

**Preliminary Summary of the
Management and Development
of Harvesting Reef Fish on Guam**

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PRELIMINARY SUMMARY OF THE
MANAGEMENT AND DEVELOPMENT OF
HARVESTING REEF FISH ON GUAM

GUAM MARINE FISHERIES
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Introduction

Much of Guam's coastline is bordered by fringing reefs of various widths. Some of the most conspicuous and economically important inhabitants of these reefs are the fishes. The reef fish are in intimate association with all other components of the reef ecology. Herbivorous fish such as the Scaridae (parrotfish) and the Acanthuridae (surgeonfish) are major consumers of algae, converting it to usable protein for members of higher trophic levels. The herbivores are also instrumental in limiting the growth of benthic algae (Randall, 1961) presumably to the benefit of coral population recruitment. Corals, the major structural component of the reef, provide a food source for some species such as the Chaetodontidae (butterflyfish), while acting as protection for the majority of reef dwelling species. All fishes, regardless of their status in the food web, help to maintain the chemical balance of the water through redistribution of consumed nutrients. In light of these relationships and many more not yet documented, it is evident that imprudent exploitation of reef fish resources could result not only in the reduction of the fish populations themselves; but also in significant changes in the reef ecosystem.

Historically, reef fish have constituted a major portion of the local diet. Dependence on this resource has decreased in modern times, although, traditional fishing practices still serve to supplement the local diet.

More recently, local reef fishermen have expressed concern over the apparent decrease in reef fish stocks. However, despite this concern, local sentiment is generally against any regulation of traditional subsistence fishing practices. Still, if current stocks are to be maintained, it will be necessary to form guidelines and policies pursuant to the preservation of this valuable resource.

A. Identification and Biological Assessment

Reef fish represent a diverse array of bony fishes which inhabit the near shore reef flats, channels, bays, lagoons and reef margin of both fringing and barrier reefs. Reef fishes are also found along the northern cut benches where little actual coral reef is present. There are also reef species on offshore reefs and banks such as Santa Rosa Reef; however, this analysis and resultant management proposals address only the near-shore fishery.

Many biological surveys of reef fish are available. The most recent and comprehensive survey is:

Studies on the Biology of the Reef Fishes of Guam, Part 1: Distribution of Fishes on the Reef Flats of Guam; Part 2: Distribution of Eggs and Larvae of Fishes at Selected Sites on Guam - Steven S. Amesbury, UOG Marine Lab Tech. Report No. 49, July 1978.

Conclusions of Part 1 of this study were that patterns of fish distribution appeared similar in all reef flat areas studied and that none of the surveyed areas showed signs of impoverishment. It must be noted, however, that only five locations were surveyed for baseline data on species present and distribution patterns. The rich variety of economically important species is evident, but an assessment of their productivity in relation to more specific habitat types and in more locations is needed for a thorough assessment of this fishery. Appendix No. 1 represents the type of stock assessment which is needed.

Part 2 of the above-referenced survey concluded that preservation of a wide variety of environments such as mangroves, seagrass beds, and coral reefs would help to insure that reef fish would be able to complete their life cycles. However, further study of the roles of specific habitats in maintenance of larval fish and juvenile stocks is also needed.

B. Statistical Monitoring of Fishery Catch and Effort

The Aquatic and Wildlife Resources Division of the Department of Agriculture has been collecting creel census data since FY'76, but survey and estimating methodology was not completely documented until FY'78. A report by the Bureau of Planning for the Guam Marine Fishery Advisory Council noted that the FY'76-FY'77 estimates are minimum figures at best and should be regarded as unreliable. Current efforts are being made to computerize the FY'79 creel census survey results. Combination of these data with marketing data from the Guam Fishermen's Cooperative should provide a more reliable source of information in the future.

