

RED TIDE AND PARALYTIC SHELLFISH POISONING IN PAPUA NEW GUINEA

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ABSTRACT

Reports of red tides and shellfish poisonings in Papua New Guinea waters are described and discussed. Descriptions are also given of various phenomena resembling red tides.

INTRODUCTION

Paralytic shellfish poisoning is caused specifically by toxins from certain dinoflagellates which are normally present in very low concentration in the sea. Occasionally, in response to a favourable change in their environment, they undergo a rapid population increase, when their numbers may attain several million per litre, forming visible patches on the surface, or "red tides". Humans are poisoned by eating bivalve shellfish which have been exposed to a red tide, and have thus ingested large numbers of dinoflagellates and stored their toxin. The symptoms are quite characteristic.

Until recently, the only published record of paralytic shellfish poisoning in the southern tropical Pacific area was a single fatal case at Manus Island, in 1962. However, in April, 1972, there were three deaths, all indigenous children, at Walai, Central District of Papua New Guinea, from paralytic shellfish poisoning. During the period March to July, 1972, a total of 28 non-fatal cases was admitted to Port Moresby General Hospital from

coastal villages between Walai and Port Moresby.

Extensive patches of red tide were seen during aerial surveys of the affected areas shortly after the Walai fatalities. Further, red tides had been observed in Port Moresby Harbour almost continuously from December, 1971, to May, 1972.

The villages affected had no history of paralytic shellfish poisoning and it is tempting to conclude that the event was an isolated phenomenon. However, there is evidence that red tides are probably common in Papua New Guinea waters and that paralytic shellfish poisonings are more frequent than is generally recognised.

Below is an annotated chronological list of reports indicative of red tide and/or shellfish poisonings in Papua New Guinea waters, together with whatever evidence is available. Most of the reports are contained in Department of Agriculture, Stock and Fisheries (DASF) files. They have been followed up where possible, to determine species of shellfish and gather other relevant background information.

OBSERVATIONS

Date.	Report.	Source.
May, 1956.	Over a period of a few days, 97 persons were affected and one elderly man died as a result of paralytic shellfish poisoning after eating bivalves (<i>Anadara maculosa</i>) from the large lagoon south of Losuia in the Trobriand Islands.	A. M. Rapson. Paper for the South Pacific Commission Conference, 1968.
May, June, 1956.	Numerous accounts of dead turtles, fish and porpoises washed ashore in the Milne Bay area (including Trobriands) with deaths "extending westwards". Dead fish and turtles were reported near Talasea, West New Britain at about this time also.	A. M. Rapson. (Ibid).

