

TESTIMONY ON PRIVATE MARINAS, June 25, 1991

As Wai'anae is a taro-planting and fishing community, we are concerned that the public be made aware of the full picture about ciguatera fish poisoning. Several years ago during the controversy over building a pilot OTEC plant on the Wai'anae coast, state health officials told us that ciguatera levels in Wai'anae were rising.

Ciguatera is a type of fish poisoning caused by eating local fish that have fed on dead or damaged coral. The SPC's (South Pacific Commission) 1973 report on 'Fish Poisoning' summarized the first world meeting on this topic held in Tahiti in 1968. It was felt at that time that outbreaks could be caused by "major works such as dredging, improvement of harbour channels, breakwater building, dumping of materials and where sewers are discharged into the sea. In some areas, there was a definite causation relationship between the incidence of fish poisoning and the increase in human interference with the marine environment. In other areas, ciguateric endemicity was not influenced" (p.13). Note that Wai'anae's sewage treatment plant is only on a primary level. A study by J.E. Randal, says the SPC, pinpoints in particular "dredging operations, blasting, shipwrecks, earth tremors, storms...changes in local hydrodynamics, and of pollutions of telluric or chemical origin which are discharged into the lagoons" (SPC,p.17).

The Commission advises against "discharging waste near the usual fishing grounds...[and] dumping obsolete or damaged equipment in the lagoons or near the reef barriers" (p. 23).

Secondly, a 1990 Greenpeace International report, "Testimonies: Witnesses of French nuclear in the South Pacific" also found many confirmed cases of ciguatera, and concluded that this likewise was caused by "human activities such as construction work, explosions and dredging" (p.18)

The group uses a 1989 study by Tilman Ruff: 'Fish poisoning in the Pacific: a link with military activities,' to complement the interviews.

It was found that for "the period 1973-87 rates of ciguatera were more than three times the South Pacific average in French Polynesia and the Marshall Islands" (p.18) where the U.S. also conducted nuclear tests. "Abortion, premature labour and neurological disease in the newborn," adds Ruff, may result if one eats the ciguatera-tainted fish during pregnancy. "And the disease may be transmitted by breast-feeding" (p.18)

1968 was a milestone year, as the Gambier Islands just east of the Tuamotu group where the N-tests are held (Tahiti is just to the west of the site) experienced an explosion of ciguatera. "The highest density of Gambierdiscus toxicus ever recorded in scientific literature was recorded in 1978 at the main island of Mangareva--over 5 x 1,000,000 cells per gram of algal sample. The 1968 outbreak," maintains Greenpeace, "provides the best documented example of the association between extensive death of corals and ciguatera. Construction activities began in 1967" which included a desalination plant, hangars, a helipad, an airfield, etc. "Between 1960 and 1984, each of the 500-600 inhabitants has, on average, had documented ciguatera more than four times" (p.47) [Ruff p. 12-13].

Lifestyle can be impacted. Lost man-hours from this illness has been estimated in value at US\$4 million per year in French Polynesia. Diets may change from the fear of eating poisoned fish. Undernutrition, for children especially, can result from the shift to imported foods which can lead to "a diet with more salt, fat and [refined] carbohydrates and subsequent increase in chronic diseases such as diabetes, hypertension and heart disease." (p.54) [Ruff p. 21]. Lastly, the report found that in at least one atoll near the test site, it was "previously free of the disease" (p.57) [Ruff p. 11].

Immediate action is needed, legislatively, or otherwise.

Mahalo a nui loa.

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(note: quoted passages are underlined)

CIGUATERA: 2 reports

1. Bagnis, Dr. R., 'Fish Poisoning in the South Pacific,' South Pacific Commission, Noumea, 1973 (report summarizing the first world meeting on this topic held in Tahiti in 1968).

"The human impact. In some islands and atolls, outbreaks of ichthyosarcotoxism broke out or occurred again two or three years after a start was made on major works such as dredging, improvement of harbour channels, breakwater building, dumping of materials and where sewers are discharged into the sea. In some areas, there was a definite causation relationship between the incidence of fish poisoning and the increase in human interference with the marine environment. In other areas, ciguateric endemicity was not influenced' (p.13).

"Synthesis. According to J.E. Randal, the first toxic micro-organisms (algae, fungi or bacteria) grow and multiply on newly exposed surfaces resulting from a local disturbance in marine environment. In this connection, special mention must be made of natural or artificial disturbances of submarine surfaces (dredging operations, blasting, shipwrecks, earth tremors, storms), of changes in local hydrodynamics, and of pollutions of telluric or chemical origin which are discharged into the lagoons" (p.17).

"Predisposing factors. Because of the many unknown pathogenic aspects of ichthyosarcotoxism, and in view of empirical considerations, in a coral environment it is advisable to refrain from:

- discharging waste near the usual fishing grounds;
- dumping obsolete or damaged equipment in the lagoons or near the reef barriers;
- fishing near wrecks, near the unloading points of fishing boats on the outer reefs or those fringing the atolls, near places where in the preceding two or three years underwater works have been carried out or where old scrap iron has been dumped.

To sum up, it must always be born in mind that areas near villages which have had a major population expansion and where human interference with the sea has suddenly increased considerably, can become ideal ground for the outbreak or renewed occurrence of ichthyosarcotoxism (p.23)."

(note: underlinings are mine)

2. Greenpeace International (August 1990), 'Testimonies: Witnesses of French nuclear testing in the South Pacific.' (Interviews collected by Dr. Andy Biedermann for Greenpeace in 1987. Design-production by Paradigm, Auckland, Aotearoa (N.Z.).

author cited

(Tilman Ruff (1989), 'Fish poisoning in the Pacific: a link with military activities.' Working Paper No. 63, Peace Research Centre, Australian National University, Canberra, Australia)

"Eating fish at Moruroa was banned in June 1966, after the first test...The majority of fish poisoning cases reported in French Polynesia are from ciguatera, Ciguatera fish poisoning is caused by eating tropical fish that have fed on a particular algae which grows on dead or damaged coral. The dinoflagellate organism, Gambierdiscus toxicus, which causes ciguatera, is named after the Gambier Islands where there was a serious ciguatera outbreak in 1968. Ciguatera outbreaks are linked to natural ecological disturbances such as storms, earthquakes and tidal waves, and to human activities such as construction work, explosions and dredging.

"Severe outbreaks of ciguatera have followed military activity and nuclear testing in the Marshall Islands. For the period 1973-87 rates of ciguatera were more than three times the South Pacific average in French Polynesia and the Marshall Islands. After the French military began conversion of the Hao atoll in the Tuamotu group as a staging base for Moruroa and Fangataufa, an outbreak of ciguatera occurred. By mid-1968 forty-three percent of the population of Hao had been affected by ciguatera. Moruroa has had a high incidence of ciguatera over the past two decades, during which time there has been extensive coral damage caused by the building of military infrastructure and the nuclear test explosions themselves. The only reported study of whether ciguatera is related to radioactivity was conducted over 30 years ago by the U.S. Atomic Energy Commission; no correlation was found, but the link deserves further study.

