Indo-Pacific Toxic Red-Tide Occurrences, 1972-1984[1]

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Introduction

The scattered literature on red tides in this region was first assembled in 1979 (Maclean 1979). At the time, only one dinoflagellate species was found to be responsible, *Pyrodinium bahamense* var. *compressa*.

The first recorded toxic blooms of this species occurred in 1972 in Port Moresby, Papua New Guinea (PNG), when three deaths from paralytic shellfish poisoning (PSP) occurred. It was found that red tides were probably regular seasonal events in various parts of PNG.

In 1976, *P. bahamense* blooms caused seven deaths in Sabah, and numerous hospitalizations there and in Brunei. Red tides were sighted in Sabah in 1977 and toxic clams discovered but there were no cases of PSP.

Given the huge and remote areas involved, 200 km of coastline in PNG and 300 km in Borneo, it was difficult to blame pollution and Maclean (1979) posed the question — was the red tide spreading? Since his report, toxic red tides do appear to have spread, but the evidence is still ambiguous.

Pyrodinium Red Tides Since 1976

Three years passed between the 1977 Borneo red tides and the next toxic blooms. From April 1980, *P. bahamense* var. *compressa* caused two deaths and a number of illnesses from PSP in Sabah over a 3-month period; blooms lasted until June 1980. Blooms were observed there again during December 1980 and January 1981. No further red tides have been observed in Sabah, yet, in three incidents over the 4 months from November 1983 to March 1984, a total of 11 children have been killed by PSP and 14 persons hospitalized.

The Philippine Islands experienced their first toxic red tides during June to September 1983, when 21 deaths and about 250 notified illnesses were reported from *P. bahamense* var. *compressa* blooms in the Samar Sea. Recently, evidence has accumulated to indicate that *Pyrodinium* blooms may be very widespread throughout the region. For example, certain crabs in Fiji have been found to contain PBT, or *Pyrodinium bahamense* toxin; there are annual red tides in Tumon Bay, Guam, and in nearby Palau, *Pyrodinium* blooms may be a permanent feature of Arumizu Bay; a dinoflagellate bloom was observed in Asau Bay, Western Samoa; shellfish poisoning resembling PSP has been confirmed in the Solomon Islands; and there may be annual red tides in Nanumea Lagoon in Tuvalu. The geographic proximity and similarity in environment — tropical, with little pollution, probably high water salinity, fringing coral reefs — indicate that all these events and probably many more as yet undescribed blooms and PSP outbreaks are due to *Pyrodinium bahamense* var. *compressa*.

Other Toxic Blooms

At the northern end of the South China Sea, Hong Kong has witnessed rapidly increasing numbers of red tides. Apart from a typhoon-induced bloom in June 1971 causing mild toxicity in shellfish, only six more non-toxic blooms were recorded in the 1970's. Since 1980, however, over 40 red-tide occurences were recorded up to the end of 1983. Only one toxic red tide so far has been recorded to be associated with fish kills. The causative organism was a *Gymnodium* sp. and the bloom occured in October 1983. No marine food poisoning has been reported.

The Gulf of Thailand has probably been host to red tides for many years, but they were first reported in 1967, as coastal aquaculture was developing in

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the gulf. No mortalities of fish or humans were reported until the period May-July 1983, when there were 60 serious illnesses and one death from PSP from a river flowing into the gulf. A number of dinoflagellate species were blooming during this period, although the major one may be *Protogonyaulax tamarensis* (or a new *Protogonyaulax* species). *P. tamarensis* causes toxic blooms in Japan. Meanwhile, *Pyrodinium bahamense* var. *compressa* has been found on the Andaman Sea coast of Thailand.

In the western Indo-Pacific, India experienced its first (recorded) PSP problem in August 1981, when there were three deaths and 82 serious illnesses reported from eating toxic bivalves in Tamil Nadu, on the east coast of peninsular India. One death from PSP and seven illnesses were reported on the west coast in April 1983. The dinoflagellates responsible are not known.

