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CIGUATERA FISH POISONING AND THE PRESUMED CAUSATIVE ORGANISM IN THE GILBERT ISLANDS, KIRIBATI.

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by

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INTRODUCTION

Ciguatoxic fish poisoning or "ciguatera" is the name given to the disease caused by ingestion of a wide variety of circumtropically distributed reef fish.

Symptoms which generally appear within 2 to 32 hours include a range of gastrointestinal, cardiovascular, neurological and dermal disorders (Bagnis 1973, Withers 1982, Yasumoto et..al. 1984). Symptoms characteristic of ciguatera include initial numbness and tingling of the extremities, tongue, lips and nose soon after ingestion followed by vomiting, diarrhoea and general malaise. Most distinctive is the reversal of temperature sensation or "dry-ice effect" (where cool material feels hot) which may occur within hours of ingestion and lasts for years in severe cases. The majority of people affected by ciguatera recover within three days. Rare fatalities (less than 1%, Bagnis et ah, 1979) occurs when paralysis occurs from respiratory or cardiovascular failure (Bagnis, 1988).

The first record of ciguatoxic fish poisoning dates back to 1606 when the Spanish explorer Ferdinandez de Quiros and several of his crew were poisoned in the New Hebrides (now Vanuatu). In 1774 Captain Cook and members of his crew were also poinsoned in the New Hebrides and New Caledonia (Helfrich 1963, Cooper 1964, Withers 1982). Ciguatoxic fish poisoning was brought to the attention of the western public following poisonings of soldiers based on Pacific islands during World War II.

The suggestion that ciguatoxic fish poisoning might be caused by ingestion of a toxin-producing benthic algae was first promulgated by Randall (1958). A toxin actively involved in ciguatoxic poisonings was extracted from fish by researchers in Hawaii and called "ciguatoxin" (Scheuer et ah, 1967). It was later shown that ciguatoxin could be accumulated in fish tissues and passed up the food chain (Helfrich and Banner 1963, Banner et al. 1966). A cooperative effort by French and Japanese researchers finally isolated and cultured the causative organism from detritus samples on dead coral in the Gambier Islands, French Polynesia (Yasumoto et al, 1977a and b).

The organism, an epiphytic dinoflagellate, was later taxonomically classified as *Gambierdiscus toxicus* (Aachi and Fukuyo, 1979). Cultured *Gambierdiscus toxicus* cells have since been shown to produce the two primary toxins responsible for ciguatoxic fish poisoning; the water soluble maitotoxin and the lipid soluble ciguatoxin (Yasumoto et al, 1979b,
Bagnis et ah, 1980, Shimizu et ah 1982).

A presumptive mechanism for ciguatera fish poisoning was thus developed based on ciguatoxins production by the dinoflagellate *G. toxicus* (Yasumoto, et al, 1977b). Herbivorous fish grazing on algal growths containing populations of epiphytic *G. toxicus* cells first absorb these toxins. Toxin is then accumulated, in the case of the lipid soluble ciguatoxin, and passed on up the food chain as predatory fish eat the grazers and each other. Man may catch fish at any level of this trophic pyramid, ingest toxin-containing flesh and so become poisoned.

Gambierdiscus toxicus cells have been found in ciguateric areas throughout the Indo Pacific since their discovery in the Gambier Islands (reviews Withers 1982, Yasumoto et al., 1984). Work has been carried out in the Republic of Kiribati (Figure 1) prior to the discovery of the causative organism (Cooper 1964, on the Gilbert Islands; Helfrich et al. 1968, on the Line Islands).

The present study discusses results obtained during surveys of the 16 atolls in the Gilbert Islands group (Figure 2) in late 1983. It also discusses recent findings from various individual researchers and bodies.

Specific aims of the survey were:

1. To obtain lists of fish species considered toxic by local fishermen on each island.
2. To identify the location of the areas on each island where these toxic fish are found.
3. To obtain an estimate of the density and distribution of the causative organism for ciguatera, *G. toxicus,* upon these islands.
4. To disseminate information on recent development into the problem.
5. To monitor the present status in relation with increase in human population, domestic, industrial and military activities.

A comparison between the results of this survey (1983) and the work of Cooper (1964) provides information concerning changes in incidence and distribution of ciguatoxic fish poisoning within the Gilbert Islands over the last 20 to 25 years. Recent work during the late 1980s have also highlighted the present situation in the group.

II. MATERIALS AND METHODS

The information gathered during this survey is discussed under two main headings. Methods used to identify ciguatoxic fish species and the location of the reefs on which they are caught are given under the heading; Interviews. Methods used during an essentially independent study of the density of *G. toxicus* in the Gilbert Islands are covered under the second heading; Algal Sampling. Additional information on the recent findings by other researchers is discussed under section; IV RESEARCH REVIEW.

Interviews

Interviews were carried out in as many villages as possible on each island in the time available. If time was restrictive, villages were chosen so as to cover as much of the island as possible. Accessibility and proximity to the toxic areas noted in a previous survey (Cooper, 1964) also in part determined choice of villages. The number of villages visited and their locations are shown on the maps of each of the Gilbert Islands given in Section III (Results and Discussion, by Island).

Within each village at least two and normally three or four experienced fishermen were interviewed. Fishermen were chosen upon the basis of their reputation within the village as "knowledgeable fishermen".

During interviews the fishermen were asked to name the fish they considered toxic. As no comprehensive list of translations between Kiribati and scientific fish names was available the fishermen were provided with sets of colored pictures of fish and asked to indicate toxic species. Colored pictures provided were from Goodson (1973), Greenburg (1983), Natural World Press (1981), Randall (1981) and Amesbury and Myres (1982). The Kiribati name and description plus the pictures chosen were cross referenced with available information and scientific names assigned where possible. Information gathered throughout the Gilbert Islands is presented in Section III (General Results and Discussion) as a list of Kiribati, Scientific and Common English names of ciguatoxic fish.

The symptoms commonly experienced during fish poisonings were discussed with the fishermen. This information was then checked against the symptoms for ciguatoxic fish poisonings (noted in Section I, Introduction) and cases were recorded as being of ciguatoxic or other origins.

Each fisherman interviewed was provided with a map and asked to indicate the areas of the island he considered toxic. Individual maps were later compiled into one final map for each island with consideration of the proximity of the interviewee to the toxic regions and any pertinent comments made during the interview.

Algal Sampling

Algal samples were collected from the reefs surrounding each island visited. Sampling locations were chosen to include both reportedly ciguatoxic areas (as given in this report and Cooper, 1964) and reefs believed free from ciguatoxic fish. On many islands algal samples were collected at sites spaced around the island perimeter to allow comparisons of *G. toxicus* densities and conclusions about areas of risk. When accessible, areas of human disturbance such as blasted passageways and boat wrecks were also sampled since such disturbance is often associated with increased *G. toxicus* densities.

The location of algal sampling sites and the number of samples collected are shown on the maps of each island in Section III (Results and Discussion by Island).

Samples of the dominant algal types common to most reef throughout the Gilbert Islands were collected at each sample site. In most cases samples of filamentous green dominated algal turf from the upper reef platform, red algal dominated turf from the mid reef platform and small, protruding clumps of mixed algal communities from just inside the reef crest were collected. Figure 3 is a diagrammatic representation of an average reef in the Gilbert Islands showing the arrangement of algal species and commonly sampled areas. The algal composition of these samples was fairly uniform throughout the Gilbert Islands. This allowed comparison of results from a range of sites.

The algae included in each sample were identified to the species level whenever possible using Chapman and Chapman (1973), Dawson (1957), Doty (1983), and

Macruder and Hunt (1979). In many cases only an imprecise identification was possible which awaits clarification by an appropriate authority. However, algal identifications were consistent throughout all samples.

A table displaying the composition of collected algal samples is included for each island in Section III (Results and discussion by Island). An explanation of the abbreviations is given in Table 1. The notation used indicates the relative abundance of the species present in each sample. The dominant algal species in each sample are given first, less abundant species then follow, enclosed in brackets.

Sampling Technique

The technique devised by Yasumoto et al.. (1980) to rapidly count numbers of *G. toxicus* with epiphytic on sampled algae was slightly modified to accommodate the great sediment content and low *G. toxicus* densities found in algal samples from the Gilbert Islands.

Approximately 100 gm of algae was gathered in each sample. Samples were carried in sealed plastic bags to a suitable work area for initial processing. This involved addition of about 500 ml fresh water to the plastic bags, strong agitation for about one minute then straining through a seive series (TEST SEIVES ENDECOTTS LAB.) Material retained on seives of 125µm mesh size and above was discarded, the residue caught on 3 8 µ m mesh was transferred to 25 ml bottles, topped up with fresh filtered sea water and 3 to 4 drops of concentrated formalin solution added as a preservative. A sample of the algal substrate was also retained and preserved for later identification.

The counting procedure first involved resuspension of the sediment by shaking of the sample bottle followed by a 30 second period to allow the heavier sand and sediment particles to settle. Samples of 0.1 ml were then taken from the top 0.5 cm of the sedimentary layer and transferred to a gridded counting slide. After dilution and even distribution of the subsample over the counting slide the number of *G. toxicus* cells per subsample was counted by microscopic examination. At least three subsamples were counted from each sample. These results were averaged then multiplied by the dilution factor (30, see below) and divided by the weight of the algal sample to give the number of *G. toxicus* cells per gram of algal substrate.

Preliminary trials showed that a 30 second settlement period following agitation of the sample bottle acted to concentrate *G. toxicus* cells in the top 0.5 cm layer of te sediment. *G. toxicus* cells were found to be least obscured by sand and detritus particles in subsample volumes of 0.1 ml giving more reliable density counts than larger subsample volumes.

The dilution factor used above is derived from division of the volume of sediment sampled by the volume of the subsample:

Volume of sediment sampled $= r^2 h$ (r=1.3 cm, h=0.5 cm)
= 3 ml (1)
Subsample volume = 0.1 ml (2)
Dilution factor [(l)x(2)] = 30 times dilution

Gambierdiscus toxicus cells were identified by comparison of the plate and pore structure with that illustrated in Yasumoto et al. (1984). *G. toxicus* presence was also verified in samples sent to Hawaii (Helfrich pers. comm.), Tahiti (Bagnis pers. comm.) and Japan (Yasumoto pers. comm.).

The above analysis produced the average density of *G. toxicus* cells per gram of algae in each sample collected. This information is presented in table form along with sample number and algal composition of each sample for each island in Section III (Results and Discussion by Island).

III. RESULTS AND DISCUSSION BY ISLAND

The results gathered from each island visited during the 1983 survey of the Gilbert Islands is presented separately in this section. Physical description and demographic information concerning the islands are available elsewhere and are not included in this report.

The results to interviews and algal surveys of each island are presented with a map displaying sampling sites and locations of reefs producing toxic fish. These results are discussed with reference to ciguatoxic history and other relevant information and conclusions pertinent to each island are given.

Results and discussion concerning the most northern of the Gilbert Islands are given first followed by those from successively more southern islands.

MA KIN ISLAND

Fishermen interviewed in the three main subsections of Makin village on the northernmost islet of Makin indicated that ciguatoxic fish were caught on the western reef adjacent to Makin village (Figure 4). The common Acanthuridae (Te riba) were considered at risk, *Ctenochaetus striatus* was positively indentified as always ciguatoxic. This species was avoided on the western reef. Small reef dwelling Lutjanid species (Te bawe, *Lutjanus fiilvus)* were occasionaly ciguatoxic, te tinaemia, *Lutjanus monostigma* was considered more often ciguatoxic than other species.

Two people from Makin were badly poisoned in 1983 and required nine days of medical attention. The symptoms described identify the poisoning as of ciguatoxic origin. Unfortunately the species of fish involved was not recorded.

Fishermen interviewed on the more southern islet of Kiebu (Figure 4) reported that the southern reefs of Makin have never yielded ciguatoxic fish.

Algal samples were collected from four locations around the northen islet of Makin (Figure 4). *G. toxicus* was present in three of the eight samples (Table 2). Highest densities of *G. toxicus* were recorded from *Halimeda* spp. sampled from the mouth of a blasted passage adjacent to Makin village. Two of the three samples collected just north of the reef reported to produce toxic fish also contained *G. toxicus* cells in relatively high numbers compared to samples from other islands.

Statistics from Tungaru Central Hospital record four cases from Makin, all in 1983, under the general heading of "Fish Poisoning" between 1978 and 1990 (Table 28).

<u>Discussion</u>

Makin Island has previously been considered free from ciguatoxic fish poisoning (Cooper 1964). Fish species considered ciguatoxic in 1983 were primary herbivores (Acanthuridae) and small predators (e.g., Epinephelidae and Muraenidae) supports the fishermen's reports of the recent appearance of toxicity. If the area had been toxic for some time then ciguatoxin should have passed through the food chain and accumulated in the tissues of the higher predators (Randall 1958, Helfrich and Banner 1963).

The present advent of toxicity does not seem to be directly related to any obvious naturally occurring disruptive event in recent history. Cooper (1964) noted severe damage of the western reef following a storm in December 1960. High waves have periodically inundated areas of Makin (Groves, 1981). Perhaps more important is the recent blasting of a passageway through the fringing reef at Makin village to allow easy launching of small boats. The relatively high density of *G. toxicus* recorded from this area suggests that the recent appearance of toxicity may be related to this blasting.

Considering the presence of *G. toxicus* outside the area currently considered toxic and the toxic history of such close neighbours as Butaritari and Marakei the western reef of Makin should be closely watched for increasing toxicity.

The latest medical record (1987-1990) shows there was one case in 1987, 10 in 1989 and 2 in 1990. The cases could not be confirmed due to unavailability of patients records. However, if the cases were ciguatera poisoning then toxicity in Makin has increased since 1983.

BUTARITARI ISLAND

Results

All of the fishermen interviewed in 1983 were in reasonable agreement about the location of reefs producing ciguatoxic fish. Ciguatoxicity was confined to the western half of Butaritari island, never having appeared anywhere west of Tanimaiaki. One fisherman claimed that *te riba (Acanthurus gahhm), te rabono (Gymnothorax sp.)* and te bakoa (Carcharhinidae) were poisonous inside the lagoon near his village, Tabonuea. All other fishermen reported the lagoon to be free from ciguatera except at Kotabu islet (Figure 5). Several fishermen reported that the northwestern islet Bikati yielded toxic *te rabono* (Muraenidae), *te ingo (Lutjanus bohar), te marati* (large *Epinephelus or Serranidae)* and *te riba (Acanthurus gahhm).* The most toxic region of Butaritari Island was reported to include the reefs stretching from Tikurere islet, surrounding Kotabu islet, crossing the southern channel and following the coast to the southernmost tip of Butaritari (Figure 5). Fish found toxic in this area include *te ingo (L. bohar),* most large *te rabono* (Muraenidae), *te marati* (large *Epinephelus sp.), te kuau* (smaller Epinephelidae notably *Cephalopholis lineatus), te riba (Acanthurus gahhm,* notably *Ctenochaetus spp.* but also including common *Acanthurus spp.)* and occasionally *te tinaemia* (small Lutjanidae). Patches of toxicity exist along the southern stretch of the island behind Ukiangang point, at Butaritari village and close to the airstrip. In these regions toxicity is mostly limited to the common *te riba* and *te tinaemia* species. *G. toxicus* was not found in algal samples collected from either the lagoon or ocean reef at Keuea village in eastern Butaritari (Table 3). Similarly, algal samples collected from adjacent to the wrecked ships in the lagoon at Butaritari village contained no *G. toxicus* cells. This suggests that if the lagoon was in fact a source of ciguatoxin in the past, the density of *G. toxicus* had decreased to unrecordable levels. *G. toxicus* cells were present in three out of four samples collected along a transect on the ocean reef at Butaritari village (Table 3). Highest densities of *G. toxicus* cells were found in algal samples scraped from dead coral just beyond the reef crest at Ukiangang point (Figure 5, Table 3). Rough weather prevented algal collection along the western ocean reef.

The parents and a child of one family required three days of medical attention after eating te riba (Acanthuridae) caught on the ocean reef at Butaritari village in April 1983. The symptoms described identified the poisoning as ciguatoxic. Statistics from Tungaru Central Hospital report 16 cases from Butaritari under the loose heading of "Fish Poisoning" between 1978 to 1983. From 1987 to 1990, 158 cases were recorded (Table 28). This shows an increase of about nine folds.

Discussion

The following history of ciguatoxic fish poisoning is provided by the results of a previous survey (Cooper, 1964). Ciguatoxic fish poisoning was first reported on Butaritari Island following World War II. Toxicity in 1958 to 1962 was confined to the southeastern part of the island from inside the lagoon close to Butaritari Village to Tikurere islet (Figure 5). Butaritari islanders considered peak toxicity to have occurred in the late 1940's. Continued reduction in toxicity was believed to have occurred till the reefs were essentially "free" from poisonous fish in the early 1960's except for the occasional large *te ingo (Lutjanus bohar), marati* (large grouper, specifically *Promicrops lanceolatus),* large *te rabono* (Muraenidae) and large *te nunua (Sphyraena sp.)* Results of the the 1983 survey show that ciguatoxic fish poisoning appears to be an increasing problem on Butaritari Island. Contrary to the reported decrease in toxicity during the 1960's, toxicity in 1983 was very common about Kotabu islet and the southern passage. Furthermore, toxicity has apparently spread to the northern most islet of Bikati and southwards to Ukiangang long enough ago that poisonous fish species can be found at all trophic levels. A comparison of *G. toxicus* densities at Ukiangang and Butaritari villages plus the confinement of toxicity to the lower levels of the food chain at Butaritari village and close to the airstrip suggest that ciguatoxicity is presently spreading along the southern shore of Butaritari Island.

Poisoning caused by ciguatoxic te ingo *(L. bohar)* were reported to have a lunar based peak of highest incidence. This is related to a tendency of te ingo to form congregations over periods of full moon. However, it is unclear whether the greater number of poisonings over this period reflects a migration of ciguatoxic fish from elsewhere into fishing areas or simply an increased catch of this species.

The alarming increase in fish poisoning to date indicates that the situation in Butaritari is worsening. The people are either getting more desperate for fish or the level of toxicity has increased dramatically since the previous survey.

MARAKEI ISLAND

Results

All fishermen in 1983 reported that toxicity was still confined to the western side of Marakei. The affected area was reported to extend from the southern side of a blasted passage just north of Rawanawi to the village of Tekarakan (Figure 6). Most species of fish living on or assoiciated with this area of the western reef were considered toxic. Various species were considered extremely toxic and were rarely if ever fished. Other species were tested occasionally which often lead to cases of poinsoning. Fishermen from this relatively heavily populated area were forced to either fish in the lagoon for *te ikari (Albula sp.), te baneawa (Chanos chanos)* and *te baua* (Mugilidae) or fish for *te onuti (Cypselurus cyanopterus)* beyond the reef at night. Consequently the relatively untouched reef supports large numbers of fish that are often larger and less diver shy than those seen on many other islands. Table 4 shows the fish species considered toxic in 1983 by the Marakei fishermen and notes some of their comments.

Algal samples were collected from locations around the perimeter of Marakei Island (Figure 6). *G. toxicus* densities were surprisingly low considering the reported high toxicity of Marakei Island's western reef. *G. toxicus* cells were found to be present in 13 out of 14 of the algal samples collected from locations on Marakei (Table 5). The highest density was found in samples of algal turf collected from the reef crest on the northern side of Baretoa passage. Relatively high densities were also recorded from another sampling site on the western reef at Rawanawi village. *Gambierdiscus toxicus* densities in samples collected south of the reef area considered toxic by fishermen (Samples 1 and 2) were roughly half the average values found in samples within the toxic area. Algal samples collected from the eastern reef at the Raweta passage mouth had approximately one-sixth the average density of those within the toxic area. *G. toxicus* presence was recorded in only three out of four samples collected from the northern end of the eastern reef.

Statistics from Tungaru Central Hospital report 214 cases on Marakei under the loose heading "Fish Poisoning" between 1978 to 1983 but the total to date is 639 (Table 28). During September 1983, two families were poisoned by fish caught on the toxic area of the western reef. One family ate *te ingo (Lutjanus bohar),* the other, *te kuau* (small Epinephelidae or Serranidae sp.). A fishermen descibing these poisonings believed that ciguatoxic and non ciguatoxic fish could be easily distinguished. Toxic fish exuded a slimy fluid when squeezed, non-toxic fish did not.

Discussion

More information is available concerning the development of ciguatoxicity on Marakei than most other islands in the Gilberts. Reasons for this include the well defined date of severe toxicity onset, the reliability of reports on toxic species and the interesting fact that the then unidentified causal agent of ciguatera was believed by Marakei islanders to be a bluegreen algae *Schizothrix calcciola* (Cooper, 1964). Analysis of quantities of this algae narrowly missed identification of the actual causal organism *G. toxicus* (Helfrich et al., 1968). Cooper (1964) reports that toxicity began in Rawanawi village in 1946 then spread southwards to Buota village by 1947 (Figure 6). By 1948 all reef associated fish were considered toxic to some degree along this stretch of coast. In 1962 the condition of the reef was considered greatly improved but still regularly yielded toxic fish.

The area of reef considered toxic on Marakei Island in 1983 had expanded southward from Buota village to include almost the entire western reef from Rawanawi to Tekarakan villages. *Gambierdiscus toxicus* density south of Tekarakan village was relatively high, suggesting that further southward spread of toxicity may be occurring. Similarly, *G. toxicus* densities recorded at Raweta passage mouth imply at least the potential for spread of toxicity along this shore as well. The low *G. toxicus* densities recorded for the northern end of the western reef reinforce the implication that toxicity spread has been primarily southwards along the western reef.

In contrast to the reported continuing severe toxicity of the western reef on Marakei, *G. toxicus* densities recorded even from supposedly most toxic regions were very low. Assuming that the technique used gives at least a fair representation of current *G. toxicus* densities at the locations sampled leads to several possible conclusions. *G. toxicus* distribution is notoriously patchy (Yasumoto at al., 1979, 1980). The sampling sites may not have been in the areas of high *G. toxicus* concentration expected to be associated with severe fish toxicity. Alternatively, the *G. toxicus* density found may be a real representation of densities throughout the toxic area. This could mean that reef toxicity is on the decline (a conclusion not supported by all other evidence) or that severe toxicity on a reef may be supported in the presence of only low densities of the causative organism. The latter possibility could be explained by the recycling of ciguatoxin on the unfisted reef such as that suggested for the Manbualau Island reef in Fiji (Helfrich and Banner, 1968).

Recent medical record indicates that fish poisoning in Marakei remains high. Future trends could be very similar to as at present.

ABAIANG ISLAND

Results

Interviews with fishermen from all major villages on Abaiang (Figure 7) confirmed that no substantiated cases of ciguatoxic fish poisoning had ever been reported. Fishermen reported in 1983 the only fish to occasionally cause poisonings were *te bakoa* (Carcharhinidae, requiem sharks) and *te buni* (Tetraondontidae, pufferfish). A possible confusion between ciguatera and hypervitaminosus in sharks and tetraodontoxin poinsonings in bufferfish is briefly discussed in the text.

Algal samples were collected from only one site on Abaiang (Figure 7). *G. toxicus* cells were not found in these samples (Table 6).

Discussion

Verified cases of fish poisoning have never been reported from Abaiang (Cooper 1964). Statistics from Tungaru Central Hospital report 152 cases from Abaiang under the loose heading "Fish Poisoning" between 1978 and 1990 (Table 28). This figure need not represent ciguatera fish poisoning. This information does however allow speculation concerning the truthfulness of Abaiang fishermen concerning fish poisoning. It is possible that the traditional belief that Abaiang is magically protected from ciguatoxic fish would make fishermen reluctant to admit its presence.

It is quite likely that ciguatera and other poisonings were regarded as same. There are cases when fish poisoning was caused by consumption of shark liver and buffer fish. Both ciguatera and Vitamin A overdose can be caused by shark liver consumption. Poisoning caused by consumption of buffer fish is not related to ciguatera poisoning. The two poisons differ.

If the cases recorded were of ciguateric in origin then the magic spell that protected Abaiang from this has lost its grip. But there is a great need to carefully examine the cases from this island to substantiate the non presence or onset of ciguatera. However, access to patients medical records is not possible at the main hospital, these can only be obtained from clinics on each respective island.

TARAWA ISLAND

Results

Fishermen interviewed in 1983-84 indicated that toxic fish were caught in chain of locations running almost the whole length of South Tarawa (Figure 8) (South or "Urban" Tarawa extends from Betio islet in the west to Tanaea islet in the east. Toxic fish were caught on Betio islet. The reef area stretching northwards from Betio to the passageway only occasionally yielded toxic fish. Most poisonings resulted from fish caught along the oceanward reef on the southern side of Betio. Species considered toxic (Table 7) were mostly reef predators (Muraenidae, Serranidae, Lutjanidae) but also included *te ribatanin (Acanthurus lineatus)* a primary herbivore.

The islets from Bairiki to Tanaea are joined by roads and causeways. Toxic fish have appeared comparatively recently along the seaward reef from Bairiki to Eita (Figure 8). The range of species considered toxic at the main villages in this stretch of coastline are displayed in Table 7. None of the interviewed fishermen could specify a date before which toxic fish were never caught. Poisonings have apparently been sporadic but in the five years prior to 1983 have increased in frequency to the point where parts of the reef were considered dangerous. Poisonings of a severe nature seem most often associated with the larger carnivores; *te rabono* (Muraenidae), *te ingo (Lutjanus bohar), te nunua (Sphyraena sp.)* as well as the smaller reef predators; *te kuau* (Serranidae). The mojority of milder poisonings seem to be associated with the abundant herbivores found along the reefs; *te inai* (Scaridae), and *te riba* (Acanthuridae). These potentially toxic species are often taken by subsistence fishermen. Presumably they consider the risk of poisoning outweighed by the abundance of this easily caught protein source.

The heavily populated village of Bikenibeu fronts onto what is currently the most toxic area of reef on Tarawa. Fishermen interviewed in 1984 were unsure when fish first became toxci but considered almost all commonly caught species to be toxic at least some of the time (Table 7, 8 and 9). The population of Bikenibeu village includes many unemployed families attracted to Tarawa from the outer islands. Many of these families are forced to sample fish from the toxic reef due to a lack of other food sources. Even so several families of fish are commonly avoided. Te *rabono* (Muraenidae) are very rarely taken due to their extremely toxic nature (85 ug of pure ciguatoxin was isolated from 2.83 kg of moray eel viscera from Bikenibeu reef) (Prof. P. J. Scheuer, pers. comm., May 1984, Table 11). Most of *te riba/ribabui* (Acanthuridae) and *te inai/nokunoku/te kamauti* (Scaridae) are avoided as are *te kuau* (Serranidae) especially *te nimanang (Cephalopholis argus,* Table 10). There was dispute concerning *te bawe* and *te tinaemia* (small Lutjanids). Several fishermen claimed the Lutjanids were always toxic while others claimed they were only sometimes toxic. A possible explanation is that these small Lutjanids have a fairly localized home range. They may be always toxic if caught in the center of the toxic reef, occasionally toxic towards the extremes of the reef and not toxic west and east of Bikenibeu.

Toxic fish are very rarely caught east of Bikenibeu, have never been recorded at Tanaea and have not yet been reported anywhere on North Tarawa.