Ciguatera symptoms include....Ciguatera during pregnancy may result in abortion, premature labour and neurological disease in the newborn, and the disease may be transmitted by breast-feeding" (p.18) [Ruff, p. 3,5,22].

"In a Japanese survey of ciguatera poison distribution in French Polynesia in 1981-2, the highest densities were found in samples from the Gambiers and from Moruroa" (p.22).

"The Gambier Islands consist of four high islands and a few atolls. They were once an independent entity within French Polynesia with their own flag. This status no longer exists, and none of the Gambier Islands are inhabited except for Mangareva which now has a population of 500.

"...Ciguatera has occurred throughout the Pacific, but there was a massive outbreak in the Gambiers in 1968, probably connected with French military activity which damaged reefs in the lagoon. Overall, rates more than three times the regional average were recorded in French Polynesia in 1973-87, with 24,000 reported cases. The SPC estimates that the official statistics reflect only 10-20% of cases' (p.43) [Ruff, p. 4, 16-17].

"Ciguatera is occasionally fatal (around 0.2 percent in the largest documented series of 12,890 cases in French Polynesia). The highest density of Gambierdiscus toxicus ever recorded in scientific literature was recorded in 1978 at the main island of Mangareva--over 5 x 1,000,000 cells per gram of algal sample. The 1968 outbreak provides the best documented example of the association between extensive death of corals and ciguatera. Construction activities began in 1967 on the island of Totegegie, including extensive land clearing, installation of four generators, construction of a desalination plant and water reservoir, eight radio and meteorological buildings, four workshop and storage hangars, a launch tower for meteorological balloons, nine buildings for living quarters, three large platforms, including a helipad, a radiation monitoring station and an airfield. In the lagoon a large concrete jetty was built, channels were dredged and 48 support blocks for antennae were put in (Le Journal de Tahiti, March 18 1969). Visits of warships to Mangareva were frequent, either to load fresh fruits and vegetables, or to be washed down with sea water in the lagoon after watching an atmospheric test.

Between 1971 and 1980, the incidence of ciguatera in the Gambiers did not go below 30 percent, peaking at 56 percent in 1975. Between 1960 and 1984, each of the 500-600 inhabitants has, on average, had documented ciguatera more than four times" (p.47) [Ruff p. 12-13].

"[Ciguatera] has had dramatic effects on the life-style of Polynesians for whom fish may be sometimes the only animal protein source. The need to avoid fish after an outbreak may exacerbate undernutrition, especially among children; fear of poisoning increases dependence on imported food which can lead to a diet with more salt, fat and complex carbohydrates and subsequent increase in chronic diseases such as diabetes, hypertension and heart disease. R. Bagnis has estimated that

the annual cost of paid work-time lost as a result of ciguatera poisoning in French Polynesia was around US \$4 million per year" (p.54) [Ruff p. 21].

[interview]

"'Fish poisoning had never been heard of before.' (interview of 'Roland, a gendarme, [who] was sent to Mangareva in 1963 and stayed there until the beginning of 1968')" (p.54).

[interview]

"'There was no fish poisoning on Hao when I was a child. It started at the time the French military arrived and began their activities in and around the lagoon' (interview of 'Mahinui [whose] father was born on Hao which is now the main French military base in French Polynesia')" (p. 57).

"The first case of ciguatera ever reported from Hao involved fish caught in August 1966 at the site where French landing craft originally landed. The first fish to become toxic were herbivores but by April 1968 sufficient toxins had moved up the food chain for carnivores to cause poisoning. In mid-1968 R. Bagnis completed a survey of medical records and a house-to-house survey and found an incidence of ciguatera of 43 percent of the population of 650, on an atoll previously free of the disease" (p.57) [Ruff p. 11].

"Ciguatera incidence between 1960 and 1984 in the Tuamotu Archipelago averaged 1,700 cases per 100,000 every year" (p.61) [Ruff p. 17].

**FISH POISONING  
IN THE  
SOUTH PACIFIC**

**L'ICHTYOSARCOTOXISME  
DANS LE  
PACIFIQUE SUD**

by

par le

**Dr R. Bagnis**

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SOUTH PACIFIC COMMISSION  
NOUMEA, NEW CALEDONIA

COMMISSION DU PACIFIQUE SUD  
NOUMEA, NOUVELLE-CALEDONIE

(1973)

*Ichthyosarcotoxisme = fish with poison*  
*Ichthyo = fish*  
*Sarco = flesh*  
*Toxisme = poison*  
**PREFACE**

Ichthyosarcotoxism is a public health problem in the South Pacific. Usually hospital statistics only record the most serious cases and do not reflect its true extent. However, surveys have shown that nearly 10 per cent of the population of some territories suffer from permanent effects of poisoning by toxic fish. This illness causes absenteeism damaging to the economy of the region. No canning factories for lagoon fish can be set up. As the dread of fish poisoning limits consumption, it contributes to deficiencies in people's diet.

It was therefore essential that the South Pacific Commission should tackle this problem. This it has done from its very early days by collaborating with research workers in the territories, institutes such as ORSTOM,<sup>1</sup> Noumea; IRMPF,<sup>2</sup> Papeete; and with universities such as Loma Linda, California, and Hawaii.

The Commission has published or circulated articles and technical papers dealing with this problem and it has compiled data from replies to questionnaires sent to medical officers in the territories. It has contributed financially to surveys. In 1968 it organized, in Tahiti, the First International Seminar on Ichthyosarcotoxism.

The subject is included in the SPIFDA programme (South Pacific Islands Fisheries Development Agency, SPC/FAO/UNDP) which began to operate in 1969.

Of course, it would be simpler to say that nothing is known about ichthyosarcotoxism. Nothing is known of the origin of the toxin. Islanders, as well as Europeans, use haphazard methods of diagnosing fish toxicity (liver to the ants, silver pieces, etc.). Amateur therapists, because no specific drugs exist, continue to have recourse to local pharmacopoeia, with varying results. Indeed,

little is known when all the unknowns are compared with the few facts which have been scientifically proved.

Nevertheless, it was felt that these facts, such as they are, should be made available. They should at least do away with the false beliefs which are still rife in the islands in spite of the costly surveys carried out over some years.

The South Pacific Commission wishes to thank Dr. J. Saugrain, Director of the "Institut de Recherches Médicales Louis Malardé", in French Polynesia, for allowing Dr. R. Bagnis, Head of the Medical Oceanography Section of the Institute to write this Handbook which sums up present knowledge of ichthyosarcotoxism. It also wishes to thank Mr. V. T. Hinds, Fisheries Officer of the South Pacific Commission, Mr. J. A. Tubb, Manager of SPIFDA, Dr. A. Guinea, Medical Officer of the South Pacific Commission, and M. Fourmanoir, Marine Biologist, ORSTOM, Noumea, for preparing the nomenclature of fish which is annexed. The Commission is grateful to Dr. Serupepeli Lomani (Fiji) who was kind enough to check the English text.