Indonesia has no fully documented records of red tides. However, northern Java has many coastal industrial centres and blooms, especially *Noctiluca,* were observed in samples taken between 1978 and 1981. In November 1983, there were two separate instances of PSP from eating clupeoid fish (*Sardinella* and *Selaroides*), which claimed four lives and hospitalized 191 others in Wulanggitang, East Flores.

In Australia, there are records of severe, toxic red tides in Sydney Harbour since the last century; toxic shellfish on the coast of New South Wales in 1935; and fish kills associated with "water discolourations" in Port Phillip Bay, Victoria, in 1950 and 1959 (and probably more recently). Even New Zealand has begun to experience dinoflagellate bloom problems: a recent export shipment of green mussels was found to contain significant amounts of DSP when examined on arrival in Japan.

A summary of these phenomena is contained in Annex A and illustrated in Fig. 1. Bibliographic sources are given in Annex A and complete references are given in Annex B.

Discussions

As more exploratory surveys are made, the incidence of red tides and PSP probably will be found to encompass the entire Indo-Pacific region.

Pyrodinium bahamense var. *compressa* appears to be capable of blooming in a variety of remote tropical situations and cannot be associated with pollution. In answer to the previously posed question, the increase in reported *Pyrodinium* red tides can only be associated with (1) natural phenomena and (2) a growing awareness of their effects, leading to more conscientious reporting.

The non-*Pyrodinium* toxic red tides, fish kills, and PSP, share somewhat different environmental situations. They are associated with urban or industrial situations and not with coral reefs. Also, they consist of several or many dinoflagellate species, either together or in succession.

It is becoming clear that there are two discrete situations in the region that require separate consideration — the industrial areas, where increased pollution is almost surely to blame for increased PSP-related problems, and the "rural" (especially coral reef) areas, where there appears to be no unnatural cause.

