Epidemiology and Impact of Ciguatera in the Pacific: A Review

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ABSTRACT—For inhabitants of the Pacific Islands, the mean reported incidence of ciguatera from 1979 to 1983 was 97/100,000. As a health problem, ciguatera also appears to be increasing on some Pacific islands that had formerly experienced lower levels of endemicity. Ciguatera also has important implications for nutrition and the development of inshore fishery resources. The epidemiology of ciguatera in the Pacific is presented, and viewing ciguatera as a phenomenon to which islanders have had to adapt for centuries, the implications for health, nutrition, and resource development are discussed.

Introduction

Ciguatera, first described in the Caribbean (Martyr, 1555), has a long recorded history in the Pacific as well. Sailors with the Spanish explorer, de Quiros, suffered from ciguatera in Vanuatu in 1606 (Dalrymple, 1770), and Anderson (1776) described an intoxication aboard one of Cook's ships, the *Resolution*, in the same island group. The pantropical distribution of ciguatera and the fact that the fish are unaffected by the toxin(s) suggest that it has existed far longer than the historical record indicates.

Ciguatera is a significant health and resource problem in tropical areas, largely because of its erratic and often unpredictable spatial and temporal distribution. The eating of toxic fish remains a risk for both seafarers and tourists, but it is a much more pronounced problem for the inhabitants of tropical islands, who depend on the resources of the seas for food and livelihood. The epidemiology of ciguatera in the Pacific has received considerable attention (Banner and Helfrich, 1964; Halstead, 1978; Bagnis, 1976, 1977; Lewis, 1981, 1984a, b). In this paper, the epidemiology is updated through 1983-84, and some considerations for health, nutrition, and specifically marine resource development are presented. Banner (1976), Withers (1982), and Baden (1983) have reviewed the etiology, chemistry, pharmacology, and ecology.

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Epidemiology

The most consistent, albeit incomplete, information on the existence of cigatoxic fish in the Pacific is from morbidity reports. Intensive investigations of the distribution of both *Gambierdiscus toxicus* and toxic fish have been made at specific sites, but these are limited in both time and extent (Bagnis, 1969, 1973a, 1977; Yasumoto et al., 1979, 1984). Morbidity for selected diseases for the Pacific Island Region (not including Hawaii and Australia) is recorded by the South Pacific Commission's South Pacific Epidemiological and Health Information Service (SPEHIS) (South Pacific Commission, 1973-84). Ciguatera incidence for 1973-83 is presented in Table 1. The region is composed of 21 island states and territories (Fig. 1), and there are a host of cultural, economic, and practical factors that influence reporting. For example, sample surveys suggest a wide range (9-75 percent) in the number of individuals who go to a western medical facility when experiencing ciguatera (Bagnis, 1973a; Dawson, 1977; Lewis, 1981). There are often considerable differences between a country's central register of disease and the statistics reported to SPEHIS. In Fiji, Naryan (1980) indicated that there were 791 cases of ciguatera reported to the Ministry of Health between 1975-78. SPEHIS, based on reports submitted to it, listed 449.

The reported annual incidence of ciguatera for the 11 years from 1973 to 1983 was 97/100,000 for the region as a whole. Using the conservative estimate that this represents 20 percent of actual incidence, then actual incidence would be 500/100,000. The regional rate has been quite constant over the 11-year period, with 1973, 1979, and 1983 being years with marginally fewer cases reported. Lawrence et al. (1980) estimated that in Miami the actual incidence of ciguatera was 5/10,000 (50/100,000), making the estimated incidence for The Pacific ten times that of Miami.

Looking at the number of cases and mean rates for individual countries for the last 5 years of the period (1979-83) (Fig. 2), we see that some have reported annual morbidity rates several times that of the region. French Polynesia (585/100,000) had an average annual rate six times that of the region as a whole, and Tuvalu (484/100,000), five times. Kiribati (462/100,000) also had a mean incidence rate almost five times as high as the region as a whole. The reported rate for Tokelau, 1,338/100,000, was exceptionally high.

