HAB Mitigation: Sediments, Flocculants, and the 14th International HA Symposium

There is increasing focus on mitigating HABs in many aquatic systems throughout the world, with innovative and progressive practices most practiced in China and Korea. At the 14th International HA Symposium in Crete last fall, Gang Pan and Dan Wang presented some recent results indicating use of local coarse sediments mixed with polyaluminum chloride and chitosan to remove a large Microcystis aeruginosa bloom in Lake Tai in China. Pan has also distributed a video of the mitigation on YouTube (www.youtube.com/watch?v=xubClyrZ13o), with substantial public interest. Pan’s work has been so favorably received that a boat specifically constructed for routine bloom mitigation has been built and deployed. In other efforts, coagulants were quite effective in precipitating harmful algae and reported as an inexpensive method to improve water quality (Yuk-kam Kai) with coagulants increasing collisions of clay particles and increased removal efficiencies (Xihua Cao, Ting Wu). Clays were also used to remove microcystins, the common toxins from M. aeruginosa and other cyanobacteria taxa in laboratory experiments, as a precursor to the use of clays in drinking water safety (Erik Prochazka).

The symposium yielded results of additional work in China to examine surface charge of various China clays in removing the raphidophyte Chattonella marina (Xiuxian Song, Ting Wu). Efforts and commitments elsewhere have also expanded. Korea has a history since 1995 for active clay mitigation of blooms that threaten its mariculture systems and Joong Ki Choi continued those studies by detailing China and Mongolia desert ‘yellow dust’ removals of several HA species including Cochlodinium polykrikoides and Prorocentrum minimum. Interest is spreading elsewhere, with other studies in the Philippines with Pyrodinium bahamense var. compressum, Alexandrium affine, Amphidinium carterae, and C. marina (Iris Orizar, Peter Paolo Rivera). In the USA, a national Prevention, Control, and Mitigation HAB program has been set up within the National Oceanographic and Atmospheric Administration’s Center for Sponsored (Cont’d on p. 2)

New Post-column Oxidation LC Method for Saxitoxins Approved by AOAC International – Training Courses

A new post-column oxidation LC fluorescence (PCOX) method for the paralytic shellfish toxins (saxitoxins) is now approved by AOAC International. Jeff Van de Riet of the Canadian Food Inspection Agency (CFIA), Study Director of the method, had previously published a single laboratory validation (SLV) and followed this with a successful large scale inter-laboratory study that had international participation. Following extensive review, the new method has been given “First Action” status as Official Method of Analysis (OMA) 2011.02. Shellfish included in the validation included mussels (Mytilus edulis), softshell clams (Mya arenaria), sea scallops (Placopecten magellanicus) and oysters (Crassostrea virginica). Within the scope of the method are the individual toxins saxitoxin, neosaxitoxin, gonyautoxins-1 to -5, decarbamoylgonyautoxins-2 and -3, decarbamoyl-saxitoxin, N-sulfo-carbamoylgonyautoxins-2 and -3. The overall sensitivity of the method for the toxin profiles and shellfish investigated allows detection of total toxicity above 0.10 mg STX dihydrochloride equivalents per kilogram of tissue (mg STX-dihCl/kg) in the edible tissues. This is 8 times lower than the current quarantine level for the saxitoxins and 4 times lower than possible with mouse bioassay. The PCOX method has already been adopted by the Interstate Shellfish Sanitation Conference (ISSC), the shellfish regulatory group in the USA, as a screening (type IV) method, based on the SLV results. OMA status could clear the way to elevation of the method’s status in ISSC and suggest consideration for “type II” method status in Codex Alimentarius.

The PCOX method was developed in a joint effort by CFIA and the National Research Council of Canada (CNR) both located in the Halifax area of Nova Scotia, Canada. Many researchers in the marine toxins community are familiar with post-column oxidation LC methods developed in the 1980s in Japan (Cont’d on p. 2)
Coastal Ocean Research (NOAA CSCOR). That program is providing support to explore bloom mitigation, with recently announced projects on clay flocculation for tidal-fresh Chesapeake Bay Microcystis blooms [1], bacteria-mediated bloom mitigation in Delaware’s coastal lagoons [2], and prevention of Alexandrium cyst excystment in Massachusetts coastal waters [3].

The Place et al. project [1] builds on Pan’s work as well as that of a 3.5 year research program by an honors undergraduate team at the University of Maryland near Washington, DC [4]. The flocculability, impacts (submersed grass growth, benthic nutrient flux, fate of microcystin, and diel dissolved oxygen dynamics), and socioeconomic considerations of clay plus flocculant additions to cultured and field M. aeruginosa populations have yielded substantial benefits, with high removal efficiencies identified for local sediments [4], minimal detrimental impacts of floccled and settled M. aeruginosa populations [5], and inexpensive and publically-acceptable mitigation possibilities for routine use of the technique (Kevin Sellner).

These sediment and flocculant studies are expanding largely due to anticipated field applications where low costs and technical skill requirements, access to local sediments, and high removal efficiencies warrant consideration. Hopefully, permitting issues will allow field demonstrations in sufficient countries where not only removal efficiencies for natural blooms can be determined but their impacts post-bloom can be quantified and used to inform local considerations for intervening responsibly in recurrent blooms to reduce biomass, toxin and toxicity, and open the system to less harmful phytoplankton.

