

### In this review:

- A. Recent articles – no abstract
- B. Recent articles with abstracts

O/A denotes an open access article or journal

### A. Recent articles – no abstract

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Schrope, M. **Red tide rising.** *Nature* 452(7183): 24-26, 2008.

Paerl, H.W. and Huisman, J. **Blooms like it hot.** *Science* 320(5872): 57-58, 2008.

### B. Recent articles with abstracts

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Mohamed, Z.A. and Mesaad, I. **First report on *Noctiluca scintillans* blooms in the Red Sea off the coasts of Saudi Arabia: consequences of eutrophication.** *Oceanologia* 49(3): 337-351, 2007.

**Notes:** Blooms of *Noctiluca scintillans* are reported for the first time in the Red Sea off the south-western coasts of Saudi Arabia. During the present study, surface water samples were collected weekly on the coasts of the Al Shuqayq region from February to April 2004-2006. The abundance of *N. scintillans* correlated negatively with most nutrients, as well as the cell densities of diatoms and dinoflagellate species. Microscopic examination of live cells from *Noctiluca* blooms showed the presence of some species of diatoms and dinoflagellates within the *Noctiluca* body - confirmation of its grazing on these microalgae. The presence of a *Noctiluca* bloom in the coastal waters off south-western Saudi Arabia could be linked indirectly to water eutrophication by an increase in prey abundance. The physico-chemical properties of Red Sea coastal waters should therefore be monitored regularly in order to minimize the formation of harmful algal blooms, which may affect all food web levels, including the human level.

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Stephen, V.C. and Hockey, P.A.R. **Evidence for an increasing incidence and severity of Harmful Algal Blooms in the southern Benguela region.** *South African Journal of Science* 103(5-6): 223-231, 2007.

**Notes:** Harmful Algal Blooms (HABs) may lead to catastrophic mortality over a range of trophic levels and impact on fisheries, local species' populations, conservation management and the health of both livestock and humans. Consequently, any increase in frequency and/or toxicity of these events is of concern. Recently this concern has been realized, with reported increases in the frequency of HABs from all continents except Antarctica. This reported rise is supported by data from the Benguela coast of western South Africa, where, since 1930, there has been a significant increase in the frequency of HABs and a slight increase in their average severity. There has been a sixfold increase in the number of HABs per decade since the 1960s, with the period 1990-2005 experiencing the greatest number of blooms, as well as the most severe in terms of associated

mortality. The recent occurrence of previously unrecorded HAB-causing species in this region may go some way to explaining this trend, and further implies that the increase is unlikely to diminish in the near future.

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Ahern, K.S., Ahern, C.R., Savage, G.M., and Udy, J.W. **Mapping the distribution, biomass and tissue nutrient levels of a marine benthic cyanobacteria bloom (*Lyngbya majuscula*)**. *Marine and Freshwater Research* 58(10): 883-904, 2007.

**Notes:** Benthic cyanobacteria blooms, including those of the nitrogen-fixing species *Lyngbya majuscula*, appear to be becoming more numerous and widespread in marine habitats worldwide, and have negative impacts on the environment and human health. The progression of a *L. majuscula* bloom in south-east Queensland, Australia was mapped along with intensive biomass and tissue nutrient sampling every 10 - 14 days over the bloom's 3.5-month duration in summer 2005-2006. Data-integrated GIS maps illustrated the changes in biomass and tissue nutrient pool of the *L. majuscula* through different growth phases (incipient, rapid expansion, plateau or peak and decline) of the bloom. At the peak, *L. majuscula* covered 509 ha and had a mean density of 115 g(dw) m<sup>-2</sup>, with the maximum density recorded 503 g(dw) m<sup>-2</sup>. The highest mean total carbon (29.4% C), nitrogen (3.5% N) and phosphorus (0.143% P) contents in *L. majuscula* tissue corresponded with the peak in biomass. Three-dimensional modelling calculated that at the peak, the bloom contained 5057 t(dw) (510 t(dw)) of *L. majuscula*; 150 000 kg C; 18 000 kg N; 720 kg P; and 5200 kg Fe. This information gives an insight into *L. majuscula* bloom dynamics and ecophysiology and provides quantitative data for models.

