



# HARMFUL ALGAE NEWS

An IOC Newsletter on toxic algae and algal blooms

<http://ioc.unesco.org/hab/news.htm>

No. 24

## • Kenya

# A cyano-anomaly? Cyanobacterial toxins as contributors to Lesser Flamingo mass deaths.

Microscopic analysis, over 70 years ago, of the stomach contents of the Lesser Flamingo, *Phoeniconaias minor*, confirmed what is apparent from the birds' ecology, feeding habits and bill structure: they feed on cyanobacteria [1]. The massive populations, at times over a million, of Lesser Flamingo at Kenya's Rift Valley saline, alkaline lakes, receive nutrients and energy from the local blooms of cyanobacteria, mainly *Arthrospira* spp. (formerly termed *Spirulina*). Although flamingos also feed on diatoms and invertebrates, e.g. brine shrimp, it is thought that the cyanobacteria can serve as the sole food of *P. minor*.

Over the past decade, episodic mass mortalities of Lesser Flamingos have occurred at the lakes [2]. The locations involved, including Lakes Nakuru, Bogoria



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## • Mexico

# First record of *Fibrocapsa* cf. *japonica* in Matanchen Bay, Nayarit, Mexican Pacific coast.

### Abstract

In the present study, significant HAB'S bloom was confirmed in Matanchén Bay during February 2003. The Raphidophyce *Fibrocapsa* cf. *japonica*, Toriumi *et* Takano 1973 (= *Chatonella japonica*) has dominated (97%) red tide event occurring lately in coastal waters of Nayarit state, with high cell concentration of 4-6 millions of cells per liter of water. The duration of this bloom could not be determined exactly due to limiting sampling. There have been no reports of fish kills or human intoxication in the locality. This study represents the first survey on the distribution of *Fibrocapsa* cf.

*japonica* in the Mexican Pacific coast. The finding adds Raphidophyceans to the list of harmful algal blooms and toxin producers in Mexico.

**Key words:** *Fibrocapsa* cf. *japonica*, Raphidophyte, Harmful algal bloom (=HAB) blooms, Nayarit State, Pacific Mexico.

### Introduction

Routine phytoplankton monitoring in Matanchén Bay has revealed the presence of several discolorations on February 2003, however the duration of this bloom could not be determined exactly from beginning to lasting due to limiting samples. The

discoloration was concentrated in the middle of the bay near to Aticama village and Arrollo de La Palma turning seawater reddish-brown appearance. Matanchén Bay extends from 21° 25' 24" and 21° 30' 40" latitude N and 105° 12' 00" and 105° 15' 00" longitude W, a little below the Tropic of Cancer. The rain precipitations are in the order of 1000 to 1500 mm per year with climate warm and sub-humid with rains in summer. This Bay of Mexico is under the influence of fresh water particularly from San Cristóbal estuary in the north, Sauta River, Arroyo De La Palma and Santa Cruz River (Fig. 1).

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and Elmenteita, are important national wildlife and tourism resources. They are also subjected to increasing human pressures as receiving waters for anthropogenic diffuse and point pollution. Multiple factors are thought to be involved in the mass die-offs, including septicemia, avian tuberculosis, pesticides and heavy metals. Environmental analyses, feeding and body burden estimates have indicated that heavy metals would not have been sufficient alone to account for the deaths.

Analyses of flamingo carcass livers and cyanobacterial samples from Lakes Bogoria and Nakuru were carried out at both the Leibniz Institute for Freshwater Ecology and Inland Fisheries in Berlin, in the framework of the BIOLOG (Biodiversity and Global Change) programme of the German Federal Ministry of Education and Research and at the University of Dundee with support from the UK Natural Environment Research Council. Both groups of investigators found cyanobacterial toxins in dead flamingo livers: two hepatotoxins (microcystin-LR and -RR) and the neurotoxin, anatoxin-a, at estimated harmful concentrations [3]. The total extractable microcystin concentrations in the bird livers were 0.21 to 0.93 µg microcystin-LR equivalents, and that of anatoxin-a, 1.06 to 5.82 µg per g fresh weight. These toxin concentrations may have been sufficient alone to have caused the bird deaths, that of anatoxin-a being consistent with observations of staggering and convulsions in the flamingos before death and with opisthotonus, post-mortem.

Our investigations indicate that the microcystins and anatoxin-a should be included among the major agents contributing to the bird deaths. The only known sources of these toxins are

cyanobacteria and it follows that the exposure of the flamingos to the toxins is largely via their diet. Further research with materials from Lake Bogoria Lesser Flamingos has identified the hepato- and neurotoxins in bird stomach and intestine contents and faecal pellets [4].

Shifts in cyanobacterial bloom composition, towards toxigenic genera, perhaps due to human intervention, could present the birds with an additional poisoning hazard. This may have occurred at Lake Nakuru, where the plankton population changed from one dominated by *Arthrospira* to one dominated by *Anabaenopsis* and *Anabaena* spp. [3]. The latter two genera include microcystin-producing species/strains and anatoxin-a can be produced by *Anabaena* spp. In addition, the birds may be exposed to cyanobacterial toxins other than via their primary food. At Lake Bogoria, the Lesser Flamingos drink in the vicinity of hot springs on the lake margin, where salinity is lower. The cyanobacterial mats around the hot springs include genera with toxigenic members (*Oscillatoria*, *Phormidium*; [4]) and it is possible that the flamingos may be exposed to the toxins via incidental ingestion of detached cyanobacterial mat biomass and/or drinking from the water nearby.

Mass die-offs of Lesser Flamingos do not appear to have been recorded during earlier decades of intensive study at these lakes [1, 5, 6], suggesting that the mass mortalities of the 1990s are relatively modern phenomena [2]. The extent to which increasing modern pressures from visitor numbers upon the breeding colonies, and pollution input from industry and agriculture interact with microbial threats to bird health, is a complex problem. The production of cyanobacterial toxins in the lakes and their presence in birds, dying after displaying typical signs of intoxication,

indicate that their primary food can present benefits and costs. The characteristics of the toxigenic cyanobacteria in the lakes, and their regulation, require investigation to further understand the multiple influences upon the health and population dynamics of the Lesser Flamingo.

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*Geoffrey A. Codd, James S. Metcalf and Louise F. Morrison, Division of Environmental and Applied Biology, School of Life Sciences, University of Dundee, Dundee DDI 4HN, UK. Email: g.a.codd@dundee.ac.uk*

*Lothar Krienitz and Andreas Ballot, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Limnology of Stratified Lakes, D-16775 Stechlin-Neuglobsow, Germany. Email: krie@igb-berlin.de*

*Stephan Pflugmacher and Claudia Wiegand, Leibniz Institute of Freshwater Ecology and Inland Fisheries, AG Detoxication and Metabolism, Muggelseedamm 301, D-12587, Berlin, Germany. Email: pflug@igb-berlin.de*

*Kiplagat Kotut, Botany Department, Kenyatta University, P.O. Box 43844, Nairobi, Kenya. Email: m.kotut2001@yahoo.com*

## • International

# X HAB Model Group

At the tenth international conference on harmful algal blooms (HABs) at St. Pete Beach, Florida a special session on MODELS AND MYTHS was convened by J.J. Walsh on 23 October 2002. This workshop addressed the status of ecological modeling of HABs, from simple concepts of one dimensional processes that must be considered in any process model to three dimensional computer homomorphs of the

“real world”, where circulation models drive those of plankton competition. Ted Smayda presented an insightful introduction on “Models we should build”. Present “Models we have built” on the Bay of Biscaye, Gulf of Maine, and the West Florida shelf were then discussed by Patrick Gentien, Dennis McGillicuddy, Bob Weisberg, and John Walsh. Topics varied from actual model results to future

constraints in modeling HABs, i.e., initial conditions, data assimilation algorithms, sampling networks, and validation methods. These oral presentations will be part of the written proceedings of the conference.

*John Walsh, Email: jwalsh@seas.marine.usf.edu*

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Surface phytoplankton samples was taken from central bay region of Matanchén Bay on February 21 and 23, 2003. The samples were stored in a 250 ml plastic bottle, and then preserved with Lugol-acetate solution. Live whole specimens were analyzed using light microscope from which photographic records were made. Phytoplankton abundance was determined by the standard Utermohl technique [1], and algal quantification, was made with 100x magnifications in aliquots of 10 ml using a 1 mm<sup>2</sup> scale Wipple disc with double cross pattern of 100 µm. Temperature was registered with a 0.1°C precision bucket thermometer and salinity was analyzed with a 1 psu precision refractometer.

Sampling results from identification and phytoplankton abundance during the bloom (Table 1) indicate 97% of total dominance of *F. cf. japonica* from over all community, although was associated with 27 species those represent only 3%. The identification of *F. cf. japonica* was based on morphological examination *in vivo* specimens which shape was spherical (possibly cyst stage) to ovoid. The vegetative cells showed their two characteristic flagella emerging from an anterior gullet and the mucocysts in posterior region consistent with the description of Loeblich III & Fine (1977) and Hara (1990) [2,3]. Another evident characteristic was the number and organization of chloroplasts (Fig. 2) and the spherical cell size of 15 µm, whereas in ovoid cells was 15-22 µm long and 15-17 µm wide. Living cells were fragile and difficult to preserve changing the body shape immediately, they can die in few minutes under light

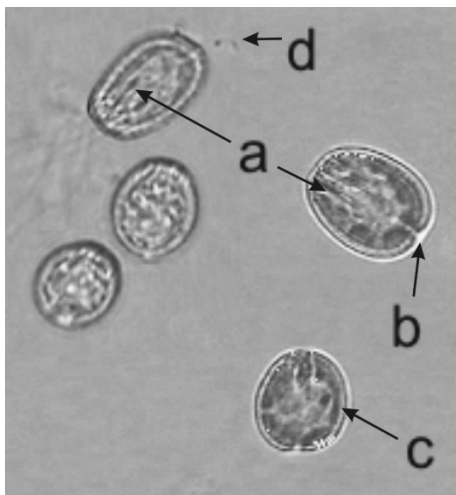


Fig. 2. Images of *Fibrocapsa cf. japonica* observed in living conditions. a) mucocysts b) gullet, c) chloroplasts arrangement d) flagella.

microscope. In addition this alga can be somewhat pleomorphic (it can have varied shapes).