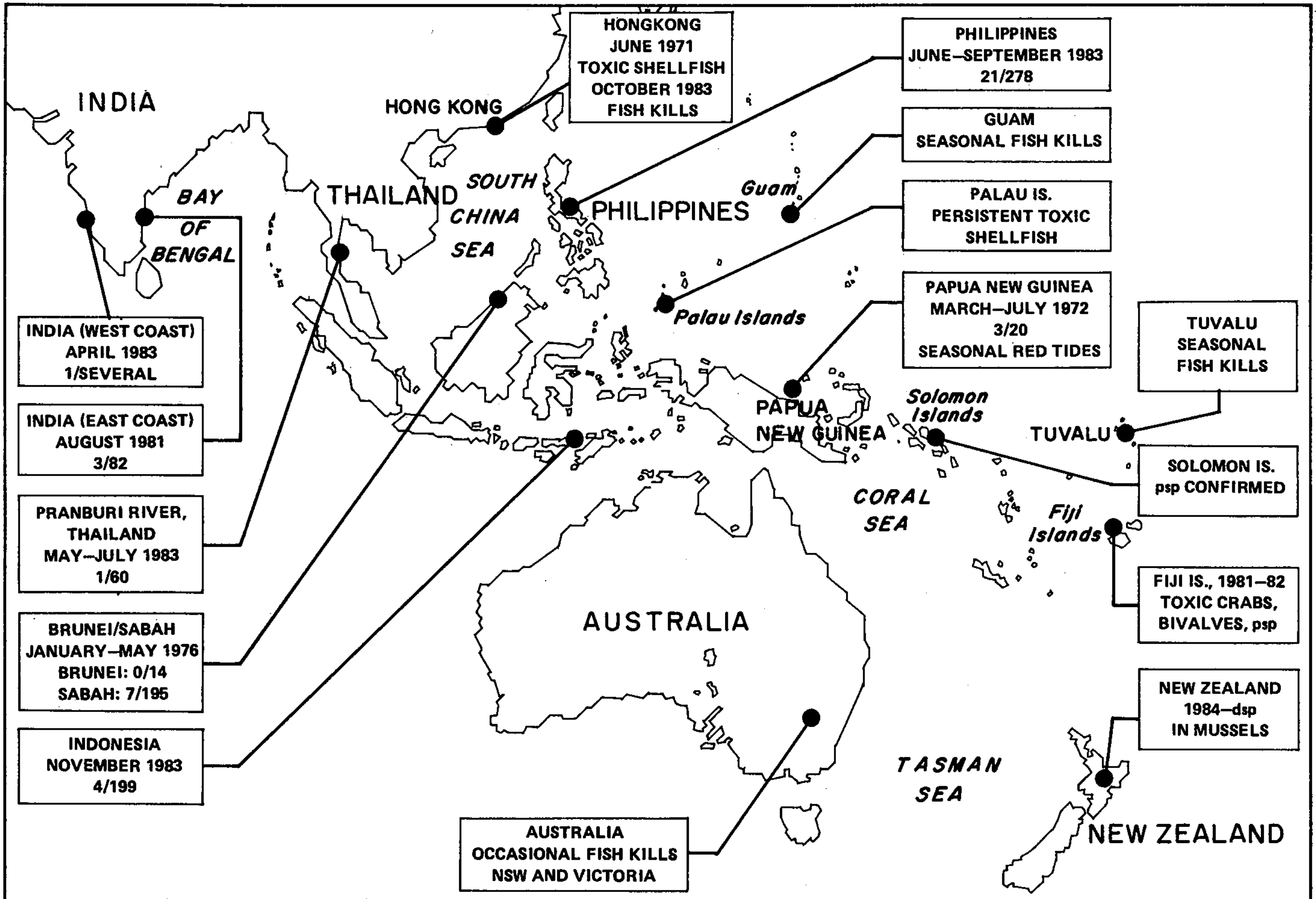

Fig. 1. Sites of Indo-Pacific red tides and paralytic shellfish poisonings. Numbers and dates in boxes refer to number of deaths/illnesses, and time of first reported incidents.

Annex A. Summary of Indo-Pacific Toxic Red-Tide Occurrences.

Country	Date	Report	Source
Australia	Irregular?	Since 1865, red water discolourations and mass oyster mortality in Sydney Harbour. Occasional blooms of *Goniaulax spinifera* and *Gymnodinium* sp.	Maclean (1979)
	1891	Extensive red tides, fish kills in Sydney Harbour by *Glenodinium rubrum* and *Glenodinium spirale.*	
	1935	Toxic mussels, south coast New South Wales.	Le Messurier (1935)
	Feb-May 1950	In Port Phillip Bay, Victoria, massive kills of bottom fish, molluscs, and crustaceans attributed to *Gymnodinium* sp. bloom.	Maclean (1979)
	March 1951	Blooms of an unarmoured dinoflagellate, Port Phillip Bay.	
	March 1959	Heavy fish kills associated with brown water discolouration in Port Phillip Bay.	
	Annual	*Peridinium* sp? seasonal blooms in Swan River, Perth.	
	Annual	Blooms in Sydney Harbour.	
Brunei	March-May 1976	First reported blooms of *Pyrodinium bahamense* var. *compressa* in Brunei; 14 nonfatal cases from eating *Rastrelliger* and *scads (Selar)* — both planktivorous fish. Whole fish and bivalves found toxic.	Beales (1976)
	1 May 1980	Red tide sighted off Brunei. People warned against eating shellfish	Straits Times (1 May 1980)
Fiji	?	Shellfish poisoning resembling paralytic shellfish poisoning has been found, attributed to the arc shell *Anadara antiquata.*	Yasumoto et al. (1984)
	1981-1982	Two of five species of xanthid crabs from Suva barrier reef and samples from Okinawa contained paralytic shellfish toxins, including PBT (*Pyrodinium bahamense* toxin) previously only found in *Pyrodinium* and *Pyrodinium*-infested bivalves.	Raj et al. (1983)
Guam	April, annually	Red water, sometimes large fish kills by *Gymnodinium* sp. in Tumon Bay, known as Father Sanvitores' Blood.	Tsuda, personal communication
Hong Kong	June 1971	Red tide of *Noctiluca scintillans* Macartney) in southern waters over 3 days following a typhoon. Caused by wind only, because normally a summer resident in Hong Kong.	Fung and Trott (1973)
	1980-1982	Five outbreaks with three fish kills increasing during 1981 and 1982, and more species identified. *Noctiluca, Prorocentrum, Gymnodinium,* and *Gonyaulax* are the most significant species, the latter two of which are potentially toxic. Since 1980, the dinoflagellate species that occur in Tolo Harbour have increased in variety. Most recently recorded is a bloom of *Exuviella* sp., which may be taxonomically identical to *Chatonella* sp., the most troublesome red tide organism in Japanese waters.	Lam (1984)