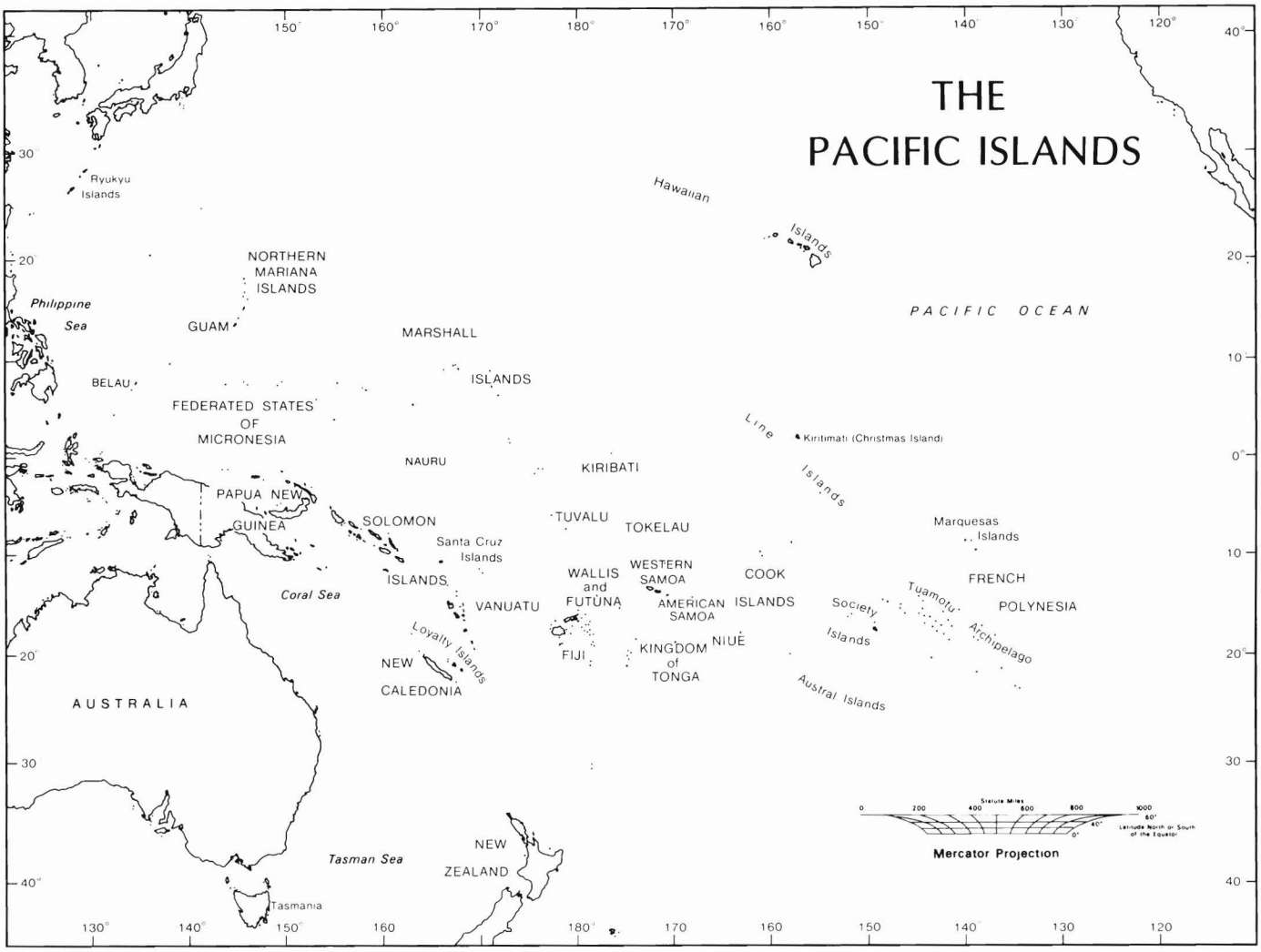

Figure 1.—The Pacific Islands.

Table 1.—Ciguatera morbidity, South Pacific Region, 1973-83, as reported to South Pacific Epidemiological and Health Information Service.

Country	Number of cases													Rate per 100,000 1973-83	Rate per 100,000 1979-83
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	Total	Mean		
American Samoa	4	0	0	0	0	0	70	30	31	97	69	301	27.36	87	179
Cook Islands	0	0	0	0	0	0	0	1	2	0	0	3	0.27	1	3
Fiji	6	26	150	29	69	201	131	265	123	71	0	1,071	97.36	16	18
French Polynesia	607	867	625	660	502	821	677	937	1,145	831	789	8,461	769.18	545	585
Guam	0	0	21	16	6	6	9	0	4	3	21	86	7.82	8	7
Kiribati	101	175	187	77	41	38	78	187	286	418	414	2,002	182.00	324	462
Nauru	0	0	0	0	0	0	1	5	0	0	0	6	0.55	7	15
New Caledonia	0	200	518	647	487	488	188	147	107	130	112	3,024	274.91	200	96
Niue	7	1	35	4	0	0	0	3	3	0	0	53	4.82	130	38
Papua New Guinea[1]	0	0	16	0	0	0	0	0	0	0	0	16	1.45	<1	<1
Solomon Islands	1	7	0	7	6	6	0	4	4	0	2	37	3.36	2	1
Tokelau	0	0	0	8	0	0	14	0	3	17	73	115	10.45	653	1,338
Tonga	11	58	12	17	43	13	8	7	2	29	14	214	19.45	21	12
TIPI	240	264	208	313	326	296	191	217	163	119	120	2,455	223.18	173	114
Tuvalu	0	0	0	49	44	71	21	27	73	47	16	348	31.64	439	484
Vanuatu	0	0	35	28	50	53	67	0	32	12	0	277	25.18	25	19
Wallis and Futuna	0	0	3	7	0	0	0	0	0	0	0	10	0.91	9	0
Western Samoa	65	89	15	17	81	179	62	115	127	98	59	907	82.45	54	59
Total	1,042	1,687	1,825	1,879	1,655	2,172	1,517	1,945	2,105	1,870	1,689	19,386	1,762.36	97.1	96.1