Tungaru Central Hospital is situated in Bikenibeu village. Medical records concerning fish poisoning have been kept for several years. Fish poisoning cases recorded by area for 1982 to 1991 are shown in Table 14. Such records are always underestimated of the incidence of ciguatoxic poisonings as only the more severely affected cases ever seek institutionalized medical help (Bagnis, 1973; Withers, 1982; Yasumoto at al. 1984). Conversely, an examination of the medical records for each of the cases shown in symptoms resembling ciguatoxic fish poisoning. The medical records between 1974 to 1983 and 1985 to 1990 were examined and the number verified cases of ciguatoxic fish poisoning recorded. Unverified cases were also presented (in superscript). The results between 1974 to 1980 were in close agreement with those of a similar study (Marriott and Dalley, 1980). The two results and those of World Health Organisation and South Pacific Commission were reconcilled as shown in Table 16.

In some hospitalized cases of fish poisoning the medical record contains the type of fish believed to have caused the poisonings. Table 8 lists fish species reported to have caused poisonings between 1974 and 1980 (Marriott and Dalley, 1980). Scientific names have been modified from Marriott and Dalley (1980) to agree with recent information concerning fish name translations, the same table was modified to include those species considered to have caused ciguatera between 1982 and 1991.

The available of storage and shipment facilities on Tarawa permitted the collection of samples of fish. Fish samples were collected from various locations on South Tarawa in 1982, 1983 and 1987 for toxicity assay. Results displayed in Tables 10, 11 and 12 were provided by the Institute of Marine Resources (University of the South Pacific, Suva, Fiji), Chemistry Department (University of Hawaii) and Department of Southern Fisheries, Deception Bay (Queensland, Austrlia), respectively, using a standard toxicity assay technique (Yasumoto et al., 1984. This technique involves the extraction and concentration of the toxin from a weighed sample of fish flesh. A range of concentration of the extracted toxin is injected intraperitonealy into mice. The lowest concentration to cause death within 24 hours is used to calculate the samples toxicity in mouse units per 100gm tissue.

Samples tested by Dr. P. J. Scheuer (Chemistry Dept., University of Hawaii, Honolulu. Hawaii) were analyzed to discover whether or not they contained sufficient quantities of toxin to make further collection and extraction of the toxin worthwhile. Samples were divided into viscera and flesh components then put through an extraction and concentration process. The process resulted in three fractions; ethyl acetate, butanoland aqueous extractions. T concentrations. The toxin included in the ethylacetate fraction is ciguatoxin (CTX), those included in the other two fractions were not specified. Recent tests (Scheuer, pers. comm.) have shown that of the Scaridae tested from Bikenibeu reef only *Scants sordidus* contain equivalent levels of ciguatoxin to any collected throughout the Pacific (Scheuer, pers. comm.).

Samples analysed by the Institute of Marine Resources, USP were part of a regional collection and testing of potentially toxic fishes from around the region. Those tested by the Southern Fisheries, Queensland were part of ciguatera monitoring in the area where the newly constructed causeway, Dai Nippon, has just been built.

The location of the Atoll Research and Development Unit at Tanaea in South Tarawa allowed a longer term algal survey to be carried out than on other islands. One of the authors (T. Tebano) undertook a study of changes in *G. toxicus* density at various locations in South Tarawa between March and December, 1983. Table 13 displays summarized results obtained from Tebano (1985). *G. toxicus* density was found to be fairly consistently low at all sites. Variations over time at any site were roughly comparable to variations between sites and lacked any major trends. Results in Table 13 are therefore averages over the sampling period. Samples were also collected from North Tarawa (Fig 8) but did not contain *G. toxicus.*

<u>Discussion</u>

Ciguatoxic fish have occasionally been caught on Betio islet, Tarawa, for as long as anyone can remember (Cooper 1964). A dramatic outburst of fish poisoning followed the World War II 'Battle of Tarawa' in 1943. During this battle a Japanese stronghold on Betio was retaken by the Americans. The islet sustained heavy- bombardment and is still littered with war wreckage. Fish toxicity became a rapidly increasing problem from 1944 onwards until almost all fish species caught in the toxic area (Fig. 8) were poisonous. A slow reduction in toxicity is then reported to have begun in the mid 1950's until by 1961 the reef was considered 'free' from toxic fish. However, causes of poisoning by large *te ingo (Lutjanus bohar)* and te marati (Serranidae) still occurred sporadically (Cooper, 1964).

The results show that since Cooper's survey twenty to twenty five years ago, ciguatoxic fish poisoning has become an increasing problem of South Tarawa. Tables 14, 15 and 16 show that dispite uncertainties concerning the true incidence of ciguatoxic fish poisoning, a considerable number of people have in fact been poisoned over the last sixteen years. Discrepancies between the figures quoted by various sources plus the problems associated with collection of medical statistics can make statements concerning trends in the incidence of ciguatera unreliable. However, verified cases obtained from medical records show that ciguatera fish poisoning is still a problem in South Tarawa. There is some indication that cases of ciguatera fish poisoning will still increase (Table 15).

It may not be possible to detect this in future due to lack of actual knowledge of ciguatera poisoning by medical statisticians who often put it together with other forms of fish poisoning under one file name, Fish Poisoning. Very often, symptoms are listed on the patient's record but fish species eaten and how the fish was cooked or stored are ignored. This is one of the biggest problems whereby the exact cause of the poisoning cannot be verified. It is understood that a standard form designed by SPC/FAO had not been used. This could substantially improve accuracy in reporting ciguatera poisoning cases.

Fish considered toxic by interviewed fishermen (Table 7) agree reasonably well with the information recorded in medical case histories at Tungaru Central Hospital (Tables 8 and 9). The species listed probably are responsible for fairly severe poisonings or the patients involved would not have sought medical help. Annex i displays a more comprehensive list of toxic species but rare species or species of marginal toxicity may still have been missed out.

The results of toxicity assays of fish specimens collected from Tarawa (Tables 10, 11 and 12 show moderate agreement with the results from interviews (Table 7). The assay results are limited since only a few species could be sampled during each collection period. However, they serve to prove that in several cases an independent test has confirmed that some species are toxic and that the poison involved is indeed ciguatoxin. A more comprehensive test of fish species would produce interesting results but would be very time consuming. The results of fish toxicity assays help to verify that the easily obtained interview results are a reasonably valid listing of toxic species.

An examination of the results shows that Betio has dropped in overall toxicity of fish species since its peak of toxicity following the Second World War. The area considered toxic in 1983/84 was limited to the southern ocean reef and the numbers of toxic speices were relatively low. Greatest numbers of toxic fish were caught at Bikenibeu. In between these two population centres lies a chain of areas where numbers of toxic species were increasing.

Possible explanations for the movement and spread of ciguatoxic fish poisoning on South Tarawa are multitudinous. Since 1947 when it was decided to make Tarawa the capital of Kiribati, almost all population increase in the Republic has been absorbed by South Tarawa (Bailey, 1983). Greatest populations are found in the villages of Betio and Bikenibeu, but substantial population increases, subsequent expansion of existing villages and creation of new centres has occurred all along South Tarawa.

Disturbance of the environment of South Tarawa has been a corollary of this population expansion. The reuirement for living quarters has meant a change from traditional land usage. The reduction of coverage by coconut palms and bush in favour of roads, dwellings and other buildings is particularly noticeable in such areas as Betio, Bairiki and Bikenibeu. The requirement for a more efficient sweage system has culminated in the Australian funded Tarawa Sewage Program initiated in 1978. This $A.6 million scheme involves the construction of a sewage system with seawater reticulation and outflows over the ocean reef. The outflow site of one earlier sewage system at Tungaru Central Hospital, Bikenibeu, marks the center of the area considered most dense in toxic fish on Tarawa.

The volume of fresh water required by the increasing population has necessitated the provision of a system to tap the atolls water lens at areas of low population and pump the water to civic centres. The Western style of living favoured on Tarawa is associated with problems of refuse disposal. Traditional techniques for disposal of organic matter do not always suit the requirements for disposal of modern inorganic refuse. Transport requirements between civic centres has instigated the connection of all South Tarawa except Betio by roads and causeways. The excavation of material for these causeways and the blasting of boat passageway has an obvious direct effect upon the ocean reef.

The interaction of the factors associated with urban growth on Tarawa is too complex to determine which, if any, are associated with the increase in the incidence of ciguatoxic fish poisoning. In summary it must be noted that one of the more dramatic increases in the distribution of ciguatoxic fish on a Kiribati atoll is also associated with the greatest increases in population and westernization.

With the completion of the causeway between Betio and the rest of South Tarawa, the level of toxicity is expected to rise (Tebano and Lewis, 1989). More causeways are being planned for North Tarawa (Kiribati Development Plan 1991). This may have some effect on the present situation of ciguatera fish poisoning which is concentrated at South Tarawa. There is a possiblity of ciguatera poisoning spreading northward. A good montioring scheme should be established.

MAIANA ISLAND

Results:

Fishermen interviewed in 1983 from all major villages except Raweai (Fig. 9) reported that ciguatoxic fish have never been caught on Maiana island. One fisherman interviewed at Raweai village claimed he knew of a case where a family displayed symptoms characteristic of ciguatera fish poisoning after eating *te ikanibong (Lutjanus gibbus)* during October 1982. However, this case of fish toxicity appears to be an isolated incident.

Algal samples were collected at four sites along the ocean reef of Maiana (Fig. 9). *G. toxicus* cells were present in eight out of the eleven samples collected, including at least one sample from each site. Greatest densities were found in algal turf samples collected from the southern end of Maiana. These samples were taken next to an extremely narrow peninsula that is neither cultivated nor inhabited. Samples from the more central and northern reefs on Maiana contained approximately equivalent low densities of *G. toxicus* (Table 17). Statistics from Tungaru Central Hospital reported 7 cases under the heading "Fish Poisoning" between 1978 and 1980, cases recorded during the time this report was first prepared. Cases between 1987 to 1990 were added making 41 cases to date (Table 28).

It was speculated in 1988 that ciguatera fish poisoning started to flare up at the boat blasted channel on the lagoon western reef (Tebano and Lewis, 1991). People claimed that a few months after the blasting took place, toxic fish have been caught from around the area.

Discussion:

Cooper (1964) reports that toxic fish were unknown on Maiana prior to and during the early 1960's.

When compared to *G. toxicus* densities recorded from other Gilbert islands of severe toxic history, those recorded from the apparently ciguatoxic free island of Maiana are surprisingly high. The results of the algal survey indicate *G. toxicus* presence in moderate densities all along the eastern ocean reef. These results suggest a ready potential for *G. toxicus* population explosion given the necessary trigger. Maiana is another island that should be closely watched for increases in cases of fish poisoning.

Although, ciguatera fish poisoning was at a low level, it has now been triggered by reef blasting. The number of cases reported for 1988 (Table 28) is the biggest in the history of ciguatera in Maiana. This indicates that ciguatera has been lying dormant for years. Now that the potential is being activated one can only assume that there is a possibility of spreading out to the nearby reefs. On the other hand it may only be concentrated in the same area. The monitoring of ciguatera level and the mapping of the affected area(s) should be considered crucial for the prevention of such a disease.

KURIA ISLAND

Results:

Fishermen interviewed in 1983 from all major villages on Kuria reported that ciguatoxic fish were never caught on the island.

Algal samples were collected from two randomly chosen sites on Kuria (Fig. 10). Surprisingly, *G. toxicus* cells were found in one of the three samples analyzed (Table 18) collected from the eastern reef of the northern islet. Statistics from Tungaru Central Hospital report 27 cases under the loose heading "Fish Poisoning" between 1978 and 1983 and another 43 between 1987 and 1990 (Table 28).

Discussion:

Toxic fish have never been reported from Kuria (Cooper, 1964). Results of the 1983 interviews also report an absence of ciguatoxic fish poisoning. However, the presence of *G. toxicus* in one of the algal samples shows that the potential for an outbreak of ciguatera exists on the island. The cases of poisoning by fish reported in Tungaru Central Hospital records are most likely to be cases of food poisoning.

It is of interest to note that while the fish from Kuria have never been toxic, a certain species of land crab (Gecarcinidae) does cause poisonings. The land crab *te manai (Cardisoma sp.)* is considered a delicacy on most islands in Kiribati. These nocturnal crabs are usually collected at night when they move out of their burrows to feed. Gathered crabs are normally grilled on a palm frond fire or boiled before being eaten. Poisoning symptoms begin with stomach pains then develop into chronic constipation with concomitant swelling of the stomach and abdomen. No deaths have been reported resulting from *Cardisoma sp.* poisoning but in several severe cases, afflicted patients have suffered from the described symptoms for four to five days. One consequence of

Cardisoma sp. toxicity is their greater abundance on Kuria than on many of the other Gilbert Islands. The toxic crabs are only rarely harvested and large number of their burrows pit the soil beneath coconut palms close to the shore.

It appears that the pattern on the seriousness of fish poisoning on this island is within the 10 year duration (compare figs for 1981 and 1990, Table 28) assuming that cases between 1984 and 1986 were also low. It has not been established whetther ciguatera fish poisoning was involved or not. The assumption that ciguatera poisoning is unlikely on this island should not prevent anyone from inferring that ciguatera may flare up any time as in the case of Maiana. There is a clear indication that all reefs in Kiribati should be treated as having the potential of becoming toxic when either natural or human-induced disasters are prevalent in any particular area.

ARANUKA ISLAND

Results:

Fishermen from all the major villages were interviewed in 1983 (Fig. 11). All reported that toxic fish were only caught from an area of reef called Tabuairoto. This reef is located at the mouth of the only major passage into Aranuka lagoon (Fig. 11). Toxicity is reportedly limited to the more southern side of the passageway plus a short stretch of the adjacent ocean reef.

Fishermen from Takaeang and Buariki villages reported that *te ingo (Lutjanus bohar)* was occasionally toxic while *te rebono* (Muraenidae) and *te kuau* (Epinephiladae), notably *te bakati, (Promicrops lanceolatus)* were frequently toxic. These fishermen, however have no real inclination to sample the fish from the relatively distant Tabuairoto reef unless moving through the passage to or from the lagoon. Fishermen from Baurua village gave a more comprehensive list of toxic fish: *te kuau* (Epinephilidea) were probably all potentialy toxic but *te bakati (P. lanceolatus)* and *te nimanang (Cephalopholis argus)* were most often toxic. Possibly the larger groupers are avoided and so were not included in the list. *Te ingo (Lutjanus bohar), te ikanibong (L. gibbus)* and *te ikamawa (Scarus pectoralis)* were often toxic. Probably all large *te rabono* (Muarenidae, moray eels) encountered were toxic. Specific names given include te ngabingabi *(Gymnothorax melagris), te kairii (G. flavimarginatus), te kunibuaka (G. eurostus)* and *te witae (G. undulatus).* All species of *te riba* (Acanthuridae) were considered at risk. Specific names of surgeonfish found to be toxic at times include *te mako (Acanthurus xanthopterus), te koinawa (A. triostequs), te ribataukarawa (A. lineatus* or *A. archilles), te ribaroro (A. nigroris* or *Ctenochaetus striatus), te rewa (C. striqosus ox A. nigrofuscus)* and general *te ribabui* (assorted Acanthuridae).

Toxic fish were believed to be becoming scarcer on Tabuairoto reef. Fishermen from Baurua village believed that *te riba* (Acanthuridae) have not been poisonous for almost one year (1983). All fishermen agreed that poisonings were more common around 1979 to 1981 and that no poisonings had occurred during the year of the survey up until the time of interview (August 1983). Unfortunately the algal samples collected from

Aranuka were lost during transport back to Tarawa.

Statistics from Tungaru Central Hospital report 2 cases under the loose heading 'Fish Poisoning' between 1978 and 1983. To date 9 cases were recorded (Table 28). None of the cases were confirmed for ciguateric Symptoms.

Discussion:

Information concerning the history of fish toxicity on Aranuka is fairly imprecise. Cooper (1964) tentatively indicated a toxic area stretching along the submerged southwestern reef (Fig. 11). However, she states that the people of Aranuka had no shortage of alternative fishing grounds and reports of toxic fish were largely gathered from inter-island boatcrews. Confirmed cases of ciguatera fish poisoning have occurred when members of these boatcrews have caught and eaten large *te maneku (Epinephelus fuscoguttatus), te marati* (large Serranidae) and *te rabono* (Muraenidae).

Results of the 1983 survey suggest that ciguatoxic fish poisoning is becoming less common on Tabuairoto reef, Aranuka. However, reexamination of the results reveals somewhat conflicting possibilities. The last fish to retain ciguatoxin during the tailing-off following an outbreak of fish poisoning should be the larger carnivores not the small herbivores (Banner et al, 1966). The fishermen's claim that toxicity was decreasing to negligible levels in 1983 clashes with their claims that such fish as *te riba* (Acanthuridae were recently toxic. The most probable explanation is that levels of ciguatoxic fish poisoning on Tabuairoto have been relatively constant since the last survey (Cooper, 1964) with only minor periods of increase and decrease. These fluctuations in toxicity would be most evident in the small and short-lived herbivores. Fishermen probably rarely sampled the larger carnivores as these were known to be dangerous. The absence of intoxications during 1983 may coincide with a period of toxicity decrease amongst the small herbivores but probably also reflects an overall avoidance of Tabuairoto reef by the fishermen.

Cardisoma sp. crabs taken on Aranuka were reported to induce similar symptoms to those noted following ingestion of these species on Kuria island. The cause of toxin in this crab has not been identified. Speculation claims certain mushrooms and lichens are responsible.

The small number of cases reported from this island between 1987 and 1990 indicates that the people of Aranuka are aware of the toxic area and fish species which they may have tried to avoid. Although the cases reported were not verified as such, it is likely that some of the cases were ciguateric in origin. It appears that there had not been any significant change in the status of ciguatera on this island since 1983. It also appears that boat channel blasting had not been carried out on the island which strengthens the assumption that such activity could trigger the onset of ciguatera on the presumed potentially toxic reefs of the Gilbert chain.

Results:

Most of the fishermen interviewed in 1983 reported that toxic fish were caught on Tetutongo reef (Fig. 12). The majority believed that toxic fish were caught in a narrow band of reef centred on the remains of the old wrecked boat north of the western passage. Two fishermen from Tabiang village believed toxic fish could be caught in the passageway and on Abatiku. The people of Abatiku, however, claim that their islet is free from toxic fish. This controversy is indicated in Figure 12 by the stipple free extension of the 1983 toxic area.

All interviewed fishermen considered toxicity about the southern passage to be confined to the northwestern section of the reef around Bike islet, which forms the southern-side of the passage mouth (Fig. 12).

Te bakoa (sharks) and *te bum* (pufferfish) poisonings are most likely to involve substances other than ciguatoxin (see Discussion below).

Species of fish reported as ciguatoxic on Tetutongo and Bike reefs, Abemama, are presented in Table 20.

Algal samples were collected from four sites on Abemama (Fig. 12). Two samples collected from either side of the reef crest at the western end of Abatiku islet did not contain *G. toxicus* cells (Table 19). Samples from the toxic area of the reef around Bike islet contained relatively low densities of *G. toxicus* cells per gram of algae sampled. Highest densities were found in a sample of algal turf scraped from rocks 7 m from the wreckage of a grounded vessel on Tetutongo reef. Another sample collected 10 m from the wreck contained only one third of this highest density. Similar densities of *G. toxicus* cells were found in samples collected 4 km north close to the airstrip (Fig. 12).

Statistics from Tungaru Central Hospital report 11 cases (2 fatalities) under the loose heading 'Fish Poisoning' between 1978 and 1983; 23 cases were reported between 1987 and 1990 (Table 28).

Discussion:

Toxic fish have been caught on the reefs close to the two main passageways into Abemama for many years (Cooper, 1964). Poisonings about the western passage are believed to date from around 1917 when a boat was wrecked on the reef known as Tetutongo (Fig. 12). Toxic fish were found in an area stretching from Tetutongo across the wetern passage to Abatiku. A reduction in toxicity around Abatiku is said to have begun in 1947. By 1961 toxicity was confined to the occasional *te ingo (Lutjanus bohar), te maneku (Epinephelus fuscoguttatus)* and *te rabono* (Muraenidae) except on Tetutongo reef where some Acanthuridae were also poisonous (Cooper 1964).

The reefs about the southern passage and the islet of Bike are believed to have become toxic following the wreck of another ship at the turn of the century (Fig. 12). Species considered toxic by Cooper (1964) were only an occasional large *te ingo, te maneku* and *te rabono.*

The overall level of ciguatoxic fish poisoning on Abemama seems little altered since the previous survey (Cooper 1964). Despite dispute over the toxicity of various families and orders of fish, as was noted in 1964, all fish considered toxic on Bike reef are higher carnivores. A comparison of the area considered toxic in 1964 to that of 1983 suggested that toxicity in this area is presently declining. The relatively low densities of *G. toxicus* at the Bike sampling site may also reflect a slow narrowing of this more southern toxic region. The abatement in toxicity on Abatiku islet mentioned by Cooper (1964) has progressed until at least its inhabitants believe it to be free from toxic fish. The algal survey results from Abatiku also lend some support to this belief.

Cooper mentions that Acanthurids as well as the usual reef carnivores were occasionally toxic on Tetutongo reef. Essentially the same situation was reported by fishermen interviewed in 1983. The algal survey results show relatively high densities of *G. toxicus* probably extend from Tetutongo towards Tabiang village. The area considered toxic in northern Abemama may be more a result of the generally held belief that toxicity is caused by wrecks than a true testing of the reef. Many Kiribati people are adamant that toxicity is directly caused by the remains of wrecked boats. The fishermen are therefore quite likely to use the remains of the wreck on the very extensive Tetutongo reef flat as a marker to pinpoint an area to be avoided. The toxic area near the southern passage in Abemama is slowly becoming smaller while that area about the island of Abatiku is now apparently free from toxic fish. Relatively high densities of *G. toxicus* on the northwestern ocean reefs along with the types of species found toxic in this area indicate that ciguatoxic fish poisoning is still prevalent on this reef and may be spreading northwards.

Fish poisoning from shark liver could either be vitamin overdose or ciguateric or a combination of both as discussed earlier on. A toxin from buffer fish differs from that of maitotoxin in origin and composition.

The status of fish poisoning on Abemama remains unchanged fro 1983 till 1989. The two cases which resulted in death (reported earlier on) were caused by consumption of turtle meat. The 22 cases reported for 1990 indicate that fish poisoning, assumed to be ciguatera, increased at this time, in synchrony with reef blasting conducted in 1988 near Bike islet and on the windward reefs. There is a threefold increase in fish poisoning cases during the 1987-1990 period as compared to the 1978-1983 period (Table 28). Other possible contributing factors to this increase (beside reef blasting) cannot be ruled out. Perhaps fish is more scarcer that fishermen tend to fish the toxic reefs. It is understood that during 1988-1990 Te Mautari on the island was buying fish from the selected fishermen as an effort to help them (fishermen) pay-off their debts owing to the company for the purchase of boats and canoes. This deal could have given the fishermen an incentive to fish the toxic areas which could have offered them higher catches.

Results:

Most fishermen interviewed had heard of a reef called Autakena/Tamnei and its reputed toxicity but only those fishermen from villages near the southern end of Nonouti had ever fished there (Fig. 13). Most fishermen chose to avoid the toxic reef except for Temotu village fishermen who must often cross it to reach other fishing grounds. These fishermen report that toxicity had dropped to such low levels that they considered the reef essentially non-toxic and that they would begin fishing there in earnest by 1984. They said no one had been poisoned during the first nine months of 1983 even though some previously toxic fish had been caught and eaten. Species previously condidered toxic were *te kuau* (Serranidae), *te ingo (Lutjanus bohar), te rabono* (Muraenidae) and *te ribaroro, (Ctenochaetus striatus).*

Te bakoa (Carcharhinidae, sharks) were considered sometimes poisonous. This concern is discussed in the previous cases discussed above.

Unfortunately, algal samples could not be collected from the toxic reef area. One of two samples collected from the northeastern ocean reef (Fig. 13) contained a moderate density of *G. toxicus* cells (Table 21).

Statistics from Tungaru Central Hospital report 74 cases under the loose heading 'Fish Poisoning' between 1978 and 1983. Another 2 cases were reported for a period between 1987 to 1990 (Table 28).

One fisherman from Abamakoro village described what was undoubtedly a case of ciguatoxic fish poisoning caused by eating moray eel viscera. Regrettably he did not remember where the eels had been caught.

Discussion

Toxic fish have been caught for many years on an area of reef in southern Nonouti known as Autakena reef (Fig. 13). Toxicity is believed to have been initiated by the wreck of a boat on this reef in 1890. Modification of the name of the wrecked boat provided an alternative name for the toxic area, Te Tamnei or The Spirit. Information provided by the crews of inter island vessels indicates a decrease in toxicity beginning in 1948-49 until by 1962 only *te ingo (Lutjanus bohar)* large *te rabono* (Muraenidae) and *te marati* (large Serranidae) were considered toxic (Cooper, 1964).

Despite the assurance of Temotu village fishermen that Autakena/Tamnei reef would be free from toxic fish in 1984, the situation appears little changed since the time of Cooper's report twenty to twenty five years ago (at time report was compiled). At least one Acanthurid species was considered toxic up until 1982-83. This implies that *G. toxicus* was still present in appreciable densities at that time. It seems unlikely that the toxin in these primary herbivores will drop out of the reef community rather than be passed on and accumulated for several years by higher trophic levels (Banner et al, 1966). What is far more likely is that Temotu fishermen's statements reflect an eternal Kiribatese optimism, at least when concerning the reduction in toxicity of fish caught close to their villages. Autakena/Tamnei reef therefore seems to be in a state of low toxicity equilibrium with sporadic minor increases and decreases in overall fish toxicity.

To date, it appears that fish poisoning on this island had been at very low key since 1983-1984 visit. A good explanation could be that that the toxic areas are not fished. The 2 cases recently reported could be other forms of fish poisoning. If they were ciguatera, they probably were part of an attempt to test if fish are still toxic at the known toxic areas. This is not new as Kiribati people are known for their readiness to take risks exploring the probable availability of this marine food source which they depend so much upon.

TABITEUEA ISLAND

Results:

Fishermen interviewed in the northern half of Tabiteuea in 1983 had normally heard of the toxic reef in Tabiteuea South but because of the great length of the island had never traveled there to fish. The fishermen interviewed from Tekabwibwi to Utiroa (Fig. 14) at this northern end agreed that toxic fish in Tabiteuea North were only found on a section of the western reef called Manekuroro. Although only some fishermen used this name, all agreed that the reef was located at the northern extreme of Tabiteuea, west of Tekabwibwi village (Fig. 14).

In 1983 toxicity according to interviewees appeared to be seasonal between April to August peaking between May to June. Species considered most toxic were *te bakati (Promicrops lanceolatus)* and *te maneku (Epinephelus fuscoguttatus).*

Information concerning the toxic area described by Cooper was mostly obtained from fishermen from Aiwa and Tewai villages. Fishermen from more southern regions apparently knew of the area's reputation and chose to avoid it. The toxic area surrounds a section of the reef where a temporary islet or kay is periodically formed. This kay was named Takoronga-inano (literal translation: far-out Takoronga). The toxic reef about Takoronga Kay is given the name Tabontekawete. The toxic reef was considered to lie on the western reef somewhere between points opposite Aiwa and Tewai villages (Fig. 14).

Currently all fish species from Tabontekawete are considered potentially toxic. Species considered toxic by the fishermen interviewed are *te kauoto* (very large Serranidae). *Te rabono* (Muraenidae) are not included in the list since they are very rarely tried for toxicity. Shark liver was considered highly toxic on occasions. Aiwa fishermen mostly catch fish from Tabontekawete reef incidently while trolling for tuna. These fish and those caught on the occasional exploration foray have always proven toxic.

Fishermen from villages further south, Nikutoru, Katabanga and Taku did not fish on Tabontekawete but note a localised periodic toxicity.

The southern most reef near Taku (Fig. 14) normally yields non-toxic *te ingo (Lutjanus bohar)* when these fish are not schooling. As the lunar cycle approaches full moon, te ingo appear in large aggregations. Te ingo caught from these aggregations are toxic.

