Distribution of a Toxic Dinoflagellate, *Gambierdiscus toxicus*, in French Polynesia

Akio INOUE*

Abstract

The distribution of *Gambierdiscus toxicus*, a toxic dinoflagellate responsible for ciguatera intoxication, was extensively investigated in several islands of French Polynesia. This unicellular alga was found to be widely distributed in the above mentioned region. The results obtained here suggest the possibility of a bloom anywhere in the study area that could cause serious problems for the inhabitants when circumstances become favorable for its rapid and mass growth.

Introduction

An epibenthic dinoflagellate, *Gambierdiscus toxicus*, is attributed to the causative organism responsible for ciguatera, which is a low motality fish poisoning common in tropical and sub-tropical regions[1]. This disk-shaped unicellular alga was found in the biodetritus of dead corals collected around Mangareva, Gambier Islands located at the east end of French Polynesia[2] and was designated as a new genus[3]. The toxin production by the organism was confirmed by its uni-algal and axenic culture[4]. The dinoflagellate was usually found to inhabit the surface of bottom substrates such as benthic macro-algae, dead corals, sands, and rocks, and rarely swims in the water in normal circusmstances. Among algae, *Jania* sp., a tufted red algae, and *Turbinaria ornata*, a brown alga, were preferable substrates. The number of *G. toxicus* cells inhabiting 1 gram of substrate macro-algae sometimes surpassed 400,000 in densely populated areas and no fish could be consumed without risk of intoxication[5].

The peculiar living pattern of *G. toxicus* in the marine environment suggested us a simple and accurate method to determine its population density[5]. Adopting this method the population was surveyed in Tahiti and other islands in French Polynesia previously. In these ecological surveys several aspects on the distribution of *G. toxicus* were discovered and the distribution patterns agree well with the results of epidemiological surveys carried out in the past. Periodic observations showed that the population could fluctuate significantly during a period of a few days. There was a distinct regional variation even within a small locality. More abundant populations were noted on reefs than in lagoons, and more in the channels of fringing reefs than in stagnant areas. Therefore when precise information is required on the distribution of *G. toxicus*, carefull attention must be paid to the sampling process.

*井上晃男，鹿児島大学南方海域研究センター
Kagoshima University Research Center for the South Pacific, 21-24, Korimoto 1-Chome, Kagoshima 890, JAPAN

In this report the author compares results obtained in previous research projects with the present on the distribution and population of *G. toxicus* and some other dinoflagellates in French Polynesia in order to confirm the growth of the toxic dinoflagellates and to minimize the occurrence of poisoning among the people in the region. This report also deals with the results in the several islands and localities where the observations were not done before to get the informations on the existence of *G. toxicus* and to inform the possiblity of the induction of ciguatera intoxication in future.

The method for the ecological survey of *G. toxicus* reported previously[6] was adopted here without any further modifications. A suitable amount (100-200 g ; wet basis) of the benthic macro-algae was contained in a plastic bag with about 300 ml of sea water. The bag was shaken vigorously for 2-3 min. The suspension was passed successively through sieves with mesh sizes of 250 μm and 37 μm in this order. The residue retained on the smaller pore-sized sieve was transferred to a vial and diluted to 25 ml with sea water. A 0.5 ml portion of the suspension was placed on a glass microscope slide fitted with a frame capable of holding 1 ml of the suspension. The suspension was then diluted to 1 ml with filtered sea water and the total number of *G. toxicus* and some other dinoflagellates were counted under microscope. The microscopic observation was repeated at least three times in the same way with another 0.5 ml samples of the suspension. When no *G. toxicus* were detected in 5 ml suspensions, the author determined that no dinoflagellates were present in this sample. The population density of the dinoflagellates were generally expressed in terms of the number of cells contained in 1 g of the algal sample. When the number of dinoflagellates was not so high, the density was calculated by the number of the cells in 100 g of the sample instead. Prolonged periods of storage resulted in a decrease in the number of dinoflagellates and therefore all the procedures for this survey except microscopic observations were conducted at the sample colletction sites.

A brown alga, *T. ornata,* the most common species in the shallow waters of the tropical region, was found to be one of the most favorable substrates for *G. toxicus.* Therefore the author selected this alga as a test substrate throughout the survey if available. When unavailable, a red calcareous alga, *Jania* sp., was used instead. If both of these species were not easily found other algae were used. The sample algae were collected in about 2×2 m area from as many individual plants as possible to obtain the most representative sample.