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Names in bold refer to the abstracts of the 14th International Conference on Harmful Algae, 1-5 November 2010, Hersonissos-Crete, Greece.

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**Information and discussion of validation** and use of officially approved methods were provided by roundtable discussions following presentations by those implementing the methods for paralytic shellfish toxins and lipophilic toxins in the United Kingdom and New Zealand.

The Marine and Freshwater Toxins Task Force and Analytical Community www.aaoac.org/marine_toxins/task_force.htm is an international group of experts and stakeholders that addresses official methods validations. In addition to addressing validation criteria, validation studies, and organizing symposia in the US and in Spain, in recent years the Task Force has offered laboratory training on both instrumental methods and rapid test kits for seafood toxins. Most recently a well attended training course was given on the PCOX method, with Van de Riet as instructor, in Seattle, WA, USA in June 2010. The PCOX method training was taught jointly with a semi-automated version of another official LC method, a pre-column oxidation LC method for the saxitoxins, AOAC OMA 2005.06. The latter method was first to offer an official alternative to mouse bioassay in 50 years, and is now applied in the United Kingdom monitoring programs, completely replacing animal-based detection of saxitoxins there. A total of three new official methods for marine toxins have been approved since the 2004 establishment of the Task Force including, in addition to the LC methods for saxitoxins OMA 2005.06 and OMA 2011.02, a commercial ELISA method for domoic acid, OMA 2006.02.

These important efforts and recent developments in marine toxin methodology validation and training will have a significant impact on shellfish monitoring approaches for detecting marine biotoxins in the protection of human health, leading to increasing use of modern analytical methods rather than outdated mouse bioassays.

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C-MANs and BreveBusters in Veracruz, Mexico (Gulf of Mexico)

A binational agreement between the USA (Environmental Protection Agency) and Mexico (Health Department, the Aquarium of Veracruz and the Institute of Ecology) for the monitoring of red tides in the Gulf of Mexico was signed on 22 April 2009. During the period from 7 to 16 September 2010, personnel of the National Data Buoy Center (NDB) of the National Oceanic and Atmospheric Administration (NOAA) worked on the installation of the Coastal-Marine Automated Network (C-MAN) at three selected sites along the coast of Veracruz: in front of La Mancha lagoon, in front of the port of Veracruz, and near Sacrificios Island (Fig. 1). In addition, personnel of the Aquarium of Veracruz were informed about the use, functioning and maintenance of BreveBuster (Fig. 2), a device designed by Mote Marine Laboratory in Sarasota, Florida, to detect *Karenia brevis* blooms by comparing light absorption by particles in ambient water with the light absorption fingerprint characteristic of *K. brevis*.

Unfortunately, on 17 September, Hurricane Karl hit the Veracruz coasts with winds of 185 km h⁻¹, reaching category 3, stopping activities and damaging the C-MAN installed near Sacrificios Island (Fig. 3). On 22 February 2011, personnel of NBD began to repair C-MANs at the three sites of Veracruz and installed the BreveBusters (Figs. 4, 5 & 6). The devices finally started transmitting data on 28 February (Fig. 7).

For the last two centuries, Veracruz has suffered HABs [1], *Karenia brevis* being the main microalga with notorious toxic effects. During the last decade the occurrence of *K. brevis* has diminished, and *Karenia* blooms seem to have been replaced by recurrent blooms of the non-toxic dinoflagellate *Peridinium quinquecorne* Abé [2]. However, in January 2010, *K. brevis* bloomed along with the morphotype preliminarily called *Karenia* “Mexican hat”, causing fish mortality north of the port of Veracruz [3]. The Aquarium of Veracruz has had a weekly HAB monitoring programme in waters near the port of Veracruz and the Aquarium since May 2005, that has let us know the sites where HABs may occur. The Institute of Ecology is implementing a monitoring programme in the La Mancha lagoon area. Universidad Veracruzana focuses on taxonomy, ecology and biogeography of phytoplankton in the Mexican coastal waters of the Gulf of Mexico.

The C-MANs and BreveBusters represent valuable devices that provide data for understanding HABs. BreveBusters are supposed to provide an early alert so that local authorities can make optimal decisions.

C-MAN stations transmit data on barometric pressure, wind direction and speed, air temperature and dewpoint temperature, which can be consulted online by the public: Station VERV4: www.ndbc.noaa.gov/station_page.php?station=verv4; Station SACV4: www.ndbc.noaa.gov/
BreveBuster data will be managed by personnel of the Mexican Health Department. Data provided by these devices will undoubtedly be a valuable source of information for joint research in situ, not only for the detection of Karenia brevis blooms, but also for the understanding of dynamics of other bloom-forming species in the Veracruz region.

Acknowledgements

The personnel of Acuario de Veracruz J. Valentín Betanzo-García, L. E. Garduño-Chávez, L. J. Martínez-Hernández, J. C. Albores-Rivero, M. A. Román-Vives, J. Zamudio-Morales, B. Poblete-Carlin and R. J. González-Díaz Mirón helped in the installation of C-MANs and BreveBusters at the three sites, under the supervision of NDB.