There have been no reports of fish kills or human intoxication in the locality although high proliferation of this specie in marine water may cause serious issues in fish industry and local aquaculture. No harmful algal bloom events have been recorded in coastal Nayarit State [4,5]. This occurrence is the first identification and published record of *Fibrocapsa cf.*

*japonica* in Mexican Pacific littoral extending their distribution to warm temperature regions. Although this specie has been detected in Point Loma San Diego California Bay [2] correspond to USA (32° latitude N), so similar than those of Japan (30°-35° latitude N) where reach large numbers. Here we found it, in warm and more temperature water >26°C and >34 psu salinity. Hence it is reasonable to assume the presence as an invader specie traslocated by their resting cysts now adapting in this region, or also as new specie. However, to prove it is necessary to know the cellular ultrastructure in electronic microscopy and compare with known species.

Toxic Raphidophyceae have been documented from other geographical regions of the world: coastal waters of Japan, Australia, New Zealand, Brazil, north-western Europe, California and Florida but, is in Seto Inland Japan where the populations showed devastating effects on mariculture [6]. Date no reported indicate fish mortality in Baja California Sur (Mexico) due Raphidophyceae in Todos Santos municipality of La Paz on July 22, 1999. So far, a few years ago flagellate resembling *Chattonella sp.* were recorded in water samples from Cabo San Lucas zone (Lat. 22° 30' N, Long. 110° 30' W) on march 1996 without blooming [7].

Toxicity PSP analysis by bioassay and chromatographic techniques was carried on by the Center for Biological Research (CIBNOR) with negative results, and conclude that the testing were not able to detect the presence of toxins. Recently in 2001 have been also reported fish kills in same geographical area of Nayarit State due Raphidophyceae assuming *Chattonella cf.*



Fig.1. Map showing the study area of Matanchén Bay in Nayarit State México with location of sampling station and presence of discoloration.

*antiqua* (Sierra-Beltrán, pers. comm.). Furthermore, a researcher from a red tide working group who usually visit this area, has been recognized the specie but in very low abundance (Gómez Aguirre, pers. comm.). The presence of these species in Nayarit State is particularly significant since they are known as NSP producers or brevetoxins-like compounds (named fibrocapsin) and to be the cause of fish kills [8].

It's clearly dominated the culture of this microalga and in unfavorable environmental condition induce cyst or non-motile spherical cells, very common feature in our samples. The precise mechanism behind the ichthyotoxic effects of the Raphidophyceae is still under debate and could be a combination of the different toxins. Furthermore, recent studies demonstrated that this microorganism flagellate is one of the reactive oxygen species (ROS), which generates superoxide O<sup>-</sup>(/)/2 and hydrogen peroxide H<sub>2</sub>O<sub>2</sub> under normal condition and may causes severe damage to fish [9]. Their results suggest that the generation of reactive oxygen species (ROS) is a common feature of this alga. There are no specific thresholds or critical values for the number of cell that pose a health risk. The abundance reported here occurred with cell numbers reaching 4 to 6 million cells L<sup>-1</sup> and should be considered as higher cell concentrations, hence is necessary to determine toxicity of the organism under consideration. This survey on the alga *Fibrocapsa cf. japonica* indicate that currently environmental conditions are conducive to exceptional *Fibrocapsa cf. japonica* bloom formation.

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Table 1.- Microalgal abundances from Matanchén Bay bloom.

species	Feb-21-03		Feb-23-03	
	cels.ml <sup>-1</sup>	%	cels.ml <sup>-1</sup>	%
<i>Fibrocapsa japonica</i>	4,751	97.13	6230	97.66
<i>Thalassionema nitzschioides</i>	3.1	0.06	141	2.21
<i>Coscinodiscus granii</i>	0.4	0.01	0.3	0
<i>Nitzschia closterium</i>	73.1	1.49	0.7	0.01
<i>Gyrosigma</i> sp.	0.3	0.01	0.3	0
<i>Pseudonitzschia</i> sp.	0	0	1.4	0.02
<i>Amphora</i> sp.	0	0	0.1	0
<i>Chaetoceros</i> sp.	0	0	0.5	0.01
<i>Navicula</i> sp.	0.2	0	0.2	0
<i>Thalassiosira</i> sp.	0.2	0	0.8	0.01
<i>Proboscia alata</i>	0	0	0.1	0
<i>Skeletonema costatum</i>	0	0	2.1	0.03
<i>Biddulphia mobiliensis</i>	0	0	0.1	0
<i>Leptocylindrus danicus</i>	0.5	0.01	0	0
<i>Detonula pumila</i>	0.1	0	0	0
<i>Protoperidinium nanum</i>	51.6	1.05	0	0
<i>Scrippsiella trochoidea</i>	4.8	0.10	0.4	0.01
Peridinales	2.3	0.05	0.2	0
<i>Ceratium falcatum</i>	0	0	0.1	0
<i>Prorocentrum gracilis</i>	0	0	0.2	0
<i>Gonyaulax spinifera</i>	0.8	0.02	0	0
<i>Dinophysis rotundatum</i>	0	0	0.1	0
<i>Gyrodinium</i> sp	2	0.04	0	0
Silicoflagellate	0.3	0.01	0	0
Ciliate: <i>Mesodinium rubrum</i>	0.1	0	0.1	0
Euglenophyte	0	0	0.2	0
Cianophyceae	0.8	0.02	0.4	0.01
total	4,892	100	6379.3	100.00

Due to its high toxicity and periodic appearance, is essential for Nayarit local government increase scientific investigation of the autoecology of *Fibrocapsa* cf. *japonica* (or new specie) to minimize further impacts and damage on fisheries, aquaculture and healthy ecosystems.

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Maria del Carmen Cortés Lara, Departamento de Ciencias. Centro Universitario de la Costa (UdeG), campus Puerto Vallarta, apdo. 48280, Jal., México.  
Email: [carmenc@pv1.udg.mx](mailto:carmenc@pv1.udg.mx)

Roberto Cortés Altamirano, Unidad Académica Mazatlán (ICMyL-UNAM), apdo. 811, Mazatlán 82040, Sin., México.  
Email: [roberto@mar.icmyl.unam.mx](mailto:roberto@mar.icmyl.unam.mx)

Amílcar Cupul Magaña, Departamento de Ciencias. Centro Universitario de la Costa (UdeG), campus Puerto Vallarta, apdo. 48280, Jal., México.  
Email: [alevi@pv.udg.mx](mailto:alevi@pv.udg.mx)

#### • USA

## ECO HAB PNW, A New West Coast, USA, Multidisciplinary Program

ECO HAB PNW is a new project whose goal is to study the physiology, toxicology, ecology and oceanography of toxic *Pseudo-nitzschia* species off the Pacific coast of Washington (WA) and British Columbia (BC). The project is funded jointly by the Division of Ocean Sciences NSF and by NOAA's Coastal Ocean Program. Recent

studies suggest that the seasonal Juan de Fuca eddy, a nutrient rich retentive feature off the WA-BC coast, serves as a "bioreactor" for the growth of phytoplankton, including diatoms of the genus *Pseudo-nitzschia* (Fig.1). Specific study objectives are: 1) To determine the physical/biological/chemical factors that

make the Juan de Fuca eddy region more viable for growth and sustenance of toxic *Pseudo-nitzschia* than the nearshore upwelling zone; 2) To determine the combination of environmental factors that regulate the production, accumulation, and/or release of domoic acid (DA) from *Pseudo-nitzschia* cells in the field; and 3)

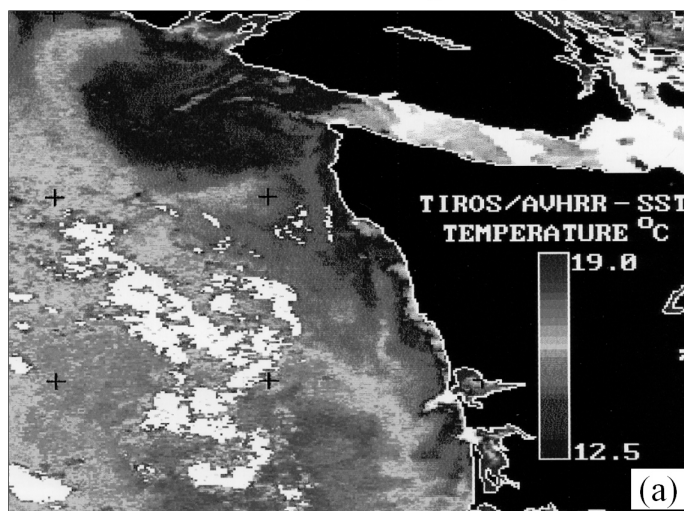
To determine possible transport pathways between DA initiation sites and shellfish beds on the nearby coast. A summary of results leading to the formation of this new program and a description of the research plans are given below. The ECOHAB PNW team welcomes collaboration with other interested scientists. For more detailed information about our program please visit our website at <http://www.ecohabpnw.org>.

### Background

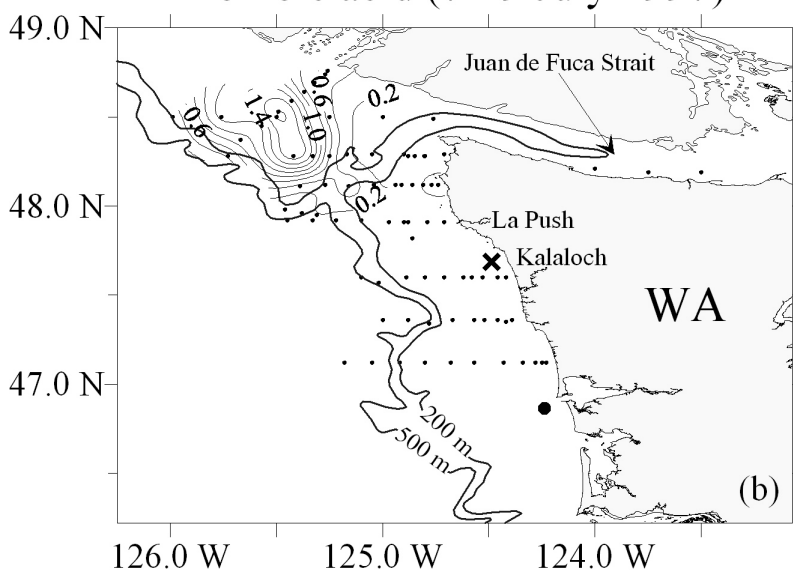
While DA poisoning was first recognized in an outbreak on Prince Edward Island, Canada [1], most of the known toxic events since that time have occurred on the U.S. west coast. DA was first implicated in the illness and death of brown pelicans and Brandt's cormorants in Monterey Bay, California in 1991 [2]. About one month following the toxic bloom in California, levels of DA above the regulatory limit of 20 mg/g shellfish tissue were found in the edible parts of razor clams (*Siliqua patula*) and Dungeness crabs (*Cancer magister*) on the Washington coast [3]. In 1998, impacts of DA to the health of marine life and to the fisheries economy were documented in several regions along the west coast. In particular, California sea lions (*Zalophus californianus*) in central California were severely affected by DA poisoning [4] and high levels of toxin in razor clams in Oregon and Washington resulted in beach closures for more than a year and a half [5].