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Wang, S.F., Tang, D.L., He, F.L., Fukuyo, Y.S., and Azanza, R.V. **Occurrences of harmful algal blooms (HABs) associated with ocean environments in the South China Sea**. *Hydrobiologia* 596: 79-93, 2008.

**Notes:** Harmful algal blooms (HABs) occur frequently in the South China Sea (SCS), causing enormous economic losses in aquaculture. We analyzed historical HAB records during the period from 1980 to 2003 in SCS. We found that HABs-affected areas have expanded and the frequency of HABs varied during this period. The seasonal and annual variations, as well as causative algal species of HABs are different among the four regions. Areas with frequent HABs include the Pearl River Estuary (China), the Manila Bay (the Philippines), the Masinloc Bay (the Philippines), and the western coast of Sabah (Malaysia). HABs occurred frequently during March-May in the northern region of SCS, May-July in the eastern region, July in the western region, and year-round in the southern region. Among the species that cause HABs, *Noctiluca scintillans* dominated in the northern region, and *Pyrodinium bahamense* in the southern and eastern regions. Causative species also varied in different years for the entire SCS. Both *P. bahamense* and *N. scintillans* were the dominant species during 1980-2003. Some species not previously recorded formed blooms during 1991-2003, including *Phaeocystis globosa*, *Scrippsiella trochoidea*, *Heterosigma akashino*, and *Mesodinium rubrum*. Variations in HABs are related to various regional conditions, such as a reversed monsoon wind in the entire SCS, river discharges in the northern area, upwelling in Vietnam coastal waters during southwest winds and near Malaysia coastal waters during northeast winds, and eutrophication from coastal aquaculture in the Pearl River estuary, Manila Bay, and Masinloc Bay.

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Vargo, G.A., Heila, C.A., Fanning, K.A., Dixon, L.K., Neely, M.B., Lester, K., Ault, D., Murasko, S., Havens, J., Walsh, J., and Bell, S. **Nutrient availability in support of *Karenia brevis* blooms on the central West Florida Shelf: What keeps *Karenia* blooming?** *Continental Shelf Research* 28(1): 73-98, 2008.

**Notes:** Identifying nutrient sources, primarily nitrogen (N) and phosphorus (P), sufficient to support high biomass blooms of the red tide dinoflagellate, *Karenia brevis*, has remained problematic. The West Florida Shelf is oligotrophic, yet populations > 10<sup>6</sup> cells L<sup>-1</sup> frequently occur and blooms can persist for months. Here we examine the magnitude and variety of sources for N and P that are available to support blooms. Annual average in situ or background concentrations of inorganic N in the region where blooms occur range 0.02-0.2 μM while inorganic P ranges 0.025-0.24 μM. Such concentrations would be sufficient to support the growth of populations up to similar to 3 x 10<sup>4</sup> cells L<sup>-1</sup> with at least a 1 d turnover rate. Organic N concentrations average 1-2 orders of magnitude greater than inorganic N, 8-14 μM while organic P concentrations average 0.2-0.5 μM. Concentrations of organic N are sufficient to support blooms > 10<sup>5</sup> cells L<sup>-1</sup> but the extent to which this complex mixture of N species is utilizable is unknown. Other sources of nutrients included in our analysis are aerial deposition, estuarine flux, benthic flux, zooplankton excretion, N<sub>2</sub>-fixation, and subsequent release of organic and inorganic N by *Trichodesmium* spp., and release of N and P from dead and decaying fish killed by the blooms. Inputs based on atmospheric deposition, benthic flux,

