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The University of the South Pacific

POPULATION DENSITY OF *GAMBIERDISCUS TOXICUS*, *PROROCENTRUM LIMA* AND *OSTREOPSIS SIAMENSIS* IN THE LAGOON AND REEF OF ABAIANG ATOLL:

The dinoflagellates presumed to be responsible for ciguatera poisoning.

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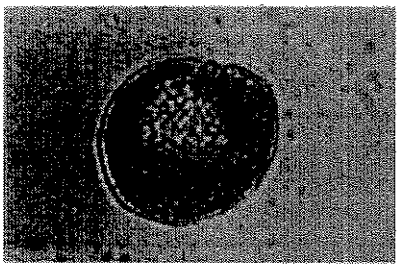
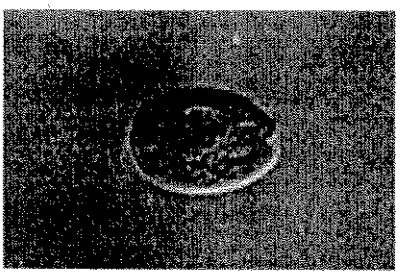
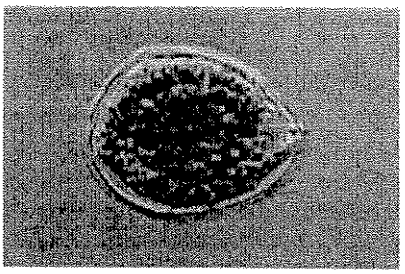

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Abstract

Data on the population density of the dinoflagellates, *Gambierdiscus toxicus*, *Procentrum lima* and *Ostreopsis siamensis* presumed to be responsible for ciguatera fish poisoning was collected from the island of Abaiang in mid June 1999. Samples were obtained from both the inner and western reef edges of the lagoon. The dominant species is *Prorocentrum lima* with an average and highest count of 2.4 and 20.4 cells per gramme alga, respectively. *Gambierdiscus toxicus* averaged 0.5 cells per gramme alga with a highest count of 3.8 cells per gramme alga. *Ostreopsis siamensis* is also present but in very low densities. The southern inner lagoon yielded an average count of 4.6 cells per gramme alga with highest count of 20.4 cells per gramme alga. The western reef averaged 8.1 cells per gramme alga with highest count of 11.9 cells per gramme alga. The host algae are *Halimeda* spp., unidentified brown algae and fine turf (both scraped off from dead reef surfaces). Unidentified fine turf and brown algae harbor the most dinoflagellates.

