomination of members of interview teams, the time period estimated required to accomplish interviewing in a given country and matching services that would be provided.

After we have received replies to these invitations, the magnitude of the field work involved can be assessed. Specific funds will be requested from U.S. government agencies in a second-year research request to pay these consultants to conduct interviews in the field.

Charts and questionnaires would be prepared by the project staff and translated where needed.

It is essential that consultants be provided with orientation and instruction in the use of questionnaires locally rather than being brought as a group to the U.S. The necessity for providing training to fishermen and fisheries personnel on their home territory has been stressed many times. Orientation-instructional sessions with consultants would be scheduled and given by senior project staff and interview data returned to Miami. Consultants would interview as many fishermen as possible to obtain a consensus of locations of poisonous fish sites, species responsible for poisoning, an evaluation of the severity of the problem, general type of habitat and any unusual

Table 1. U.S. imports of snapper and grouper (January to June 1979)*

	(thousand lb)		(thousand lb)
Bahamas	4.5	Bahamas	8.5
Belize	59.9	Belize	39.1
Cayman Islands	0.7	Cayman Islands	25.5
Costa Rica	57.7	Colombia	1.0
Honduras	21.6	Costa Rica	347.6
Mexico	686.4	Dominican Republic	3.0
Nicaragua	15.7	Guatemala	1.4
Turks Island	0.6	Honduras	17.5
		Mexico	567.7
		Nicaragua	164.1
		Panama	67.1
Totals	847.1		1,242.5

*Unpublished information provided by the prompt cooperation of statistical agents of the Southeast Fisheries Center, National Marine Fisheries Service.

environmental factors. Data analysis would be compiled with respect to seasonality, habitat and geographic locations of poisonous and non-poisonous fishes.

From these data, lists of coordinates with geographic names will be prepared for locations which have been found to harbor toxic fishes all or part of the time. A relative ranking scale will be attempted so that user-groups can make decisions regarding the balance of the economic value of the resource versus the potential harmful effects to people and the legal liabilities that could follow from negligent management.

We would also prepare geographic charts showing these ranked toxic locations and make them available to the fisheries community in general and to public health officials, should it be deemed necessary to establish closed areas.

We would also attempt to determine any historic changes of toxicity of reefs based on fishermen's personal knowledge. Also, the consultants will be encouraged to continue long-term monitoring to ascertain if toxicity in any location is increasing or decreasing with time.

Finally, exporters and importers would be encouraged to use these results in their sales and purchases of fish from the region.

IMMEDIATE BENEFITS

Immediate benefits from the results of this research will be to consumers of seafood from the tropical western Atlantic who might become poisoned from eating ciguatoxic fishes. Knowledge of the geographic areas known to harbor ciguatoxic fishes will encourage fishermen, wholesale fish dealers and retail markets to avoid catching or purchasing fish from known toxic regions. Clearly, the results of this study would have to be used on a voluntary basis,

but the increasing occurrence and more widespread recognition of ciguatera should motivate fishery managers to respond to this study.

Reports delineating ciguatoxic areas will be provided to governments with recommendations that management action is needed to protect local populations. Such action might include that toxic reefs be declared closed. This would also assure that export products are not impounded by the Food and Drug Administration and similar protective agencies other than U.S. In view of the Food and Drug Administration's financial support to develop an assay to identify ciguatoxic fish, both domestic and imported seafood will be subject to seizure if found to be ciguatoxic. This plan for testing will thus provide further incentive for those countries which have moderate to severe ciguatera problems to restrict fishing in ciguatoxic areas.

International organizations such as WECAF and IOCARIBE are charged to assist with the expansion and improved management of the fishery resources of the Caribbean. Prior knowledge of ciguatoxic areas would permit better planning and more efficient use of their time and resources by avoiding the repetitive evaluations of the potential of ciguatoxic areas.

Both private sources of commercial credit and institutions such as the "Caribbean Branch of the World Bank" are required to evaluate requests for loans for expanded fishing. Knowledge of specific or even generally ciguatoxic areas would be of substantial benefit to these credit sources.

Wide dissemination of the immediate results of these studies would be made by reports given at the annual Gulf and Caribbean Fisheries Institute and their subsequent publication in the *Proceedings*. This would insure that a wide professional audience of fisheries scientists, administrators and members of the fishing industry would be made aware of the dangerous areas.

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Appendix Table 1. Western Atlantic fishes reported to be occasionally to frequently ciguatoxic. Species are presented in phylogenetic order. Common names based on FAO nomenclature.

Albula vulpes, bonefish
Harengula humeralis, redear sardine
Opisthonema oglinum, Atlantic thread herring
Gymnothorax moringa, spotted moray
Lycodontis funebris, green moray
Ophichthus ocellatus, pale-spotted eel
O. ophis, spotted snake eel
Strongylura caribbaea, needlefish
Hemiramphus brasiliensis, ballyhoo
Hyporamphus unifasciatus, halfbeak
Acanthurus chirurgus, surgeonfish
Alectis crinitus, African pompano
Caranx bartholomaei, yellow jack
C. crysos, blue runner
C. fasciatus, segundo
C. hippos, crevalle jack
C. latus, horse-eye jack
C. lugubris, black jack
C. ruber, bar jack
Elagatis bipinnulatus, rainbow runner
Selar crumenophthalmus, bigeye scad
Selene setapinnis, Atlantic moonfish
S. vomer, Atlantic lookdown
Seriola dumerili, greater amberjack
S. rivoliana, almaco jack
Alectic crinitus, African pompano
Trachinotus falcatus, permit
Uraspis secunda, cottonmouth jack
Coryhpaena hippurus, dolphin
Bodianus rufus, Spanish hogfish
Lachnolaimus maximus, hogfish
Lutjanus apodus, schoolmaster
L. buccanella, blackfin snapper
L. cyanopterus, cubera snapper
L. jocu, dog snapper
L. vivanus, silk snapper
L. aya, red snapper
Ocyurus chrysurus, yellowtail
Scarus croicensis, striped parrotfish
Scarus vetula, green parrotfish
S. coeruleus, blue parrotfish
S. guacamaia, rainbow parrotfish
Sparisoma viride, stoplight parrotfish
Scomberomorus cavalla, king mackerel
S. regalis, cero
Cephalopholis fulvus, coney
Epinephelus adscensionis, rock hind
E. guttatus, red hind
E. morio, red grouper
E. nigritus, misty grouper
Myctoperca bonaci, black grouper
M. tigris, tiger grouper
M. venenosa, yellowfin
Paranthias furcifer, creolefish
Rypticus saponaceus, soapfish
Calamus calamus, saucereye porgy
Sphyraena barracuda, great barracuda
S. guachancho, guaguanche
S. picudilla, southern sennet
Alutera monoceros, unicorn filefish
A. schoepfi, orange filefish
A. scripta, scrawled filefish
Balistes vetula, queen triggerfish
Lactophrys trigonus, buffalo trunkfish
Balistes capriscus, triggerfish
Canthidermis sobaco, triggerfish
Stephanolepis hispidus, planehead filefish
S. setifer, pygmy filefish
Opsanus pardus, leopard toadfish
O. tau, oyster toadfish