and N<sub>2</sub>-fixation, were minor contributors to the flux required to support growth of populations > 2.6 x 10<sup>4</sup> cells L<sup>-1</sup>. N and P from decaying fish could theoretically maintain populations at moderate concentrations but insufficient data on the flux and subsequent mixing rates does not allow us to calculate average values. Zooplankton excretion rates, based on measured zooplankton population estimates and excretion rates could also supply all of the N and P required to support populations of 10<sup>5</sup> and 10<sup>6</sup> cells L<sup>-1</sup>, respectively, but excretion is considered as "regenerated" nutrient input and can only maintain biomass rather than contribute to "new" biomass. The combined estuarine flux from Tampa Bay, Charlotte Harbor, and the Caloosahatchee River can supply a varying, but at times significant level of N and P to meet growth and photosynthesis requirements for populations of approximately 10<sup>5</sup> cells L<sup>-1</sup> or below. Estimates of remineralization of dead fish could supply a significant proportion of bloom maintenance requirements but the rate of supply must still be determined. Overall, a combination of sources is required to maintain populations > 10<sup>6</sup> cells L<sup>-1</sup>.

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McManus, M.A., Kudela, R.M., Silver, M.W., Steward, G.F., Donaghay, P.L., and Sullivan, J.M. **Cryptic blooms: Are thin layers the missing connection?** *Estuaries and Coasts* 31(2): 396-401, 2008.

**Notes:** Harmful algal blooms (HABs) are common in Monterey Bay, CA, and have resulted in repeated closures of shellfish fisheries and the poisoning and death of marine mammals. In the majority of instances, HAB events in this region are first detected by the presence of sick or dying animals. The phrase "cryptic blooms" was adopted to denote the appearance of poisoning at higher trophic levels with no prior evidence of a large phytoplankton bloom. We hypothesize that the onset of many HAB events goes undetected because the bloom is initially concentrated in discrete thin subsurface layers in the water column that are easily missed by conventional sampling and monitoring methods. In this paper, we report on the detection and monitoring of a subsurface layer of phytoplankton in northern Monterey Bay, CA, using a high-resolution, autonomous profiler. This 'thin layer,' which measured from 10 cm to 3 m in thickness (85% < 2 m; 54% < 1 m), persisted over a 7-day period near the base of the pycnocline. The phytoplankton assemblage in the layer was primarily composed of a multi-species assemblage of *Pseudo-nitzschia* including the toxin-producing species *Pseudo-nitzschia australis*. Concentrations of toxic phytoplankton (*P. australis*), cyanobacteria, and bacteria in the layer were significantly higher than outside the layer (P < 0.05). Counts of total *Pseudo-nitzschia* spp. showed similar levels of enrichment in the layer compared to outside the layer. Our findings indicate that, when monitoring for HABs, it is critical to sample at scales appropriate to resolve thin layers. Thin layers have been identified as a common recurrent feature in a variety of coastal systems, suggesting that the use of autonomous high-resolution vertical profilers coupled with targeted sampling, could allow more timely detection of HABs in many coastal environments.

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Glibert, P.M., Alexander, J., Meritt, D.W., North, E.W., and Stoecker, D.K. **Harmful algae pose additional challenges for oyster restoration: Impacts of the harmful algae *Karlodinium veneficum* and *Prorocentrum minimum* on early life stages of the oysters *Crassostrea virginica* and *Crassostrea ariakensis*.** *Journal of Shellfish Research* 26(4): 919-925, 2007.

**Notes:** The eastern oyster, *Crassostrea virginica* (Gmelin, 1791) has been in decline along the eastern seaboard, and especially in Chesapeake Bay, for decades because of over-harvesting, disease and declines in water quality and suitable habitat. Eutrophication has also been increasing over the past half century, leading to increases in hypoxia and harmful algal blooms (HABs). The effects of two common Chesapeake Bay HAB dinoflagellates, *Karlodinium veneficum*, and *Prorocentrum minimum* were tested on larvae of *C. virginica* and the Asian oyster being considered for introduction to Chesapeake Bay, *C. ariakensis*. When embryos from freshly spawned *C. virginica* and *C. ariakensis* were exposed immediately to *K. veneficum* at 10<sup>4</sup> cells mL<sup>-1</sup>, virtually all of the developed larvae were deformed within 48 h in one experimental trial, but not in a second trial in which algae were at a different growth stage. No deformities, and mortalities of < 45%, were observed in controls to which a standard diet of the haptophyte *Isochrysis* was added. When 2-wk-old larvae of both species were exposed to the same HAB species, the effect was a severe reduction in motility with *K. veneficum*, but with *P. minimum* only *C. ariakensis* was affected and not *C. virginica*. Comparisons were made of the frequency of these HABs in Chesapeake Bay from long-term data analysis and the temporal period of spawning. Whereas both blooms are more common during the summer months, the frequency of blooms of *K. veneficum* and the period of oyster spawning, June to September, coincide more strongly. To compare spatial similarity, results of a larval transport model were compared with observational data for *K. veneficum*. This comparison demonstrated a significant overlap in July, particularly in the northern reaches of the Bay. These eutrophication-related HABs thus have the potential to reduce survival of early life history stages of oysters and hence to reduce oyster recruitment. Any reduction in recruitment either spatially or temporally, combined with an overall reduction in sheer numbers of larvae that survive, will make