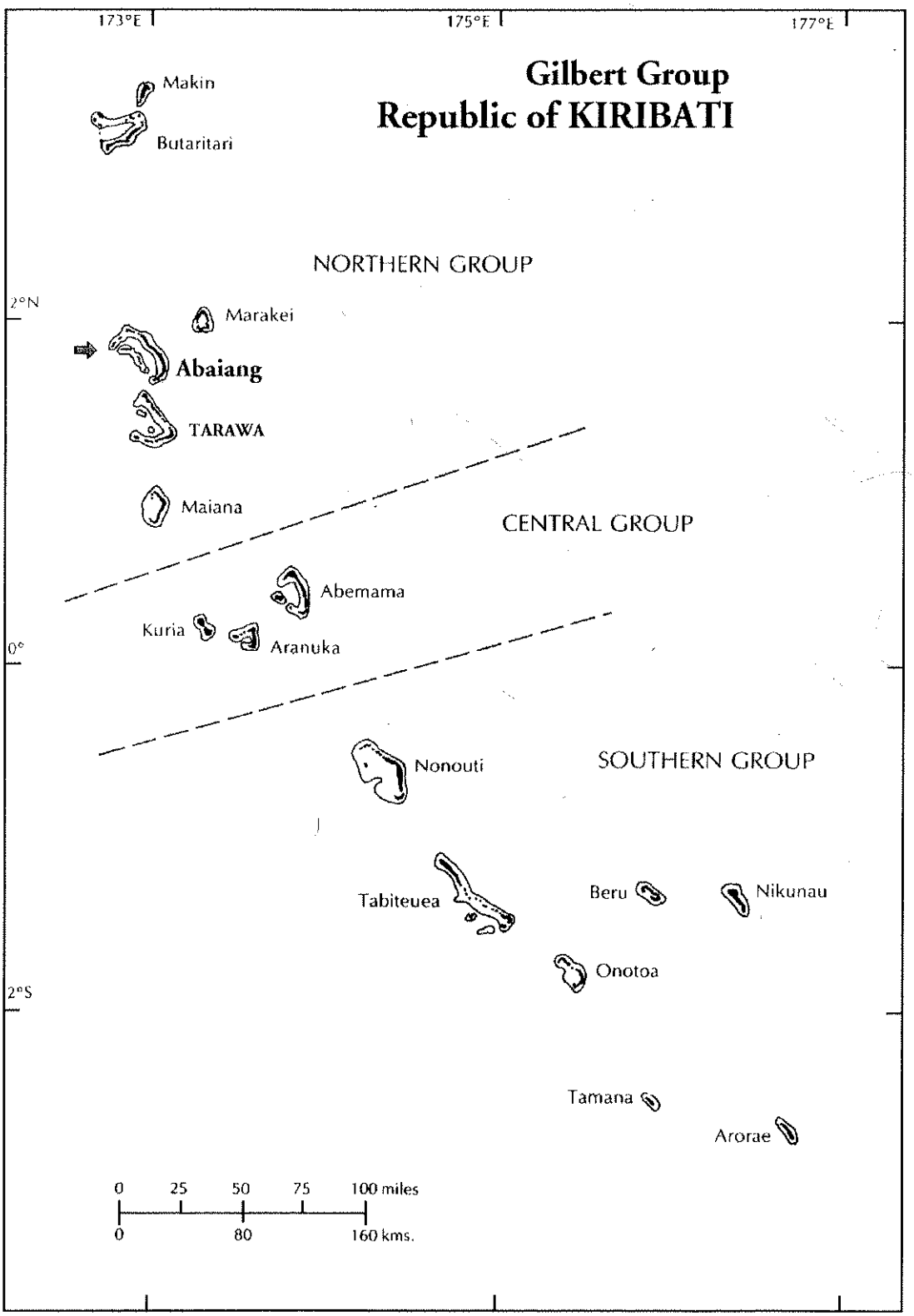

Figure 1a: Map of the Gilbert Group in the Republic of Kiribati, Abaiang Island pointed with arrow.

1.0 Introduction

The density population study on the dinoflagellates presumed to be the causative organisms in ciguatera poisoning was carried out as a small component of the larger programme - the assessment of grouper stocks in the lagoon and reefs of Abaiang Atoll (Fig. 1a). The latter was jointly conducted by the Fisheries Division of the Ministry of Natural Resources of the Government of Kiribati and the Atoll Research Programme, with the assistance of a consultant from the South Pacific Community (SPC) based in Noumea, New Caledonia. The assessment was in response to a request previously made by the Abaiang Island Council to look into grouper stocks as a safeguard against a possible over-exploitation by foreign companies wanting to operate on the island. The collection of algal samples for this study complemented the main programme by providing crucial information on the status of ciguatera poisoning on the island as it may adversely affect the proposed grouper industry as had happened a few months earlier when one grouper shipment from the southern islands was identified as the cause of ciguatera incidences in one of the Hong Kong restaurants. The incidence caused the closure of the industry that has provided an alternate source of cash income for the rural fishermen in the southern islands.

Abaiang (abaia-ang) meaning 'land of the wind' is a true coral atoll that lies north of Tarawa Atoll (Fig. 1a) at approximately 1.50°N latitude and 172°55'E longitude (Peason, 1999) (Fig.1.3). The island is almost rectangular in shape spanning 33 km long and 12 km wide. Numerous islets surround an inner lagoon to the northern end and a long stretch of land at the central and southern portion forming a continuous stretch of landmass.

Like other islands in the Gilbert group Abaiang has developed on a northwest trending series of subsiding, mid-oceanic volcanoes on the western edge of the Central Pacific Basin. The age of the oceanic crust at the northern Gilbert (to which Abaiang falls) is Late Jurassic (139 ma) (Gillie, 1993). Woodroffe and McLean (1992) claimed that there is considerable evidence that the sea stood 1-2 m above its present level with respect to many coral atolls of the Pacific and Indian Oceans about 4,000-3,000 years ago and that in the last few thousand years sea level has fallen relative to those islands.