Currently, until the FY'79 figures become available, the only reliable data are those obtained from the FY'78 creel census (DAg, 1978). The report considers five major inshore fishing methods; hook and line, cast net, gill net, surround net and spearfishing. For purposes of reef fish analysis, offshore spearfishing and fish weir data should also be considered. Combining the calculated yearly harvest estimates of all methods results in a figure of approximately 50,000 kg (110,000 lbs.) for the FY'78 harvest of reef fishing.

Of the various inshore fishing methods, hook and line fishing was most popular but least effective in terms of a catch per unit effort (CPUE) of 0.22 kg/man-hour. Surround net fishing was most effective (CPUE = 1.00 kg/man-hour). Surround net fishing and gill net fishing accounted for the largest portion of the total catch for inshore fishing (36 and 30 percent respectively).

Combining inshore fishing methods with offshore spear fishing, and weirs, the percent total harvest for the various methods is as follows:

<u>FISHING METHOD</u>	<u>PERCENT TOTAL KG</u>
Fish Weir	30%
Surround Net	21%
Gill Net	18%
Spear Fishing (total inshore & offshore)	15%
Hook and Line	8%
Cast Net	8%
	<u>100%</u>

The estimated harvest from fish weirs is an extrapolation of data obtained from 7 of 12 fish weir sites in 23 monthly reports. Permits to operate fish weirs are issued with the stipulation that monthly catch reports be made; however, until the monthly catch record requirement is strictly enforced, accurate catch estimates will be difficult to obtain.

C. Identification and Evaluation of Techniques and Facilities for Harvesting, Handling and Processing

Six major methods of legally harvesting reef fish are currently being employed. These include hook and line, cast net, surround net, gill net, spear fishing and fish weirs. In addition to the traditional/conventional practices, some individuals employ methods that result in the widespread destruction of the reef and its organisms, such as the use of poisons or explosives. Such practices are prohibited in the Game and Fish Laws of the Government Code.

Currently, the only methods requiring permits are the operation of fish weirs, the use of small mesh hand nets, and bait fish harvesting using small mesh nets.

Limitations and prohibitions regarding fish weir operation are delineated in the Department of Agriculture Regulation No. 4, dated December 18, 1957 and amended on May 18, 1961.

Net fishing is governed only by mesh size regulations as outlined in P.L. 12-215. Nets are restricted to a mesh size of greater than 1½ inch except in the case of cast nets (talaya) at all times and surround nets (chinchulo) when harvesting various juvenile species in the traditional manner.

Permits are required in order to use small mesh nets to catch live fish for aquarium purposes and small mesh surround nets (chinchulo) to harvest common bait fish such as Spratelloides sp. (menis), Atherinidae (ginyo) and Engraulidae (fadya).

At this time, the use of hook and line, cast nets, spears and spearguns, and small mesh nets used in the harvesting of juvenile species is unregulated.

Until extensive stock assessments are made, it is difficult to judge what effect various fishing techniques, traditional or otherwise, have on local fish populations. One indication, however, is evident in the absence, in 1978, of the normally heavy seasonal juvenile rabbitfish (mañahak) runs in shallow reef waters, possibly indicating insignificant population recruitment of this species during the previous year. Eventhough the harvest of various juvenile stocks is a traditional practice, making its regulation extremely controversial, it may become necessary to impose some regulations in order to ensure that the traditional fisheries are not lost through gross stock mismanagement.

The other unregulated fishing techniques (hook and line, cast net and spear-fishing) together only account for 31 percent of the total yearly harvest and thus, until further stock assessment is made, indicating the contrary, are probably not in need of regulatory controls other than restrictions imposed by designating preserve areas.

D. Assessment of Costs of Production

Costs of production with respect to the harvest of reef fish vary widely, depending on the method of harvest.

The only method currently requiring a license fee is the placement of fish weirs at \$1.00 per permit. Materials for the type of weir used locally run about \$500.00 per weir.

