



HARMFUL ALGAE NEWS

An IOC Newsletter on toxic algae and algal blooms

No. 18

◆ China and Hong Kong

An unusual year for the occurrence of harmful algae

The Year 1998 has been a special HAB year for mainland China and Hong Kong. There was a huge toxic algal bloom which covered almost all Hong Kong and nearby south China waters in March and April, caused by *Gyrodinium aureolum*(?), followed by some smaller HAB events caused by *Alexandrium* sp. and *Cocholodinium polykrikoides* at the

same time. They are thought to be the most devastating HABs in the history of Hong Kong, affecting about two-thirds of the fish farms and causing losses estimated at HK\$350 million (about US\$ 42 million). In early May, another algal bloom occurred in Hau Hoi Wan. The causative species was *Gyrodinium ins-triatum*. A bloom of *Ceratium furca* oc-

curred in Port Shelter in September. The most recent red tide was caused by *Mes-odinium rubrum* in early November. Seven beaches were closed to the public due to the red tide. A new HAB record was created in mainland China in September 1998, when *Ceratium furca* cov-

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Hong Kong fish farmers are cleaning fish farms and surrounding waters (article by Yang and Hodgkiss page 4)

◆ Mediterranean

A new PSP-like toxin in *Alexandrium andersonii* (Dinophyceae)

During an investigation on dinoflagellate cyst production in the Gulf of Naples (Tyrrhenian Sea, Mediterranean Sea), spherical, smooth-walled cysts,

which germinated into *Alexandrium andersonii* Balech, were recorded in July-September (1). *A. andersonii* is a small-sized species, which differs from *A.*

minutum in only a few minor morphological characters: the peculiar shape of

(Cont'd on p. 3)

◆ Hong Kong

A *Gymnodinium mikimotoi* occurrence spring 1998

The first reports of *Gymnodinium mikimotoi* came from an upwelling area off the coast of Xiamen China just south of Taiwan in an area referred to as “Nan-ao”. Near the northern border of Canton (Guangdong Province) between the coastal cities of Swatow and Chichyang is a group of islands where upwelling from the deep waters of the Bashi Channel brings nutrients to the fishing grounds of this area. According to the Chinese Press, *G. mikimotoi* was first reported in this area in late February of this year. The next report of this species was on 19 March when a chocolate brown to reddish brown bloom was reported by the Agriculture and Fisheries Dept. personnel (who identified *G. mikimotoi* as the dominant organism) from Crooked Island (Fig. 1, area 1) in the northeastern sector of Hong Kong and three other nearby sites. By 18 March, *Gymnodinium mikimotoi* had reached densities of 210,000 cells per litre in Port Shelter. *Scrippsiella trochoidea* reached 81,000 cells/L and *Gymnodinium sanguineum* had reached 290,000 cells/L. By the following week (24 March) *G. mikimotoi* at Port Shelter had declined to 34,000 cells/L and *Scrippsiella trochoidea* to 40,000 cells/L. On 27 March the bloom of *G. mikimotoi*

had progressed to two new sites in the Sai Kung Peninsula (Fig. 1, area 2). On 1 April, a diatom pulse occurred at Port Shelter with *Pseudonitzschia* and *Chaetoceros* species forming the dominant genera. A week later *Noctiluca*, the giant dinoflagellate, reached densities of 10,000 cells per litre and by 14 April *Gymnodinium mikimotoi* had returned to Port Shelter and reached densities of 270,000 cells/L with a standard deviation of 43,000 cells/L for three replicate counts.

By 12 April, the Hong Kong press had reported that the worst red tides this decade had wiped out hundreds of thousands of fish (1,500 tonnes of fish stocks, the equivalent of half the entire amount produced in Hong Kong waters last year and more than all the chickens killed in Hong Kong as a result of the Chicken Flu virus which struck Hong Kong in November, 1997). Fish in holding pens (mariculture cages) were killed when mucus produced by *Gymnodinium mikimotoi* coated their gills resulting in their asphyxiation. The government estimated breeders’ losses at HK\$80 million (US\$10.3 million), but fish farmers claimed the figure was at least HK\$250 million. About 1,000 of Hong Kong’s 1,500 fish farms were devastated by the

red tides. Red tides usually subside in a few days, but this one “has spread out like an infectious disease,” said Hong Kong Fish Culture Association Chairman Wong Yung-kan.

According to Dominic Lau (Hong Kong, April 15, Reuters) – Hong Kong’s health chief, Margaret Chan, director of health, told reporters that anybody who decided to eat the sea fish should remove the gills and innards. Considered a delicacy by some, these parts could contain toxins if affected by the algae according to Margaret Chan. Hong Kong leader, Tung Chee-hwa visited some of the fish farms on outlying Lamma Island on Wednesday (April 15) to see the damage. Christopher Cheung of the Hong Kong Fisherman’s Association said, “The government does not know the whole picture,” he said. “Fish are continuing to die and losses are going up every minute. I think the whole industry will collapse because waters inside and outside of Hong Kong are covered by this algae.”

By 10 April, the *Gymnodinium mikimotoi* had reached Lamma and Lantau islands. The surface waters at Mo Tat Wan on Lamma Island (fig. 1, area 3) were sampled on 15 April, 1998 by Manna Wan. *Gymnodinium mikimotoi* had reached densities of 102,000 cells/L and *Prorocentrum sigmoides* (8,300 cells/L) and *Proto-peridinium* species (4,500 cells/L) were rare by comparison. Government scientists reported *Gymnodinium mikimotoi* densities in the millions of cells per litre but we did not observe such high numbers in our weekly surface water samples from Lamma Island and Port Shelter. By 15 April, many of the Lamma Island fish farmers had moved their enclosures from Sok Kwu Wan to the deeper more open waters of Mo Tat Wan. By 21 April, strong winds had begun to disperse the bloom and fish farmers began moving their fish enclosures back to Sok Kwu Wan.

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ered 3,000 square kilometres in Bohai Bay; it persisted longer than any previous bloom.

The year has also been an unusual year in terms of the seasonal distribution of toxic and harmful algal species in Hong Kong waters. In regular years, the most toxic algae, especially unarmored dinoflagellates, are abundant in spring, mostly from March to May, and are scarce in summer. But this year, toxic or harmful species were present almost throughout the year in Junk Bay, in south east Hong Kong. The number of toxic or harmful species in summer was even higher than in spring. These included *Alexandrium catenella*, *Alexandrium* sp., *Chattonella antiqua*, *Ch. marina*, *Chrysochromulina* sp., *Gonyaulax polygramma*, *Gymnodinium catenatum*, *G. breve*, *G. sanguineum*, *Gyrodinium instriatum* and *Phaeocystis pouchetii*.

There are 'rich resources' of harmful algae in Hong Kong waters and, so far, most of the known harmful algal species have been found here. Hong Kong has been, and is constantly facing the threat of HABs, since the causative species are there and can bloom whenever there are suitable environmental conditions. But, why has this year been the record year for HABs in both mainland China and

Hong Kong, and why were toxic species so abundant this summer?

Statistics from the Hong Kong Observatory show that 830.2 mm of rain fell between January and May, 213.8 mm more than the seasonal norm and 205.1 mm more than in the same period last year. This heavy rain increased the input of nutrients into the sea and, together with the effect of water temperature changes, HABs could be easily formed. These events could well have been connected with the effects of El Nino this year.

Toxic algae new to Hong Kong

Gambierdiscus toxicus

Ciguatera is one of the most common forms of seafood poisoning in Hong Kong. About 100 people were reported to be sick after being poisoned by coral fish last year. So far this year, at least 3 ciguatera poisoning events have been reported and 72 people were involved. The majority of marine fish consumed in Hong Kong are imported from overseas and, according to government figures, 76 percent of fish eaten last year was imported. Most of the locally produced fish is cage cultured and so it was considered that the poisoned fishes came from other countries.

The origin of the ciguatoxin is believed to be *Gambierdiscus toxicus*, a

tropical dinoflagellate growing in association with corals and seaweeds. This species is widely distributed in tropical waters, but has not previously been reported from Hong Kong waters. In the summer of last year and again this year, *Gambierdiscus toxicus* was found in Junk Bay east of the Kowloon Peninsula.

Phaeocystis pouchetii

In November and December 1997, there was a huge *Phaeocystis pouchetii* bloom in the waters of north Guangdong Province and south Fujian Province, China. It killed thousands of caged cultured fish in the area. During the bloom, there was a thick layer of foam; the diameter of the gelatinous colonies was as large as 2 to 3 cm. The water looked like "dead water" when the blooming took place. *Phaeocystis pouchetii* is a cosmopolitan species. Blooms caused by this species were frequently reported in cold water areas such as north Europe, but blooms in subtropical waters have rarely been documented. The species is a newly identified one in Hong Kong waters. It was isolated from Junk Bay in September 1998, and is now in culture.

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the 6th precingular plate (6'') and the anterior sulcal (S.a.) platelet (2).

A. andersonii has been described from the coastal waters of the eastern United States and, to our knowledge, the finding of this species in the Mediterranean Sea represents the first report outside its type locality. This species was reported as non-toxic (2, 3); however, our preliminary investigation carried out on culture material from the Gulf of Naples has revealed the presence of PSP-like toxins.

A. andersonii was grown in K medium without silicates, at a temperature of about 20 °C, and a photon flux rate of 100 mmol photons m⁻¹ s⁻¹. Late exponentially growing cells were concentrated with a tangential flow filtration system, and centrifuged to obtain a pellet. The pellet was resuspended in an

equal volume of 0.5 N acetic acid and subjected to three successive 20s sonifications. Supernatant obtained after centrifugation (3000 g, 20 min) was injected intraperitoneally into CD-1 Swiss male mice (19-20 g). The injection produced visual signs resembling the effect of paralytic shellfish poisoning (PSP) produced by some *Alexandrium* species. Death occurred a few minutes after injection. HPLC fluorometric analysis, based on alkaline oxidation of the PSP toxins to fluorescent derivatives, was carried out to detect the presence of dinoflagellate PSP toxins. Three different isocratic conditions were adopted for the toxins, based on their basicity (4), using authentic PSP toxins as references. However, the retention times of the standard disagreed with those of toxin(s) present in our sample, thus suggesting the occurrence of a new PSP toxin in this Mediterranean strain of *A. andersonii*.

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◆ Hong Kong

Massive fish killing by *Gyrodinium* sp.

