# Ciguatera and Other Marine Poisoning in the Gilbert Islands[1]

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AMONG THE ANIMALS that live in the sea are many that may be poisonous to eat; these animals include fish, sharks, crabs, molluscs, and turtles. Of all marine animals the most important are fish, which are for so many people an essential source of food. There are a number of different ways in which teleost fish may be poisonous. Some fish are naturally poisonous; puffers for instance are always toxic. Some species of fish can be poisonous at certain seasons; in Fiji there is a species of sardine which may be deadly poisonous in the later months of the year. A third type of poisoning is found where some fish are poisonous to eat when they are caught on certain reefs or parts of a reef, and yet when caught on other parts of the same reef, or on nearby reefs, are perfectly safe to eat. This type of poisoning, known as ciguatera, is common throughout the tropical Pacific, usually on oceanic islands and isolated reefs.

Ciguatera is not, as many people think, a recent development. Captain Cook, in the journal of his second voyage to the Pacific in 1772–1775, relates how all of his officers who ate "two reddish fish, about the size of bream and not unlike them" were poisoned and the pigs, that were given the offal, died. These fish were taken in the New Hebrides, and Cook refers to an earlier record of poisonous fish in those waters when he remarks that these reddish fish must be the same kind as those mentioned by Quiros, and called by him "pargos." Pedro de Quiros was in the New Hebrides in 1606. However, prior to World War II there were few reports of ciguatera poisoning in the Pacific; cases of poisoning did occur, but unless a stranger to the Pacific was involved little notice was taken. During and after World War II attention was drawn to the problem, as there were many more people in the Pacific who were poisoned by supposedly good food fish, often in areas where toxic fish had been previously unknown.

Although the symptoms of ciguatera poisoning, the species of fish likely to cause it, and many of the areas harboring toxic species have been recorded, several aspects of the problem still remain to be solved. In spite of recent research into ciguatera poisoning an antidote to the poison, a field test for distinguishing a toxic fish from a nontoxic one, the true nature of the toxin, and the cause of the development of ciguatera among fishes have not yet been discovered.

This paper is a review of the history and location of ciguatera poisoning in the Gilbert Archipelago and of the various Gilbertese beliefs about marine poisoning, together with identifications of the species considered toxic by the Gilbertese, and some of the author's opinions on the development, cause, and spread of toxicity.

The Gilbert Islands are a group of 16 atolls lying north and south of the equator; latitude 3° N passes through the most northerly island and latitude 3° S passes a few miles south of the most southerly island. The group lies between longitude 172° and 173° E of Greenwich. From north to south the 16 atolls are Makin, Butaritari, Marakei, Abaiang, Tarawa, Maiana, Abemama, Kuria, Arunuka, Nonouti, Tabiteuea, Beru, Nikunau, Onotoa, Tamana, and Arorae. Atolls are of two distinct kinds, lagoon islands and reef islands. A simple lagoon island consists of a lagoon, a body of fairly shallow water set off from the ocean, according to tradition, by a ring of small islets; in fact, the islets are usually in a chain lying on the weather side of the lagoon, with submerged barrier reefs on the lee side. A simple reef island is a small island with a fringing reef round it and no enclosed body of water. Many islands appear to be a mixture of both types. The total land area was estimated

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by Dr. Rene Catala at 114 square miles. The population in 1947, the time of the last census, was 27,000; in 1958 the Gilbertese population was estimated to be 32,652 (Doran, 1960).

The information presented here was collected during the period 1953–1962 while the author was resident in the Gilbert and Ellice Islands Colony with her husband, who was an administrative officer with the Gilbert and Ellice Islands Colony Government. Residence was maintained for varying periods of time on Tarawa, Christmas Island (in the Line Islands), and Ocean Island; personal visits were made to all the Line and Phoenix islands, including Washington Island, and to almost all of those in the Gilbert group. During this time the author learned the Gilbertese language, which permitted her to gather information directly from the islanders.

In the course of a study of the scientific equivalents of the Gilbertese names for fish it was found that while some names would encompass all members of a whole family of fish, other names were restricted to a single species, and some names defined the development stages of a generic group. Through the initial study of Gilbertese names for fish, the author became interested in Gilbertese traditions and customs associated with fish, and finally in an investigation of fish toxicity in the archipelago.

The intimate association of the Gilbertese with the sea, almost their only source of dietary protein and fat, makes them reliable givers of factual information about fish poisoning. This dependence upon the sea means that every adult member of a community must have a basic knowledge about the reefs and the fish species around his island, particularly in the area of his village. Although in recent years the traditional dependence on fish as a major source of food has been lessened to some extent by introduction of imported foodstuffs, the detailed knowledge of environment has been preserved and is still known by the elders of the Gilbertese community who are the traditional custodians of natural lore. These "old men"—the term in Gilbertese is traditionally one of respect—have proved to be the most fruitful source of information when dealing with the history of fish toxicity. Younger men, active fishermen, have provided information on the species caught and the areas fished.

Due to the restricted nature of the Gilbertese diet, there are very marked preferences for certain species of fish. Fish considered to be very fatty or greasy are greatly sought after, because the Gilbertese at times develop a craving for animal fats. These sought-after species include *Lutianus bohar, Lethrinus variegatus, Acanthurus xanthopterus, Epinephelus fuscoguttatus, Cephalopholis mineatus, Myripristis* spp., *Chanos chanos,* and Muraenidae spp. The larger these fish, the more tasty they are considered to be. Some of these species have been found to be toxic, even dangerously so, in certain areas in the Gilberts. But even if a species is known to be toxic, there comes a time when the Gilbertese find it impossible to resist the temptation of a good fatty meal. This craving for animal fats is not restricted to the Gilbertese. Harry (1953) relates that the islanders of Raroia Atoll, in the Tuamotus, were unable to resist eating certain species of fat fish even when they knew that these species were toxic, and that as a result there were frequent cases of poisoning. Population pressure, together with particular food preferences, forces the Gilbertese to continue sampling a known toxic area. On account of this, a fairly accurate picture of the evolution of toxicity in an area may be obtained.

Considerable information was collected from Gilbertese visiting Tarawa, from assistant medical officers (graduates of the Fiji School of Medicine), and from officers and crews of the various ships operating in the colony. This information was later checked by the author, who was able to visit all the "toxic islands" with the exception of Tabiteuea and Arunuka, and by her husband, whose duties took him to all the Gilbert Islands. A special visit was made by the author to Marakei to obtain a more detailed picture of a toxic area than was possible when surveying the group as a whole.

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The population statistics were taken from the "Report on Tarawa Atoll," by E. Doran (1960); the land areas are taken from "Report on the Gilbert Islands: Some Aspects of Human Ecology," by Rene L. A. Catala (1957). The rainfall figures were kindly given me by the New Zealand Meteorological Service, Laucala Bay, Suva. The maps, except that of Onotoa, are adapted from admiralty charts. The Fiji Government Printer gave great assistance in preparing the maps of Nikunau and Tabiteuea. The map of Onotoa was adapted from P. E. Cloud's map, based on aerial surveys (Atoll Research Bulletin 12, 1952).

Above all, the greatest acknowledgment and thanks are due to the many Gilbertese old men and women, fishermen, and the "general public," who patiently discussed for endless hours just "fish."

## SYMPTOMS OF CIGUATERA POISONING IN THE GILBERTS

Ciguatera poisoning is regarded as an occupational hazard by the Gilbertese, especially by those who have lived all their lives in a toxic area. As a result, they consider ciguatera poisoning to be a "Gilbertese sickness," and they prefer to treat such sicknesses with their own remedies, as opposed to what they consider to be imported "European illnesses," for which European medicines are logically more suitable. Gilbertese do not normally go to a medical officer when poisoned by a fish, except on rare occasions when the victim is obviously on the point of death. Colony medical officers, therefore, do not see or record many cases of fish poisoning. Although mild cases of poisoning are very frequent on some islands, medical department records are relatively few.

The following sequence of symptoms of ciguatera poisoning has been collected from talks with several assistant medical officers and colony dressers (male nurses trained at the Colony Central Hospital, Tarawa). At first, several hours after eating a toxic fish, there is nausea, followed by vomiting and severe stomach pains, which may be accompanied by diarrhea and fever. There is tingling of the arms and legs followed by numbness and a heaviness of the limbs, which may lead to complete loss of coordination or even to paralysis. The sense of balance is lost. In severe cases there may be great thirst. Intense itchiness is followed by peeling of the skin. Finally, in fatal cases the victim lapses into coma and dies.

The following case histories were taken from the assistant medical officer stationed on Betio, Tarawa. He, his wife, mother-in-law, and two teenage boys were poisoned in March, 1962. He caught a small *Lutianus bohar* on the Betio lagoon reef. The fish was cooked and eaten on his return home, but no symptoms of poisoning appeared until 12 hr later. The five people involved ate varying amounts of the fish and had different symptoms.

The assistant medical officer and his wife ate only a little of the fish. His symptoms, which appeared about 10 PM, were nausea but no vomiting; his legs tingled and then felt numb; next morning the cement floor felt like ice to his bare feet and he was "very shivery" in the wind, but far too hot out of it. He managed to work for half the day, but then he felt too ill so went to bed. Next day he was better, the symptoms had all gone, but on the third day the tingling sensation in his legs returned and persisted for several days. His wife suffered nausea, vomiting all night, and a severe stomach-ache. She stayed in bed the next morning and complained of numbness in her arms and legs all day. She recovered by the second day, except for a shivery feeling and an intensified tingling in her legs every time she put her hands in water. These feelings persisted for about a week.

The old woman, the mother-in-law, ate more fish than the preceding two. She suffered from nausea, vomiting, and a severe stomach-ache all night. Next day and the day after, the vomiting and stomach-ache continued; she complained that she could not walk, her legs felt heavy, and

she remained lying on her mat. By the fourth day she could walk again, but she vomited and complained that her legs felt tingly for a week, by which time she was well enough to travel to another part of the island where she considered she could get more expert treatment. It is possible that her vomiting was aggravated by her own home-made medicines.

One of the boys ate but little of the fish; he suffered from nausea during the night, and the next morning his legs tingled but he was able to go to work. The other boy finished the fish, and in doing so ate far more than the others. He was taken ill about 2 hr before the rest of the family, at about eight o'clock, with nausea, vomiting, severe stomach-ache, and a fever of 102 F. The assistant medical officer did not realize that it was ciguatera poisoning until the others became ill as well, so at first he treated the boy with penicillin for appendicitis. The boy vomited all night, as well as having acute diarrhea and pain. The next day he was still ill, with fever, nausea, vomiting, and diarrhea; he lost his sense of balance, his legs were powerless, and he remained on his bed. By the third day he had completely recovered; he returned to work and suffered no lingering symptoms or after-effects.

The three adults were in agreement on certain symptoms; they all say that one of the first signs, which at the time they did not realize was the start of an attack of poisoning, was a funny feeling in their noses, as if the air passages were enlarged and they could breathe more freely. They also agreed that the numbness in their legs persisted for several days, and that water on their skins caused shivery feelings, as well as making their legs tingle again.

Another man who was poisoned by a *Lutianus bohar,* also in March, 1962, from the Betio, Tarawa, toxic reef, said that he had nausea and vomiting, but he complained that the most persistent symptom was a feeling of numbness and swelling of his lips and tongue. This sensation, together with pins and needles in his legs, persisted for about 10 days.

It has not yet been proved whether the severe poisoning caused by large Muraenidae is true ciguatera or is caused by a different, although perhaps allied, toxin (Banner *et al.,* 1960; Helfrich, 1961; Bouder *et al.,* 1962). The Gilbertese consider it to be ciguatera poisoning but very much more severe than that from other fishes. They say that moray eels grow large, have voracious appetites, and are able to eat so many smaller toxic fish that they become deadly from the stored toxin. It has been proved that ciguatera toxin is passed along the food chain, at least for toxic *Lutianus bohar,* which when fed to a previously nontoxic *Acanthurus xanthopterus* Cuvier and Valenciennes, made the flesh of the latter toxic (Helfrich and Banner, 1963). In the Gilberts large moray eels may be deadly poisonous but only when caught in an area in which other species of fish are toxic. Outside these areas large moray eels are a popular food fish (see section on Nonouti). In 1961 two men died after eating part of a large moray eel caught on the Betio, Tarawa, toxic reef. The eel was cooked in the usual manner, without gutting or cleaning, and the family went to the cinema without eating any of it. While they were away two men, an old man and a young one, ate part of this eel. When the family returned from the cinema they found both men very ill, with violent vomiting and severe stomach-ache. They were both taken to the Betio hospital, in charge of the assistant medical officer, where the old man lapsed into a coma and died at 2 AM the same night. The younger man lived for a week, but the only symptoms remembered by the assistant medical officer were that he suffered intense itchiness, that his skin peeled away, and that finally he went into a coma and died.

The following history was supplied by an assistant administrative officer who was poisoned by an eel on Canton Island, in the Phoenix Islands, in 1947. The eel, a big, black moray, was caught in the lagoon and cooked and eaten by six men. True to normal practice, it was not gutted before being cooked. Of the six men who ate the eel, only this one man was poisoned; the others were completely unaffected. He was a newcomer to Canton Island and was given the choicest part of the eel, the fatty part from the belly, whereas the others ate only the meat. About half an hour after eating the eel, he began to feel very ill. At first he felt very cold in the wind, so he moved out of it, and then felt far too hot. Then he felt as if he were standing on the bows of a ship in a rolling sea; this was

followed by a severe pain high in his stomach, accompanied by violent vomiting and diarrhea. He lost his sense of balance, his legs became powerless, and he just lay on his bed, suffering from acute pain in his stomach for a week. After this time the pain in his stomach eased, and he felt that perhaps he was not going to die. During the second week, although he suffered from intense itchiness, he began to feel much better and slowly regained his sense of balance. When he left his bed, he said, he almost had to relearn to walk. By the third week he was very much better, the itchiness finally having subsided with the flaking away of the skin from all over his body. This was the first time that this man had been poisoned, and he thought that it was because he was a newcomer to the island and had not had time to build up an immunity to the poison. The other five men, who ate the eel with him, had been living on Canton Island for some months, and considered that they had become partly immune to toxic fish during the time they had lived there. At that time, 1947, mild cases of ciguatera poisoning on Canton Island were not infrequent.