References:


ISSHA’s Corner

Bill Silvert

Just when this new issue of HAN was completed we heard the sad news about Bill Silvert. He was a theoretical ecologist who worked at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, Canada, until he moved to Portugal in 1998. In the last years, Bill lived in the Algarve (Southern Portugal), worked in association with the University of Faro, and even established his own “Centre for Gastronomic Research”. Some of us met him when he was still full of energy at the ICES-IOC WG on HAB Dynamics held in Huelva (April 2009). Many HAB/phycotoxin experts will remember Bill as the creator of “Phycotoxins”, an e-mail list that since the early 1990’s has worked as an excellent network and communication system. Our sincere condolences to his wife Emilia (Mi), researcher at the IPIMAR in the Algarve (micunha@ipimar.pt). More information about Bill is available at http://bill.silvert.org/

Abstracts 14th ICHA

Abstracts from the 14th International Conference on Harmful Algae (Hersonissos, Crete, 1-5 November 2010) are now available at: www.ishsa.org.

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Fish mortality associated with *Alexandrium cf. fundyense* in Lobito Bay, Angola

Since the 1950s, harmful algal blooms have become more frequent along the Angolan coast, especially in Luanda, Benguela and Namibe provinces. Between 1953 and 2007, dinoflagellates such as *Prorocentrum balticum*, *Gyrodinium spirale*, *Alexandrium spp.*, *Gymnodinium catenatum*, *Gambierdiscus toxicus*, *Pyrodinium bahamense* and *Proterocentrum micans* have been detected, sometimes in association with resource mortalities [1–4]. These blooms and associated mortalities usually occur between July and September, and disappear in October, but are not unknown in the cold season (May–July).

On September 26, 2008, surface samples were collected at 2 stations. The water temperature was 22°C. These samples were fixed with 2% formol. Species identification and counts were made with an Axiovert 200 inverted microscope equipped with phase contrast.

*Alexandrium cf. fundyense* was the dominant species (Fig. 2), with cell concentrations reaching 16 x 10³ cell L⁻¹ at Cais Sul and 14 x 10³ cell L⁻¹ at Cais Norte (Fig. 3). Other species identified in low concentrations were *Proterocentrum micans*, *Proterocentrum diabolicus*, *Gonyaulax spinifera*, *Chattonella antiqua*, *Pleurosigma sp.*, *Synedra* and *Navicula distans*.

The *Alexandrium cf. fundyense* bloom caused mortality of several demersal fish species including *Pomadasy jubelini*, *Albula vulpes*, *Ethamalosa fimbriata*, *Lutjanus agnnes*, *Eucinostomus melanopterus* and *Magil bananensis*.

In South Africa in 1997, sardines mortalities occurred in St Helena Bay, and *A. catenella* was responsible. Stomach content analysis showed 60 to 80 x 10⁵ *Alexandrium* cells in each stomach, and analysis of the viscera revealed toxin concentrations exceeding the harvestable limit of 80 µg toxin 100 g⁻¹ of viscera [5]. In the northern Benguela, *A. tamarense* is a regular red tide species in the Walvis Bay region [5]. *A. tamarense* is recorded in phytoplankton from the central region of the Angola coast [7], a frontal area where the cold Benguela Current and warm Angola Current meet.

An earlier bloom of *Alexandrium* sp. that caused fish and crab mortalities, occurred in Luanda Bay on 24–25 September 2002 with a maximum concentration of 5.1 x 10⁶ cell L⁻¹ [8].

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Harmful algae blooms along the coast of the Baja California Peninsula

The Baja California Peninsula is located in northwestern Mexico and has a coastal zone of ~3,000 km (Fig. 1). The first studies of the phytoplankton began with sporadic expeditions by foreign investigators on both coasts. They provided the first species lists and noted the areas of high concentrations of phytoplankton. From these antecedents, Mexican researchers studied the phytoplankton communities. Special emphasis was placed on species that produce harmful algae blooms (HABs), which were reported by the first Spanish conquerors and explorers. Officially, the first red tides were recorded in the southern part of the peninsula and in Bahía Concepción in 1878. These blooms were caused by the photosynthetic ciliate *Myrionecta rubra* and the dinoflagellate *Noctiluca scintillans* [1]. An exhaustive review of the literature on red tides and unpublished information indicate that more than 80 events and more than 40 bloom-forming species have been reported. From these investigations, four red tide areas have been studied in the last 25 years. These include: Bahía de La Paz and Bahía Concepción on the eastern coast and Bahía Magdalena and Bahía de Todos Santos on the western coast (Fig. 1) [2, 3]. Most of the red tides were innocuous. Red tide species of dinoflagellates include: *Akashiwo sanguinea* (Fig. 2), *Alexandrium affine* (Fig. 3), *Ceratium furca*, *C. balechii*, *Cochlodinium polykrikoides* (Fig. 4), *Ensciculifera* spp., *Dinophysis caudata*, *Gonyaulax polygramma*, *Gymnodinium catenatum* (Fig. 5), *Gyrodinium instriatum* (Fig. 6), *Katodinium glaucum* (Fig. 7), *Lingulodinium polyedra* (Fig. 8), *Noctiluca scintillans* (Fig. 9), *Peridinium quinquecorne*, *Prorocentrum diminutum*, *P. rhathymum*, *P. micans*, *P. minimum*, *P. triestinum*, *Scrippsiella trochoidea*. Diatoms include: *Bellerochea malleus* (Fig. 10), *Chaetoceros compressus*, *C. debilis*, *C. socialis*, *C. radicans*, *Cylindrotheca closterium*, *Eucampia zodiacus* (Fig. 11), *Hemiaulus membranaceus*, *Nitzschia sigma*, *Probuscia alata*, *Pseudo-nitzschia fraudulenta", *Rhizosolenia debyana*, and *Thalassiosira sp.* (Fig. 12). Cyanobacteria include *Trichodesmium erythraeum*. Among the raphidophytes, identified species include: *Chattonella marina* var. *ovata* (Fig. 13), and *C. marina* var. *marina* (Fig. 14), *C. subsalsa*, (Fig. 15); prasinophytes including *Pyramimonas grossi* and silicoflagellates include *Dictyocha californica* (Fig. 16), *D. messanensis*, and *D. octonaria* (Fig. 17).