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Observations.—continued

Date.	Report.	Source.
January-May 1961.	Red tides were visible around Talasea, New Britain, the sea was red by day and phosphorescent by night. Many fish and turtles were found dead along the shore.	Health Officer, Talasea, in DASF Files.
March, 1961.	Three non-fatal cases of paralytic shellfish poisoning were treated at Talasea at this time—an adult male from Talasea and, on another occasion, two boys, aged 3 and 11, from Pangalu village, 5 kilometres north of Talasea. The adult was poisoned by the Brachiopod, <i>Lingula</i> .	Ibid. Brachiopod species identified by Prof. Chuang from samples collected by the author following discussion with the man poisoned.
20th April, 1961.	A girl aged 2½, of Garili village, 10 kilometres south of Talasea, died 3 hours after eating raw oysters (<i>Saccostrea cucullata</i>). Her mother, who also ate the oysters, died an hour later. A third death, that of a woman, occurred about a week afterwards in the same village.	DASF Files. Oysters identified by Mrs Whybrow, British Museum.
May, 1961.	Red tide was present along the West New Britain coast, being worst in Reibeck Bay. Intermittent patches and streaks extended almost as far north as Rabaul.	A. H. Banner, in DASF Files.
23rd May, 1962.	A man at the Lombrum Naval Base, Manus Island, died as the result of eating three or four cooked shellfish (<i>Spondylus ducalis</i> Roding) from a lighter which had been placed in dry dock. Symptoms were of paralytic shellfish poisoning. A second man who removed the stomach portion and recooked the meat before eating it, was unaffected. Six days prior, three out of five persons eating cooked <i>S. ducalis</i> from the same source exhibited mild symptoms of paralytic shellfish poisoning.	Acting District Commissioner, Manus, and DASF Files. Species identified by Australian Museum. Brief mention of the fatality was made by Halstead (1965).
28th May, 1963.	Red tide had been present in the Talasea (New Britain) area over the previous few weeks. Some villagers who were collecting shellfish in this area became acutely and seriously ill, presumably from eating the shellfish. However, a further five people after bathing in red tide contaminated seawater, were treated for the following symptoms; (1) sensitivity of the skin as sunburn, and (2) formation of hive-like lumps and/or weals on the skin. One woman had died from respiratory failure 2 hours after eating food prepared in water contaminated by red tide. (See March, 1973, report from West New Britain.)	DASF Files
29th June, 1963.	Red tide was still present in patches off the coast near Talasea. Some dead turtles and fish had been washed up.	Ibid.
5th July, 1963.	Except for a few small patches, red tide had disappeared by this time from the Talasea area.	Ibid.
September-November, 1969.	Red tide was seen during this period in Bostrem Bay near Madang. The causative organism was the dinoflagellate <i>Gonyaulax polygramma</i> .	Observations by Dr B. Sweeney, Alpha-Helix expedition (unpublished).
16th November, 1970.	A patch of dying juvenile skipjack tuna (<i>Katsuwonus pelamis</i>) over half a kilometre long was reported in an area of red coloured water outside Bootless Bay, near Port Moresby. It is possible that the fish were <i>Rastrelliger kanagurta</i> and their behaviour was surface feeding. However, the presence of red water is significant.	DASF Files. <i>Rastrelliger</i> information from Dr R. Kearney.
April, 1971	A fatal paralytic shellfish poisoning of an indigenous woman at Kiriwina, Trobriand Islands, by the cockle <i>Anadara maculosa</i> , locally called "tumeri". A further 17 affected villagers reported to the hospital at the time. Tumeri is known by the Trobriand Islanders to be	From Losuia hospital records. Shellfish identified following discussion with villagers.

Observations.—*continued*

Date.	Report.	Source.
	sometimes dangerous to eat. (See also entry of May, 1956 above.) Apparently the water in parts of the shallow "lagoon" along the western side of Kiriwina become "murky" for a short time in April or May of most years. At night the discoloured water is phosphorescent, which is the signal for villagers to stop eating shellfish. Tumeri is a major dietary item of Kiriwinans—90 per cent of their shellfish diet—and villagers probably do not abstain from tumeri for a sufficiently long period following the phosphorescent displays to avoid occasional poisonings. The doctor at Losuia pointed out that illness from toxic shellfish is more common than health records show, since most villagers prefer to accept sickness and death at home rather than seek medical attention.	
7th April, 1971.	Red water, over one square kilometre in area, was observed 14 kilometres east of Lae, Morobe District, about a kilometre off shore. It was apparently the third report of red tide near Lae that year. There was no sign of dead bird or marine life. A fisherman reported that he experienced irritation to his hands and forearms while fishing in the red water. The causative organism was described as being unicellular and often in 8 cell chains. (This description fits observations of dinoflagellate division. <i>Pyrodinium bahamense</i> commonly form 8 cell chains.)	DASF Files. Author's observations.
18th April, 1971.	Red tide was observed in Marshall Lagoon, Central District.	DASF Files.
April-May 1971.	Red tide, later identified as <i>Pyrodinium bahamense</i> was present in Port Moresby Harbour during these months. It was apparently present in February and March also.	Discussion with biologists at the pearl farm in Fairfax Harbour, Port Moresby.
31st May, 1971.	More red tide patches were sighted near Salamaua and inlets in the vicinity of Lasanga Island and Kui, Morobe District.	DASF Files.
November, 1971.	A red tide and numerous dead turtles and fish were found along the Morobe District coast between Lae and Morobe Harbour. Villagers ate the dead animals without ill effect. (See also report for November-December 1972 below.)	Discussions with Morobe villagers and Mr B. Burgess, Fisheries Officer, Lae, December, 1972.
December, 1971-May, 1972.	Red tide was observed to occur in Port Moresby Harbour and Fairfax Harbour almost continuously during this period. The dinoflagellate was again <i>P. bahamense</i> . Indigenous labourers at the pearl farm ate pearl oyster (<i>Pinctada maxima</i>) meat on several occasions during the time of red tides, apparently with no ill effect.	Discussions with pearl farm biologist Mr Asakawa. Also DASF Files. Identification of dinoflagellate by Dr Dodge, Birbeck College, University of London.
February-March, 1972.	During this time three patients were admitted to Port Moresby General Hospital suffering from paralytic shellfish poisoning.	Retrospective diagnosis after Walai fatalities. Unpublished PNG Health Dept document, reference 120/9/72.
13th March, 1972.	Red tide was observed off Ela Beach, Port Moresby.	DASF Files.
27th-29th April, 1972.	Extensive red tide, <i>P. bahamense</i> , was seen along the Central District coast between Walai and Port Moresby. Three indigenous children died and 20 other adults and children from Walai were hospitalised suffering with paralytic shellfish poisoning from the cockle <i>Anadara maculosa</i> (Motu name is Kuwadi).	Investigations by PNG Health Dept (Unpublished) document 120/9/72 Shellfish toxicity tests by DASF chemists; field observations by the author.