As seen in the Tables, the survey had been carried out for one year from May, 1981 to March, 1982. Some environmental factors such as pH, salininity, temperature, volume of suspended particulate matters and several inorganic nutrients were also measured. These results will be reported separately.

Results and Discussions

The distribution of *G. toxicus* and some other dinoflagellates were investigated in Tahiti, Moorea, Tetiaroa, Huahine, and Bora Bora of the Society Islands ; Mataiva and Mururoa of the Tuamoto Islands ; and Mangareva of the Gambier Islands, all in French Polynesia. Among these eight islands more extensive surveys were carried out in the

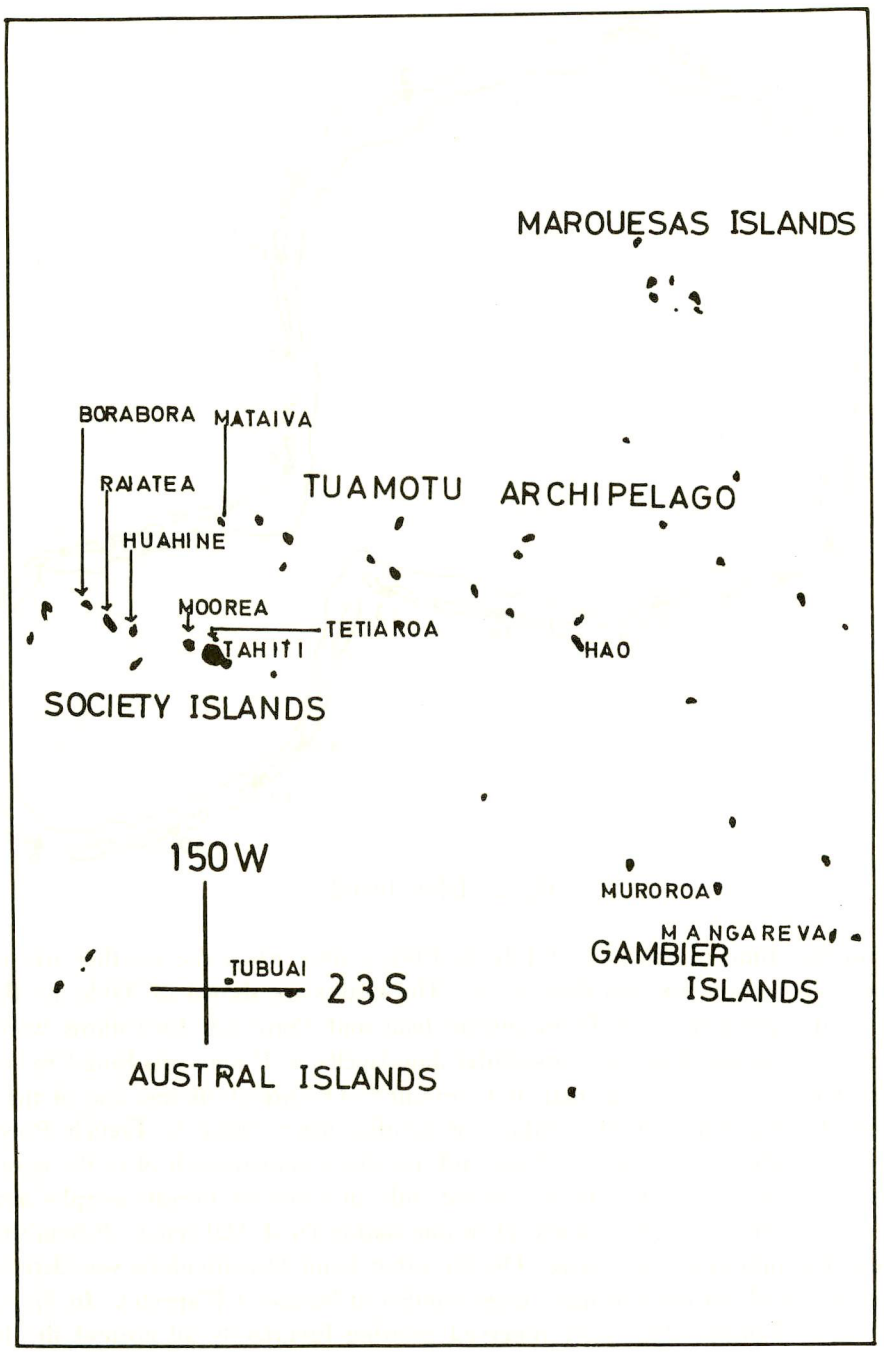

Fig. 1 French Polynesia

three islands of Tahiti, Mangareva, and Mataiva.