Nevertheless, some microalgae have been harmful, such as blooms of *Akashiwo sanguinea*, *Ceratium furca*, *Cochlodinium polykrikoides*, and *Thalassiosira* sp. that caused captive fish mortalities, and deaths of lobsters and cultured oysters [4–6]. Increasing incidents involve *Gymnodinium catenatum* which produces paralytic toxins [7–9], but this has not caused public health problems. Other paralytic toxin producers are *Alexandrium catenella* and *A. tamiaianavichii*. Recently, two varieties of *Pyrodinium bahamense* were detected along the southern coast of the peninsula [10]. The presence of *P. bahamense* var. *compressum* along the coast of the State of Guerrero (central western Mexico) and in the peninsular littoral during 2010 has been linked to El Niño conditions [10, 11]. Several potentially toxin-producing species of *Dinophysis* have been detected (*Dinophysis acuminata*, *D. caudata*, *D. cuneus*, *D. fortii*, *D. norvegica*, *D. mitra*, and *D. rapa*). Among the diatoms, *Pseudo-nitzschia australis* and *P. fraudulenta* have proliferated on both coasts of the peninsula. These species are producers of domoic acid, which was detected in field samples and in bivalves during a June 2006 bloom in Bahía de La Paz [12].

Fig. 1. Baja California Peninsula. Bahía de La Paz (BP), Bahía Concepción (BC), Bahía Magdalena (BM), Bahía de Todos Santos (BTS).
Environmental conditions that cause microalgal blooms along the peninsula are partly understood, known to be associated with some combination of nutrient availability, nutrient ratios, and water temperature. Human activities that increase nutrient concentrations (eutrophication) have minor influence on the increase of HABs in some areas. Microalgal blooms have been examined in experimental and commercial shrimp ponds. Main blooming species include the diatom *Nitzschia sigma* and dinoflagellates *Cochlodinium polykrikoides*, *Ensiculifera* var. *marina*, *Gymnodinium*, *Coccolithus* *heatsi*, and *Protoperidinium cinctum* along the coasts of the peninsula [2, 3, 7, 13]. Upwelling intensity is very variable, and depends on wind strength and direction and currents. Blooms also occur after breakdown of the summer thermocline.

Many microalgae form cysts that can easily be transported to the surface, where they germinate and initiate a bloom. Dinoflagellate cysts are common along the coasts of the peninsula [2, 3, 7, 14]. At least 25 different dinoflagellate cyst types were found in surface net phytoplankton (20 µm) samples in Bahía de La Paz. Some dinoflagellate cysts not previously recorded in the bay are shown in Figs. 18–25. Cysts found were related to their vegetative stages in fixed phytoplankton samples. Temporary cysts of *Gyrodiscus*, *Coccolithus* and *Warnowia* were also found. In many cases during diatoms blooms, especially of Chaetoceros spp., resting spores have been observed.

This study was presented for the commemoration of the 25-year celebration of the Planctología Mexicana at the XVI Reunión de la Sociedad Mexicana de Planctología. Funding came from two IPN projects (SIP-20100192, SIP-20110281). The author received support as a COFAA and EDI fellow of IPN.

References:


Mortality of marine fauna in Luanda Bay (Angola)

Records of harmful algae blooms (HABs) have been frequent in Luanda Bay [1–4]. These events are more frequent between August and October, during the transition from the cold season to the warm season [1]. This bay is one of the most economically important in Angola and supports artisanal shellfish extraction, coastal fisheries, and recreational activities, and a large commercial and fishery harbour.

Several dinoflagellates (Prorocentrum, Alexandrium, Gyrodinium, Gymnodinium, Pyrodinium, Prorocentrum micans) and diatoms like Pseudo-nitzschia (1–5) are the main organisms that have caused blooms in Luanda Bay. On 10 September 2010, a great mortality of demersal and pelagic fish and lobsters was recorded on the beach around the Panorama Hotel (8º47’62” S; 13º13’54” E) (Fig. 1).

In the morning of 30 August 2010, a brown colour was seen in the water off Ponte Cais do Carvão (8º45’80”S; 13º15’75”E) in the bay. In the afternoon of the same day and on 31 August, dead fish, mainly demersal species, were observed.

The dead marine species were: Pelagic fish—Liza falcipinis; demersal fish—Pomadasys incisus, Pomadasys peroteti, Dentex bernardi, Diplodis sarguis campesis, Boops boops, Pagellus belotti, Eucnootostomis melanopterus, Parakuhlia macrophthalmus; crustaceans such as Panulirus regius, and Chondrichthyes Dasyatis margarita and Torpedo torpedo.