Observations.—*continued*

Date.	Report.	Source.
12th-23rd May, 1972	Four indigenes including two children, from three villages in the Port Moresby area (Tatana, Vabukori, and Korobosea) were admitted to Port Moresby General Hospital with symptoms of paralytic shellfish poisoning. All had eaten bivalve shellfish.	PNG Health Dept document 120/9/72.
July, 1972	One male indigene was admitted to Port Moresby General Hospital, suffering from mild paralytic shellfish poisoning after eating oysters (<i>Crassostrea echinata</i>) from the main wharf in Port Moresby Harbour.	PNG Health Dept document 120/9/72. Oyster identified by the author.
October, 1972.	Red tide was reported off the Morobe District coast about 40 kilometres east of Lae.	Mr B. Burgess, Fisheries Officer Lae, communication.
November-December, 1972.	Extensive red tide was reported along the Morobe coast between Lae and Morobe Harbour. <i>P. bahamense</i> blooms were observed in Morobe Lagoon. Mullet were dying and being eaten by villagers without harm.	Investigations by Mr B. Burgess and the author.
February-June, 1973.	Red tide (<i>Pyrodinium bahamense</i>) was visible in Port Moresby harbour on 15th February, 1973 for the first time since May, 1972. Subsequently it remained in the harbour almost continuously until the end of June. Bivalves from the harbour were found to be highly toxic, and warnings publicised: no poisonings were reported.	Investigations by the author. Toxicity tests by DASF chemists.
February, 1973.	Red tide was seen in Milne Bay. Two types of red water are found in this area, a pink variety, probably <i>Trichodesmium</i> , and one which is associated with a pungent smell, presumably of dinoflagellate origin. The February red tide was of the latter type. See also entry of 26th June, 1973.	Observations by Mr N. Stanton, DASF officer.
20th February, 1973.	A large crescent shaped patch of red tide was observed outside Amazon Bay, Central District. Paralytic shellfish poisoning deaths have occurred in this area. See Discussion.	Aerial observation. Mr F. Fletcher, DASF officer.
9th March, 1973.	Extensive red tide was seen along the Central District coast from Kapa Kapa to Hood Point.	Aerial observation. Mr N. Stanton, DASF officer.
March, 1973.	Towards the end of the month, red tide was observed in areas between Bagum, Kondoka and Moputa villages, West New Britain. Nine cases of poisoning, six female and three male adult villagers of Kondoka, were named, but the report stated that "quite a number of people were reported sick". Symptoms were vomiting and general paralysis two to three hours after eating shellfish. The symptoms were severe among those who ate shellfish and also drank the "soup" in which they were boiled, but not severe in persons who ate the shellfish only. This situation provides a probable explanation for the 1963 Talasea fatality from eating food prepared in red tide contaminated water. Significant numbers of <i>P. bahamense</i> were found in plankton samples taken near Talasea on 10th May, 1973.	Dr Pulau, Health Officer, TALASEA.
March-June, 1973.	Red tide, <i>P. bahamense</i> , was present intermittently on Central District coast between Port Moresby and Hood Point. No cases of poisoning were reported during this time.	Author's Investigations. Special weekly observation flights.
11th May, 1973.	Red tide sighted in the vicinity of Rutiger Point, West New Britain.	Investigation by the author.
26th June, 1973.	Red tide was sighted near Alotau, Milne Bay. A plankton sample taken there on 10th July, 1973 showed <i>Pyrodinium bahamense</i> to be the strongly dominant phytoplankton.	Aerial investigation by Mr T. O'Connell, DASF officer. Author's plankton collection.