TAHITI ISLAND Twenty sampling stations, mostly at the channels of barrier reefs surrounding the island, were established as indicated in Fig. 2. The results obtained in the 1978 investigation have already been reported[6]. Some sampling stations in the present study coincide with those in the previous survey. The investigation was carried

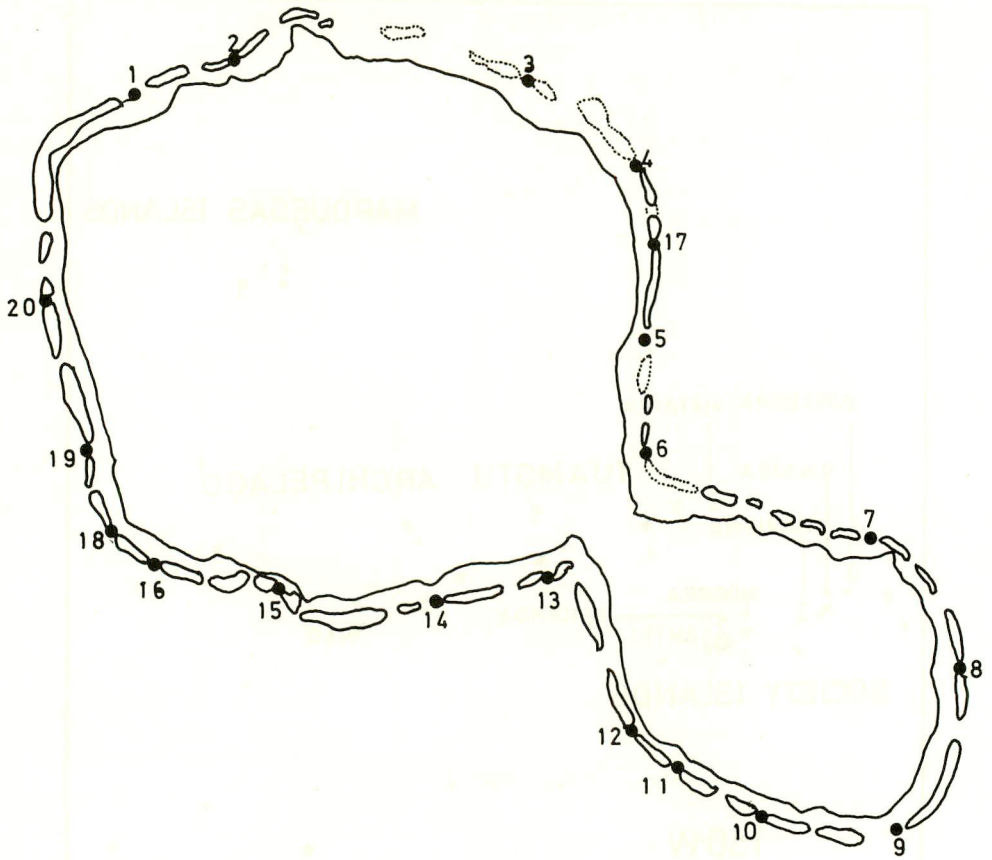

Fig. 2 Tahiti Island

out from late June to the end of July in 1981, a time when the weather was cooler and the precipitation was less than usual. The results are shown in Table 1. Besides *G. toxicus* the population of *Prorocentrum lima* and *Ostreopsis lenticularis* were also investigated. Among these two unicellular dinoflagellates, *P. lima* was found to contain a different kind of toxin from that of *G. toxicus*[7]. *O. lenticularis* was one of the most common dinoflagellates on the surface of benthic macro-algae in French Polynesia, and is very similar to *G. toxicus* in shape and size which sometimes lead to the confusion of these two species. *G. toxicus* was found only in seven of twenty samples and the population density was very low except in one station (St. 4, Mahaena). *P. lima* showed a similar distribution to *G. toxicus*. On the other hand *O. lenticularis* was detected in most samples with an extraordinary large number at Station 1 (Papeete). In the survey period macro-benthic algae were observed growing luxuriantly all around the Island. Some floating algae mainly composed of *Sargassum* sp. was noticed and when the same assay method was applied to these algal flocculations, *G. toxicus* were found. This fact suggests that the dinoflagellate can be conveyed to distant places in this manner. The number of dinoflagellates has generally decreased since the last survey in this island. In some reputed toxic areas where no fishes had actually been served as food for several years the inhabitants have started to eat fish with little or no trouble. But it is well known that environmental changes in the coral reef ecosystem often ignite