Surface samples for phytoplankton and dissolved oxygen analyses were collected on these dates. The qualitative and quantitative phytoplankton analyses were performed using Utermöhl methodology, an inverted microscope with phase contrast “Axiovert 200” and dissolved oxygen determination were done using the Winkler procedure.

The phytoplankton analyses of 30 and 31 August found a multispecies bloom with mainly Alexandrium tamarense, Protoceratium reticulatum, Prorocentrum micans, Gyrodinium spirale and Ceratium furca. On 10 September, a similar bloom with Prorocentrum micans 57 x 10³ cell L⁻¹ representing 61% of the total, followed by the flagellate Euglena acusformis with 27 x 10⁴ representing 28% (Fig. 2).

Other phytoplankton species were present in lower numbers (Table 1).

The dissolved oxygen concentrations (DO) in the water in the August and September events were 2.0 and 2.3 mg ml⁻¹ respectively, showing anoxia events caused by multispecific blooms in the Ponte Cais do Carvão and Panorama Hotel areas. In Luanda Bay, high concentrations of Prorocentrum micans causing fish mortality [4] are starting to be frequent, although this species has already caused fish mortalities elsewhere in Angola [5]. Trainer et al [6] describe low-oxygen events that suffocate fish and benthic organisms, often linked to the high respiratory demand of the settling organic matter following bloom decay, and perhaps the most common negative effect of high biomass blooms.

Table 1. Qualitative and quantitative analyses of the phytoplankton bloom

<table>
<thead>
<tr>
<th>Phytoplankton species</th>
<th>Density 10⁴ cell L⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prorocentrum micans</td>
<td>59.7</td>
</tr>
<tr>
<td>Euglena acusformis</td>
<td>27.2</td>
</tr>
<tr>
<td>Scrippsiella trochoidea</td>
<td>6.5</td>
</tr>
<tr>
<td>Ceratium furca</td>
<td>4.4</td>
</tr>
<tr>
<td>Peridinium bipes</td>
<td>1.6</td>
</tr>
<tr>
<td>Gyrodinium spirale</td>
<td>1.1</td>
</tr>
<tr>
<td>Leptocylindrus minimus</td>
<td>0.4</td>
</tr>
<tr>
<td>Gonyaulax turbynei</td>
<td>0.2</td>
</tr>
<tr>
<td>Peridinium diversgens</td>
<td>0.2</td>
</tr>
<tr>
<td>Gonyaulax spinifera</td>
<td>0.2</td>
</tr>
<tr>
<td>Ceratium fusus</td>
<td>0.1</td>
</tr>
<tr>
<td>Dinophysis acuminata</td>
<td>0.1</td>
</tr>
<tr>
<td>Peridinium sp</td>
<td>0.1</td>
</tr>
<tr>
<td>Scrippsiella spinifera</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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**Pseudo-nitzschia pungens** (Grunow ex. Cleve) Hasle from Pakistan coastal waters

Some species of the diatom *Pseudo-nitzschia* produce domoic acid, a toxin responsible for Amnesic Shellfish Poisoning (ASP). *Pseudo-nitzschia* species are cosmopolitan and widely distributed in the Atlantic, Pacific and Indian Oceans, with approximately two dozen species reported from various regions of the world [1]. *P. pungens* has not previously been identified in Pakistan coastal waters bordering the northern Arabian Sea. Samples were collected in July, 2007 from inshore waters of Manora Channel, Karachi (24°58’N, 65°59’E), (Fig. 1). Manora Channel is influenced by coastal pollution and sewage discharges from Layari River.

Samples were collected with net tows (55 µm mesh), and preserved in 1% acid Lugol’s solution. Specimens were air-dried for scanning electron microscopy (SEM), and mounted on the specimen stub and gold coated in the usual manner. A JSM6380A analytical scanning electron microscope was used, and identification mainly based on keys [2–3]. Light microscopy reveals that *Pseudo-nitzschia pungens* forms stepped colonies that are united by the overlapping of valve ends. The cells are strongly elongated in girdle view, margins are parallel through the valve length, gradually narrowing towards the apices (Fig. 2A-B). Valve tips are attenuated and sharply rounded (Fig. 2A-B). The apical axis ranges from 77.5 to 105 µm and transapical axis ranges from 4.2 µm to 4.6 µm. (Fig. 2B). Fibulae and interstriae are 15 in 10 µm. (Fig. 2B). Striae are as dense as fibulae with 15 in 10 µm. Striae end below the apical ending of the raphe (Fig. 2C-D). Central interspace is absent (Fig.2D). Raphe apical ends are located close to the margin of the valve face. Striae are composed of two rows of large poroids and close to the interstriae (Fig. 2D). There are 3 or 4 poroids in 1 µm (Fig. 2D).

**Acknowledgement**

Special thanks to Dr. P. E. Miller (University of California Santa Cruz, CA, USA) for guidance.

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![Fig. 2](image_url)
Algal blooms in the Caspian Sea

Fig. 1. Map of the study area, Station A: Bandar Anzali coasts near the harbor, Station B: Sepidrud River estuary, Kiashshr Region, Station C: Chaboksar Region, Station D: Tonekabon Region, Station E: Nowshahr Region.