DISCUSSION

The above reports cover 13 separate outbreaks of red tide and/or paralytic shellfish poisoning, over a period of 18 years, which have resulted in 10 known deaths and over 160 treated illnesses.

Table 1 below indicates the relative severity of each outbreak. Deaths of marine life are noted in the table as either widespread and numerous (+++), many (++) , few sightings (+) or none reported (-). Figure 1 shows the distribution of reported red tides and shellfish poisonings in Papua New Guinea.

The red tide species have been identified as *Pyrodinium bahamense* in the Morobe and Central Districts, Milne Bay and West New

Britain (Talasea), and *Gonyaulax polygramma* in the Madang District. The causative organisms in the Trobriands and Manus Island remain unknown.

The ten deaths listed here are probably only a fraction of the total fatalities from paralytic shellfish poisoning in Papua New Guinea. Doubtless there have been other fatalities where villagers, unaware of the dangers of shellfish poisoning have attributed deaths to other causes, notably to the intervention of magic. There have also been fatalities, not reported to hospitals, where villagers are aware of the cause and generally abstain from certain shellfish during periods of red tide, as in the case of the Trobriand Islanders. Another such group are the villagers of Mailu, off Amazon

Table 1.—Summary of reports of red tides and/or shellfish poisonings in Papua New Guinea waters, 1956-1973

Year	Area	Apparent Red Tide Season	Human Fatalities	Non-fatal Cases	Dead Marine Life
1956	Trobriands	May-June	1	97	+++
1961	Talasea, New Britain	January-May	3	3	++
1962	Manus Island	May	1	5	-
1963	Talasea	May-July	1	5	++
1969	Madang	September-November (?)	-	-	-
1970-71	Port Moresby	November-May	-	-	+
1971	Trobriands	April	1	17	-
1971	Lae	February (?) - April	-	-	-
1971	Lae	November	-	-	+++
1971-72	Port Moresby	December-May	3	28	-
1972	Lae	October-December	-	-	++
1973	Central District Coast, Port Moresby to Amazon Bay and Milne Bay	February-June	-	-	-
1973	Talasea	March-May	-	>9	-

Bay, Central District of Papua, who traditionally abstain from oysters, as well as *Anadara* and *Chama*, during times of red tides. These bivalves are known to become toxic in this District during blooms of *Pyrodinium bahamense*. A medical orderly from nearby Margarida reported that "many" people have been killed by paralytic shellfish poisoning in the past. Older villagers remember the deaths and the toxic properties of red tide are common lore in the area.

Past annual reports of the Health Department rarely listed individual forms of poisoning. There are over 7,000 cases annually in the New Guinea region alone, although fewer than ten deaths are recorded each year. Some of the annual reports for Papua in the 1950's presented detailed Health Department information. The 1957-1958 report mentions the death of an indigenous girl in the age group 1 to 10 years, from "shellfish poisoning". The only other shellfish poisoning death recorded

in Papuan annual reports is that of a native labourer in 1927-1928. These two deaths were probably due to paralytic poisoning, although it is possible that the cause of death was allergy or bacterial food poisoning. Both are unlikely, especially the latter, since shellfish are collected fresh and usually boiled for some time before eating. This was the case in the 1972 Walai tragedy.

The water in which toxic bivalves are cooked also becomes toxic, a poisonous "soup". This provides further danger, since villagers commonly cook other foods in the soup left after boiling shellfish. One of the cases of paralytic shellfish poisoning at Walai (April, 1972) was of a person who had not eaten shellfish but who had eaten boiled foods prepared in the shellfish soup. In the West New Britain poisonings of March, 1973, poisoning symptoms were most severe where affected persons consumed the soup as well as the boiled shellfish. It is likely that the fatality there in 1963 was the result of a similar situation.

Other effects of New Guinea (*Pyrodinium*) red tide are also noteworthy: an allergic type of response and extensive fatalities of marine life. Neither is a constant feature of the outbreaks. The two recorded instances of "allergic" reactions were in areas where *Pyrodinium* is believed to have been responsible, Talasea (May, 1963) and Lae (April, 1971). However, the author and others have frequently dived into and through blooms for sampling purposes and to determine their depth. As well, concentrated samples of *Pyrodinium* from plankton hauls have been handled without harmful effect.