In spite of the cost involved, it was felt essential to illustrate this Handbook with colour plates, obtained from the U.S. Government Printing Office, which have already appeared in "Poisonous and Venomous Marine Animals of the World" by B. Halstead (1965-1967).

The Commission hopes this will provide the health services personnel of the South Pacific region with a useful working tool which will enable them to help in solving some aspects of ichthyosarcotoxism which remain unclear.

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1. ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer).
2. IRMPF (Institut de Recherches Médicales Louis Malardé, Polynésie Française).



In a given species toxicity often depends on the size and weight of the fish. In some places, fishermen systematically discard groupers, merous, *C. undulatus*, barracudas and sea perches over 60 centimetres. Jacks are often considered dangerous for human consumption when they weigh more than six or seven kilos. The increase in toxicity with size is not as evident in surgeon fish, tetrodons, *clupeidae* and parrot fish, amongst others.

For a given fish, the viscera (the intestine, the nervous system, the ovaries, the liver) are often more harmful than the muscle, but the degree of toxicity varies according to species. In moray eels, groupers, merous and other trigger fish, the liver, in particular, is far more rich in poison than the muscle. The ovaries of tetrodons and similar fish have a highly dangerous concentration of toxins.

Lastly, all individuals of one species are not necessarily or equally toxic; but in a given batch of fish originating from any one place, the percentage of specimens harmful to man is not constant.

#### THE SEASON

During the spawning period, at the time of maximum gonad activity, the concentration of toxins seems to be greatest in the ovaries and the liver of tetrodons. This period of maximum sexual activity occurs in May and June in the South Japan islands. In the Pacific, with a few exceptions, spawning takes place in November/December.

Outbreaks of clupeoid poisoning are also seasonal. In Fiji, outbreaks occur mostly during the hot season when the shoals of sardines, herrings or mackerel come close to the coast in search of food.

In Polynesia, ciguatera outbreaks caused by various species occur throughout the year. Though surgeon fish are reputed locally to have a seasonal toxicity, this is not borne out by statistics.

#### THE TIME FACTOR

Fluctuations in intensity in time show clearly the cyclic character of the phenomenon and its evolution by periodic outbreaks whose frequency and seriousness vary.

Thus the endemic rate seems to have decreased during the last 20 or 30 years in some islands; it seems to be increasing in others, and to be stationary elsewhere.

#### THE HUMAN IMPACT

In some islands and atolls, outbreaks of ichthyosarcotoxism broke out or occurred again two or three years after a start was made on major works such as dredging, improvement of harbour channels, breakwater building, dumping of materials and where sewers are discharged into the sea. In some areas, there was a definite causation relationship between the incidence of fish poisoning and the increase in human interference with the marine environment. In other areas, ciguateric endemicity was not influenced.

#### THE SPECIES OF FISH IN AN AREA AT A GIVEN MOMENT OF THE EVOLUTION OF THE OUTBREAK

In a given area surgeon fishes and other fishes are the first to be affected in the ciguateric phenomenon. No carnivorous species is affected for at least several weeks. They become gradually toxic when a sufficient quantity of crude toxic product accumulates in their liver and muscles.

Yet, at a given time, in a given place, any species of benthic fish, herbivorous or carnivorous, may become a vector of ciguateric poisoning.

#### PREPARATION OF THE FISH FOR EATING

Cooking affects fish toxicity most when cooking tetrodon. Most cases of fish poisoning occur after ingestion of a fish soup of puffer fish (muscle, viscera and skin).

### Synthesis

According to J. E. Randall, the first toxic micro-organisms (algae, fungi or bacteria) grow and multiply on newly exposed surfaces resulting from a local disturbance in marine environment. In this connection, special mention must be made of natural or artificial disturbances of submarine surfaces (dredging operations, blasting, shipwrecks, earth tremors, storms), of changes in local hydrodynamics, and of pollutions of telluric or chemical origin which are discharged into the lagoons.

It would seem that the transfer of the toxin to the various centres of the nervous system occurs through the food chain: the first optional or obligatory links could be either invertebrates, herbivorous fish or coral-eating fish, which then become a prey for the carnivorous or omnivorous species. Man is poisoned by eating any one of the animal links in the toxic chain.

Furthermore, it should be noted that, as it passes through the various links of the ciguateric food chain, the fish may undergo chemical changes.

## 2. NATURE OF TOXIC COMPOUNDS AND PHARMACOLOGY

Various toxic compounds have been extracted from poisonous fish, but the only one which, up to now, has been purified and crystallized is the tetrodon toxin.

The tetrodon toxin has been found in all the tissues of poisonous fish but it is mostly concentrated in the gonads, the ovules, the liver and the gall bladder. It is soluble in water and alcohol. The

powder obtained by crystallization is white, insoluble in ether and ordinary organic solvents. When ingested by cats and administered intraperitoneally to mice it produces paralytic disorders similar to those which occur in man. It is a neurotoxin whose empirical chemical formula is  $C_{11}H_{17}N_3O_9 = YH_2O$ .

Ciguateric toxins seem more complex. A fat-soluble toxin called "ciguatoxin" has been found in the flesh and the liver of some groupers and moray eels; it probably plays a major rôle in the pathogenesis of the attack. The data from both the chemical and the spectral analysis show that it is a large molecule, extremely complex, containing lipids, hydrocarbons and amino moieties. The empirical formula of the muscular extract seems to be closer to  $C_{15}H_{45}NO_3$ ; that of the liver extract to  $C_{20}H_{35}N_7O_3$ . It seems that the action of these compounds is mainly cholinergic and leads to vagal hyperexcitation symptoms in man.

In most ciguateric fishes a water-soluble toxin has also been found in the liver and called "ciguaterin". Its pharmacological properties are at present being studied.

Other toxins have been extracted from the viscera of a trigger fish, the liver of a shark, the flesh of some barracuda and the skin of a bass. No investigations have yet been made on the toxin in *Clupeidae*.

The crude toxic product of whatever species is concerned seems to be resistant to boiling, to freezing at  $-20^{\circ}C$ , to dehydration and to lyophilization.

## V. PUBLIC HEALTH

### 1. GEOGRAPHICAL DISTRIBUTION

Ichthyosarcotism, in its widest meaning, is not an exclusive feature of tropical regions. Nevertheless, there is no doubt that this phenomenon finds the most suitable conditions to flourish in warm and hot waters, near rocky coasts, along coral reefs and in lagoons which are rich in madrepores. This is why it occurs principally within  $35^{\circ}$  of the equator

It is less prevalent near continents (Africa, America and Eurasia) and near large islands (Australia, Madagascar, Ceylon, Jamaica, etc.) than around the small high islands and atolls. Thus there is a tendency to consider ichthyosarcotism as a phenomenon which only affects insular regions.