In March through April 1998, a massive red tide occurred in south China, including Hong Kong, coastal waters. This red tide covered a huge area (Fig. 1). It was reported that the red tide started from Nanao, which is located in the Shenzhen Special Economic Region of China, the other side of Mirs Bay. It showed up in Hong Kong waters on 18 March at Crooked Island. It then travelled southward to Grass Island, the Portshelter area at Saikung and Tung Lung Chau, reaching, by the beginning of April, the south and southwestern waters of Potoi Islands, Lamma Island, Cheung Chau Island, Soko Islands, and Mainland China's Wanshan Islands and Guishan Island, from where it continued up to the mouth of the Pearl River. This red tide event infected a large area and lasted for more than one month. By 20 April, it was reported to be declining and was predicted to have no further momentum to distribute on a large scale.

The deleterious effect and economic loss

Wherever the red tide passed it killed fishes, leaving scenes of fish farms as shown in the photo on the front page. The fish kills were claimed to show no

discrimination, including, as claimed by the farmers, coral-trouts, coral cods, grouper, giant grouper, yellow grouper, brown spotted grouper, mud grouper, tiger grouper, mangrove snapper, red snapper, russell's snapper, sea-perches, Japanese sea-perch, seabream, black seabream, gold-lined sea bream, head grunt, eel, red pargo, yellow croaker, purple amberjack, and pampano. The red tide killed not only various kinds of caged fishes, it was also reported to affect nearly all kinds of natural coral fishes and killed some of them. Some fishes were claimed to have disappeared from the area they used to inhabit; butterfly fish for instance.

By 17 April, about one month from the start of the bloom, the red tide had invaded nearly all corners of the coastal waters of Hong Kong, including 22 of the 26 fish farms and 5 bathing beaches. In Hong Kong alone, 1,260 fishery households were affected, 2,500 tonnes of fishes were killed, and a direct economic loss of 250 million HK\$ was estimated by the fish farmers. In Mainland China's Guangdong waters, it was reported that by 17 April, this red tide had killed more than 260 tonnes of fishes, causing a direct economic loss of about 40 million Yuan RMB.

Changes in meteorological and hydrochemical parameters

Normally, during the winter period (October – March), Hong Kong coastal waters are influenced by two water masses (Williamson, 1970), the North China Coastal Water (Taiwan Current) which is characterised by moderate temperatures ranging from 19-23°C and salinities from 31-33 ppt, and the Kuroshio Current which originates in the Pacific and enters from the Luzon Straits and is characterized by high temperature (26-29°C) and high salinity water (34.4-35 ppt). Due to the El Nino event, this year's weather was characterized by a higher than normal air temperature and a higher volume of rainfall. From February 1998, wet, cloudy and foggy weather brought in by maritime airstreams was followed by a cold front and storms, and then an irregular short period of sunny days. These weather types formed a circle and were recircled several times. From February, Port-Shelter water started to become green to dark and an increasing trend of algal growth was recognized. Entering March, the weather was mainly cloudy with strong easterly winds affecting the coastal areas on the first two days. Winds moderated on 3 March before a band of squally and thundering showers accompanying a cold front swept across Hong Kong on the morning of 4 March. It became fine and clear the next day but clouds returned in the evening. Easterly winds freshened during the day on 6 March. Due to the maritime airstream, fog formed on 7 and 8 March. The next day it was very warm and the weather was cloudy with some showers. On 10 March, a cold front accompanied by rain passed across the coast of Guangdong. A northerly wind became strong offshore in the evening and moderated gradually the next day. And, on 12 March, it became cooler and temperature dropped to 12.4 degrees, the lowest in the month. On 17 March, the day on which red tide was reported from Nan-



Fig. 1
A direct loss of 250 million HK\$ was estimated by Hong Kong fish farmers

ao it became foggy, and this lasted for several days. On 18 March when the red tide was reported first from Crooked Island fish farms, red tide could also be recognized in situ at our sampling station located in Port-Shelter. Laboratory counts showed a concentration of the fish killing species at about 2×10^5 cells/L. A fast increase in sea surface water temperature was also recognized at this time, which is earlier than the rise in air temperature. The sea surface water temperature kept rising until the mid of May while the air temperature started to drop on 20 March. This may have indicated the influence of warm Pacific water brought by the Kuroshio Current. We believe that it was this current that triggered the algal bloom. Moreover, both the Kuroshio Current and the Taiwan Current during this time helped form a northeast to southwest coastal water flow that distributed the red tide over such a wide range.

The occurrence of the red tide event this year coincided with records of similar red tide occurrences in the past, as described by Wong (1989): "in September, 5-10 days before the bloom there were usually tropical depressions with strong wind and heavy rain followed by warm sunny weather for a few days. In December, the weather pattern usually involved a cold front with strong wind followed by some rain and then a fine sunny period".

Causative species

The causative species has been studied morphologically using light and scanning electron microscopy. It superficially resembles *Gyrodinium aureolum* from the eastern coast of America and northern European coastal waters, and *Gymnodinium mikimotoi* from Japanese waters. However, it is different from them in certain aspects. A detailed description of the species is under preparation.

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Announcement

Proceedings of the 8th International Conference on Harmful Algae is now available. It is published jointly by the Xunta de Galicia (Spain) and the Intergovernmental Oceanographic Commission, IOC.

The advantage of the joint effort is that this 630 page publication is available at a very low price. To libraries and laboratories in developing countries it is free of charge. For all others there is a 30 USD handling fee.

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◆ USA

A toxic bloom of *Pseudonitzschia Australis* in Monterey Bay, California

These days just about everything that goes awry is blamed on El Niño. Should we add a toxic bloom of *Pseudonitzschia australis* with associated sea lion illness and mortality to the list? Good question.

I've had lots of reporters ask me if I think this is so, and since I could not give a definitive answer^{1/4} the question quickly became something like, "Are sea lions suffering because irresponsible farmers are polluting our waters?" My response in this case: "No comment – we need more data." Well, that was good enough for the local papers, but as the National Ocean Conference got underway in Monterey, California, with both the President and Vice President in attendance, television crews scurried about for environmental news that would make headlines. Let's see, toxic algae killing marine mammals in a National Marine Sanctuary – not bad. So when the television crews came I spoke of increased awareness, of the fact not all blooms are necessarily linked to human activities, and the challenge being to sort through all the possibilities to understand what REALLY drives these events. After all, you've got your chemistry and physics, your bottom-up and top-down controls, and so on. "Interesting," said the media, "forget chemistry and physics for now, but how about global warming – did the sea lions die because of global warming? Is that what made those toxic cells go crazy...?"

No doubt that Monterey Bay did experienced about a 2-3 week bloom of *Pseudonitzschia australis* in the latter half of May that reached its peak in one sample at 200,000 cells per litre. Concentrations of domoic acid thus far appear to rise and fall in concert with those cells (G. Doucette et al., unpubl. obsv.). It seems that *P. australis* may have been at the right place at the right time. A small storm passed through the Monterey Bay region dumping rain and churning the waters that had been supporting a mixed assemblage of diatoms and dinoflagellates, including toxigenic *Alexandrium catenella*. The storm passed, the sun shone bright and the rivers and streams

continued to pump fresh water with nutrients into the near shore environment. Within a few days the concentration of *P. australis* rose sharply, but the cells were restricted to the immediate near shore region of the Bay. The nearly mono specific bloom increased in size covering a larger portion of the Bay, but nevertheless remained close to shore. On the water one could observe slicks of cells – dense patches – that smelled quite strongly. Little upwelling was observed during this time (F. Chavez et al., pers. comm.), suggesting that source of nutrients fuelling the bloom was of terrestrial origin. The latter possibility remains an active topic of study at present.

With the *P. australis* bloom in full swing, anchovies helped themselves to what must have been welcome feast. Indeed, the stomachs of anchovies collected during the peak of the bloom are packed with *P. australis* frustules (M. Silver and P. Miller, unpubl. obsv.), and as might be expected the fish were toxic too (50 –250 ppm domoic acid for whole fish; Susan Luscatoff. pers. comm.). At about the same time, there were reports of sea lions suffering from symptoms that included seizures, disorientation and unresponsiveness to human presence, even death. It is now clear that at least some of those animals suffered from domoic acid poisoning (F. Van Dolah, G. Doucette, V. Trainer, F. Gulland, and many others were involved in this work – I'm sure we'll hear lots more about this in the near future). As far as I know, this is the first documented case of marine mammal mortality linked to domoic acid. What also makes this event unique is that we were able to track the evolution of the bloom in real-time using species-specific DNA probes in both whole cell and cell homogenate formats, and the response of the cells towards the probes can now be viewed in light of measured amounts of toxin as well as prevailing nutrient regimes, etc. More detailed information about the latter is forthcoming. For now, suffice it to say that the probes allowed us to see the early stages of the bloom that might otherwise have escaped detection, and by knowing what was growing in the water

we were able to offer a possible explanation for the rash of sea lion illnesses.

Although we may never be able to say exactly what drove the *P. australis* bloom, what we can say is that domoic acid remains a potential threat to humans and wild life and can not be ignored, El Niño or not.

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◆ USA

Domoic acid poisoning afflicts sea lions and birds

This past May, approximately 72 sea lions suffering from gran mal seizures, disorientation, diarrhea, and vomiting, were treated at The Marine Mammal Center in Sausalito, California. Of those treated, about 50% have died. The exact number of dead animals that have washed ashore remains unknown. The strandings began in mid May 1998 in San Luis Obispo, located on the central Californian coast, but seizing sea lions have since been found on several beaches to the north in Santa Cruz and Monterey counties. In addition, dead sea birds have been observed in Monterey Bay and the Gulf of the Farallones. Unlike California sea lions and northern fur seals that have been washing ashore emaciated as a result of El Nino, the animals which stranded in this event were in good physical condition with normal blubber depth.

Initial autopsies of the dead sea lions turned up no obvious cause of death although lesions were noted in brain tissues. Lesions, along with other symptoms exhibited by the sea lions, indicated that these animal illnesses and deaths may have been related to a recent bloom of the diatom *Pseudo-nitzschia australis* which produces domoic acid. *Pseudo-nitzschia* spp., were found in high concentrations (up to 200,000 cells per litre) in Monterey Bay, and was also present in the guts of anchovies, a primary prey of sea lions.

After completing several blood, tissue, and other biological tests, investigators now believe domoic acid to be the probable direct cause for the event and not El Nino, chemical human pollutants or an infectious disease. Post-mortem examinations of these animals revealed lesions in particular sections of the brain that are consistent with known effects of domoic acid. The National Oceanic and Atmospheric Administration's (NOAA) Coastal Ocean Program helped to direct the scientific response to the domoic outbreak. Biotoxin analyses were performed by both NOAA's National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center and the National Ocean Service (NOS) Charleston Lab resulting in four confirmed positive results for domoic acid. The

NOS Charleston Lab stated that although a positive test result for domoic acid is a sure indication of exposure to the substance, a negative finding is not necessarily indicative that an animal was not exposed. This statement is based on findings in experimental exposures of domoic acid in mice, where the toxin metabolizes in about four hours.