Statistics from Tungaru Central Hospital report 20 cases under the loose heading 'Fish Poisoning' between 1978 and 1983, and another 99 between 1987 and 1990 (Table 28).

Algal samples were collected from four sites in Tabiteuea North (Fig. 14). All samples contained *G. toxicus* cells in moderate densities (Table 22).

Discussion:

Survey results collected from Tabiteuea and the presence of *G. toxicus* in moderate amounts support the conculusion that fish poisoning is still essentially the same state as twenty to twenty-five years ago (at the time the report was first compiled). Despite the claim reported by Cooper (1964) that toxicity of Tabontekawete reef was declining by the 1960's, all fish caught on the reef are currently believed toxic. The periodic toxicity of te ingo on the reef near Taku can also be explained in terms of toxicity on Tabontekawete reef. Toxic te ingo may move from Tabontekawete and form aggregates on Taku reef. The impulse to aggregate may be directly induced by the tidal/lunar cycle or alternatively the fish may group to feed on another organism with a lunar based cyclical abundance. Aggregations of te ingo (Lutjanus bohar) and their seasonal preference for certain food types has been noted in the Line Islands (Helfrich, et al, 1968). Another possible explanation is that *te ingo* toxicity on Taku reef is constant. More *ingo* may be caught when the monthly aggregations increase its local abundance. More people may be poisoned at these times simply because more people are eating *te ingo.*

Similar arguments could apply to the reef in Tabiteuea North where large Serranidae are seasonlly toxic. The fact that these large carnivores are toxic whereas the smaller carnivores and herbivores on the reef are not suggests that toxin may be imported by the groupers from another location. Algal samples taken from Tabiteuea North do contain *G. toxicus* cells in moderate densities but the lack of reported cases of toxic herbivorous fish implies that recently these densities have accumulated the toxin at Tabontekawete and migrated northwards seasonally. Conversely, the reef at Tekabwibwi may have been toxic in the past. The remnants of this toxicity may now only be found in the large Serranidae. The slow reduction in toxicity of these fish over the turn of the decade and the seasonality of current toxicity may reflect an annual surfacewards migration of the remaining toxic fish to the shallower reefs where they are caught.

A four-time increase in fish poisoning cases since 1987 up to 1990 as compared to 1978-1983 period (Table 28) indicates that this health hazard is becoming more frequent. It can only be inferred at this stage that fish is getting scarce on the island that the fishermen tended to fish the toxic reefs. Another explanation could be that toxicity had spread out from the known area(s) to the other reefs which the fishermen frequented. It is also quite probable that these poisonings could have been caused by the consumption of *te* *maneku* (large Serranidae), *te kauoto* (large Serranidae) and *te ingo* (L. bohar) during their seasonal migration as discribed earlier. There is, however, a need to examine medical records on the cases during the 1987-1990 period so that a more comprehensive analysis could be drawn.

ONOTOA ISLAND

Results:

Fishermen interviewed in 1983 from the southern villages of Onotoa (Fig. 15) knew of fish toxicity of Aontebaba reef in northern Onotoa but claimed southern Onotoa has always been free from poisonous fish. Fishermen from the northern villages verified this claim.

Species considered very toxic included *te rabono* (Muraenidae). Probably all species of large Muraenidae are poisonous but specific names given were: *te ngabingabi (Gymnothorax meleagris), te kairii* (G. *flavimarginatus) ,te kunibuaka (G. eurostus)* and *te witae (G.undulatus). Te marati* (large Epinephelidae), were thought highly toxic by one fisherman, *te kuau* (smaller Serranidae), notably *te nimanang, (Cephalopholis argus)* by several others. *Te ingo (Lutjanus bohar)* was thought often toxic, *te ikanibong (L. gibbus)* only occasionally. Te *riba* (Acanthuridae) were considered always toxic by some fishermen and often toxic by others. Although the most common surgeon fish are probalby all toxic, specific names given include: *te ribaroro (Ctenochaetus striatus), te mako (Acanthurus xanthopterin)* as well as the more general name, *te ribabui*.

Algal samples were collected from Aontebaba reef (Fig. 15). All four samples contained *G. toxicus* cells (Table 23). Large numbers of *G. toxicus* cells were found in a small sample of unidentified filamentous red algae growing on dead coral (sample 2, Table 23). A more reliable count obtained from a 150 g sample of algae tentatively identified from the preserved specimen as *Codium sp.* The average number of *G. toxicus* cells in each 0.1 ml sample was 770, density in the whole sample was therefore 154 cells per gramme.

Statistics from the Tungaru Central Hospital reported 11 cases under the loose heading 'Fish Poisoning' between 1980 and 1983 (Table 28). Seventeen cases were reported for the period between 1987 and 1990 (Table 28).

Discussion:

At the time of Cooper's report (1964) toxic fish were only caught on Aontebaba reef in northern Onotoa (Fig. 15). Toxicity of fish was said to have followed the wrecking of a boat on this reef many years ago. The number of toxic speices was considered to have declined over the years until the reef was thought free from toxic fish by 1960s. Cooper points out however that Onotoans would not eat large *te rabono*

(Muraenidae) caught on the reef and that *te ingo(Lutjanus bohar)* was still mildly poisonous.

In general, toxicity was believed to have been decreasing for many years. Species that were always toxic several years ago were thought to be more rarely toxic in 1983. Fish were considered to be more toxic during periods of drought.

In comparison with samples collected from other Gilbert Islands two of the samples from Onotoa contained exceptionally high densities of *G. toxicus* cells (Table 23).

The results of the 1983 survey show that fish poisoning is a continuing problem on Aontebaba reef in Onotoa. Members of each trophic level in the reef community are still toxic. This fact alone would allow a conclusion of continued toxicity but additional verification is given by the high densities of *G. toxicus* cells recorded from the reef.

Contrary to this conclusion the people of northern Onotoa are still making essentially the same statements as they did twenty to twenty-five years ago. They still believe that several years ago fish toxicity was much more severe than at present and in a very short while the reef will be safe to fish. This reflects a combination of reluctance on the part of the Onotoans to think poorly of their home island and a general Kiribati trait of apparently unflagging optimism.

A comparison of the areas defined as toxic in 1964 with that of 1983 (Fig. 15) suggest a possible reduction in size. Fishermen interviewed in 1983 considered the toxic reef to be sharply defined. It is possible that the size difference mentioned merely reflects a lack of certainty by the fishermen about the limits of the toxic reef when drawn on a map.

One fisherman believed fish poisoning were increased in severity over the periods of drought often experienced in the more southern Gilbert Islands. There are at least three possible explanations for this. The restricted diet experienced during drought conditions may either increase susceptibility to ciguatoxin or lead to increased fishing effort and consequent greater consumption of toxic ish. The final possibility is that some environmental change linked to periods of drought causes increased *G. toxicus* density and consequent increased poisonings.

It appears that fish poisoning had not changed since the 1983/1984 survey. The people of Onotoa may well be contended with the amount of fish caught from other fishing grounds. It should also be of importance to note that no channel blasting had been conducted on the island since 1984. Incidently, the newly constructed causeway linking the northern and southern portions of the island is nearing completion. It is quite unlikely that the causeway may have any effect on fish poisoning, but the fact that the potential is there cannot be ruled out. There is a need to monitor the effect of this man-made structure on health, social, biological and environmental stress and degradation.

BERU ISLAND

Results

In 1983 fishermen from several of the villages distant from Taboiaki village (Fig. 16) believed that northern Beru had never produced toxic fish. Their information about toxicity at Taboiaki was only hearsay so they felt disinclined to comment. Fishermen with more personal knowledge claimed that *te rabono* (Muraenidae), *te kuau* and *te maneku* (large and small Epinephelidae) were always toxic on the reef adjacent to Taboiaki village (Fig. 16). *Te kairii (Gymnothorax flavimarginatus)* was mentioned by one fisherman but most considered all large moray eels toxic. *Te nrekereke (Cephalopholis cyanastigma)* was specified by one fisherman as especially toxic, te maneku *(Epinephelus fuscoguttatus)* by another but most used the more general name for smaller Serranidae species - *te kuau*. *Te ingo (Lutjanus bohar)* was considered always toxic by some fisherman and occasionally toxic by others.

Algal samples collected from three sites on Beru (Fig. 16) all showed the *presence* of *G. toxicus* cells (Table 24). Greatest densities were found in samples collected from the toxic reef at Taboiaki (average =1.1 cells/g). Average density in samples collected from the southmost *tip of* Beru *was ten times lower, average density in samples from* Rongorongo was six times lower.

Statistical records at Tungaru Central Hospital report 79 cases under the loose heading of 'Fish Poisoning' between 1978 to 1983. To date 127 cases were reported, 48 were recorded for the 1987-1990 period (Table 28).

Discussion:

Fish toxicity on Beru appears to have remained fairly stable since last reported by Cooper (1964). Sporadic increases in the numbers of toxic species in the last twenty to twenty-five years (at the time the report was prepared) either have not occured or have been forgotten. Cooper mentioned that in 1964 Beru was a dry, poor and relatively crowded island where people were forced to risk fish poisoning to obtain enough food. Beru is currently a moderately wealthy island, many people have migrated elsewhere to find work (Bailey, 1983) and imported food stuffs are normally available. These factors may explain the reduction on general knowledge concerning fish poisoning until it has been almost forgotten by some fishermen distant from Taboiaki.

Species considered toxic in 1983 were similar to those reported in 1960s by Cooper. Only the large carnivorous reef dwellers are believed toxic. The long sustained and localised toxicity of these species may be a reflection of their longevity or a recycling of ciguatoxin within the localised ecosystem (Helfrich and Banner, 1968).

The presence of moderate desities of *G. toxicus* in the algal samples however, suggests another possibility. Levels of toxin in the primary herbivores may be too low to cause poisoning symptoms in humans. Toxicity may only become apparent when

(Muraenidae) caught on the reef and that *te ingo (Lutjanus bohar)* was still mildly poisonous.

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The presence of moderate desities of *G. toxicus* in the algal samples however, suggests another possibility. Levels of toxin in the primary herbivores may be too low to cause poisoning symptoms in humans. Toxicity may only become apparent when concentrated in the tissues of the reef's higher carnivores.

The wreck of a New Zealand ship on the Taboiaki reef was believed to have caused fish toxicity. Toxic fish were said to have decreased in number from 1958 to 1962 however, a comparison of the reef area considered toxic in 1964 (from Cooper, 1964) and that in 1983 (Fig. 16) suggests a possible narrowing of the dangerous area over this period. Unfortunately, there is no good way for the accuracy of representation in either report.

The number of cases recorded for 1987-1990 period shows that this phenonmenon had neither increased nor decreased. It can be assumed that the people of Beru are well aware of the toxic reefs and fish species. The cases recorded may not be all ciguateric but also other forms of poisonings related to the consumption of fish. The ongoing testing of fish if they are still poisonous could have contributed to the occassional poisonings recorded. Patients' medical records from this island were not available at the Central Hospital. It could, however, have been very helpful to have them on hand.

There is no knowledge of any channel blasting or dredging being carried out on this island during the 1987-1990 period, which may substantiate a no significant change in the level of fish poisoning on the island.

NIKUNAU ISLAND

Results:

Fishermen from the major villages were interviewed in 1983 (Fig. 17). They generally agreed the toxic fish have been caught from the reef by Murubenua and Tabutoa villages for a long time and claimed that the reef by Rungata was free from toxic fish until the beginning of the 1980s. The fishermen believed the wreck of the Sacred Heart Mission Ship, "St. Teretia II" (in 1955) was responsible for the current toxicity at Rungata.

Te rabono (Muraenidae) were considered always toxic by some fishermen and often toxic by others. *Te kuau* (small Epinephelidae) and *te maneku (E. fuscoguttatus), te ingo (Lutjanus bohar)* and *te nunua (Sphyraena sp.)* were thought toxic at times. *Te inai* (Scaridae (were believed to be almost always toxic, *te riba* (Acanthuridae, notably *te katawa - Acanthurus lineatus)* were considered often toxic.

Algal samples were collected from seven sites on the western reef of northern Nikunau (Fig. 17). *G. toxicus* density was fairly low in algal samples collected north of Muribenua and south Manriki villages (Fig. 17, Table 25-samples 1-4, 9 and 10). Samples collected in the toxic zones north and south of Rungata (Table 25, Samples 5-9) contained roughly equivalent relatively high densities of *G. toxicus* cells (average = 3.0 cells/g). Algal samples collected from the reef at Rungata about two metres north of the boat passage contained the highest densities of *G. toxicus* cells (Table 25, samples 1 and 2).

Statistics from the Tungaru Central Hospital report forty four cases from Nikunau under the loose heading "Fish Poisoning" between 1978 to 1983 and 95 cases between 1987 and 1990 with 1987 being the highest (78 cases, Table 28).

Discussions:

A comparison of 1983 survey results with the statements in Cooper's (1964) report reveals an unusual changing pattern of reef toxicity. Cooper reported that Nikunau islanders believed toxicity began in Rungata, spread north and south when at peak intensity then withdrew towards the center again at Rungata's reef toxicity declined. Apparently, the people of Nikunau have forgotten this information.

The statement made in 1983 show that during the last twenty to twenty-five years (up to the time this report was in preparation) toxicity at Rungata had declined to a negligible level while toxicity at Muribenua and Tabutoa had increased markedly and was considered the area of long standing toxicity. Recently the reef at Rungata had again begun to produce toxic fish. Cooper noted the wreck of the St. Teretia II on Rungata reef in 1955 and mentioned the apparent lack of any aggravating effect upon fish toxicity in that region over the next seven years. It would appear that whereas the boat wreck prior to the 1950s and the fish toxicity supposedly caused by that event have been forgotten by the fishermen, the more recent boat wreck in 1955 has been remembered and seized upon to explain the recent poisonings at Rungata. The relationship between fish toxicity and boat wrecks is discussed further in the Literature Review section.

It appears from the 1987-1990 records that fish poisoning flared up in 1987 and then cooled down the following years (Table 28). Unfortunately, the exact position of reef where this flare up took place or what might have triggered its onset could not be pinpointed due to unavailability of patients' medical record and information on any activities that may have been carried out prior to the onset. However, one can only speculate that this could be a natural cycle occurring every 6 years (compare figures for 1981 and 1987) or toxicity had spread out further. The later assumption can be predicted from previous observations made about 7 years ago.

Results of the algal survey (Table 25) show that *G. toxicus* density within the areas considered toxic in both 1964 and 1983 is comparable to levels found in other toxic areas throughout the Gilbert Islands. Both herbivorous and small and large carnivorous reef fish have been described as toxic in 1983. These facts support a conclusion that despite fluctuations in intensity, ciguatoxic fish poisoning is firmly entrenched along the western reef of northern Nikunau.

TAMANA ISLAND

Results:

Fishermen interviewed from the major village (Fig. 18) in 1983 agreed that no specific area on Tamana produced ciguatoxic fish. One fishermen described how a nearby family became sick after consuming *te riband (Acanthurus lineatus).* This is unlikely to have been ciguatoxic poisoning as symptoms were limited to diarrhoea, the fish were kept in cold broth for one day before consumption and normally *te ribanti* are eaten by others with no ill effects. Another fisherman said that very occasionally *te nunua (Sphyraena sp.)* were mildly toxic. Only one case of poisoning was believed to have occured in 1983. *Te bakoa* (Carchrhinidae) were said to sometimes have toxic livers, the rest of the shark could be eaten without risk.

Statistics from Tungaru Central Hospital record thirteen cases from Tamana under the broad heading "Fish Poisoning" between 1978 to 1983 and eight cases between 1987 to 1990 (Table 28).

Algal samples were collected from one site just north of a boat passage at Bakaka village (Fig. 18). *G. toxicus* were present in moderate to low densities in all samples (Table 26).

Discussion:

Ciguatera fish poisoning had never been recorded on Tamana at the time of Cooper's 1964 report. At present ciguatoxic fish poisoning is not a problem on Tamana. A possible explanation for *te nunua (Sphyraena sp.)* toxicity is given by the presence of G. toxicus on Tamana reefs. Possibly levels of toxin in herbivores and lower carnivores are insufficient to cause poisoning in man until concentrated in the tissues of higher carnivores such as barracuda. However, it seems unlikely that other common large predators such as *te rabono* (Muraenidae) and *te marati* (Epinephelidae) would not be toxic also. As yet no medically substantiated cases of ciguatera fish poisoning have been reported from Tamana. An examination of medical records from the island would help reflect the past and present status of fish poisoning, but ciguatera in particular.

The wreck of a Korean fishing boat on the reef west of Bakarawa village or boat channel blasting and dredging had no way been suspected to have anything to do with ciguatera fish poisoning on Tamana.

ARORAE ISLAND

Results:

Fishermen interviewed from several main villages in 1983 agreed that toxic fish had recently begun to be caught on the western reef by Tamaroa village (Fig. 19). All agreed that less toxic fish had been caught in 1983 than previous years. One fisherman believed that a certain area on the reef west of extend end of northern reef by Tamaroa.

Species of fish found to be sometimes toxic in 1983 included: *te bawe* and *te tinaemia* (small Lutjanidae), *te ingo (Lutjanus bohar), te riba* (Acanthuridae), notably *te katawa (Acanthurus Meatus), te mako (A. xanthopterus), te matakore (Monotaxus grandoculus), te nunua (Sphyraena sp.)* and *te nuonuo (Batistes sp.)*

Algal samples were collected from two sites on Arorae (Fig. 19). *G. toxicus* was present in all samples (Table 27). Relatively high densities were recorded in one sample from the toxic reef at Tamaroa (Table 27, sample 1) moderate to low densities were found in other samples from the western and eastern reefs.

Statistics from Tungaru Central Hospital record thirty cases from Arorae under the loose heading "Fish Poisoning" between 1978 to 1983 (Table 28). Cases between 1987 to 1990 were also been included raising the number of cases to forty five.

Discussion:

The results of the 1983 survey of Arorae clearly record a recent localised flare up of a ciguatoxic fish poisoning in the last several years. There was disagreement about the exact date of onset. Some fishermen said toxicity began in 1982, one claimed toxicity began in 1975 to 1976 and reached a peak in 1980.

Fish species believed toxic include herbivores, primary and several secondary carnivores. Algal samples show that *G. toxicus* is still present in appreciable numbers both in the toxic zone and elsewhere on the reefs about Arorae. Statements by fishermen concerning the reduction in numbers of poisonings in 1983 may reflect a real drop in the intensity of fish toxicity or a possible increased worriness of those close to the toxic areas.

Medical records for the period 1987-1990 show that fish poisoning is still there and that the pattern of occurence appears to be alternating on a one-year basis (Table 28). This pattern can not be linked to any known natural or unnatural phenomena but it is stipulated that this could be a natural cycle, also evident in the 1978-1983 period.

Cooper (1964) had claimed that Arorae people were indignant at the suggestion of toxic fish being produced on their island. The belief by Arorae people that toxicity has been much less than in previous years and that their land will return to a respectable untroubled state once more no longer holds. Statistical evidence indicates that toxicity remains.

BANABA, PHOENIX AND LINE ISLANDS

Although there were no surveys conducted on fish poisoning in these groups, there were numerous unofficial reports told about it, some were serious (pers. comm.). Banaba, also known as Ocean Island, had been known to be free of fish poisoning. The single case reported in 1982 (Table 28) could have been some sickness associated with fish consumption. It should be noted that the reef surrounding the island must be under constant fishing pressure and that the fish are unlikely to be toxic. One should also realise that the reef may be toxic but the level of the toxin is not high enough to cause any public concern.

The first recorded outbreak at Fanning Island, previously free of ciguatera, followed the dumping of war materials (tank mines, ammunition, batteries, etc.) by the US Army in July of 1945, before evacuation of the island (Ruff, 1989). The ninety five cases recorded for 1946 and 1947 were believed to have been caused by the consumption of fish caught in areas where war material had been dumped (Ruff, 1989). Prior to 1939-1945 war no ciguatoxicity had been reported. Medical records for the 1978 to 1990 period show that Fanning Island still experiences fish poisoning but on a very low and irregular basis (Table 28).

Ciguatera appeared on Kiritimati after 36 nuclear explosions were conducted between 1958 and 1962 by the US military based in the Pacific (Ruff, 1989). Ciguatoxicity is still here ever since as evidenced by medical records for the 1978-1990 period (Table 28).

Washington which was then known to be free of ciguatoxin was never occupied prior to World War II, had 49 fish poisoning cases during the post war period 1978-1990 (Table 28). This suggests that the onset could have been aggravated by boat channel dredging or regular visists made by Kiribati cargo boats. It is also quite likely that toxicity in the neibouring islands (Fanning and Kiritimati) had spread to this island.

Canton which was once one of the Allied airforce base in the Pacific had not been on ciguatera record. It is understood that there are probably only about 10 families on the island. Land crab and milkfish are known to be plentiful and it is quite likely that these people have no need to fish the reefs surrounding the island except for grayfish (lobster). No survey had been conducted on the island so the status of ciguatera is not clearly understood.

LITERATURE REVIEW

1. CIGUATERA AS A GLOBAL HEALTH CONCERN

Ciguatera fish poisoning has been a global health concern in the Indo-Pacific realm. There also has been a lot of issues regarding increases in incidences and what might have caused them. Research is still continuing on the exact causative organism, triggering mechanisms, nature of the toxin, cure and reliable tests for toxic fish.

A report compiled by the South Pacific Commission for a two-year period (1989-1990) suggests a dramatic increase in fish poisoning in Kiribati. This quite contradicts my finding which shows that there were no dramatic decrease or increase over the 11-year period (Table 28). One explanation is that the records presented by Health Statistics were not verified as opposed to verified cases extracted from the records. A lot of cases put under fish poisoning were more of food poisoning. Another explanation is an increase in number of clinics over the past five years resulted in more cases being reported (pers. Comm.).

In Fiji, the rate of incidents had dropped from 1.4 to 0.7 during the same period. A similar drop is also observed in Vanuatu whereas in French Polynesia and New Caledonia the number of incidences are fairly similar for both years (Appendix iii).

Cook Islands, Tuvalu, Tokelau and Marshalls have been experiencing ciguatoxicity for a long time. An analysis made in 1986 on the rate of mobidity related to fish poisoning shows that at one stage Tokelau had the highest followed by Tuvalu, Kiribati and French Polynesia (Lewis, 1986).

One classic example whereby reef disturbance had triggered ciguatera fish poisoning is on the island of Nauru. A boat/canoe channel was blasted out of Anibare reef in 1990. Prior to this ciguatera was not known by the Nauruans but ever since the channel was created toxic fishes have been caught causing a lot of public and economic problems to the local community. Toxicity had spread to the neighbouring reefs.

2. OTHER INCIDENCES

A fish poisoning case caused by consumption of fresh water fish believed to be herbivorous, thus feeding on blue-green algae, was reported in 1987 (Bhat et al, 1988). The symptoms were similar to that of ciguatera. The possible cause suggested were attributed to ingestion of certain aquatic biotoxin through fish. The toxins could have been formed in the pond as a result of ecological imbalance due to partial filling up of a pond during the preceding month which was earlier polluted heavily by the discharge of effluents from industries (Bhat et al, 1988). This finding casts some shadow on the nature and origin of the toxin that supposedly is causing ciguatera. Several sea water algae have been identified (by numrerous researchers) to harbour the presumed causative organism, *Gambierdiscus toxicus.* Confirmation on the origin of the toxin in this case had not been carried out. So one can assume that if the dinoflagellate *G. toxicus* can survive in fresh water environment it must have been the causative organism. It is also quite likely that in this case another dinoflagellate could be respoinsible.

3. CIGUATERA LINKED WITH MILITARY ACTIVITIES

This is one of the hottest issues in the history of ciguatera. This phenomenon has been coined with both natural and human induced disturbances. Military activities have been condemned as to have aggravated the onset and increase in ciguatoxicity in many parts of the Pacific.

A lot of concerns have been raised regarding the effect of nuclear bomb testing, war material dumping and military base installations on both the environment and health. There are numerous cases which clearly substantiate the association of ciguatera occurences and outbreaks such activities.

Some prominent scientists claimed that ciguatera had not occurred in Hao, French Polynesia before January 1965. But the conversion of the atoll for nuclear testing which required coral dredging and other construction, has triggered the onset of ciguatera (Robie, 1989, Ruff, 1989). Gambier Islands and Tuamotu Islands in particular Muroroa had suffered the same fate. Muroroa and Fangataufa have been the centre of nuclear bomb blasting in French Polynesia (Ruff, 1989).

In Micronesia, Marshall Islands, Gilbert and the Line Islands have also been identified as being affected by military activities. Some of the islands that were known to be free of ciguatoxin (Enewetak, Fanning and Kiritimati) were affected during the post-war period (Ruff, 1989). Increase in toxicity level as indicated by the rising number of cases in other islands were also assumed to be associated with military activities (Ruff, 1989).

On the single island nation of Niue, ciguatera was a more serious problem following WW II (Bagnis, 1973b), but ciguatera has been declining in recent years as it has in the French Territiory of Wallis and Futuna (Lewis, 1986).

It is quite apparent that these human disturbances can trigger the onset or aggravate ciguatera fish poisoning in any one locality. It is also evident that any reef existing within the tropics is likely to harbour a potentially toxic dinoflagellate, *Gambierdiscus toxicus.*

It is of great interest to note that according to the South Pacific Epidemiological and Health Information Services, the 1973-87 rates more than three times the regional average were recorded in French (eastern) Polynesia, some of the isolated island groups in the north central Pacific (Kiribati, Tokelau and Tuvalu), the Marshall Islands in north east Micronesia and Vanuatu (Ruff, 1989). Compared with the experience in French Polynesia, ciguatera occurs less commonly in the Melanesian nations to the west (Papua New Guinea) and the Solomon Islands), where the population is less dependent on marine resources (Ruff, 1989).

4. OTHER FORMS OF FISH POISONING

About over 200 species of marine fishes are known or thought to be venomous. Most of them are shallow-water or inshore species commonly found in the Pacific waters. Of course there are also those that inhabit deeper waters. The venom of these fishes quite differ from the toxins of the poisonous fishes, and from the toxin of the other venomous animals (Bagnis, 1983). Some of the most occurring fish poisonings will only be discussed. (For further reading on the subject, refer to WHO article "Marine Fish Borne Disease in Tropical Region" authored by Dr. Raymond Bagnis, 1983).

Shark liver poisoning

Shark liver poisoning can be of two forms, ciguateric and hypervitaminosus. Most of the sharks are carnivorous (prey on other smaller and even larger fishes or mammals).

Ciguatoxin, the principal toxin in ciguatera poisoning, could be obtained from herbivorous or other carnivorous fish. This toxin accumulates in the liver and thus can cause ciguatera fish poisoning. On the other hand, the liver which is rich in vitamins, especially Vitamin A can also cause a poisoning known as hypervitaminosis A (Vitamin A overdose).

Clupeotoxicity

This is one of the common forms of fish poisoning caused by consumption of fish like sardines and those in the Clupeidae and Atherinidae families. Tarabuti *(Herklotsichthys quadrimaculatus)* has been found to be toxic at times in Kiribati. The source is believed to be three toxins found in the viscera, one of them is very similar in polarity to that of ciguatera (Raj., 1984).

Scombrotoxicity

This poisoning is caused by eating fish belonging to Scombridae (tunas) and Atherinidae (hardyhead) or *rerekoti.* It is common in tropical Australian waters, Queensland, Hawaii and in the Pacific in general. The Sphyraenidae (*nunua)* is known to be occassionally toxic in Kiribati.