At present, it seems that there are no toxic fish in the Mediterranean or

be prepared for eating according to the technique described above.

**Tuna and bonito must be refrigerated or consumed as quickly as possible** after the catch. If, when eaten, the flesh has a "sharp" or "peppered" taste, it must be discarded immediately.

#### **Predisposing factors**

Because of the many unknown pathogenic aspects of ichthyosarcotoxism, and in view of empirical considerations, in a coral environment it is advisable to refrain from:

- discharging waste near the usual fishing grounds;
- dumping obsolete or damaged equipment in the lagoons or near the reef barriers;
- fishing near wrecks, near the unloading points of fishing boats on the outer reefs or those fringing the atolls, near places where in the preceding two or three years underwater works have been

carried out or where old scrap iron has been dumped.

To sum up, it must always be borne in mind that areas near villages which have had a major population expansion and where human interference with the sea has suddenly increased considerably, can become ideal ground for the outbreak or renewed occurrence of ichthyosarcotoxism cases.

#### **Freshness**

Finally, it can never be stressed enough that fish must be eaten fresh or processed by proven refrigeration techniques. Indeed, many cases of food poisoning due to stale products have been wrongly attributed to ichthyosarcotoxism.

If all these methods and the advice given are followed, this will not necessarily afford full protection against ichthyosarcotoxism, but any cases which occur will be considerably less serious.

## **VI. CONCLUSIONS**

As the population of the world increases, the hunger problem in many countries of our planet will become more acute. Nearly two-thirds of the inhabitants of the globe are in desperate need of low-priced high-quality protein food products.

The oceans produce annually about four hundred million metric tons of animal proteins suitable for harvest and use by man. In one century the world catch of fish products, according to the latest FAO statistics, has increased from 1.5 million tons to nearly 60 million tons, of which more than 85% are fish. Yet, out of some 25,000 species recorded, only a minute quantity are fished commercially. In the Pacific, only a few species are caught in large quantity (tuna, bonito mostly). Others are fished but unexploited commercially (reef fish) and this at a time when the development of insular shore fisheries in the atolls is under consideration.

Yet, to the normal range of fish processing methods available until recently (mostly fresh, frozen, dried or canned fish)

can now be added fish meal and fish protein concentrates which, according to most nutritionists, may help to solve the world protein shortage. Indeed, the product is of good quality, processing is not costly, the sources available are untapped in many areas of the world (in particular in tropical and subtropical zones), storage and transportation of the concentrate are easy.

The issue is how to exploit commercially these gigantic natural fish ponds, which most of the Pacific atolls could become, until the spectre of ichthyosarcotoxism has been removed.

What would be gained by developing aquiculture in the lagoons or in reef environment if the harvested products were found to be toxic (especially since we know that the toxicity of most fish is not affected by drying or heat)?

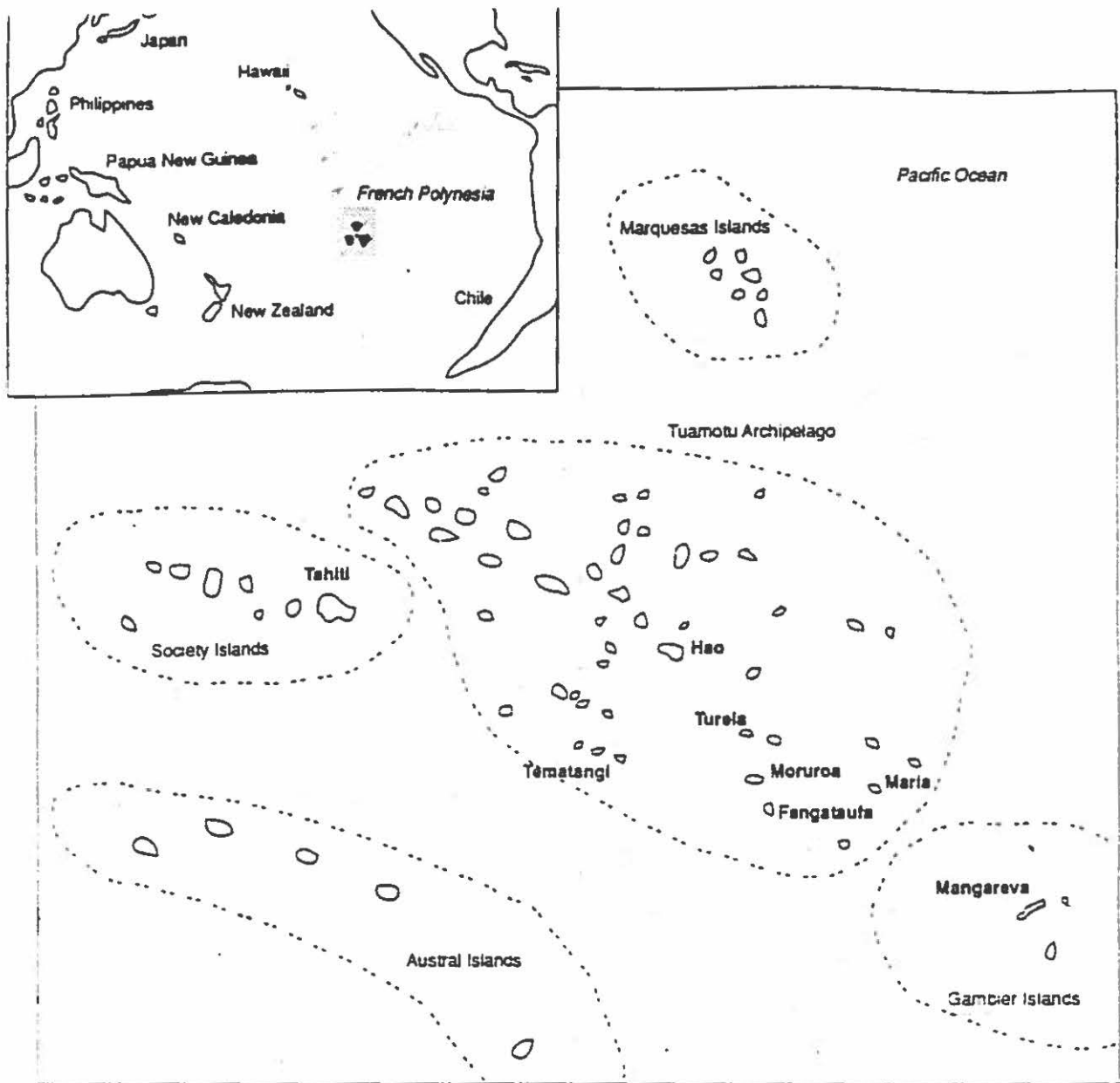
The crucial issue is therefore to ascertain the true extent of these toxicological obstacles which are a constraint on the development of our reef resources.