restoration or establishment of significant, self-sustaining populations of natural or introduced oyster species much more difficult.

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Jin, D., Thunberg, E., and Hoagland, P. **Economic impact of the 2005 red tide event on commercial shellfish fisheries in New England.** *Ocean and Coastal Management* 51(5): 420-429, 2008.

**Notes:** Over the last several decades, harmful algal bloom (HAB) events have been observed in more locations than ever before throughout the United States. The 2005 bloom of *Alexandrium fundyense* was the most widespread and intense in New England waters since a similar event more than three decades ago. In this study, using historical data from the National Marine Fisheries Service, the Massachusetts Division of Marine Fisheries, and other sources, we develop estimates of the direct economic impacts of the 2005 event on commercial shellfish fisheries in Maine and Massachusetts. Results of our regression analyses suggest that the 2005 event had broad spatial and temporal effects on the shellfish market. In response to a supply shortage resulting from local closures, there was an increase in shellfish imports to New England during the red tide. Further, shellfish closures in Maine were the most likely cause of observable price changes on the Fulton Fish Market in New York.

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Aligizaki, K., Katikou, P., Nikolaidis, G., and Panou, A. **First episode of shellfish contamination by palytoxin-like compounds from *Ostreopsis* species (Aegean Sea, Greece).** *Toxicon* 51(3): 418-427, 2008.

**Notes:** In order to investigate the toxicity of *Ostreopsis* species present in Greek coastal waters, cultures of *Ostreopsis* sp. and *Ostreopsis ovata*, mixed *Ostreopsis* field populations and shellfish collected from coastal waters of North Aegean Sea during late summer and autumn periods of 2004, 2005 and 2006 were examined by both mouse bioassay (MBA) and hemolysis neutralization assay (HNA). MBA testing was based on two different extraction protocols, while HNA also included the use of ouabain, a known palytoxin (PLT) antagonist. Results indicated the presence of a compound in both *Ostreopsis* cells and shellfish tissues, which was strongly toxic to mice. This compound exhibited characteristic symptomatology in mice (death, numbness, waddling gait and blindness) to that of PLT, as well as delayed hemolytic activity, which was neutralized by ouabain. HNA indicated that *Ostreopsis* cells contained a PLT-like compound (putative PLT, p-PLT) at concentrations ranging between 0.4 and 0.9 pg/cell, whereas concentration in shellfish tissues was estimated to range from about 33.3 to 97.0 µg-p-PLT/kg tissue. To our knowledge, this is the first report of p-PLT contamination of shellfish by natural *Ostreopsis* species populations in European coastal waters and possibly globally, and also the first evidence on *Ostreopsis* cells' toxicity in the Eastern Mediterranean Sea.

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Hinton, M. and Ramsdell, J.S. **Brevetoxin in two planktivorous fishes after exposure to *Karenia brevis*: implications for food-web transfer to bottlenose dolphins.** *Marine Ecology Progress Series* 356: 251-258, 2008.