This poisoning results from a spoilage if fish are not well refrigerated or left too long in the open as is often the case in most Pacific islands. If the fresh fish is not properly stored a bacteria found on the skin of the fish acts on the fish's flesh to break down a compound known as histidine, which normally occurs in high concentrations in tuna, barracuda, mackerals and others (Kizer, 1982).

Tetraodontoxism

Roe and viscera from buffer fish, blowfish, baloon and similar species, may cause this poisoning. Fatality may result if the fish is not properly cleaned. In some species the same poison found in the roe and viscera is also found in the skin (Kizer, 1982).

Symptoms occur immediately after eating a fish or they may be delayed by several hours later. These include numbness of entire body, extreme weakness, nnausea, vomitting, headache, sweating, tightness in the chest, breathing difficulty and various others (Kizer, 1982 and Raj, 1983).

These fish are a delicacy on some islands. Marakei people are known to be the experts in bufferfish and similar species preparation.

Mullet poisoning

This is also known as 'sleeping sickness' which is often caused by the consumption of mullet species, te aua. Other species are known to have caused this poisoning in most parts of Fiji (Raj, 1984), Hawaii as well as Kiribati. It is being reported that smoking can make this poisoning worse but no serious cases have been reported (pers. comm.).

The exact sources of the poison is not known but it is believed to originate from the fish itself and not to be the result of spoilage or anything that the fish eats (Kizer, 1982). Symptoms include dizziness, loss of balance, hallucination, phsycological depression, itchness, paralysis and many more (Kizer, 1982).

Some believe that the causative organism is bacteria accumulating in the gills, some are ingested with food as fish scavenges the water surface. More work is needed in the identification of the exact causative organism.

Canned fish poisoning

This is common throughout the world. The causes are multiple-bacterial contamination, old stock, spoilage during processing, and so forth.

Shellfish poisoning

Shellfish poisoning is common in Asia and the Pacific. There are a variety of toxic shells. *Te Bun (Anadara maculosa)* has been identified to be one of the shells that helped spread diarrhoea in Kiribati in the 1970s.

A very interesting incidence occurred (October, 1991) where members of the University of South Pacific Council that met in Tarawa, Kiribati, were involved. An unofficial report claimed that a puffet was held at a local hotel and a variety of local foods were served. Among them was a strombus shellfish locally known as '*te nouo'* This was blamed to be the cause of the sickness (vomitting, diarrhoea, etc.) which most of the council members had.

Anadara antiquata or *kaikoso* as they call it is one of the shells being identified in Fiji (Raj, 1984) that can cause shellfish poisoning. The causative organisms can be benthic, bacteria and even a natural toxin in the animal itself.

Symptoms vary from shell to shell and from locality to locality. These include vomitting, diarrhoea, dizziness, seating and others previously mentioned.

Crab poisoning

This is common in Kiribati. Red crab as previously mentioned is a problem in Kuria and Aranuka. This crab is not poisonous elsewhwere in Kiribati. The origin of the toxin is unknown. But marine crabs such as Zosimus aeneus are known to be deadly.

Turtle posioning

This is one of the poisonings that is often reported. There were cases where some of the consumers died while others were not. It has not been established what might be the cause of this poisoning in Kiribati. One speculation is that a particular turtle species has some toxic visceral parts; others suggest that one particular turtle species preys on puffer fish and that the toxin from the roe and viscera (of a buffer fish) is accumulated in the liver of the turtle (pres. comm.). The authencity of these claims has not been investigated.

5. TEST AND CURE

There has been a tremendous work done by various researchers to try and develop reliable and effective antidotes. Traditional testing methods and medicines have been put aside and the emphasis is concentrated on scientific approach. Traditional methods have been tested for their authencity but failed while herbal remedies have not bee fully investigated (Banner et al, 1963). The modern and scientific approaches will be discussed briefly.

Testing methods

Three testing methods are known: Mouse test, Mosquito test and Poke test. A mouse test was developed by Yasumoto (Japan) and associates while mosquito and poke tests were developd by Bagnis (French Polynesia) and Hokama (Hawaii), respectivley. A mouse test involves the injection of the toxin extracted from the fish into a mouse and then observed for any change in behaviour. A mosquito test works on the same principle while a poke test involves the immersion of end of bamboo sticks covered with a white liquid eraser. The end of the stick is poked into a fish flesh and then dipped in a series of reactants. A colour change determines fish's toxicity. This test is sold commercially in Hawaii and the United States mainland.

Cure

There is no antitode being approved by the World Health Organisation. However, a successful treatment with intravenous mannitol was reported by Palafox and coworkers (Palafox et al, 1988). Over twenty patients with acute ciguatera fish poisoning were treated with intravenous mannitol, and each patient's condition improved dramatically. Those patients in coma responded quite well (Palafox, et al, 1988). The pharmacological nature of mannitol on ciguatera patients is not well understood and more work is needed in this area. It may also be of importance if a full scale investigation is made on the effect of herbal medicines being used by the Pacific Islands people.

V. SUMMARY

A survey of the Gilbert Island, Kiribati, was carried out in the second half of 1983 to investigate current levels of ciguatoxic fish poisoning.

Specific aims of the survey were to discover which fish species were considered ciguatoxic, the location of reef areas where these toxic fish are caught and an indication of the density and distribution of the causative organism, *G. toxicus,* on each island.

Results were obtained by interviewing fishermen from the major villages on each of the 16 islands plus collection and analysis of algal samples.

Fish species considered toxic on each of the Gilbert Islands are listed. Appendices are included containing a compilation of scientific and Kiribati names of fish species mentioned as ciguatoxic on on the island during the 1983 survey. Other fish names are listed for reference only.

Types of fish most commonly implicated as ciguatoxic throughout the Gilbert Islands are given below in approximate order of decreasing probability of severe toxicity:

1. *Te rabono* (Muraenidae, moray eels)
2. *Te ingo (Lutjanus bohar,* red snapper)
3. *Te riba* (Acanthuridae, surgeonfish, notably *te ribaroro,* C. striatus and *te ribatanin, Acanthurus lineatus).*
4. *Te kuau* (Epinephelus, groupers and coral cod, notably *te bakati, Promicrops lanceolatus, te maneku, Epinephelus fuscoguttus, te nimanang, Cephalopholis argus.*
5. *Te nunua (Sphyraena sp.,* barracuda)
6. *Te bawe/tinaemia* (small *Lutjan Lutjanus monostiqma* and *L. fulvus)*
7. *Te inai* (Scaridae, parrotfish, notably *te ikamawa, Scarus pectoralis, te ikamawa)*
8. *Te nuonuo/bubu* (Balistidae, triggerfish)

Maps of each of the Gilbert Islands are included showing areas of fish toxicity recorded in 1983 compared to those recorded in the late 1950's in an earlier survey.

During the 1983 survey, fishermen reported that toxic fish were present on 14 of the 16 Gilbert Islands. Toxic fish were still caught on the 10 islands recorded as toxic in the 1950's: Butaritari, Marakei, Tarawa, Abemama, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau and Onotoa. Two islands had recently begun to produce toxic fish: Makin and Arorae. Rare catches of toxic fish were reported from Maiana and Tamana. Only Abaiang and Kuria were believed free from toxic fish.

The number of Gilbert Islands producing toxic fish had therefore increased by an additional two and possibly up to four islands over the 20 to 25 years prior to the survey.

Major increases in the area of reef producing toxic fish had occurred on the northern islands of Butaritari and Tarawa since the earlier survey. Smaller increases had occurred on Marakei and Nikunau.

The area of reef producing toxic fish appears to have decreased on the islands of Beru and Abemama. Results suggest smaller decreases in areas of reef producing toxic fish on Aranuka, Nonouti and Onotoa.

The 1983 survey results demonstrate a general pattern of ciguatoxic presence in the Glbert Islands. Ciguatoxic fish may rapidly appear in a formerly non-toxic location. More commonly, however, reefs with histories of production of ciguatoxic fish undergo sporadic flare-ups and decrease in toxicity but retain an overall higher probability of production of toxic fish than areas with no toxic history.

The results of the algal survey indicate that the causative organism of ciguatoxic fish poisoning (*Gambierdiscus toxicus)* is common throughout the islands tested.

The mean density of *G. toxicus* in areas producing toxic fish throughout the Gilbert Islands was 7.7 cells per gram of sampled algae (range = 0 to 14 cells/gr). Highest densities were recorded from Onotoa and Nikunau. The average density of *G. toxicus* in areas considered free from toxic fish was 0.46 cells/gm algae.

Gambierdiscus toxicus densities recorded in the more northern Gilbert Islands were, on average, lower than those recorded in the more southern islands.

The results strongly suggest that a more comprehensive survey would reveal *G. toxicus* on all of the Gilbert Islands at almost any reef location. At least the potential for a ciguatoxic flare-up, given appropriate environmental conditions, therefore exists on any ocean reef in the Gilbert Islands.

The combined results of the 1983 survey show that ciguatera fish poisoning is an increasing problem in the Gilbert Islands. Latest information obtained from medical records (1978-1990) show that occurence and flare up in toxicity on some reefs were attributed to boat channel blasting and dredging. There are also signs of possible seasonality ranging from one to seven years. Fish poisoning remains a public health problem.

Fish poisoning (most probable ciguatera) is also a problem in the Phoenix and Line Islands where the onset was claimed to be caused by military presence and war material dumping during and after WWII. It is a problem in most Pacific island nations. French Polynesia is the most affected followed by Micronesia and Tokelau in Polynesia. Melanesian countries appear to be least affected.

REFERENCES

Adachi, R., **Y. Fukuyo, 1979.** The thecal stucture of a marine toxic dinoflagellate *Gambierdiscus toxicus* gen. et sp. nov. collected in a ciguatera endemic area. Bull. Jpn. Sci. Fish. Vol. 45, pp. 67-61.

Amesbury, S. S., **R. F.** Myers, **1982.** Guide to the coastal resources of Guam. Vol. 1. The Fishes. University of Guam Press, 141 pp.

Bagnis, R.S., 1983. Review of recent research related to ciguatera at Louis Malarde Institute for medical research, Tahiti, French Polynesia. In: Second Expert Committee on Ciguatera, SPC, Jan.

Bagnis, R. 1973. Fish Poisoning in the South Pacific. South Pacific Commision Publications Bureau, 112 pp.

Bagnis, R., 1979. Ciguatera and natural catastrophies.
Communication presented to the 14th Congress of Pacific
Science of Khabarosk (USSR), 20 Augus -5 September 1979.
(Session No. D4, Symposium No. 1.111.1). Manuscript.

Bagnis, R.,T. **Kuberski, S. Laugier, 1979.** Clinical observation on 3,009 cases
of ciguatera (fish poisoning) in the South Pacific. Am. J. Trop. Med. Hyg., vol. 28, p. 1067.

Bagnis, R., **S. Chanteau,** E. **Chungue, J.** M. **Hurtel,** T. **Yasumoto, A. Inoue, 1980.** Origins of ciguatera fish poisoning: A new dinoflagellate, *Gambierdiscus toxicus.* Adachi and Fukuyo, definitively involved as a causal agent. Toxicon, vol. 18, pp. 199-208.

Bhat, R.V., **Gautami, S; Sashidar, R.B., Lakhani, A.G., 1988.** A foodborne disease outbreak in man due to fish consumption possibly containing phycotoxins in Bombay, India. Proc. Jpn. Assoc. Mycotoxicol No. 28.

Bailey, E.E., **1983.** Report on the 1978 census of population and housing. Vol. Ill: Analytical Report: Population Distribution and Migration. Land, Housing and Services, Education and Religion. Ministry of Home Affairs and Decentralization publication, Bairik.,, Tarawa, Kiribati.

Banner, A. H., **P. Helfrich,** T. **Piyakarnchana, 1966.** Retention of Ciguatera Toxin by the Red Snapper, *Lutjanus bohar.* Copeia, No. 2, pp 297-301.

Banner, A.H., Shaw, S., **Alender, C, Helfrich, P., 1963.** Fish intoxication. Notes on Ciguatera, Its mode of action and **a** suggested threrapy. In: South Pacific Commission Technical Paper No. 141.

Chapman, V. J. and D. J., **1973.** The Algae. Macmillan and Co. Ltd., 497 pp.
Cooper, M. J., 1964. Ciguatera and other marine poisonings inthe Gilbert Islands. Pacific Science, Vol 18, pp. 411-440.
Cross, R., **1978.** Fisheries Research Notes (September 1976 to October 1977). Fisheries Division, Ministry of Natural Resource Development, Tanaea, Tarawa, Kiribati. 135 pp.

Dawson, E. Y., **1957.** An Annotated list of marine algae from Eniwetok Atoll, Marshall Islands. Pacific Science VXI, 1957, pp 92-132.

Doty M., **1983.** An expanded field key to common seaweeds. In Field keys to common Hawaiian marine animals and plants. State of Hawaii Department of Education, pp B-l to B47.

Fisheries Information Project, South Pacific Commsission, 1991. Ciguatera Information Bulletin, No. 1, May.

Goo, F. C. C, A. **H. Banner, 1963.** A preliminary compilation of Gilbertese animal and plant names. University of Hawaii, Honolulu, privately issued mimeograph, 65 pp.

Goodson, G., **1973.** The many splendored fishes of Hawaii. Marguest Coluorguide Books, Palos Verdes Estates, California, 91 pp.

Groves, G. W., **1981.** High waves at M'akin in December 1979. Institute of Marine Resources/Atoll Research Unit, University of the South Pacific, private issue, 9 pp.

Greenberg, M., **J. Greenberg,** 1983. Hawaii fishwatchers guide. Seahawk Press, Miami, Florida, waterproof display poster.

Helfrich, P., 1963. Fish poisoning in Hawaii. Hawaii Medical Journal, Vol. 22, pp. 361-372.

Helfrich, P., A. **H. Banner, 1963.** Experimental induction of ciguatera toxicity in fish through diet. Nature, vol. 197, pp. 1025-1026.

Helfrich, P., T. **Piyakarnchana, P. S. Miles, 1968.** Ciguatera fish poisoning. I. The ecology of ciguateric reef fishes in the Line Islands. Occasional Papers of B. P. Bishop Museum, Honolulu, Hawaii, vol. 23, no. 14, pp. 305-369.

Helfrich, P., A. **H. Banner, 1968.** Ciguatera fish poisoning. II. General patterns of development in the Pacific. Occasional Papers, B. P. Bishop Museum, Honolulu, Hawaii, Vol. 23, No. 14, pp. 371-381.

Holmes, M.J., Lewis, R.J. and Gillespie, N.C., **1990.** toxicity of Australian and French Polynesias strains of *Gambierdiscus toxicus* (Dinophyceae) grown in culture: Characterisation of a new type of mai**totoxin.** Toxicon Vol. 28(10); 1159-1172.

Kizer, K**.W., 1982.** Non-Ciguatera Fish Poisoning in Hawaii.

Lewis, N.D., **1986.** Epidemiology and Impact of Ciguatera in the Pacific: A Review, pp. 13.

Lobel, P. S.,**1978.** Gilbertese and Ellice Islander names for fishes and other organisms. Micronesia, vol. 14 no. 2, pp. 177-197.

Macruder, W. H. and J. W. Hunt, 1979. Seaweeds of Hawaii, A photographic identification guide. The Oriental Publishing Co., Hawaii (1979), 116 pp.

Marriott, S. P., B. G. Dalley, **1980.** Quelgues observations sur les etudes de la ciguatera dans 1 atoll de Tarawa. South Pacific Commission Publication, Fisheries 12/WP.14, 9 pp. Natural World Press (1981) Guide to Hawaiian reef fish. (Water-proof display poster).

Masuda, H.Amaoka, K.,**Araga,** C, Uyeno, **T**., **Yoshino, T. (editors), 1985.** The Fishes of the Japanese Archipelago-TEXT. Tokai University Press.

Masuda, H., **H.Amaoka,** K., **Araga,** C, **Uyeno, T**., **Yoshino, T. (editors), 1985.** The Fishes of the Japanese Archipelago-PLATES. Tokai University Press.

Olakowski, T., **R. Taylar, 1983.** Fish poisoning in the Pacific **Islands during five** years period (1977-1981). Private Issue for W.H.O. sponsored training course in fish poisoning, Suva, Fiji, 11-21 Jan. 1983, 2 pp.
Natural World Press, **1981.** Guide to Hawaiian reef fish. (Waterproof display poster).

Olakowaski, T. and Taylar, R., **1983.** Fish Poisoning in the Pacific Islands during five year period (1977-1981). **Private Issue for WHO** sponsored training course in fish poisoning, Suva, Fiji, 11-12 Jan., 2 pp.

Palafox, N.A., **Jain, L.G., Pinano,** A.Z., **Gulick, T.M., Williams, R**.K., **Schatz, I.J., 1988.** Successful treatment of ciguatera fish poisoning with intravenous Mannitol. Ciguatera Fish Poisoning, JAMA, May 13; 259(18).

Raj, U., **1984.** Ciguatera and other seafood poisoning in Fijian waters and their impact to the utilisation of marine resources. Institute of Marine Resources, University of the South Pacific.

Randall, J.E. **Allen, G.R.,** Steene, **R.C., 1990.** The complete diver's and fishermen's guide to fishes of the Great Barrier Reef and Coral Sea. Crawford House Press, Bathurst.

Randall., E., **1958. A** review of ciguatera tropical fish poisoning with a tentative explanation of its cause. Bull. Mar. Sci. Gulf Caribb. Vol. 8, pp. 236-267.

Randall, J. E., **1981.** Underwater guide to Hawaiian reef fishes. Harroweed Books, 71 pp. Robie, D., 1989. Ciguatera: Blame it on the bomb? PIM, April/May.

Ruff, T. A., **1989.** Ciguatera in the Pacific: A link with military activities. In: The Lancet: Environmental Health, January, 28, pp. 201-206.

Scheuer, P. **J**., **W. Takahashi, J. Tsutumi, T. Yoshida, 1967.** Ciguatoxin. Isolation and chemical nature. Science, Vol. 155, pp. 1267-1268.

Shimizu, Y., **H. Shimizu,** P. **J. Scheuer, Y. Hokama, M. Oyama, J.T. Miyahara, 1982.** *Gambierdiscus toxicus,* a ciguatera-causing dinoflagellate from Hawaii. Bull. Jap. Soc. Sci. Fish., vol 48, no. 6, pp. 811-813.

Tebano, T., **1991.** A preliminary survey of ciguatera fish poisoning on Nauru. Marine Studies Programme Technical Report No. 7, 12pp.

Tebano, T., **1991.** Fish Poisoning and causeway construction, Tarawa, Kiribati.

Tebano, T., **1985-.** Population density study on a toxic dinoflagellate responsible for ciguatera fish poisoning on South Tarawa Atoll, Republic of Kiribati. Atoll Research and Development Unit, University of the South Pacific, Publication, 46 pp.

Withers, N. **W**., **1981.** Pacific Ciguatera. University of Hawaii, manuscript for Ciguatera Workshop, March 18-20, 1981, Honolulu, Hawaii.

Withers, N. **W**., **1982.** Ciguatera fish poisoning. Ann. Rev. Med., vol. 33, pp. 97-111.

Yasumoto, T., **R Bangis, S. Thevenin, M. Garcon, 1977.** A survey of comparative toxicity in the food chain of ciguatera. Bull. Jap. Soc. Sci, Fish., vol 43, no. 8, pp. 1015-1019.

Yasumoto, T., **I. Nakajima, R. Bagnis, R. Adachi, 1977.** Finding a dinoflagellate as a likely culprit of ciguatera. Bull. Jap. Soc. Sci. Fish., vol. 43, no. 8, pp. 1021-1026.

Yasumoto, T., **I. Nikajima, Y. Oshima, R. Bagnis, 1979.** A new toxic dinoflagellate found in association with ciguatera. In: Toxic Dinoflagellate Blooms. Eds. Taylor, Seliger. Elsevier, North Holland, Inc.

Yasumoto, T., **A. Inoue, R. Bagnis, 1979.** Ecological survey of a toxic diniflagellate possibly responsible for the induction of ciguatera. Bull. Jap. Soc. Sci. Fish., vol. 45, no. 3, pp. 395-399.

Yasumoto, T,. **K. Fujimoto, Y. Oshima, A. Inoue, J. Ochi, R. Adachi, Y. Fukuyo, R. Bagnis, 1980.** Ecological and distributional studies on a toxic dinoflagellate responsible for ciguatera (April 1978-March 1980). Report to the Ministry of Education, private issue.

Yasumoto, T., **Y. Oshima, A. Inoue, Y. Fukuyo,** T. **Harada 1981.** Studies on ciguatera. University of Hawaii, manuscript for Ciguatera Workshop, March 18-20, Honolulu, Hawaii.

Yasumoto, T., U, **Raj, R. Bagnis, 1984.** Seafood poisonings intropical regions. Laboratory of Food Hygene, Faculty of Agriculture, Tohoku University, Japan, 74 pp.

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Table 1. List of the algal species included in algal samples collected from the Gilbert Islands and abbreviations of these species names used in Section iii (Results and Discussion by Island).

ALGAE	ABBREVIATION
CYANOPHYTA;	
Hormothamnion enteromorphoides	ENT
Schizothrix calciola	SCH
Oscillatoria sp.	OSC
Unidentified filamentous green	UIFG
CHLOROPHYTA	
Enteromorpha sp ENT	
Bryopais sp.	BRY
Caulerpa racemoaa	CAU[1]
C. serrulata	CAU[2]
C. peltata	CAU[3]
Codium sp.	COD
Dictvosphaeria cavernosa	DICT
Halimeda macroloba	HAL[1]
H. opuntia	HAL[2]
H. cylindracea	HAL[3]
Halimeda sp.	HAL
Microdictyon japonicum	MIC
Petrocladia caerulescens	PTC
Valonia sp.	VAL[1]
V. aegaqrophilia	VAL
Unidentified green macroalgae	UIG
Unidentified turf forming green algae (possibly related to Valonia sp)	TFG[1]
Unidentified turf forming green algae (fine rhizomaceous and upright branches)	FTG[2]
PHAEOPHYTA:	
Lobophora varieqata	LOB
Turbinaria ornata or murravana	TURB
Dictvota sp	DOT
Unidentified brown algae	UIB
RHODOPHYTA;	
Gelidium sp	GEL
Jania sp	JAN
Laurencia sp	LAU
Liaqora sp	LGA
Hypnea sp	HYP
Lomentaria sp	LOM
Unidentified filamentous red algae	UIFR
Unidentified red macroalgae	UIMR

Table 2. Gambierdiscus toxicus density (cells/g) in algal samples collected from Makin Island.

Sample Number	Algal Type**	G. toxicus (cells/g)
1	Hal	3.33
2	Hal	0
3	Jan, Mic, UIG, Hal	1.50
*4	Jan, Mic, Lom	1.0
5	UIMR	0
6	MIC	0
7	Jan	0
8	UIFR	0

* Sample 4 included algae encrusted coral broken from dead coral stands just beyond the reef crest. Algal weight could only be estimated so this figure is no precise.

** Abbreviations and notation used are explained in Section 2 (Materials and Methods)

Table 3. G.toxicus density (cells/g) in algal samples collected from Butaritari Island.

Sample Number	Algal Type **	G. toxicus (cells/g)
1	LAU	3.9
2	JAN, UIFR	3.3
3	JAN, UIFR	1.2
4	UIFG	0
5	ENT	0
6	UIFG	0
7	LAU, JAN Dict.	0
8	MIC	0
9	VAL[l], UIFG	0
10	Jan, (HYP)	0
11	JAN	0
12	HYP, (VAL)	0.15
13	UIFG	0.28
14	VAL, (JAN)	0.01

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 4. Fish species considered poisonous by the fishermen of Marakei Island, 1983.

FISH LOCAL/ENGLISH NAME	COMMENTS
Te Bakoa (Shark, Carcharhinidae)	Species not indicated.
Te Rabono (Moray eel, Muraenidae)	Large individuals of all commonly caught morays but especially te kairoro the 'black moray' (*Gymnothorax javanicus*
Te Nunua (Barracuda, *Sphyraena*)	Rawannawi fishermen consider barracud to be toxic.
Te Urua (Trevally, Carangidae)	Large trevally probably considered sepecially toxic by severa fishermen.
Te Kuau (Rock cod, Serranidae)	Coral cods/trouts or small groupers agreed to be toxic; notably dangerous are the three species listed; probably the larger groupers (te marati) are never tested.
Te Ingo (Red bass, Lutjanidae)	All fishermen considered this toxic
Te Bawe (Red tail snapper)	species that is sometimes dangerously
Te Tinaemia (Emperor fish, Lethrinidae)	toxic; all fishermen believed that these species were very toxic.
Te Matakore (Big eye emperorfish)	Considered toxic by Rawannawi fishermen.
Te Rou (Variegated emperorfish)	Bainuna fishermen believed this species is toxic.
Te Mon (Squirrelfish, Holocentridae)	Rawannawi fishermen consider squirrel and soldierfish to be toxic.
Te Bureinawa/Bureiwa (Squirrelfish Holocentridae)	Considered toxic by Rawannawi fishermen
Te Karon (Wrasse, Labridae)	Tekarakan and Rawannawi fishermen consider this species toxic.
Te Newekabane (Wrasse, Lbridae)	Small wrasses believed toxic by Rawannawi fishermen.
Te Ikamaawa (Parrotfish, Scaridae)	All of the parrotfish are agreed to be
Te Kamauti (Parrotfish sp.)	generally toxic. Larger individuals of
Te Inai (Banded parrotfish)	the most common species are considered
Te Wiiatiibu (Parrotfish sp.)	most dangerous.
Te Riba (Surgeonfish, Acanthuridae)	All species normally encountered
Te Ribabui (Surgeonfish sp.)	considered potentially toxic. Probably
Te Ribatanin (Surgeonfish sp.)	the species listed are those considered
Te Ribataukarawa (Surgeonfish sp.)	most tasty or most easily captured and
Te Koinawa (Convict surgeonfish)	so most often tested for toxicity.
Te Roa (Unicornfish)	Considered toxic at times.
Te Bubu (Whitebanded triggerfish, Balistidae)	Triggerfish and filefish are agreed to be toxic to extrememly toxic.
Te Nuonuo (Yellowmargin triggerfish)	Large forms are often toxic.

Table 5. *G. toxicus* density (cells/g) in algal samples collected from Marakei Island.

Sample Site Number	Algal Type **	*G. toxicus* (cells/g)
1	LAU, JAN	0.88
2	TFG^{1}, TEG^{2} (VAL, DICT, JAN, LAC)	0.68
3	TFG^{1}, JAN (UIFG)	4.35
4	HAL, (CAU^{2})	0.53
5	JAN, (TEG^{1})	1.50
6	JAN, TFG^{1}, (TFG^{2}, LOM)	0
7	HAL	0.02
8	JAN	0.11
9	UIMR	0.38
10	SCH, (JAN, TFG^{2})	1.07
11	TFG^{2}, JAN (HYP., PTC)	2.33
12	JAN (OSC)	0.14
13	VAL, DICT, JAN, (OSC, UIMR)	0.32

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 6. *G.toxicus* density (cells/g) in algal samples collected from Abaiang Island

Samples Number	Algal Type**	*G. toxicus* (cells/g)
1	LAU, JAN, TFG^{1} (UIB, UIR)	0
2	LAU, (JAN)	0
3	TFG^{1}	0

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 7. Fish species considered toxic by South Tarawa fishermen.