# Testimonies

## *Witnesses of French nuclear testing in the South Pacific*



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Cover: After Gauguin by Bobby Holcomb, 1986.

This painting hangs in the office of the mayor of Faa'a, Oscar Temaru.

© Greenpeace International, August 1990

ISBN 0 473 01008 9

The interviews in this book were collected by Dr Andy Biedermann for Greenpeace in 1987. The testimonies have been edited by Stephanie Mills, Julie Miles, Madaleen Helmer and Saskia Kouwenberg.

Thanks for information, photographs, and permission to reproduce text are due to Dr Tilman Ruff, Dr Manfred Hochstein, Elaine Shaw, Bunny McDiarmid, Marie-Therese and Bengt Danielson, Michael Szabo, Mark Derby, Gil Hanly, Lorete Dorreboom, the New Zealand Herald and the US Natural Resources Defense Council.

Special thanks for black and white photographic services to Paradise Colour Ltd, and for video services to Vidcom, Auckland.

Design and production - Paradigm, Auckland, Aotearoa (NZ)

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- 18 The King of Tonga, the politically conservative King Taufa'ahau Tupou IV was invited to Moruroa by the French in July 1987. The Finance Minister of Western Samoa at that time, Tagaloa Pita, and other Tongan and Samoan officials joined the King on a tour of the atoll.

Eating fish at Moruroa was banned in June 1966, after the first test. In a 1971 interview in *La Depeche*, the head of the French Service Mixte de Controle Biologique (SMCB) said that massive destruction at point zero and the dispersal of various fission products had led to secondary contaminations, following which the eating of fish was prohibited. In August 1968, scientists at the University of Baja, California, blamed French tests for high degrees of radioactivity detected in fish caught along the Baja Peninsula (Mexico). The majority of fish poisoning cases reported in French Polynesia are from ciguatera. Ciguatera fish poisoning is caused by eating tropical fish that have fed on a particular algae which grows on damaged or dead coral. The dinoflagellate organism, *Gambierdiscus toxicus*, which causes ciguatera, is named after the Gambier Islands where there was a serious ciguatera outbreak in 1968. Ciguatera outbreaks are linked to natural ecological disturbances such as storms, earthquakes and tidal waves, and to human activities such as construction work, explosions and dredging.

Severe outbreaks of ciguatera have followed military activity and nuclear testing in the Marshall Islands. For the period 1973-87 rates of ciguatera were more than three times the South Pacific average in French Polynesia and the Marshall Islands. After the French military began conversion of the Hao atoll in the Tuamotu group for use as a staging base for Moruroa and Fangataufa, an out-break of ciguatera occurred. By mid-1968, 43 percent of the population of Hao had been affected by ciguatera. Moruroa has had a high incidence of ciguatera over

the past two decades, during which time there has been extensive coral damage caused by the building of military infrastructure and the nuclear test explosions themselves. The only reported study of whether radioactivity is related to ciguatera was conducted 30 years ago by the US Atomic Energy Commission; no correlation was found, but the link deserves further study.

Ciguatera symptoms include acute vomiting, diarrhoea and stomach pain, accompanied by sensory and/or motor disturbances including paralysis and joint pain. Weakness may necessitate ventilatory support. Abnormally slow heart beats, depression of the heart muscle and collapse of nerves controlling the blood vessels may occur. Ciguatera during pregnancy may result in abortion, premature labour and neurological disease in the newborn, and the disease may be transmitted by breast-feeding. Ciguatera is occasionally fatal, but more commonly it runs for weeks, months, or years, with constitutional symptoms, diffuse tingling pain, hot and cold flushes etc. Subsequent attacks tend to be more severe than first attacks, and symptoms may recur with ingestion of non-toxic fish, alcohol and other foods, or with illness. Such "sensitisation" may persist for years after an attack of ciguatera. (Ruff p3,5,22)

I was there when the French invited the King of Tonga to visit Moruroa. They never showed him the contaminated areas, only a drilling site which of course wasn't contaminated. He wasn't shown the places where I and others went to pick up dead fish a few days after an underground test... It would be embarrassing for the French to contaminate the King of Tonga. After he arrived at the airport he was driven to the living area in a fancy car brought in for that purpose. Then they took him by helicopter to Fangataufa. On the way back they landed on Tila, the drilling boat, and he was shown around. But the king didn't really know what was going on and knew nothing about radiation. Some people have been there for more than ten years. The King was there for twenty minutes.

It's still forbidden to fish at Moruroa, but you can't stop Polynesians eating fish. Of course, we all knew that it was dangerous to eat fish but the food we got from the military was bad. The fish was old and we always got potatoes. So most of us ate local fish when we were on Moruroa and Fangataufa. And most of us got sick. I remember a group of ten people on Fangataufa who ate fish. They all got seriously ill and had to be evacuated to Tahiti for treatment.

People died from eating contaminated fish. One of my friends ate a crab and became ill. His skin started to itch and he scratched himself so much that he started to bleed but he couldn't stop scratching. Then he got problems with his eyesight and soon afterwards he died.

I know of four people who have died from eating poisoned fish, and many others who have had symptoms of fish poisoning. When people die on Moruroa they are put in metal coffins and the seams are welded so that nobody can open them any more.

Even now, in the last three months that I was there, there were people who got ciguatera. An ocean-going fishing boat was brought to Moruroa so that the Tahitians could get fresh fish from outside the lagoon. But it's the French who eat those fish now, so we continue to fish in the lagoon.

My uncle has been working on Moruroa for about 15 years. He can't have kids. He had his sperm analysed and the doctor told him that he was sterile. I think it was due to radioactive contamination.

I've had five children. The youngest was born with a kidney missing and no anus. He had to have an artificial intestinal opening made in the wall of his stomach. Hopefully, in a few months time, this artificial opening can be closed and a normal one reconstructed.

I know, of course, that there are a lot of bad things happening on Moruroa but I need the money. There is a lot of unemployment in Tahiti and I have a large family to look after. Before each test everybody was warned not to tell our friends and family about it. If the French find out that I've been talking, I'll be dismissed. But I don't care. I think it is important to tell people what is happening.