Beach and harvest closures resulting from the toxigenic *Pseudo-nitzschia* blooms have a severe economic impact on both coastal economies and on tribal communities. In 1991, the closure of Washington State beaches to recreational and commercial shellfish harvesting resulted in a \$15-20 million revenue loss to local fishing communities [6]. The commercial Dungeness crab industry on which Washington's Quileute tribe depends for employment lost 50% of their income in 1998 due to harvest closures. The entire razor clam harvest of the Quinault tribe, on which they depend for both subsistence and commercial revenue, was also lost in the fall of 1998 [7]. Razor clam beaches have again been closed this winter and spring (2003) and devastating economic impacts have resulted in an estimated \$10 million loss to the recreational razor clam industry alone. With sufficient warning, tribal fishers could seek alternative buyers for eviscerated crab, and shellfish managers might have longer lead times to schedule closures. Moreover, mitigation strategies to reverse or moderate cell toxicity may soon be available [8].

## AVHRR (18 July 1997)



## Domoic acid (7-19 July 1997)



## *Pseudo-nitzschia* cells (7-19 July 1997)

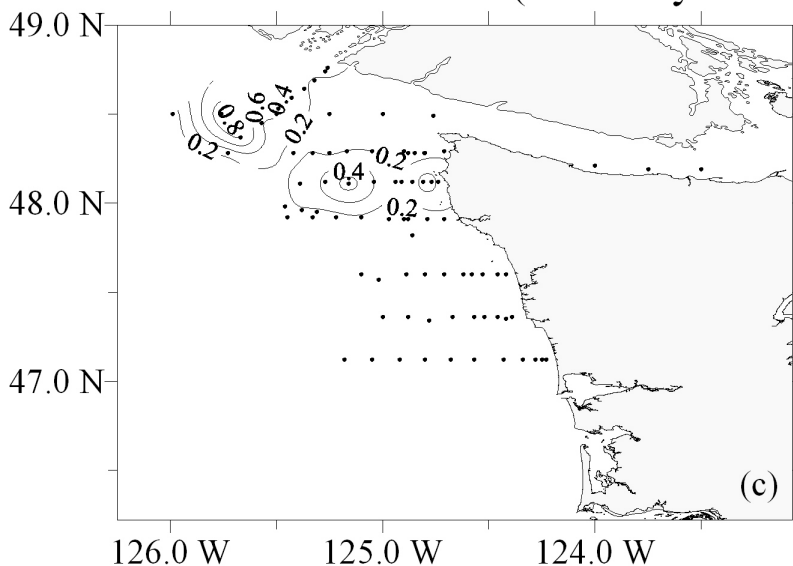


Fig. 1. Satellite-derived sea surface temperature, particulate DA (mg/L) and total *Pseudo-nitzschia* cell numbers ( $10^6$  cells/L) in surface seawater in July 1997 (Trainer et al., 2002). Dots represent all sampling stations where DA measurements and *Pseudo-nitzschia* cell counts were made. Spatial patterns show a coincidence of colder temperature, higher DA and greater numbers of *Pseudo-nitzschia* cells offshore of Juan de Fuca strait. The colder offshore water is indicative of the Juan de Fuca eddy. Colder water next to the Washington coast is indicative of local upwelling at the coast.

Both the species of *Pseudo-nitzschia* (including *P. multiseriata*, *P. australis*, and *P. pseudodelicatissima*) and the relative levels of toxicity [4, 9, 10, 11, 12] vary in time and space along the west coast of North America. Moreover, it is not uncommon for potentially toxic *Pseudo-nitzschia* cells to be present without detectable DA [8, 11]. The environmental regulation of DA production by *Pseudo-nitzschia* has not been determined in field populations due primarily to the ephemeral nature of these toxic events. Based on laboratory studies of unialgal cultures (primarily *P. multiseriata*), two predominant triggers for the production of DA have been suggested: 1) the degree of cellular stress based on Si and P availability [13, 14, 15], and 2) the effects of micronutrient (Fe, Cu) conditions [8, 16].

A survey of DA along the entire U.S. west coast continental shelf in summer 1998 [11] suggests a strong relationship between DA concentration and mesoscale topographic features. Off northern California where large coastal promontories and hence rapid offshore transport occur, DA levels are low. However, at more retentive sites along the coast, such as offshore of the Strait of Juan de Fuca, over Heceta/Stonewall Bank in Oregon, offshore of Monterey Bay (inshore of the Farallone Islands) and near the Santa Barbara Channel, DA levels are higher. Recent

studies suggest that the seasonal Juan de Fuca eddy is an initiation site for toxic blooms of *Pseudo-nitzschia* that impact shellfish on beaches along the Washington coast. Measurements made during cruises and beach sampling of seawater and shellfish are all consistent with the possibility that during some years DA from this eddy appears to move southward in prolonged upwelling events and then onshore during the first major storm of the fall season, where it results in high levels of DA in razor clams on coastal beaches [5].

### Study Strategy

To test our hypotheses on the origin of toxic blooms, multidisciplinary field surveys and drifter deployments will be performed in the region of the Juan de Fuca eddy and the nearshore coastal upwelling region (Fig. 2). The temporal context for observed variability as well as seasonal changes will be provided by an array of moored sensors measuring PAR and *in vivo* fluorescence, currents, winds, temperature, conductivity as well as time-dependent water samplers (preserved plankton and DA) deployed in both eddy and coastal environments as well as in the mouth of the strait. Results from the field studies will be used to configure and test numerical physical and biophysical models to determine bio/chem/physical conditions conducive to bloom and/or toxin production

as well as transport pathways of *Pseudo-nitzschia* or toxic *Pseudo-nitzschia* to the coast.

The backbone of this project will be 6 three week cruises scheduled in July and September of 2003, 2004 and 2005. The length of the cruises was selected to ensure that a variety of growth regimes, including both upwelling and relaxation or downwelling, will be studied. *In situ* process studies will be made both in the eddy and coastal upwelling regimes as well as following aging water from each of these areas. Coastal *Pseudo-nitzschia* and DA data from the ORHAB (Olympic Region Harmful Algal Bloom) program and related state monitoring programs will be used to determine when and where toxic *Pseudo-nitzschia* arrive along the Washington coast resulting in toxification of razor clams. The field sampling plan, moored sensor arrays at key locations and drifter deployments will allow us to:

- Contrast characteristics of the nutrient-rich eddy with nutrient-rich nearshore upwelling areas. We will determine whether physical and biological factors that control DA production differ significantly in the two regimes.

- Contrast healthy and aged natural assemblages of *Pseudo-nitzschia* to compare and contrast the environmental controls on DA production in cells at different stages of growth *in situ*.

- Determine the biophysical mechanisms of *Pseudo-nitzschia* advection to the coast, resulting in shellfish toxification. Possible mechanisms include the following scenarios: a) a healthy *Pseudo-nitzschia* population is advected directly from the offshore eddy to coastal shellfish during a storm event; b) an aged *Pseudo-nitzschia* population is advected from the eddy to the coast where it becomes a "seed" population that becomes toxic only when later supplied with nutrients from local coastal upwelling; or c) the nearshore, "seed" population toxifies the coastal shellfish directly after local upwelling followed by a storm.

The integrated field and modeling studies of ECOHAB PNW described above will make significant strides toward satisfying our long term goal—to develop a mechanistic basis for forecasting toxic *Pseudo-nitzschia* bloom development here and in other similar coastal regions in Eastern Boundary upwelling systems.

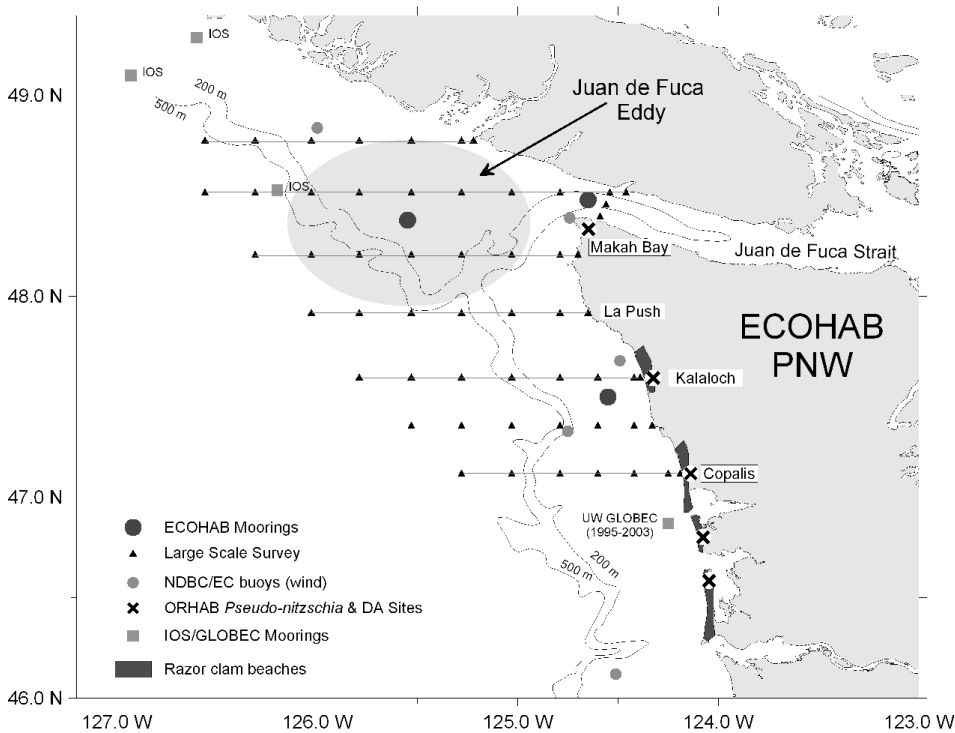


Fig. 2. Schematic large scale survey and locations of three interdisciplinary moored arrays. Locations of existing mooredings, wind measurement buoys, razor clam beaches, and ORHAB sampling sites are also shown. The approximate location of the Juan de Fuca eddy is drawn as a lightly shaded area. Institute of Ocean Sciences (IOS) mooredings are instrumented with current, salinity and temperature sensors at 3-4 depths between about 25 m and the bottom. ECOHAB PNW mooredings will be instrumented with T, S, ADCP profilers and other current meters, time-dependent water samplers, PAR, wind and fluorescence.