The Marine Biotoxin group from the Northwest Fisheries Science Center, the Channel Islands National Marine Sanctuary, and California Fish and Game have been conducting research cruises since June 5. Researchers are focusing in the areas of reported sea lion and bird mortalities from Monterey Bay to Point Conception, CA, to trace the algal bloom temporal and spatial progression. *Pseudo-nitzschia* has been observed along the coast, particularly south of Point Conception during the first two weeks of June. Another research cruise by Dr. Barbara Prezelin (UCSB), was underway at the end of June and will continue to collect samples for additional analyses.

Researchers will be sampling for algal cells, toxins (both domoic acid and saxitoxin), nutrients, chlorophyll, salinity, temperature, and trawling for planktivorous fish, the primary prey item of pinnepeds. Information exchange and coordination between in-place state and Federal monitoring programs for water quality, shellfish, and fish is on-going. Real-time remotely sensed chlorophyll distributions are also being sought to further document spatial distributions of the dense aggregations of *Pseudo-nitzschia* spp. through time.

(The Monterey Bay Aquarium Research Institute and the National Marine Fisheries Service Northwest Fisheries Science Center contributed to this article)

Fish kills on Florida's east coast may be linked to *Cryptoperidiniopsis*

The Florida Department of Environmental Protection (FDEP) is continuing to investigate a fish disease event on Florida's east coast. Diseased mullet

were first reported to the FDFP Fish Kill Hotline on March 2, 1998. Anglers have reported 33 species of fish with lesions, with the majority being mullet. The range of affected fish is from the Ponce de Leon Inlet near New Smyrna Beach to North Palm Beach, but the majority of the reports have been from the St. Lucie estuary. Many potential factors in the fish disease event are under investigation by numerous federal, state, and local agencies including: overall water quality, pesticides, heavy metals, toxic dinoflagellates, fresh water inflow from Lake Okeechobee, and disease agents such as bacteria and fungi. FDEP is investigating the potential that several factors are interrelated.

Cryptoperidiniopsis, a dinoflagellate, first found in June 1997 in the St. Johns River near Jacksonville, FL by FDEP researchers, has been found at five sites in the St. Lucie estuary (Roosevelt Bridge, Jaycee Park on the Stuart Causeway, Bird Island, northern Hobe Sound, and South Point. This dinoflagellate, a type of microscopic algae, is a possible factor in the on-going fish disease event because it was also found in areas in Maryland where fish with lesions were found last summer. All samples are being screened for known and new species of dinoflagellates. FDEP has also found other small dinoflagellates that may play a role in this fish disease event. Each of these species is being identified and will be tested for potential toxicity.

The FDEP laboratory in St. Petersburg has received over 400 fish representing 22 species from the east coast. The severity and types of lesions are being characterized and documented. Selected specimens are further analyzed to look for microscopic changes in the fish tissue. Specimens of mullet and jacks with lesions have been sent to Texas A&M University for analysis of pesticides and heavy metals. Samples of other species with lesions, unaffected species, and healthy specimens of affected species were sent for analysis the week of May 18. Results of these analyses will be made available when they are completed. Water and sediment are being tested for pesticides and heavy metals at the FDEP Central Laboratory in Tallahassee, and for bioactive compound testing at NOAA's National Ocean Service Charleston Lab. In addition, NOAA's Coastal Ocean Program is providing funding for identifying *Pfiesteria*-like organisms. Historical water

quality data collected by several agencies are being analyzed by researchers and compared with current information.

Bacteria isolated from the fish have primarily been those types normally found in fresh water. Fungi were found in the ulcers in mullet collected in early March and are believed to be saltwater species. These bacteria are primarily opportunistic pathogens. This means they are not a problem for fish except under unusual conditions or stress. Bacteria isolated from fish kidneys appeared to be in the process of being excreted by the fish. The only organisms that appeared to be involved in the actual formation of mullet ulcers were the fungi. No one type of bacteria has so far been implicated in causing the ulcers observed in the different species of fish, although many of the bacteria isolated may be contributing to the problem. Towards the end of March, and in both April and May, other bacteria indicative of terrestrial runoff were also found in the fish and water samples. Normal freshwater bacteria however, predominated in the samples. Samples are still being analyzed.

During the week of April 20 fish populations in the lower Indian River Lagoon and the St. Lucie River were sampled. Established FDEP Fisheries Independent Monitoring (FIM) sampling protocols were used to obtain a statistically valid "snapshot" of the fish populations. Each of 5,825 fish caught in the 41 hauls of a 600 ft. seine was identified to species, measured, and examined for any external damage, abnormalities or lesions. Overall, 97% of the fish caught were healthy and only 45 fish had lesions (0.77%). In the St. Lucie River area, 925 fish were caught and 39 fish had lesions (4.22%). Any fish showing abnormalities were transported to St. Petersburg for further analysis. Additionally, the number and variety of fish caught in the Indian River sites were similar to those collected in sampling previous to the fish disease event. This type of sampling has not been conducted in the St. Lucie River so numbers are not available for comparison.

(The Florida Department of Environmental Protection contributed to this article)

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◆ South Africa

Brown tides on the west coast

Saldanha Bay is a semi-enclosed embayment which is linked to the Benguela upwelling system on its western side and feeds Langebaan lagoon, a shallow tidal body of water, situated at the southern end of the Bay (Figure 1). Both systems are suitable for mariculture, not only because they offer the protected waters often necessary for cultivation, but their strong link to the highly productive west coast upwelling system ensures a food environment and temperature regime optimal for the farming of shellfish.

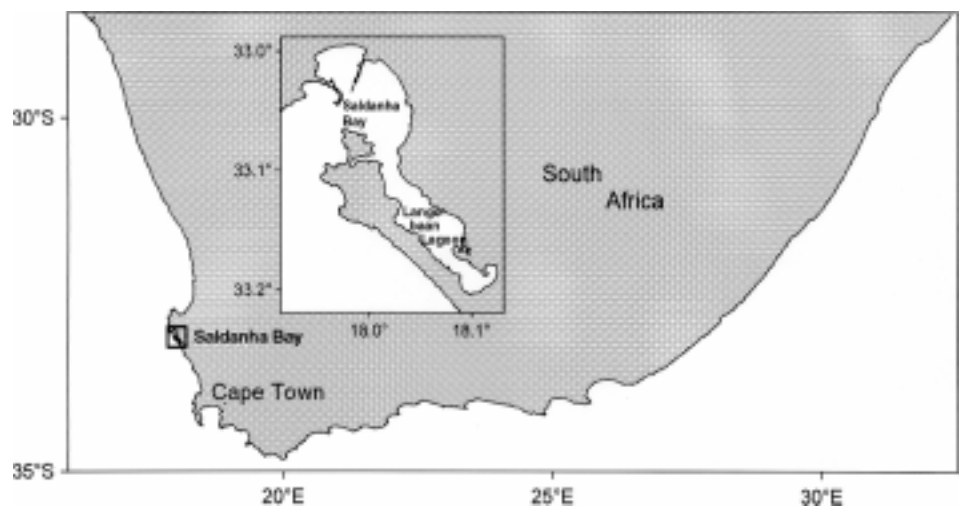
During the latter months of the summer of 1997, oyster farmers in Saldanha Bay complained of discoloured water and reduced oyster growth rates, and inspection of water samples revealed the presence of many minute (2-3 mg), coccoid, non-motile cells. Again during the latter months of the summer of 1998 similar complaints were received. On this occasion queries and complaints were also received from the public and from conservation groups as the entire Saldanha Bay and Langebaan Lagoon turned a very unusual and distinct golden brown colour. The same non-motile coccoid cells were again evident on examination of water samples.

In further examining the 1998 event it was difficult to establish exactly when the bloom manifest itself within the Bay and Lagoon. Although the bloom was

first reported on the 11 February 1998 it is thought that the bloom may have been present for some time before this date. Oyster harvest figures from the farm *Seafarms* clearly depicted the impact of this bloom on oyster growth (Figure 2). The oyster farm operates by continually sorting and harvesting oysters greater than 50 g mass. For the period November 1996 – May 1998, two periods of reduced harvest in addition to the seasonally induced low in winter were evident. During both years the harvest was lowest during February and March when the bloom was present in the Bay. In 1998 when the bloom was particularly noticeable the oyster harvest and sales were extraordinarily low. In addition to the impact on oyster growers, mussel farmers were also negatively affected. Instead of obtaining typical yields in excess of 70 kg per rope for that time of the year, the yield of market size mussels in March 1998 dropped to about 20 kg per rope. Mussels also developed an uncharacteristic ridge on the shell during the period of the bloom indicating growth arrest during this period. Both oyster and mussel growth rates appeared to recover following the very sudden disappearance of the bloom on 18 March 1998.

At the level of the light microscope identification of the small coccoid cells so dominant in water samples was diffi-

Figure 1: Saldanha Bay a semi-enclosed embayment on the west coast of South Africa, linked to the Benguela upwelling system on its western side and feeding Langebaan lagoon at its southern end.



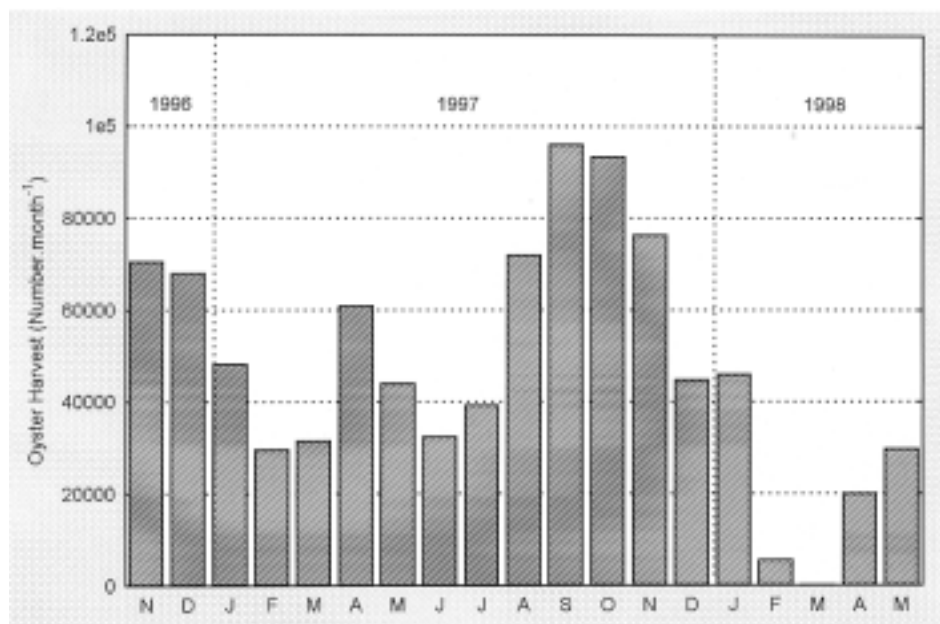


Figure 2: Oyster harvest figures from the farm Seafarms for the period November 1996 May 1998.