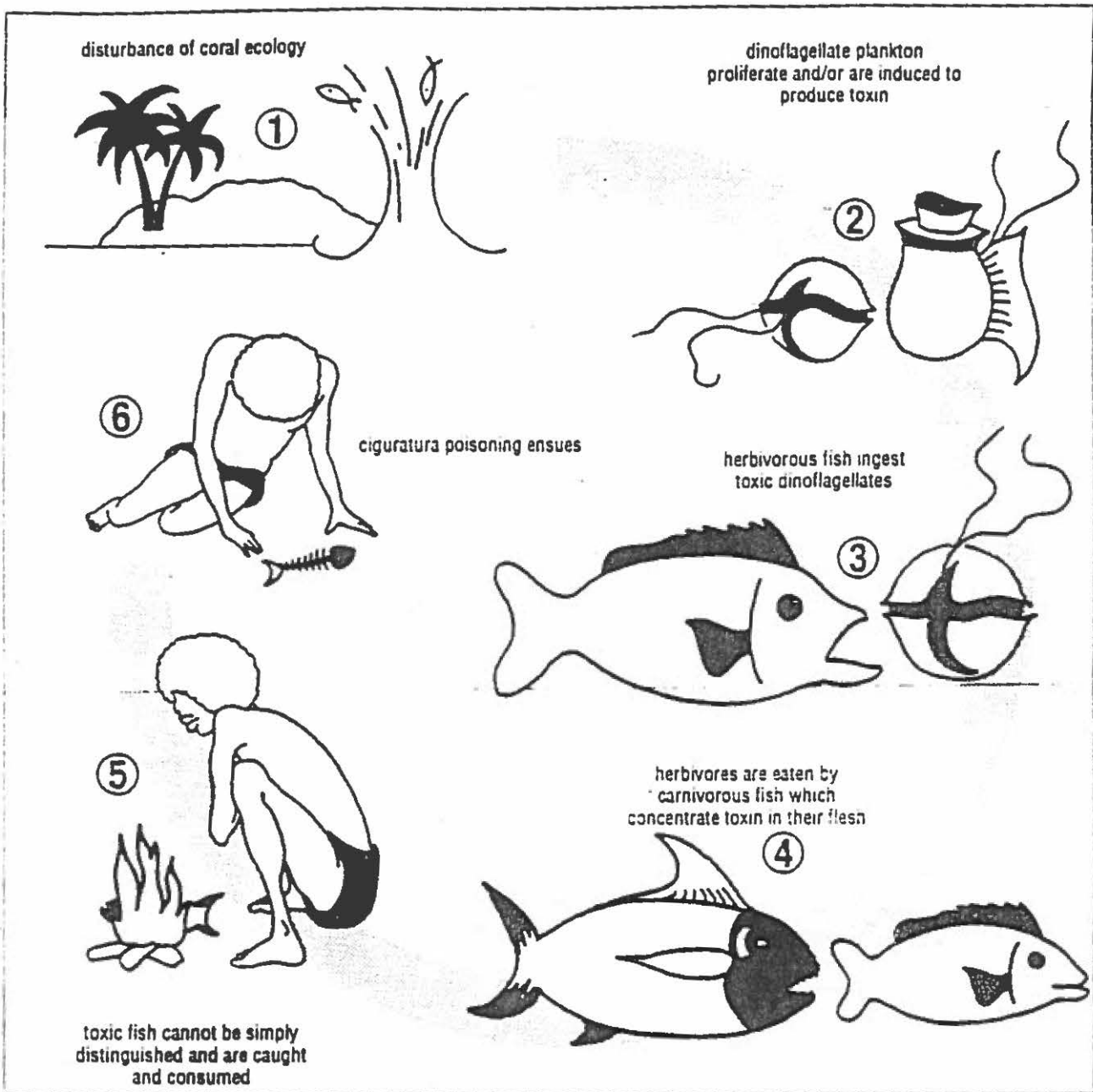


Diagram of the ciguatera cycle

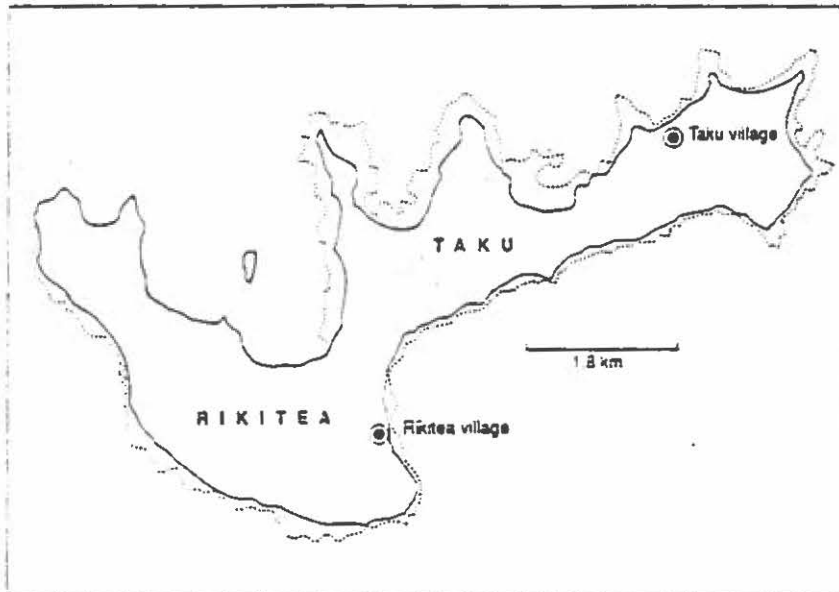
The long-term effects of exposure to radiation include increased incidence of sterility, cancer, cataracts, miscarriage and still births and genetic defects in children such as abnormal body parts, lack of eye development, tumours of the thyroid, leukaemia, slow mental development and small head size.

The unemployment rate in French Polynesia is 15 percent, made up largely of young Tahitians, particularly those arrived recently from the outer islands. Tahiti is estimated to need 2,300 new jobs annually to meet demand but can only expect 1,000 at most. The CEP now provides 12.5 percent of local jobs, 55 percent of all the territory's external financial aid and accounts for 22 percent of GDP. Half the population of 190,000 is under 20, and many live in insanitary slums around Papeete and Faa'a. This is in spite of the fact that Tahiti is touted as having one of the region's highest per capita incomes. (PIM June 1990 p8-12).

the atoll where they were drilling at the time. By now the tests were underground, and I could see the workers drilling on the reef. We weren't allowed off the ship so I couldn't see any fissures. They still had hotel ships and there was still a large village on shore.

I first went to Mangareva in 1959 and then again in 1963. Everything was fine and there weren't any military there. All the major islands in the Gambiers were inhabited. Roughly 2000 people were living there, with about five villages on Mangareva alone.

There was not much ciguatera then, except for the usual amount normally found in tropical waters. Everybody knew which fish were ciguatoxic and in which areas of the lagoon they were found. It was not a problem. And if, by accident, someone did eat a toxic fish the symptoms were mild enough to be treated with some local medicine such as sugar, milk and ginger root. This did not stop the disease but it helped to relieve the symptoms a little.



My next visit was in 1972 and by then all the fish were poisoned, though apparently it wasn't as bad then as it had been. Even the maoa were ciguatoxic which was unheard of previously. The consumption of most species of fish was prohibited except for fish caught in the open ocean.