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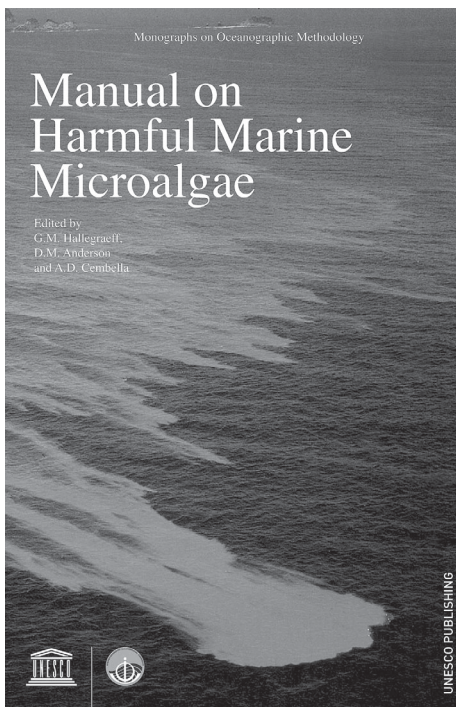
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*B. Hickey, University of Washington, School of Oceanography, Box 355351.  
Email: bhickey@u.washington.edu*

*V. Trainer, Northwest Fisheries Science Center, 2725 Montlake Blvd. E. Seattle, WA 98112;  
Email: Vera.L.Trainer@noaa.gov.*

*The ECOHAB PNW Team: B. Hickey, E. Lessard (U. Washington), V. Trainer (NOAA Fisheries), M. Foreman, E. Peña, R. Thomson (Institute of Ocean Sciences), W. Cochlan (San Francisco State U.), M. Wells, L. Connell (U. Maine) and C. Trick (U. Western Ontario).*



## MANUAL ON HARMFUL MARINE MICROALGAE

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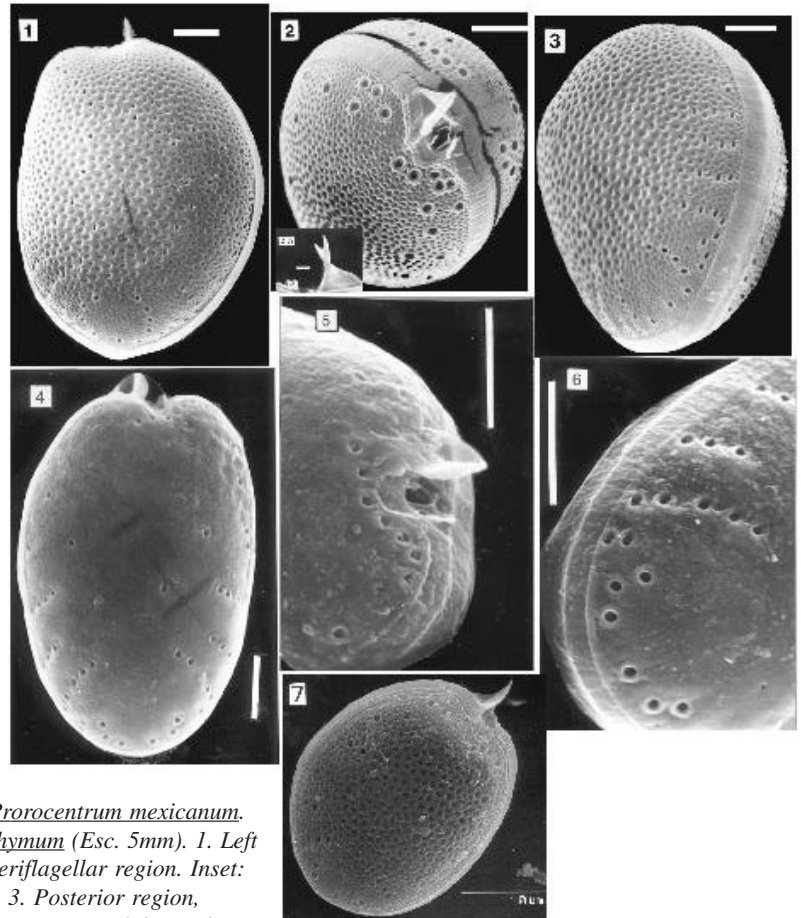
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## • Mexico

*Prorocentrum mexicanum* and *P. rhathymum* are different species

Osorio-Tafall (1942)[1] was the first to describe *P. mexicanum* under light microscope (=LM). He found the cells collecting plankton samples off Oaxaca, into the Gulf of Tehuantepec on the Mexican south Pacific. Loeblich III *et al.* (1979)[2] described *P. rhathymum* by scanning electron microscope (=SEM), from the clone 486 of samples obtained from surface waters in Cinnamon Bay, St. Johns, Virgin Islands. Later, since 1983, the species were marked as synonyms and further records and studies were labeled as *P. mexicanum* [3]. When observing samples of red tides dominated by *P. balticum* in Mazatlán Bay, México, during March and April, 1999-2000, we found several cells that perfectly fit the original description of Osorio-Tafall. When a detailed analysis of the morphology was made by SEM, we found several differences between *P. mexicanum*(=*Pm*) and *P. rhathymum*(=*Pr*) [4]. While *Pm* shape resembles a letter "D", *Pr* is neatly oval (Figs. 1 and 4 respectively). The periflagellar region and in particular, the spines, are different with two or three points in *Pm* (a unique characteristic of the species) (Figs. 2 and 5). Furthermore, trichocyst pores in the periflagellar rim are present in both valves in *Pm* while in *Pr* occur only in the valve where the periflagellar region is delimited, the right, according to Taylor [5]. The whole surface of the valves is covered by poroids increasing in size from the margin to the center of the cell of *Pm*. On the contrary, in *Pr*, the surface is smooth or rough, and the few trichocyst are aligned as radii along depressions or trenches (Figs. 3 and 6).

As mentioned above, at the moment, all records of *Pm* referred *Pr* like cells, the former is a planktonic organism and the natural habitat of the later is benthic as shown by its low mobility and the mucus layer that frequently produces. Nevertheless, *Pr* can be observed as picoplanktonic, as the bloom reported in La Paz Bay, México [7], the origin of cells in Figs. 4, 5 and 6. Toxicity reports of *Pr*-like cells are common while in true *Pm*, the toxicity has not been proved yet. The known distribution of *Pr* is wide, being found in temperate and tropical regions. The knowledge of *Pm* distribution is scarce, in Mazatlán, is not very abundant and at the moment has not been observed causing discolorations by itself. The abundance of



Figs. 1-3 *Prorocentrum mexicanum*. 4-6 *P. rhathymum* (Esc. 5mm). 1. Left Valve. 2. Periflagellar region. Inset: bifid spine. 3. Posterior region, annular arrangement of the trichocyst pores. 4. Right valve. 5. Periflagellar region, a single line of trichocyst pores. 6. Posterior

*Pm* seems to increment in direction to the Equator. *P. maximum* (= *Pmax*), a species which also may be easily confused with *Pm*, has not been re-described by SEM yet. Preliminary data obtained with samples collected in the Gulf of Nicoya, Costa Rica, indicates that the cells resembles *P. micans* and the spine in the periflagellar region is lanceolated (fig. 7) [8]. Cells mentioned as *Pmax* have been reported in estuaries in the Gulf of Guayaquil, Ecuador [9], with abundances close to 1000 cells/ml, dominating the area. A detailed (SEM) descriptions of the cells is not available, in particular the spine and periflagellar region, thus, it remains to be demonstrated to which of the three mentioned taxa they belong.

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Roberto Cortés Altamirano, Plankton Laboratory, Unit Academic Mazatlán (ICMyL-UNAM), Apdo. 811, Mazatlán 82040, Sin., Mexico.

Email: roberto@mar.icmyl.unam.mx

Arturo Sierra Beltrán, Molecular Genetics Laboratory, CIBNOR, Apdo. 128, 2300 La Paz, BCS, Mexico.