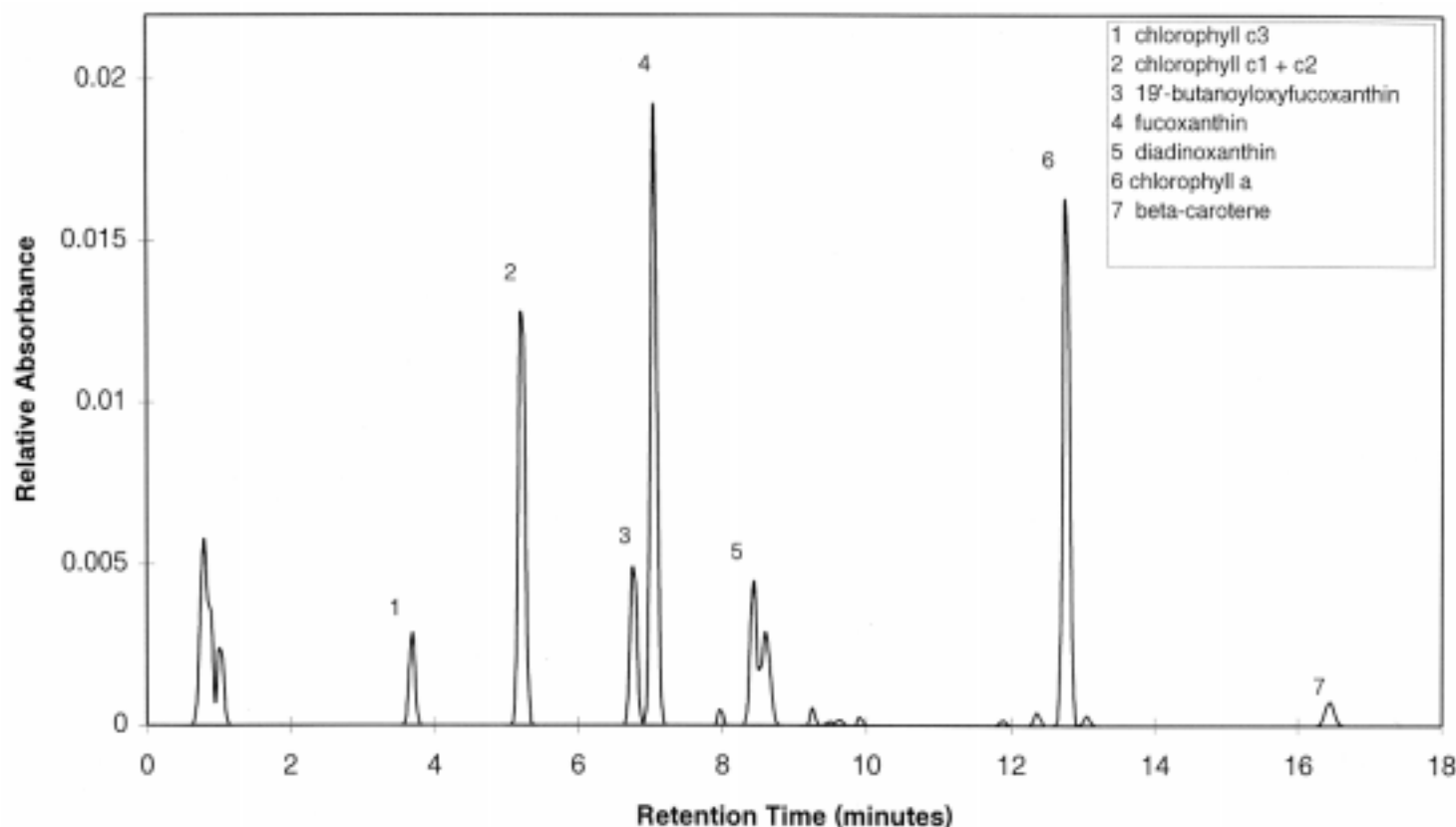
cult and further studies of this organism using transmission electron microscopy are ongoing (Figure 4[4]). Surface water samples collected during March 1998 from several localities within the Bay and Lagoon indicated that concentrations of the coccoid picoplankton ranged from $1.2-3.1 \times 10^9$ cells.l⁻¹ and corresponding chlorophyll *a* concentra-

tions from 21.3-41.0 mg.m⁻³. Although these small non-motile cells dominated the samples a species of *Chrysochromulina* was also common and in the only sample in which it was counted a concentration of 67×10^6 cells.l⁻¹ was recorded (Figure 4[1-3]).

Although the exact identity of the dominant picoplankton has yet to be established observations during this event were very similar to those during the so-called "brown tide" blooms, which have impacted coastal embayments along the

mid-Atlantic coast of the United States since the mid-1980s. These blooms were attributed to the Chrysophyte *Aureococcus anophagefferens*, which was found to inhibit bivalve grazing, including scallops and mussels, as a result of the production of toxic or at least inhibitory substances on the cell surface. *A. anophagefferens* and a few other Chrysophytes such as *Pelagococcus subviridis* are characterised by various pigments including certain chlorophyll *c* pigments, 19'-butanoyloxyfucoxanthin, fu-

Figure 3: Chromatogram of a Saldanha Bay sample collected during March 1998.



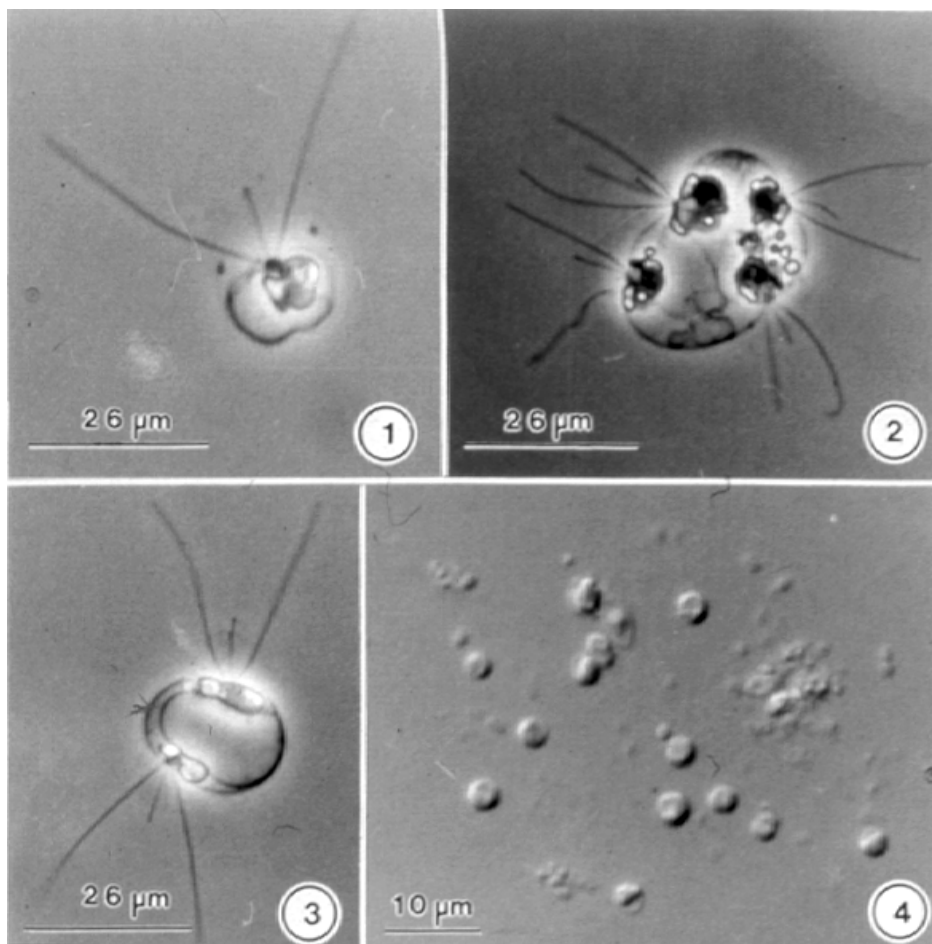


Figure 4: Light micrographs of (1-3) a *Chrysochromulina* species and (4) the small, coccoid, non-motile cells which together dominated the phytoplankton of Saldanha Bay and Langebaan Lagoon during February and March 1998.

coxanthin, diadinoxanthin, chlorophyll *a* and β -carotene. Analysis of Saldanha Bay samples by means of High Performance Liquid Chromatography revealed the presence of the same pigments including 19'-butanoyloxyfucoxanthin which distinguishes *A. anophagefferens* and *P. subviridis* from most other Chrysophytes which lack this pigment (Figure 3).

As was the case in the embayments of the United States, the reduced shellfish production in Saldanha Bay was most likely attributable to the small coccoid chrysophyte which dominated the phytoplankton. However, the possibility of the *Chrysochromulina* species, which was also a conspicuous component of the phytoplankton, impacting negatively on the shellfish cannot be discounted, as certain species of this genus are known to produce toxins. Few sites are suitable for mariculture on the South African coast and although present mariculture concerns in Saldanha Bay are relatively small, there is considerable

potential for expansion of shellfish culture. The entire mussel industry is for example located in Saldanha Bay where the mussel *Mytilus galloprovincialis* is cultivated on ropes suspended from rafts, and although various explanations and causal mechanisms for these brown tides have yet to be explored their recurrence may well threaten the future development of shellfish culture within this region.

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FIRST ANNOUNCEMENT



JUNE 19-24, 2000

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◆ South Africa

Saving a wetland and a marine mussel resource impacted by cyanobacterial hepatotoxins

In the first such incident recorded in South Africa, microcystins produced in a coastal wetland accumulated in black mussels, *Choromytilus meridionalis*, in the intertidal zone at the point of discharge of the wetland to the sea. This necessitated a four-month ban on harvesting, during which time a bold initiative was launched to eradicate the responsible cyanobacterium.