## SOME GILBERTESE REMEDIES FOR CIGUATERA POISONING

Gilbertese have a variety of herbal remedies for ciguatera poisoning but, apart from an emetic, it is doubtful if any of them is of real value. If a fish has already been eaten and is then thought to be toxic, the best thing is to get rid of it. An emetic may be made from the juice of a commonly found spurge, "te tarai," *Euphorbia atoto* (Forst). A few drops of the milky sap are squeezed into a small drinking coconut and this, when drunk, usually has the desired effect.

One of the oldest remedies may be made from the fruits of the Indian mulberry, "te non," *Morinda citrifolia* (Linnaeus). Three unripe fruits are crushed with three ripe fruits and mixed with the juice from a drinking coconut; sometimes only three unripe fruits are used. This very bitter concoction is one dose, which may be repeated when needed.

A newer but very popular remedy on the more northern islands may be made from the buds of the seedless breadfruit tree, "te bukiraro," *Artocarpus* sp. One terminal bud is finely chopped, put in a cloth, and squeezed with about half an inch of rain water in a mug until all the juice is extracted. This must be drunk immediately, and is one dose. It may be repeated as often as necessary. Another new remedy is made from the fruits of the papaya, *Carica papaya* (Linnaeus). Several unripe fruits are chopped and crushed and the milky sap extracted. This is added to an unspecified amount of rain water; the mixture must be boiled and taken as soon as it is cool enough. This is again one dose and may be repeated when required.

Finally, a very popular medicine for many ailments, including ciguatera poisoning, may be made from the fruits of the saltbush, "te mao," *Scaevola frutescens* (Mill); an indefinite number of ripe fruits are gathered, and the bitter juice from them is squeezed into a drinking coconut. This dose may be repeated when it is thought to be needed.

## SOME GILBERTESE OPINIONS ABOUT CIGUATERA POISONING

Gilbertese opinions as to the cause of toxicity in fishes vary from island to island, and even between individuals. On Abemama, Nonouti, Tabiteuea, Onotoa, Beru, and Nukunau the islanders say that the fish have been toxic since a vessel was wrecked on the reef which is toxic at the present time, and blame the wrecks for the toxicity. On Tarawa the war with its resulting bombs, increase in shipping and in rubbish of various sorts dumped in the sea, is blamed for the violent increase in toxicity which began in about 1944. On Butaritari the increase in shipping and above all the rubbish dumped by the ships during the war is thought to have caused the poisoning there. All these islanders agree with Randall (1958), who found that on many islands wrecks were cited as the location of a toxic reef, and that rubbish dumped in the sea was often blamed for toxicity. Randall's hypothesis (1958) that toxicity may be caused by an alga that is the first alga to grow on a new substrate appears at first sight to be borne out by these Gilbertese statements. Wrecks, rubbish, and bomb craters all form new surfaces in the sea.

On Marakei, where toxicity suddenly appeared in 1946, the people blame a certain kind

of alga. They say that their fish became toxic when this alga, which they had not seen before, began to grow on the now toxic reef. This alga, a blue-green *Schizothrix calciola* (Agardh) Gomont,[3] grows on top of fine algae already growing on the reef (see section on Marakei). If this alga should be associated with toxic conditions, then this upholds Randall's hypothesis (1958) that a fine, blue-green alga might be one of the basic causes of toxicity in fishes.

Many Gilbertese believe that certain people are immune to fish poison, and many even eat a toxic fish without harm. It is commonly said that there have been occasions when a family group has partaken of a large fish, and some of them have been severely poisoned, others not at all. However, neither the amount of fish nor the parts eaten are taken into consideration. A little-known belief which still lingers, especially among the older people, is that of family totem fishes. It is almost impossible to find out very much about this belief, as the Gilbertese are very loathe to talk about it. When discussing toxic fish with Gilbertese it should be realized that some older people still consider that certain families may be magically affected by certain species of fish.

Some Gilbertese think that the toxin is concentrated in the liver and guts of a fish, and that the viscera may be toxic when the flesh is not. This idea has been confirmed by Halstead and Bunker (1954). Other Gilbertese think that the toxin is concentrated in the blood, and that if the throat, guts, and large blood vessels are ripped from a still living *Lutianus bohar* then that fish will be safe to eat. Banner *et al.* (1963) report that large specimens of *Lutianus bohar* killed, filleted, and frozen within half an hour of catching proved just as toxic as specimens kept for several hours after death. In spite of these ideas the Gilbertese do not usually bother to clean or gut carnivorous or small fish before cooking them. It is considered a waste of time to gut such fish as *Lutianus bohar* or species of Muraenidae, as the Gilbertese say the guts are too small to bother about. It is customary, however, to clean and gut certain herbivorous fish such as *Mugil* spp. or *Kyphosus* sp.

Randall (1958) mentions that if a person who is recovering from an attack of ciguatera poisoning eats a reef fish he may experience a return of certain symptoms. He suggests that therefore the fish must contain toxin at a level sufficient to raise the toxin in the eater to the threshold level, but not sufficient to affect people who have not been recently poisoned. The Gilbertese people agree with this contention, but maintain that *all* fish will accentuate the neurologic symptoms in someone who is recovering from ciguatera poisoning, including species that have never been known to cause ciguatera, for instance flying fish.

The Gilbertese have the usual superstitions, proved false by Banner *et al.* (1963), that flies will never settle on a toxic fish, that a silver coin will turn black if it is cooked with a toxic fish, and, one superstition that appears to be peculiar to the Gilbertese, that grated coconut will turn bright green if baked inside a toxic fish. A more promising method of testing for a toxic fish occasionally practiced is to give one of the household cats a sizable piece of the suspect fish; if the cat is not ill in a few hours then the fish is not toxic. Another, probably more frequent "test," is for one of the family to act as guinea pig and eat some of the fish, although this is not considered foolproof because people react differently to the toxin. It is customary in toxic areas for old people to eat part of a large fish first. Later, if no symptoms of poisoning develop, the rest of the family will finish the fish. Experienced residents of toxic areas never allow their children to eat doubtful or uncommon fish until several hours, preferably a night, after it has been tried by the older members of the family.

This custom makes most puzzling the statement of Cavallo and Bouder (1961) and of Bouder *et al.* (1962) that ciguatera poisoning was a primary cause of infant mortality on Sydney Island (which the author visited in 1953). Sydney Island, in the Phoenix group, had no indigenous population prior to 1939, when it was settled by Gilbertese from the southern Gilberts, but had at times been worked for guano and copra. It is a most unfertile, drought-stricken atoll, the enclosed lagoon being too salty to sup-

[3] This alga, originally identified as *Plectonema terebrans* (Bornet and Flahault) by Dr. Franci Drouet, has been assigned to the above species by Drouet. See Drouet, 1963, Ecophenes of *Schizothrix calciola,* Proc. Acad. Nat. Sci. Phila. 115(9):261–281.

port marine life. The whole population suffered severe protein deficiency, certainly due in large measure to the toxicity of the reef fish, which deprived the settlers of their natural source of animal protein. This general deficiency undoubtedly contributed to the infant mortality referred to above. The population of Sydney Island was evacuated to the Solomon Islands in 1958, the island having been found unsuitable for permanent settlement.

## EVOLUTION OF TOXICITY IN THE GILBERTS

In the Gilbert Islands the evolution of toxicity of an island seems to follow a pattern. When toxicity first appears in an area only a few fish caught on a small patch of reef are found to be toxic. Within a few months many more fish become toxic, the toxicity is more severe, and the area where toxic fish are caught extends over some of the neighboring reefs. Within a short while (on Marakei about 2 years), nearly all species of reef-dwelling food fish and the roving carnivores that normally prey on them have become very poisonous. After some years have passed (on Marakei about 10), the toxicity begins to decrease. Small specimens of certain species become safe to eat; this improvement appears to start at the periphery of the toxic area and gradually works its way toward the center. The small fish of a species become safe to eat before the large ones of the same species, and the "safe" size becomes progressively larger; certain species become safe to eat before others. Eventually a stage is reached when all fish are being eaten, although sporadic cases of poisoning may still occur; at this stage the Gilbertese do not admit to having a toxic area on their island. It is not known whether a reef, once "poisoned," ever becomes completely free of all toxic fish, but from accounts collected in the Gilberts it seems highly unlikely. The reefs appear to go into a "quiescent stage" when only an occasional large specimen of *Lutianus bohar, Promicrops lanceolatus* (specimens of 200–300 lb are sometimes landed, but they are very uncommon), or of Muraenidae may cause poisoning. The toxicity may flare up again, when the cycle will be repeated, and it appears that, until a valid field test for toxicity has been discovered, any fish caught in a known toxic area should be regarded with suspicion.

Unfortunately, due to the rapidity with which toxicity increases, it has not been possible to determine either the order in which species become toxic, or the first species to become toxic. However, at the height of toxicity most members of the following families or genera of fish are toxic: Acanthuridae, Balistidae, *Caranx* spp., Cirrhitidae, Holocentridae, Lethrinidae, Lutianidae, Mugilidae, Muraenidae, Scaridae, Serranidae, and Sphyraenidae; certain Mullidae may be toxic, and Labridae are also probably toxic, especially the larger ones, but information on this family is lacking, as the Gilbertese do not like their taste and prefer not to eat them.

As the toxicity declines, amongst the first fish that become safe to eat are the Holocentridae, Mugilidae, Cirrhitidae, Mullidae; the smaller species of grouper, *Epinephelus merra,* and allied species and *Cepholopholis urodelus;* small specimens of *Lutianus kasmira* and *L. vaigiensis.* On the other hand, some species remain toxic far longer than others, and among the ones that may remain toxic for many years are the following: *Acanthurus xanthopterus, Ctenochaetus* spp., *Lutianus bohar, L. semicinctus, L. monostigma, Lethrinus variegatus, Epinephelus fuscoguttatus, Cephalopholis argus, C. mineatus, Variola louti, Plectropomus truncatus, Promicrops lanceolatus,* large *Caranx* spp., *Scarus* spp., large *Sphyraena* spp., large Muraenidae. *Monotaxis grandoculis* and *Gnathodentex aureolineatus* may also remain toxic, but these fish are not at all common. More and more species become safe to eat, but *C. mineatus* and *P. truncatus* are particularly slow, and *E. fuscoguttatus* even slower to improve. Finally the reefs enter the quiescent stage with only a few species, *Lutianus bohar, Promicrops lanceolatus,* and large Muraenidae, remaining potentially toxic. Large *Sphyraena* sp. have been found to remain very toxic in the vicinity of a toxic area, which in the Gilbert Islands may be almost anywhere in the colony.

## WINDS AND CURRENTS

Throughout the Gilbert Islands the prevailing winds are the trade winds, blowing from the northeast, east, or southeast, with an occa-

sional stronger wind blowing from the north, usually after a period of calm. The prevailing ocean current is from the southeast; this current splits on coming to an atoll, sending a very strong current sweeping northward up the eastern side, with a much slacker current being deflected round the southern tip and up the western side. The effect of these winds and currents on the atolls is very marked. On the eastern weather sides there is constant heavy surf, while on the western lee sides calmer seas prevail. The "land" of the atolls is often more developed on the weather side than on the lee. This is especially noticeable on the larger lagoon islands, which have islets all along the weather sides, while the lee remains a mass of barrier reefs and shoal patches (as in Butaritari, Abaiang, Tarawa, Maiana, and in particular Arunuka, Nonouti, and Tabiteuea). The main anchorages on all the atolls are on the western lee sides, and, in the case of lagoon islands, so are the main ship or boat channels into the lagoon.

Between the months of October and March, there may be gales from the west bringing heavy rain, but several years may pass without any westerly weather developing. In years of heavy or continual westerly winds, an ocean current may develop from the southwest; the Gilbertese believe that a change in current actually precedes a severe westerly gale. During this westerly weather, big seas develop on the usually calm western sides, heavy surf breaks on the barrier reefs and may even sweep right across the lagoons. These westerly gales do not normally last for more than a few days, but they may blow up without warning and may be the cause of an occasional shipwreck, even in these days of motor vessels (as at Nikunau, in 1955).

## DETAILS OF TOXIC AREAS BY ISLANDS

### *Makin*

Makin (in U. S. Sailing Directions, Little Makin or Makin Meang) is the most northerly of the Gilbert Islands. It is small, about 2.8 square miles in land area, with a population in 1958 of 1,130. Annual average rainfall is 107 inches, which makes it one of the wettest islands in the Gilberts. Toxic fish are unknown to the Makin people. Although Makin is classed as a reef island, it is unusual in having a shallow lagoon on the eastern side of the island. On the western or lee side there is a narrow fringing reef, which at low tide is covered by about 4 ft of water; this reef drops away suddenly and steeply to deep water. Vessels may anchor only during exceptionally calm weather, and even then they must moor onto the edge of the reef.

In 1956 this narrow lee reef was a mass of luxuriant corals, with deep sandy-bottomed surge channels lined with many species of corals and a large and varied population of fish. In November, 1961, this magnificent reef was found to be completely changed; the corals were broken and the surge channels full of the debris, and there were not nearly so many fish. Enquiries showed that this very extensive damage had been caused by an exceptionally severe gale accompanied by heavy seas just before Christmas, 1960. However, no toxic fish have yet appeared.