Email: asierra@cibnor.mx

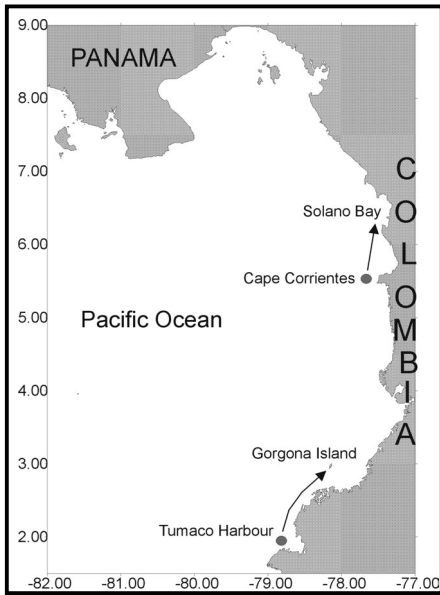
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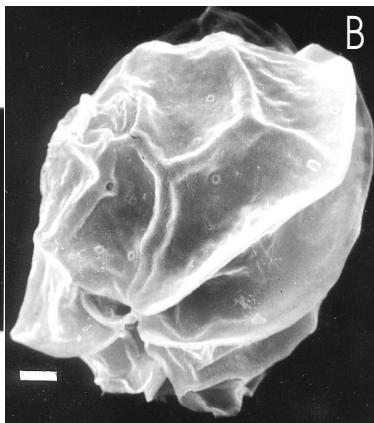
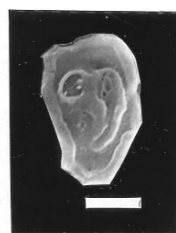
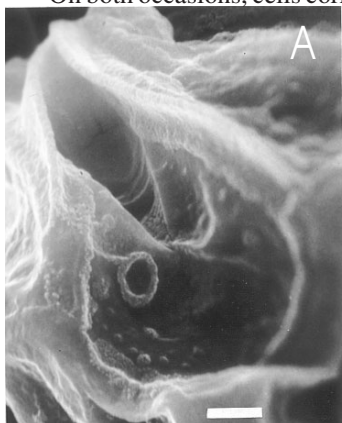
• Colombia

# HABs due to *Alexandrium tamarense* on the Pacific coast of Colombia.



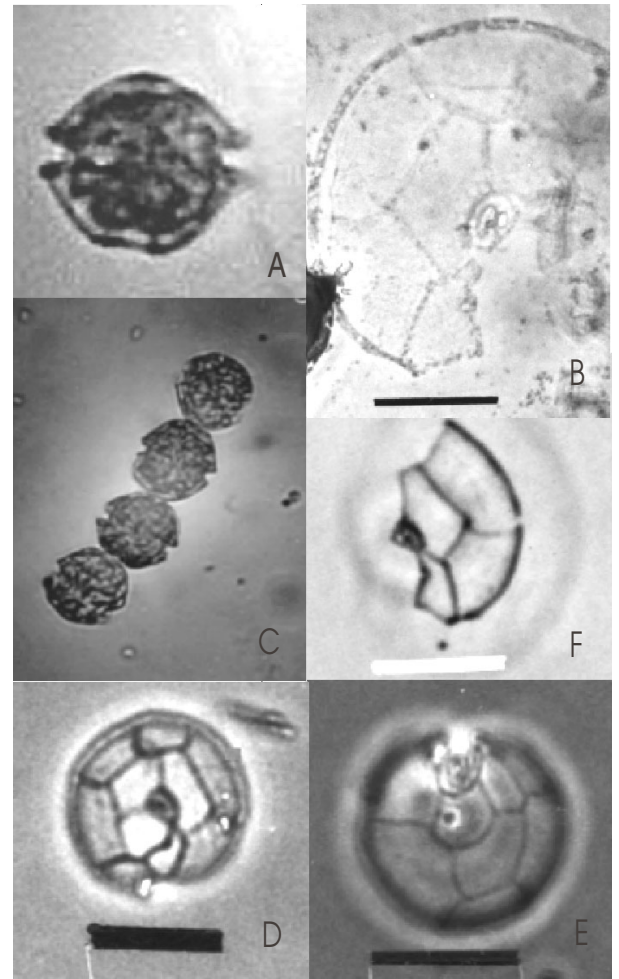
From 26 April to 15 May, 2001, a huge bloom was observed off Tumaco Bay, on the tropical Pacific coast of Colombia (Fig. 1 MAPA). This was the first time a harmful algae bloom (HAB) is reported in the region, reaching north to Gorgona Island. A year later (10 March, 2002), a new offshore occurrence of a HAB event developed from Corrientes Cape to Solano Bay, also on the Pacific of Colombia. Cell counts during these blooms reached  $7.5 \times 10^6$  cells.l<sup>-1</sup> and  $1.6 \times 10^6$  cells.l<sup>-1</sup>, respectively. During both events, low temperature and high salinity were recorded. While the average measurements in the area are 27-27.5°C and 30-31.5 psu, the values observed during the events were 24-24.6°C and 33-34 psu, 3°C below the normal and more than 2.5 psu above the average values, indicative of local upwelling at the time of the events. During these events there were no reports of observable effects on the marine biota or human poisoning, since the blooms occurred offshore and far from exploited shellfish beds.

On both occasions, cells corresponding



to the *Alexandrium* complex represented 99-100% of the biomass. Samples were preserved in Lugol-acetate solution. Phase contrast observations with the aid of Klein's silver stain, allowed detailed description of the apical pore complex, the first apical plate and the posterior sulcal plate of cells collected in 2002 (Figs. 2a-e FOTOS PHASE). Shape, dimensions (L= 25-40µ, X= 32µ, W= 25-37.5µ, n = 50) and detailed structure of the plates were consistent with *Alexandrium tamarense* [1, 2]. It was difficult to differentiate the cells from *Alexandrium catenella*, but the presence of short chains of only 4 cells (single cells represented most of the biomass) was suggestive of *A. tamarense*. Some cells were gold/palladium-coated and observed in SEM. Following the description of Fukuyo [1], the shape and position of the ventral pore on plate 1' and a cell shape slightly longer than wider confirm the identification (Fig. 3 FOTO SEM).

*Alexandrium tamarense* is normally found in temperate waters (16°C in average) [3], but is also reported in warmer regions (= *Gonyaulax tamarensis* f. *excavata*) [4, 5]; it has not been reported before in the tropical Pacific. In 1976 a red tide was recorded in summer (July and September) North of Cape Corrientes but the causative organism was not reported [6]. The Centro de Control de Contaminación del Pacífico of the Colombian Navy has been monitoring the area since 1994



without previous records of this species or HABs, and it may represent an introduction which is favoured by local upwelling.

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Roberto Cortés Altamirano, Plankton Laboratory, (ICMyL-UNAM), Apdo. 811, Mazatlán 82040, Sin., Mexico.  
Email: roberto@mar.icmyl.unam.mx

Ingrid García Hansen, Section Ecology and Marine Biology, (CCCP- Capitanía de Puerto), Mexico.  
Email: igarciahansen@hotmail.com

Arturo Sierra Beltrán, Molecular Genetics Laboratory, CIBNOR, Apdo. 128, 2300 La Paz, BCS, Mexico.  
Email: asierra@cibnor.mx

## Elusive red tides in Kuwait coastal waters

The shallow (<33 m), well mixed, and illuminated but eutrophicated Kuwait Bay waters constitute a highly stressed ecosystem in the arid Arabian Gulf region. These waters contain about 15 potentially harmful phytoplankton taxa some of which attain red tide proportions ( $>20 \mu\text{g chl a l}^{-1}$  and  $5 \times 10^6 \text{ cells l}^{-1}$ ). During the year 2000, two red-water episodes occurred which were ephemeral and massive ( $>4525 \mu\text{g chl a l}^{-1}$  and about 2 billion cells  $\text{l}^{-1}$ ) with the patches extending from  $50 \text{ m}^2$  to  $15 \times 10^4 \text{ m}^2$ . The dominant species differed each time e.g. *Prorocentrum* spp. *Pseudo-nitzschia seriata*, *N. longissima*, *Leptocylindrus* sp. and *Trichodesmium erythraeum*. The blooms were orange greenish-brown and appeared as thick foamy rafts, meshes and strands entraining gas bubbles. In experimental growth studies, eolian dust rich in essential micronutrients for phytoplankton growth had a positive effect on summer phytoplankton growth and yielded  $526.8 \text{ mg chl a m}^{-3}$ , similar to red tide proportions. Blooms of *Karenia* sp. during September–October 1999 were implicated in the mortality of 30 tons of wild mullets and 150 tons of caged sea bream at a cost of \$7 million, but the cause could not be linked to phycotoxins as no toxin analyses were done. Suggestions are presented for a regional institutionalized long term approach to generate a high frequency sampling over extensive areas, to elucidate physiological ecology of suspect phycotoxin producing algae and to investigate the role of dust storms as a major ecological force in the formation of algal blooms.

The Arabian Gulf is a shallow (mean depth 30 m), sub-tropical, hypersaline, and enclosed basin. The Tigris, Euphrates and Karun rivers join to form the Shatt al-Arab River which empties into the northern region of the Gulf (Fig.1). The Shatt al-Arab outflow of about  $1456 \text{ m}^3 \text{ s}^{-1}$  [1] is nutrient rich and is the main fresh water input to the Gulf [2]. As evaporation exceeds run off and because of its semi-enclosed nature, the Gulf acts as a negative estuary [3] and a trap for pollutants as well [1]. With an annual spill of about 200,000 barrels of oil and associated products the Gulf is extremely polluted [4].

To the south of Shatt al-Arab is Kuwait Bay, a highly stressed body of water. The sources of stress include nutrients from the Shatt al-Arab, discharges from 12 major industries including two petrochemical companies, three refineries, discharges of raw sewage, thermal and chlorinated