[1]Papua New Guinea has been excluded from the regional analysis.

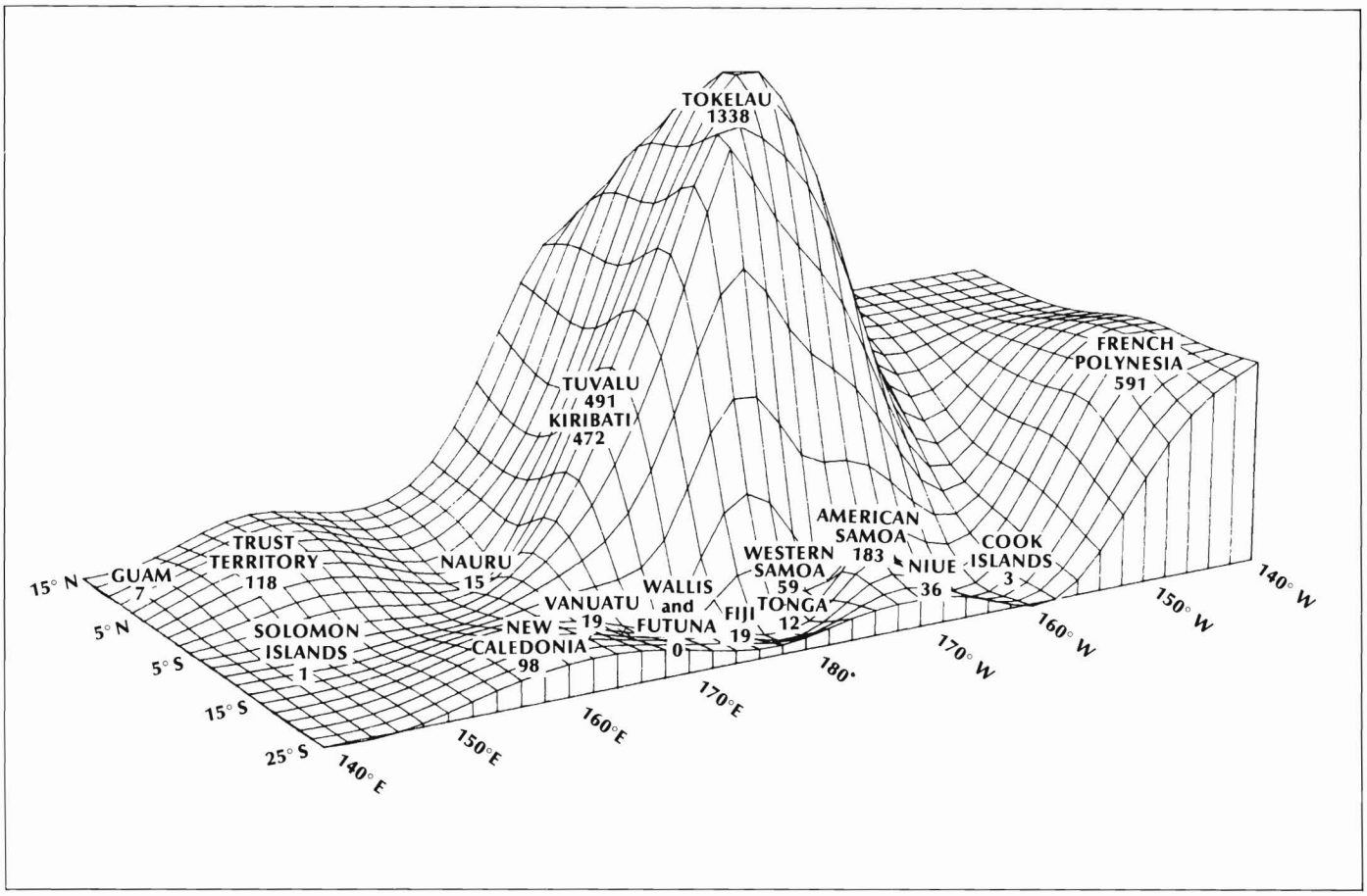

Figure 2.—Mean annual incidence of ciguatera (cases per 100,000), 1979-83.