### *Butaritari*

Butaritari (in U. S. Sailing Directions, Makin Atoll) is a large lagoon island in the northern Gilberts with a land area of some 4.5 square miles and a population in 1958 of 2,118. It is the wettest island in the group, with an annual average rainfall of 125 inches. Poisonous fish were first reported from Butaritari after World War II. Small ships may enter Butaritari lagoon, which is large, through a passage in the southwest by Kotabu Islet, but large ships must remain outside the lagoon. During the war many ships were anchored in the passage and there are wrecks both here and inside the lagoon. About 25 years ago the "St. George" was wrecked in the lagoon opposite Ukianang village; and nearby the "Alexis" was bombed and sunk by the Japanese a couple of years later. No toxicity followed the earlier wreck, nor appeared for some years after the latter. The remains of a crashed Catalina flying boat are still to be seen near Butaritari village.

The toxic area, which is in the southeastern part of the island (Fig. 1), extends from a point somewhere between Butaritari village and Ukianang village inside the lagoon southward through the South Channel by Kotabu, thence to the northwest along the fringing and barrier reefs both inside and outside the lagoon, as far as Tukurere Islet. This toxic area is composed of

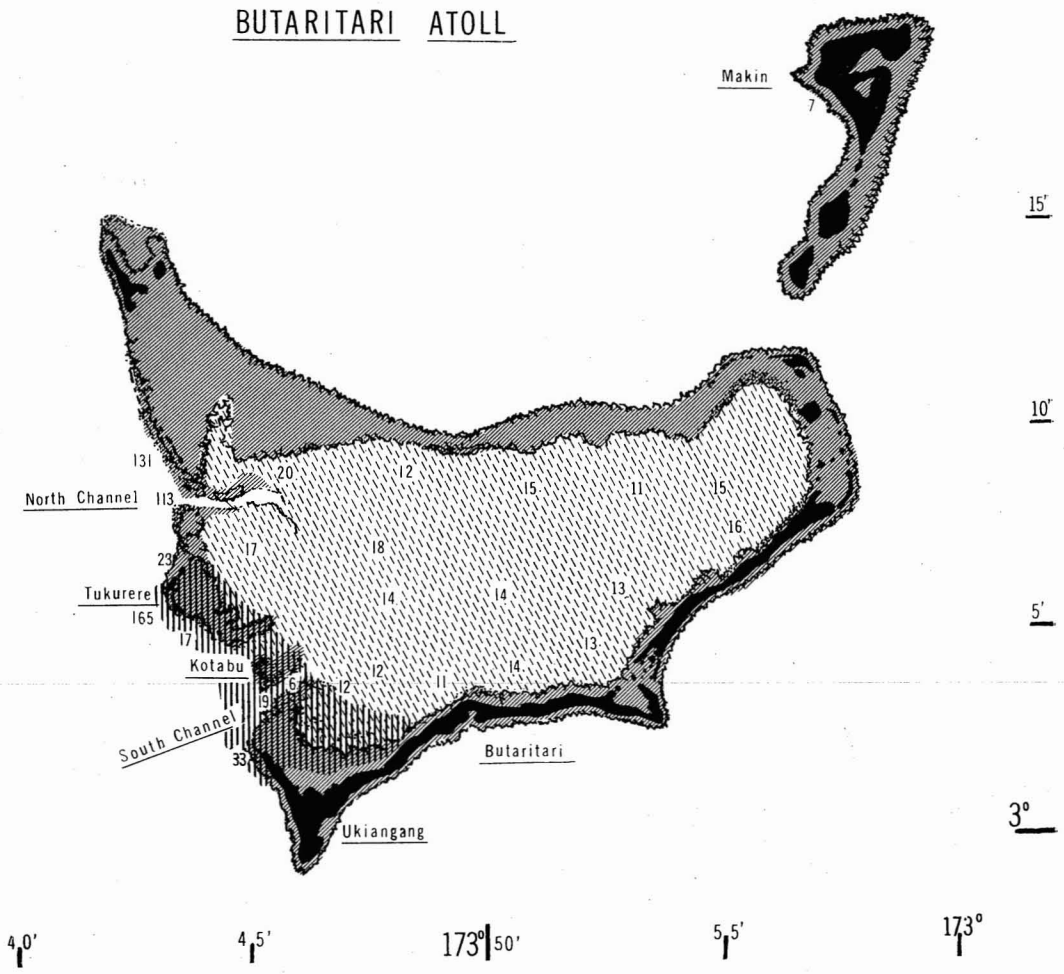


FIG. 1. Map of Butaritari Atoll.

sandy-bottomed lagoon opposite Ukianang village, deep water in the passage and anchorage outside, and living coral on the reefs.

Toxic fish were first reported from Butaritari about 1947–1948, and one of the earliest recorded cases of poisoning was the crew of the London Missionary Society's vessel, "John Williams VI." They caught a number of *Acanthurus xanthopterus* in the lagoon anchorage near Ukianang and, having had no previous experience of poisonous fish in Butaritari, they ate them. So many of the crew were poisoned that the vessel was unable to sail on time.

It is not known when the toxicity began to clear, but by 1956 there was already a great improvement in the condition of the reefs around Kotabu and Tukurere, where many species of fish were safe to eat. The toxicity took much longer to clear in the lagoon by Ukianang, the South Passage, and anchorage. The "John Williams VI" was again involved in a case of poisoning in 1956, but this time it was the European passengers and the captain of the ship who were very severely poisoned by an unidentified fish. The health of one of the passengers was so seriously affected that he was forced to resign from his work.

By 1959 all species of fish, with the exception of large *Lutianus bohar* and the Muraenidae, were again being eaten in all toxic areas. By 1961 the Butaritari people claimed that they were free of poisonous fish, except for an occa-

sional specimen of *Lutianus bohar* or an exceptionally large *Promicrops lanceolatus* or muraenid. However, early in 1962 the crew of the Sacred Hearts Mission ship, "St. Teretia," were poisoned by a barracuda (*Sphyraena* sp.) said to be about 3.5 ft long, which they had caught just outside the South Passage.

*Marakei*

Marakei is a small lagoon island in the northern Gilberts, lying some 60 miles to the northeast of Tarawa. The lagoon on Marakei is shallow, although full of fish, and is connected with the sea by only two passages, one on the southwest and one on the east. Both passages are very shallow and almost dry at low spring tides. There are seven villages; the largest is Rawanawi, in the northwest, which is also the Government Station where the medical dispensary and wireless station are situated. The Sacred Hearts Mission maintain a school at Rawanawi with two resident sisters and a resident parish priest, who were most helpful in this survey. There are two anchorages. The main one, for ships up to 150 tons and usuable only during east to southerly winds, is off Rawanawi, where there is a boat passage through the fringing reef. This anchorage, although poor, is better than the more southerly one by the western lagoon entrance.

A more detailed survey of the toxic fish problem was made on Marakei than on the other islands. Marakei was chosen for a variety of reasons, the most important being that the start of the toxicity in 1946 was recent enough to be clearly remembered by the Marakei people and it was said that they knew which alga was responsible. The population on Marakei, about 1,790 in 1958, is rather large for the size of the island, which is a mere 3.94 square miles in land area, and it is one of the most densely populated islands in the group. Although Marakei is not one of the "drought" islands, the rainfall, averaging 79 inches a year, is not high, and the people are accustomed to finding a large proportion of their food from marine sources. Thus, when the reef fronting the main village, Rawanawi, the most heavily populated area of a heavily populated island, suddenly began producing toxic fish, the Marakei people were very hard hit by the loss of a good proportion of their food supply. They were forced by the need for protein food to keep sampling this reef, in an effort to find out just what they could eat without fear of poisoning and what was too toxic. In this way a good local knowledge of the behavior of the toxicity on this reef was gradually amassed by the older people of Marakei.

The toxic reef on Marakei is the fringing reef on the west or lee side of the island (Fig. 2), extending from the vicinity of the village of Rawanawi southward to the village of Buota.

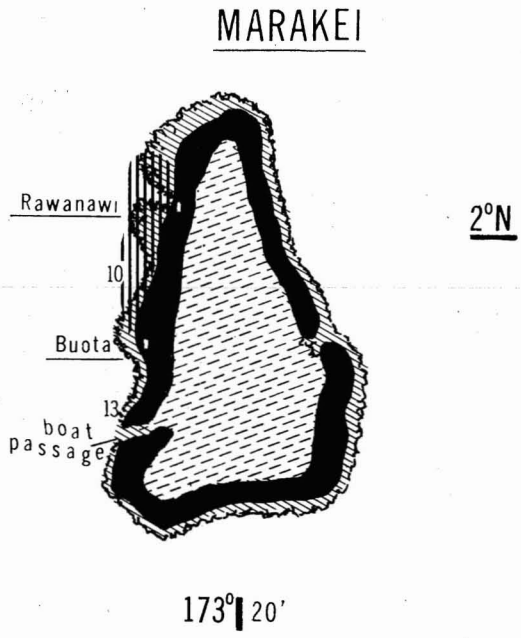


FIG. 2. Map of Marakei.

The reef flat is narrow, with a few very shallow tide pools and small boulders. It is covered with fine algae and has a greenish aspect. Just below low water mark (see Fig. 3) where the reef never dries out, there is a belt of red-colored algae. Beyond this the reef drops a little and is covered with a dense growth of millipore coral. Between the stands of coral there are deep sandy-bottomed channels, whose sides are lined with a great variety of marine life. There are a few red algae between the branches of the millipore coral, and some brilliant green species on the floor and sides of the channels; in places there

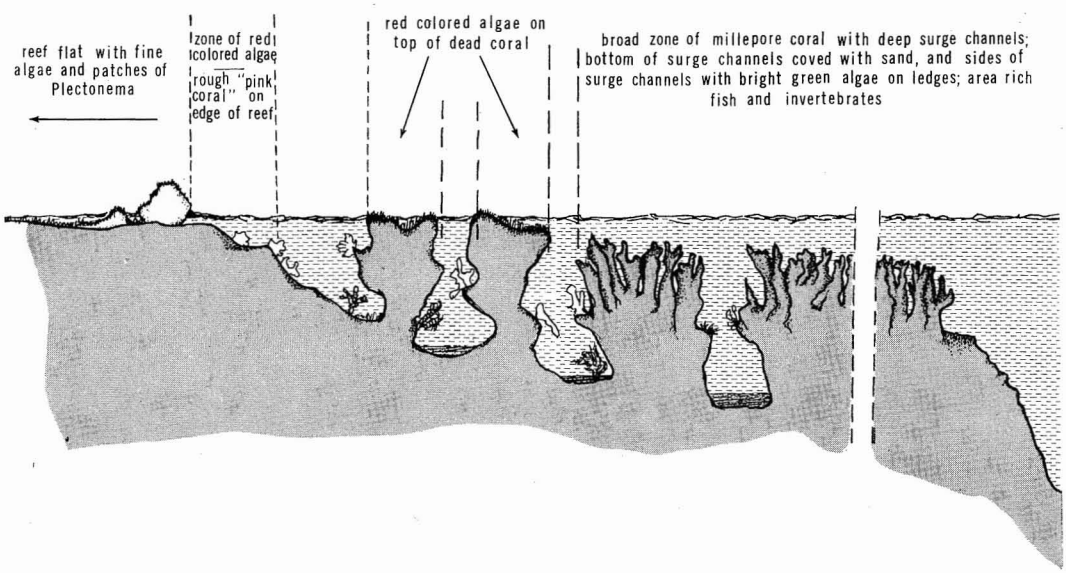


FIG. 3. Diagrammatic sketch of toxic area of reef at Marakei, water at low tide; depth of top of submerged heads of millepores about 4 feet below low tide level. "Red-colored algae" are mostly *Laurencia mariannensis*.

are dead coral pinnacles which reach almost to the surface, and the tops of these are covered with red algae. On the whole there was little algal growth below low water mark compared with the quantity on the reef flat. Beyond the belt of millipore coral, the reef face drops away fairly steeply to deep water. Many fish of different species were swimming above the coral, in the channels, and over the edge in the deeper water.

With the exception of tetraodonts and diodonts, toxic fish were unknown on Marakei prior to 1946. In that year a few fish caught on the reef near Rawanawi were found to be poisonous. By 1947 the affected area had spread southward along the reef as far as Buota, and many more fish were found to be toxic. By 1948 "all" fish were said to be toxic in some degree, when caught anywhere along this reef. Although the Gilbertese say "all" fish were poisonous, there were a few species, chiefly pelagic and oceanic, that were not affected, but it was not safe to eat most reef-dwelling or reef-hunting species. Many people were poisoned but few died, the only remembered deaths being the very old people and those already debilitated by disease. The Marakei people were forced to discontinue regular fishing on this reef, although they continued to collect octopus and other molluscs, none of which became toxic.

When toxic fish first appeared the Marakei people, having had no previous experience of toxicity, did not know what was making them ill. As more fish became toxic and the intoxications increased in severity, they realized that the fish had become poisonous; they were exceedingly angry and surprised, and immediately sought around for a reason. At first many people blamed the medical dresser, saying that he had fouled the reef with old medicines and dressings. Even to this day the Marakei people are loath to go to any medical officer when poisoned by a fish.

Another idea, a usual one throughout the Gilberts in an unknown, unpleasant situation, was that someone was making black magic and had poisoned the reef. The blame for this was put on a Maiana man who had been imprisoned on Marakei by the Marakei Island magistrate. Some people blamed a party from Butaritari, who arrived on the Sacred Hearts Mission ship, "St. Teretia"; they brought with them some alumi-

num from the wrecked catalina in Butaritari lagoon. Aluminum is a highly prized metal in the Gilberts, used for making combs; when the visitors landed on Marakei they were swamped in the boat passage and the aluminum was swept onto the reef. Although an attempt was made to recover it, some metal remained on the reef, and this metal was thought to have affected the fish.