The other methods require no license fee, costs of production being limited to the cost of equipment. Cast nets (talaya) can be obtained for \$30.00 - \$80.00 (8 feet in diameter) depending on the fiber and workmanship. Prices for drag and surround nets (chinchulo) depend on mesh size and length. The long (700') small

mesh ($\frac{1}{2}$ ") nets, used for the harvest of juveniles are obtainable for about \$80.00. Gill nets (tekin) on the other hand are extremely inexpensive (about \$8.00) contributing to the problem of their being left on the reef to trap fish when retrieval is inconvenient.

Pole and line fishing requires an investment of about \$50.00 for each rod and reel.

Spearguns for spearfishing vary between \$30.00 for a wooden Palauan style gun to \$50.00 for an aluminum "Arbalet" style speargun. The cost of scuba equipment can be added to this for harvesting species found in deep water.

Currently, no reef species intended for consumption are being shipped off Guam, so that marketing costs consist chiefly of the investment required for an ice chest and ice in which to store the catch until it can be sold on the local market.

E. Marketability and Value of Resource

The demand for reef fish is high not only among the local population but also in the Micronesian and the Filipino sectors. These people traditionally prefer the smaller inshore species to large migrating fish, such as tuna, which are harvested by the offshore fishery.

Currently, reef fish are being imported, primarily from Palau and the Philippines, to satisfy local demand. Local fishermen have up until now experienced difficulty in marketing their catch, depending on the whims of local "mom and pop" stores and upon the availability of imported fish with which they cannot compete in price. Recently, since July 1979, the Guam Fishermen's Cooperative has been buying and selling fish out of the Public Market until permanent facilities can be constructed.

The current (Feb. 1980) price to the fisherman for reef fish is \$1.50 per pound, whole, and the Co-op will buy and market all fish brought in by members. Local

stores pay between \$1.00 and \$1.25 to the fisherman depending on availability and demand.

F. Environmental Concerns

The complexity of ecological interrelationships on the reef makes difficult a precise assessment of potential impacts resulting from any environmental disturbance. As already noted, the reef fish act as consumers on all trophic levels, recycling organic molecules within the ecosystem. They are directly or indirectly dependent upon algae, the primary producers, as well as upon the invertebrates for both food and protection. Since species of reef fish are so highly dependent upon the reef habitat for food and shelter, it is possible that, for many species, selective pressure is against wandering, and members of these species tend to remain within relatively limited areas of the reef. This tendency to remain within a limited home range creates ties to a particular area of the reef intensifying the impact of local ecological disturbances.

Some of the most devastating effects on reef ecology result from common and illegal fishing practices. One of the most destructive methods is a variation of the traditional poisoning of fish with various intoxicating root extracts. Today, the use of hypochlorite bleach (e.g. "Clorox") is a common practice. This activity not only kills target fish, but virtually, eliminates all organisms under its influence. Recovery of the reef is slow, requiring years.

The use of explosives is another practice having long term negative effects. Not only are target fish killed, but juveniles and small fish are also victims, thus reducing future fish stocks. Since explosive charges are most often set off near coral heads, this method also results in the destruction of fish habitats, which has been determined to be a limiting factor in the population dynamics of some reef fishes. Coral communities, once destroyed, require years to recover.

The harvesting of coral by souvenir hunters and commercial interests is also a factor contributing to the destruction of reef fish habitats. P.L. 12-168 limits the taking of coral to depths below the 10-fathom contour, unless a permit is obtained from the Department of Agriculture. This is difficult to enforce and restrictions should be extended to include the entire zone within which the hermatypic, reef building corals are found.

Also adversely affecting coral populations, and thus indirectly fish populations, are dredging activities that cause an increase in siltation. Thermal effluent from power plants has also been shown to reduce coral cover, with a resultant decrease in resident butterflyfish (Chaetodontidae) (Neudecker, 1977).

Point discharge from sewers and storm drains directly affects fish populations. Oil, grease and toxins from urban runoff have an obvious negative effect on fish.

Nutrients from sewage and runoff may actually increase overall productivity, but fish harvested from these areas should be considered a health hazard due to the presence of coliform bacteria.