During late 1997, a partial collapse of the sago pondweed (*Potamogeton pectinatus*) community in the Wildevoelvrei wetland, situated on the west coast of the Cape Peninsula, south of Cape Town (see Map), resulted in a dense bloom of *Microcystis aeruginosa*. Shortly after the onset of the bloom, the hepatotoxins microcystin-YR and -LR were detected in freeze-dried algal extracts, and subsequently in the tissue of mussels collected from the reef adjacent to the wetland outflow to the sea (Figure 2). An immediate ban was placed on the collection of shellfish by a community relying on this resource for both food and income.

The Wildevoelvrei wetland, a shallow (mean depth = 1 m), 25 ha system comprised of two interconnected basins, receives between 4 and 7 megalitres of treated wastewater effluent per day and, as a consequence, is perennially-hypertrophic. The wetland is further threatened by the uncontrolled inflows of three large urban runoff carriers. As a consequence of this regulation, the wetland has lost both its seasonal character, and the beneficial effects of intermittent tidal ingress.

In order to eradicate the bloom of *M. aeruginosa*, an initiative, proposed by the author, was launched to temporarily enhance the salinity of the eastern basin of wetland through the addition of coarse rock salt. Alternative options to pump seawater were neither practicable nor feasible. Experience gained from other coastal lakes and estuaries in the region indicated that *M. aeruginosa* has low salinity tolerance, while the other, desirable components of the wetland biota could withstand an elevation of salinity levels to between 7 and 10 ppt for a short period.

After lowering the water level of the wetland, 600 tonnes of salt was added to approximately

50 000 m³ of water in the eastern basin (see Map). The salt was applied, in two 300 tonne batches, seven days apart, as a solid using aerial application from a purpose-built pallette transported by a helicopter, and in dissolved form via one of the clarifiers in the adjacent wastewater treatment plant. For the duration of the operation, effluent outflows from the wastewater treatment plant to the wetland were curtailed.

Salinities rose to 3.5 ppt after the first application, and to 8 ppt after the second. There was an immediate decline of the *M. aeruginosa* bloom, with the concentration of chlorophyll-a falling from 700 to 150 microgrammes per litre during the first week. Thereafter the cyanobacterium was replaced by a bloom of *Kirchneriella* sp., followed by a clear

water phase (chlorophyll-a less than 5 microgrammes per litre), dominated by chlorophytes and diatoms, together with the zooplankter *Daphnia longispina*. Salinities started to decline after 14 days, i.e. once it became necessary to once again release effluent to the wetland. The ambient salinity of the system had returned to zero by end-May.

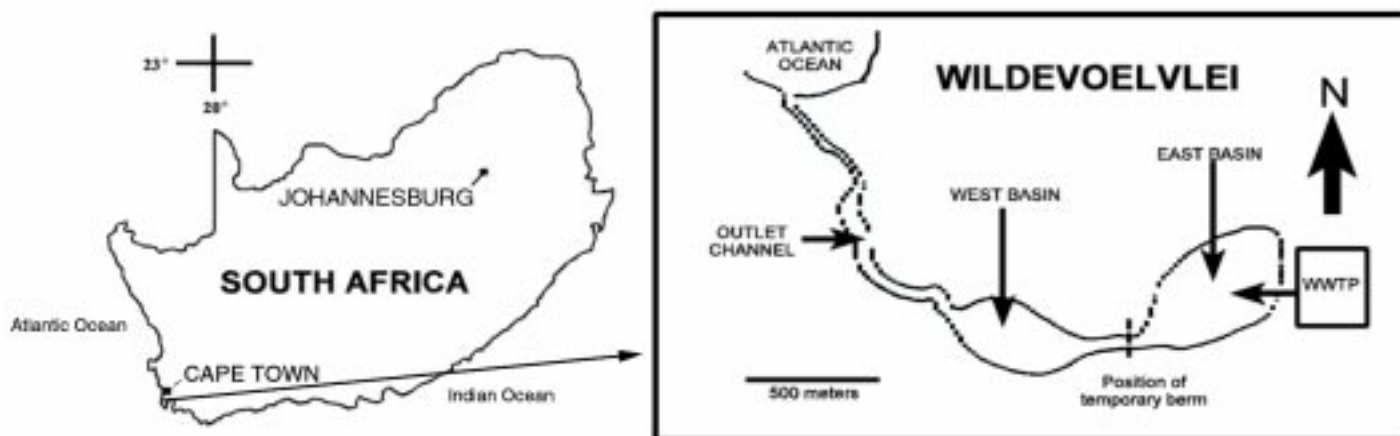
By the end of April complete depuration of the mussels had occurred, such that the restrictions on harvesting could be safely be lifted by end-May.

The bold use of artificial salinity enhancement on this scale demonstrated the value of this environmentally-sensitive technique for use in coastal lakes and estuaries where site-specific characteristics and logistics allow. The short-term elevation of the ambient salinity of this, previously-estuarine, system resulted in the rapid and total eradication of the toxin-producing cyanobacterium, and the concomitant alleviation of the risks to human and animal health in both the freshwater and marine environments. The application further highlighted the intrinsic value of retaining estuarine character and tidal interaction in coastal lake systems which have been modified through catchment development.

Dr William R Harding, Department of Scientific Services, Cape Metropolitan Council, P O Box 16548, Vlaeberg 8018, South Africa. e-mail: wharding@ctcc.gov.za

Figure 1:

Map showing the location of Wildevoelvrei in relation to South Africa, together with an insert showing the essential features of the wetland.



◆ International



INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
 COMMISSION Océanographique Intergouvernementale
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 МЕЖПРАВИТЕЛЬСТВЕННАЯ ОКЕАНОГРАФИЧЕСКАЯ КОМИССИЯ
 اللجنة الحكومية لعلوم المحيطات
 政府间海洋学委员会



SCOR

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

IOC and SCOR launches new science programme on HAB

From 13th to 17th of October 1998, 37 scientists including phytoplankton ecologists, physical oceanographers, algae-physiologists and marine chemists met at Havreholm, Denmark, to formulate the outline of a new international science programme on the ecology and oceanography of harmful algal blooms, - GEOHAB

The initiative for this new science programme is taken jointly by the IOC and the Scientific Committee on Oceanic Research, SCOR.

The ecological, economic and health problems caused by harmful marine microalgae are expanding. The HAB phenomena have many causes, both natural and anthropogenic, but what can be done about them in a practical sense? The answers, of course, require scientific investigation, and fortunately the community of scientists working on HAB problems has grown in size and skill in parallel with the expansion of the problem. To date, however, there is little effective international coordina-

tion of these efforts, at least in the realm of scientific research. What is clearly needed is a coordinated international scientific program on HABs that incorporates the full participation of numerous countries. The rate and extent of progress will depend in large part on how effectively the skills and energies

The participants at the SCOR-IOC GEOHAB Workshop, Havreholm, Denmark, October 1998. (The HAB research community is getting younger and younger....)



of the scientific community can be targeted on key problems. In particular, there is a need to understand the population dynamics of the toxic species, leading to predictive capabilities and management strategies, and, to the extent possible, mitigation plans. This requires a thorough understanding of the ecology and oceanography of harmful algal blooms.

Consequently, SCOR and the IOC have taken joint initiative for a new international science programme on the global ecology and oceanography of harmful algal blooms – GEOHAB. Along with several agencies in the US and in Europe, SCOR and IOC agreed that the first step was to bring together key researchers to agree on common objectives for this coordinated approach. The goal of the workshop was thus to develop consensus on the objectives and to draft a Science Plan for the proposed programme for approval by IOC and SCOR. Recently, the governing bodies of both the IOC and SCOR have endorsed GEOHAB as a new joint programme.

The focus of GEOHAB is squarely on ecology and oceanography. Beyond that, it is up to the participants to define the programme. The draft Science Plan is in essence a request to proceed, which is expected to lead to a much broader consultation to identify the major features of an international programme. The main purpose of the Havreholm Workshop was thus to set in motion a much larger and inclusive process aimed at developing an Implementation Plan as soon as possible. The Organizing Committee of the Havreholm Workshop was Don Anderson, John Cullen (Chair), Patrick Gentien, Edna Graneli, Kaisa Kononen, Tom Osborn, Adriana Zingone, Henrik Enevoldsen (IOC), Elizabeth Gross (SCOR), Kaisa Kononen (Nessling Foundation), Kevin Sellner (US-NOAA), Bjorn Sundby (SCOR), Phil Taylor (US-NSF), M. Carr (US-NASA).

The development of GEOHAB will be report in this newsletter including announcements of coming activities.

The Report from the Havreholm SCOR-IOC GEOHAB Workshop is available at

<http://www.phys.ocean.dal.ca/~jhurst/SCOR/GEOHAB/GEOHAB.html>

Additional information can be required from either the IOC at fax: +45 33 13 44 47, E-mail: hab@bot.ku.dk, or the SCOR Secretariat at fax: 1-410-516-4019, e-mail: scor@jhu.edu

◆ International

The fourth international conference on toxic cyanobacteria, Beaufort, North Carolina, 27 September-1 October 1998

Whether the maritime community of Beaufort, North Carolina, at times beset with problems with *Pfiesteria piscicida*, the attendant media interest, and hurricanes, was aware of the Fourth International Conference on Toxic Cyanobacteria in their midst, I am not sure. If so, they may have wondered, justifiably, “why us?” and “what next”? The reasons included the facts that Beaufort was an excellent location for a scientific conference and that the necessary experience and ability in the fields of cyanobacterial toxicology and ecophysiology were on hand (W.W. Carmichael, H.W. Paerl and colleagues) to attract and organise an international forum in these developing multi- and interdisciplinary fields. About 157 participants attended from 27 countries and about 50 oral papers and 65 posters were presented.

The Beaufort Conference differed from a series of recent triennial international meetings on cyanobacterial toxins due to its US location and to a broadening of interest and participation in relevant environmental, applied and management issues, in addition to advances in the basic science of the subject. Previous international meetings on cyanobacterial toxins over the past decade have been held in Europe and Australia. This has reflected a relatively high level of interest and action among environmental agencies, health authorities and water utilities/companies in the occurrence, properties and impact of toxic cyanobacterial blooms and the toxins in European and Australian environments and resources. The holding of the latest meeting in the USA has coincided with a noticeable increase (to this European participant) in the recognition and need for management of toxic cyanobacterial blooms and toxins in North America, taking into account the long-established core of US research expertise in the field. This was evidenced, for example, by the financial support and high level of interest of the US Environmental Protection Agency at the Conference, in

addition to the US National Oceanic and Atmospheric Administration.

Presentations were organized in the following sessions:

- Chemistry, Detection, New Toxins
- Cyanobacterial Toxin Regulation, Production, Degradation and New Approaches to the Taxonomy of Toxic Cyanobacteria
- Ecology, Toxic Waterbloom Formation and Biotic Interactions
- Toxicology, Health and Economic Consequences of Toxic Cyanobacteria
- Cyanobacterial Toxin Risk Factors, Occurrence and Management of Toxic Waterblooms.