Various patterns emerge in the three subregions of Oceania, Polynesia, Micronesia, and Melanesia. Incidence in French Polynesia has been consistently high throughout the period with a peak in 1981. While the longstanding research efforts of Raymond Bagnis and his colleagues at the Institut Recherches Medicales Louis Malardé in Papeete may have led to increased reporting, evidence suggests that ciguatera is a more serious problem in French Polynesia than in some other parts of the Pacific. The island groups within French Polynesia exhibit different levels of toxicity. It has been highest in the Gambiers, but this is not reflected in the morbidity statistics because of avoidance of locally caught fish. Species incriminated in the other groups are listed in Table 2. Disastrous hurricanes hit French Polynesia in 1982-83 and because of the long acknowledged association between disruption of marine substrate and increases in ciguatera, researchers are monitoring for increases in the causative organism. Islands to the west in Polynesia exhibit a less clear picture; the Cook Islands are in many respects a ciguatera anomaly with very low rates of ciguatera. Tonga also has relatively low rates of ciguatera. In Samoa, toxic fish were reported soon after the turn of the 20th century (Jordan, 1902; Spear, 1904) and the toxicity has persisted, but not at high levels. The species responsible (Table 2) are primarily carnivores. It is in the Tokelau that ciguatera seems to be most serious. Tokelau is a tiny territory of New Zealand made up of three coral atolls with a population of 1,600 and land area of only 10 km^2. The incidence rate was 1,338/100,000 for the period 1979-83. For 1983 alone the incidence was 4,867/100,000 and partial data from 1984 indicate an even higher rate. The seriousness of this, particularly in the last 2 years, which showed a precipitous increase, is obvious for this small population. They are isolated and highly dependent on the resources of the sea, and they are also distant from hospital facilities that can treat severe cases. Tuvalu is another small Pacific country with elevated rates of ciguatera, 484/100,000 annually from 1979 to 1983, based on a population of 7,600. On the single island nation of Niue, ciguatera was a more serious problem following World War II (Bagnis, 1973b), but ciguatera has been declining in recent years as it has in the French Territory of

Table 2.—Species perceived as commonly toxic in selected Pacific Islands (Lewis, 1984b).

Species	Marquesas						Tuamotus				Societies					Samoa			Other					
	Hiva Oa	Tahuata	Fatu Hiva	Nuku Hiva	Ua Pou	Ua Huka	Takaroa	Manihi	Rangiroa	Other	Tahiti	Moorea	Huahine	Raiatea	Bora Bora	Tutuila	Upolu	Savai'i	Tonga	Fiji	Vanuatu	New Caled.	Hawaii
Carcharhinidae																☆	☆	☆	★				
Clupeidae																☆	☆	☆	★	★		★	★
Lycodontis sp.	●	●	●	●	●	●	□	□				■			■	☆	☆		★	★	★	★	
Sphyraena barracuda	●		●		●	●	□	□	□	□	■	■		■		☆	☆	☆	★	★	★	★	★
S. fosteri							□									☆	☆			★			
Gymnosarda unicolor		●		●							■										★	★	
Mugilidae											■									★			★
Acanthocybium solandri																						★	
Scomberomorus commersoni																				★	★	★	
Caranx sp.			●	●			□			□		■	■	■	■	☆	☆		★	★	★	★	★
Seriola dumerili																							★
Plectropoma maculatum																						★	
P. leopardus							□	□	□	□	■	■		■	■								
P. melanoleucus																						★	
Variola louti			●											■						★	★	★	
Serranidae																☆	☆	☆					
Cephalopholis argus	●		●	●			□	□	□			■	■	■	■					★	★	★	
Epinephelus tauvina	●		●				□	□		□		■		■									
E. merra	●	●												■						★			
E. microdon												■									★	★	
E. fasciatus	●																						
Epinephelus sp.																☆	☆	☆		★		★	★
Lutjanus monostigma			●	●	●		□	□			■	■	■	■	■	☆			★	★			
L. bohar	●	●	●	●	●	●	□	□	□	□	■	■	■	■	■	☆	☆	☆	★	★	★	★	
L. rivulatus											■	■								★			
L. argentimaculatus																	☆	☆	★		★	★	
L. gibbus	●	●	●	●	●		□	□			■	■		■		☆	☆			★			
L. fluviflamma																					★	★	
Lutjanus sp.																							★
Aphareus furcatus																							★
Aprion virescens			●						□														★
Monotaxis grandoculis				●	●	●	□	□				■										★	★
Gnathodentx aurolineatus	●	●	●	●			□	□															
Diagramma pictum																					★	★	
Lethrinus miniatus	●	●	●								■	■		■	■							★	
Lethrinus sp.									□							☆		☆	★	★	★		
Mullidae																☆							★
Cheilinus undualtus							□	□	□	□	■			■	■								
Cheilinus sp.																							★
Scaridae	●	●	●	●	●		□	□	□	□	■		■	■	■								★
Ctenochaetus cynoguttatus	●	●	●	●	●																		
C. striatus							□	□	□	□	■	■	■	■	■								
Acanthurus olivaceus				●																			
A. achilles				●																			
A. lineatus		●	●																				
Acanthurus sp.																							★
Naso brevirostris	●		●																				
N. herri	●		●																				
Balistidae	●	●	●	●	●		□	□	□	□	■	■		■	■				★			★	
Balistoides viridescens							□	□	□														
Arothron sp.																☆		☆					