Annex A. (continued)

Country	Date	Report	Source
	1983	During the period September-December 1983, the following observed blooms and effects were reported, mostly in Tolo Harbour: 19-20 Sept., *Ceratium furca;* 18 Sept.-17 October (at least), *Gymnodinium* sp. (*breve?*), with kills of wild and cultured fish; 14 Dec., *Prorocentrum* spp., 12-16 Dec. *Gymnodinium* sp. and *Noctiluca;* 28 Dec. *Gymnodinium* sp? (not the same as the toxic species in October).	Phillips, personal communication
		There have been at least 12 red tides (up to August) in 1983. More than 20 since 1979. Red tides at the mouth of the Pearl River in China are affecting Hong Kong fish stocks.	South China Morning Post (25 Aug. 1983)
	1984	The frequency of red tides in Hong Kong waters has increased dramatically in the last few years. After the 1971 red tide, no serious incidence up to 1980. Since then many, mostly localized, occurrences especially in Tolo Harbour. There are now 13 bloom species present; only one toxic so far.	Morton, personal communication; Lam (1984)
India	August 1981	In Tamil Nadu, three children died, 82 others had neurotoxic symptoms. *Meretrix casta* clam was responsible. Toxicity assays made.	Davy and Graham (1982 quoting Bhat 1981)
	Annual?	*Noctiluca miliaris* formed a dense bloom in May 1977 following the decay of the *Trichodesmium* bloom off Goa.	Devassy et al. (1979)
	April 1983	One PSP death; several hospitalized from clams in Kumble estuary, Mangalore. *Meretrix casta* responsible. Variety of bivalves found highly toxic.	Karunasagar et al. (1984)
Indonesia	November 1983	Two incidents in Wulanggitang, East Flores of PSP from clupeiod fish *Sardinella* and *Selaroides;* four dead, 191 hospitalized	Adnan (this volume)
New Zealand	1984	Diarrhetic shellfish poison found in shipment of green mussels to Japan.	F.H. Chang, personal communication
Palau	Continuous?	Arumizu Bay, Koror, may have high levels of *P. bahamense* var. *compressa* year round as toxic shellfish were found in May and December. Red tide observed once. Identity of toxins discovered in dinoflagellate and shellfish.	Harada et al. (1982)
Papua New Guinea	Annual	Red tides of *Pyrodinium bahamense* var. *compressa,* periodic in various sites. Many incidences of paralytic shellfish poisoning. Toxin found in range of bivalves.	Maclean (1973, 1975)
	September 1969 Dec. 1975-Feb.1976	*Gonyaulax polygramma* bloom near Madang. Vast red tide near Madang, probably *Trichodesmium,* but two illnesses from eating planktivorous fish reported.	Maclean (1973)
Philippines	Pre-1908	Rusty, bioluminescent red tides seasonal in Manila Bay; January-March 1908; adverse effects on marine life, attributed to *Peridinium.*	Smith (1908)

Annex A. (continued)