The lagoon is about 12 m deep on average (Tebano pers. comm.). A fringing reef marks the western edge with several passes deep enough to allow medium size cargo boats to bring in food supplies and other necessary items to the island. Patch reefs are scattered unevenly throughout the lagoon. The sea-grass beds are concentrated in the more sheltered central part of the atoll along the low tide mark and toward the lagoon while mangroves are common towards the more exposed northern and southern tips (Tebano, 1990). No hydrological work had been done on the island. The tidal reference station is at Tarawa Atoll. There is no tidal gauge on the island, however its tidal range is assumed to be the same as for Tarawa whose mean is 1.00 m above datum. The mean neap tide range is 1.2 m and the mean spring tide range is 1.8 m (Hydrographer of the Navy, UK 1992).

The mean air temperature for Abaiang is 29°C, water temperature averages 32.3°C (Meteorological, 1999). The dry season (Au Maiaki or south easterlies) brings in very little rain while the wet season (Au Meang or north-easterlies) brings in lots of rain (Tebano, 1985). The average rainfall is 1.5 m during the low sun season and >1 m during the high sun season (Meteorological, 1999). Strong westerlies occasionally occur around December (Tebano, 1985). The late 1990s El Niño has reversed the weather pattern (pers. Comm.). Water clarity had not changed much as the island is still a rural area. To date no bathymetric work had been done in the lagoon of Abaiang.

The latest human population level is well over seven thousand (unconfirmed 2000 estimates). The main sources of income include copra, seaweed, octopus, small clams (*Tridacna maxima*) and finfish. The sale of copra is the oldest form of cash income while the latter have been recently introduced with the establishment of a national seaweed company, Atoll Seaweed, a Japanese octopus market (Pacific International Incorporated) and the local markets. All are based in Tarawa, the capital of the Republic.

The reef of Abaiang provides an abundance of food sources for the local people. Open water fishing for tuna and related species does not form part of the daily fishing activities as other inshore and shallow water species are readily available.

There had not been any comprehensive studies on ciguatera and the causative organisms prior to a study done by Tebano and MacCarthy (1991) that indicated that there was no trace of *Gambierdiscus toxicus,* the presumed precursor of ciguatoxin, on the island. The perception of the local residents (Tebano & MaCarthy pers. comm.) implied that the island is free of the toxin since there has been no incidence of ciguatera poisoning in the past. Medical records obtained by Tebano & MaCarthy (1991) could not confirm if ciguatera poisoning has occurred on the island since details of the recorded incidences were not specific enough to point at ciguatera. At the same time all cases were categorized under fish poisoning that included all forms of poisoning associated with the consumption of fish.

This complimentary study was intended to assess the population density of the presumed precursors of ciguatera fish poisoning namely *Gambierdiscus toxicus*, *Prorocentrum lima* and *Ostreopsis siamensis* in and around the reefs and lagoon of Abaiang Atoll. The study provides preliminary baseline data that will compliment the findings of the grouper study. It is anticipated that such information will be crucial in future work in the design and implementation of management and conservation strategies and polices related to the grouper and other finfish resources on the island.

2.0 Methodology

Sampling sites

Data was obtained from 5 selected sampling sites namely the North West Reef, West Passage Entrance, Western Reef, South Inner Lagoon and Western Inner Lagoon (Figure 1b). Samples were collected from depths between 5 - 15 metres using scuba.

Quantitative Analysis

Samples were placed in plastic bags and transported back to the Atoll Research Programme's laboratory in Tarawa. The treatments involved vigorous shaking of the plastic bags with contents for several minutes to dislodge the epiphytic dinoflagellates from the host substrate. The murky substrate was sieved using mess sizes of 500, 125 and 38µm. The finest residue retained on the 38µm sieve was transferred to a 25ml vial, 2-5 drops of concentrated

formalin was added as a preservative and the sample vial was filled with filtered rainwater. The larger particles retained on the largest mess sieve (500µm) were weighed using a digital balance. All wet weights were recorded in grams to 1 decimal point. After weighing small portions of the algae/debris was preserved for later identification.