**Notes:** Brevetoxin uptake was analyzed in 2 common planktivorous fish that are likely food-web vectors for dolphin mortality events associated with brevetoxin-producing red tides. Fish were exposed to brevetoxin-producing *Karenia brevis* for 10 h under conditions previously reported to produce optimal uptake of toxin in blood after oral exposure. Striped mullet *Mugil cephalus* were exposed to a low dose of brevetoxin, and uptake and depuration by specific organs were evaluated over a 2 mo period. Atlantic menhaden *Brevoortia tyrannus* specimens were used to characterize a higher brevetoxin dose uptake into whole body components and evaluate depuration over 1 mo. We found a high uptake of toxin by menhaden, with a body to water ratio of 57 after a 10 h exposure and a slow elimination with a half life ( $t_{1/2}$ ) of 24 d. Elimination occurred rapidly from the intestine ( $t_{1/2} < 1$  wk) and muscle ( $t_{1/2} \approx 1$  wk) compartments and redistributed to liver which continued to accumulate body stores of toxin for 4 wk. The accumulation and elimination characteristics of the vectoring capacity of these 2 fish species are interpreted in relation to data from the Florida Panhandle dolphin mortality event of 2004. We show that due to slow elimination rate of brevetoxin in planktivorous fish, brevetoxin-related dolphin mortality events may occur without evidence of a concurrent harmful algal bloom event.

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Saito, K., Drgon, T., Krupatkina, D.N., Drgonova, J., Terlizzi, D.E., Mercer, N., and Vasta, G.R. **Effect of biotic and abiotic factors on in vitro proliferation, encystment, and excystment of *Pfiesteria piscicida*.** *Applied and Environmental*

**Notes:** *Pfiesteria* spp. are mixotrophic armored dinoflagellates populating the Atlantic coastal waters of the United States. They have been a focus of intense research due to their reported association with several fish mortality events. We have now used a clonal culture of *Pfiesteria piscicida* and several new environmental isolates to describe growth characteristics, feeding, and factors contributing to the encystment and germination of the organism in both laboratory and environmental samples. We also discuss applied methods of detection of the different morphological forms of *Pfiesteria* in environmental samples. In summary, *Pfiesteria*, when grown with its algal prey, *Rhodomonas* sp., presents a typical growth curve with lag, exponential, and stationary phases, followed by encystment. The doubling time in exponential phase is about 12 h. The profiles of proliferation under a standard light cycle and in the dark were similar, although the peak cell densities were markedly lower when cells were grown in the dark. The addition of urea, chicken manure, and soil extracts did not enhance *Pfiesteria* proliferation, but crude unfiltered spent aquarium water did. Under conditions of food deprivation or cold (4°C), *Pfiesteria* readily formed harvestable cysts that were further analyzed by PCR and scanning electron microscopy. The germination of *Pfiesteria* cysts in environmental sediment was enhanced by the presence of live fish: dinospores could be detected 13 to 15 days earlier and reached 5- to 10-times-higher peak cell densities with live fish than with artificial seawater or f/2 medium alone. The addition of ammonia, urea, nitrate, phosphate, or surprisingly, spent fish aquarium water had no effect

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Halinen, K., Jokela, J., Fewer, D.P., Wahsten, M., and Sivonen, K. **Direct evidence for production of microcystins by *Anabaena* strains from the Baltic Sea.** *Applied and Environmental Microbiology* 73(20): 6543-6550, 2007.