Table 3—Ciguatera breakdown for Trust Territory of the Pacific Islands, 1982-83.

Islands	No. of cases 1982	No. of cases 1983	1982-83 rate per 100,000
Federated States of Micronesia	0	4	2
Marshalls Islands	100	85	282
Commonwealth of the Northern Marianas	17	31	130
Palau	0	0	0
Total	117	120	81

Wallis and Futuna (Table 1).

In Micronesia, ciguatera was a problem for both Japanese and American forces during World War II, and this focused scientific attention on ciguatera. Until 1982, statistics, for what is now the Trust Territory of the Pacific Islands, were aggregated. The annual incidence rate for the unit as a whole from 1979 to 1983 was 114/100,000. This is a decline from the period from 1973 to 1978 (232/100,000), which may in fact reflect a general decline in morbidity reporting that came with decentralization in mid-1978. The individual units show significant differences based on the 1982-83 statistics (Table 3). The 2/100,000 in the Federated States of Micronesia undoubtedly represents underreporting. Palau reported no cases, but the residents of Palau have long prided themselves on the fact that their fish are safe to eat. Earlier reports (Hiyama, 1943; Pacific Islands Territory High Commissioner, 1961; Banner and Helfrich, 1964) indicated that in the Caroline Island chain (with Palau to the west and the Federated States of Micronesia arching to the east), toxic fish were found in the eastern islands but absent in the west. The incidence for the Marshalls, 282/100,000 annually, was the highest reported from the former Trust Territory and may still represent significant underreporting. Ciguatera incidence in the Marianas archipelago, including Guam, is apparently increasing (Tables 1, 3).

Incidence is also low on the independent phosphate rich island of Nauru, 15/100,000. The low incidence may reflect poor reporting or reduced fishing effort. The Nauruans have one of the highest per capita incomes in the world and are highly dependent on imports. In Kiribati, ciguatera is a significant and an apparently increasing problem, with an annual incidence of 462/100,000, from 1979 to 1983. Kiribati is also one of the newly independent states of the Pacific facing the greatest development challenges. It is an atoll nation with limited land area, rapidly growing population (densities in urban Tarawa reach 1,137 km^2), and there are very limited natural resources.

Less information on ciguatera is available from the Melanesian realm. By and large, these are larger, less developed islands with both interior and coastal populations. In general, they are less dependent on the resources of the ocean. Papua New Guinea, with 61 percent of the region's population, has been excluded from the regional computations. The population of Papua New Guinea is widely distributed in the Highlands and other interior locations. Many are not dependent on marine resources and morbidity reporting is very