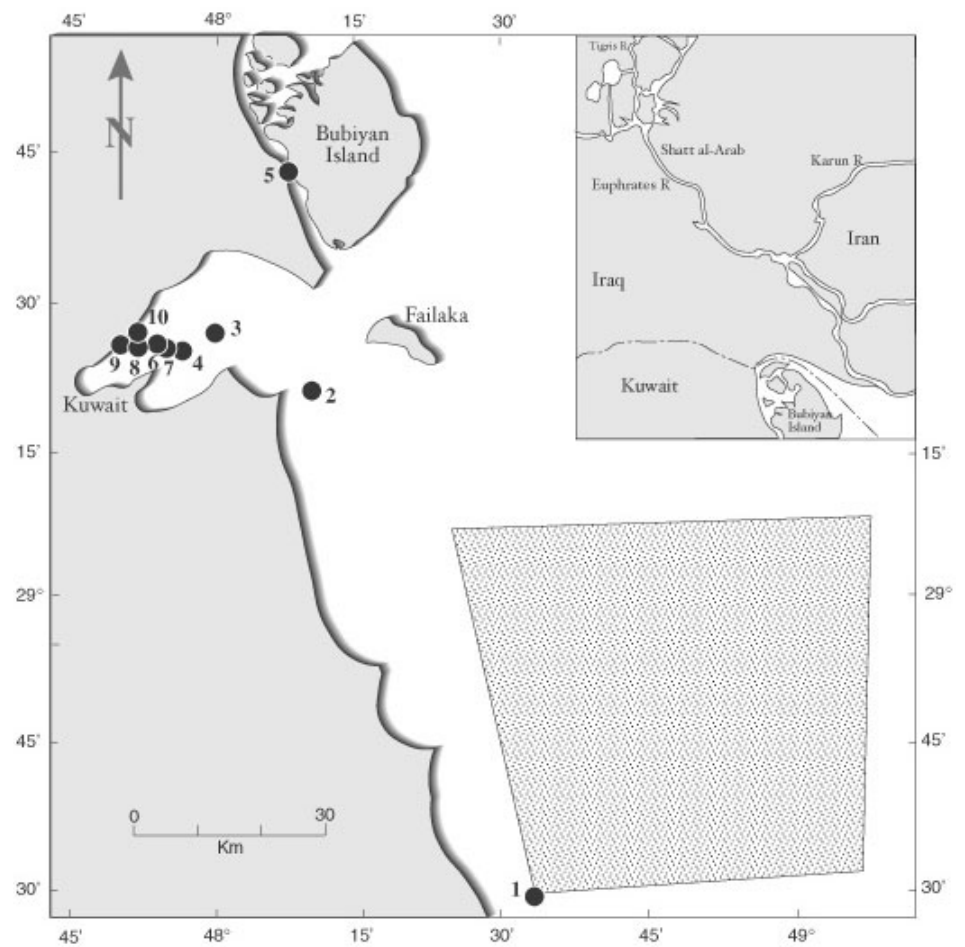


Fig. 1. Kuwait Bay and stations where red tides occurred during May 1997 to July 2000. Numbers represent the sequence of occurrence of blooms (see Table 1). Shaded area represents *Trichodesmium erythraeum* blooms on 19<sup>th</sup> May 2000.

effluents from six dual purpose desalination plants, wastes from slaughter houses, hospital wastes and pollutants associated with the extensive shipping industry [5]. For example in addition to the  $0.003 \times 10^6 \text{ km}^3 \text{ d}^{-1}$  sanitary wastewater,  $0.023 \times 10^6 \text{ km}^3 \text{ d}^{-1}$  wastewater from petrochemical refineries and fertilizer and polypropylene industries [6] and  $0.282 \times 10^6 \text{ km}^3 \text{ d}^{-1}$  raw or partially treated sewage are discharged into the Bay [7]. This sewage has the highest organic content amongst the Gulf countries [8]. Daily discharges from the power plants amount to  $33.6 \text{ km}^3$  chlorinated cooling water and about 17 metric tons of residual oxidants [9]. Because of infilling, dredging of the shipping channels has to be continuous with  $4.66 \times 10^6 \text{ m}^3$  silt dredged annually. On the tacit assumption that the ongoing urbanization of the coastal areas in these arid Gulf countries will increase, stresses on the marine environment are also bound to intensify.

These stressed territorial waters of

Kuwait and Kuwait Bay support a variety of biotopes including some of the world's most northerly coral reefs [10]. The Bay waters are well illuminated with  $325\text{--}575 \text{ W m}^{-2}$  and  $83\text{--}275 \text{ W m}^{-2}$  near the surface and the bottom respectively, sufficient for phytoplankton growth [11]. With a pronounced (3.5 m) tidal amplitude [12], and absence of thermal stratification, the water column is well mixed, and oxygenated except in waters deeper than 30 m where a strong cold bottom current exists in contrast to the upper layer (J.M. Al-Hassan unpublished). These waters are eutrophic and never stripped of the macronutrients i.e. phosphate, silicate and nitrate [11] but cannot be included under the 'very eutrophic category' [13]. Phytoplankton biomass, however, was usually low [10] and ranged between 0.01 to  $12.8 \text{ mg chl a m}^{-3}$  in individual samples and in the column from  $3.8 \text{ mg chl a m}^{-2}$  to mostly less than  $90.0 \text{ mg chl a m}^{-2}$ .

Red tides are almost unknown from the arid zone waters. The absence of

pronounced typical or atypical buildup of biomass in the nutrient rich, well illuminated and well mixed waters off Kuwait, is of prime interest. Red tides have escaped attention, save for a few anecdotes from this region. One of us (J.M. Al-Hassan) observed red tides in 1981 and 1982, but did not report them. Subba Rao *et al.* [14] reported qualitative and quantitative changes in algal species, size fractionated biomass and their primary production characteristics of a red tide from Kuwait coastal waters in 1997. In this paper we have integrated recent observations which illustrate how red tide episodes off Kuwait are frequent, ephemeral and massive.

Surface waters were collected by bucket from a private yacht, stored in polypropylene bottles and transported in ice-coolers to the laboratory for standard chemical and plankton analyses. Salinity was determined using the Orion Conductivity/Salinity Meter, Model 140. Nutrient analyses were based on procedures described in the ROPME manual [15] using Per Storp Analytical Autoanalyzer System and Beckman DU Series 600 Spectrophotometer. Unfortunately on 19 May 2000, phosphate levels, which would have been of significance in view of the *Trichodesmium* bloom could not be determined. Following examination of live water samples under a microscope, samples were preserved with 1% paraformaldehyde+ glutaraldehyde (50:50 volume). Phytoplankton cell densities were enumerated using an inverted plankton microscope. Chlorophyll *a* was estimated

by the fluorometric method [16].

Following three days of calm weather in the waters between 28°30' and 29° 05' Lat. N and 48°20' to 49°05' Long. E, (Fig. 1, Station #1 and hatched area) massive blooms of the blue green alga *Trichodesmium erythraeum* occurred on 19<sup>th</sup> May 2000]. These blooms had >900 µg chl *a* l<sup>-1</sup> and consisted of 100 million cells l<sup>-1</sup>; nitrate and silicate levels were 3 and 39 µg at l<sup>-1</sup> respectively. From our field observations, captured in figure 2 (panels A to D), it is possible to reconstruct the formation of the local red tide patches. The patches consisted of strands and lattice-like structures (panel A) at the surface, which coalesced into extensive floating mats (panel B). The algal aggregates varied from a thin sheen to approximately two cm thick; the thick layers included foamy oily complexes with heterogeneous strands, lattice, or rope-like structures in hues of green, blue, pink, red, orange, brown, and gray (panel C). The approximate size of the patches varied from 50 m<sup>2</sup> to 15 x 10<sup>4</sup> m<sup>2</sup>. Intact patches at the sea surface had a smell similar to decaying vegetables, mechanical agitation resulted in the release of a pungent odor, which affected the human nervous system causing difficulty in breathing, nausea, coughing, choking, irritation to the eyes, a lethargic feeling and loss of co-ordination. Upon storage the odor worsened over 24 h making removal of samples for analysis difficult. Biototoxicity tests could not be carried out because of a lack of facilities. By the following day (20<sup>th</sup> May) a strong northerly wind and the ebb tide caused the blooms to

advect south and disappear.

On 7 July, 2000 (Fig.1, Station #2) massive blooms with *Pseudo-nitzschia seriata* cell densities (749.5-1008.9 millions per litre) were present in the scum thus at least an order of magnitude higher than any literature values from seawater. Other cell densities (millions per litre) were for picoplankton (720.1-962.8), *Prorocentrum* spp. (2.9-4.3), *Nitzschia longissima* (10.1-11.5), *Leptocylindrus* sp. (5.76-10.09), *Gymnodinium* spp. (2.9). Chlorophyll levels were very high (2906.75 – 4525.47 µg chl *a* l<sup>-1</sup>). The salinity of the water ranged from 42.2- 42.4 PSU. Despite the heavy blooms nutrients were not exhausted and ranged (µg at l<sup>-1</sup>) between 0.02 and 1.20 PO<sub>4</sub>, 0.06-0.24 NO<sub>2</sub>, 0.01-0.52 NO<sub>3</sub>, and 11.65-37.07 SiO<sub>3</sub>. The algal cells formed orange greenish- brown thick foamy rafts, meshes and strands that could be scooped from the surface (Fig. 2, Photos A-D). These patches were ~20x30 m in extent and a 12 cm perched bird – *Sylvia nana* (Mutrag in Arabic) could not free itself (Fig. 2, Panel D). Upon storage this foam turned greenish-brown. Although there were several entrained live phytoplankton cells, these rafts contained many dead and decayed phytoplankton cells (unusually large die-offs of the bloom species). Gas bubbles, of undetermined chemical composition, were entrained in the scum for more than 48 h. Under the influence of southeast winds, the associated currents and the high amplitude of tides these patches meandered into Kuwait Bay (Stations #3, 4, 6 to 10). By the third day the blooms had advected out of the bay

Table 1: Summary of occurrences of algal blooms and their biomass (Chl. *a* µg or x 10<sup>6</sup> cells l<sup>-1</sup>) in Kuwait Bay

Occurrence	Station	Taxonomic group	Taxa	Biomass	Reference
Nov. to Jan., March and May 1987 to 1988	Kuwait Bay	Haptophyte	<i>Phaeocystis</i> sp.	136 <i>a</i>	Al-Hassan <i>et al.</i> 1990 #28
October 1996		Ciliates	<i>Myrionecta rubra</i>	156 <i>a</i>	Al-Yamani <i>et al.</i> 1997 #29
May 1997	1	Diatom	<i>Nitzschia</i> spp. and	501 <i>a</i>	Subba Rao <i>et al.</i> 1999a
		Dinoflagellates	<i>Gymnodinium</i> sp.		#19
May 2000	9	Cyanobacteria	<i>Trichodesmium erythraeum</i>	900 <i>a</i>	Present report
July 2000	10	Diatoms	<i>Pseudo-nitzschia seriata</i>	749.5 to 1008.9 cells 2906.75 to 4525.47 <i>a</i>	Present report
	10	Diatoms	<i>N. longissima</i>	10.1-11.5 cells	
	10	Diatoms	<i>Leptocylindrus</i> sp.	5.8-10.1 cells	
	10	Cyanobacteria Picoplankton		720.1 to 962.8 cells	
	10	Dinoflagellates	<i>Prorocentrum</i> spp.	2.9 to 4.3 cells	
	10	Dinoflagellates	<i>Gymnodinium</i> spp.	2.9 cells	