A selection of developments, particularly since the previous international cyanobacterial toxins conference (Bornholm, Denmark, 1995) includes:

1, increased applications of molecular and computer-based methods to cyanobacterial taxonomy to complement the traditional phenotypic and environmental approaches (e.g. J. Komarek; B.A. Whitton; C.J.S. Bolch and S.I. Blackburn; J. L€ehtim€aki *et al.*, F. Pomati *et al.*, M. Gugger *et al.*, D. Schatz *et al.*, B.A. Neilan).

2, increased attention to the structure and activities of numerous cyanobacterial peptides in addition to microcystins and nodularins (e.g. R.E. Moore; K. Sivonen *et al.*; A. Forchert *et al.*; K-I. Harada *et al.*).

3, the analysis, fate and management of cylindrospermopsins, produced by *Cylindrospermopsis raciborskii* and *Aphanizomenon ovalisporum* (e.g. G. Shaw; R. Chiswell *et al.*; R.L.G. Norris *et al.*; M.J. Smith *et al.*; A.K. T€or€okn€e *et al.*).

4, the toxicological significance of cyanobacterial picoplankton. Toxicity associated with cyanobacterial picoplankton (e.g. *Synechocystis*, *Synechococcus*) is occasionally reported and the need to determine whether strains and mass populations of these common members

of the phytoplankton have the capacity to produce toxins exists (e.g. L. Blaha *et al.*; B. Oudra *et al.*), not least because these small cells can pass through some conventional water filtration systems.

5, advances in cyanobacterial detection and analytical methods. Although physico-chemical methods continue to be applied and occupy a central role, immunoassays, mainly for microcystins (and nodularins) are being used increasingly. These include ELISA using antibodies to microcystin-LR (e.g. W.W. Carmichael *et al.*; K.A. Beattie *et al.*; E.Y. Hirooka *et al.*) and CIPPIA, a microcystin immunoassay coupled to protein phosphatase inhibition assay (J.S. Metcalf *et al.*; S.G. Bell *et al.*).

6, advances in the basis and mechanisms of toxin production. The genetic and enzymic basis of microcystin production continues to be identified: a large gene cluster has been identified and cloned in *Microcystis* which is characteristic of microbial non-ribosomal cyclic peptide synthetases (D. Tillett *et al.*) and is involved in microcystin production in *Microcystis* strain PCC 7806 (E. Dittmann *et al.*; T. Börner *et al.*). A cyclic peptide synthetase operon has also been cloned from an *Anabaena* strain and characterization of the peptide product is in progress (L. Rouhiainen *et al.*).

7, identification and implementation of quality control procedures and standards for cyanobacterial dietary supplements. Although cyanobacteria have been used as traditional foods in ancient societies (e.g. China, Mexico, North Africa), the recent industrial scale of cyanobacterial biomass production for human dietary supplements, and increasing awareness of the occurrence and health significance of cyanobacterial toxins, have focussed attention on the need for policy development and procedures to ensure that cyanobacterial toxins, if present, are within acceptable limits. C. Drapeau and F.B. Gutermuth, and D.J. Gilroy and F.S. Chu presented posters on these needs and the actions now being established. The latter authors detailed the background to the establishment of (perhaps the world's first?) regulatory standard for a "safe level" for microcystins in cyanobacterial products, namely 1 microgram per gram dry wt, introduced by the Oregon Health Division in 1997.

8, policy development for the protection of health. One of the most obvious developments since Bornholm '95 was the

increase in interest which has been given at inter- and multinational level to the development of policies for the recognition and management of circumstances leading to the presentation of unacceptable health risks by cyanobacterial toxins. Previous national initiatives e.g. in the United Kingdom, Australia, Germany and the USA are now complemented by a World Health Organization development. The work of the WHO in developing "guidelines" for the protection of health has been extended to cyanobacterial toxins. The derivation in 1997 of a WHO (provisional) Guideline Value of 1 microgram of microcystin-LR equivalents per litre for drinking water was discussed (I.R. Falconer) and an outline presented by J. Bartram of a forthcoming WHO book on cyanobacterial toxins in water, to which a number of the Conference participants had contributed.

At times in the Conference, I was reminded of the films, which everyone must have seen, on the construction of an igloo. The blocks of packed and neatly-sawn snow are built up by the igloo-maker and the structure begins to rise and narrow to completion. As indicated at this Conference, blocks, the "wheres", "whens", "whats" and "hows" of cyanobacterial toxins understanding, are being identified and fitted. Many spaces between the adjacent blocks still need to be filled, an exercise of vital importance to turn an igloo from a circle of snow blocks into a strong, usable cohesive structure. The key element which is needed to hold the igloo together, and, if fashioned from a slab of ice, which can provide some light to the interior, is the uppermost, central "key" block. This latter can be considered to be the "why" of the cyanobacterial toxins "igloo" and a suitable block has yet to be found. There may be more than one reason for cyanobacterial toxin production and candidates (such as deterrence against grazers and intracellular signalling messengers) continue to promote speculation and experiment. However, understanding of the reason(s) for cyanobacterial toxin production remains inadequate and must surely remain as a major requirement in the subject. For the present, Wayne Carmichael and Hans Paerl and their colleagues are thanked for a most useful and enjoyable Conference.

Geoffrey A. Codd, Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, Scotland, UK, email: g.a.codd@dundee.ac.uk

Announcement

APEC-IOC Symposium on management and mitigation of HAB's Philippines, May 1999

The purpose of this Symposium is to facilitate the management and mitigation of the impacts of HABs. The symposium is a cooperative effort of several organizations, including APEC (Asia Pacific Economic Cooperation) and the IOC, which have recognized the need for focused programs on the management of HABs. It is intended that the symposium will provide managers with training and exposure to current methods and strategies used throughout the world for managing HABs and their diverse impacts. It is also intended that the symposium will provide the basis for compatible regulatory procedures.

The geographic emphasis of the symposium are in the Asia Pacific region, in recognition of the significant impact HABs have had in that region and the importance of fish and shellfish for food and for commerce throughout the region.

Distinct from the many scientific conferences on HABs the Conference will focus attention primarily on exploring practical, currently available options for their management and mitigation. It is hoped that there will emerge from the symposium a consensus with a solid technical and practical basis that will provide for policy makers a spectrum of management options applicable to the needs of diverse economies and cultures, faced with an array of HAB problems and societal constraints. In addition to the proceedings, it is intended that the symposium will produce a brief guidance document, outlining these management options, that will assist the various economies in developing or improving their own HAB programs. Practical training workshops and demonstrations will be held before, after, and throughout the symposium.

For more information please contact: Dr. Sherwood Hall, FDA HFS-426, 200 C Street SW, Washington, DC 20204, E-mail: SHall@bangate.fda.gov

International Society for the Study of Harmful Algae

ISSHA

The increasing public and scientific awareness of the destructive effects of harmful algae, coupled with reports of increasing frequency, intensity and geographical distribution (now worldwide) of these events, led to the formation of the International Society for the Study of Harmful Algae (ISSHA), an international non-governmental, nonpolitical and not-for-profit organization. The realization of the need for the creation of ISSHA arose through a series of international conferences on harmful algae that began in 1974 with the First International Conference on Toxic Dinoflagellate Blooms.

The initiative for ISSHA was given further impetus by the request of the Intergovernmental Oceanographic Commission (IOC) of UNESCO for an international programme on harmful algae. The formation of the Society was first addressed at the Sixth International Conference on Toxic Marine Phytoplankton, October 1993, in Nantes, France. The Society was formally established at the Seventh International Conference on Harmful Algae, Vigo, Spain, June 1997 by the election of officers (President, Secretary, and Treasurer) who are charged with the responsibility for coordinating the initial activities of ISSHA.

President: Prof. F.J.R. Taylor, University of British Columbia, Canada

Secretary: Dr. Allan Cembella,
Institute for Marine Biosciences, Canada
Fax: +1 902 494 3877,
e-mail: Allan.Cembella@nrc.ca

Treasurer: Henrik Enevoldsen,

IOC Science and Communication Centre on Harmful Algae, Oster Farimagsgade 2 D, DK-1353 Copenhagen K, Denmark. Fax; +45 33 13 44 47, E-mail hab@bot.ku.dk.

Requests for membership should be directed to the Treasurer, all other inquiries to the Secretary.

The Society will seek affiliation to the ICSU family of organizations as constituent part of the International Union of Biological Sciences (IUBS) through the International Association of Biological Oceanography (IABO). Ob-

server status will be sought from the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

The Society shall; a) promote the study of harmful algae, including their occurrence, related oceanographic factors, ecophysiology, taxonomy & systematics, genetics, toxin chemistry, toxicology, management and mitigation; b) collect, evaluate and disseminate information on harmful algae; c) promote harmful algal research, training and extension for fostering the related management and mitigation; d) develop material for the promotion of public awareness of the social, economic and ecological effects caused by harmful algae; e) arrange and co-sponsor national, regional and international conferences, seminars, symposia and working group meetings; organize lectures and courses; publish scientific and popular articles; f) support and implement research projects and programmes; g) promote consultation and cooperation with other appropriate organizations, public and private; h) take any other action deemed appropriate to further the objectives of the Society.

The Society is registered in Copenhagen, Denmark, and has at the moment a membership of 230 scientists worldwide. The membership of the society

compromises (i) honorary members: such members will be elected by the Council, on the recommendation on the Executive Committee, in recognition of their outstanding services to the furthering of the objectives of the Society; (ii) institutional members: such members will be from government organizations, academic and research institutions, science academic, professional societies, public and private industries, and bilateral and international organizations; (iii) individual members: such members will be from individuals interested in promoting the aims and objectives of the Society.

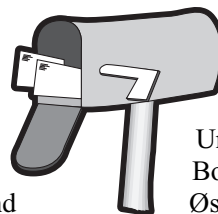
The Society has revenue derived from annual contributions paid by members. Institutional members will pay an annual subscription of not less than 40 US dollars or its equivalent in Danish Crowns/EURO. Individual members will pay an annual subscription of not less than 20 US dollars or its equivalent in Danish Crowns/EURO. The Society has generously received a significant contribution from the Organizers of the 7th International Conference on Toxic Phytoplankton, which was held in 1995 in Sendai, Japan.

The 1999 activities of the Society will be announced in the next issue of this newsletter.