Table 1. Distribution of *G. toxicus* in Tahiti

Sampling Station	Date of Sampling	Substrate	No* of *G. toxicus*	No.* of other spp.	
				*O. lent.***	*P. lima****
1	July 27, '81	*T. ornata*	0	223,000	0
2	June 24, '81	〃	49	3,000	0
3	June 16, '81	〃	0	2,400	180
4	June 18, '81	*Jania* sp.	5,100	80	80
5	June 18, '81	*T. ornata*	0	60	0
6	July 8, '81	〃	0	120	0
7	July 8, '81	〃	75	0	75
8	July 9, '81	〃	50	250	1,100
9	July 9, '81	〃	0	800	0
10	July 21, '81	〃	120	1,000	0
11	July 21, '81	〃	0	600	0
12	July 21, '81	〃	0	1,100	0
13	July 21, '81	〃	60	370	0
14	July 2, '81	〃	0	50	60
15	July 2, '81	〃	0	0	0
16	July 1, '81	〃	0	50	0
17	July 21, '81	*Jania* sp.	70	70	50
18	July 1, '81	*T. ornata*	0	7,700	0
19	July 1, '81	〃	0	4,900	0
20	June 23, '81	〃	0	130	0

*No. of cells per 100 g of substrate algae
**Ostreopsis lenticularis*
***Prorocentrum lima*

outbursts of ciguatera intoxication. Though the population densities of *G. toxicus* are very low at present in Tahiti, we must not neglect to carefully monitor the area in order to prevent or minimize the intoxications. Ciguatera symptoms, described in some papers[8,9] are still found among people in the area because they dared to take fishes and other marine animals for foods even in the vicinities densely populated by the dinoflagellates. Frequent observations are required.

MANGAREVA ISLAND This island is located at the east end of French Polynesia being about 1,000 km distant from Tahiti and near the Tropic Capricorn. When compared to other islands investigated in this survey, this island is characterized by cooler water temperature, below 23 C in the cold season. Some environmental factors of this island had been reported previously. It was also shown that most benthic algae growing here harboured dense populations of *G. toxicus*. *Jania* sp. was selected as a substrate algae for the dinoflagellate because of the unavailability of *T. ornata*. In the first survey of 1977, *Jania* sp. or other calcareous red algae was found to flourish on decayed corals. This time the author observed that all the corals were growing well and it was rather difficult to get *Jania* samples in the areas where such algae as Padina, Hypnea, and mixtures of various algae were taken as substrate algae. The locations of the sampling stations and results are displayed in Fig. 3 and Table 2 respectively.

The regional distribution of *G. toxicus* seems to have changed completely since the last survey. The highest density was 24,800 cells per 1 g of substrate alga at Station 7.