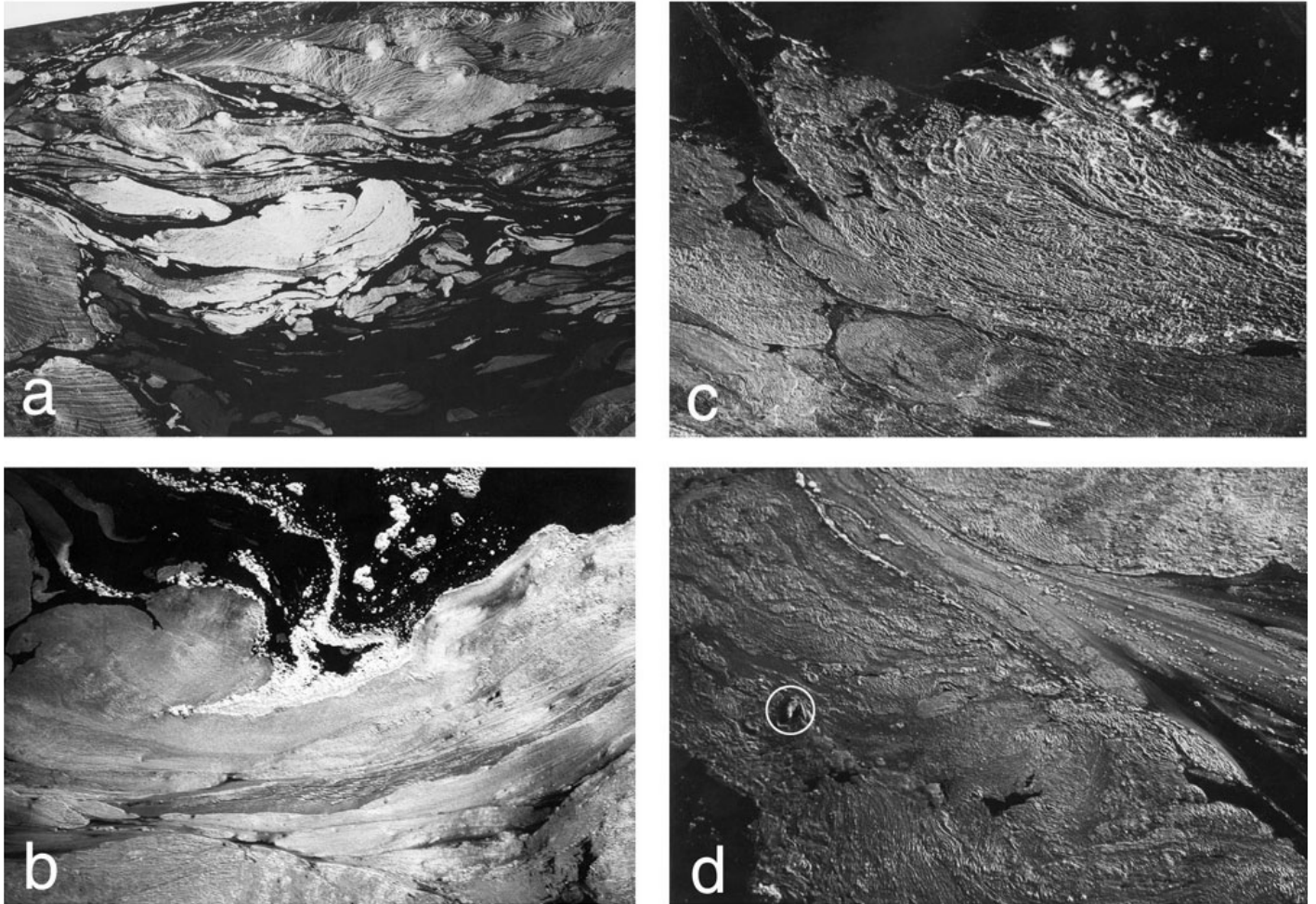


Fig. 2. Panels A,B,C and D showing progressions and patterns of discoloration due to red tide in Kuwait Bay. Panel D shows an entangled bird *Sylvia nana*.

eastwards (Station 5) towards Failaka Island and finally south into the open Gulf.

In this arid zone sea with no pronounced seasonal growth of phytoplankton, the time of occurrence of algal blooms, their constituents and magnitude varied widely in contrast to red tide episodes in the temperate embayments. Thus blooms of *Phaeocystis* species occurred during November-January, March and May [17] with  $136 \mu\text{g chl a l}^{-1}$ , with *Myrionecta rubra* ( $156 \mu\text{g chl a l}^{-1}$ ) during August [18], *Pseudo-nitzschia* spp. and *Gymnodinium* spp. blooms ( $501 \mu\text{g chl a l}^{-1}$  Station #1) during May 1997 [14], and with the benign diatoms *Chaetoceros curvisetus*, *Nitzschia longissima*, and the ciliate *Myrionecta rubra*, and the gymnodinian *Karenia* sp. [19] ( $265 \mu\text{g chl a l}^{-1}$ ) during September-October 1999 (Stations #2, 3, 4, 6, 7 and 8).

On average Kuwait experiences 27 dust storms annually with an average annual dust fall of  $33.38 \text{ g m}^{-2}$  in Kuwait Bay [20]. Phytoplankton samples collected during summer and enriched with dust produced more rapid doublings of biomass than the control and attained chlorophyll values as high as  $526.8 \text{ mg chl a m}^{-3}$ , similar to red tide proportions [21]. The response of

phytoplankton to the addition of eolian dust was rapid and dose dependent in the range of  $10^5$  to  $10^7 \text{ mg m}^{-3}$  enrichments; the differences in the doubling rates and biomass were statistically significant. Of the 29 species initially present, a small Naviculoid diatom ( $<6 \times 3 \mu\text{m}$ ) attained red tide proportions ( $23.1 \times 10^6 \text{ cell l}^{-1}$ ) [21]. The dust contained trace metals in the following ranking:  $\text{Fe} > \text{Zn} > \text{Cu} > \text{Mn} > \text{Co} > \text{Ni}$ ,  $\text{V} > \text{Pb} > \text{Cr}$ , some of which constitute essential micronutrients for phytoplankton growth. Because of their impact, the role of dust storms as a major ecological force in the formation of algal blooms must also be included in any environmental study. The “iron hypothesis” proposes that iron is the limiting nutrient in “high nutrient low chlorophyll” (HNLC) regions, and extensions of it suggest the iron can be supplied by dust storms. There is now quite a large literature about this, and Walsh and colleagues have suggested that wind blown iron makes nitrogen available to *Karenia* via N-fixing *Trichodesmium* blooms.

In Kuwait waters, the 1999 bloom was implicated in the death of 30 tonnes of surface feeding wild mullets and 150 tonnes of caged sea bream, resulting in a loss of

\$7 million and consumer confidence. Confirmatory data on the identity of the suspect toxigenic organisms, nature of the toxin, bioassay, total quantity of toxin delivered are not available but are crucial before implicating the ephemeral algal patches as causative agents of fish kills. Gills of sea bream from the cage cultures yielded levels ( $\mu\text{g g}^{-1}$ ) of As (20-24), Fe (274-987), Ni (7-13.5), Cu (18-31) and Zn (45-252) much higher than the corresponding 4, 36, 1.6, 1.9, and 15 in the gills of wild sea bream. The Se:Ni, Fe:Ni, Zn:Pb ratios in the gills were higher than those in wild fish. It is plausible these metallic elements may have played a compounding role in causing mass mortality of the sea bream [19].

Because of the heavy sea traffic either for recreation, trade, fishing and defence, and because the population is mostly coastal in this arid zone kingdom, the users should be alert to any red tide sightings and report these to a central agency. A regional multinational, multidisciplinary institutionalized marine science program, backed by remote sensing to track red tides would be highly desirable.

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D.V. Subba Rao, Mariculture and Fisheries Dept., Kuwait Institute for Scientific Research, P.O. Box 1638, Salmiya 22017, Kuwait.  
Present address: Habitat Ecology Division, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, NS, Canada, B2Y 4A2.  
Email: DurvasulaSR@mar.dfo-mpo.gc.ca

J.M. Al-Hassan, Dept. of Biological Sciences, Kuwait University, P.O. Box 5659, Safat 13060, Kuwait.

F. Al-Yamani, K. Al-Rafaie, and W. Ismail, Mariculture and Fisheries Dept. Kuwait Institute for Scientific Research, P.O. Box 1638, Salmiya 22017, Kuwait.

C.V. Nageswara Rao, Dept. of Biological Sciences, Kuwait University, P.O. Box 5659, Safat, 13060 Kuwait.

Present address: Dept. Chemistry, K.V.R. College, Nandigama, 521185, Andhra Pr. India.

M. Al-Hassan, Dept. of Biological Sciences, Kuwait University, P.O. Box 5659, Safat 13060, Kuwait.

## • Italy

# Harmful epiphytic dinoflagellate on Tyrrhenian Sea reefs

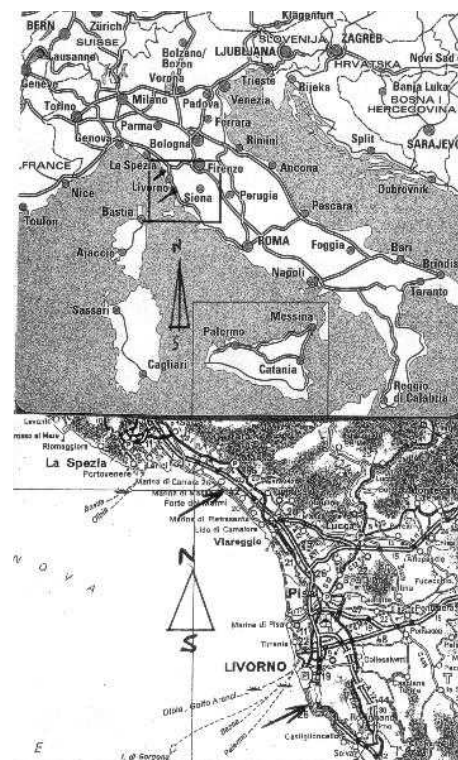
Epiphytic and benthic dinoflagellates present on the reefs of the Tuscany shore have been studied. at two main monitoring areas: one of them on the artificial reef located in submerged sand opposite Marina di Massa beach, to prevent erosion; the other, on natural reefs in the Livorno oligotrophic lagoon. Macroalgae samples (*Corallina mediterranea*, *Cystoseira spicata*, and others) were collected in bags with surrounding seawater. The macroalgae were shaken in sampling water to remove dinoflagellates and weighed. The seawater

was filtered through 125 mm mesh net, and the volume measured. Cell counts were made with an inverted microscope at 100 x, while algae identification was carried on at 600 x UV after colouring thecal plates with calcofluor. The first stage of research showed a bloom of *Ostreopsis ovata*, see table 1 from Simoni et al (2002).