To estimate the density of a dinoflagellate, the sample in a 25-ml vial was vigorously shaken and 0.25 millilitres (mls) was pipetted. Two to three drops of the sample from the pipette were placed onto a counting microscope slide. An average of 3 counts were made for each sample vial. Samples were examined under a 200X magnification. Any dinoflagellates present were identified using colour pictures from reports by Yasumoto et al. (1980, 1981).

Density per 100 grams of algae for each sample was calculated by taking the average count and multiplying it by 100 to obtain an estimate of cell density per 25mls (volume of the vial bottles). This value was divided by the wet weight of the sample to obtain a value for each 100 gram host algae. All calculations and plotting were carried out using Microsoft Excel 97™

Fish Poisoning on Abaiang

Reported cases of fish poisoning from Abaiang were obtained from the Tungaru Central Hospital at Nawerewere. It was noted that all cases of food poisoning associated with fish consumption were recorded under fish poisoning. From the descriptions given the cases included ciguatera poisoning, scombrid poisoning, shark liver poisoning, food contamination, and other forms of fish consumption related. One has to accept that some cases were genuinely ciguateric in nature according to the descriptions. At the same time the widespread and endemicity of the disease in the tropics (Marriott, S.P. and Dally, B.G., 1980; Yasumoto, T., Fujimoto, K., Oshima, Y., Inoue, A., Ochi T., Adachi R. and Fukuyo, T., 1980; Yasumoto, T., Oshima, Y., Inoue, A. and Harada T., 1981; Tebano T., 1984; Ruff, T. A., 1989; Tebano, T., 1991; Tebano, T. and MacCarthy, D., 1991; Ichinotsubo, D., Asashina, A. Y., Titus, E., Chun, S., Hong, T. L. W.P., Shirai, J.L. and Hokama, Y.,1994;) will undoubtedly affect a certain portion of a human population from time to time.

2.0 Results

Density Count

The presumed causative organisms of ciguatera poisoning namely *Gambierdiscus toxicus*, *Prorocentrum lima* and *Oestropsis siamensis* are present in various densities in the lagoon and reef of Abaiang Atoll as samples from various locations around the island show. Of the total number of samples collected, 36% contained the dinoflagellates, the remaining 64% did not.

Both *Gambierdiscus toxicus* and *Prorocentrum lima* were relatively common, and found in 28% of the samples while *Oestropsis siamensis* was rare and only present in the remaining 8%. *Prorocentrum lima* appears to be the dominant dinoflagellate with an overall average density for all samples of 2.4 cells per gram alga and a highest count of 20.4 cells per gram alga. *Gambierdiscus toxicus* has an overall average density of 0.5 cells per gram alga with a highest count of 3.8 cell per gram alga (Figure 2). Of all the samples that contained the 3 dinoflagellates *Prorocentrum lima* was found in 84.13% of the samples, *Gambierdiscus toxicus* 15.53% and *Ostreopsis siamensis* 0..34% (Figure 3).

Within the sites, the South Inner Lagoon harbors the highest density of the dinoflagellates with an average of 4.6 cells per gram alga and a highest count of 20.4 cells per gram algae. The most dominant species is *Prorocentrum lima* which was present in 83% of the samples and *G. toxicus* in the remaining 17%. The Western Reef averaged 8.1 cells per gram alga with a highest count of 11.9 cells per gram. Again the dominant species is *Prorocentrum lima* with 91% followed by *G toxicus* with the remaining 9%.

Algal Sample Composition and Host

Twenty eight percent (28%) of the algal samples that were collected was made up of unidentified fine turf and brown algae scraped off the reef surface. The remaining 72% was composed of *Halimeda* spp. It was noted that the fine turf harbored the most dinoflagellates while a brown algae followed. *Halimeda* spp. harbored none to very few dinoflagellates. This

suggests that the unidentified fine turf and brown algae are among the favored hosts of the dinoflagellates studied.

Medical Record on Cases of Fish Poisoning from Abaiang

Table 1.

Year	1992	1993	1994	1995	1996	1997	1998
Number of cases	4	0	1	3	29	2	4

The number of cases reported in 1996 is notably high as compared to other years. This implicates that there must have been activities or natural reef disturbances in previous months or years that are related to this record.