Species	Village 1	2	3	4	5	6	7	8
Te Bakoa (shark liver)								ST
Te Rabono (Muraenidae)	ST(L)	MT(L)	T	ET	UT	T(*)		AT(L)
Gymnothorax sp.	UT(L)							AT(L)
G. flavimarginatus								AT(L)
G. undulatus	UT(L)							AT(L)
Te Nunua (*Sphyraena* sp.	(M-L)							(M-L)
Te Urua (*Caranx ignoblis*)								ST(L)
Te Kuau (small Epinephelidae)	ST	T	T					ST, UT
Te Nimanang (*Cephalopholis argus*)	UT	T	T			T		UT, AT
Te Bakati (*Promicrops lanceolatus*)	OT							ST
Te Marati/Kuau (large Serranidae sp.)								ST
Te Ingo (*Lutjanus bohar*)	ST	MT	T	UT	ST	MT	ET	ST
Te Ikanibong (*L. gibbus*)		ET	ST			T		
Te Bawe (*L. fulvus*, etc.)								AT, NT
Te Tinaemia (*L. monostigma*)				ST	ST		T	AT, ST
Te Ikakoa (*Aphareus* sp.)								ST
Te Nrekereke (*Plectoryhnchus orientalis*)								ST
Te Rou (Lethrinidae)							T	
Te Okaoka (Lethrinidae)						MT		
Te Ikamatoa (Lethrinidae)				OT		MT		
Te Ikawain (Lethrinidae)						MT		
Te Inonikai/Rironikai (*Kyphosus vaigenis*)					ST			ST
Te Ibaba (Chaetodontidae)								ST
Te Karon (*Chaeilinus undulatus*)								ST
Te Inai (small Scaridae)		T	T		ST	T	MT	ST
Te Oningea (small dark Scaridae)								ST
Te Ikamaawa (*Scarus pectoralis*)			T	T	ST	ST	T	ST
Te Roa (*Naso* sp.)				T				
Te Kataawa (*Acanthurus lineatus*)					ST		T	
Te Riba, te ribabui (Acanthesridae)		T	T	ST	UT		MT	ST
Te Ribatanin (Acanthuridae)	UT			OT	UT		MT	ST
Te Ribaroro (*Ctenocaetus striatus*)		T	T	OT	ST			UT
Te Ribataukarawa (*A. archilles*)		T			AT	T	T	ST
Te Mako (*A. xanthopterus*)					ST			ST
Te Koinawa (*Acanthurus triostegus*)								ST
Te Ibaba (*A. guttatus*)								ST
Te Reiawawa (*Exallias brevis*)	T							
Te Buni (Tetrodontidae)						AT		AT
Te Nuonuo (*Balistes* sp.)								ST

Keys: NT-not toxic, OT-occassionally toxic, ST-sometimes toxic
UT-usually toxic, AT-always toxic, ET-extremely toxic
MT-meder. toxic, T-toxic, L-large, M-medium
1-Betio, 2-Bairiki, 3-Nanikaai
4-Teaoraereke, 5-Banraeaba, 6-Taborio
7-Eita, 8-Bikenibeu

Table 8. Fish species recorded as causing ciguatera fish poisoning in South Tarawa between 1974 and 1980 (Tungaru Central Hospital Statistics, Marriot and Dalley, 1980).

Kiribati Name		Scientific Name
Te Riba	*	Acanthurus qahhm
Te Matabareka		Gnathodentex aureolineatus
Te Morikoi	*	Lethrinus nebulosus
Te Ingo	*	Lutianus bohar
Te Nimanang	*	Cephalopholis arqus
Te Kuau	*	Ephinephelus merra
Te Inai	*	Scarus qhobban
Te Inai	*	Scarus sp.
Te Nunua	*	Sphvraena barracuda
Te Rabono	*	Gvmnothorax sp.
Te Nuonuo	*	Pseudobalistes fuscus
Te Bakoa	*	Triaenodon obesus

The following, in addition to those with *, were also recorded as causing ciguatera posioning between 1982 and 1991.

Te Ikamaawa	Scarus pectoralis
Te Bakati	Promicrops lanceolatus
Te Ika-uraura	Priacanthus sp.
Te Ikanibong	Lutianus qibbus
Te Matakore	Monotaxis qrandoculis
Te Karon	Cheilinus undulatus
Te Tinaemia	Lutjanus monostiqma
Te Rou	Lethrinus miniatus
Te Bokaboka	Naso unicornis
Te Kataawa	Acanthurus lineatus
Te Kauoto	Epinephelus sp.
Te Awai	Lethrinus sp.
Te Urua/rereba	Caranx iqnoblis
Te Bawe	Lutianus fulvus
Te Koinawa	Acanthurus triostequs
Te Inonikai/rironika-i	Kvphosus vaiqensis
Te Mako	Acanthurus xanthopterus

Table 9. Fish species by village recorded in Tungaru Central Hospital Statistics as having caused ciguatera fish poisoning in South Tarawa, 1983.

Kiribati/English Name	Village								
	1	2	3	4	5	6	7	8	9
Te Bakoa (Shark)									x
Te Rabono (Morray eel)									x
Te Nunua (Barracuda)	x	x							
Te Kuau (Grouper)			x				x		x
Te Ingo (Red bass)	x	x		x					x
Te Ikanibong (Paddle tail)							x		
Te Bureinawa (Squirrel fish)									x
Te Rou (Variegated emperor)						x			
Te Morikoi (Spangled emperor)									x
Te Inai (Parrot fish)					x				x
Te Ikamaawa (Parrot fish)	x				x		x		x
Te Te Roa (Unicorn fish)						x			
Te Riba (Surgeon fish)			x		x				
Te Mako (Yellowfin surgeon" fish)									

Keys: 1-Bairiki 2-Nanikaai 3-Teaoraereke 4-Banraeaba
5-Taborio 6-Eita 7-Bangantebure 8-Bikenibeu
x-indicates village where fish species is known to be toxic.

Table 10. Toxicity assay of fish samples collected in 1982 from Tarawa. Results obtained from Institute of Marine Resources, University of the South Pacific, Suva, Fiji.

SAMPLING LOCATION	FISH SPECIES	TOXICITY SCORE M.U100q FLESH
Taborio (South Tarawa)	(Scaridae)	
	Scarus sordidus	5.0
	S. niger	
	(Holocentridae)	
	Adioryyx violaceus	2.5
	(Cirrihitidae)	
	Cirrihitus pinnulatus	2.5
	(Balistidae)	
	Melichthys vidus	5.0
	Amanses carolae	4.0
	(Acanthuridae)	
	Naso brachycentron	5.0
	Acanthurus lineatus	3.0*
	A. lineatus	N.D*
	A. olivaceus	5.0
Bikenibeu	(Acanthuridae)	
	Ctenochaetus striatu3	3.0
	Acanthurus xanthopterus	3.0
	(Serranidae)	
	Cephalopholis argus	5.0
Tanaea/Buota	(Acanthuridae)	
	Ctenochaetus striatus	3.0*
	C. striatus	N.D*
	(Lutjanidae)	
	Lutjanus fulvus	2.5
South Tarawa (unspecified)	(Acanthuridae)	
	Ctenochaetus striatus	3.0
	(Scaridae)	
	Scarus sp.	N.D*

More than one fish tested. N.D* no death in test mice.
NB One mouse unit (MU) is the minimum amount of ciguatoxin required to kill a standard 20 kg mouse within 24 hours. 2.5MU/100g has been accepted as the safety level for consumption.

Table 11. Toxicity; assay of fish samples collected in 1983 from Tarawa (Scheuer*, University of Hawaii).

Area captured	Fish species tested	Toxin Ethyl/Acetate Fraction	Assay Butano/ Fraction	Results Aqueous Fraction
Bikenibeu	combined Scaridae (Parrot fish)			
	flesh	CTX(*)	none	none
	viscera	CTX	none	none
Bikenibeu	combined Acanthuridae (Surgeon fish)			
	flesh	CTX	none	none
	viscera	CTX	toxic	toxic
Bikenibeu	*Amanses carolae* (Leather jacket)			
	flesh	none	none	
	viscera	none		none
Bikenibeu	*Aphareus furcatus* (Snapper)			
	flesh	none	none	toxic
	viscera	none	toxic	toxic
Taborio	combined Scaridae (Parrot fish)			
	flesh	none		
	viscera	none	toxic	toxic
Teaoraereke	Scaridae (Parrot fish)			
	flesh	CTX	none	none
	viscera	none	none	none
Betio	Scaridae (Parrot fish)			
	flesh	none		
Tanaea	Holocentridae (Squirrel fish)			
	flesh and viscera	none		
	Muraenidae (Moray eel)			
	viscera	none		

(*)CTX-ciguatoxic

Table 12. Toxicity level in fish collected from around Nei Tebaa/Dai Nippon Causeway, South Tarawa (Tebano and Lewis, 1990).

Fish Name	Toxicity level
Te Rabono (*Gymnothorax sp.*)	toxic/extremely toxic
Te Ribaroro (*Ctenochaetus striatus*)	toxic
Te Ikabata (Parrot fish)	slightly toxic/toxic
Te Te Kuau (*Ephinephlus merra*)	slightly toxic
Te Nimanang (*Cephalopholis arqus*)	slightly toxic
Te Kataawa (stripped surgeon fish)	slightly toxic
Te Riba (*Acanthurus gahhm*).	slightly toxic
Te Kiritauno (*Lethrinus sp.*	slightly toxic

Table 13. Mean *Gambierdiscus* *toxicus* [illegible] l samples collected from March to December fr[illegible] [illegible]outh Tarawa (Tebano, 1983).

Sampling Site	Algal type	B
Tanaea	*Padina* sp	0.8
	Hypnea sp	4.1
	Caulerpa [illegible]	[illegible]
	Enterom[illegible]	
	[illegible]	
	Laurencia [illegible]	
	Liagora sp.	

A-% of samples that contained *G.* *toxicus*
B-*G.* *toxicus* density averaged from those months when present in samples (cells/g).

Table 14. Fish poisoning cases recorded by area from 1982-1991 (Tungaru Central Hospital Medical Records/Statistics).

<u>Area</u>	<u>Number hospitalised</u>								
	1982	1983	1985	1986	1987	1988	1989	1990	1991
Tanaea	0	0	0	0	0	0	0	0	0
Bonriki	4	2	0	4	7	0	0	0	7
Bikenibeu	32	29	5	12	24(**149**)	**54**	**107**	**194**	**16**
Abarao	0	2	0	0	0	0	0	0	0
Eita	11	11	5	6	5	0	0	5	0
Tangintebu	0	2	0	0	0	0	0	0	0
Taborio	0	0	0	0	0	0	0	0	3
Ambo	0	1	0	0	0	0	0	0	0
Banraeaba	4	1	1	5	6(**14**)	**30**	**22**	**33**	**0**
Antenon	0	1	0	0	0	0	0	0	0
Teaoraereke	8	1	0	0	0	0	0	0	0
Nanikaai	1	8	0	0	0	0	0	0	0
Bairiki	6	13	2	5	5(**40**)	**24**	**22**	**26**	0
Betio	0	44	0	0	2(**170**)	**229**	**187**	**604**	**4**
Nuatabu	0	1	0	0	0	0	0	0	0

Figures in **bold** were provided by Statistics Department; the rest are verified ciguatera cases.

Table 15. Verified cases of ciguatera fish poisoning between 1974 and 1987 (Tungaru Central Hospital/WHO); fish poisoning cases between 1988 and 1990 (Tungaru Central Hospital Statistics).

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
No. cases	64	87	82	14	17	69	128	58	91^{42}	117

	1985	1986	1987	1988	1989	1990	
	13^{22}	38^{23}	470^{29}	339	361	910	unspecified cases in subscript

Table 16. Fish poisoning in all Kiribati between 1974 and 1981 and between 1987 and 1990 (Tungaru Central Hospital Statistics).

Year	1974	1975	1976	1977	1978	1979	1980	1981
No. cases	175	187	77	41	38	78	187	286

	1987	1988	1989	1990
	780	571	570	1207

Note that these cases have not been verified due to unavailability of patient record where symptoms can be examined.

Table 17. G.toxicus density (cells/g) in algal samples collected from Maiana Island.

Sample Number	Algal Type**	G.toxicus (cells/g)
1	DICT. (LAU)	0
2	LAU (JAN, HYP)	1.12
3	TFG^1, (UIFR,VAL^1,LAU)	0.11
4	VAL^1, (JAN)	0.05
5	JAN, LAU, LOM, (UIFR)	0
6	TFG^2	0.19
7	JAN, LAU, (DICT, LOM)	0.17
8	LAU, (JAN, LOM)	0
9	TFG^1, TFT^2, (LAU)	0.62
10	JAN, LAU, LOM, (DICT)	1.17
11	TFG^1, TFG^2, (JAN)	2.56

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 18. G.toxicus density (cells/g) in algal samples collected from Kuria Island.

Sample Number	Algal Type**	G. toxicus (cells/g)
1	HAL	0
2	JAN, (TFG^2, OSC, COD)	0
3	JAN, LAU (LOM)	0.20

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 19. G. toxicus density (cells/g) in algal samples collected Abemama Island.

Sample Number	Algal Type**	G. toxicus
1	JAN, (LGA)	0
2	JAN, LAU, (LOM)	0
3	JAN, LAU, (LOM)	0.1
4	LAU	0.25
5	JAN, HYP (ENT)	3.47
6	JAN	1.38
7	JAN, LAU (TFG^1)	1.56
8	LAU (JAN)	0.82
9	JAN (LAU, DICT)	2.46

** Abbreviations and notation used are exlained in Section 2 (Materials and Methods).

Table 20. Fish species considered toxic by Abemama fishermen.

Species	Location: Tetutonqo Reef	Location: Biike Reef
Te Ingo (*Lutjanus bohar*)	often toxic	often toxic
Te Kuau (Serranidae)*	occasionally toxic	occasionally toxic
Te Rabono (Muraenidae)	possibly toxic	occasionally toxic
Te Ikanibong (L. *gibbus*)	rarely toxic	rarely toxic
Te Nuonuo (*Balistes* sp.)	rarely toxic	rarely toxic
Te Ribaroro (C. striatus)	toxic before 1982	not toxic
Te Mako (*Acanthurus xanthopterus*)	large individuals are toxic	not toxic
Te Bakoa (Carcharhinidae)	**occasionally poisonous	occasionally poisonous**
Te Buni (Tetraodontidae)	**often poisonous	often poisonous**

* Some fishermen reported that only te marati (large Epinephelidae) were toxic, while others said that only the smaller species within the family (notably) te nimanang (*Cephalopholis argus*) were toxic.

** Te Bakoa (sharks) and Te Buni (bufferfish) poisonings are most likely to involve certain substances other than ciguatoxin.

Table 21. G. *toxicus* density (cells/g) in algal samples collected from Nonouti Island.

Sample Number	Algal Type**	G. *toxicus* (cells/g)
1	LOB	0.94
2	LAU	0

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 22. G. *toxicus* density (cells/g) in algal samples collected from Tabiteuea Island.

Sample Number	Algal Type**	G. *toxicus* (cells/g)
1	TFG[2]	0.40
2	LAU, JAN	0.83
3	JAN, LOM	0.73
4	JAN, (DICT, VAL[1] LAU, LOM, TFG[2]	0.08
5	TFG[2]	0.57

** Abbreviations and notations used are explained in Section 2 (Materials and Methods.

Table 23. G toxicus density (cells/g) in algal samples ted from Onotoa Island.

Sample Number	Algal Type**	G. toxicus (cells/g)
1	CAU^{2}	0.07
2	UIFR	37.50
3	COD	154.00
4	HAL^{1}	1.93

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

24. G. toxicus density (cells/g) in algal samples collected from Beru Island.

Number	Algal Type**	G.toxicus (cells/g)
1	JAN, LAU	0.11
2	HAL^{1}	0.14
3	LAU, (HAL)	0.11
4	TFG^{1} (JAN)	0.09
5	JAN, (TFG^{2})	1.6
6	LOT	0.39
7	JAN	0.91
8	LAU, HYP (JAN, CAU^{3})	2.06
9	LAU, HYP, JAN, UIB	0.41
10	LAU, JAN, LOT, (HYP)	0.26
11	TFG (FAU, TFG^{1}	0.07
12	TFG (JAN)	0.27

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 25. G. toxicus density (cells/g) in algal samples collected from Nikunau "Island.

Sample Number	Algal Type**	G. toxicus (cells/g)
1	JAN, (HYP, TFG^{2}	23.67
2	JAN, (VAL^{1}, HYP, TFG^{2}	10.5
3	GEL	0.07
4	JAN, (VAL, LAU)	0.12
5	JAN	1.74
6	LAU, JAN (VAL^{1}) CAU^{2})	4.91
7	JAN	4.92
8	JAN, (HYP, TFG^{1})	2.78
9	JAN, LAU, (HYP, VAL^{1})	5.04
10	JAN, LAU, (VAL^{1}, DICT)	0.36

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 26. *G. toxicus* density (cells/g) in algal samples collected from Tamana Island.

Sample Number	Algal Type**	*G. toxicus* (cells/g)
1	LAU	0.32
2	JAN	2.01
3	LOT	0.26
4	BRY	0.27

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 27. *G. toxicus* density (cells/g) in algal samples collected from Arorae Island.

Sample Number	Algal Type**	*G. toxicus* (cells/g)
1	UIB, (JAN)	9.50
2	HAL	0.86
3	HAL	0.30
4	CAU	0.17
5	DICT	1.38
6	CAU	0.25

** Abbreviations and notation used are explained in Section 2 (Materials and Methods).

Table 28. "Recorded Cases of 'Fish Poisoning' in the Republic of Kiribati excluding Tarawa. (Tungaru Central Hospital, Statistics Dept. 1984)"

Island	Year and Number of cases recorded										
	1978	1979	1980	1981	1982	1983	1987	1988	1989	1990	Total
Makin	-	-	-	-	-	4	1	0	10	2	17
Butaritari	-	-	-	5	2	9	44	69	25	20	174
Marakei	8	4	-	27	102	173	90	41	64	130	639
Abaiang	-	2	-	11	47	92	22	17	0	2	193
North Tarawa	-	-	-	-	-	-	22	14	13	12	61
Maiana	-	-	-	-	6	1	5	25	1	3	41
Kuria	-	-	-	23	-	4	8	7	6	26	74
Aranuka	-	-	-	2	-	2	1	4	0	0	9
Abemama	1	1	-	2	2*	3	0	1	0	22	32
Nonouti	-	8	-	47	-	19	0	1	1	0	76
Tabiteuea North	-	-	-	8	-	-	28	14	2	29	81
Tabiteuea South	-	-	-	9	-	3	2	0	15	9	38
Onotoa	-	-	2	3	2	4	0	4	4	9	28
Beru	2	-	-	37	14	26	3	3	18	24	127
Nikunau	6	4	1	27	-	6	78	12	1	4	139
Tamana	1	-	-	-	7	5	0	0	5	3	21
Arorae	6	-	-	12	2	10	0	13	0	2	45
Banaba	-	-	-	-	1	-	0	0	0	0	1
Kiritimati	-	-	-	21	6	8	1	0	5	3	44
Fanning	-	-	-	4	2	-	7	0	0	3	16
Washington	-	3	-	4	4	-	4	7	26	1	49
Canton	-	-	-	-	-	-	-	-	-	-	0
TOTALS	24	22	3	242	197	369	316	232	196	304	1905

*The two cases recorded resulted in deaths.

Figure MAP OF THE CENTRAL PACIFIC SHOWING THE GILBERT ISLANDS

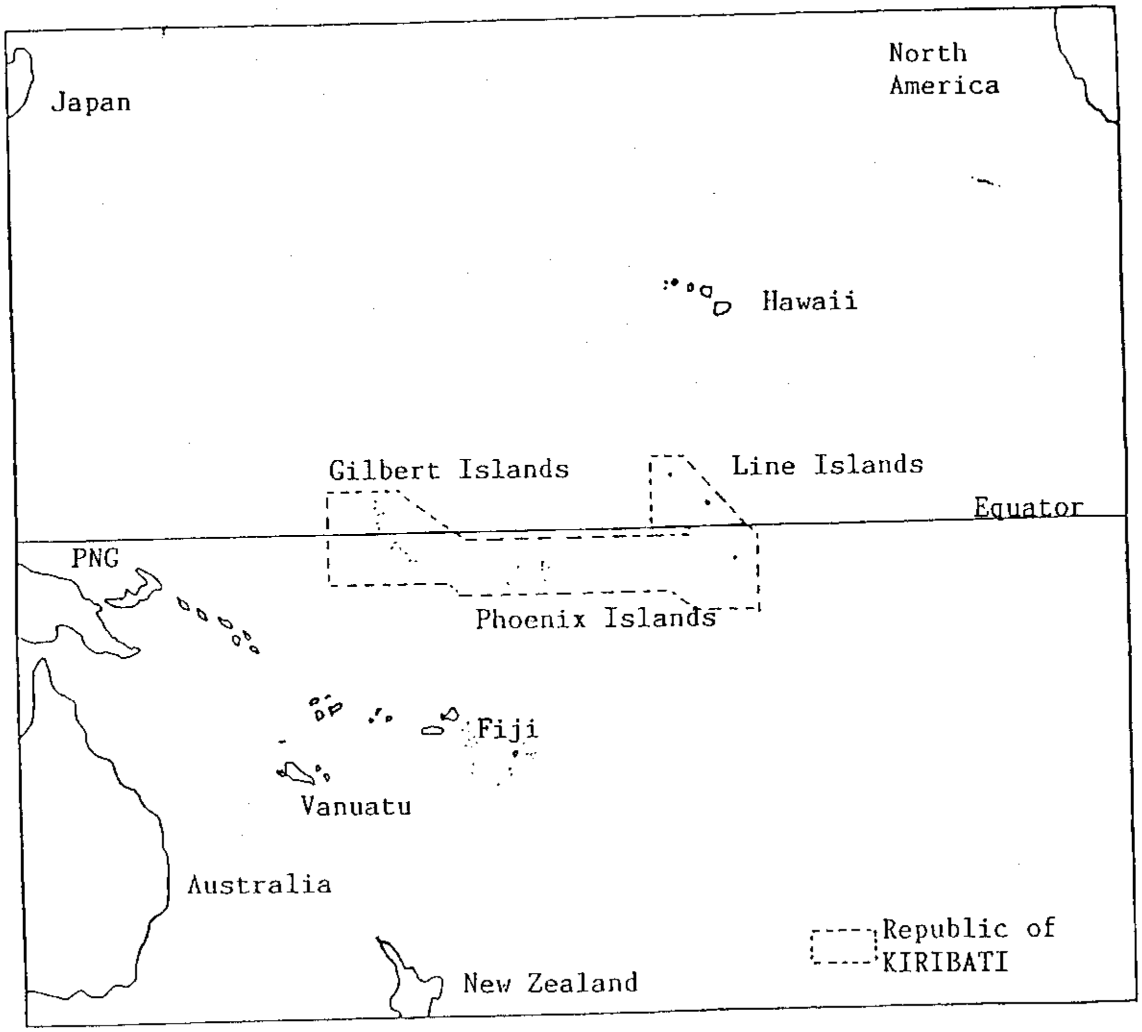
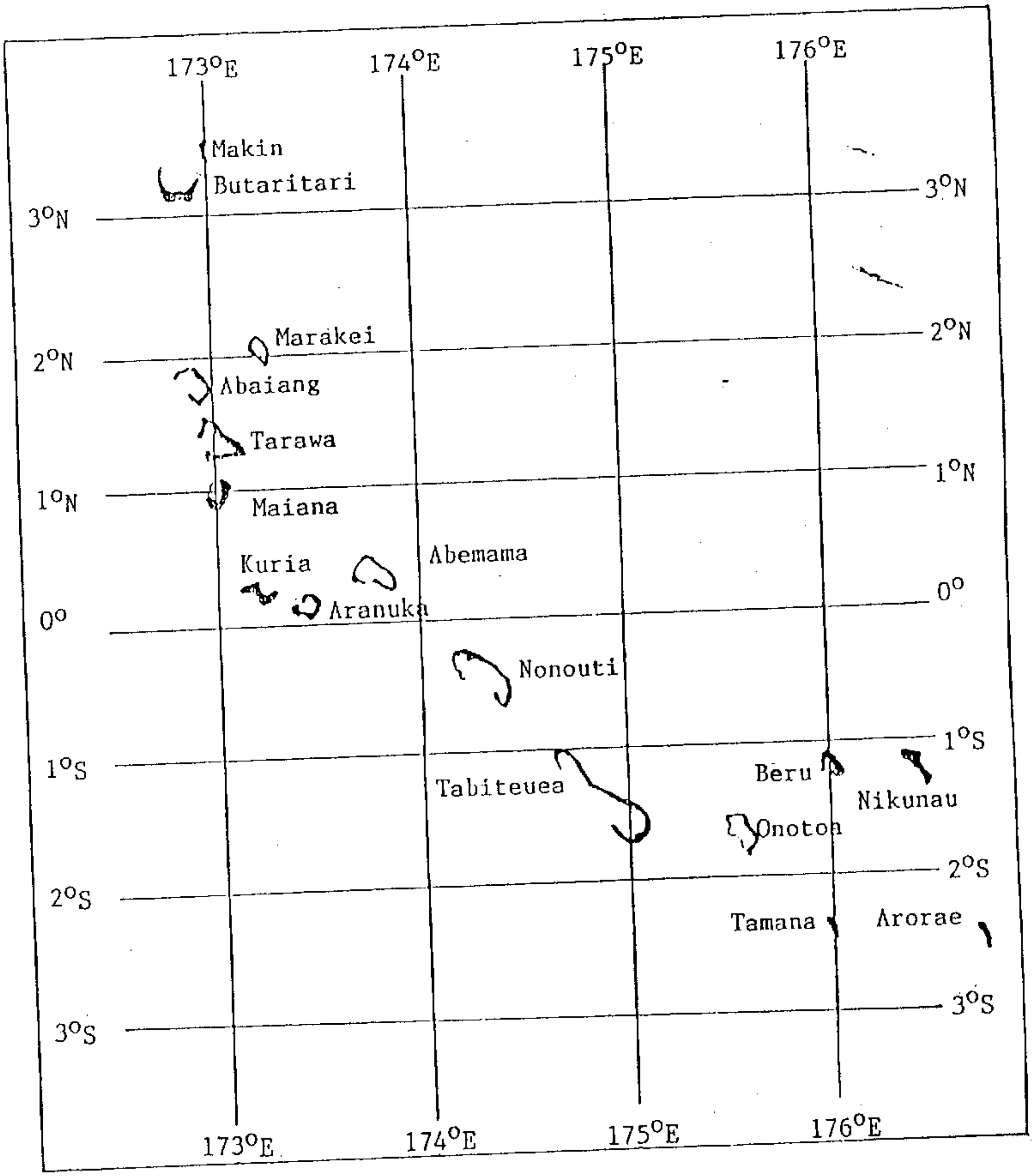


Figure 2. MAP OF THE GILBERT ISLANDS, KIRIBATI



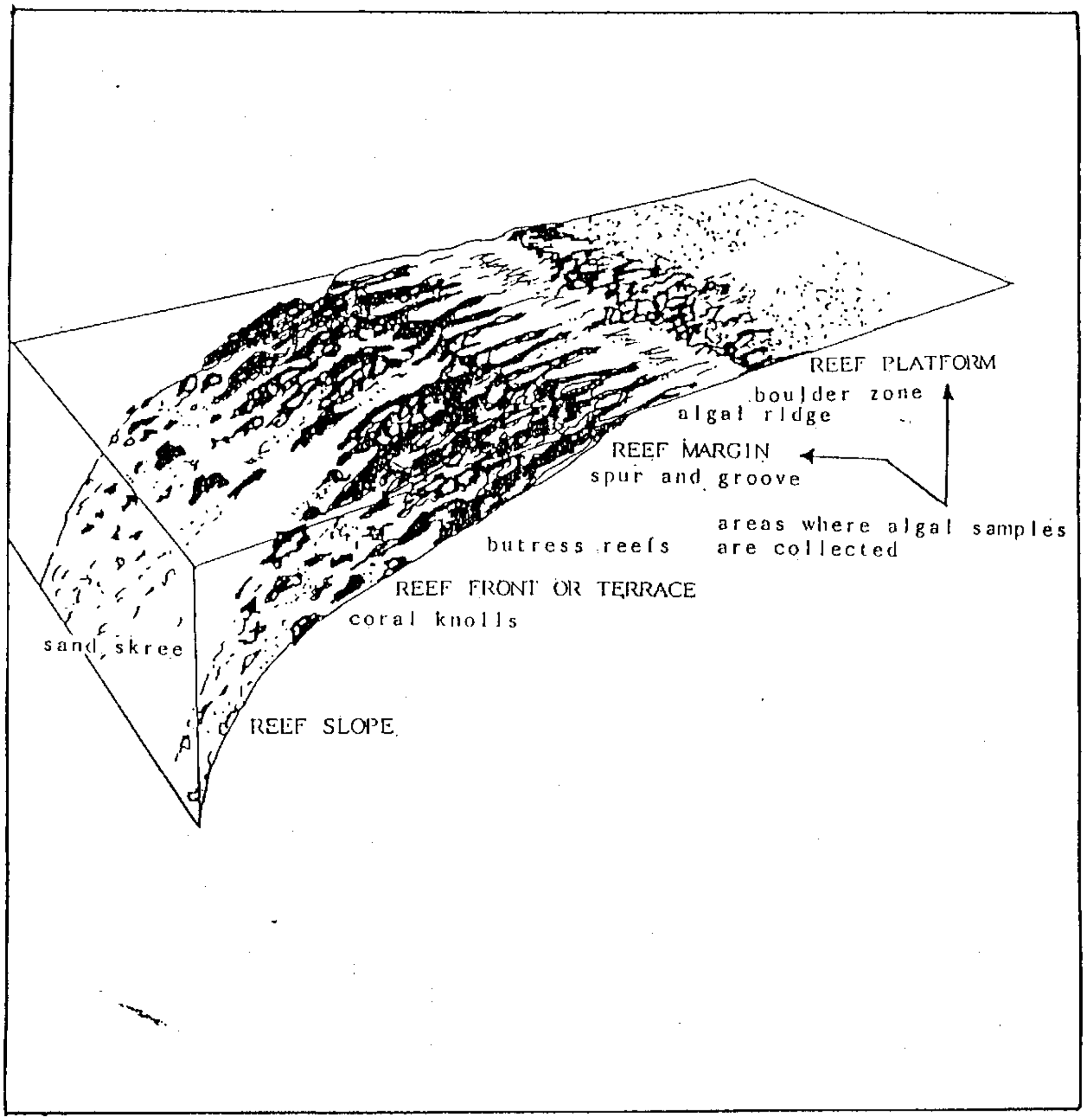


Figure 3. Typical reef topography of the Gilbert Islands.