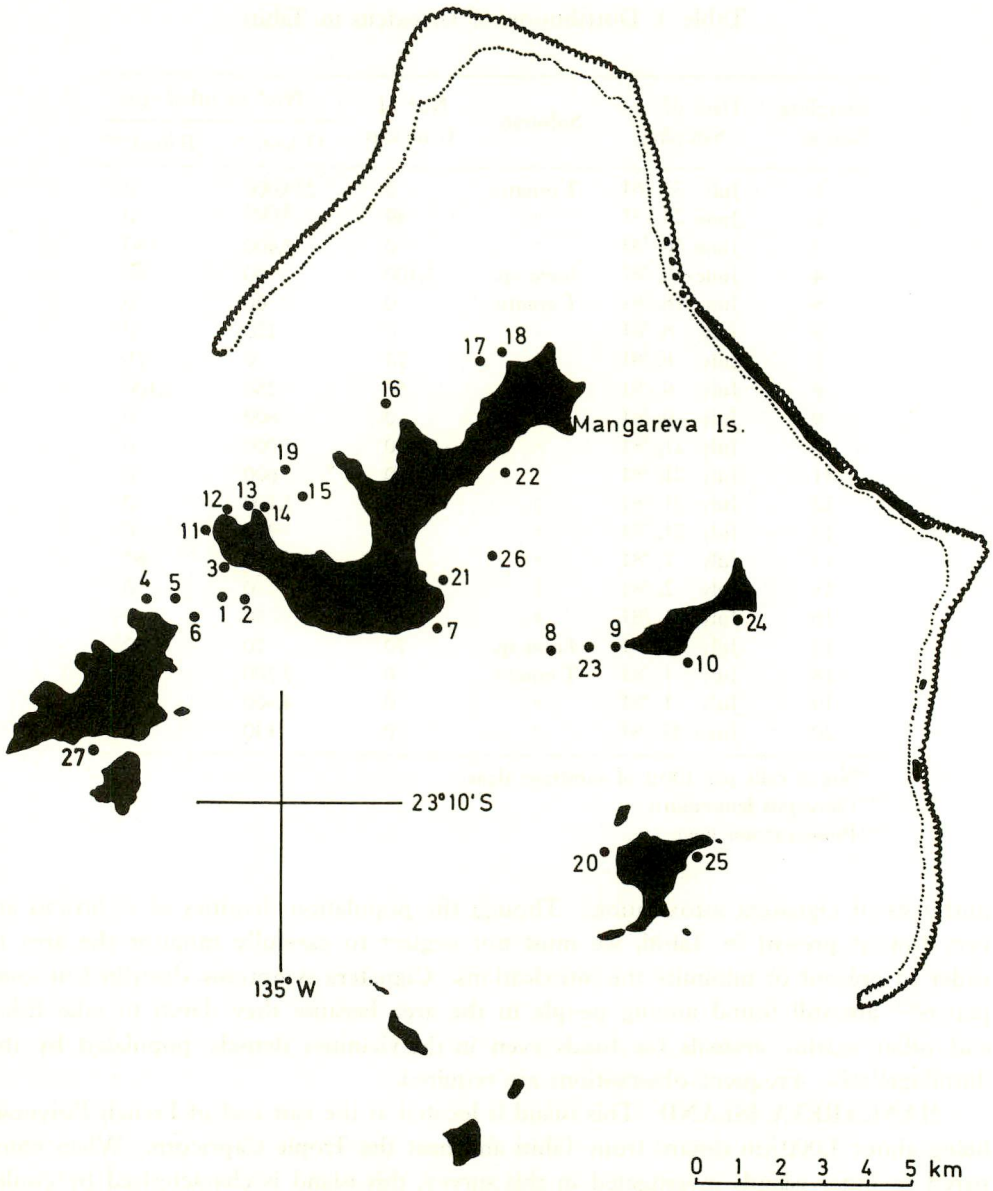

Fig. 3 Gambier Islands

This number is extraordinary large when compared to the results obtained at other islands. Exceptionally high densities had been recorded in 1977 at Stations 15 and 19 having values of about 400,000 and 200,000 respectively[5]. Now the most densely populated area has moved East, i. e., to Aukena Island. The densities of the dinoflagellate decreased conspicuously during the past five years. This phenomena was commonly recognized throughout the stations and bore a resemblance to the Tahiti Island. Since the beginning of the 1970's, people had stopped consuming fish caught around Mangareva Island as food. But they commenced to eat fish with little problems especially around Stations 3, 14 and 15.

Table 2. Distribution of *G. toxicus* in Mangareva

Sampling Station	Date of Sampling	Depth (m)	Substrate (Sp. of alga)	No.* of *G. toxicus*
1	Feb. 4, '82	5	*Jania* sp.	880
2	〃	5	〃	160
3	〃	2	*Padina* sp.	0
4	Feb. 5, '82	5	*Jania* sp.	110
5	〃	2	〃	390
6	〃	4	〃	130
7	〃	2	〃	24,800
8	Feb. 6, '82	2	*Hypnea* sp.	1,200
9	〃	2	〃	40
10	〃	3	〃	320
11	〃	3	〃	510
12	Feb. 7, '82	2	*Jania* sp.	1,600
13	〃	2	〃	7,200
14	〃	4	〃	0
15	〃	3	〃	30
16	Feb. 8, '82	1	〃	70
17	〃	1	Mix. Alg.**	0
18	〃	1	〃	0
19	〃	5	*Padina* sp.	600
20	Feb. 9, '82	2	*Jania* sp.	1,500
21	〃	1	Mix. Alg.	30
22	〃	1	*Jania* sp.	50
23	〃	2	〃	10
24	〃	2	〃	900
25	〃	2	〃	2,900
26	〃	2	Mix. Alg.	1,800
27	Feb. 5, '82	2	*Jania* sp.	0

*No. of cells per 1 g of substrate algae
**Mixed red algae. Species unknown.