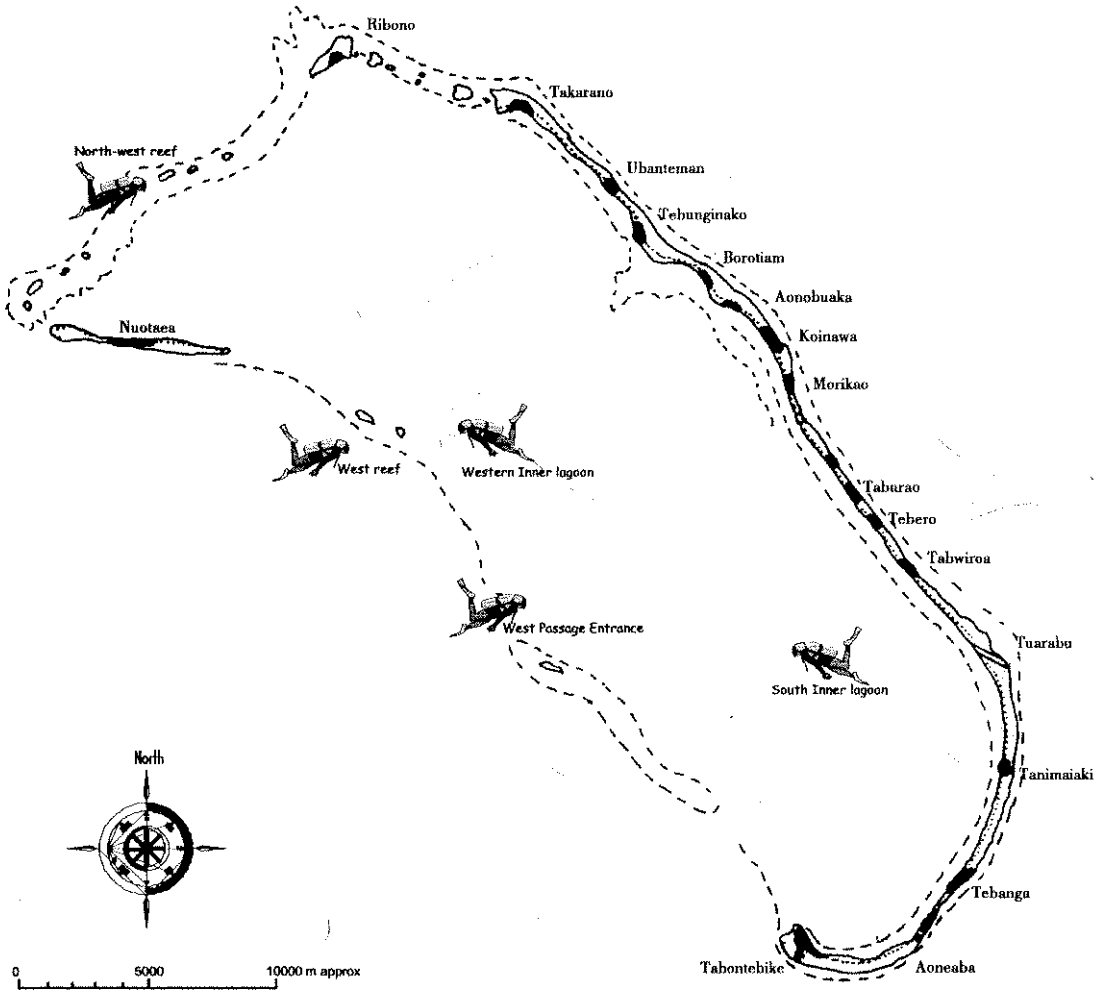

Figure 1b: Map of Abaiang Atoll showing the sampling sites.