The destruction of marine life has varied greatly in the various outbreaks. The most extensive fish-kill was undoubtedly in 1956, while significant kills have also occurred in 1961, 1963, 1971 and 1972. At present it seems probable that these incidents can all be attributed to *Pyrodinium* red tides.

Fish kills from red tides result from either reduced oxygen levels or the poisonous effects of toxin released into the water. *Gonyaulax polyedra*, the California red tide organism, causes mortality in fish and molluscs by oxygen depletion associated with blooms of that dinoflagellate. It does not cause shellfish to become toxic (Sykes 1965). On the other hand, *Gymnodinium breve*, the Florida red

tide, has a poisonous effect on fish. *Gymnodinium* blooms also emit a gas or vapour which is irritating to the eyes, nose and throat (Torpey and Ingle 1966). As well, it has recently been found that they produce some toxicity in bivalve shellfish (Morton and Burklew 1969).

The New Guinea (*Pyrodinium*) red tide affects air-breathing turtles and dolphins as well as fish, which indicates involvement of the toxin rather than simple suffocation. In this respect, the New Guinea red tide resembles *Gymnodinium*. However, fish kills are a more regular feature of blooms of the latter. Interestingly, villagers have eaten fish and turtles washed ashore during New Guinea red tides without ill effect (Lae 1971 and 1972).

It is difficult to find a seasonal pattern in the red tide outbreaks summarised in Table 1. Red tides have occurred in every month of the year except August. For most of the New Guinea islands and the Milne Bay area, dangerous months appear to be from January to July inclusive. On the Central District coast of Papua, November to May are indicated as red tide months, corresponding roughly with the rainy season. The situation is more complicated in Lae and the Morobe District coast. Probably red tides can be expected there at any time between October and April inclusive. In Madang District, the known red tide months, September-November, may represent part of the season only.

However, dinoflagellates are not the only sources of discoloured waters in Papua New Guinea. As a result of the Walai fatalities in 1972, the importance of red tides as potential health hazards in Papua New Guinea has been stressed, and all recent reports of discoloured waters have been investigated to determine their nature. Other than dinoflagellate red tides, the following blooms have been observed.

1. *Salps*.—In July and August, 1972, wide orange streaks were observed inside and close to the outer reefs in the sea off the Central District coast about 70 kilometres south east of Port Moresby. From the air these patches were similar to those of *Pyrodinium*, but later sampling revealed the source of the colour to be a bloom or swarm of salps (*Thalia* sp.). A less pronounced swarm of the same species occurred over shallow reefs in Port Moresby harbour in December, 1972.