The results indicate that the *Ostreopsis ovata* quickly colonizes the algae of the natural and artificial reefs in late spring and in summer, when the temperature of water reaches 22 °C. *Ostreopsis ovata* is

Table 1

Sampling zone	Date	pH	water temperature	<i>Ostreopsis ovata</i> (density +, ++, +++)
Marina di Massa	30/08/00	8.7	26.5 °C	+++
Marina di Massa	27/09/00	8.4	22.5 °C	++
Marina di Massa	01/12/00	8.3	14.5 °C	+
Livorno	01/12/00	8.8	17.5 °C	+
Livorno	14/02/01	8.8	12 °C	0
Livorno	29/04/01	8.8	15 °C	0
Marina di Massa	04/05/01	8.3	16.9 °C	0
Marina di Massa	01/06/01	8.3	20 °C	0
Livorno	22/06/01	8.4	22 °C	+++
Livorno	03/08/01	8.5	23 °C	+++
Marina di Massa	09/08/01	8.4	24 °C	+++



MONITORING AREAS



# GEOHAB

## Global Ecology and Oceanography of Harmful Algal Blooms

### Announcement of an Open Science Meeting on the Core Research Project: HABs in Upwelling Systems

LISBON, PORTUGAL

Instituto Nacional de Investigação Agrária e das Pescas - INIAP-IPIMAR

17-20 November 2003

#### Conveners

Teresa Moita, Portugal  
Grant Pitcher, South Africa

#### Co-ordinating Committee

Francisco G. Figueiras, Spain  
Raphe Kudela, USA  
Trevor Probyn, South Africa  
Vera Trainer, USA

#### GEOHAB

The GEOHAB Programme, endorsed by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is an international programme aimed at fostering and promoting co-operative research directed toward improving the prediction of harmful algal bloom events.

#### Core Research Project: HABs in Upwelling Systems

The GEOHAB Core Research Project on Harmful Algal Blooms (HABs) in Upwelling Systems must be comparative, interdisciplinary, and international. It will directly address the goal of GEOHAB of improved prediction of HABs by determining the ecological and oceanographic mechanisms underlying their population dynamics, integrating biological, chemical, and physical studies supported by enhanced observation and modelling techniques.

Upwelling systems can be classified according to their physical, chemical and biological characteristics. Development of a Core Research Programme on HABs in Upwelling Systems is built on the premise

that understanding the ecology and oceanography of HABs in upwelling systems will benefit from a comparative approach. The comparative method is the method of choice when controlled experimentation is not practical. To the extent that experimental control in the study of marine ecosystems is problematic, comparison presents an alternative for drawing scientific inference. Comparisons will allow the grouping of harmful species from similar habitat types. The extent, to which HAB species respond in a similar way, in systems which share similar characteristics, will assist in establishing the oceanographic processes that influence HAB population dynamics and community interactions. Equally important will be identification of similar systems that do not have the same functional HAB species or groupings. Understanding the response of harmful algae to perturbations within upwelling systems will assist in prediction, and identification of divergences from predicted responses will also be informative. Sharing of expertise and resources, the formulation of common research objectives and methods, and the implementation of similar research activities and field investigations in each of the designated upwelling systems will permit comparison.

#### Invitation

This announcement serves as an invitation to the broad scientific community to participate in the formulation and design of a GEOHAB Core Research Project on HABs in Upwelling Systems. Scientists working in physical, chemical and/or biological disciplines related to harmful algal research, and on the development of relevant instrumentation and models are encouraged to participate.

#### Meeting Format and Objectives

Monday & Tuesday:

Presentations relating to our current knowledge and understanding of HABs in upwelling systems. Presentation topics will relate to:

- Identification of the HAB species in given upwelling systems
- Identification of the physical, chemical and biological processes that define or characterise upwelling systems and quantification of the response of HAB species to these processes
- Development of models of HABs in upwelling systems to support fundamental research and predictive capabilities.

Wednesday & Thursday:

- Review of current national and regional projects/programmes in order to identify elements of research that could contribute to the Core Research Project.
- Formulation and design of a plan to guide core research in upwelling systems.
- Identification of framework activities to support the research plan.
- Identification of interested participants and designated regions for comparative research.

Friday:

- A GEOHAB Core Research Project Planning Committee will meet in closed session to finalise a report of the Open Science Meeting.

#### For further information:

About the GEOHAB Open Science Meeting: <http://ioc.unesco.org/geohabcore/>

About local arrangements please contact: Teresa Moita, Email: [tmoita@ipimar.pt](mailto:tmoita@ipimar.pt) or Sofia Palma, Email: [sofia@ipimar.pt](mailto:sofia@ipimar.pt), Instituto Nacional de Investigação Agrária e das Pescas, Av. Brasília 1449-006 Lisboa, Portugal, INIAP-IPIMAR (website: <http://ipimar-iniap.ipimar.pt>)

# GEOHAB

Global Ecology and Oceanography of  
Harmful Algal Blooms

## Announcement of an Open Science Meeting on the Core Research Project: HABs in Fjords And Coastal Embayments

VALPARAÍSO, CHILE

COMITE OCEANOGRÁFICO  
NACIONAL

26-30 April 2004

### Conveners

Leonardo Guzman, Chile  
Allan Cembella, Germany

### GEOHAB

The GEOHAB Programme, endorsed by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is an international programme aimed at fostering and promoting co-operative research directed toward improving the prediction of harmful algal bloom events.

### Core Research Project: HABs in Fjords and Coastal Embayments

The GEOHAB Core Research Project on Harmful Algal Blooms (HABs) in Fjords and Coastal Embayments must be comparative, interdisciplinary, and international. It will directly address the goal of GEOHAB of improved prediction of HABs by determining the ecological and oceanographic mechanisms underlying their population dynamics, integrating biological, chemical, and physical studies supported by enhanced observation and modelling techniques.

The overall objective is to understand and quantify the critical processes underlying HAB population and community dynamics in fjords and coastal embayments at temperate latitudes.

Fjords and coastal embayments are combined in this GEOHAB Core Research Project because they share features such as the importance of geographical constraints on water exchange and bloom retention and the dominance of meso-scale structures. Classic fjords, usually characterised by a high ratio of length to width, a deep wedge-shaped basin, freshwater input, and a sill located toward the mouth, create retention and/or initiation zones that favour the proliferation of a particular suite of HAB species. Many groups of key species (e.g., *Alexandrium* spp., *Pseudo-nitzschia* spp., and various raphidophytes) are virtually identical in fjords in the Northern and Southern hemispheres at similar latitudes. Such ecosystems are often only marginally affected by human activities because of low population densities, thus they are usually not subject to eutrophication. Coastal embayments are a broader category of an ecosystem type; generally, such systems comprise relatively shallow nearshore marine environments, partially surrounded by land, and often affected by terrigenous run-off, but on a smaller spatial scale than open coastal or upwelling systems. As with fjords, the hydrodynamic processes may be complex, with an accentuated role of tidal flux, storm surges, wind-driven mixing, and salinity and thermal stratification. The physical processes associated with HABs in these systems are most often related to «density adjustment» problems, that is, buoyancy and frontal dynamics, geostrophic adjustment, establishment of a pycnocline after a storm and perhaps topographic frontal motion. The effects of benthic-pelagic coupling are likely to be crucial in understanding HAB dynamics in fjords and coastal embayments. Coastal

embayments with limited exchange to the open coast may serve as «seed beds» for benthic cysts or relict populations of HAB species. Such systems are particularly vulnerable to anthropogenic changes in the biological and chemical regime, and the introduction of exotic species via debalasting and transfer of aquaculture stock. Many fjords and coastal embayments are well characterised in terms of long-term plankton records and toxicity events. Optical data sets on ocean colour and relevant plankton patches are becoming increasingly available from these systems. Furthermore, basic circulation models (both 2-D and 3-D) are already available from several locations around the world.

**Overall Objective:** To understand and quantify the critical processes underlying HAB population and community dynamics in fjords and coastal embayments in temperate latitudes.

### Invitation

This announcement serves as an invitation to the broad scientific community to participate in the formulation and design of a GEOHAB Core Research Project on HABs in Fjords and Coastal Embayments. Scientists working in physical, chemical and/or biological disciplines related to harmful algal research, and on the development of relevant instrumentation and models are encouraged to participate.

### For further information:

<http://ioc.unesco.org/geohabcore/> or  
<http://www.jhu.edu/scor/OSM2Program.htm>

About local arrangements please contact: Leonardo Guzmán  
(lguzman@ifop.cl)

## HARMFUL ALGAE NEWS

Compiled and edited by Tim Wyatt, Instituto de Investigaciones Marinas, CSIC, Eduardo Cabello 6, 36208 Vigo, Spain; Tel.: +34 986 23 19 30/23 19 73; Fax: +34 986 29 27 62; E-mail: [twyatt@nautilus.iim.csic.es](mailto:twyatt@nautilus.iim.csic.es) and Mónica Lion, Centro Científico y de Comunicación sobre Algas Nocivas COI-IEO, Apdo. 1552, 36200 Vigo, Spain; Tel.: +34 986 49 21 11; Fax: +34 986 49 20 03; E-mail: [monica.lion@vi.ieo.es](mailto:monica.lion@vi.ieo.es)

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Project Coordinator: Henrik Enevoldsen, IOC Science and Communication Centre on Harmful Algae University of Copenhagen, Botanical Institute, Øster Farimagsgade 2D, DK-1353 Copenhagen K, Denmark  
Tel.: +45 33 13 44 46, Fax.: +45 33 13 44 47  
E-mail: [hab@bot.ku.dk](mailto:hab@bot.ku.dk)  
Production Editor: Botanical Institute, Copenhagen