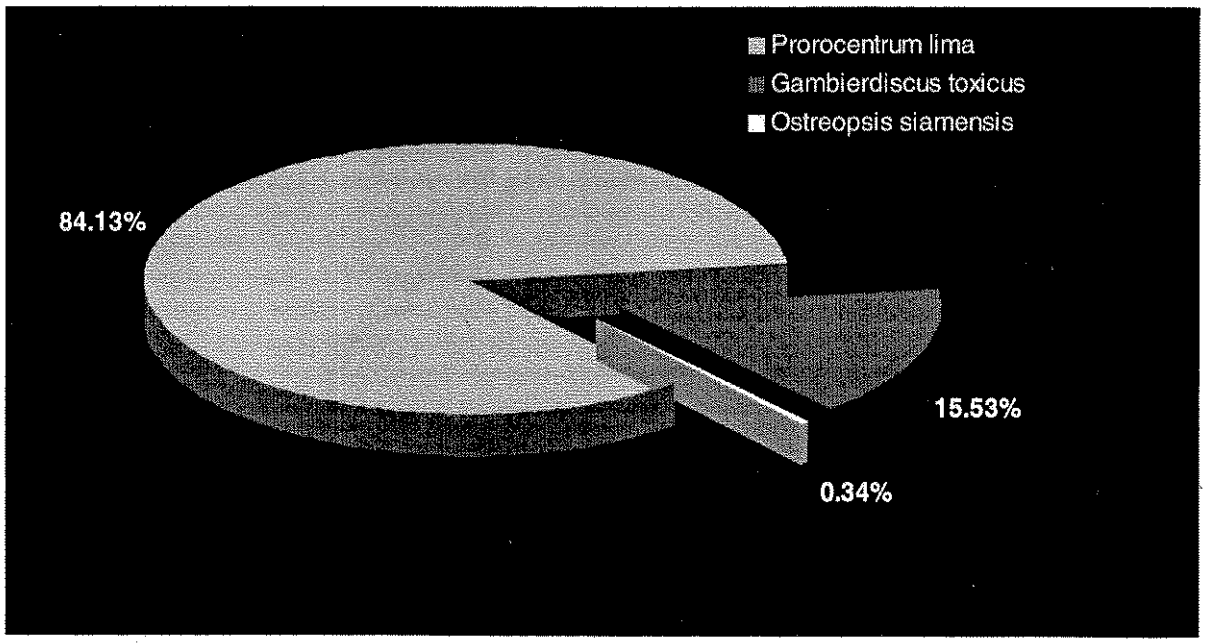

Figure 2. Proportion of each dinoflagellates in all samples.