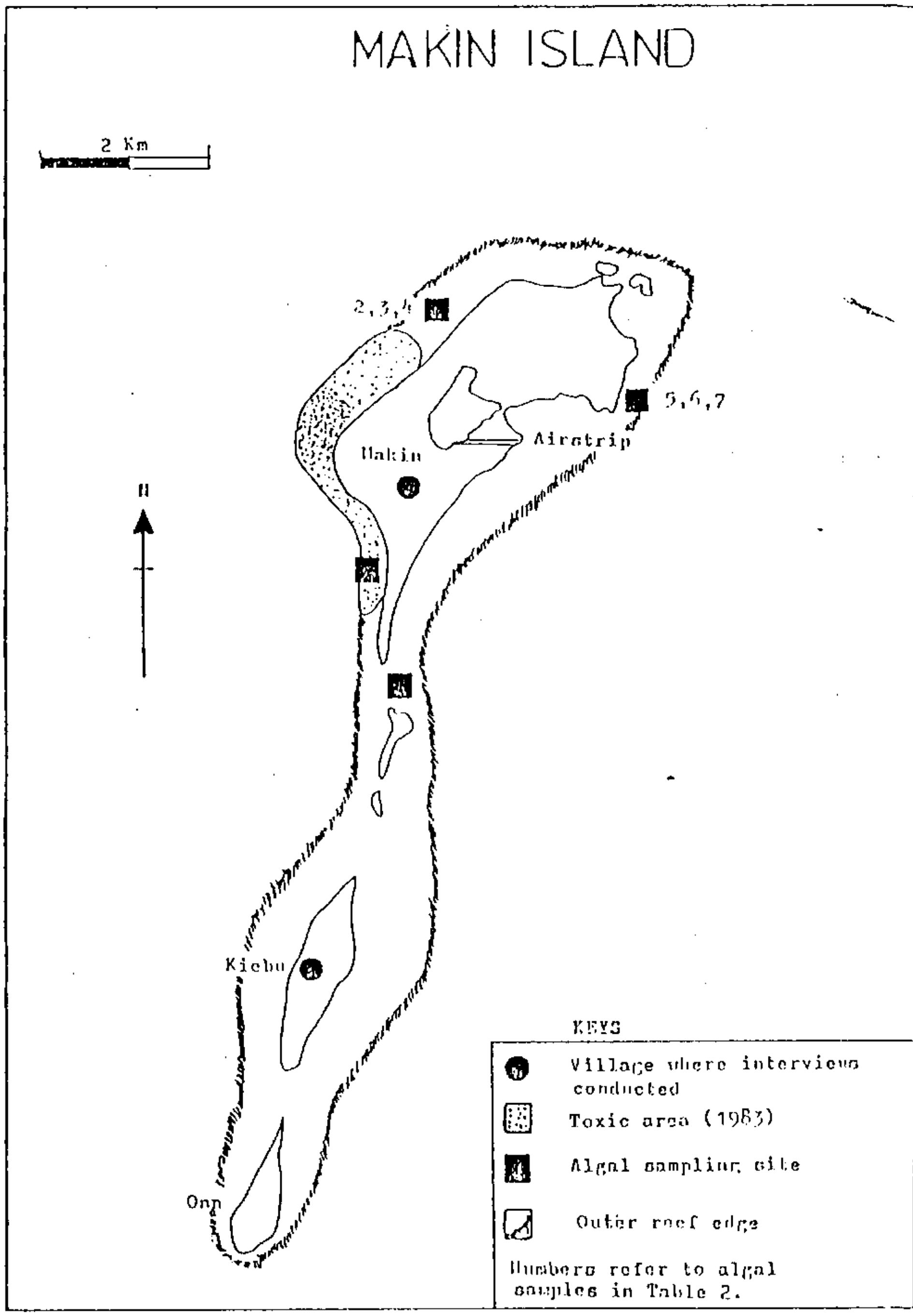


Figure 4. Map of Makin Island

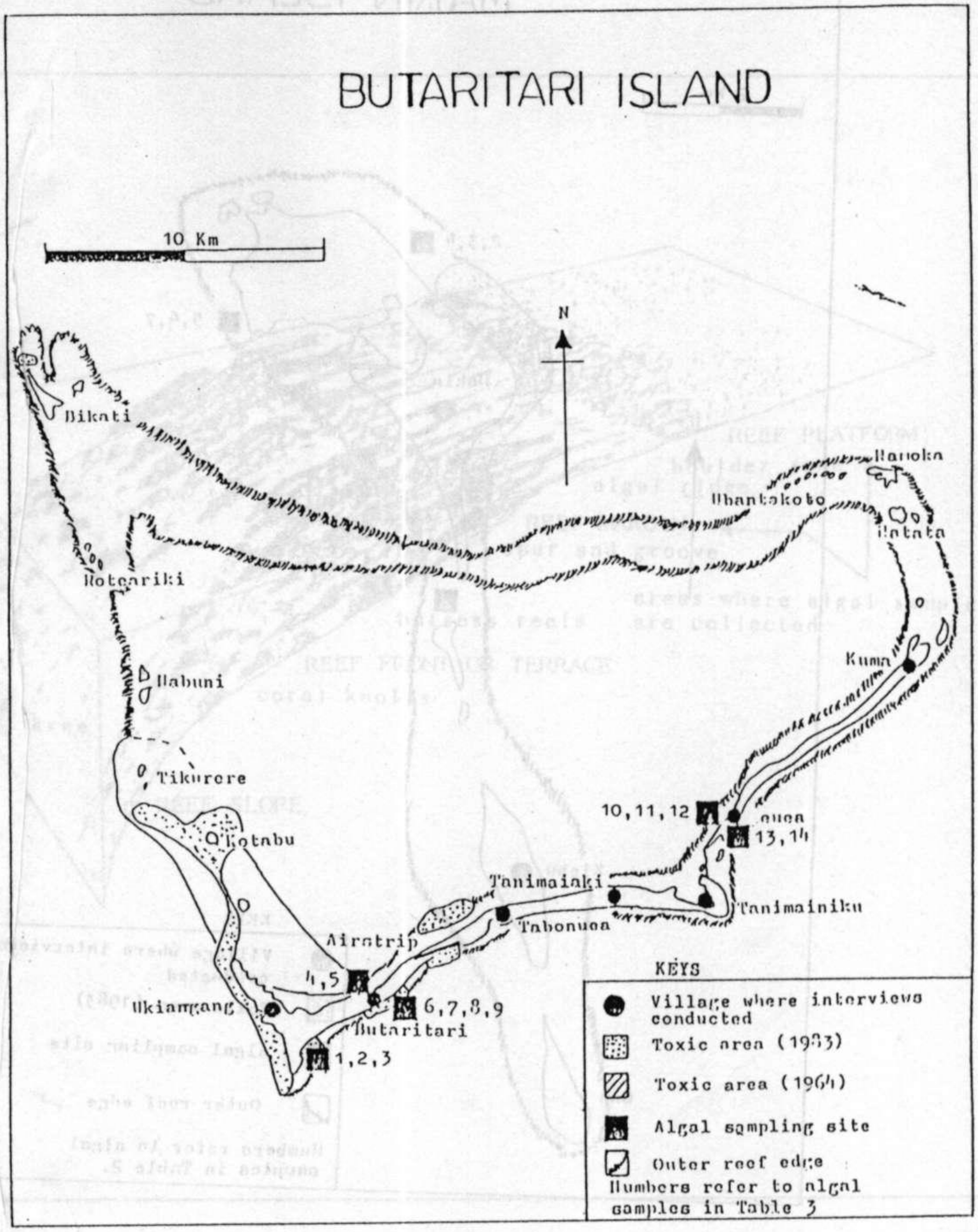


Figure 5. Map of Butaritari Island.

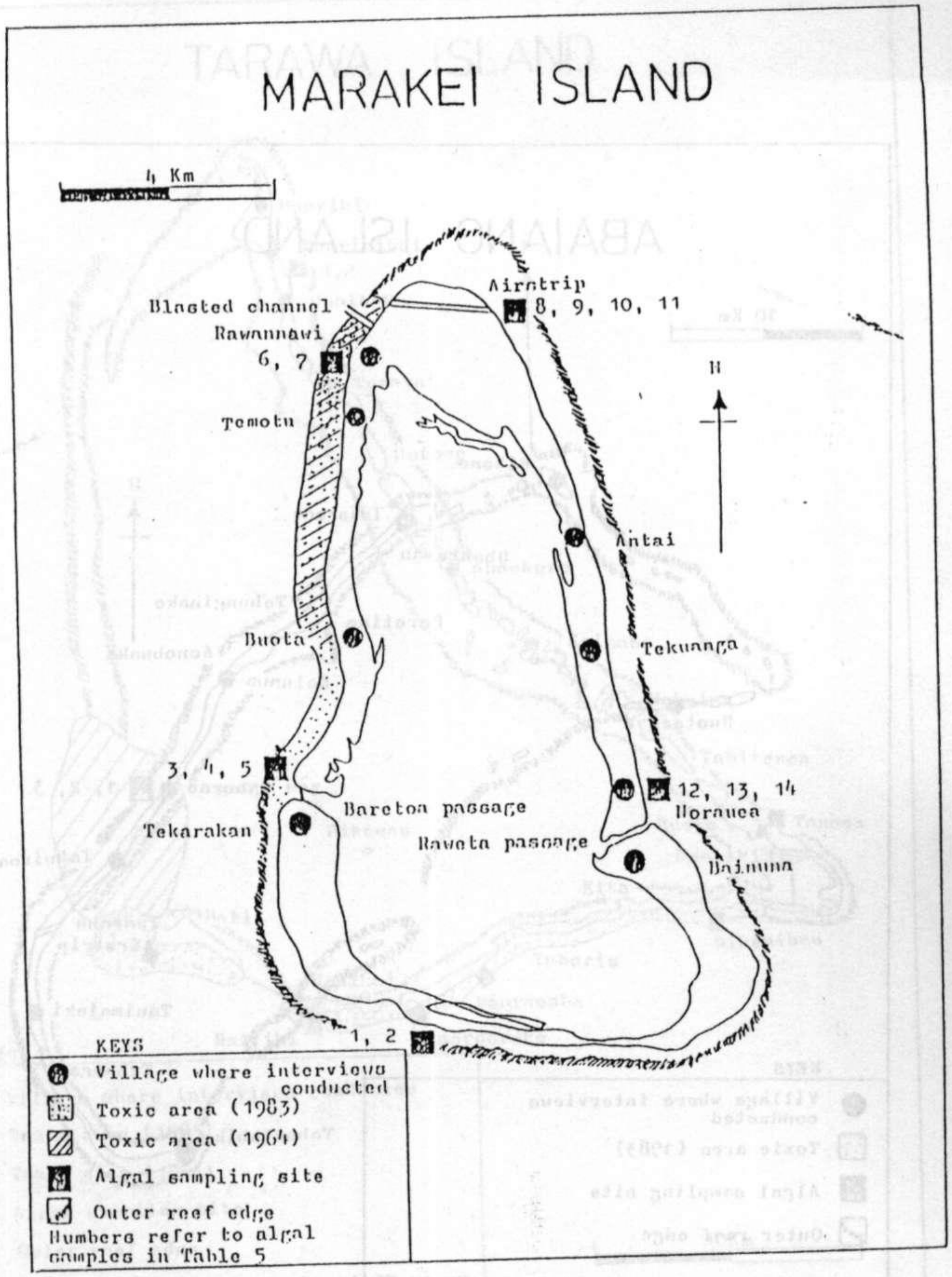


Figure 6. Map of Marakei Island

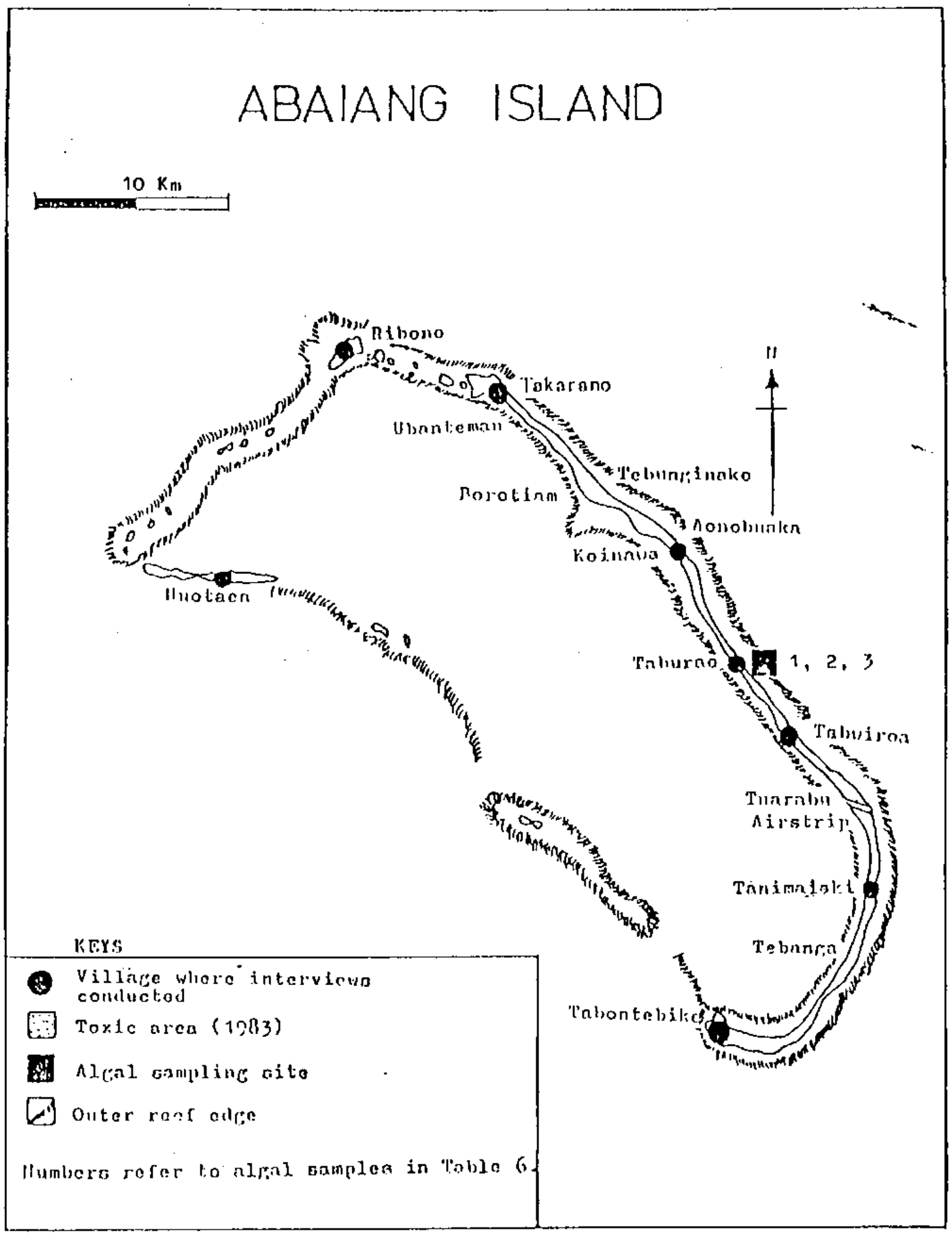


Figure 7. Map of Abaiang Island.

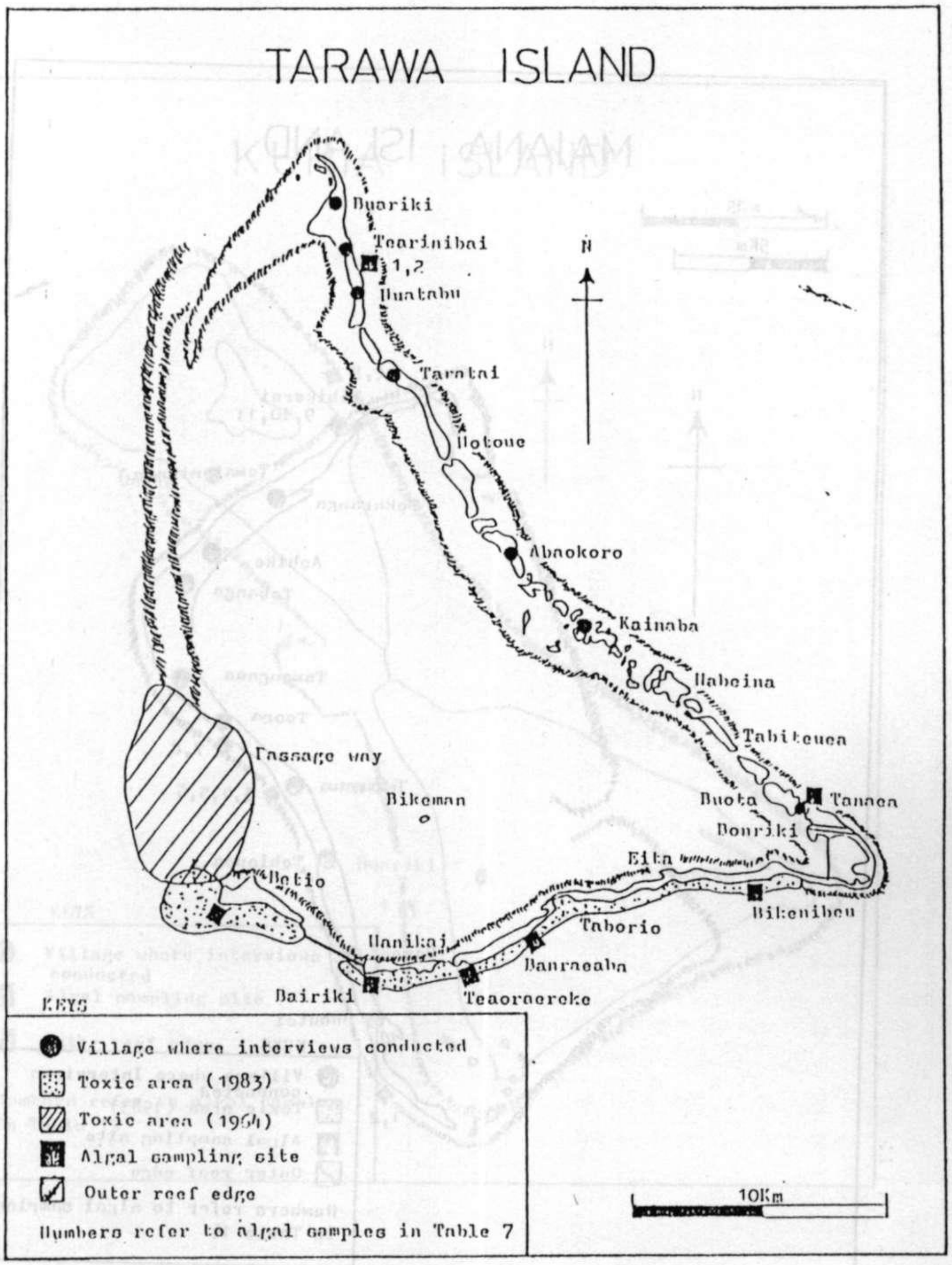


Figure 8. Map of Tarawa Island.

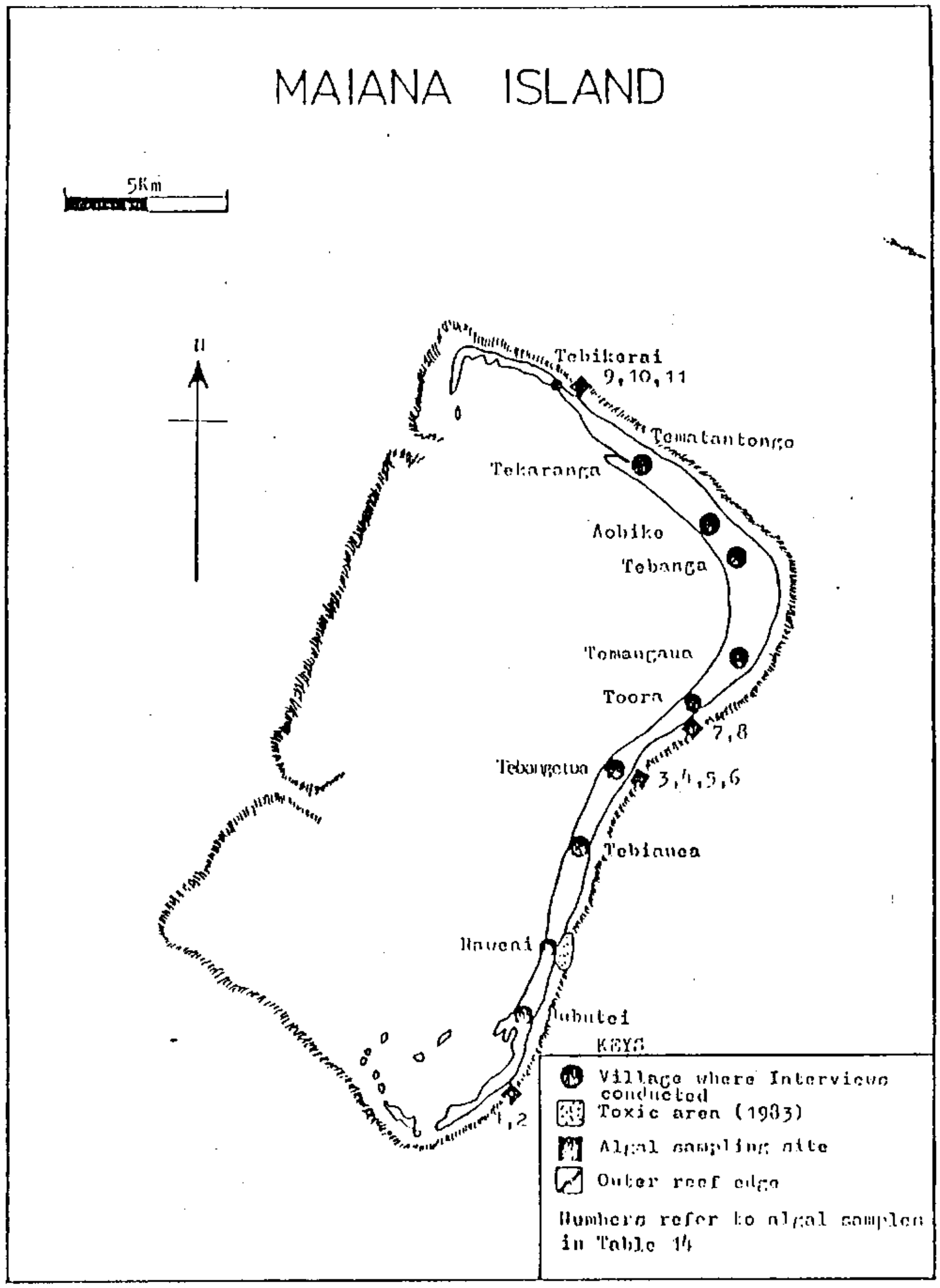


Figure 9. Map of Maiana Island.