Other people blamed "the Americans," in particular "an American ship which came to Marakei, grounded on the reef at Rawanawi, and when the tide came in again, left." Enquiries at Tarawa showed that a United States L.S.T. had made several trips to Marakei from Tarawa sometime in 1945 or early 1946, to load thatch and wood for the new houses that were then being built on Tarawa. At that time toxic fish were a serious problem on Betio, Tarawa, and this L.S.T. was based on Betio.

The "old men," on this occasion a specially called-together group of experienced fishermen as well as the usual village elders, aver that when the poisoning started they noticed a change in the appearance of the reef flat fronting Rawanawi. They say it appeared to have *tan-tan,* a Gilbertese word used to describe lichens and also certain fungus diseases of the skin. This *tan-tan* was caused by a brown-colored alga of a kind which they had never seen before. The alga began as a small circular patch growing on top of existing algae, sand, or stones, and as the patches grew larger small pieces broke away from the center. As in *tan-tan,* or fungal skin infections, this alga first appeared as a few small patches but spread rapidly, and then gradually died away until only a few patches were left, as at the present time. The "old men" say that this alga first appeared at Rawanawi, and spread along the reef to Buota; they insist that they have never seen it on any other reef on Marakei. This alga was clearly seen on the reef flat at low tide; it is orange-brown in color and grows in circular patches which may be picked up together with the underlying algae. At high tide vast numbers of acanthurids graze along this reef, and appear to nibble at this alga in turn with the other fine varieties on the reef flat. This alga has been identified by Dr. Drouet of the Philadelphia Academy of Science as the blue-green alga *Schizothrix calciola* (Agardh) Gomont.

Unfortunately the "old men" could not remember which species of fish was first noticed to be toxic, but they agree that a specimen of *Cephalopholis argus* was responsible for one of the earliest cases of severe poisoning.

The "old men" said that they continued to eat *Albula vulpes* (Linnaeus), *Chanos chanos,* and one unidentified species of Mullidae, together with flying fish—luckily very plentiful off Marakei—tunas and other deep-sea fishes, and of course fish from the other reefs and the lagoon. Strangely enough, one of the most popular and safe species, provided it was cleaned correctly, was puffer fish.

By 1962, although there had been a great improvement in the condition of the reef, many fish were still toxic. The fish population had increased enormously during the many years' rest, and the Marakei people (whose population had also increased) were not able to resist the easy fishing and disregarded the risk of being poisoned. Cases of poisoning were frequent and became an accepted part of Rawanawi village life.

### *Abaiang*

Abaiang (in U. S. Sailing Directions, Apaiang Island) is a lagoon island just north of Tarawa, with a land area of 11 square miles, a population in 1958 of 3,234, and an annual average rainfall of 83 inches. There is a large lagoon, deep in parts, with an abundance of fish. Small vessels may enter the lagoon but larger ones must remain outside. There was no increase in shipping during the war.

Poisonous fish have never been reported from Abaiang; its people claim that this is entirely due to the efficacy of their magic.

### *Tarawa*

Tarawa, the headquarters of the Colony Government, is a large lagoon island with a land area of 7.5 square miles. The population in 1958 was 6,982 Gilbertese and 141 expatriates; this includes some 1,500 on Betio, a small islet in the southwest. There is an annual average rainfall of 70 inches. Poisonous fish have been known on Tarawa for as long as anyone can remember. The lagoon is large, with extensive barrier reefs on the western side, in the midst of which is the main deep-water entrance to the

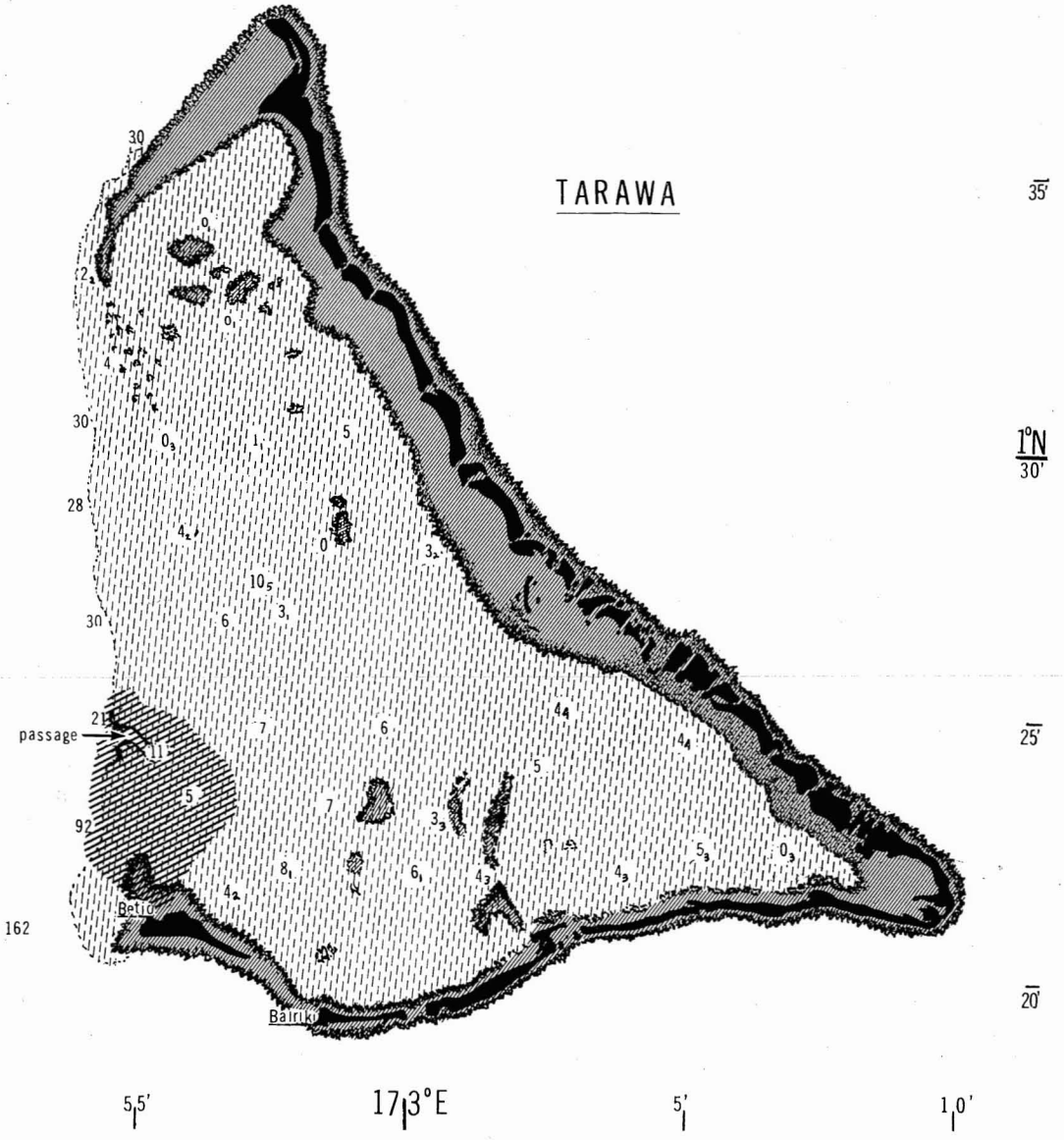


FIG. 4. Map of Tarawa.

lagoon. The anchorage, which is in the southwestern part of the lagoon, is an excellent deep-water anchorage and small ships may anchor very close to Betio. Tarawa, and in particular Betio, may be remembered as the site of the World War II Battle of Tarawa in 1943.

The toxic area on Tarawa (see Fig. 4) is situated in the southwestern part of the atoll. It is centered round the reef which runs north from the west end of Betio, and includes the deep water on the ocean side of the reef and the deep-water entrance which marks its northern extremity. Part of the reefs bordering the other side of the entrance, the ship passage inside the lagoon from the entrance to the anchorage and the parts of the lagoon bordering this passage, and the lagoon beach west of Betio are also toxic.

This toxic area includes deep water, a sub-

merged barrier reef, living coral, sandy areas, and a fringing reef flat that dries out at low-water springs. During normal weather conditions seas are slight on these reefs, but at times of westerly gales heavy surf develops. A very strong current sweeps out over the toxic area from the lagoon during the ebbing tide.

It is not known when poisonous fish first appeared on Tarawa. According to Gilbertese tradition, Betio was notorious for being the place where strangers dare not eat fish for fear of being poisoned. Among the old people the idea is held that toxic fish always have been, and always will be, found on this reef—it is part of the natural order of things. However the war, with the resultant increase in shipping, bombs, wrecks, rubbish, and surplus war material dumped on the reef, is blamed for the violent increase in toxicity in the late forties and early fifties.

There still remains about Betio much of the wreckage of the invasion of 1943, but these wrecks are not well correlated with the toxic areas. Thus landing craft left stranded, now rusted out and disintegrating, are present not only on the toxic reef flat but also on the edges of the inshore reefs all along the lagoon side of the island. Other war wreckage may be found in the deeper parts of the toxic section of the lagoon, but is also found in the nontoxic areas.

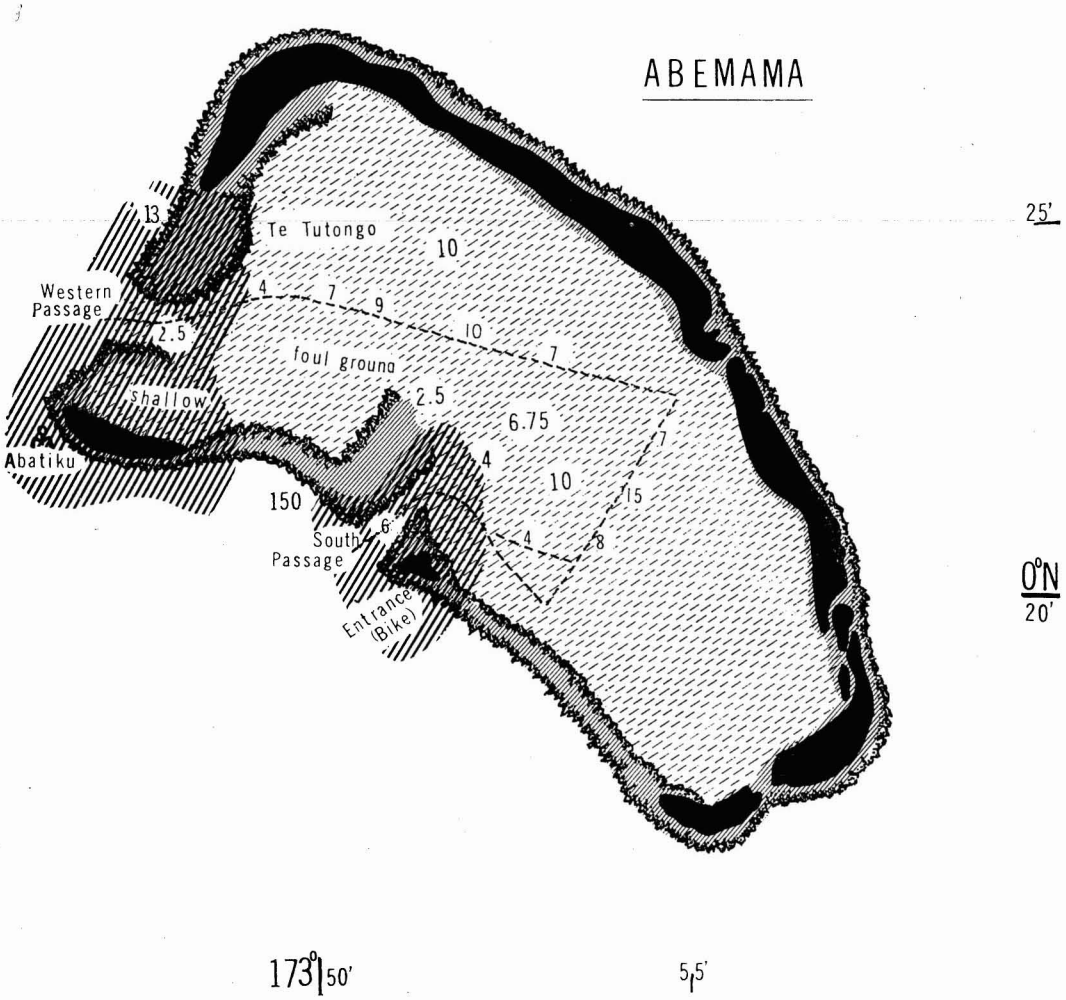


FIG. 5. Map of Abemama.

Finally, although there is a large quantity of ammunition and other materials to be found on the toxic reef flat, there is a considerably greater amount on other reefs which are not toxic. At various times from 1944 to 1963, coral heads have been blasted from the main lagoon entrance and passage to Betio, and from the seaplane alighting area near Bairiki; the former area is toxic, the latter is not.

There are several well-remembered cases of poisoning from before the war, mostly attributed to *te maneku,* large spotted grouper (probably *Epinephelus fuscoguttatus*) and red snapper (probably *Lutianus bohar*). However, the first recorded case was that of an elderly Australian shipmaster in 1944 (Halstead and Lively, 1954) who ate a red snapper. This is commonly thought to have been the start of the toxicity on Tarawa, whereas it was merely the first time it had been brought to the notice of the outside world. It was, however, the start of the resurgence of poisoning.