Another health hazard, peculiar to tropical reef fish, is that of ciguatera poisoning. The source of the toxicity of certain reef fish, known to island people long before western contact, has only recently been elucidated (Yasumoto et al., 1977). There is some speculation that ecological disturbances can result in an increase in ciguatoxic fish (Yasumoto et al., 1978). Appendix 2 contains a review of the nature of ciguatera poisoning, its probable cause and environmental and socio-cultural implications.

Even traditional fishing practices are not without their adverse environmental impacts. The use of small mesh surround nets in the harvest of various juvenile species is suspected of effectively reducing the respective adult populations. Although this practice is most likely self-limiting, resulting in less overall disturbance of the reef ecosystem, it is theoretically possible to reduce stocks

of a particular species at the point where they can no longer compete and are thus eliminated as a fisheries resource.

G. Socio-Cultural Concerns

Traditionally, the Chamorro people have depended on reef fish as major source of high-quality protein, terrestrial protein sources being most often inadequate in the tropics. Excavations of precontact village sites have turned up artifacts such as fish hooks and gorges and net and line sinkers (Reinman, 1977), indicating a fair degree of sophistication in fishing methodology.

Contact with Western civilization and the advent of food and livestock importation have drastically decreased the dependence of native inhabitants on local reef products. Traditional fishing methods, however, are still practiced as a form of recreation and, to some extent, as a means of dietary supplementation. The annual mañahak (juvenile rabbitfish) and atulai (mackerel) runs, for example, are social occasions where the catch is often distributed among friends and relatives in the traditional manner.

The economic and dietary importance of harvesting reef fish varies greatly among households. Despite individual values attached to reef fishing, there is an overall concern that the loss of traditional techniques represents an erosion of cultural knowledge. Therefore, it is inadvisable to completely ban certain cultural practices. However, since some of the same practices are known to be counterproductive to fisheries stock management, it will be necessary to regulate some forms of traditional fishing in order to preserve the fishery itself.

H. Legal Issues, Federal Constraints, Federal Funding and Regional Opportunities

1. Legal Issues

The taking of reef fish is governed by Chapter IV, Article I of the Government Code of Guam, as amended by various bills and supplemented by executive orders which makes enforcement confusing to the average citizen. The following regu-

tations apply directly to the taking of reef fish:

a. General

Section 12311 of the Government Code provides that fish may be taken by lawful means at any time except as prohibited by Section 12321 which allows for the establishment of (a) seasons, (b) time restrictions, (c) bag or possession limits, (d) restrictions on the buying, selling and transporting of game (e) restrictions on methods of taking, (f) area restrictions, and (g) provisions for licensing.

P.L. 12-163 adds Section 12311.1 to the Government Code of Guam to make it unlawful for any person to kill, maim or injure any fish or game without making any effort to retrieve it.

P.L. 13-83 adds Section 12325 to the Government Code of Guam declaring that all departments and agencies shall seek to conserve endangered and threatened species. As no reef fish are currently listed as threatened or endangered, this regulation has only a potential effect at this time.

b. Fishing Methods

Sections 12303-7 state that it is unlawful to possess, use, or take fish with explosives or any poison or intoxicating substance.

The Department of Agriculture Regulation No. 4 as amended regulates the use of fish weirs as follows:

- (1) a permit is required from the Department of Agriculture for all fish weirs;
- (2) the mesh must be at least one inch in square measure;

- (3) the dimensions of the main weir may not exceed 500 feet total length for the leader and 300 feet total length for the wings;
- (4) the dimensions of any auxiliary weir may not exceed 250 feet total length for the leader and 150 feet total length for the wings;
- (5) no weir may be placed within:
 - (a) 100 feet of the mean high water mark;
 - (b) 150 feet of any boat channel;
 - (c) 600 feet of any sewer outlet;
 - (d) 200 feet of any weir under another permit;
- (6) a fish weir shall be in place within 60 days of the issuance of the permit, and shall be replaced within 30 days if it is removed or destroyed.
- (7) a fish weir shall be removed within 30 days of the expiration of the permit;
- (8) a fish weir shall not be left unattended for 15 consecutive days;
- (9) it is illegal to fish or cause a disturbance within 100 feet of any fish weir without the owner's consent.