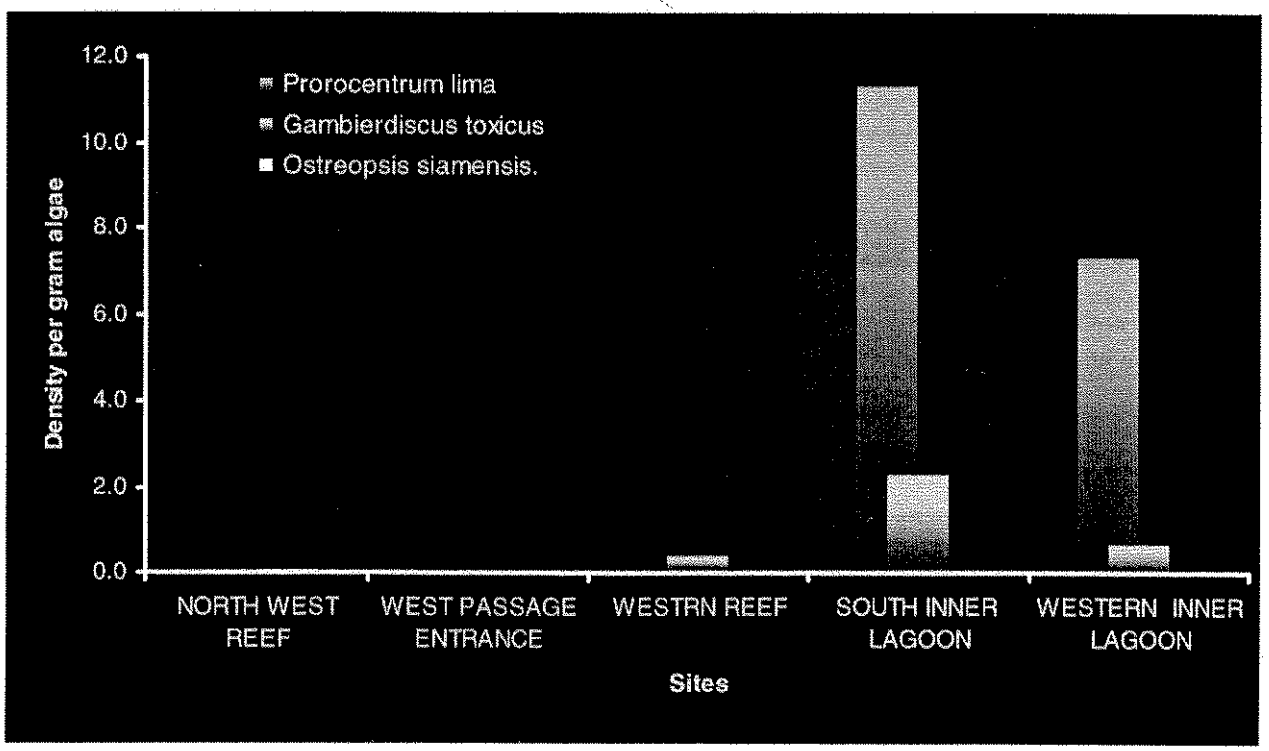

Figure 3. Average density of toxic dinoflagellates for each of the sites surveyed

4.0 Discussion

Gambierdiscus toxicus, and *Prorocentrum species* are present in the lagoon and reef of Abaiang but in low densities. This is quite reflected in the low number of cases reported from the island (Table 1). The first survey done by Tebano and MacCarthy (1991) showed that there had not been any cases of ciguatera poisoning on the island since time immemorial up until the late 1970s. The people of Abaiang believed that the loving god, Nareau, had spared the "island of the winds" from all forms of diseases (Tebano and MacCarthy, 1991). That perception has slowly changed over the years. Incidences of ciguatera have been reported. The low cell counts could be linked with the small number of incidences recorded from the island, except for 1996. But many cases (and probably more) are believed to be unreported as is the case in many Pacific islands (Tebano T., 1984; Ruff, T. A., 1989; Tebano, T., 1991; Tebano, T. and MacCarthy, D., 1991; Ichinotsubo, D., Asashina, A. Y., Titus, E., Chun, S., Hong, T. L. W.P., Shirai, J.L. and Hokama, Y.,1994). The incidence of ciguatera poisoning on the island is not accidental. The southern reef facing the village of Tabontebike was blasted in the late 1980s to make boat channels thus allowing skiffs and small crafts enter and leave the lagoon with ease. This cuts down on time and fuel consumption as crafts previously had to enter or leave the lagoon from the south-western passage. Ciguatera incidences must be linked with reef disturbance at this particular portion of the lagoon-reef. It is here too that the highest counts have been noted. Several Island Council and government workers on the island pointed out that outbreaks in ciguatera fish poisoning have been localized and could be attributed directly or indirectly to coral communities and reef disturbance, for example, channel blasting and dredging. It is very unlikely that the high number of recorded cases for one particular year (1996) may have been the work of medical officers who were not familiar with ciguatera symptoms.

As far as the favored hosts is concerned, the 3 dinoflagellates have been found in various algae. There had not been any reports claiming any particular algae as the favored host throughout the tropical region. In the same manner *Gambierdiscus toxicus* has been implicated in many reports as the principal toxin in ciguatoxin but *Prorocentrum lima* has also been suspected as one of the potential precursors in the toxin make-up with *Ostreopsis siamensis* to a lesser extent. The mystery surrounding ciguatera is still unresolved and not fully understood.

Whichever dinoflagellate(s) is/are responsible for ciguatera is not a real issue. The real issue is that all reefs in the tropical Pacific have the potential to become toxic. As rule of thumb in all biological processes, any system is in equilibrium and if this equilibrium is offset then other things are bound to happen. In any reef system, a population of any of these dinoflagellates has to match the amount of space available, the amount of food required, and all other requirements. If a reef is blasted, huge junks broken into smaller pebbles will increase the amount of surface area many folds. The population of that dinoflagellate will also increase many fold, thus the suspected toxin(s). Herbivorous fish will increase their intake of the algae and of the dinoflagellate and its toxin. The level of the toxin(s) in the herbivorous fish also increases and more toxin is passed on to other fish in the food chain. Finally it reaches man.