**Notes:** *Anabaena* is a filamentous, N-2-fixing, and morphologically diverse genus of cyanobacteria found in freshwater and brackish water environments worldwide. It contributes to the formation of toxic blooms in freshwater bodies through the production of a range of hepatotoxins or neurotoxins. In the Baltic Sea, *Anabaena* spp. form late summer blooms, together with *Nodularia spumigena* and *Aphanizomenon flos-aquae*. It has been long suspected that Baltic Sea *Anabaena* may produce microcystins. The presence of microcystins has been reported for the coastal regions of the Baltic proper, and a recent report also indicated the presence of the toxin in the open Gulf of Finland. However, at present there is no direct evidence linking Baltic Sea *Anabaena* spp. to microcystin production. Here we report on the isolation of microcystin-producing strains of the genus *Anabaena* in the open Gulf of Finland. The dominant microcystin variants produced by these strains included the highly toxic MCYST-LR as well as [D-Asp<sup>3</sup>]MCYST-LR, [D-Asp<sup>3</sup>]MCYST-HtyR, MCYST-HtyR, [D-Asp<sup>3</sup>,Dha<sup>7</sup>]MCYST-HtyR, and [Dha<sup>7</sup>]MCYST-HtyR variants. Toxic strains were isolated from the coastal Gulf of Finland as well as from the easternmost open-sea sampling station, where there were lower salinities than at other stations. This result suggests that lower salinity may favor microcystin-producing *Anabaena* strains. Furthermore, we sequenced 16S rRNA genes and found evidence for pronounced genetic heterogeneity of the microcystin-producing *Anabaena* strains. Future studies should take into account the potential presence of microcystin-producing *Anabaena* sp. in the Gulf of Finland.

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Negri, A.P., Bolch, C.J.S., Geier, S., Green, D.H., Park, T.G., and Blackburn, S.I. **Widespread presence of hydrophobic paralytic shellfish toxins in *Gymnodinium catenatum*.** *Harmful Algae* 6(6): 774-780, 2007.

**Notes:** The toxic dinoflagellate *Gymnodinium catenatum* Graham produces a newly discovered sub-class of paralytic shellfish toxins (PSTs, saxitoxins) that contain a hydroxybenzoate moiety in place of the carbamoyl group (GC toxins: GC1-GC3). GC toxins bind strongly to sodium channels and their lipophilic nature may increase their potential to bioaccumulate in marine organisms. Cultures of Australian *G. catenatum* strains were found to contain 12-63 mol% GC toxins. The GC toxins were also detected in strains from China (39 mol%), Japan (1-2 mol%), Portugal (58 mol%), Spain (36-54 mol%), and Uruguay (10-16 mol%). A cluster analysis of molar proportions of saxitoxin derivatives produced by strains showed clear clustering by country/region of origin, indicating that GC toxins may be very useful markers to identify the source of *G. catenatum* in the case of new outbreaks. The GC toxins dominate the toxin profiles of many *G. catenatum* strains, and can contribute significantly to sample toxicity, yet these toxins may easily escape detection using conventional chromatography, resulting in significant underestimates of sample toxicity. This has significant implications for shellfish monitoring and safety.

Bargu, S., Powell, C.L., Wang, Z.H., Doucette, G.J., and Silver, M.W. **Note on the occurrence of *Pseudo-nitzschia australis* and domoic acid in squid from Monterey Bay, CA (USA).** *Harmful Algae* 7(1): 45-51, 2008.

**Notes:** Over the past decade diatom blooms of domoic acid (DA)-producing *Pseudo-nitzschia* spp. have been responsible for numerous marine mammal and bird mortalities in Monterey Bay, CA. One possible toxin vector is the market squid, *Loligo opalescens*, a small pelagic mollusk that plays an important role in the near-shore food web of the California Current ecosystem as a favored vertebrate prey species. This study examined the trophic link between toxic *Pseudo-nitzschia* and *L. opalescens* using toxin and stomach content analyses of animals collected from Monterey Bay, CA in 2000. Receptor binding assay data (confirmed by tandem mass spectrometry), demonstrated the presence of DA in squid during a toxic *Pseudo-nitzschia* event, with *P. australis* frustules observed in stomach samples. Though DA levels were low ( $< 0.5 \mu\text{g DA g}^{-1}$  tissue) in *L. opalescens* during the study period, it is now clear that this potent neurotoxin can occur in squid and is likely delivered through its krill prey species, which are known to retain DA after feeding on toxic *Pseudo-nitzschia*. Our findings suggest that further study of the relationship between *Pseudo-nitzschia* blooms and DA contamination of squid is warranted to better evaluate the potential health risk to humans and wildlife associated with this major commercial seafood species and important prey item.