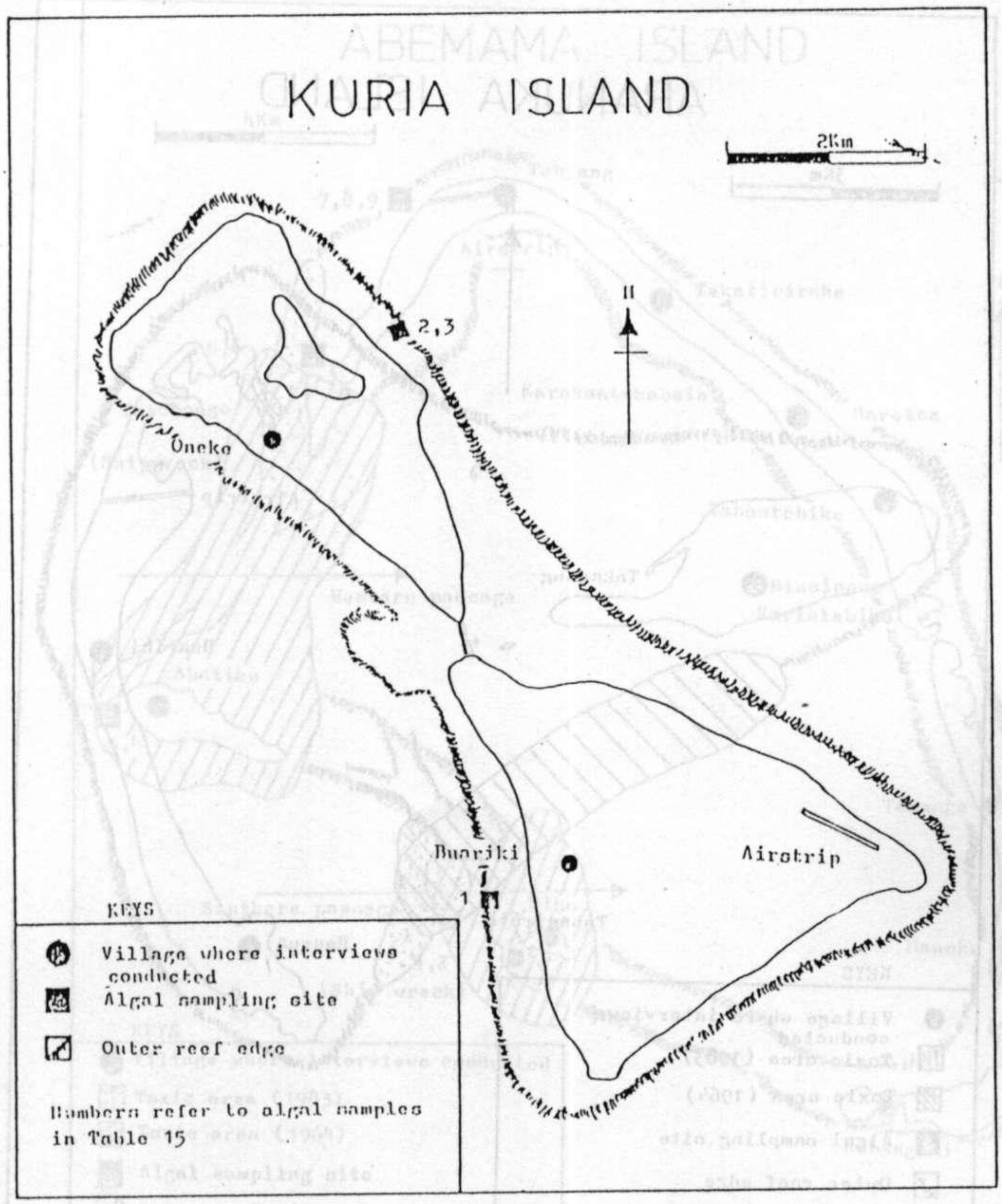


Figure 10. Map of Kuria Island.

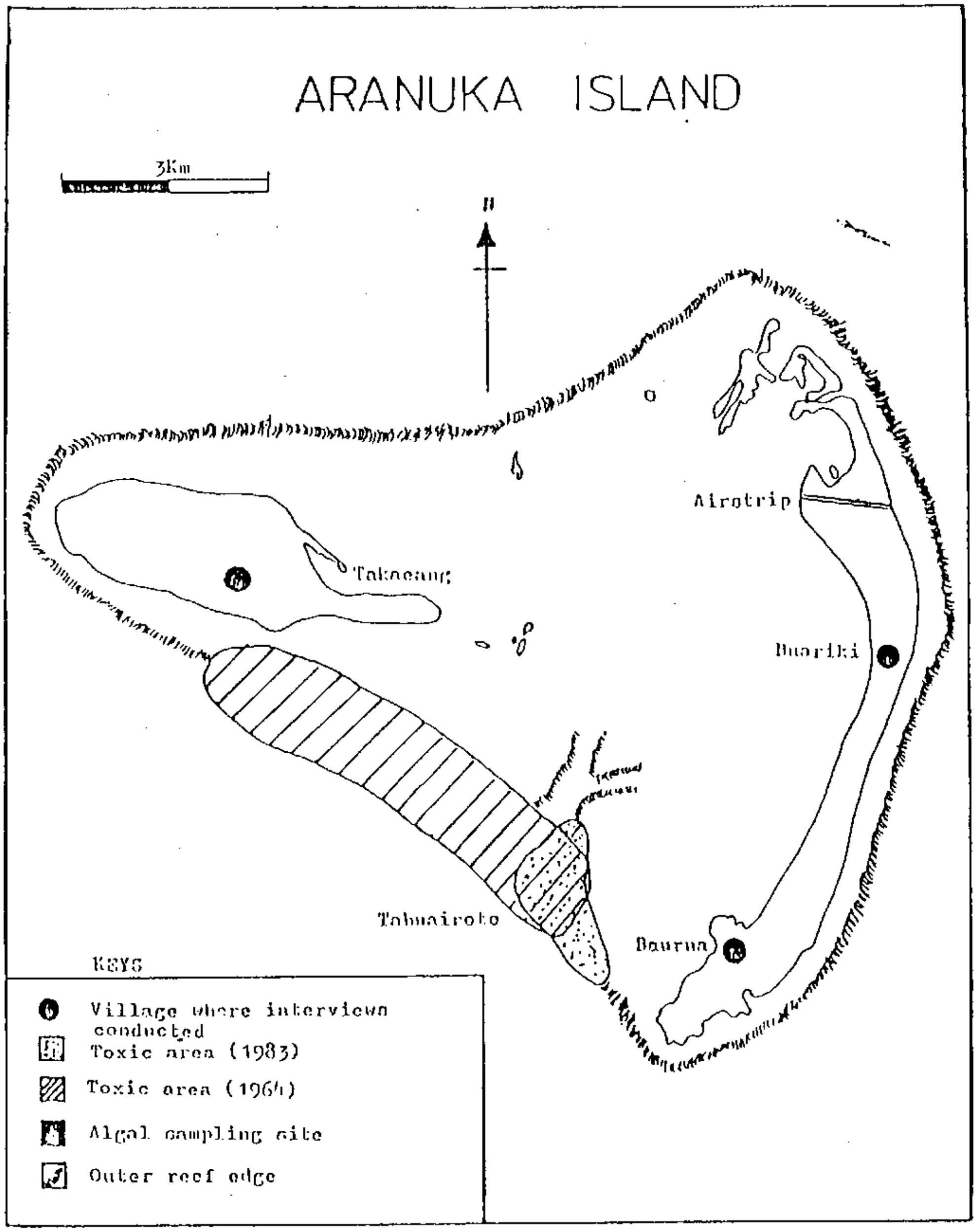


Figure 11. Map of Aranuka Island.

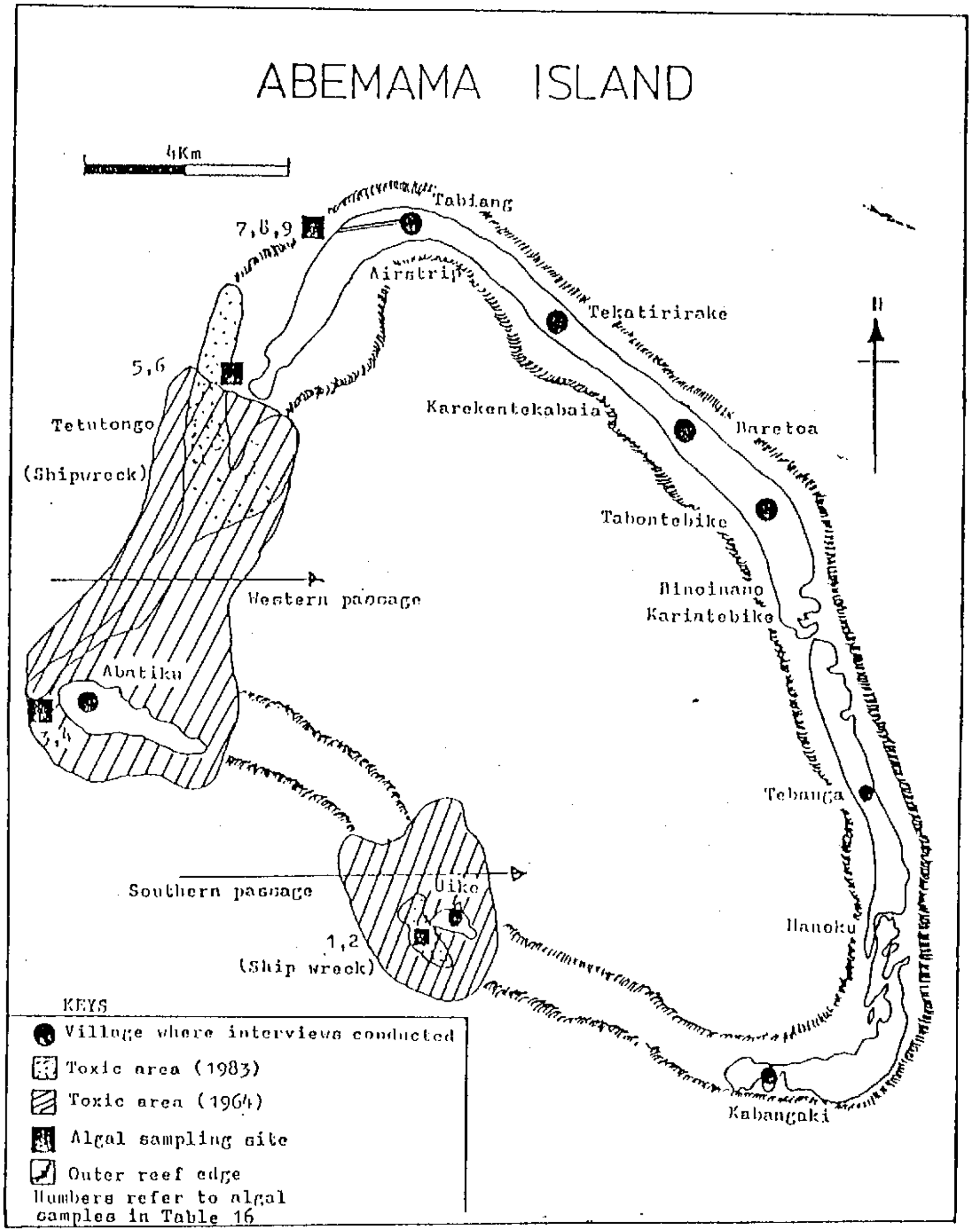


Figure 12. Map of Abemana Island.

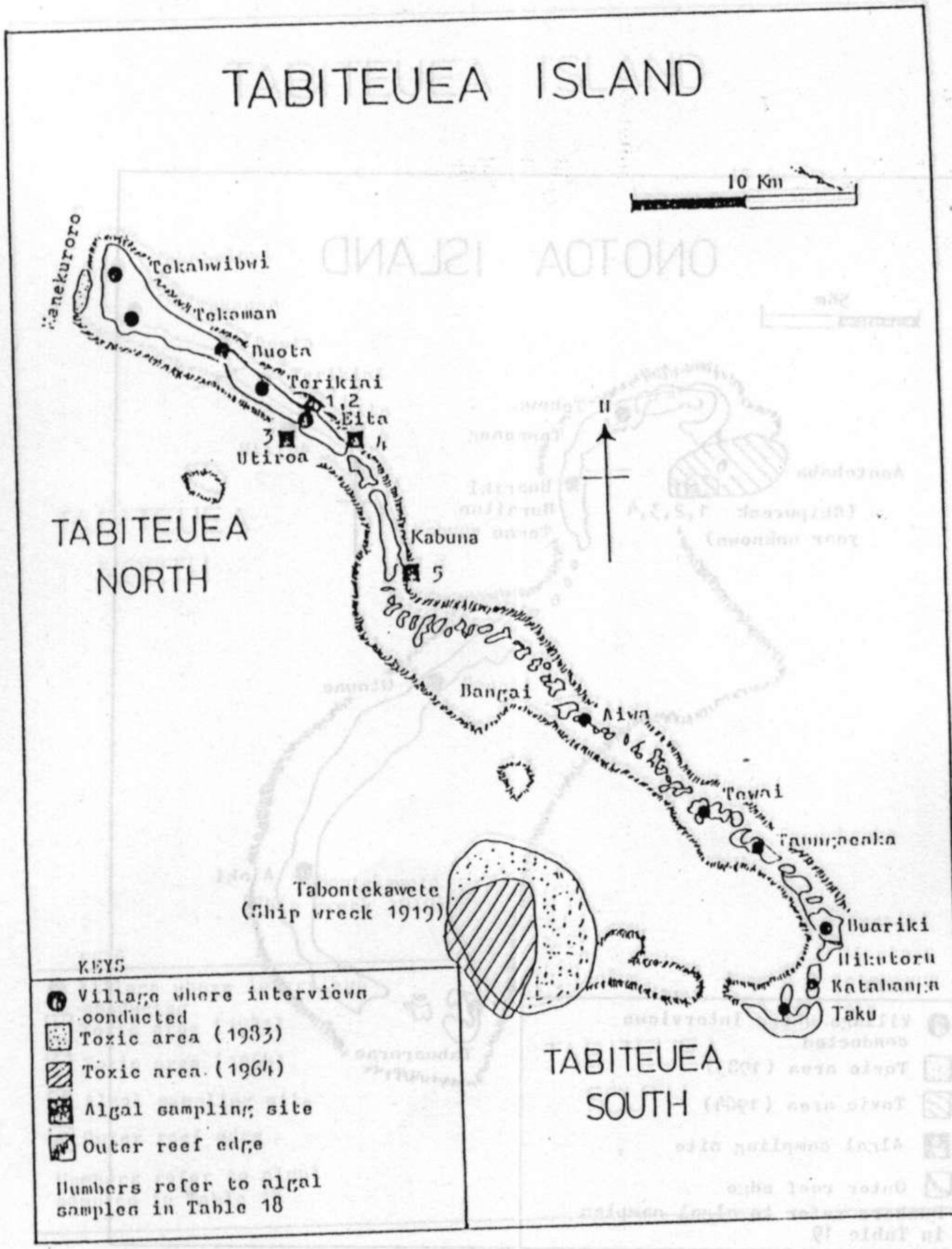


Figure 14. Map of Tabiteuea Island.

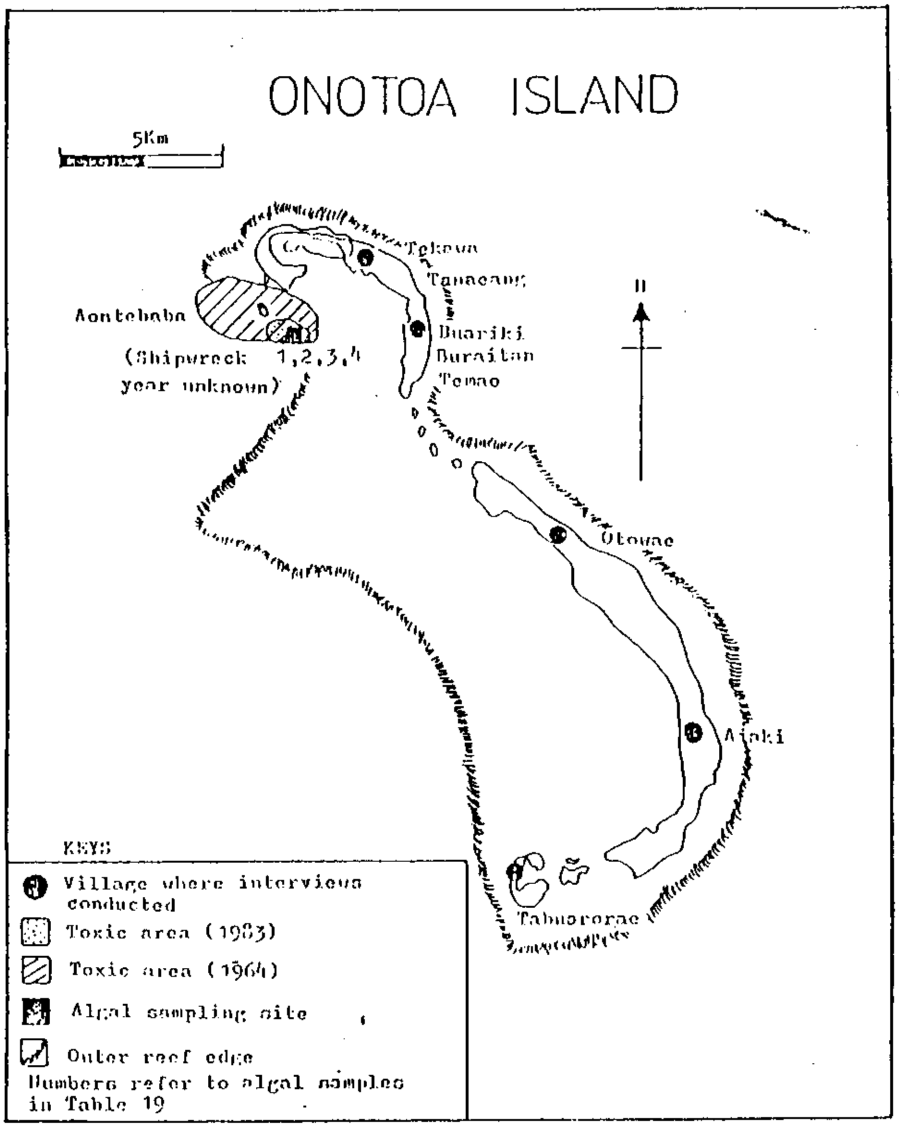


Figure 15. Map of Onotoa'Island.

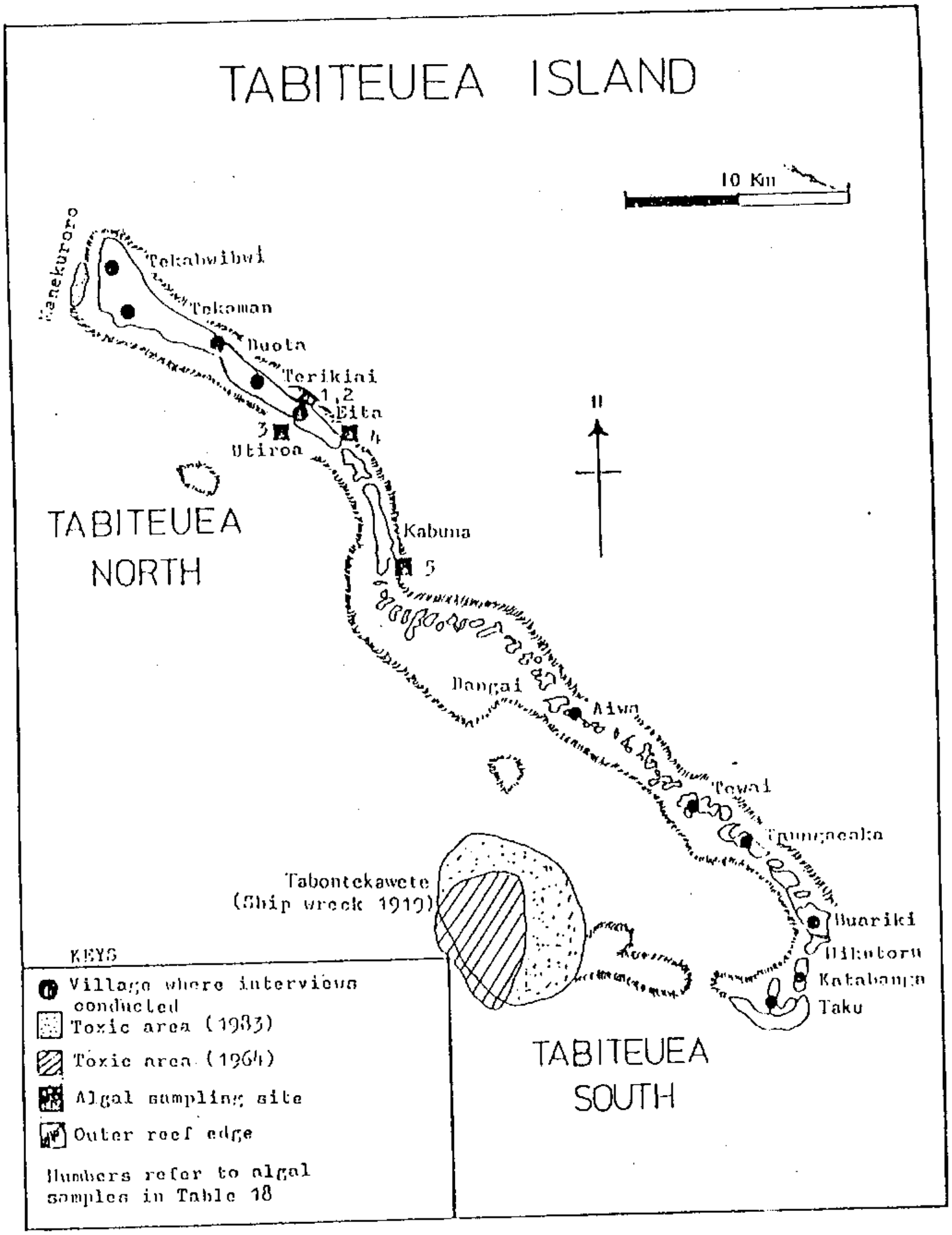


Figure 14. Map of Tabiteuea Island.

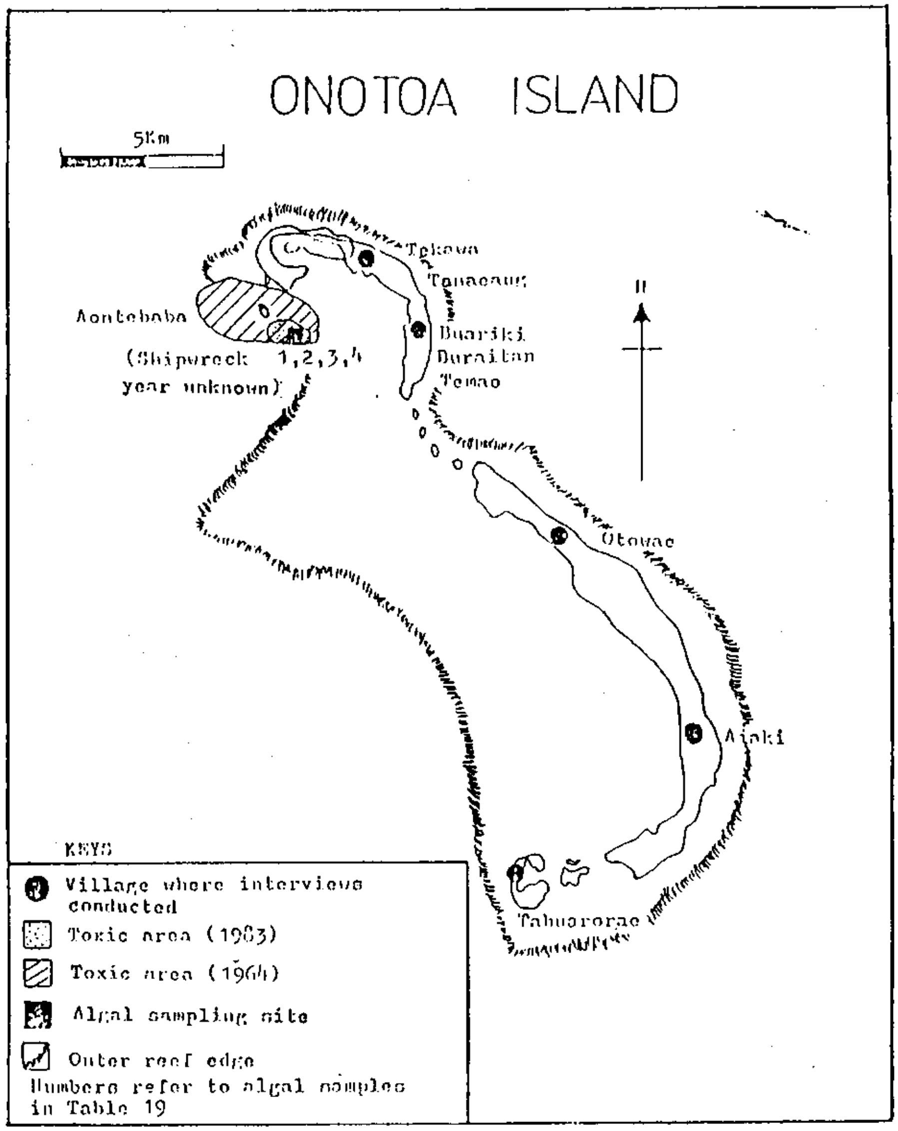


Figure 15. Map of Onotoa Island.

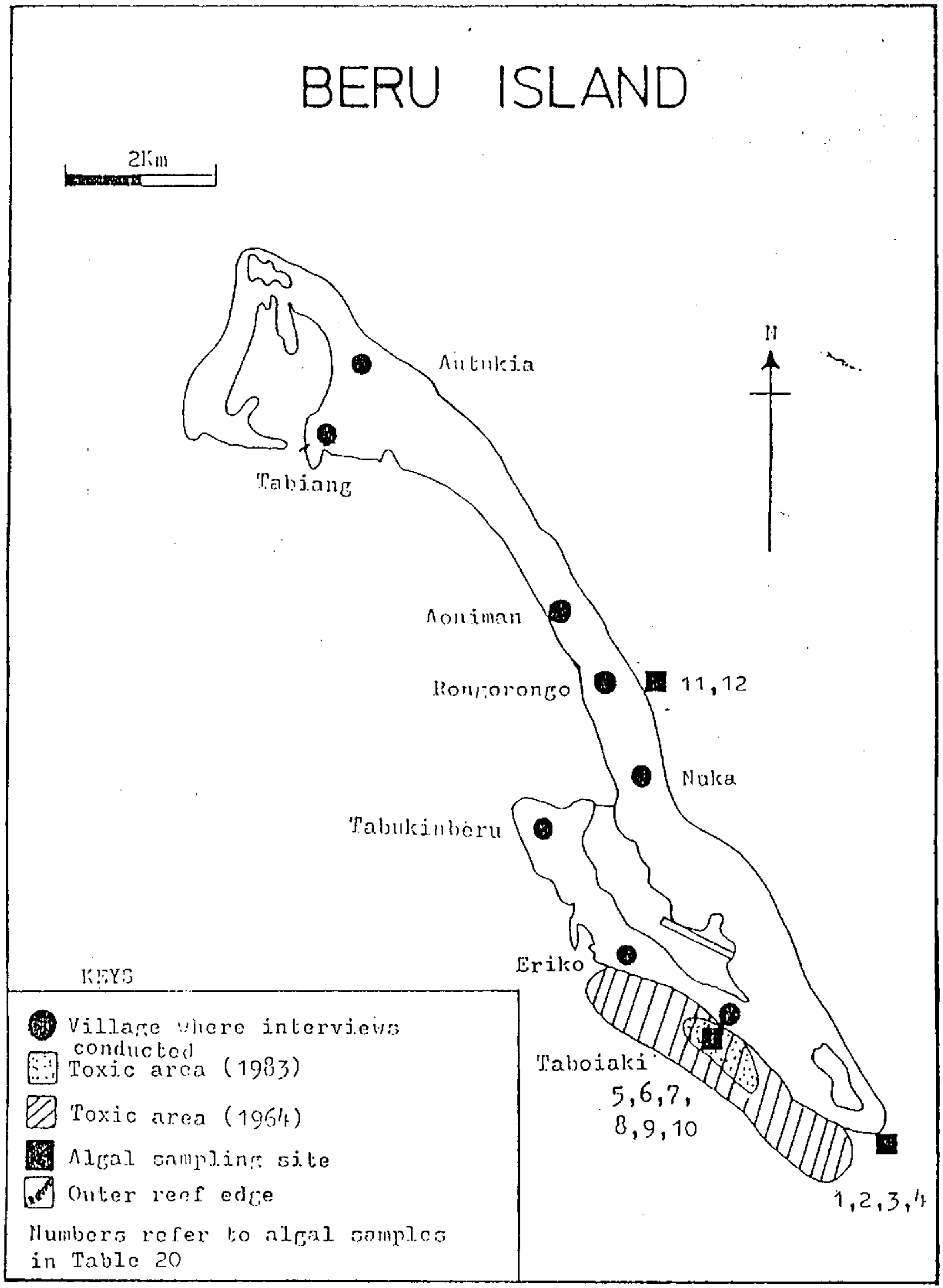


Figure 16. Map of Beru Island.