Protecting a fishery from ciguatera poisoning cannot be achieved unless specific measures are taken. These include, the ban of reef blasting and all other forms of human reef disturbance from the island, a regular check on the level of population of the presumed dinoflagellates, a regular check on the level of ciguatoxin in the fish caught from the island and a more accurate recording system pinpointing the actual symptoms associated with ciguatera. There is much concern over a number of "development" projects on the island. One of them is a reef blasting for boat and canoe channels. If these activities continue and carried are out on larger scales the problem of ciguatera on the island will become worse as is presently reported. Small commercial fisheries on the lagoon and reef fishes could also be jeopardized. The long and irreversible adverse impact on the social, economic and health status on the island and the neighboring island, Tarawa, will be felt. This cannot be compromised.

5.0 Bibliography

Gillie, R.D., 1993. Coastal erosion problems in the Gilbert Islands group, Republic of Kiribati. South Pacific Applied Geoscience Commision (SOPAC) Technical Report 167. 74 pp.

Hydrographer of the Navy, UK, 1992. *Admiralty Tide Tables and Tidal Stream Tables, Vol. 3, Pacific Ocean and Adjacent Seas.*

Ichinotsubo, D., Asashina, A. Y., Titus, E., Chun, S., Hong, T.-L. W.P., Shirai, J.L., and Hokama, Y. 1994 Survey for ciguatera fish poisoning in west Hawaii. Memoirs of the Queensland Museum, Vol. 34, Part 3. Merino Lithographics, Queensland.

Juranovic L.R. and Park D.L., 1991. Foodborne Toxins of Marine Origin: Ciguatera. Reviews of Environment Contamination and Toxicology, Vol.117. Springer-Verlag New York Inc. 44pp.

Marriott S.P., and Dally B.G., 1980. Some observations on ciguatera studies on Tarawa Atoll. SPC/Fisheries 12/WP 14, October 30.

Meteorological Office, Republic of Kiribati, 1999. Temperature and rainfall records for the Gilbert group, 1996-1998.

Pearson, M., 1999. Kiribati: NASA. Geographical location of Kiribati.

Ruff T.A., 1989. Ciguatera in the pacific: A link with military activities. In: Lancent: Environmental Health, January 28, pp 201-206.

Tebano T. and Lewis R.,1990. Ciguatera Fish Poisoning and Reef disturbance. Observation on ciguatoxin level in reef fishes at Nei Tebaa channel, Dai Nippon Causeway, South Tarawa, Kiribati. Prepared for the Ministry of Health and Family Planning, Ministry of Natural Resource and Development and Ministry of Communication, Government of Republic of Kiribati. 18pp.

Tebano T. and MacCarthy D., 1991. Ciguatera fish poisoning and the presumed causative organism in the Gilbert Islands, Kiribati. University of the South Pacific Publication, 86pp.

Tebano T., 1984. Population Density study on a toxic Dinoflagellate responsible for fish poisoning on South Tarawa Atoll, Republic of Kiribati. Atoll Research and Development Unit. University of the South Pacific Publication. 46pp.

Tebano, T., 1985. Atoll Environment in Kiribati: A geography book on Kiribati. Atoll Research and Development Unit, University of the South Pacific, Tarawa, Kiribati. 30 pp.

Tebano, T., 1990. Some aspects of the biology and ecology of the cockle *Anadara maculosa* in the Gilbert Island, Kiribati. MSc thesis, James Cook University of North Queensland, Australia. 206 pp.

Tebano. T., 1991 Ciguatera Fish Poisoning and the causative organism in the Gilbert Islands, Kiribati. Institute of Marine Resource. Suva Fiji.

Woodroffe, C.D. and McLean, R.F., 1992. Kiribati vulnerability to accelerated sea level rise: a preliminary study based upon research and field visit funded by Department of Arts, Sports, Environment and Territories, Government of Australia. 82 pp.

Yasumoto T., Fujimoto K., Oshima Y., Inoue A., Ochi T., Adachi R., and Fukuyo, 1980. Ecological and Distributional Studies on a toxic Dinoflagellate Responsible for Ciguatera. Report to the Ministry of Education, in Aid for Overseas Scientific Survey No. 304109 and 404308. 50pp.

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