From 1944 onwards the toxicity increased rapidly, until nearly all the food fish caught in the toxic area were poisonous. The Betio people ceased to fish that area. In about 1956 a slow amelioration began, and by 1960 the reef was considered safe enough for fishing to be generally resumed. In 1961, although sporadic cases of poisoning still occurred, the reef was considered to be clear of toxic fish, and all species were being eaten. A few recorded cases of poisoning since 1958 are as follows:

*1958* A Betio woman died after eating an 18-inch *Epinephelus fuscoguttatus.* I personally investigated this case, as the woman was the wife of a fisherman employed by me. This fisherman had brought this grouper to my house, where he was told it was a toxic fish and was sacked on the spot. He then took the fish home to his wife, who ate it and died.

*1959* Several people ate a large *Lutianus bohar* and two of them were mildly poisoned.

*1961* Two men died after eating a large moray eel. (See above, under Symptoms.)

*1961* Two men were mildly poisoned by a *Lutianus bohar.*

*1962* A man was mildly poisoned by a *Lutianus bohar.*

*1962* The assistant medical officer stationed on Betio and his family were poisoned by a *Lutianus bohar.* (See above, under Symptoms.)

*1962* Two children were mildly poisoned by an *Epinephelus fuscoguttatus.*

*Maiana*

Maiana is a lagoon island just south of Tarawa. There is a land area of about 10.2 square miles, a population in 1958 of 1,359, and an annual average rainfall of 62 inches. Maiana lagoon is fairly large but very shallow, navigable by the smaller colony vessels at high spring tides only. Toxic fish have not been reported from Maiana.

*Abemama*

Abemama (in U. S. Sailing Directions, Apemama) is a lagoon island in the central Gilberts. It is a fertile island, 6.5 square miles in land area, and has an annual average rainfall of 57 inches. The population in 1958 was 1,341, but settlers from the overpopulated southern islands have increased it. There is a large lagoon with two deep water entrances through the reefs on the western side. Toxic fish have been found in both these passages for many years. (See Fig. 5).

The northernmost toxic area is around the Western Passage; it comprises the passage itself, the reefs both inside and outside the lagoon around the point of "land" (in fact, a reef flat known as Te Tutongo) on the north side of the passage, and the reefs around the islet of Abatiku on the south side of the passage. A vessel owned by Burns Philip and Co. was wrecked on Te Tutongo about 1917, and the poisoning is said to date from this time. Parts of the engines of this vessel are still visible on Te Tutongo at low tide, and the Abemaman people think that some fish will remain toxic until all the ship's remnants have disintegrated. The condition of the reefs around the islet of Abatiku began to improve about 1947; and in December, 1961, both there and in the passage, an occasional *Lutianus bohar* or *Epinephelus fuscoguttatus* were the only fish found to be poisonous. On the reefs around Te Tutongo some acanthurids were still poisonous, as well as the above species.

The southernmost toxic area comprises the South Passage and the reefs around the islet of

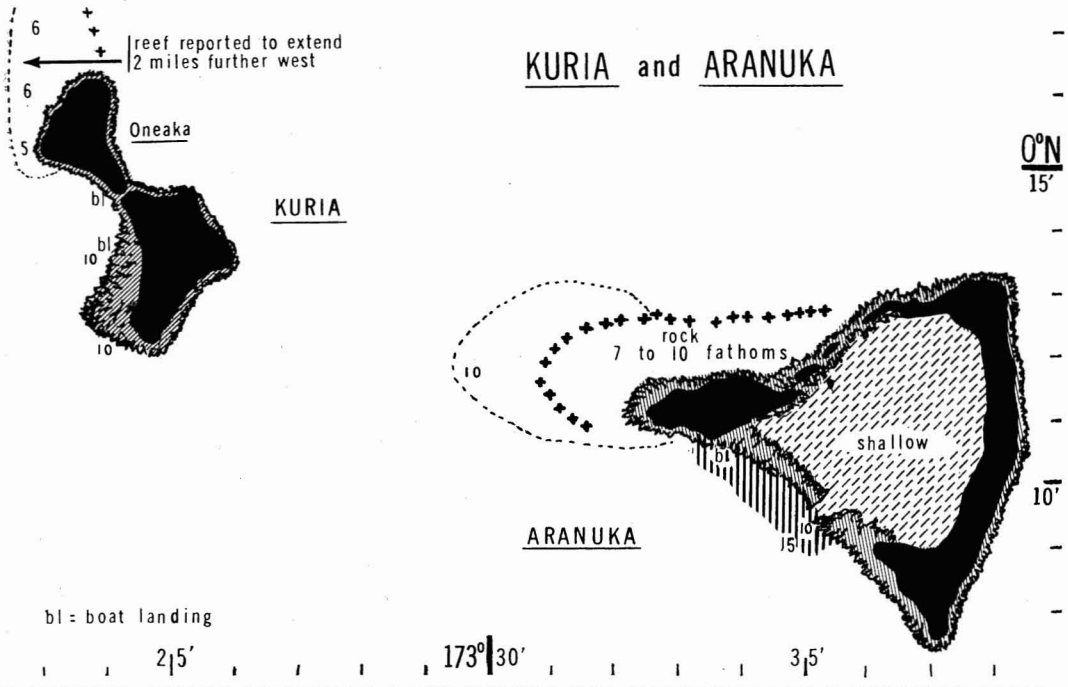


FIG. 6. Map of Kuria and Arunuka [Aranuka].

Bike, to the south of the passage. A ship remembered as "Te Tambou" sank in this area some 60 years ago and is blamed for the start of the poisoning. An occasional extra-large specimen of *Lutianus bohar* or *Epinephelus fuscoguttatus* are the only species to have caused poisoning here for many years.

Although these two areas are so close together, the islanders maintain that there has always been a stretch of reef between them which has been free of toxic fish.

Before the war large *Caranx* spp., which were often caught by ships' crews in the deeper water off the passages, were said to have been especially poisonous. During World War II many ships were anchored in both these passages, but there does not seem to have been any increase in the toxicity.

In 1961 details were collected from different old men, including the island magistrate, who swore that eels had never been toxic on Abemama. This is contrary to the information collected in 1958, when the author was told that large eels were poisonous in both toxic areas. It is possible that the small and comparatively wealthy population of Abemama is not forced to fish for eels in these localities, and that they and the new settlers have forgotten the last time someone was poisoned.

*Kuria*

Kuria is a reef island, 5 square miles in land area, in the central Gilberts, with a population of 541 in 1958; the annual average rainfall is 55 inches. There are two islets, joined and surrounded by extensive reefs. Toxic fish have not been reported from Kuria.

*Arunuka*

Arunuka is a lagoon island in the central Gilberts, with an annual average rainfall of 53 inches. The lagoon is full of coral heads and is not navigable except by launches. Ships must anchor by the entrance to the lagoon on the west side of the island. (See Fig. 6.)

The population of Arunuka, a mere 571 in 1958, is very small for the size of the island, which is nearly 6 square miles in land area. Many of these people are settlers from the overpopulated southern islands. These settlers do not

know the reefs around the island, nor the traditions associated with fish on Arunuka. This and the fact that the small population finds plenty of fish in the lagoon for all their needs, mean that there is a lack of local knowledge concerning the outside reefs. In fact, the present Arunukans maintain that there are no poisonous fish on the island. However, many people, all members of ships' crews, have been poisoned at Arunuka; the fish have been caught either in or somewhere near the anchorage, or on the reefs on the north side of the anchorage by an uninhabited islet. It has not been possible to find out the exact positions of the reefs that are considered to be toxic, and those marked on the map of Arunuka are tentative only. It is definite, however, that toxic fish have not been found inside the lagoon.

It is not known when fish became toxic on Arunuka, but between 1929 and 1937 many species are reputed to have been dangerous to eat. Just before World War II two members of the crew of the Burns Philip vessel *Moamoa* ate a large *Epinephelus fuscoguttatus* which had (probably *Epinephelus fuscoguttatus*), and were severely poisoned. Another time, according to one old Arunukan, a whole village went out communal fishing and caught "over one hundred big grouper," of which only one fish was poisonous, and the unlucky family who consumed it were very ill.

Despite the Arunukans' ideas to the contrary, all the ships' crews still consider that large *Lutianus bohar, Epinephelus fuscoguttatus,* and Muraenidae are toxic when caught in or near the anchorage. In January, 1962, the crew of the Co-operative vessel "Aratoba" were poisoned by a large *Epinephelus fuscoguttatus* which had been caught by the reefs on the north side of the anchorage.

*Nonouti*

Nonouti is a lagoon island in the southern Gilberts, with a land area of nearly 10 square miles and a population in 1958 of 2,143. There is an annual average rainfall of about 50 inches. Poisonous fish have been known on Nonouti for many years. Ships may enter Nonouti lagoon, which is large, north of Autaken reef (see Fig. 7), but the passage is not easy and many ships' masters prefer to remain at anchor just south of Autaken reef and work the island by boat. The toxic area is around this southern anchorage and includes the neighboring reefs. There are no toxic fish inside the lagoon.

The "old men" of Nonouti told us that they could not remember a time when fish were not toxic on this reef—which memory probably dates back 50 years to 1910—but that they remember hearing that a vessel was wrecked there in 1890, and that this was the start of the poisoning in the area. The Gilbertese name for this area, *Te Tamni* (not on the Admiralty charts), was derived from the name of the wrecked ship. The Nonouti people are not quite certain which species are still toxic there because, from long-standing custom, they do not fish on those reefs. However, crews of all ships do fish in the anchorage, and they say that in 1948 and 1949 very many fish were toxic on these reefs and that by 1958 only a few species remained poisonous. In 1962 *Lutianus bohar,* all large Muraenidae, and any particularly large groupers (Serranidae) were the only fish they considered still remained toxic.

Eels are very plentiful on Nonouti, and a specialty of the island is dried eel. Eel traps are set in the deep water of the lagoon and boat passages. The large eels which are so caught are cut into pieces and dried in the sun. The resulting rather smelly, very greasy pieces of fish are sold for a remarkably high price to the Chinese on Nauru. The "old men" say that, as long as the eels are taken only from the lagoon and boat passages, they are not toxic, and that by customary law no Nonouti fisherman would dare to trap eels outside the lagoon.

*Tabiteuea*

Tabiteuea (in U. S. Sailing Directions, Tapiteua), the largest of the Gilbert Islands, with a land area of 19 square miles, is a lagoon island in the south. The population in 1958 was 3,266, and the annual average rainfall is 47 inches. There is an extensive area of reefs and shoal patches lying to the west of the southern portion of Tabiteuea. These reefs are not shown on the Admiralty chart, as the survey of Tabiteuea is not yet completed. Somewhere among these reefs is a shoal patch known on Tabiteuea as Takoronga Inanon, which at times is large enough to be covered with a growth of *Scaevola frutescens,* and at other times is a mere sandbank

awash at high tide. The reefs all around this islet harbor toxic fish, and the area is extensive enough to include the entrance channels into south Tabiteuea (see Fig. 8).

A vessel of some sort is said to have been wrecked on Takorongo about 1919, and the poisoning dates from that time. Although many fish remained very toxic for many years, occasional fishermen continued to visit the area because there were so very many fish there that the temptation was great enough to risk poisoning. Men who had dived there said that the ribs and keel of a vessel are to be seen near Takorongo, and that other remains are scattered over the area.

In 1958 many species still remained toxic off Tabiteuea, although the Tabiteueans considered that there were fewer than there had been. By 1962 still fewer species were considered toxic, but it was not possible to obtain details of which

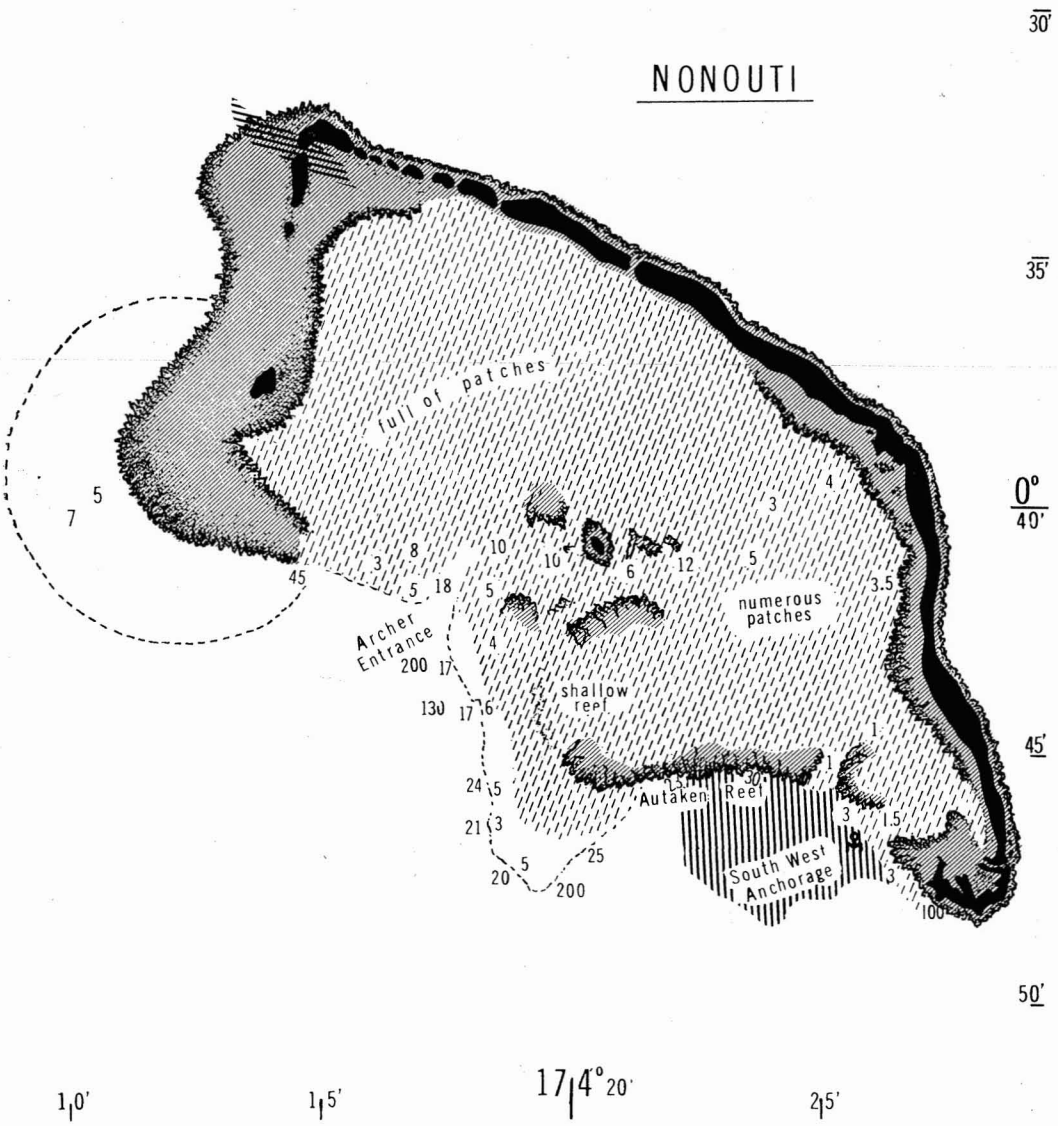


FIG. 7. Map of Nonouti.