Identification Service

The IOC Science and Communication Centre on Harmful Algae, Copenhagen, and the Asian Natural Environmental Science Center offers an identification service. If you have problems with identification of harmful algal species, the Centres may assist you. You should send samples to one of the two addresses given below. It should be noted that this assistance is not given for routine identification/monitoring of samples, but applies to particularly difficult species, or to

species that require special techniques e.g. electron microscopy, for identification.



IOC Science and Communication Centre on Harmful Algae, University of Copenhagen, Botanical Institute, Øster Farimagsgade 2D, DK-1353 Copenhagen K., Denmark

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◆ New Zealand

Mortality among marine life in Wellington Harbour

Wellington City is the capital of New Zealand and surrounds a shallow natural harbour located at the southern tip of the North Island of New Zealand about 41° 16' S; 174° 50' E. The harbour has a surface area of about 85 km², a maximum depth of 31 m, and is, on average, 14 m deep with a volume of about 1,400 m³. Freshwater input into the harbour is relatively small (daily maximum 180 X 10⁶ m³; minimum 2.6 X 10⁶ m³) from a catchment of 630 km². Residence time of water in the harbour is about 9 days and is replaced by clean oceanic water from Cook Strait.

During the last week of February, 1998 a *Gymnodinium mikimotoi* bloom of unprecedented intensity developed within the harbour, and at its height in early March, cell densities reached 30 million per litre. Dead and dying marine fish including seaward migrating freshwater eels were first noted during the first week of March, 1998. Mortalities were being actively harvested by sea gulls with no apparent effects on the scavengers. Fish and some shellfish continued to be washed up along the harbour beaches over the next two weeks. Concurrently, seawater entrapped in the more sheltered eastern bays and in the inner Harbour became straw coloured, and a build-up of yellow-green deposits on the surface of the sub-tidal sediments began to accumulate.

On Tuesday 24 March, video footage of the phenomenon was taken between 1.0 m and 10.0 m. The video revealed that marine life at all levels of complexity and representing all trophic levels, with the possible exception of macroalgae, had been affected, and that both invertebrates and vertebrates had been dying for at least two weeks, as estimated from the state of decomposition shown by animal carcasses. Dead and dying animals were not being scavenged or predated, and this indicated an absence of predators. Also, there were no signs of bioturbation, indicating that animals living beneath the sediment surface were also inactive or dead. This was confirmed during April, when sediment samples from the harbour basin showed that species richness, abundance, and biomass of the benthic biota was down to about 10% of previous baseline levels. The zooplankton and pelagic fish fauna recovered quite rapidly within one month, primary through infusion of new Cook Strait water.

I lead a small team of staff and graduate students at the Victoria University Marine laboratory who are committed to evaluating the present post-bloom status of the intertidal and benthic biota. We will be concentrating on the benthic biota of the harbour basin (depths > 10 m) which is a low energy environment with sediment organic carbon levels of

6% or more. About 90% of the sediments lie in the silt/clay fractions. We are fortunate in that our previous work provides a reasonably good quantitative baseline for the pre-bloom biota, and specific stations are re-locatable by differential GPS. These have already been sampled with a vanVeen grab. It appears that only the larger, deep burrowing crabs, maldanid and eunicid polychaetes have survived – the previously dominant smaller crustaceans such as amphipods, the echinoderms, bivalves, echiurids, flounders and epibenthic fish are all mostly absent.

We intend to monitor the recovery of the harbour biota over time, perhaps for 3 or 4 years so that cycles of dominance can be seen. We will be using the usual shannon-weiner indices of diversity and evenness, indices of similarity, and ABC k-dominance statistical methods to back up our qualitative observations and species identifications. Our present opinion is that although the migrant species may be relatively unaffected, and that the intertidal biota may recover quite rapidly, the benthos may take some years to return to pre-bloom community structure. It will be interesting to see what will occur in the absence of bioturbation and nutrient recycling by the benthos.

*Dr R.G. Wear, Associate Professor,
School of Biological Science, NZ*

REVIEW

By Roger Bradburry, Bureau of Resources Sciences, Canberra, Australia

The Ecology and Oceanography of Harmful Algal Blooms

A special issue of *Limnology and Oceanography*

(Volume 42, Number 5, part 2, 1997) D M Anderson & D J Garrison (eds)

I had, in my formative years, a professor who liked his whiskey neat and his science pure. This was in the years before such barbarisms, such mongrels, as whiskey & cola or environmental science, so Bill's greatest worries were that some barman might reflexively dis-

lute his drink and that someone, somewhere might find his science useful.

I am not, of course, talking about someone finding his science useful in the scientific sense: that some other scientist, some peer, might use his science to ad-

vance his own, to help that peer add another brick to science's edifice. Bill fully embraced the cooperative, collegial ethos of science. What he was afraid of, rather, was that some outsider, some lay person, might find his science useful for solving a non-scientific problem, might

dilute his science with some utilitarian concern of the workaday world.

As a result, Bill had a broad and fertile scientific career, as he moved from field to field pursued by the phantom of utilitarianism. He began as an experimental physiologist with elegant work on the excretory system of the liver fluke, *Fasciola hepatica*, not because this might help sheep farmers, but because parasites offer superb scientific challenges in understanding adaptation in the ultimate habitat, another organism. However such basic knowledge helps design parasite control strategies. He worked for a while on the behaviour of alpheid shrimp, the ones that click with their nippers to defend their territories, and became fascinated with the underwater soundscape, until the navy, with its more covert interests, offered to fund his research. Crab taxonomy came next, but this led to an interest in numerical taxonomy, and from that flowed work on the classification and ordination of benthic communities, just as coastal development accelerated, and his techniques were in demand for Environmental Impact Statement for every coastal project in the nation.

Had he not retired, I think Bill would have moved to algal ecology next. Now there is a safe scientific backwater, a place where one could take the time to think and dream and understand.

Or so I thought until the special issue (Volume 42, Number 5, Part 2, 1997) of *Limnology and Oceanography* landed on my desk. It is entitled "The ecology and oceanography of harmful algal blooms" and it is an issue that just reeks of utility. Indeed the whole field of harmful algal blooms or HABs, as they say in the journal, has the feel of a subject on a roll ("unstoppable momentum"). It has the indicators of some science that has suddenly found itself useful. It has found a market for its product. For starters, it has gentrified itself, tried to move its brand upmarket, as it were, by some clever rebranding, draping itself in a sonorous sobriquet instead of the simpler 'red tide'. HABs sound so much more serious and expensive, so much more bankers' pinstripe, than the blue denim of red tides. It has changed its advertising to reflect this new positioning: HABs are much more complex than previously thought, and hence their science that much more expensive to

buy. It has diversified its product line to saturate the market: there are more sorts of HABs than you can point a stick at, each in urgent need of work.

Thus HAB research is going the way of climate research and other environmental crises that make a special claim on the public purse beyond the apparent merit of their science. Because such rent-seeking is completely intertwined with the science, when we review the science, we must also review the special pleading, and the interaction between the two. Funds, it seems in the world of crisis, follow fear, just as surely as in biology, form follows function. So we must ask questions about the merit of the science, and also whether the privileged access to the funds has resulted in a commensurate rise in the quality of the science.

So what do I see when I look at HAB research from this perspective, using the L&O issue as the primary evidence?

Firstly, I see a science that is Newtonian rather than Darwinian. One might say proudly or even muscularly Newtonian. The papers of Franks and Donaghay & Osborn are a case in point. Here blooms are treated as if they are the result of the working through of a Newtonian dynamics applied to some particles or fluids. Much is made, in several papers of the first section of the issue, of environmental forcings setting up a bloom. In this reading of the science, it seems to me to be in thrall to physics rather than biology. Perhaps the fact that the organisms involved are so small makes them seem as if they are more like inanimate particles than living things. Perhaps the need for a lot of hardware in studying blooms encourages the development of physical rather than biological metaphors in their analysis. Perhaps the physical oceanographers just claimed the territory first.

Now this is a pity, because Newtonian approaches are particularly unsuitable for these sort of phenomena, even if we set aside any general disquiet about the misfit of Newton and biology. Think instead about some of the defining characteristics of blooms: they are outbreaks, singularities, discontinuities; they are complex, heterogeneous; they have histories. Newtonian approaches are ill-equipped to deal with such phenomena. Classic Newtonian systems are cyclic not

singular, continuous not discontinuous, simple not complex, ideal not historic.

So I looked hard amongst the physics for Mr Darwin, searching for the wildflowers amongst the thistles and weeds. And I only found his shadow, or where he might have been. The physiology and biochemistry, molecular biology and genetics, such as the papers by Plumley and Sellner, were strong and good. Like many cell biologists, they tacitly acknowledge Mr D in their talk of adaptation and so on, but they don't really think about it too deeply, being content to leave such stuff to the ecologists. They utter their Darwinisms as a catechism, a necessary cost of being part of modern biology, while they get on with their essentially Linnaean work of describing the taxonomy of the cell. They do not ask the terrible 'why' question that only Darwin answers.

Darwin was missing too in the ecology papers, and thus they are really natural history papers, because we cannot imagine an ecology uninformed by evolution. Those papers captured the natural history of blooms with great force and erudition, and the classification of blooms that emerges from the issue will be one of its enduring benefits.

Despite these strengths, the issue had a retro, back-to-the-sixties flavour for me, as I looked in vain for words like 'complexity', 'emergence', or 'novelty' but stumbled instead over words like "forcing" and "control". It reminded me of all the trees sacrificed for now-forgotten IGBP publications, of how we biologists forgot about Darwin and tried to ape physics, and how we thought that we could understand ecological phenomena with more instrumentation, more environmental measurements, and more and more boxes of punch cards.

The sixties was the high point of that ecological detour called trophodynamics, where things like carbon and energy flows were seen to be the key to ecology because they were commensurate with the state variables of physics and chemistry, and were accountable with the instruments of those disciplines. My problem is that the ecology of HABs presented in this issue reeks of this sort of trophodynamics.

So I returned to one of my ecological heroes of that era, L B Slobodkin, who

also happened to like plankton and even worked on red tides, as a few of the authors in the issue acknowledge. I reinforced my doubts about trophodynamics by rereading his elegant put-down, as fresh and relevant today as it was in 1969. The problem, according to Slobodkin in a review of a book by Harold Morowitz, is that trophodynamics leads us to commit Schrödinger's Fundamental Biological Error:

"Essentially, Schrödinger said that animals consume food because they are thermodynamically open systems which are producing positive entropy and must consume an equal amount of negative entropy to maintain their steady state. In a sense this is equivalent to saying that animals must eat to avoid starving to death. The fallacy arises from the fact that for, say, a normal rabbit population, being eaten is a much more important source of death than starvation.