Country	Date	Report	Source
	1976	The marine red tides from Sabah entered the Tawi-Tawi Island group. Dead fish observed; no fatalities.	Tamesis (1976)
	June-Sept. 1983	Vast red tides through Samar Sea caused by *Pyrodinium bahamense* var. *compressa*. Several hundred affected, officially about 20 dead, mostly from eating fish, *Rastrelliger, Sardinella*, and mullets — one instance milkfish (*Chanos chanos*).	Hermes (1983) Hermes and Villoso (in press)
	Annual March-May	Red tide like blooms of *Peridinium* cf. *quinquecorne* Abe in Maribago Bay, Cebu. Only in bright sunlight, otherwise sessile, attaches to substrate.	Horstmann (1980)
Sabah	Jan.-March	A total of seven children died, another 195 ill in three incidents of shellfish poisoning near Kota Kinabalu and in Brunei Bay.	Roy (1977)
		Pyrodinium bahamense var. *compressa* responsible. Red tides and dead fish prevalent. Blooms went to a depth of 8 m; extremely low oxygen tension especially below 10 m, H_2S smell below 10 m with large numbers of decomposing organisms; thermocline 5-6 m deep. All invertebrates (including corals) and most fish killed at some reefs.	Wood, personal communication
		Red tide disappeared at the end of April, toxins negligible by mid-June.	Snell (1977)
	Mar. 1977	Red tide sighted. *Meretrix* spp. clams very toxic	
	April-May 1980	Red tide noted end April in Brunei Bay. On 17 May, two children died and about 30 others affected — all Vietnamese refugees on an island set aside for them.	Sabah Department of Fisheries (1980)
	19 June 1980	Red tide again in Brunei Bay.	Ting Thieng Ming, personal communication
	30 December 1980	Red tide in Brunei Bay.	
	28 January 1981	Brunei Bay red tide still present.	
	November 1983	Four children died and five hospitalized from PSP.	
	7 January 1984	Two children died, six given emergency treatment for PSP.	
	15 March 1984	Five children died, three hospitalized. Bivalves associated with the November 1983-March 1984 deaths found highly toxic. No red tides seen since 1981.	
Samoa (Western)	June 1983	Dinoflagellate bloom at experimental mussel farm, Asau Bay. No ill effects on those eating raw mussels.	Bell et al. (1983)
Solomon Islands	?	Shellfish poisoning resembling paralytic shellfish poisoning have been confirmed.	Yasumoto et al. (1984)
Thailand	Annual	Red tides more common from late January to August. Common in the inner sector of the Gulf of of Thailand.	Piyakarnchana et al. (1984)

Country	Date	Report	Source
	May 1983	Red tide along Chonburi to Chanthaburi province coastlines. Bad odour and caused fish kills in nearby fish farms.	
	May-July 1983	PSP outbreak in Prachuab Kirikhan province. 60 severe cases, 1 death. First reported occurrence in Thailand. *Protogonyaulax, Gymnodinium,* and *Peridinium* in blooms, but *Noctiluca miliaris* dominant in estuaries.	National Research Council of Thailand and Srinakharinwirot University, Bangsaen (1984)
	September 1983	*Ceratium furca* red blooms in the inner Gulf of Thailand.	
	December 1983	*Dinophysis caudata* caused red blooms in the inner gulf along the northern coastline. Some children ill from bivalves (not PSP, however).	
		P. bahamense var. *compressa* in plankton in Andaman Sea near Phuket.	F.J.R. Taylor, personal communication.
Tuvalu	Annual?	Periodic red tides in Nanumea lagoon cause fish die-offs.	Uwate et al. (1984 quoting Fisheries Development Limited 1976)

Annex B. A Bibliography on Toxic Red Tides and Shellfish Poisoning Related to the Indo-Pacific Region[1].

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Introduction

References to toxic red tides in the Indo-Pacific mainly concern the dinoflagellate *Pyrodinium bahamense* var. *compressa*. The literature is small because the organism was not discovered in the region until 1972. It is appropriate to compare this variety with the other variety of the species in the Red Sea and central America, *P. bahamense* var. *bahamense;* a separate reference list on this variety is provided.

Even more recently, the causative agent of the ciguatoxin-type poisons was found to be a benthic dinoflagellate, *Gambierdiscus toxicus*. Elements of this family of poisons are found in the Indo-Pacific in shellfish-poison type dinoflagellates, crustaceans, molluscs, and fish. A selection of references on this subject is also provided.

Finally, new — for the region — red tide dinoflagellates are implicated in recent poisonings in the Gulf of Thailand. This bibliography will be enlarged to include relevant references when the species concerned have been identified.

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