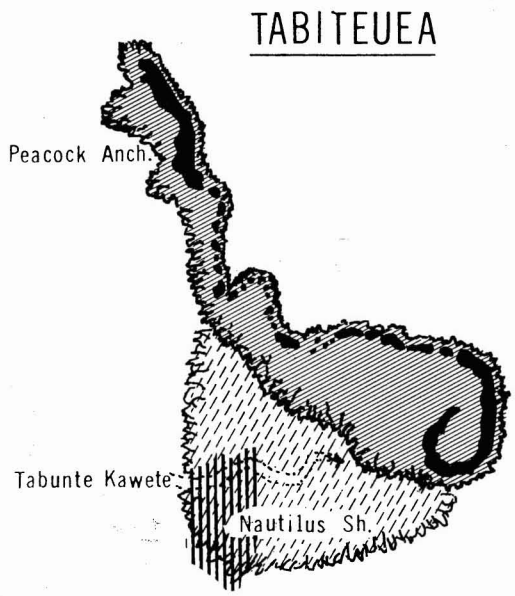


FIG. 8. Map of Tabiteuea.

species remained poisonous. In December, 1961, both the mate of the colony vessel "Moanaroi" and a passenger, Mr. H. R. Cooper (husband of the author), were mildly poisoned by an unidentified fish caught in the entrance passage to south Tabiteuea.

*Beru*

Beru is a lagoon island in the southern Gilberts, with a land area of 8.15 square miles. The population in 1958 was 1,968 and the annual average rainfall is 49 inches. Until recently, the headquarters of the Gilbert Islands Mission of the London Missionary Society was located there. Toxic fish have been known on Beru for as long as anyone can remember. Ships cannot enter the lagoon, which is very shallow with extensive sandbanks at low tide and is considered to be silting up. (See Fig. 9.)

There are three anchorages on Beru, one in the south, off the village of Taboiaki, which was in use many years ago. In about 1936 a boat passage was blasted at Espiegle Anchorage in central Beru by the London Missionary Society and this became the main anchorage. The boat passage has gradually silted up, and the southern and northern achorages have been used more than Espiegle Anchorage in recent years. It is around the southwestern anchorage that toxic fish are found, opposite the village of Taboiaki. This area is a leeward fringing reef and does not include any part of the lagoon.

The Beru people say that long ago a New Zealand ship was wrecked on this reef, and that the poisoning dates from that time. They say that at times many species may be toxic, at other times only a few, but that this variation appears to follow no rules. Beru is a dry, poor island and population pressure forces the people to continue to fish this reef in spite of the risk of severe poisoning.

The poisoning caused by toxic fish on Beru appears to be more severe than on other islands. The staff of the London Missionary Society report that cases of poisoning among their students—many of whom were from other islands—were often severe enough to cause paralysis. In the late thirties several people became ill after eating a *Lutianus bohar* and were taken to the London Missionary Society's headquarters, where two men died. (This is a well-remembered incident, as the victims were all Roman Catholics.) Other deaths are remembered and red snapper (probably *Lutianus bohar*), *te ingo,* is blamed for most of them.

In January, 1962, the Beru people said that there were far fewer fish toxic than in 1958,

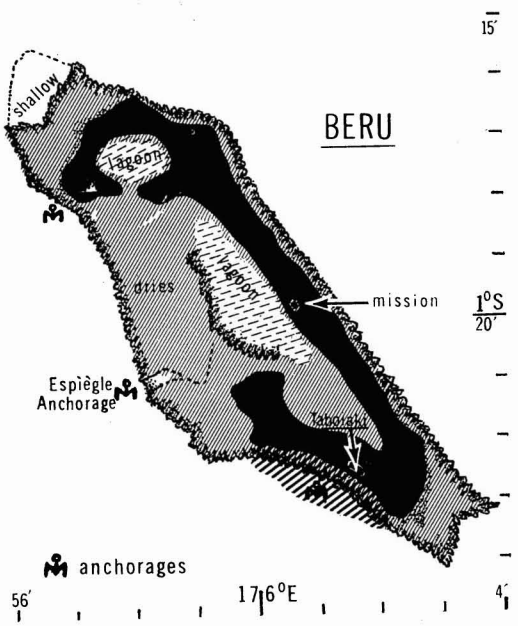


FIG. 9. Map of Beru.

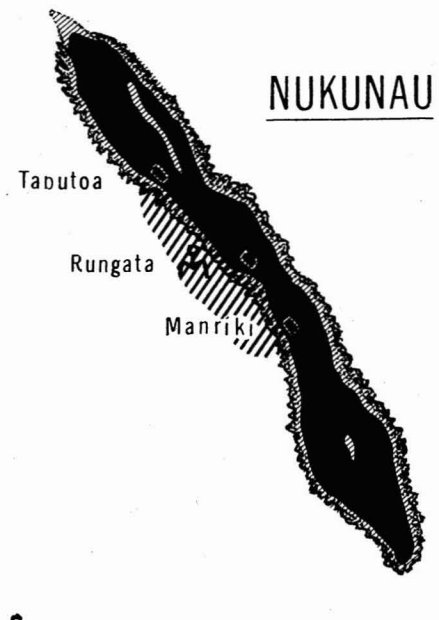


FIG. 10. Map of Nikunau [Nukunau].

and that they were eating everything except large Muraenidae and the uncommon, enormous *Promicrops lanceolatus*. However, they said that they were taking a risk, and that any specimen of *Lutianus bohar, Epinephelus fuscoguttatus,* or *Cephalopholis mineatus* could be poisonous.

*Nikunau*

Nikunau is a reef island in the southern Gilberts with a population in 1958 of 2,011 and a land area of about 7 square miles. Although the average annual rainfall on Nikunau is the same as Onotoa's, 44 inches, and differs only by a few inches from several other islands, it appears to be a much drier island and is subject to severe droughts. Poisonous fish have been known on Nikunau for a very long time.

The toxic area is on the western or lee side of the island (see Fig. 10), and stretches along the fringing reef from the village of Tabutoa in the north to the village of Manriki in the south. Between these two villages is the village of Rungata, the Government Station and main anchorage. There is a boat passage through the fringing reef in front of the village. The reef flat is alga-covered and there are luxuriant corals in the deeper water.

A vessel is said to have been wrecked on the reef by Rungata village at some time in the past, and the poisoning dates from that wreck. The Nikunau people say that the poisoning began at Rungata, but spread north and south along the reef. After a while it began to recede and the reefs near Manriki and Tabutoa have always produced fewer toxic fish than those in the center by Rungata. At one time very many species were toxic, but by January, 1962, all species, except large Muraenidae, were being eaten; the occasional large specimen of *Lutianus bohar* may still cause mild poisoning.

In 1955 the Sacred Hearts Mission ship, "St. Teretia II," driven on to the reef by a very local westerly current and wind, was wrecked opposite Rungata village. However, this accident appears to have made no difference to the toxicity of the reef.

*Onotoa*

Onotoa is a lagoon island in the southern Gilberts with a land area of 5.21 square miles and a population in 1958 of 1,542 people. It is another dry island subject to drought and having an average annual rainfall of 44 inches. Poisonous fish have been known on Onotoa for many years. The toxic reef is in northwest Onotoa, is known as Aontebeba (see Fig. 11), and is considerably smaller than other toxic areas in the Gilbert Islands. There are three anchorages outside the lagoon on Onotoa, and the toxic reef lies just to the north of the northernmost anchorage. A ship is said to have been wrecked on Aontebeba during a southwesterly gale, and the poisoning dates from that time. It has not been possible to discover when this wreck took place; it was, however, a very long time ago.

Onotoans say that at one time very many species of fish were toxic on Aontebeba, but that their numbers have declined and the reef has been considered to be clear of toxic fish for some years. However, Onotoans still will not eat large Muraenidae caught there and admit, though somewhat reluctantly, that the occasional large *Lutianus bohar* is still found to be mildly poisonous.

*Tamana*

Tamana is a very tiny reef island in the southern Gilberts; the land area is a mere 2 square

miles, the population in 1958 was 1,142, and the average annual rainfall is 48 inches. There is a poor anchorage on the western side of the island, opposite the only village. Toxic fish have never been reported from Tamana.

*Arorae*

Arorae is a small reef island and the most southerly of the Gilbert Islands. There was a population in 1958 of 1,551 and a land area of 5 square miles. There are three anchorages, all described as poor. Toxic fish have never been reported from Arorae, and both the Tamana and Arorae people are most indignant at the idea that either island could ever produce a toxic fish.

The fringing reefs on Arorae are wide, especially in the north and south. A ship is reputed to have been wrecked on the southernmost tip of Arorae, but there is no sign of any remains.

*Ocean Island*

Ocean Island, lying 160 miles west-southwest of Tarawa, is not in the Gilbert Archipelago although it is a part of the Gilbert and Ellice Islands Colony. Ocean Island is a higher island than the low atolls of the Gilberts, and has an annual average rainfall of 68 inches. It rises to 265 ft, and beyond the fringing reefs drops abruptly to great depths. The fringing reef is rather different from those of the atolls, being composed in places of much rougher rocks; there are steep cliffs of very sharp weathered rock and few sandy beaches. There are, as on the atolls, deep surge channels in the edges of the reefs. There are deep pools on the reef flat, joined by tunnels in the reef, and living corals grow luxuriantly in these more protected waters. There is a very large fish population, composed not only of reef dwellers, but also of oceanic and deepwater species.

Ocean Island has large deposits of phosphates which have been worked since the early 1900s. Phosphate-loading vessels tie to moorings laid in very deep water. There is an old boat harbor with a wide deep passage through the reef on the western side which was blasted out of the reef in 1904. Since then a large new harbor has been built on the southeastern side, entailing extensive blasting of the reef. There is much cement and iron work on the reef, both in use and in the process of disintegrating from the old and new cantilever piers.

All rubbish is thrown over a chute on these cliffs, to fall on the reef beneath; from there it is slowly washed away by high tides. Sewage is pumped out over the reef. The "Ocean Trader" was wrecked sometime ago on the southeast side, and was followed in 1952 by the "Kelvinbank," which went on the reef on top of the remains of the previous vessel. The wrecks are still there, slowly disintegrating. During normal trade winds, blowing from the northeast through southeast, there is heavy surf on the eastern side of the island, but westerly weather is apt to cause heavy seas to beat all round the coast.

In spite of all this reef damage extending back over 60 years, no poisonous fish have ever been reported from Ocean Island.

*Discussion*

Of the 16 islands in the Gilbert Island archipelago, 10 have toxic reefs where certain species of fish have been poisonous for varying lengths of time. These "toxic" islands are Tarawa, Abemama, Arunuka, Tabiteuea, Beru, Nonouti, and Onotoa, lagoon islands, and Nikunau, a reef island, on all of which some fish have been toxic for many years; on Butaritari and Marakei, toxic

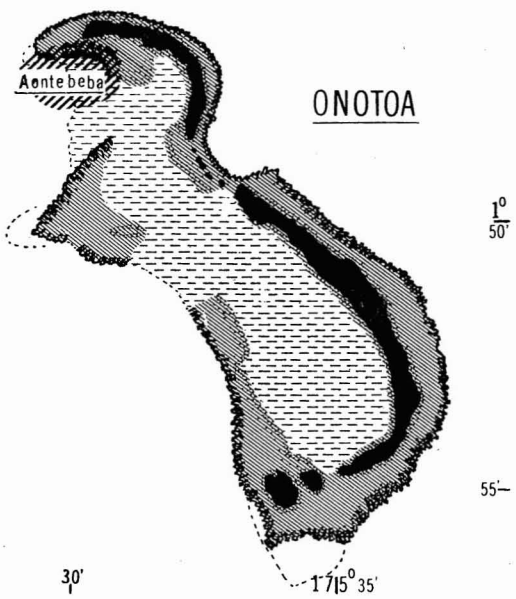


FIG. 11. Map of Onotoa.

fish have appeared only comparatively recently. The remaining six islands, Abaiang and Maiana, lagoon islands, Makin, Kuria, Tamana, and Arorae, reef islands, have no history of toxic fish.