P. L. 12-215 provides that it is unlawful for any person to use a net having a stretched mesh of less than $1\frac{1}{2}$ inches with the following exceptions:

- (1) persons may use small mesh cast nets (talaya) during all months of the year;
- (2) persons may use nets of smaller mesh to take manahak during all months of the year;
- (3) persons may obtain permits to use small mesh scoop nets to take aquarium fish;
- (4) persons engaged in tuna fishing may obtain permits to capture live bait fish;

- (5) native inhabitants shall at all times enjoy traditional rights to conduct gadi and lalago fishing; (undefined in the law)

Executive Order No. 68-5 requires that permits may be obtained from the Department of Agriculture through the Office of the Commissioner of the District of Inarajan prior to conducting atulai fishing in Inarajan and Agfayan Bays.

2. Federal Constraints

No identifiable federal constraints with respect to the taking of reef fish have been determined at this time.

3. Federal Funding

Efforts to identify federal funding for stock assessments and provision of enforcement personnel must still be undertaken.

4. Regional Opportunities

Near-shore reef fish stocks are truly a territorial resource which is not shared with regional entities due to overlap in habitat areas, joint use of the fishery or migration of species. Therefore, management and development of reef fish stocks is mostly an insular responsibility. However, some regional opportunities may exist in biological research with respect to life history, growth rates, etc. in those species that are found throughout the Pacific.

I. Recommended Policies

- (1) Conduct a thorough stock assessment of economically important reef fish stocks and revise and develop regulations accordingly.
- (2) Upgrade surveillance and enforcement of fishery regulations.
- (3) Preserve traditional fishery practices to the extent that they do not have a serious deleterious effect on reef ecology.

- (4) In cases where traditional practices have been determined to be injurious to the industry, such as the wholesale harvest of juveniles, attempt to develop policies that regulate rather than restrict such methods.
- (5) Establish marine sanctuaries where all fishing is prohibited to act as "seed" areas for the recruitment of juveniles.
- (6) Strictly regulate the taking of coral at all depths to preserve critical fish habitats;
- (7) Strictly control the discharge of sewage and urban runoff onto the reef flat.
- (8) Conduct a public awareness program of fishery regulations and the justification for their existence, including an awareness program aimed at tourists.
- (9) Analyze any developments affecting reef fish stocks and minimize impacts through the enforcement of local and federal controls.

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University of Guam Marine Laboratory

Reef Fish Stock Assessment and Mapping for Guam

One of Guam's most important commercial, recreational, and aesthetic resources is its reef fish fauna. As is typical of tropical islands, the fish assemblages of Guam are rich in species, many of which are harvested for food by spearing, trapping, netting and handlining. Effective management of these resources requires that the stocks be protected from overfishing and that their habitats be maintained. Fundamental to these management goals is adequate information on the status of economically important fish stocks on Guam's reefs and a knowledge of their distribution within various reef habitats.

We have recently developed a technique for assessing stocks of economically valuable reef fishes and for plotting their distributions. This technique was used successfully in Saipan Lagoon (Amesbury et al., 1979) and the same technique, with some improvements, will be used on Guam. On the basis of aerial photographs and underwater observation, reef areas are subdivided into recognizable habitats. Twenty-four habitats were delimited in Saipan Lagoon, but the number recognized depends on the particular reef under study. Within each habitat, three investigators will swim through the water, each making two 10-minute counts of economic fishes within certain categories. The categories of foodfish to be used will be the following:

sharks	snappers
large squirrelfish	leiognathids
mulletts	sparids
barracuda	rudderfish
large groupers	goatfish
slender jacks	large wrasses
high-bodied jacks	surgeonfish
juvenile parrotfish	rabbitfish
adult parrotfish	other groups as appropriate