Part of the food eaten by rabbits is required to maintain the rabbits against thermodynamic decay, but a large part is to keep one jump ahead of the foxes and dogs. The energetic requirements of a population are therefore partially predictable from the thermodynamic properties of the animals but the residual part is predictable only if we know the precise ecological situation of the rabbit population. The actual energy flow patterns in nature are neither simple and direct consequences of thermodynamic theory, nor are they directly predictable from any extant evolutionary theory."

Slobodkin reminded me that HABs are, at base, ecological phenomena. And, all ecological phenomena are, at base, contemporary expressions of ongoing evolutionary dynamics, as Hutchinson, that other planktologist, reminded us. We cannot hope to understand them without using entities that are evolutionarily co-ercive-species, individuals, genes. Having now done the natural history of HABs at all sorts of levels, the task is now to inject some Darwin and start to look seriously at real population dynamics. That might even appeal to the Bills of the world.

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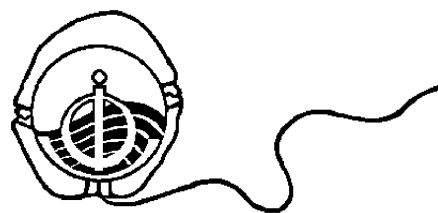
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◆ Spain

Bloom of *Gonyaulax polygramma* in the Galician Rías

In November 1997, a bloom of *Gonyaulax polygramma* Stein occurred on the Galician coast (NW Spain) and caused red coloration especially in the Rías de Pontevedra Vigo and Arousa. The Centro de Control da Calidade do Medio Mariño carries out a monitoring program in the Galician Rías (1) and samples at 40 coastal stations weekly. *Gonyaulax polygramma* cells were first detected in net samples during southerly winds on 20th October at almost all stations. This was a period of downwelling with an influx of oceanic water of 35.2 PSU and 17 °C at 15 meters (Fig. 2). In the following two weeks the same situation was maintained with a slight rise in cell numbers at stations in the Ría de Pontevedra, but always below 8700 cells l⁻¹. The maximum concentrations were detected in mid-November. The highest cell concentration (767,800 cells l⁻¹) of *G. polygramma* was detected on 17th November at a station in Ría de Pontevedra. The same week, a concentration of 233,160 cells l⁻¹ was observed in Ría de Vigo. However, maximum cell concentrations may have been much higher since very intense red patches were observed at several points. The same oceanographic conditions were maintained throughout the bloom.

In spite of the problematic identification of the *Gonyaulax* (2), the cells ob-

served showed the typical sculpture with longitudinal ridges and small regular alveoli, elongated cell with tapered epitheca and hypotheca, epitheca convex to angular, hypotheca symmetrical, rounded or truncate, may have a variable number of short antapical spines, girdle descending, displaced about 1.5 widths. These characteristics are in accord with revised taxonomic descriptions (3, 4, 5). Some naked forms were seen, probably due to elimination of thecae before cell division (6).

There are several reports of *G. polygramma* in Galicia waters (7), but a visible bloom of this species had not previously been reported. Blooms of this species have been observed elsewhere, and have sometimes had serious consequences such as wild fish mortality in Cape Town, South Africa (8); mass mortality of fish and shellfish in Japan (9); mass mortality of marine organisms in Venezuela (10), in this last case associated with the presence of *Alexandrium tamarense* and *Gymnodinium catenatum*. There was no evidence of low oxygen levels during the event reported here. The only noxious effect of this bloom was the social alarm due to the red coloration of the sea. It was reported in press and Galician television and caused special alarm in the shellfish harvesting sector.

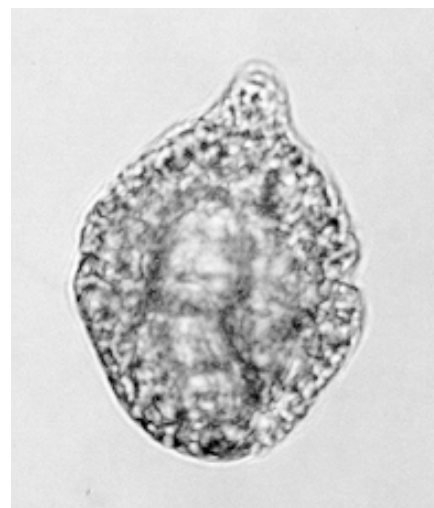


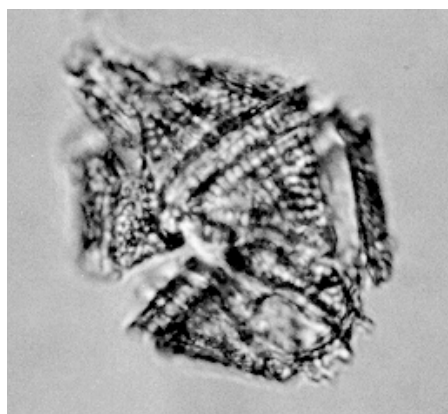
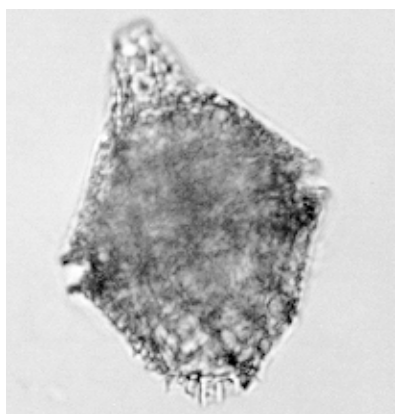
Fig. 2
Light microscope view of a naked form (without thecae).

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Fig. 1.
Light microscope view of a cell of this bloom with (left) and without (right) cytoplasm.



Future events

July 1999

IOC Danida Training Course on the Taxonomy and Biology of Harmful Marine Microalgae, July 1999. This two weeks course will focus on identification and preparation techniques supplemented by lectures on different aspects of the biology of harmful algae. Teaching staff will include: Dr Yasuwo Fukuyo (Univ. of Tokyo), Prof. Øjvind Moestrup (Univ. of Copenhagen), Dr Jacob Larsen (Univ. of Copenhagen/IOC Centre), Organized by the University of Copenhagen, and IOC Science and Communication Centre on Harmful Algae, Copenhagen. For application forms, contact: the IOC Science and Communication Centre on Harmful Algae, Botanical Institute, Ø. Farimagsgade 2D, DK-1353 Copenhagen K, Denmark; fax: +45 33 13 44 47. Email: hab@bot.ku.dk. Deadline 1. April 1999.

February 2000

9TH INTERNATIONAL CONFERENCE ON HARMFUL ALGAL BLOOMS, 7-11 February 2000, Tasmania, Australia. The conference will provide a broad forum for phycologists, microbiologists, toxicologists, physiologists, molecular biologists, aquatic ecologists and managers to address and exchange research findings and perspectives concerning all aspects of toxic and harmful algae, including freshwater cyanobacteria and ciguatera (fish poisoning). Harmful algae and their toxins pose a growing global problem for human health, aquaculture, fisheries, seafood trade, tourism and the aquatic environment at a time when human reliance on coastal zones for food, recreation and commerce is expanding. Contributions are invited which address the following topics:

- Taxonomy of harmful algae, using conventional

as well as sophisticated molecular and immunological approaches

- Population dynamics of harmful algal blooms, including coupling of physical and biological processes, and interactions with zooplankton, viruses and bacteria
- Ecophysiological, chemical and pharmacological aspects of algal toxins, with a focus on new analytical methods and novel toxins or toxic episodes
- Monitoring and management of harmful algal blooms as they relate to eutrophication, aquaculture, public health and shipping (ballast water problem). Options for prevention, control and mitigation will be especially emphasized.

Contact: HAB 2000 Conference Secretariat, Conference Design Pty Ltd, PO Box 342, Sandy Bay Tasmania 7006, AUSTRALIA, Tel: +61 3 62243773, Fax: +61 3 62 243774, E-mail: mail@cdesign.com.au, or: Gustaaf M. Hallegraef, School of Plant Science, University of Tasmania, GPO Box 252-55, Hobart, Tasmania 7001, AUSTRALIA, Tel: +61 3 62 262623, Fax: +61-3-62 262698, E-mail: Hallegraef@utas.edu.au (Gustaaf Hallegraef), Web Page: http://www.utas.edu.au/docs/plant_science/P.S._Homepage.html.

For a more comprehensive overview of up-coming activities and events you should visit the IOC International Marine Meeting List at the IOC homepage at <http://www.unesco.org/ioc/infserv/meets.htm>. The list of meetings related to the International Year of the Ocean might also be of interest <http://www.unesco.org/ioc/iyo/conferences.htm>

Literature for developing country libraries

Limited copies of the following titles are available from the IOC Science and Communication Centre on Harmful Algae, Denmark (see address below), to libraries of marine science institutions in developing countries only:

- The Genus *Alexandrium* Halim (Dinoflagellata). **E. Balech, 1994.**
- Algae. An Introduction to Phycology. **C. van den Hoek et al., 1995.**
- Identifying Marine Phytoplankton. **C. Thomas et al. (eds.), 1997.**
- Proceedings of the International Symposium on Ciguatera and Marine Natural Products, Hawaii, 8-10 August 1994. **Hokama et al (eds.) 1995.**
- Proceedings of the First International Congress on Toxic Cyanobacteria, Denmark, 20-24 August 1995, and, Proceedings of the First Maj and Tor Nessling Foundation Symposium on 'Recent developments in Cyanobacterial Research', Finland 16-18 August 1995. **Moestrup et al (eds.) Phycologia, Vol.35 No.6, 1996**
- Photography through the microscope. Kodak. **J.G. Delly, 1997.**

Applications must be submitted and signed by the responsible librarian, and should indicate why the requested title is of specific interest to your institution and its ongoing research or teaching. No requests from individuals will be honoured.

IOC publications

- Summary Report of the Fourth Session of the IOC Intergovernmental Panel on Harmful Algal Blooms, Vigo 30 June - 2 July 1997. Available in English, French, Spanish.
- Amnesic Shellfish Poisoning (ASP), Volume 1, IOC *Manuals and Guides*, No. 31.

These publications are free of charge and available from the IOC Secre-

tariat.
1, Rue Miollis, 75732 Paris, Cedex 15 France, Fax: +33 1456858, e-mail: hab.ioc@unesco.org

- Manual on Harmful Marine Microalgae, IOC Manual and Guides No. 33.

The Manual is free of charge but a fee of US\$ 30 will be charged for handling.

A cheque issued for the IOC SCCHA, University of Copenhagen (see address below), should accompany all orders. Only prepaid orders will be accepted. Excepted from the handling fee are marine science libraries and scientists in developing countries which can apply for delivery free of charge.

HARMFUL ALGAE NEWS

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