poor. Inclusion of Papua New Guinea would only magnify underreporting in the region as a whole. Reports from the Solomon Islands are almost as poor. The reported incidence of 2/100,000 undoubtedly reflects underreporting, but it is difficult to get an accurate picture of the situation there. Somewhat better information exists for both Vanuatu and New Caledonia. In Vanuatu where morbidity reporting is poor and the annual reported incidence was only 19/100,000, Bagnis (1977) estimated an incidence rate of 130/100,000. More recently, Guillo (1984) estimated that there were 600 cases a year (512/100,000), thus Vanuatu would be experiencing the mean for the Pacific. The Melanesian island of New Caledonia is one of the places in the Pacific where there has been an apparent decline in ciguatera incidence over the last several years. Known locally as "la gratte" for the intense itching that is often one of its symptoms, ciguatera incidence was high from 1975 to 1978 (Table 1) and has declined since then. While reported ciguatera incidence is low in Fiji, researchers at the University of the South Pacific Institute of Marine Resources, led by U. Raj, have been monitoring the situation in the Fiji group. More than 17 species were confirmed to be toxic either experimentally or from medical records (Raj et al., 1982). Discussions with both researchers at the Institute of Marine Resources and medical staff indicate that ciguatera is indeed a problem and may be on the increase. Researchers (Yasumoto et al., 1984) found two different toxins in the roe and another in the viscera of *Etelis carbunculus*, a deepwater snapper from Lauthala Island. The chromatographic properties of the toxins were different than those of ciguatoxin.

Hawaii continues to experience ciguatera outbreaks. Between 1975 and 1981 there were 81 outbreaks involving 203 individuals, giving an annual rate of 3/100,000 (Anderson et al., 1983). The authors estimated that this represented about 10 percent of the actual intoxications. In 1982, incidence was low with only 18 cases reported; 51 were reported in 1983 and 80 in 1984. It is tempting to speculate that the increase in 1984 was due to damage caused by hurricane Ewa which hit Hawaiian shores in November 1983. While the evidence is not conclusive, at least 50 intoxications have been reported from Kauai during the first 4 months of 1985. Kauai was the hardest hit of all the islands in the Hawaiian chain. In Australia, too, the ciguatera problem is apparently escalating. For decades, episodes of ciguatera poisoning have been reported sporadically from the great Barrier Reef of Northern Queensland. Reef species have usually been responsible, including the commercially important *Plectropoma maculatum*. However, since 1976, fish from Southern Queensland, in the vicinity of Hervey Bay, have been incriminated. It is the commercially important pelagic *Scomberomorus commersoni* or Spanish mackerel that is the main species responsible. Lewis and Endean (1983) have isolated the ciguatoxin-like substance from Southern Queensland *S. commersoni*.

The information that we have on the distribution of ciguatera in the Pacific basin comes from incomplete morbidity reporting and a few circumscribed, intensive investigations of the distribution of both *G. toxicus* and toxic fish. The information is far from complete and the fact that few cases are reported from the large less developed Melanesian island groups in the western Pacific, Papua New Guinea, the Solomons, and Vanuatu must be viewed with the realization that morbidity reporting for all causes from these groups is very poor. Despite this, it does seem that ciguatera is a more serious and escalating health problem in the eastern Pacific, notably French Polynesia, and in several of the more isolated island groups of the north central Pacific, Tuvalu, Tokelau, Kiribati, and the Marshalls. The anomalies in the Pacific distribution of ciguatera also deserve attention, e.g., the Cook Islands. One fruitful research frontier that may provide clues to help to unravel the ciguatera mystery is comparative analysis in the Pacific and Caribbean. It is disturbing that, in the Pacific, some of the most vulnerable island groups are the ones experiencing an elevated incidence of ciguatera.

Current Impact in the Pacific Region

While ciguatera remains a problem for islanders living in subsistence communities in the Pacific, its impact is exacerbated by the changing nature of Pacific residence, life-style, fishing, and marketing. Excluding the large, less developed islands of Melanesia, where ciguatera may generally be less of a problem, many Pacific nations have from 40 to 100 percent of their population living in the main urban center. Wage labor, often for the government, is common and individuals are moving farther and farther away from subsistence life-styles and modern aspirations are replacing traditional ones. At the same time, Pacific populations are growing, migration to the urban center continues, reef and shore modification projects are undertaken, particularly near urban centers, and there is an increased likelihood for the creation of ciguatoxic biotopes in the vicinity of the highest population densitites. Populations are becoming increasingly dependent on the purchase of fresh fish in urban markets and fish export is being encouraged. I have written at length about how island dwellers have adapted to the existence of ciguatera, beliefs about etiology and strategies for detection, prophylaxis, and cure (Lewis, 1981, 1983, 1984b). Traditional strategies, relatively effective in subsistence situations, become less so in urban areas, and when export from the point of capture is commonplace.

Morbidity statistics underline the importance of ciguatera as a public health problem in the Pacific. Except in the most highly toxic locations, it is exceedingly difficult to assess the impact of ciguatera on community nutritional status. Disease patterns are now emerging in the Pacific that mirror those of the developed world with elevated rates of diabetes, hypertension, and cardiovascular disease. Furthermore, there may be a genetic predisposition to these conditions, at least in Polynesian populations (Prior, 1981). Dietary patterns that rely on western processed foods exacerbate the health risks in these vulnerable populations, and ciguatera may

increase the tendency to rely more heavily on imported foods, both canned fish and meat and other refined, high-fat and carbohydrate foods. While it is still difficult to unravel the many factors involved, it may be easier to determine the impact of ciguatera on small-scale fisheries development.