The toxic area on all these islands is in the same relative position on the atoll; that is, each toxic area is on the sheltered lee side, either in the northwest, west, or southwest. This finding does not agree with Brown (1945), who reports that in the Bahamas the windward, exposed areas are more likely to be toxic than the leeward, sheltered ones. On a few islands part of the lagoon is toxic, but in no case is the toxicity confined to the lagoon; no non-navigable lagoon has any toxic reefs. Randall (1958) suggests that a body of water set off from the ocean by reefs may be more likely to contain toxic fish than more open water. In the Gilberts, although all the toxic reefs are in reasonably sheltered areas, there is a steady but not powerful ocean current, as well as currents caused by ebbing and flowing tides constantly washing over them.

The islands of the Gilberts vary from wet toxic Butaritari (125 inches) and dry toxic Nikunau (44 inches), to wet nontoxic Makin (107 inches) to dry nontoxic Tamana (48 inches). There is no island in the Gilberts with a fresh water stream, nor is the rainfall ever heavy enough to cause run-off.

Wrecks are often cited as the location and cause of a toxic area (Randall, 1958). In the Gilberts, on no less than seven toxic reefs out of eleven, wrecks are given as the reason for the start of the toxicity. Of these seven wrecks only one may still be seen (on northern Abemama); the rest are merely remembered. Within the last thirty years there have been five authenticated wrecks, two at Ocean Island, two at Butaritari, and one at Nikunau, none of which appear to have had any effect on the areas concerned. The Nikunau reef was already toxic when the wreck occurred, but the toxicity was not increased. The two wrecks at Butaritari occurred within a couple of years of each other, during the Pacific war, but the toxicity was not reported from Butaritari until some years later. It should be noted that all the wrecks referred to are in or very near anchorages or passages to navigable lagoons.

Again, heavy reef damage has been suggested as a possible factor in the chain of events leading to toxicity (Randall, 1958). Yet damage to the Makin lee fringing reef (by storm), to Beru lagoon reef (by blasting), and to Ocean Island reefs (by continual blasting and workings) produced no change in toxicity. Of particular interest is Beru, where the fringing reef downcurrent from the blasted area was already toxic. However, on Tarawa there was a resurgence of the toxicity following the Battle of Tarawa with its reef damage, wrecks, and heavy casualties on the reefs, all of which must have produced at least a temporary change in the ecology of the reef areas around Betio.

Vessels not only anchor in the usual cargo-working anchorages, as at Tarawa, Butaritari, Arunuka, Onotoa, and south Nonouti, where all these anchorages are in toxic areas, but, as may not be generally realized, vessels planning to enter a lagoon often must first anchor outside, in the entrance, or even in the passage itself, to await the optimum angle of the sun's rays before navigating the unmarked channels through the reef patches. In these days of radar and depth indicators this approach is not so vital as it was a few years ago. It has been found that these anchorages at lagoon entrances and in reef passages are frequently toxic, as at Tarawa, Abemama, Butaritari, and Tabiteuea. Nonouti is an island with a very difficult entrance into the lagoon, and many ships' masters prefer to work the island from the southern anchorage (which is toxic), or to wait there before attempting to navigate the entrance which is to the north of Autaken reef. Nikunau and south Beru have rather poorer anchorages than the islands so far mentioned, but nevertheless vessels do anchor off these places to load cargo and, once again, these anchorages are toxic.

Fanning Island, often quoted in papers on ciguatera (Randall, 1958; Banner et al., 1960), is another example of an atoll where the anchorage is toxic. In fact P. F. D. Palmer is quoted by Randall (1958) as saying that the areas where fish were toxic were only where the ships anchored. Randall continues to say that in the Line Islands where toxic fish appeared large ships had previously been anchored. The toxic area on Palmyra is also near the channel entrance (Banner et al., 1960). The toxic area on Christmas Island in 1953–54 was in and around the anchorage by the main lagoon entrance; since that time it has extended southward a con-

siderable distance (Helfrich, unpublished data).

It is of interest that, with the exception of Abaiang, islands which are free of toxicity have the worst anchorages and are islands where vessels must often drift while working cargo (for instance Makin, Kuria, Tamana, and Arorae). Marakei, another island with a very poor anchorage, is toxic, but it has been suggested that the cause of toxicity was an L.S.T. which was able to "land" on the reef. Abaiang, an island with excellent anchorages for small ships inside the lagoon, is near enough to Tarawa for vessels to time their arrival so that they may enter the lagoon at daylight without anchoring in the entrance. Larger vessels, infrequent at Abaiang, must drift off the island. Maiana, another nontoxic island very close to Tarawa, has a very shallow lagoon, navigable only by the smaller colony vessels (length about 50 ft) at high spring tides. All cargo and copra is worked on Maiana by these vessels or by larger vessels on the drift.

Washington Island, in the Line Islands, so often cited as one which is inexplicably free of toxic fish (Randall, 1958; Banner et al., 1960; Bouder et al., 1962), under normal conditions has no anchorage. Continual, heavy surf beats all around the atoll. Cargo, copra, and passengers must be moved in surf boats, while the vessel being loaded drifts some way off the island.

From evidence in the Gilbert and Ellice Islands Colony, it would appear that shipping may in some way be associated with the spread of toxicity. Allen (1953) discusses the large part played by ships in the world-wide distribution of a variety of marine invertebrates. He suggests that, as well as invertebrates, certain algae, in particular *Enteromorpha intestinalis* (Linné) and *Ulva lactuca* (Linné), may owe their almost universal distribution to ships. There is a minimum number of new organisms, he says, that must be introduced to start a new population, and concludes that in Australia harbors are the logical place for this to happen. In the Gilbert Islands there are no harbors, but merely anchorages; and it may be noted that all the most frequently used anchorages (lying outside lagoons) in the Gilbert Islands are toxic. Perhaps this means that there is a particular organism found in and around these anchorages which is not found elsewhere in the Gilbert Islands. If wrecks are indeed "the cause" of toxicity, perhaps the wrecked vessels were carrying this organism, which then spread along the reef.

## OTHER TYPES OF POISONING

### *Sharks' Liver Poisoning*

The liver from large sharks is thought to be potentially poisonous throughout the Gilberts, whether the shark is caught in a lagoon or in the ocean. The Gilbertese have a great liking for shark flesh, considering it more digestible than the flesh of other fish. In particular they like the liver; sometimes this is made into a kind of sausage, using the shark intestines as the casing. Not all large sharks have toxic livers; certain species are more likely to be toxic than others. According to the Gilbertese the most dangerous species are the tiger shark, *Galeocerdo cuvieri* (Lesueur), and the "white tipped lagoon shark" (possibly *Triaendon obesus* [Ruppell]), but they say that any exceptionally large shark may have a toxic liver.

The different assistant medical officers consulted say that there appears to be no difference in the symptoms caused by sharks' liver poisoning and those caused by toxic teleost fishes; their list of symptoms for sharks' liver poisoning is the same as that described under ciguatera poisoning. However, the poisoning caused by toxic sharks' liver is extremely rapid and severe; the victims often become comatose after suffering from severe vomiting, stomach cramps, and diarrhea. There are no Gilbertese remedies for sharks' liver poisoning other than those given for ciguatera.

It has been considered that sharks' liver poisoning may be due to an excess of Vitamin A (Lonis, 1950). However, in 1949 samples of sharks' livers from the Gilberts were analyzed for Vitamin A content with a view to starting an industry. The report stated that there was insufficient Vitamin A to make commercial extraction worthwhile. The Vitamin A content of livers from several species of sharks from various areas in the tropical Pacific was also investigated by the U. S. Fish and Wildlife Service in 1949; none were found to contain enough to be used as a commercial source (unpublished report).

The traditions associated with sharks' liver poisoning vary slightly from island to island, but

inhabitants of all islands, with the exception of Abaiang, agree that the liver of large sharks can be very poisonous. The Abaiang people maintain that their magic prevents sharks from having toxic livers in the same way as it prevents their fish from producing ciguatera; they are not really believed by other islanders, who ridicule them, but not within their hearing. The Marakei people say that sharks caught at night are more likely to have poisonous livers than those taken during the day. Arunukans, Abemamans, and Butaritarians say that a toxic liver is always longer than a nontoxic one and has one lobe doubled back underneath itself. Others say that a toxic liver is darker than a nontoxic one or has dark spots on it. There are the same superstitions as there are for toxic fish; i.e., flies will not settle on a toxic liver, a silver coin is blackened, or grated coconut turns green when cooked with a toxic liver.

Several people died on Beru in 1957 after eating some tiger shark liver; again in 1960 and 1961 people died on Tabiteuea, poisoned by liver from the same species.

Shark flesh has never been reported to be toxic in the Gilbert Islands.

*Poisoning by Tetraodont and other Plectognath Fishes*

Puffer fishes, species of the family Tetraodontidae, are rather uncommon in the Gilberts, although on certain islands in other parts of the colony, particularly Fanning Island, they are very plentiful. Puffer fish poisoning is well known to the Gilbertese who, on the whole, do not especially like to eat these fish. Nevertheless, there are many people who do eat them; and they say that, provided the fish is skinned and gutted and the ovaries are removed immediately while the fish is still alive, the flesh will not be poisonous. Sometimes, despite these precautions, a puffer may still be deadly. On Maiana a large blue puffer fish, probably *Lagocephalus lagocephalus* (Linnaeus), which was taken at sea on a bait for flying fish, severely poisoned all who ate it, killing two, in spite of being "correctly" cleaned when it was caught.

Porcupine fish, Diodontidae, are considered far too toxic to risk eating. The toxin is thought by the Gilbertese to be concentrated in the ovaries, and they say that "even if only one egg is broken" the fish will be deadly. Sharp back puffers, *Canthigaster* spp., are also known to be deadly poisonous, but these little fish are too small to be used as food; *Canthigaster solandri* (Richardson) is the only species of any interest to the Gilbertese, as this species is used for fighting in the same way as are the Siamese fighting fish.

Trigger fish, Balistidae, are eaten whenever caught, but the majority are not particularly liked. Large specimens of *Pseudobalistes flavimarginatus* (Ruppell) or *Rhinecanthus aculeatus* (Linnaeus) are considered to be more tasty than other kinds of Balistidae. These fish do not appear to be toxic all the time, and the Gilbertese say that they have always eaten them with impunity. Trigger fish may be very poisonous, however, in a ciguatera-producing area, but only when the outbreak of poisoning is at its height.

File fish, Monocanthidae, are not at all liked as food fish, but are occasionally eaten and do not appear to cause poisoning. The flesh of *Aleutera scripta* (Osbeck) is described as being rather bitter, but this fish was eaten in times of famine and does not have the reputation of being poisonous.

*Hallucinatory Mullet Poisoning*

The heads of certain species of mullets, Mugilidae, and of certain species of surmullets, Mullidae, have the reputation of causing a mild form of poisoning, described by some Gilbertese as a "madness," by others as a "forgetfulness," or "sleepiness." It was very difficult to get Gilbertese to admit to any knowledge of this form of poisoning. Fuller inquiries showed that the heads of certain of these fish were eaten with the full expectation and possible enjoyment of the hallucinations or dreams which followed.

Helfrich and Banner (1960) reported that in Hawaii this form of poisoning is restricted to certain localities and times of the year. Sufficient information was not obtained from the Gilbertese to be able to decide if this was true in the Gilberts or not.

It may be of interest to note that the Gilbertese consider two more species of fish capable of causing a "madness" or "forgetfulness" form of poisoning, *Epinephelus corallicola* (Cuvier

and Valenciennes) and *Abudefduf septemfasciatus* (Kendall and Goldsborough). These fish are customarily eaten only by the old people—who are forgetful anyway. It was not possible to find out if these fish were at times genuinely "toxic," or merely considered so on account of their habits.

*Scombroid Poisoning*

There is no evidence of any scombroid poisoning in the Gilbert or Ellice islands. This type of poisoning appears to be caused by a bacterium (Kawabata et al., 1956), which may be found in the flesh of certain scombroid fishes. This microbe reacts on certain chemicals in the flesh of the fish when too long a time is allowed to elapse between catching and cooking the fish. The reaction is quickened by tropical temperatures. In the Gilberts scombroid fishes of various species are frequently caught early in the morning and left in the sun, and later the flesh is salted for consumption the next day. No poisoning has been reported, and it is thought that the scombroid fishes inhabiting this part of the Pacific are not infected with the specific bacterium (Banner, personal communication).

*"Castor Oil" Fish Poisoning*

On a few islands where the sea is very deep, close to the shore is found the castor oil fish, *Ruvettus* sp. Although this is a favorite food, it has the reputation of causing poisoning from the purgative properties of the oil in its flesh (Fish and Cobb, 1954). The choicest part of the fish is considered to be the roe, which is boiled whole, but the flesh is eaten as well. If the fish is cooked soon after catching, no "poisoning" results. However, the Gilbertese, and in particular the Ellice people, are well aware of its purgative properties; indeed, if there is a prolonged shortage of them, perhaps due to rough seas, the amount of epsom salts sold by the stores increases to quite staggering proportions.

*Clupeoid Poisoning*

During the time that the author was in the Gilberts, clupeoid poisoning was unreported. However, in November 1962 two children are reported to have died and other people have been taken ill after eating "sardines" (*te tarabuti*) caught off Betio, Tarawa. No details are known, except that there were two separate catches involved.

Some years ago at Bairiki, Tarawa, a woman died after eating what was described as "sardines" (possibly *Harengula* sp.). This woman was the only person taken ill among a number of people who ate the catch. At the time she was blamed for her own death, as she threaded her fish on an old piece of corroded brass wire before cooking them, instead of using a piece of coconut midrib: it was considered that she had died from copper poisoning.

*Turtle Poisoning*

The hawksbill turtle, *Eretmochelys imbricata* (Linnaeus), is considered to be deadly poisonous throughout the Gilbert and Ellice islands. It is not generally eaten, but occasionally one will be eaten in error, either in mistake for the green turtle or by someone who does not know the hawksbill's reputation.