Sipia, V.O., Neffling, M.R., Metcalf, J.S., Nybom, S.M.K., Meriluoto, J.A.O., and Codd, G.A. **Nodularin in feathers and liver of eiders (*Somateria mollissima*) caught from the western Gulf of Finland in June-September 2005.** *Harmful Algae* 7(1): 99-105, 2008.

**Notes:** Nodularins are cyanobacterial hepatotoxins, which may cause intoxication at very low exposure levels. The nodularin-producing cyanobacterium *Nodularia spumigena* usually forms massive blooms in much of the Baltic Sea during the summer season. Breast feathers and liver samples from common eider (*Somateria mollissima*) were analysed for nodularins by liquid chromatography-mass spectrometry (LC-MS) and enzyme-linked immunosorbent assay (ELISA). Fifteen eiders from the western Gulf of Finland were caught by hunters between June and September 2005. Blue mussels (*Mytilus edulis*), a dietary component of the birds, were also obtained by diving near the same marine area and time as the collection of the ducks. Eider breast feathers contained 6-52  $\mu\text{g}$  nodularin-R (Nod-R)/kg dry weight (dw) by ELISA, and 8-43  $\mu\text{g}$  Nod-R/kg dw by LC-MS. No *Nodularia* filaments were adhered to feather samples according to light microscopy assessment. Liver samples from the same individuals contained Nod-R between 3 and 48  $\mu\text{g}/\text{kg}$  dw by LC-MS. Mussel samples from the area contained Nod-R at concentrations of 12-80  $\mu\text{g}/\text{kg}$  dw by LC-MS. Analysis of bird feathers offers a facile and non-invasive means of assessing the exposure of birds to nodularins.

Gobler, C.J., Berry, D.L., Anderson, O.R., Burson, A., Koch, F., Rodgers, B.S., Moore, L.K., Goleski, J.A., Allam, B., Bowser, P., Tang, Y.Z., and Nuzzi, R. **Characterization, dynamics, and ecological impacts of harmful *Cochlodinium polykrikoides* blooms on eastern Long Island, NY, USA.** *Harmful Algae* 7(3): 293-307, 2008.

**Notes:** We report on the emergence of *Cochlodinium polykrikoides* blooms in the Peconic Estuary and Shinnecock Bay, NY, USA, during 2002-2006. Blooms occurred during late summer when temperatures and salinities ranged from 20 to 25°C and 22 to 30 ppt, respectively. Bloom patches achieved cell densities exceeding  $10^5 \text{ ml}^{-1}$  and chlorophyll *a* levels exceeding  $100 \mu\text{g l}^{-1}$ , while background bloom densities were typically  $10^3$ - $10^4 \text{ cells ml}^{-1}$ . Light, scanning electron and ultrathin-section transmission electron microscopy suggested that cells isolated from blooms displayed characteristics of *C. polykrikoides* and provide the first clear documentation of the fine structure for this species. Sequencing of a hypervariable region of the large subunit rDNA confirmed this finding, displaying 100% similarity to other North American *C. polykrikoides* strains, but a lower similarity to strains from Southeast Asia (88-90%). Bioassay experiments demonstrated that 24 h exposure to bloom waters ( $> 5 \times 10^4 \text{ cells ml}^{-1}$ ) killed 100% of multiple fish species (1-week-old *Cyprinodon variegatus*, adult *Fundulus majalis*, adult *Menidia menidia*) and 80% of adult *Fundulus heteroclitus*. Microscopic evaluation of the gills of moribund fish revealed epithelial proliferation with focal areas of fusion of gill lamellae, suggesting impairment of gill function (e.g. respiration, nitrogen excretion, ion balance). Lower fish mortality was observed at intermediate *C. polykrikoides* densities ( $10^3$ - $10^4 \text{ cells ml}^{-1}$ ), while fish survived for 48 h at cell densities below  $1 \times 10^3 \text{ cells ml}^{-1}$ . The inability of frozen and thawed-, or filtered ( $0.2 \mu\text{m}$ )-bloom water to cause fish mortality suggested that the thick polysaccharide layer associated with cell membranes and/or a toxin principle within this layer may be responsible for fish mortality. Juvenile bay scallops (*Argopecten irradians*) and American oysters (*Crassostrea virginica*) experienced elevated mortality compared to control treatments during a 9-day exposure to bloom water ( $\sim 5 \times 10^4 \text{ cells ml}^{-1}$ ). Surviving scallops exposed to bloom water also experienced significantly reduced growth rates. Moribund shellfish displayed hyperplasia, hemorrhaging, squamation, and apoptosis in gill and digestive tissues with gill inflammation