The population had declined considerably by then. I gather that in the years after the nuclear testing programme began, people had started to leave. A lot of people left to join the civilian labour force needed by the military for construction work on Hao, Moruroa and Tahiti. Others left because the fish was ciguatoxic and couldn't be eaten. So men left and their families followed, going to Tahiti because of the conveniences there and the poisoned fish at home. The people remaining were mostly the old people, young children and a handful of middle-aged.

In the beginning the only military presence on Mangareva was at the meteorological station. There were six to ten permanent weathermen at the station and about 30 support people. First they were on Taku but after the airstrip was built at Totogegie they all moved there. Later, they had a rest and recreation centre at Totogegie. When I was on Moruroa the legionnaires would

The Gambier Islands consist of four high islands and a few atolls. They were once an independent entity within French Polynesia with their own flag. This status no longer exists, and none of the Gambier Islands are inhabited except for Mangareva which now has a population of 500.

There is no proven treatment for ciguatera. Mannitol, a type of alcohol generally used to increase urine production, and amitriptyline, an anti-depressant drug used in a variety of pain syndromes and nerve diseases have had some effect. Ciguatera has occurred throughout the Pacific, but there was a massive outbreak in the Gambiers in 1968, probably connected with French military activity which damaged reefs in the lagoon. Overall, rates more than three times the regional average were recorded in French Polynesia in 1973-1987, with 24,000 reported cases. The South Pacific Commission estimates that the official statistics reflect only 10-20 percent of cases. (Ruff p4,16-17)

Map of Mangareva

Maoa is a sea-snail.

Recruiting by the CEA virtually emptied many outer islands in the 1960-70s. Attracted by relatively high wages and the bright lights of Papeete, one source estimates that the population of the Gambiers, once numbering 5,000, fell to 500. Rapid urbanisation led to the emergence of slums in Papeete, disruption of traditional social structures and values, dependency, corruption and prostitution.

See map for location of Totogegie airport. Meteorological buildings were erected on Totogegie in 1967.



## 'Molestation of young girls'

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Construction of a major military base at Totegegie began in 1967, but back-up facilities for Moruroa would have been erected earlier.

*In Poisoned Reign (p75) increasing crime and alcoholism are described as a result of the influx of French soldiers. Soldiers were advised not to walk alone at night or wear uniform in Papeete because of the risk of being attacked by Tahitian men: "Owning cars and having plenty of money, they [the soldiers] could find girls without any difficulty. Each new conquest meant that a local man lost his wife or sweetheart..."*

Roland, a gendarme, was sent to Mangareva in 1963 and stayed there until the beginning of 1968. His wife and their youngest child went with him but his two older children stayed in Tahiti to go to school.

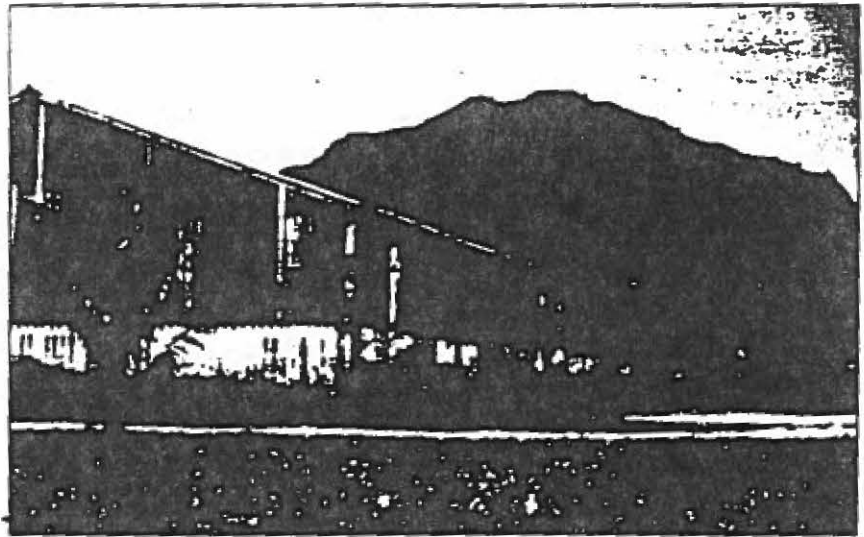
"When we arrived on Mangareva, there were 700 people living there. I was surprised to find that there were also about 20 legionnaires living on the island building a wharf and road.

The people of Mangareva lived mainly on what they grew and by fishing. Fish poisoning had never been heard of before.<sup>1</sup>

When I was offered the posting to Mangareva, I was promised a beautiful island, nice people and no problems. However, the situation had changed with the arrival of the legionnaires. They had become the "kings" of the island because they had money and alcohol. They got women by getting husbands or fathers drunk, or by buying them off. Some of the local men had gone to work on Moruroa, which made it "easier" for the legionnaires.

Fighting and the molestation of young girls were major problems. But no legal action was ever taken, either because people struck private deals or were too afraid to speak out. Maybe it was also because of the peaceful nature of the Mangarevans. In a single year, alcohol consumption increased by five times on Mangareva.

In 1966 the first nuclear bomb was exploded at Moruroa. On Mangareva we saw the flash and a little later, felt the shockwaves. There was an earthquake. There were no shelters for this first explosion. Although they were constructed later, people didn't use them. Nobody told us about fallout.



Shelter built at Rikitea.

<sup>1</sup> The fish poisoning referred to, ciguatera, has had dramatic effects on the life-style of Polynesians for whom fish may be sometimes the only animal protein source. The need to avoid fish after an outbreak may exacerbate undernutrition, especially among children, fear of poisoning increases dependence on imported food which can lead to a diet with more salt, fat and complex carbohydrates and subsequent increases in chronic diseases such as diabetes, hypertension and heart disease. R. Bagnis has estimated that the annual cost of paid work-time lost as a result of ciguatera poisoning in French Polynesia was around US \$4 million per year. (Ruff p21)

## 'They drink until they can't drink anymore'

Therese married a man from Tureia a few years ago, and has lived on Tureia for the past four or five years.

There are about 100 people living on Tureia, if you include the children and those who are on Tematangi cutting copra.

In the past there were quite a few military living on the island. But they have all left now, except for two people who look after the meteorological station. While the military was here there was always a doctor on the atoll but since they left there has only been a nurse. The airstrip has just been finished so that people can be evacuated if need be. Today, from the fifth month on, every pregnant woman is evacuated.

Luckily there was a doctor around when I got ciguatera after eating a fish. I got very sick and had to have a lot of injections. I think I would have died otherwise. It was silly of me to eat the fish, I guess, as it is known that almost all the fish from the lagoon and even the reef fish on the ocean side are contaminated.