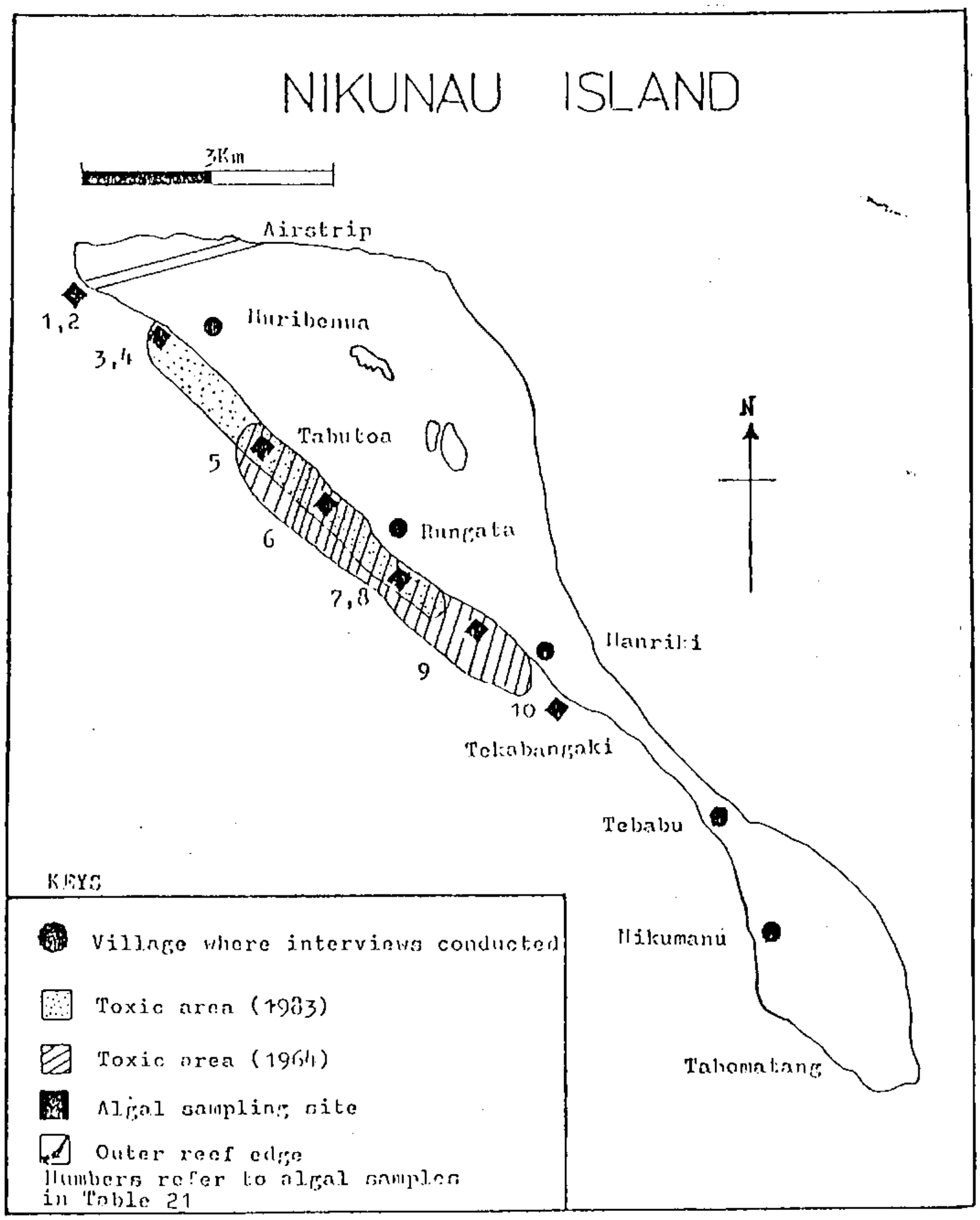


Figure 17. Map of Nikunau Island.

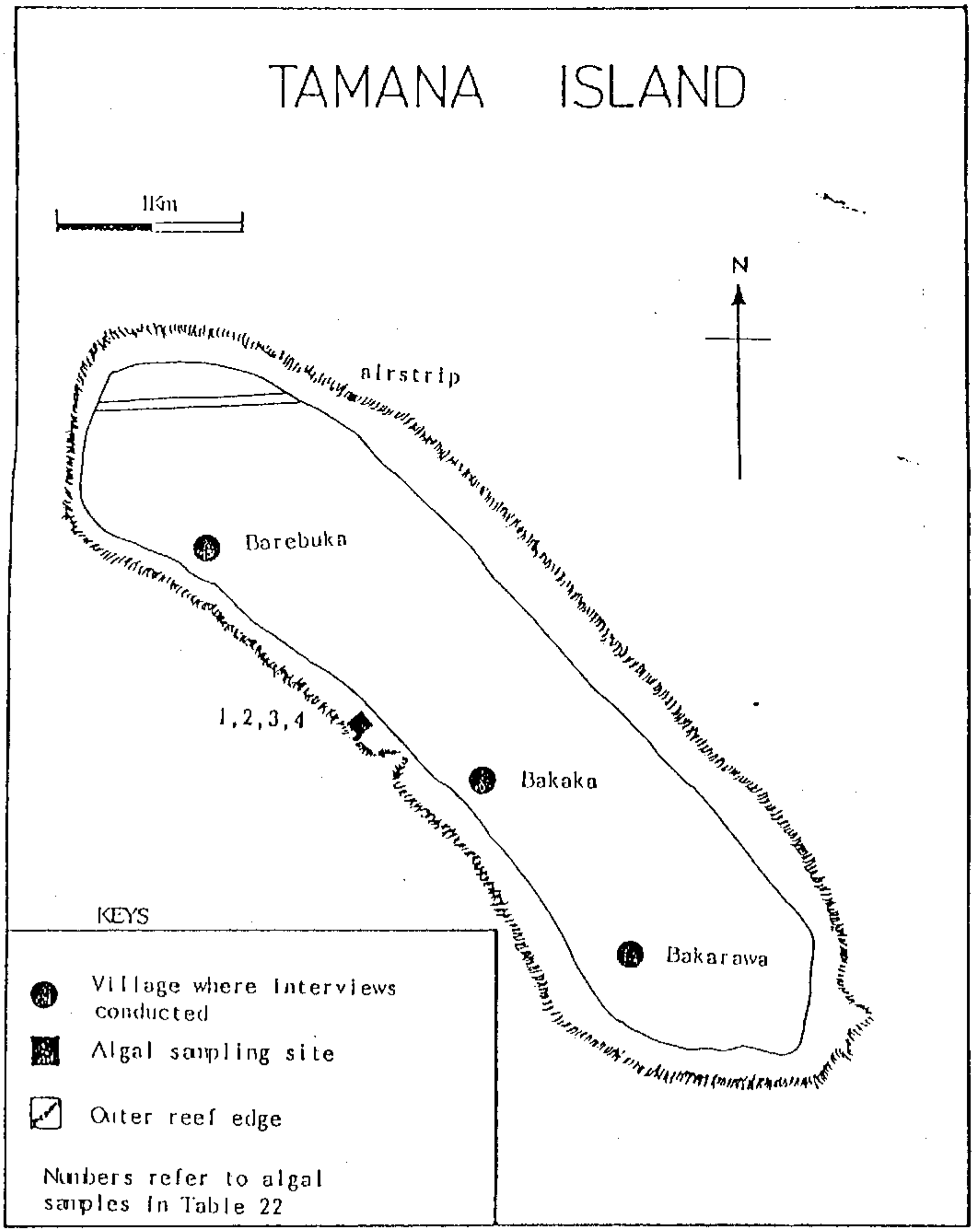


Figure 18. Map of Tamana Island.

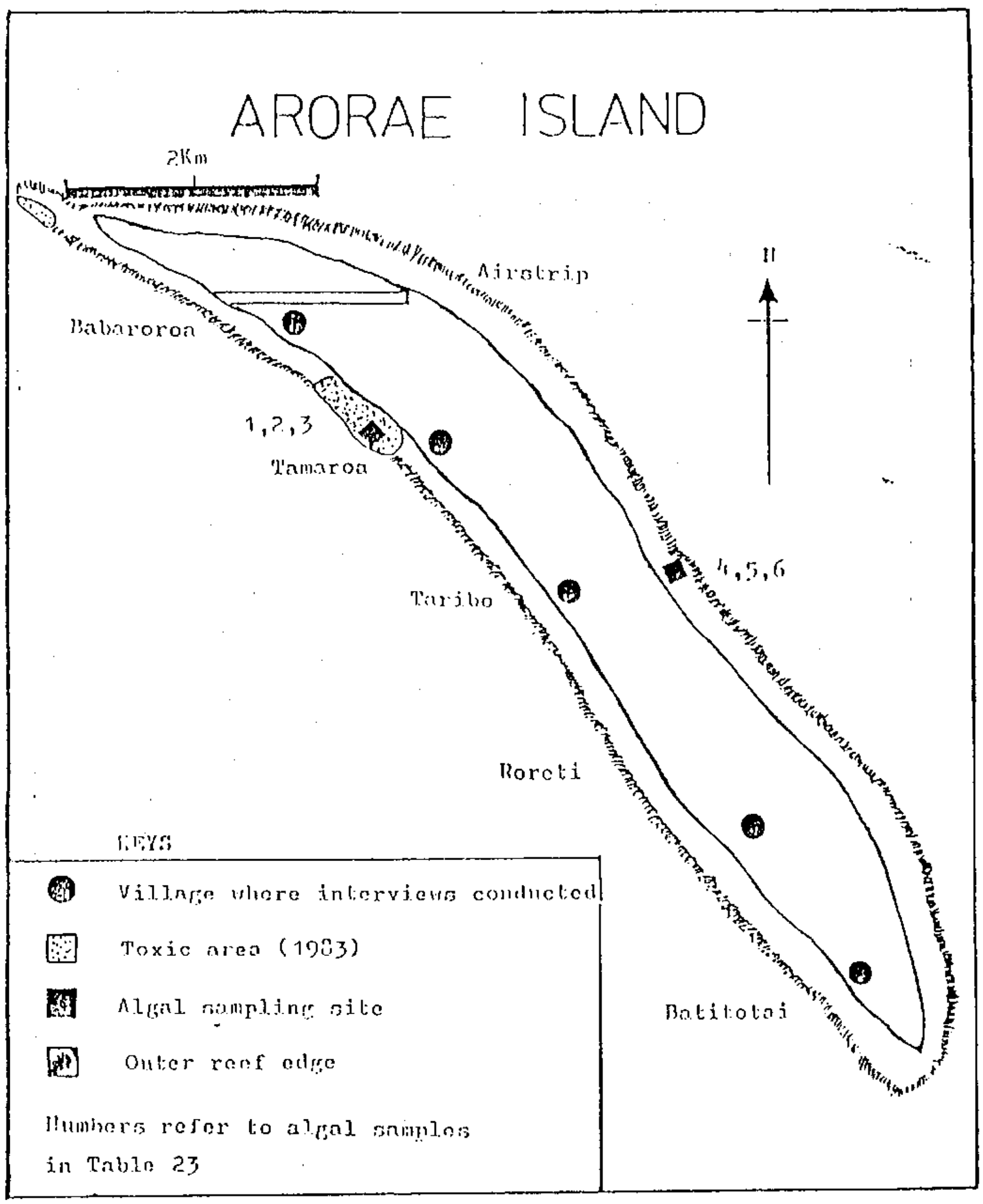


Figure 19. Map of Arorae Island.

Appendix i: Potentially toxic fishes of Kiribati.

Kiribati Name	English Common Name	Family Name	Scientific Name
Bakoa(baiburoro)	Blacktip reef shark	Carcharhinidae	*Carcharhinus melanopterus*
Bakoa	Whitetip reef shark	"	*Triaenodon obesus*
Rabono(kairoro)	Moray eel	Muraenidae	*Gymnothorax flavimarginatus*
Rabono	Moray eel	"	*G. spp.*
Mon	Orangelined squirrel	Holocentridae	*Myripristis berndti*
Bureinawa	Squirrelfish	"	*Sargocentron spiniferum*
Nunua, bwaninua	Barracuda	Sphyraenidae	*Sphyraena barracuda*
Urua	Great trevally	Carangidae	*Caranx ignobilis*
Matabareka	Goldspot trevally	"	*Carangoides fulvogutattus*
Rereba	Bluefin trevally	"	*C. melampygus*
Kuianrereba	Papuan trevally	"	*C. papuensis*
Barebuu	Dusky trevally, big eye	"	*C. sexfasciatus*
Kuau	Cod or Grouper	Serranidae	*Epinephelus merra*
Bakatii	Honeycomb rockcod	"	*Epinephelus hexagonatus*
Bakati	Grouper	"	*Promicrops lanceolatus*
Nimwanang	Peacock rockcod	"	*Cephalopholis argus*
Marati	Large grouper	"	*Cephalopholis spp.*
Kauoto, maneku	Grouper	"	*Cephalopholis spp.*
Ingo, booingo	Red bass	Lutjanidae	*Lutjanus bohar*
Bwawe	Red tail snapper	"	*Lutjanus fulvus*
Bwaweata	Striped seaperch	"	*Lutjanus spilurus*
Ikanibong	Paddletail snapper or	"	*Lutjanus gibbus*
	Humpbacked red snapper	"	*L. gibbus*
Takabe	Bluelined snapper	"	*Lutjanus kasmira*
Tinaemia	Emperorfish	"	*Lutjanus monostigma*
Aratabaa	Red snapper	"	*Etelis carbunculus*
Awai	Green jobfish	"	*Aprion virescens*
Matakore	Bigeye emperorfish	Lethrinidae	*Monotaxis grandoculis*
Rou	Emperorfish	"	*Lethrinus miniatus*
Roubaneawa	Variegated emperor	"	*Lethrinus rhodopterus (L. variegatus)*
Morikoi	Spangled emperorfish	"	*Lethrinus nebulosus*
Karon	Humpheaded wrasse	Labridae	*Cheilinus undulatus*
Newekabane	Wrasse	"	*Coris spp.*
Ikamaawa	Parrotfish	Scaridae	*Scarus frontalis*
Kamauti	Parrotfish	"	*Scarus spp.*
Inai	5-banded parrotfish	"	*Scarus venosus*
Wiiatiibu	Parrotfish	"	*Scarus spp.*
Oouru	Bluebarred orange	"	*S. ghobban*
Riba	Surgeonfish	Acanthuridae	*Acanthurus gahhm*
Ribabui	Surgeonfish	"	*Ctenochaetus striatus*
Ribataanin	Surgeonfish	"	*Acanthurus lineatus*
Kataawa	Bluebanded surgeonfish	"	*Acanthurus lineatus*
Ribataukarawa	Surgeonfish	"	*Acanthurus archilles*
Ribaroro	Surgeonfish	"	*C. binotatus*
Koinawa	Convict surgeonfish	"	*Acanthurus triostegus*
Mako	Surgeonfish	Acanthuridae	*Acanthurus xanthopterus*
Roa	Unicornfish	"	*Naso spp.*
Bokaboka	Bluespine unicornfish	"	*Naso unicornis*

Bubu	Whitebarred trkafish	Balistidae	*Balistes aculeatus*
Bub	Triggerfish	"	*Balistes undulatus*
			B. aculeatus
Nuonuo	Triggerfish	"	*Pseudobalistes flavimarginatus*
Imnai	Rabbitfish	Siganidae	*Siganus punctatus*
Imnai	Silverspinefoot	"	*Siganus argenteus*
Imnai	Rabbitfaced spinefoot	"	*Siganus rostratus*
Inonikai	Rudderfish	Kyphosidae	*Kyphosus vaigenis*
Rironikai	Topsail drummer	"	*Kyphosus cinerescens*
Buni*	Bufferfish	Tetraodontidae	*Arothron hispidus*
Buni*	Diagonalbanded	"	*A. aerostaticus*
Buni	Narrowlined toadfish	"	*A. immaculatus*
Toaaua	Longhorned cowfish	"	*Lactoria cornuta*
Nou**	Reef stonefish	Scorpaenidae	*Synaceia verrucosa*

*Tetradontoxin found in this fish is quite different from maitotoxin found in other fish. It should also be noted that sometimes fish poisoning caused by shark liver consumption can be Vitamin A overdose, it may also be ciguatoxin poisoning or a combination of both.

**Spines are poisonous.

Appendix ii. Some Common Fishes of Kiribati.

Kiribati Name	English Common Name	Family Name	Scientific Name
Anoi	Hammerhead shark	Carcharhinidae	*Sphyrna leweni*
Bakoa	Tawny shark	"	*Ginglymostoma ferrugineum*
Bakoa	Shark	"	*Nebrius ferrugineus*
Bakoa(baiburoro)	Blacktip reef shark	"	*Carcharhinus melanopterus*
Bakoa	Whitetip reef shark	"	*Triaenodon obesus*
Rokea	Tiger shark	"	*Galeocerdo cuvier*
Ati	Skipjack tuna	Scombridae	*Katsuwonus pelamis*
Ingimea, bwaewe	Yellowfin tuna	"	*Thunnus albacares*
Bwaara	Wahoo	"	*Acanthocybium solandri*
Baiura	Bigeyed tuna	"	*Thunnus obesus*
Tawatawa	Mackerel tuna	"	*Auxis thazard*
Buaari	Dogtooth tuna	"	*Gymnosarda unicolour*
Raku	Black marlin	Istiophoridae	*Makaira indica*
Rakuriri	Pacific sailfish	"	*Istiophorus platypterus*
Atiburu	Mackerel tuna	Scombridae	*Euthynnus affinis*
Kamaa	Rainbow runner	Carangidae	*Elagatis bipinnulatus*
Nari	Queenfish	Carangidae	*Scomberoides lysan*
Kimokimo	Scad, salmon mackerel	Scombridae	*Grammatorcynus bilineatus*
Barii	Bigeyed scad	Carangidae	*Selar crumenophthalmus*
Rakutakua	Swordfish	Xiphiidae	*Xiphias gladius*
Onauti	Flyingfish	Exocoetidae	*Cypselurus cyanopterus*
Aonga	Black trevally	Carangidae	*Caranx lugubris*
Ree	Golden trevally	"	*Gnathanodon speciosus*
Kuia	Clubnosed trevally	"	*Carangiodes chrysophrys*
Tauman, kona	Blue trevally	"	*C. laticardis*
Ika-n-arina	Blackspot swallowtail	"	*Trachinotus bailloni*
Takua	Dolphin fish	Coryphaenidae	*Coryphaena hippurus*
Ikanarina	Blackspot swallowtail	Carangidae	*Trachinotus bailloni*
Urua	Great trevally	"	*Caranx ignobilis*
Matabareka	Goldspot trevally	"	*Carangoides fulvogattatus*
Rereba	Bluefin trevally	"	*C. melampygus*
Kuianrereba	Papuan trevally	"	*C. papuensis*
Barebuu	Dusky trevally	"	*C. sexfasciatus*
Ntibetibe	Diamond trevally	"	*Alectis indicus* *A. ciliaris*
Auamaran, bwaua	Bluetail mullet	Mugilidae	*Valamugil seheli*
Taningamea	Mullet	"	*V. buchanani*
Auatabaa	Diamondscale mullet	"	*Liza vaigiensis*
Bwaua	Silverbelly	"	*L. acrolepsis*
Ikari	Bonefish	Albulidae	*Albula neoguinaica*
Baneawa	Milkfish	Chandidae	*Chanos chanos*
Ninimwai	Silverbiddy	Gerreidae	*Gerres oyena* (*G. argyreus*)
Maebo	Goatfish	Mullidae	*Upeneus arge* (*U. taeniopterus*)
Tewe	Goatfish	"	*Mulloides vanicolensis* (*M. auricilla*)
Mawa	Bicolour goatfish	"	*Parupaneus barberinus*
Mawa	Goldsaddle goatfish	"	*P. chryserydros*
Neia	Goldline bream	Lethrinidae	*Gnathodentex aurolineatus*

Ikamatoa	Longnose emperorfish	Lethrinidae	*Lethrinus elongatus*
Matakore	Bigeye emperorfish	"	*Monotaxis grandoculis*
Rou	Emperorfish	"	*Lethrinus miniatus*
Roubaneawa	Variegated emperor	"	*Lethrinus rhodopterus* (*L. variegatus*)
Morikoi	Spangled emperorfish	"	*Lethrinus nebulosus*
Tinaemia	Emperorfish	"	*Lutjanus monostigma*
Kuu	Scarletfin squirrel	Holocentridae	*Adioryx spinifer*
Bureinawa	Violet squirrelfish	"	*Holocentrus violaceus*
Kuu	Squirrel/Soldierfish	"	*Holocentrus spp.*
Mon	Orangelined squirrel	"	*Myripristis berndti*
Bureinawa	Squirrelfish	"	*Sargocentron spiniferum*
Nimako	Flagtail rockcod	Serranidae	*Cephalopholis urodelus*
Kuaubanni	Marbled rockcod	"	*Epinephelus maculatus*
Kuau	Cod or Grouper	"	*Epinephelus merra*
Bakati	Emperorfish	"	*Promicrops lanceolatus*
Nimwanang	Peacock rockcod	"	*Cephalopholis argus*
Marati	Large grouper	"	*Cephalopholis spp.*
Kauoto, maneku	Grouper	"	*Cephalopholis spp.*
Nrekereke	Bluespotted rockcod	"	*Cephalopholis cyanastigma*
Bwaru	Purple rockcod	"	*Epinephelus flavocaeruleus*
Kuaubanni	Marbled cod	"	*E. maculatus*
Maneku	Rockcod	"	*E. spp.*
Ikauraura	Lunartailed cod	"	*Variola albimarginatus*
Buki-iaroo	Yellowtail snapper	Lutjanidae	*Pristipomoides auricilla*
Aratabaa	Red snapper	"	*Etelis carbunculus*
Awai	Green jobfish	"	*Aprion virescens*
Ikakoaa	Jobfish	"	*Aphareus spp.*
Bukinrin	Jobfish	"	*Pristipomoides filamentosus*
Bukiura	Redfinned jobfish	"	Aphareus *rutilans*
Ingo, booingo	Red bass	"	*Lutjanus bohar*
Bwawe	Red tail snapper	"	*Lutjanus fulvus*
Bwaweata	Striped seaperch	"	*Lutjanus kasmira*
Ikanibong	Paddletail snapper or Humpbacked red snapper	" "	*Lutjanus gibbus* *L. gibbus*
Takabe	Bluelined snapper	"	Lutjanus kasmira
Kaabubu	Garfish	Hermiramphidae	*Hyphorhamphus dussumieri*
Anaorooro	Longfinned garfish	Hermiramphidae	*Euleptorhamphys viridis*
Mwake	Garfish	Belonidae	*Strongylura leiura*
Anaa	Longbilled garfish	"	*Rhynchorhampus georgi*
Tau	Longtom	"	*Tylosurus crocodilus*
Tau	Longtom	"	*T. incisa*
Kekerikaaki	Smooth flutemouth	Fistularidae	*Fistularia petimbsa*
Ikabwaauea	Seapike	Sphyraenidae	*Sphyraena forsteri*
Nunua, bwaninua	Barracuda	"	*Sphyraena barracuda*
Tarabuti	Goldspot herring	Clupeidae	*Herklotsichthys quadrimaculatus* (*H. punctatus*)
Auan	Blue sprat	"	*Spratelliodes delicatulus*
Tiatiin	Blue sardine	"	*Sardinella sirm* *Amblygaster sirm*

Rerekoti	*Slender hardyhead*	*Atherinidae*	*Atherinomorus lacunosus*
Rerekoti	Hardyhead	"	*Hypoatherina barnesi (Allanetta ovalaua)?*
Rerekoti	Broadbanded hardyhead	"	*Pranesus pinguis*
Ibwabwa	Threadfin coralfish	Chaetondontidae	*Chaetodon auringa*
Ibwabwanrotuma	Pennant coralfish	"	*Heniochus acuminatus*
Ibwabwa	Longnosed batfish	Ephippidae	*Platax orbicularis*
Nikatang	Spinyeyed cardinalfish	Apogonidae	*Apogon fraenatus*
Nikatang	Fragile cardinalfish	"	*A. fragilis*
Nikatang	Cardinalfish	"	*A. fowleria*
Ikakiraati	Cardinalfish	"	*A. cypselurus Rhabdamia cypselurus*
Nikatang	Angelfish	"	*Pomacanthus spp.*
Reibu	Damselfish	Pomacentridae	*Pomacentrus sp.*
Baibai	Leopard flounder	Bothidae	*Bothus pantherinus albimarginatus*
Ntaremwa	Goby fish	Gobiidae	*Valenciennea spp. Amblyeleotris spp. Ptereleotris spp.*
Baiku, maii	Stingray	Dasyatidae	*Himantura spp. Dasyatis spp.*
Iku	Leatherskin ray	"	*Rhinoraja longicauda*
Baimanu	Devil headed mantaray	Mobulidae	*Mobula spp.*
Atunaomata	Spotted eagleray	Myliobatididae	*Aetobatus narinari*
Beru	Bridles beauty	Labridae	*Labroides dimidiatus*
Nimaninaba	Arabian eelpike	Muraenidae	*Muraenesox cinereus*
Imoone	Spotted snake eel	Ophichthidae	*Myricthus maculosus*
Montaibakoa	Lunartailed bullseye	Priacanthidae	*Priacanthus humrur*
Ikanibeka	Oilfish	Gempylidae	*Ruvettus pretiosus*
Uningaaboo	Variegated lizardfish	Synodontidae	*Synodus variegatus*
Karon	Humpheaded wrasse	Labridae	*Cheilinus undulatus*
Newekabane	Wrasse	"	*Coris spp.*
Ikamaawa	Parrotfish	Scaridae	*Scarus frontalis*
Kamauti	Parrotfish	"	*Scarus spp.*
Inai	5-banded parrotfish	"	*Scarus venosus*
Wiiatiibu	Parrotfish	"	*Scarus spp.*
Oouru	Bluebarred orange	"	*S.ghobban*
Riba	Surgeonfish	Acanthuridae	*Acanthurus gahhm*
Ribabui	Surgeonfish	"	*Ctenochaetus striatus*
Ribataanin	Surgeonfish	"	*Acanthurus lineatus*
Kataawa	Bluebanded surgeonfish	"	*Acanthurus lineatus*
Ribataukarawa	Surgeonfish	"	*Acanthurus archilles*
Koinawa	Convict surgeonfish, tang	"	*Acanthurus triostegus*
Mako	Surgeonfish	"	*Acanthurus xanthopterus*
Roa	Unicornfish	"	*Naso spp.*
Bokaboka	Leatherjacket	"	*Naso unicornis*
Bubu	Triggerfish	Balistidae	*Balistes undulatus B. aculeatus*
Bubu	Whitebarred	"	*B. aculeatus*
Nuonuo	Triggerfish	"	*Pseudobalistes flavimarginatus*
Rabono(kairoro)	Moray eel	Muraenidae	*Gymnothorax flavimarginatus*
Imnai	Rabbitfish	Siganidae	*Siganus punctatus*
Imnai	Silverspinefoot	"	*Siganus argenteus*
Imnai	Rabbitfaced spinefoot	"	*Siganus rostratus*
Inonikai	Rudderfish	Kyphosidae	*Kyphosus vaigenis*
Rironikai	Topsail drummer	"	*Kyphosus cinerescens*
Buni	Bufferfish	Tetraodontidae	*Arothron hispidus*
Buni	Diagonalbanded	"	*A. aerostaticus*
Buni	Narrowlined toadfish	"	*A. immaculatus*
Toaaua	Longhorned cowfish	Ostracidae	*Lactoria cornuta*
Nou	Reef stonefish	Scorpaenidae	*Synaceia verrucosus*