Skipjack tuna baitfish will also be censused. Categories of these are the following:

silversides	fusiliers
cardinalfish	blue <u>Chromis</u>
clupeoids	other groups as appropriate

The six 10-minute counts (2 counts per diver x 3 divers) will be averaged to obtain the average number of fishes in each category per 10 minutes. We have determined that ten minutes of surveying covers approximately 200 m² of underwater area, enabling us to convert the average counts to an average density estimate for each fish category within each habitat. The habitats will be mapped to

scale, and the area of each habitat determined with a planimeter. By multiplying the average fish density (in no. per m²) in each habitat times the area (in m²) of the habitat, an estimate of the total number of fish of each category can be calculated for each habitat. Summing these totals for all habitats gives the total number of fish in each category for the entire reef area. Maps will be prepared showing the distribution of each category of fish over the reefs surveyed. These maps are useful in showing reef areas which are particularly rich in various categories of economically valuable fish to help guide future planning of reef development. The estimates of total fish abundance can be used, in conjunction with published information on generation time of various types of fish, to estimate annual rates of harvesting which will maintain fish populations in equilibrium.

This project will primarily serve to provide technical support for the planning and implementation of a Fisheries Management and Development Plan for Guam by the Guam Marine Fisheries Advisory Council. The project will also provide critical information to support federal and GovGuam efforts to identify, designate, and plan for areas especially suited for water-related economic development and to encourage government and private interests to locate major commercial and industrial activities in areas which have the least impact on identified fragile resources.

In the absence of the kind of information provided by this project, shoreline developments involving effluent discharge onto the reef or dredging and filling or otherwise modifying reef environments may be sited in areas which are important habitats for economically valuable fish resources. Additionally, lack of information on stock sizes and estimated annual harvest limits makes management of reef fish populations on Guam difficult if not impossible.

The University of Guam Marine Laboratory is directly concerned with the sound management of marine resources in Guam waters.

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Appendix 2. Ciguatera in Tropical Reef Fish

Ciguatera is a term given to a type of food poisoning that results from the ingestion of certain species of tropical and subtropical reef fish. It is dealt with in respect to the management and development of a reef fishery here not only because it constitutes a serious health hazard, but it is also a constraint to the exploitation of species implicated as being ciguatoxic and to the utilization of afflicted areas.

One of the most curious aspects of the ecology of this disease is that the toxicity of a given species of susceptible fish varies with location and time (Banner, 1976). Additionally, for a particular location at any given time, not all of the members of a specific population will bear the same degree of toxicity, if any.

Generally, species likely to be affected are near-shore fishes, found in less than 60 m of water. They are closely associated with reefs, feeding on benthic algae or detritus, particularly the surgeonfish (Acanthuridae) and the parrotfish (Scaridae); or they are the larger piscivorous carnivores that prey on the above-mentioned herbivores. Carnivorous candidates include some of the reef sharks (Carcharhinidae), moray eels (Muraenidae), jacks (Carangidae), wrasses (Labridae), snappers (Lutjanidae), scavengers (Lethrinidae), inshore tunas (Scombridae), groupers (Serranidae) and barracuda (Sphyraenidae) (Banner, 1976).

In a 1976 base-line report to the Division of Biomedical and Environmental Research of the Atomic Energy Commission, Banner and Randall reported the following species from Enewetak and Bikini to be highly toxic:

Gymnothorax javanicus, (a moray eel)
Cephalopholis argus, (a grouper)
Epinephelus hoedtii, (a grouper)
Epinephelus microdon, (a grouper)
Plectropomus leopardus, (a grouper)
Aprion virescens, (a snapper)
Lutjanus bohar, (a red snapper)
Lethrinus kalliapterus, (an emperor)

Other species that have been recorded elsewhere as being potentially toxic, especially with respect to the large specimens, include:

Sphyraena barracuda, (a barracuda)
Caranx ignobilis, (a jack)
Cheilinus undulatus, (a wrasse)
Seriola dumerelii, (amber jack)

Table 1 lists ciguatera cases for Guam recorded by the Guam Department of Public Health and Social Services.