There are two bunkers on the atoll. One was for the military and the other one was for the civilians. We haven't used them recently as the bomb explosions have all been underground. But in 1983 we had a cyclone, so we all used the bunker. Once we had got inside and closed the door we couldn't hear a thing of what was going on outside. The walls and doors were very thick. When the cyclone was over we came out and saw that the whole village had been totally destroyed.

The houses have all been rebuilt now. They are very luxurious with sliding doors and windows and smart inside. Most people have videos and there are quite a lot of motorbikes and one or two cars even though there are scarcely any roads. We manage to get these goods with the money we earn from selling copra. Copra is subsidised so we get good prices for it. With the money people here also buy a lot of alcohol. It's a real problem on Tureia. It was freely available in the past especially when the military were there. The CEP sold alcohol. And people tend to drink until they can't drink any more. Mainly on Fridays and Saturdays but other days as well.

A lot of the coconut trees are damaged. They don't give as much copra as they used to. Something has made them weaker and there are also insects now which make the crop even smaller.

I think there have been more skin diseases on the island since the atmospheric tests started. Quite a lot of kids have skin eruptions a bit like burns which itch and then get infected and start to suppurate. There is one child who was okay at birth, but when she was five she started to have eye problems and she's now partially paralysed and cannot walk. In the last four years since I have been on Tureia there have been two deaths which could have been cancer. My mother-in-law, who had always lived on Tureia died, at 61 years of age, of cancer of the intestines, I was told. She had lost blood through her anus. The mother-in-law of a friend of mine who had also lived on Tureia all her life died of a problem with her throat. She started to have difficulty swallowing and then found it difficult to breathe. She had an operation at Mamao - they put a tube down her throat so that she would be able to breathe again. She came back to Tureia to die.

The economy of the Tuamotus is based on cultured pearls and copra. Harvesting copra is tedious, back-breaking work that involves splitting ripe coconuts with a machete, drying them in the sun, plucking the meat out and drying the meat once more. Generous subsidies from the government keep the price of copra artificially high to ensure it provides a worthwhile income. However, production of copra fell dramatically with the arrival of the CEP, and production fell 40 percent between 1962 and 1967.

Ciguatera incidence between 1960 and 1984 in the Tuamotu Archipelago averaged 1,700 cases per 100,000 every year. (*Ruff*, p17)

There were several cyclones in 1983. On 25 January, Cyclone Nano, with winds of 150km an hour, swept through the Tuamotu Islands, leaving hundreds homeless. Military installations on Hao were devastated. On 23 February, Cyclone Oratia struck the Tuamotus, flattening coconut plantations and increasing the number of homeless. French authorities provided detailed information of all damage incurred in the Tuamotus, with the exception of Moruroa atoll. In April, the French newspaper *Le Canard Enchaîné* published a document from the Civil Protection and Prevention Commission of the Superior Council of Meteorology in France dated 23 March, stating that all atolls in the Moruroa area suffered extensive damage as a result of the cyclones. The report also indicated that the Gambier Island group had been moved on the Superior Council's map several degrees north east, so that cyclone Reva, which passed over Moruroa in March, would appear to have missed the Gambiers. (*Chronology* p36)

FREEDOM FOR THE SEAS IN THE 21ST CENTURY:  
A NEW LOOK AT OCEAN GOVERNANCE AND STEWARDSHIP  
December 10-12, 1990  
Honolulu, Hawaii

A Workshop of  
the Centre for International Environmental Law,  
the Spark M. Matsunaga Institute for Peace  
at the University of Hawaii,  
Greenpeace,  
and the Peace Research Centre  
at the Australian National University

Agenda

Sunday, December 9, 1990

6-8 p.m. Reception at the New Otani Kaimana Beach Hotel, Diamond  
Head Room (Second Floor)

Monday, December 10, 1990. (All working sessions will be at the  
Waialae Tea Room in the Manca Valley)

9-12 a.m.

Chair: Elisabeth Mann Borgese

Welcoming Remarks--

Majid Tanranian

Durwood Zaelke

Andrew Mack

Sebia Hawkins

Overview Papers on Governance and Stewardship of the High Seas--

Elisabeth Mann Borgese--A Review of Efforts to Build an  
International Ocean Regime During the Past Three Decades,  
with Special Attention to the Need to Protect the Ocean's  
Resources

Jackson Davis--The Need for a Comprehensive Treaty to Regulate  
All Forms of Ocean Pollution

Cliff Curtis--International Ocean Pollution Agreements: What  
Is Needed?

Christopher Stone--Guardianship of the Oceans and a Global  
Commons Trust Fund

[Break, 10:30-10:45]

R.P. Anand--The Historical Basis of the Freedom of the  
Seas Concept and an Analysis of Alternative Approaches to  
Ocean Governance

Philip Allott--Beyond the Power Relationships of the 1932 Law  
of the Sea Convention: An Alternative Approach to Ocean  
Governance

Artemy Saguirian--The USSR and the New Law of the Sea  
Convention: In Search of Practical Solutions

Commentators: Arvid Pardo, Gwenda Matthews, Norton Ginsburg,  
Douglas Johnston

Discussion

Rapporteur: Douglas Johnston

Pollution:

Jackson Davis, Chair  
Elisabeth Mann Borgese  
Claudia Carr  
Clarence Ching  
Cliff Curtis  
Kilifoti Eteuati  
Moana Jackson  
Casey Jarman  
Douglas Johnston  
Ian Townsend Gault  
Ratu Joni Madraiwiwi  
Mere Pulea  
Christopher Stone  
Salema Va'ai  
Miranda Wecker  
Durwood Zaelke  
Rapporteur: Norton Ginsburg

12 Noon: Lunch

1 P.M.: Group Photo

1:15-5:00 P.M.

Chair: Durwood Zaelke

Stewardship of the Oceans: Pacific and Indigenous Approaches  
Toward Environmental Protection--

Kilifoti Eteuati--The 1986 Convention for the Protection of  
the Natural Resources and Environment of the South  
Pacific Region (the SPREP Convention)

Salema Va'ai--The Strengths and Weaknesses of the 1986 SPREP  
Convention

Mere Pulea--The Unfinished Agenda for the Pacific to Protect  
the Ocean Environment

Paul Holthus--The Work of SPREP

Moana Jackson--The Sovereign Rights of Indigenous Peoples to  
Ocean Resources

Hayden Burgess (Poka Laenui)--The Views of Indigenous Peoples  
to the Ocean Resources of the High Seas

Clarence Ching--The Work of the Office of Hawaiian Affairs  
Relating to Ocean Resources

Commentator: Mark Valencia

[Break 3:30-3:45]

Stewardship of the International Commons and Ocean Pollution Issues

Ian Townsend Gault--New Approaches Toward the Development of  
an International Environmental Ethic, with Specific  
Applications to the International Commons

Jon Van Dyke--International Governance and Stewardship of the  
High Seas and Its Resources