The Caspian Sea is the world’s largest inland body of water, lying to the east of the Caucasus Mountains and to the west of the Central Asian steppe, and bordered in the south by Iran. The southern Caspian shores are formed by the Gilan-Golestan lowlands, with the high peaks of the Talish and Elburz Mountains beyond. The region is temperate with high annual average precipitation (Fig. 1). Algal blooms in the southern Caspian Sea were first reported in 2005 (station A) when a bloom of Nodularia spumigena extended over an area of 2 km². In 2006, a bloom of Heterocapsa sp. was observed in Bandar Anzali, then in 2009 and 2010 blooms of Nodularia spumigena were reported in the vicinity of Tonekabon (Station D) and Nowshahr (station E) where water depth is 15–40 m.

Bloom of Nodularia spumigena appeared as masses of cotton like opaque filamentous algae easily visible to the naked eye (Fig. 2) with 90% of the algae being N. spumigena. The surface water temperature at the time of the bloom in September 2005 was 27°C and pH and salinity were 8.4 and 9 PSU respectively. Nutrient concentrations are shown in figure 6.

Other blooms were observed off Chaboksar (station C) in March 2006 and April 2009, some 80 km from station A. The main component of these blooms was Pseudosolenia calcar-avis (Rhizosolenia calcar-avis) contributed 95% of algal numbers. The algal mass formed a sluggish layer covering gill nets set out for sturgeon fishing, and was traced to the depth of 50m (Fig. 2); it exerted adverse effects on the sturgeon catch. The algal mass was also characterized by colloidal detritus particles in the water column. Blooms of P. calcar avis were first observed in the Gorgan Gulf in 1934 and 1935 [1], and throughout the southern Caspian Sea, and in the drainage canal of the Anzali Lagoon in spring and summer.

Fig. 2. Nodularia spumigena filaments collected at the time of bloom in the south Caspian Sea coastline, A: see on water surface with the naked eye. B: N. spumigena filaments (20x) C: N. spumigena filaments (100x) D: N. spumigena filaments (400x). E and F: The Mass seen in the form of a sluggish layer covering gill nets G: Pseudosolenia calcar-avis

Fig. 3. Average concentrations of N-N03, P-PO4 & SiO2 at 2-100 m depths in the south Caspian Sea coastline adjacent to Bandar Anzali region (1999-2006).
Caspian Sea level also varied significantly, and the difference was evident in 2005 coinciding with the bloom event. Significant changes in wind velocity in 2005 and 2006 might also have promoted the bloom.

The Sepidrud River discharges heavy sewage loads into the Caspian Sea [5], and the main pollutants are agricultural, food processing, pulp and paper, industrial and urban wastes [6]. Discharges from fish farms and hatcheries are important sources of phosphate, especially in shallow coastal regions.

Salinity varied from 9 to 12 PSU from near shore to offshore and pH from 8 to 8.4. Fluctuations in salinity are linked to heavy rainfall and flooding events of the rivers draining into the Anzali Lagoon and the Caspian Sea. Increase in freshwater input probably provided ideal conditions for aggregation of cyanophyte cells.

References:

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Continued international commitment to enhance capacity and advance HAB research

In 1991 the IOC established an intergovernmental Panel on Harmful algal Blooms (IPHAB) to foster the effective management of, and scientific research on, harmful algal blooms in order to understand their causes, predict their occurrences, and mitigate their effects. From 12-14 April 2011 the Panel met for the tenth time to identify and decide on priorities for international cooperation on HABs and to recommend to the IOC a work plan for the IOC HAB Programme for the period 2012-2013. Following a presentation by the IPHAB Chair to the full Assembly on 29 June that covered the functions, accomplishments and priorities of the Panel and the IOC HAB Programme, the IOC Assembly endorsed the Work Plan with strong support from many Member States. Additional Member States were encouraged to participate in IPHAB, its task teams and workshops.

Through its working groups, task teams and regional groups the IOC HAB Programme directly engages close to 400 people. A community of 2000 people receives the printed version of 'Harmful Algae News'.

An important task of IPHAB is to review achievements. A brief summary of achievements 2010-2011 includes implementation of ten training courses to identify harmful HAB species and/ on their toxins for protection of public health and in support of critical research; the development and launch by GEOHAB of three new international research plans addressing HABs in fjords and coastal embayments, GEOHAB implementation in Asia, and benthic HABs; the continued strengthening of activities in IOC regional HAB groups - ANCA, FANS A, HANA, and WESTPAC-HAB; provision of the primary communication platform for the international HAB research and management community via the IOC newsletter 'Harmful Algae News'; scientific synthesis and identification of emerging issues from the ICES-IOC WGHABD, and the continued development of the integrated IPHAB-IODE Harmful Algae Information System (HAIS) with links to OBIS. Additional detail on important accomplishments over the past two decades is summarized in Oceanography Vol. 23, No. 3.

IPHAB-X decided on priorities for the coming biennium.

Regarding regional HAB Programme development it was decided to assess the feasibility of regional networks or groups in the Red Sea-Gulf-Arabian Sea-Northern Indian Ocean region, Southern Africa, and Pacific Islands Countries and Territories.

In relation to biotoxin monitoring, management and regulations a Task Team was established to maintain regular contact with FAO, WHO and other regulatory bodies and recommend priorities for research, capacity development and engagement with regulatory bodies to address the most pressing issues and threats posed by HAB toxins.