Table 1. Incidents of Ciguatera Poisoning
Recorded for Guam from 1973-1979

Ingested Species	No. of Cases	No. of Incidents
Red Snapper	17	8
Mackerel	8	5
Squid	4	1
Rockfish	4	1
Jacks	3	1
Barracuda	3	1
Mullet	2	1
Unidentified	5	2
TOTAL	46	20

The data indicate that the occurrence of ciguatera on Guam is rare. However, the severity of the disease varies depending on the amount of toxin ingested; most incidents probably do not require hospitalization and are, thus, not recorded. Evidence of this is that certain large reef fish that have been known to be ciguatoxic are considered "poisonous" by the older Chamorros, indicating a history of the disease. That red snapper (probably in most cases Lutjanus bohar) is listed as the major offender on Guam is not surprising as it is generally recognized as being among the most toxic fish in the Pacific (Banner, 1976). However, it is curious that there are no reported cases of ciguatera following the ingestion of moray eels (Gymnothorax sp.). Banner and Randall (1976) reported that all six eels collected from Enewetak were highly toxic. On Guam the fish is highly suspect among local fishermen who will testify to its toxicity. The basis for this attitude, unsubstantiated by the data in Table 1, should be the subject of investigation.

The symptoms of ciguatera are primarily neurological, though the first symptoms to appear may be gastrointestinal (Banner, 1976). Characteristics of the disease include tingling of the lips, mouth and tongue, intense itching of the skin, exhaustion, muscular weakness, generalized aches and pains, visual disturbance, profuse sweating, rapid but weak pulse, loss of reflexes, coma and respiratory failure in extreme cases.

The etiology of the disease has long been a subject of speculation. Up until very recently all that was known is that the toxin originates at the base of the food web and is passed on to higher trophic levels with no observable metabolic/biochemical alteration of the toxic moiety (Banner, 1976). Yasumoto et al. (1977) was able to show that ciguatoxin is most likely produced by a dinoflagellate that lives attached to the surface of dead coral, benthic algae and detritus. The candidate is the a toxin-producing dinoflagellate, Gambierdiscus toxicus, described by Adachi and Fukuyo (1978). Herbivorous fish feeding on algae with which the organism is in close association constitute the first step in the transmittance of ciguatoxin to the higher trophic levels (Yasumoto, 1978).

The identification of G. toxicus as the likely etiological agent for ciguatera poisoning agrees with many of the epidemiological and ecological observations relative to the disease. Fish likely to be affected are reef-dwelling herbivores or their respective predators. Within a given species of carnivore, it is more likely that the larger, older individuals will be highly toxic as they have accumulated more of the toxin over a period of time.

There is evidence that human disturbance of coral reefs can trigger outbreaks of ciguatera (Banner and Randall, 1976; Yasumoto, 1978). Disturbances of submarine surfaces result in coral death and promote the growth of benthic algae, exposing new surfaces for the proliferation of G. toxicus. The increase in suitable habitable surfaces in combination with as yet undefined ecological conditions could trigger a dinoflagellate bloom such that the local fish population becomes toxic.

The severe nature of ciguatera is such that even a small number of occurrences can become a serious constraint to the development and exploitation of the near-shore fishery. Therefore, an attempt should be made to accurately document all known cases of ciguatera, the offending species ingested and where it was captured.

Additionally, any major ecological disturbances on the reef, such as construction projects, should be monitored for the appearance of Gambierdiscus toxicus and for the appearance of ciguatoxin in resident fish species. Until more is understood about the appearance of ciguatoxin in the environment, it will continue to impose limitations on reef fishery development.

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