MATAIVA ISLAND Mataiva is an atoll as seen in Fig. 4. The water exchange between lagoon and outside ocean occurs through only several channels. Phosphurous mining was taking place around Stations 10 and 11 and inorganic phosphates in the water was ten times as high as shore waters of other regions. At the beginning of 1981, some workers were intoxicated by fish caught in the lagoon. The survey in this island was carried out in April. Twenty stations were placed both inside and outside of the lagoon. Most places were of sandy bottom. Benthic algal growth was very poor at all stations. The largest number of the dinoflagellate, about 2,500 cells/g of substrate algae, was found at Stations 12 and 15. The organism was distributed rather evenly within the lagoon at comparatively low population densities. No direct correlation was recognized between the quantity of inorganic phosphate and the number of *G. toxicus*. Periodical surveys conducted in this island showed little fluctuation until the end of 1982.

OTHER ISLANDS Sampling stations at each island are shown in Fig. 5 to 8. The results are summarized in Table 4. The assay samples in the Tetiaroa Island were collected near the airports on the fringing reef. The samples from Mururoa had been sent to the author for testing and the sampling sites were not mentioned precisely.

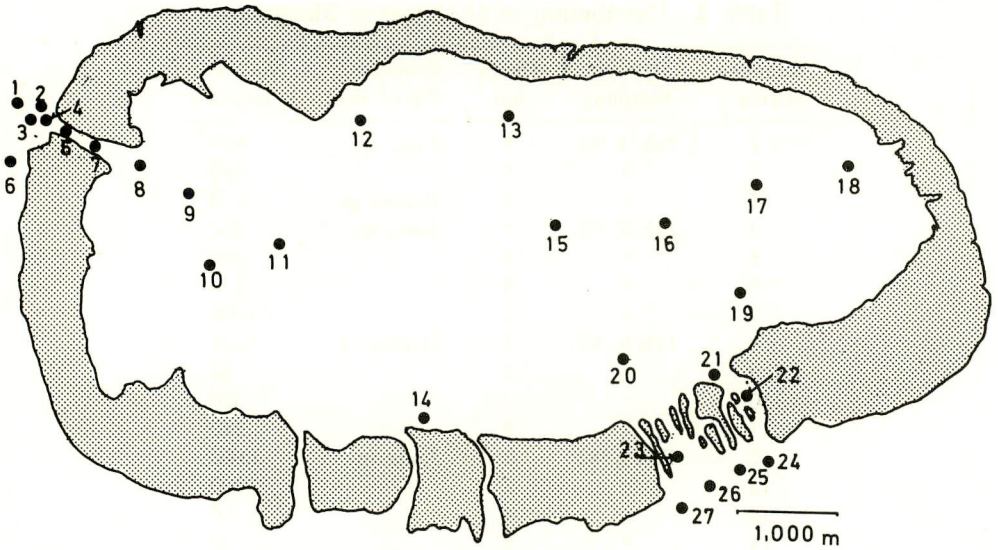

Fig. 4 Mataiva Atoll

Table 3. Distribution of *G. toxicus* in Mataiva Atoll

Sampling Station	Substrate	Number of Cells*** *G. toxicus*	*O. lent.*	*P. lima*
1	Mix. Alg.*	60	0	30
2	*Gelidium* sp.	250	0	0
3	〃	750	0	0
4	*Halimeda* sp.	0	0	0
5	Mix. Alg.	490	0	0
6	*Halimeda* sp.	230	0	0
7	〃	250	30	30
8	〃	280	0	0
9	〃	0	0	0
10	Mix. Alg.	0	0	90
11	〃	100	50	50
12	〃	2,500	330	330
13	〃	50	0	0
14	〃	520	0	70
15	〃	2,800	0	750
16	*Halimeda* sp.	0	0	0
17	Mix. Alg.	0	0	0
18	*Halimeda* sp.	0	0	0
19	Mix. Alg.	390	0	0
20	*Halimeda* sp.	0	0	0
21	*Microd. agard.***	0	0	170
22	*Halophila* sp.	0	0	0
23	〃	0	0	0
24	Mix. Alg.	310	0	150
25	*Jania* sp.	0	0	0
26	Mix. Alg.	180	0	0
27	〃	0	0	0