The GEOHAB Research Programme, within the joint framework of IOC and SCOR, is expected to conclude its activities by the end of 2013. IPHAB recognized in a resolution that to fully realize the benefits of the accumulated investments in GEOHAB, and to address any new priorities identified by the IOC in collaboration with SCOR, it would be desirable to extend specific CRPs and framework activities within the GEOHAB Terms of Reference beyond the end 2013. The GEOHAB Scientific Steering Committee was requested to present to IPHAB- XI for consideration a revised Science Plan and outline of an Implementation Plan for GEOHAB beyond 2013.

IPHAB noted that more than 150 countries worldwide operate desalination plants to produce drinking water from seawater and recognised that desalination capacity is forecast to grow rapidly in the coming years as demand for fresh water grows. Furthermore, in recent years, HABs have caused serious impacts at desalination plants. It was decided to organise a meeting on “Impacts and management of toxic and harmful algal blooms at desalination plants and related seawater facilities” before the end of 2012.

Acknowledging the progress made by the IPHAB Task Team on Algal Taxonomy in publishing and updating the IOC Taxonomic Reference List of Harmful Marine Microalgae as an integrated element of the World Register of Marine Organisms and the IOC/ HABP-IODE HAIS it was decided to continue the Task Team.

IPHAB also noted that warming of surface layers of the ocean may lead to the geographical spreading of HAB species and an increase in the seasonal occurrence of some HAB species and therefore decided to identify central unresolved issues that limit advances in understanding how projected climate change may influence HAB events by convening an ICES/I OC/PICES workshop of HAB experts.

Finally based on the IOC co-sponsored "International Workshop on Fish-killing Marine Algae held in Oslo, Norway, April 2011; and recognising that there is increasing concern about the impact of ichthyotoxict algae on society and aquaculture in particular, IPHAB decided to establish a Task Team on Harmful Algae and Fish Kills to prepare an overview of the scale of the issue and priorities and to support the organization of a joint ICES/I OC/PICES meeting to better define global understanding of the broad issues.

The Panel elected its new Chair, Dr. Robert Magnien (USA), and Vice-Chair, Dr. Gires Usup (Malaysia). The outgoing Chairs Dr. Leonardo Guzman (Chile) and Phil Busby (New Zealand) were thanked for their commitment and contribution to international cooperation on HABs.

All reports on IOC HAB activities can be found at www.ioc-unesco.org/hab/ and any extra information about IPHAB, can be provided by contacting the Chairs (rob.magnien@noaa.gov, giresusup@gmail.com) or the IOC Secretariat (h.enevoldsen@unesco.org).
Johanna Fehling in memoriam

25 October 1974 - 17 February 2011

Johanna Fehling died after a long fight against recurrent brain tumours on the 17 of February, at home in Germany with her family, at the tragically young age of thirty six. At her request, Johanna’s parents released her ashes into the North Sea on Tuesday the 8th of March. She was known to many in the harmful algal community. An in memoriam of Johanna including recollections from colleagues and friends is already displayed on the ISSHA website.

Her parents have requested that anyone who wishes to honour her memory can donate to the German brain cancer support group. They have set up an account in her name that is reached from this link (www.hirntumorhilfe.de/en/helfen-spenden/):
Konto 1010 036 900
BLZ 860 502 00 Sparkasse Muldental

(Unfortunately credit cards are not accepted online)

Career History

2007 – 2010: Post-doctoral Research Fellow, Department of Systematic Botany, Evolutionary Biology Centre, Uppsala University, Uppsala, Sweden. Continuing the same project: Rooting the Eukaryote Tree of Life

2005 – 2007: Post-doctoral Research Fellow, Department of Biology, University of York, York, UK. Rooting the Eukaryote Tree of Life

2004: Research assistant, Culture Collection of Algae and Protozoa, Dunstaffnage Marine Laboratory, Oban, Scotland.


Supervisor: Prof. Dr. M. Spindler

March 1996 – September 2000: Short-term contracts as a support scientist at the Institute for Marine Research, Kiel, Germany, and the Institute for Polar Ecology, Christian-Albrechts University of Kiel, Germany. Microscopy of marine protists in sea-ice and water samples from the Baltic Sea, Arctic and Antarctic Ocean


More Relevant References


The Research on Harmful Algae present at the last ICES Annual Science Meeting in Nantes (France)

Last September 2010, the scientific HAB community had the opportunity to showcase its latest advances to a wide research audience at the ICES Annual Science Meeting 2010 that was held in Nantes (France). An entire session was devoted to the Oceanography and Ecology of HABs and covered a range of issues, focusing on physical/biological interactions and climate change but also including other topics. The session was convened by D. M. Anderson, G. Lacroix and Patrick Gentien. Patrick had been working hard to ensure the success of the session until his untimely demise last May 2010. Below, D.M. Anderson offers a nice summary of the communications presented in the event, which commenced with a dedication in Patrick’s memory. The presentations covered highly diverse processes occurring at wide spatio-temporal scales, but it was heartening to see the level of GEOHAB connected research which was presented. Talks relating to the GEOHAB modelling workshop and HABs in Stratified Systems Core Research Programme activities were presented during the session.

All participants at the meeting had an opportunity to watch videos, including one resulting from the GEOHAB endorsed project F I N A L (Forecasting the Initiation of HABs) which was carried out in France, Scotland and Ireland. Several of the GEOHAB documents were available to participants, including our brochure and the new “HABs in Fjords and Coastal Embayments” report. The new GEOHAB banner was also prominently on display (see photo). In the picture are Robin Raine (chair of GEOHAB, 2006-2009) and Elisa Berdalet (current vice-chair).