By and large, local small-scale commercial fisheries are very poorly developed in the Pacific. In the region as a whole, the pelagic catch by Asian fleets is many times greater than the local fishery. With the establishment of the 200-mile Exclusive Economic Zones, island nations have begun, not without problems, to participate in this fishery, primarily through licensing agreements and joint venture projects. This participation is obviously important for economic development, but is does not obviate the need for the development of local small-scale commercial fisheries. There are many reasons to encourage subsistence and artisanal commercial fisheries development and the consumption of fresh fish, from benefits to the local economy, to a reduced dependence on imported food.

Accurate, comparable statistics on local catch, both subsistence and small-scale commercial fisheries, are very difficult to obtain. In the late 1970's, for example, in American Samoa, based on fish catch assessment surveys, local production was estimated to be 316,338 kg/year. Some other annual catches include: Cook Islands 606,654 kg; Fiji 5,030,362 kg; French Polynesia 2,885,667 kg; Tonga 1,039,089 kg, and Western Samoa 1,307,955 kg (this last includes subsistence catch only) (Lewis, 1981). Kent (1980), citing 1977 FAO data, gives local catch from the region as a whole as 82,696 t. This is approximately one-tenth of 1 percent of the total global catch and, while proportional to the region's population, is very low considering access to fish stocks. This figure includes local pelagic catch but not subsistence catch. Salvat (1980) estimated that the reef and lagoon catch for the region as a whole to be as high as 100,000 t. Nonetheless, in many Pacific locations as much as 90 percent of the fish eaten comes out of a can. It is difficult to generalize, but while overfishing and reef depletion have occurred where population densities are high, in the region as a whole, more fish could be taken on a sustained yield basis.

Ciguatera has been only one factor, and probably a relatively minor one, in fisheries development in the Pacific. With the changing nature of fish marketing and export, however, cinguatera or the specter of ciguatuera may have increasing impact. Many factors have contributed to change in traditional dietary patterns, to different agricultural and fishing practices, and to a dependence on imported food. One result has been that canned mackerel and sardines are often considerably less expensive than fresh fish. In 1977 the price of the least expensive fresh fish in the Cook Islands, French Polynesia, and Fiji ranged from (Australian) $1.34 to 1.50/kg. The price of canned mackerel (424 g), all of which is edible, was 43-48 Australian cents (A$ 1.00 = US$ 1.14). It is also widely distributed, relatively nutritious, and keeps without refrigeration. Furthermore, though the majority of Pacific islanders would respond that they prefer fresh fish, canned fish is a popular, easy, and relatively inexpensive protein source.

What evidence is there from the Pacific to suggest that ciguatera has affected or may affect the market for fresh fish? Urban consumers have a more generalized fish avoidance, e.g. "all the red fish" or "all the very big fish," and highly suspect species, *Lutjanus bohar*, *Lycodontis* (*Gymnothorax*) *javanicus*, or new or unfamiliar species, than individuals in subsistence situations (Lewis, 1981). This makes sense, as the urban consumer is commonly further removed from knowledge of the marine realm, may have no knowledge of who caught the fish, most likely will not know where it was caught, and, if it is filleted, may or may not know what species it is. Despite this, the ultimate responsibility for choosing a "safe" fish usually rests with the purchaser. A publicized outbreak of ciguatera associated with fish purchased from the urban market will have an adverse effect on the future marketability of that species, as it did with a catch of toxic *L. bohar* sold in the municipal market in Apia, Western Samoa. A gift to a church group of a large barracuda from an Asian longliner offloading at one of the canneries in American Samoa had a similar effect. In a follow-up study (Lewis, 1981), all those who had been poisoned said that they would avoid barracuda, and the church group voted not to serve it again.

Of all the intoxications reported in Tahiti in 1976, 52 percent were from fish caught outside of Tahiti and 18 percent were of unknown origin. Of those caught outside of Tahiti, 73 percent were caught in the Tuamotus. The population of French Polynesia is concentrated in the Papeete urban zone and the local reef resource is depleted. There is a ready market for reef fish in Papeete. Fish from several of the atolls in the Tuamotus to the north find their way to the urban market. Inhabitants on one atoll, no longer exporting fish, blamed an outbreak of ciguatera in the early 1970's for the cessation of their export. A change in interisland schooner schedules may have been equally responsible. As the statistics indicate, the fish are sometimes toxic.