*Mixed algae
**_Microdydron agardhianum_
***No. of cells per 100 g of algae

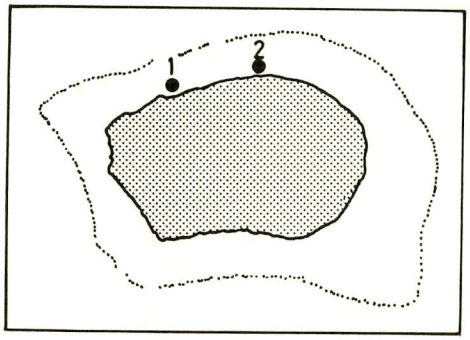

Fig. 5 Tubuai Island

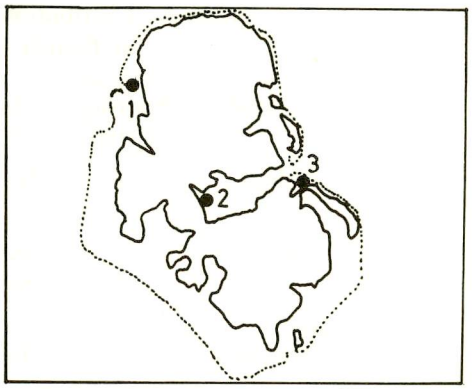

Fig. 6 Huahine Island

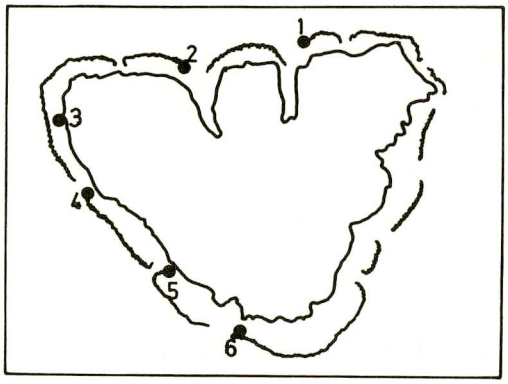

Fig. 7 Moorea Island

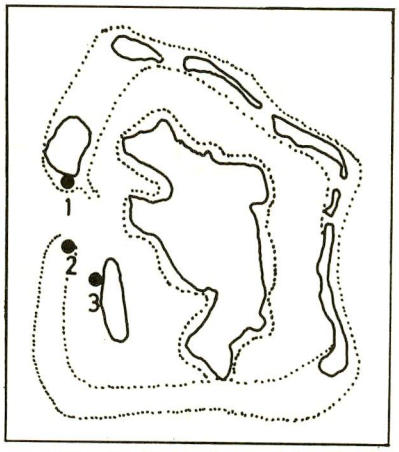

Fig. 8 Bora Bora Island

G. toxicus was found in at least one sample from every island. An extraordinary dense population was found at Mururoa Island. As far as investigated in French Polynesia, the dinoflagellate was found in every island with varying degrees of population densities. This would indicate that all the areas are potentially toxic, and moritoring the growth of *G. toxicus* and other species is essential in order to reduce incidences of poisoning in this region.

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Table 4. Distribution of *G. toxicus* in some islands of French Polynesia

Island	Sampling Stations	Date of Sampling	Substrate	No.* of *G. toxicus*
Tubuai	1	Jan. 2, '82	*T. ornata*	90
	2	〃	〃	60
Huahine	1	May 2, '81	*T. ornata*	190
	2	May 3, '81	〃	0
	3	〃	〃	100
Moorea	1	Aug. 15, '81	*T. ornata*	70
	2	〃	〃	30
	3	〃	〃	0
	4	〃	〃	0
	5	〃	*Boodlea*	790
	6	〃	*Colpomenia* sp.	810
Mururoa	1	May 16, '81	Mix. Alg.	162,700
	2	〃	*Jania* sp.	480
Tetiaroa	1	Sep. 26, '81	*T. ornata*	0
	2	Sep. 27, '81	〃	1,800
Bora Bora	1	Sep. 12, '81	*T. ornata*	190
	2	〃	*Jania* sp.	0
	3	〃	*T. ornata*	2,500

*No. of cells per 100 g of substrate algae

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