Oceanography and ecology of HABs: physical/biological interactions, climate change, and other current issues

Theme Session - ICES Annual Science Meeting

Conveners: D.M. Anderson (USA), G. Lacroix (Belgium), and P. Gentien* (France)

A theme session focusing on HABs was held at the ICES Annual Science Meeting in Nantes, France in September, 2010. This concept was developed during joint meetings of two ICES working groups – the Working Group on Harmful Algal Bloom Dynamics, and the Working Group on Physical Biological Interactions.

The session began with a dedication in memory of our friend and colleague Patrick Gentien, co-convenor of the session who sadly passed away prior to the meeting.

The session covered a wide range of model formulations and HAB species. Some of the models were empirical, including approaches such as utilizing sustained wind from specific directions to generate a “wind index” that had a predictive value for Dinophysis and Karenia blooms in southwest Ireland (R. Raine). Other models focused on small-scale behavior and physics such as the scales of turbulence that affect HABs (E. Berdalet), and a population health model of the distribution of Alexandrium cells infected by the parasite Amoebophrya (M. Sourisseau). This study demonstrated that it is realistic to have spatial separation of infected cells from healthy cells with the appropriate behavior. Larger regional-scale models were also presented including a complex ecosystem model that simulated cyanobacterial blooms in the Baltic given different nutritional initial conditions (U. Daewel). Another large-scale model was a coupled physical-biological model of Alexandrium bloom dynamics in the Gulf of Maine (D. Anderson). That model captured the regional dynamics of this species with some skill and is now being used in short-term (days) to seasonal (months) forecasts. In this instance the abundance of resting cysts is a strong determinant of the magnitude of the resulting bloom, though results in 2010 demonstrated how large cyst germination can still fail to provide a significant bloom if growth conditions are not favorable in the water column. The session included regional reports on the monitoring of toxic phytoplankton from three Icelandic fjords (H. Gudfinnsson), biogeochemistry of cyanobacterial blooms in the Baltic Sea (O. Savchuk), population dynamics of Dinophysis acuminata in the Ría de Pontevedra in Northwest Spain (L. Velo-Suárez) and transport of Dinophysis blooms along...
the south coast of Ireland (R. Raine). Looking to the future, a new project entitled “ASIMUTH” was introduced (J. Silke); this will integrate Earth Observation data, models and in situ data to provide regular HAB bulletins in six locations along the western European Atlantic coast. A series of poster presentations complemented the oral session. Topics included climate change and the impact of storms on HABs (S. Aleksandrov), the rate of domoic acid production in cultures with different forms of nitrate (G. Calu), and the detection of domoic acid by using Solid Phase Adsorption (G. Hermann). Regional presentations included the summer phytoplankton in the Baltic (E. Lange) and monitoring programme in the southern Caspian Sea (M. Monshizadeh). A model of the life cycle of dinoflagellates demonstrated the role of life cycle transitions in regulating bloom dynamics (A. Kroll). Overall the breadth of model types presented for different HABs and different management needs were impressive. It is encouraging that this aspect of the HAB field is progressing at a productive pace. At the entrance of the session, the assistants had the opportunity to receive several documents regarding the IOC/SCOR program GEOHAB. These included brochures, the reports of the GEOHAB Core Research Projects “HABs in Stratified Systems” and “HABs in Fjords and Coastal Embayments”, and “Harmful Algal Blooms in Asia. A comparative approach”.

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Future events

AUGUST 2011

Cyanobacteria and Human Health: Merging Ecology, Epidemiology and Neurologic Disorders

4-6 August 2011 Bowdoin College, Brunswick, Maine, USA

Bowdoin College is sponsoring a three-day workshop, preceded by a one-day short course, focused on the linkages between marine and freshwater cyanobacterial blooms, toxicity, and human health impacts. The goal is to bring together specialists in medicine, neurology, toxicology, epidemiology, ecology, oceanography and limnology from medical, academic, research, federal, state and tribal institutions discuss the current state of understanding at the crossroads of these diverse fields as they relate to Cyanobacterial Blooms and Human Health. The workshop will consist of invited plenary lectures, short invited talks and contributed posters in all relevant areas. Participants are encouraged to submit a poster abstract. Further info: www.bowdoin.edu/earth-oceanographic-science/workshops/index.shtml

OCTOBER 2011

Comparative genomics of eukaryotic microorganisms: understanding the complexity of diversity

15-22 October 2011, San Feliu de Guixols, Spain

The EMBO conference on Comparative Genomics of Eukaryotic Microorganisms will address the big evolutionary questions of what makes a eukaryote, how multicellularity arose, the evolution of reproduction, pathogenesis, and so on. Lineages of the Eukaryotic Tree of Life (TOL) that until now received only moderate attention, such as the Excavates, Archaeplastids, Amoebozoa and Choanozoa, will be discussed, together with the better-studied Chromalveolates and Fungi. There will be opportunities for participants to present both short talks and posters, which will be conducted interactively with plenty of time reserved for questions and discussions. In addition there will be interactive workshops on ‘Do It Yourself’ genomics, databases and bioinformatics.

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Harmful Algae News

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Previous issues of HAN and newsletters of the IOC HAB Programme can be downloaded at http://ioc.unesco.org/hab/news.htm

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