Ciguatoxicity is not the only potential health problem associated with the consumption of these fish. They may be 6 days old and are often poorly iced. While the fish are not in prime condition, given the shortage of local reef fish and food preferences, they sell. This is probably the same reason that potentially ciguatoxic fish still have a market. Although one assumes that at some point if intoxications become more common or more severe, it will affect the marketability of these fish.

The Northern Line Islands of Kiribati, three equatorial islands 1,800 km south of Hawaii, loom large in that government's development plans. When there is regular airline service from Christmas Island to Honolulu, reef fish as well as spiny lobster are exported to Hawaii. Ciguatera has been a problem in the past and some species, primarily high-level carnivores, are toxic at the present time.

The potential for ciguatoxic biotopes may increase with proposed resettlement schemes. Ciguatera could also adversely effect the government's attempts to establish a sport-fishing-

oriented tourist trade. Until recently, the offshore bottom fishery (100-300 m) was poorly developed in the Pacific. It is receiving increasing attention, but some of the species caught can be ciguatoxic (Crossland, 1980).

Individuals in institutions may be at greater risk of intoxication. Large fish may be relatively inexpensive, perhaps because they are suspect, and hence find their way to institutional kitchens. In both Vanuatu and Fiji, inmates in the local jail were poisoned in the late 1970's. In 1980 in Kiribati, 54 students at the government boarding school were poisoned after a meal of barracuda (Marriott and Dalley, 1980). Large feasts are an important component of social interaction in the Pacific. The American Samoan example cited previously is only one where a single large fish prepared for a feast resulted in a common source outbreak.

Isolated populations, not only indigenous populations on outer atolls, but the crew aboard vessels or military personnel at isolated outposts can also be at risk. In 1982, 13 U.S. Navy personnel on Midway were evacuated to Hawaii after consuming a toxic *Seriola dumerili*.

Ciguatera can be a threat to the hotel and restaurant business in particular and tourism in general. The results of intoxication may include loss of business for the individual establishment and potentially for a circumscribed locale if the problem is severe enough. In the United States there is an added risk, given the litigiousness of our population.

The difficulty of assessing, except in the most highly toxic locations, the impact of ciguatera on fisheries and fisheries development has been stressed. In some parts of the Pacific, ciguatera may have been used as a convenient excuse for the lack of development. The threat of ciguatera may be as damaging as the actual incidence of intoxications. Scientific interest in the phenomenon has increased in recent years. In addition to articles in research publications, it has increasingly been the subject of letters to the editor, editorials, and articles in clinical journals in the United States, Canada, the United Kingdom, Australia, France, and the Pacific islands region. Many of these articles have alerted physicians in the United States or Europe to the fact that a patient returning from a tropical vacation with a perplexing set of symptoms may in fact be suffering from ciguatera.

Ciguatera has also become a subject of interest in the popular press. In an article in the *Australian Financial Review* (1984), the author commented that ciguatera was worrying both medical authorities and tourist promoters throughout the South Pacific. Even a few cases of ciguatera can have a drastic effect on the use of reef resources and fish avoidance can have an adverse economic impact on small-scale fisheries. In Hawaii, there is a generally increasing awareness of the problem, and interest in the origins of the red snapper that is commonly sold in large supermarket chains. It is carefully identified as New Zealand red snapper, undoubtedly because of this.

The research community, clinicians, fisheries officers, and the general public are becoming more aware of the existence of ciguatera. This can obviously have many positive effects from increased research funding, to correct diagnosis and appropriate detection and control strategies. However, care must be taken that the magnitude of the problem not be exaggerated. Tatnall et al. (1980) present a case where a West Indian was poisoned after consuming dried fish brought back from Antigua. They suggest that control in Britain rests on strong discouragement by such bodies as the Fishmongers' Company of commercial importation of moray eels and potentially ciguatoxic fish, such as amberjack and barracuda. Wholesalers do have a responsibility that should be self-evident. In the United States the potential for legal action elevates the stakes. The radioimmunoassay testing of amberjack (kahala) in Hawaii was successful; there were no intoxications from commercial purchased amberjack during the test period, but it was prohibitively expensive and also resulted in false positives. What is needed, of course, is a more complete understanding of the etiology, ecology, and epidemiology of ciguatera and a simple, inexpensive test to determine toxicity. Until then, we will have to rely on correct species identification, care to avoid both internal sale and export of toxic species, communication, and cooperation among fishermen, wholesalers, retailers, and the scientific and medical community.

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