The poisoning caused by the hawksbill is very severe, and the Gilbertese describe it as being similar to ciguatera but very much worse. It is so rare for anyone to eat this turtle, and so to be poisoned, that none of the assistant medical officers who were consulted had ever seen a case. The details of the following cases were supplied by eye witnesses on whom the severity of the poisoning had made an everlasting impression.

On Arorae, about 15 years ago, a group of people ate a hawksbill turtle. All of them became very ill and five of them died. Their symptoms were described as follows: vomiting; very severe stomach ache, and diarrhea; their skin was "very hot to touch; they were very thirsty, but something was wrong with their mouths and they were unable to drink; they were unable to move their arms and legs; finally, their skin peeled off as if they had been cooked." One man was so severely poisoned that he is said to have died less than a day after he ate the turtle, but even in that short time he peeled. The others died at various intervals, the longest surviving about a week.

The symptoms in a more recent incident on Tabiteuea involving an unknown number of people were described as follows: vomiting; severe stomach ache, and diarrhea; gradual paralysis; flaking skin, leaving great sores, especially

## Summary of Toxic Conditions in the Gilbert Islands

| ISLAND TYPE | | BUTARITARI Lagoon | | MARAKEI Lagoon | | TARAWA Lagoon | | ABEMAMA N. Lagoon | | ABEMAMA S. Lagoon | | ARUNUKA Lagoon | | NONOUTI Lagoon | TABITEUEA Lagoon | | BERU Lagoon | | NIKUNAU Reef | | ONOTOA Lagoon | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ANNUAL AVERAGE RAINFALL (IN INCHES) | | 125 | | 79 | | 70 | | 57 | | 57 | | 53 | | 50 | 47 | | 49 | | 44 | | 44 | |
| YEAR TOXICITY COMMENCED | | About 1948 | | 1946 | | Unknown; resurgence 1944– | | Unknown (1917?) | | Unknown (more than 50 years) | | Unknown; but resurgence 1929–37 | | Unknown (1890?) | Unknown (1919?) | | Unknown (more than 40 years ago) | | Unknown (more than 40 years ago) | | Unknown (more than 40 years ago) | |
| SPECIES TOXIC IN YEAR STATED | COMMONEST VERNACULAR NAME | 1958 | 1961 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1962 | 1958 | 1962 | 1958 | 1962 | 1959 | 1962 | 1958 | 1962 |
| *Holocentrus* spp. (Gunther) | Ku | | | + | | | | | | | | | | | | | | | | | | |
| *Myripristis* spp. (Cuvier) | Mon | | | + | | | | | | | | | | | | | | | | | | |
| *Epinephelus merra* (Bloch), and allied species | Kuau | | | + | | | | | | | | | | | ? | | | | | | | |
| *E. corallicola* (Cuv. & Val.) | Kuaurang | | | + | | + | | + | | | | | | | ? | | | | | | | |
| *E. fuscoguttatus* (Forskål) | Maneku | + | L+ | + | + | + | L+ | + | + | | | + | L+ | L+ | + | ? | + | L+ | + | ? | L+ | ? |
| *Cephalopholis argus* (Bloch & Schneider) | Nimanang | | | + | + | + | | + | ? | | | | | | + | ? | + | | | | | |
| *C. mineatus* (Forskål) | Nrekereke | + | | + | + | + | | + | ? | | | | | | + | ? | + | + | | | | |
| *Plectropomus truncatus* (Fowler) | Rekimoa | + | | + | + | + | | ? | ? | | | ? | ? | ? | + | ? | ? | ? | ? | | | |
| *Variola louti* (Forskål) | Bukitakeiau | ? | | + | + | + | | + | | | | | | | + | | | | | | | |
| *Promicrops lanceolatus* (Bloch) | Bakati | L+ | L+ | + | + | L+ | L+ | L+ | L+ | ? | ? | ? | ? | ? | ? | + | + | L+ | ? | L+ | ? | ? |
| *Caranx* spp. (undetermined species) | Tauman, Aurua | ? | | + | L+ | L+ | | L+ | | | | | | ? | L+ | | ? | | | | | |
| *C. lugubris* (Poey) | Aongo | L+ | | + | + | L+ | | L+ | | | | | | ? | L+ | ? | ? | | | | | |
| *Acanthurus* spp. (undetermined species) | Riba | ? | | + | + | + | | + | + | | | ? | ? | ? | ? | ? | + | | | | | |
| *A. triostegus* (Linnaeus) | Koinawa | | | + | | | | | | | | | | | ? | ? | | | | | | |

SUMMARY OF TOXIC CONDITIONS IN THE GILBERT ISLANDS (cont.)

| ISLAND TYPE | | BUTARITARI Lagoon | | MARAKEI Lagoon | | TARAWA Lagoon | | ABEMAMA N. Lagoon | | ABEMAMA S. Lagoon | | ARUNUKA Lagoon | | NONOUTI Lagoon | TABITEUEA Lagoon | | BERU Lagoon | | NIKUNAU Reef | | ONOTOA Lagoon | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ANNUAL AVERAGE RAINFALL (IN INCHES) | | 125 | | 79 | | 70 | | 57 | | 57 | | 53 | | 50 | 47 | | 49 | | 44 | | 44 | |
| YEAR TOXICITY COMMENCED | | About 1948 | | 1946 | | Unknown; resurgence 1944– | | Unknown (1917?) | | Unknown (more than 50 years) | | Unknown; but resurgence 1929–37 | | Unknown (1890?) | Unknown (1919?) | | Unknown (more than 40 years ago) | | Unknown (more than 40 years ago) | | Unknown (more than 40 years ago) | |
| SPECIES TOXIC IN YEAR STATED | COMMONEST VERNACULAR NAME | 1958 | 1961 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1958 | 1962 | 1962 | 1958 | 1962 | 1958 | 1962 | 1959 | 1962 | 1958 | 1962 |
| *A. lineatus* (Linnaeus) | Katawa | | | + | + | + | | | | | | | | | ? | ? | | | | | | |
| *A. xanthopterus* (Val.) | Mako | ? | | + | + | + | | + | + | | | | | | | | + | | | | | |
| *Ctenochaetus* spp. (*striatus* and *strigosus*) | Ribabui | ? | | + | + | + | | ? | ? | | | | | | ? | | ? | | | | | |
| *Aprion virescens* (Val.) | Awai | ? | | + | + | + | | | | | | | | | + | | | | | | | |
| *Lutianus vaigiensis* .... (Quoy & Gaimard) | Bawe | | | + | | | | | | | | | | | | | | | | | | |
| *L. monostigma* (Cuvier) | Baweina | | | + | | | | | | | | | | | + | | | | | | | |
| *L. bohar* (Forskål) | Ingo | L+ | L+ | + | + | + | L+ | + | + | L+ | L+ | + | L+ | L+ | + | L+ | + | L+ | L+ | L+ | L+ | L+ |
| *L. gibbus* (Forskål) | Ikanibong | | | + | + | | | | | | | | | | | | + | | | | | |
| *L. semicinctus* (Quoy & Gaimard) | Tinaemea | ? | | + | + | + | | + | ? | | | | | | ? | ? | ? | | | | | |
| *Lethrinus* spp. (undetermined species) | Rou | | | + | ? | ? | | | | | | | | | ? | ? | | | | | | |
| *Scarus* spp. | Inai | ? | | + | + | ? | | + | ? | | | | | | + | ? | ? | | | | | |
| *Sphyraena* sp. (unidentified species) | Nunua | + | L+ | + | + | + | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ |
| *Mugil* spp. and other mullets | Aua | | | + | + | | | | | | | | | | | | | | | | | |
| Muraenidae | Rabono | + | L+ | + | + | L+ | L+ | L+ | ? | L+ | ? | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ | L+ |

\+ Denotes a species which may be toxic.
L+ Denotes a species in which large specimens only are potentially toxic.
? Denotes a species about which there is insufficient information on its toxicity.

The author would like to point out that the above list refers to the more common toxic species in the Gilberts. To discuss the degree of toxicity of all possible species is beyond the scope of this paper.

on the mouth, lips, and in the armpits; intense thirst, but due to the condition of the mouth, inability to drink; finally, the victims died, described as being unable to breathe.

The green turtle, *Chelonia mydas* (Linnaeus), is eaten throughout the Gilbert Islands and has not been implicated in any poisoning.

It should be noted that the hawksbill turtle is primarily a carnivore (Loveridge, 1946), preferring crabs and molluscs, although in captivity they will eat fish as well as seaweeds. On the other hand, the green turtle is primarily a herbivore, grazing many hours a day on beds of *Thalassia* (Loveridge, 1946, citing Deraniyagala, 1939). In captivity the green turtle may prefer animal food (Loveridge, 1946). In the Gilberts young green turtles are sometimes kept until they are large enough to eat, being fed almost exclusively on fish.

The hawksbill and green turtles were and still are Gilbertese family totems. Members of the families concerned will often maintain that all turtles are poisonous.

*Invertebrate Poisoning*

Several species of crabs are considered by the Gilbertese to be deadly poisonous, but very few species of crabs are commonly eaten. *Te kukua, Zozymus aeneus* (Linnaeus), is reported by Banner and Randall (1952) to be deadly poisonous on Onotoa; although Tarawa people would agree that it is toxic, this species is eaten on Arorae, Beru, and Nonouti. Another species, *Carpilius convexus* (Forskål) generally considered to be poisonous, is similar to a commonly eaten species, *te ntababa,* the red-eyed crab, and in the dark may easily be confused with it, especially by an inexperienced fisherman. Another with the reputation of being deadly poisonous is an uncommon small black and green or yellow crab. Because of its size it would never be taken for food; but it is said to have been used by the practitioners of black magic to poison their victims. However, the Gilbertese are reluctant to discuss such practices and the crabs involved.

In September 1961 a Bairiki, Tarawa, woman died after eating crabs. The crabs had been collected by torch fishermen on the Bairiki reef. When they returned they flung the whole catch on the ashes of a fire, an unusual procedure, boiling being the usual Gilbertese method of cooking crabs. It is said that the woman, being greedy, did not wait until the crabs were fully cooked, but grabbed them half-cooked from the fire and ate them. She was taken ill, removed to the Colony Central Hospital, and died. The assistant medical officer who dealt with the case described her death as being due to acute allergy poisoning. As it was dark when the crabs were cooked and eaten, identifying the species responsible was not possible.

Molluscs are not considered to be toxic by the Gilbertese on any island. Banner and Randall (1952) stated that the Onotoans reported that large tritons, *Charonia tritonis* (Linnaeus), were toxic; however, they could find no specific case of intoxication from this snail (Banner, personal communication). The large conch, *Strombus* sp., has been reported as toxic from certain areas in the Bahamas (Randall, 1958), but apparently this mollusc is not found in the Gilberts. The blood-mouth conch, *Strombus* sp., is one of the most common shellfish in the Gilberts. Vast numbers are collected and eaten, either raw or cooked, but so far none have caused any poisoning. Both small and large spider conches, *Lambis* spp., found on the algae-covered reef flats as well as in deeper water, are commonly eaten by the Gilbertese, but have never been reported toxic. The commercial trochus, *Trochus niloticus* (Linnaeus), is not found in the Gilberts, but smaller *Trochus* spp. are not uncommon; although these are eaten when collected during general gleaning on the reef, they are considered somewhat small for food. Turban shells, *Turbo* spp., are eaten and are commonly used for bait. These snails are picked up on the reef, broken open, a piece is bitten off and put on the hook, and the rest is eaten raw at the time. Cowries of various kinds are found throughout the Gilberts, but are never eaten by the Gilbertese. Many varieties of pelycopods are eaten without any causing illness.

The Gilbertese, surprisingly enough, do not make as much use of the various seafoods on their reefs as do many islanders in the Pacific. Sea urchins, again reported by Randall (1958) as causing a ciguatera-like poisoning, are not eaten by the Gilbertese.

During the Japanese occupation some varieties of seaweeds were eaten by the Gilbertese, but as soon as food supplies returned to normal

ISLANDS THAT ARE FREE FROM TOXICITY

| ISLAND | MAKIN | ABAIANG | MAIANA | KURIA | TAMANA | ARORAE | OCEAN ISLAND |
|---|---|---|---|---|---|---|---|
| TYPE | Reef | Lagoon | Lagoon | Reef | Reef | Reef | High, reef |
| RAINFALL | 107″ | 83″ | 62″ | 55″ | 48″ | 56″ | 63″ |
| ANCHORAGE (outside lagoon) | Very Poor | Poor | Nil | Poor | Very Poor or Nil | Poor | Moorings only |

this ceased. No information is available, therefore, as to the toxicity of any alga in the Gilbert Islands.

## SUMMARY

The Gilbert Islands were surveyed for fish poisoning, using local Gilbertese as informants. The following observations were made:

1. Ten out of 16 Gilbert Islands have fish that cause ciguatera.

2. The toxic areas are all found on the western lee sides, and are usually confined to open sea reefs and anchorages in this area, seldom penetrating into lagoons.

3. There is a definite evolution of toxic conditions over the years, with a few species being initially toxic, almost all reef fish being toxic at maximum, and, in the final stages, only large eels, certain snappers, and groupers remaining toxic. This cycle appears to take at least 8 years.

4. Of the other fish in the archipelago, the liver of some sharks, the heads of some mullets and surmullets, the "castor oil fish," and some sardines all have reputations for varying degrees of toxicity. In addition, the hawksbill turtle is also reported to be toxic. At least the shark's liver and the hawksbill turtle produce symptoms somewhat similar to those of ciguatera.

5. Of the invertebrates, only two species of crab and one species of gastropod have been said to be toxic; no other crustaceans or molluscs were considered as being toxic.

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