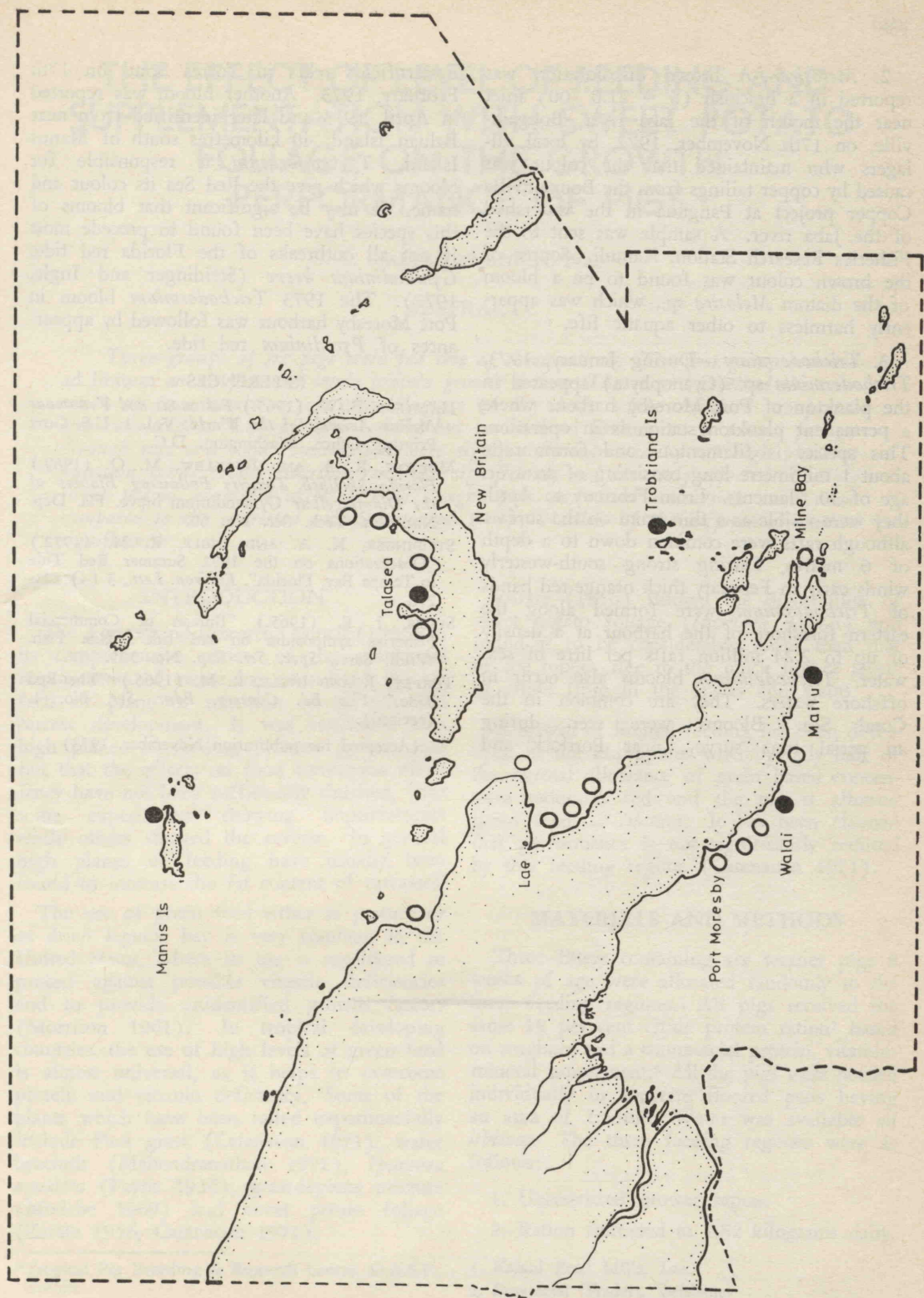


Figure 1—Papua New Guinea showing areas in which fatal paralytic shellfish poisonings (solid circles) and red tides (open circles) have been reported.

2. *Melosira*.—A brown discoloration was reported in a brackish ($S = 21.0^{\circ}/00$) inlet near the mouth of the Jaba river, Bougainville, on 17th November, 1972, by local villagers who maintained that the colour was caused by copper tailings from the Bougainville Copper project at Panguna in the watershed of the Jaba river. A sample was sent to the Fisheries Research Station, Kanudi. Source of the brown colour was found to be a bloom of the diatom *Melosira* sp., which was apparently harmless to other aquatic life.

3. *Trichodesmium*.—During January, 1973, *Trichodesmium* sp. (Cyanophyta) appeared in the plankton of Port Moresby harbour where a permanent plankton station is in operation. This species is filamentous and forms rafts about 1 millimetre long consisting of an average of 30 filaments. From February to April, they were visible as a thin scum on the surface although rafts were common down to a depth of 6 metres. During strong south-westerly winds early in February thick orange-red bands of *Trichodesmium* were formed along the eastern foreshore of the harbour at a density of up to 2.24 million rafts per litre of seawater. *Trichodesmium* blooms also occur in offshore waters. They are common in the Coral Sea. Blooms were seen during an aerial tuna survey, near Portlock and

Easternfields reefs in Torres Strait on 17th February, 1973. Another bloom was reported in April, 1973 and later identified from near Baluan Island, 40 kilometres south of Manus Island. *T. erythraeum* is responsible for blooms which give the Red Sea its colour and name. It may be significant that blooms of this species have been found to precede most if not all outbreaks of the Florida red tide, *Gymnodinium breve* (Steidinger and Ingle, 1972). The 1973 *Trichodesmium* bloom in Port Moresby harbour was followed by appearances of *Pyrrodinium* red tide.

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