specifically associated with areas containing *C. polykrikoides* cells. In summary, our results indicate *C. polykrikoides* blooms have become annual events on eastern Long Island and that bloom waters are capable of causing rapid mortality in multiple species of finfish and shellfish.

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Curtiss, C.C., Langlois, G.W., Busse, L.B., Mazzillo, F., and Silver, M.W. **The emergence of *Cochlodinium* along the California Coast (USA).** *Harmful Algae* 7(3): 337-346, 2008.

**Notes:** A sudden and nearly synchronous emergence of the red tide forming dinoflagellate *Cochlodinium* along more than 800 km of California coastline was initially observed in late summer 2004. Thereafter high cell concentrations; have been detected on an annual basis. Here, we present quantitative and semi-quantitative data indicating that *Cochlodinium* was uncommon in the phytoplankton community in California prior to 2004 and is now persisting as a more regular component and one that seasonally can cause red tides. The quantitative portion of this study was primarily conducted in Monterey Bay, where cell densities reached at least  $6 \times 10^4$  cells  $L^{-1}$  during the initial outbreak. A semi-quantitative comparison of California coastal counties by the California Department of Health Services (CDHS) was also made: of the 15 counties surveyed (most with multiple sites per county), cells were detected only from Los Angeles County in the south to San Mateo County in the central region (seven counties), but not in the northern part of the state (six counties). Two counties in the central region of the state, San Luis Obispo and Santa Cruz, displayed intense and frequent periods of elevated *Cochlodinium* cell abundances. Although not observed in the state-wide CDHS survey, we occasionally found cells in San Diego County with densities up to  $2.7 \times 10^4$  cells  $L^{-1}$ . Though these colonial dinoflagellates have been recognized in California for over 80 years, with several "blooms" recorded prior to 2004, the species' geographic range and abundance in recent years suggest significant shifts in the nearshore phytoplankton community of this region of the eastern Pacific.

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Twiner, M.J., Rehmann, N., Hess, P., and Doucette, G.J. **Azspiracid shellfish poisoning: a review on the chemistry, ecology, and toxicology with an emphasis on human health impacts.** *Marine Drugs* 6(2): 39-72, 2008. **O/A**

**Notes:** Azspiracids (AZA) are polyether marine toxins that accumulate in various shellfish species and have been associated with severe gastrointestinal human intoxications since 1995. This toxin class has since been reported from several countries, including Morocco and much of western Europe. A regulatory limit of 160  $\mu g$  AZA/kg whole shellfish flesh was established by the EU in order to protect human health; however, in some cases, AZA concentrations far exceed the action level. Herein we discuss recent advances on the chemistry of various AZA analogs, review the ecology of AZAs, including the putative progenitor algal species, collectively interpret the *in vitro* and *in vivo* data on the toxicology of AZAs relating to human health issues, and outline the European legislature associated with AZAs.

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Paz, B., Daranas, A.H., Norte, M., Riobó, P., Franco, J.M., and Fernández, J.J. **Yessotoxins, a group of marine polyether toxins: an overview.** *Marine Drugs* 6(2): 73-102, 2008. **O/A**

**Notes:** Yessotoxin (YTX) is a marine polyether toxin that was first isolated in 1986 from the scallop *Patinopecten yessoensis*. Subsequently, it was reported that YTX is produced by the dinoflagellates *Protoceratium reticulatum*, *Lingulodinium polyedrum* and *Gonyaulax spinifera*. YTXs have been associated with diarrhetic shellfish poisoning (DSP) because they are often simultaneously extracted with DSP toxins, and give positive results when tested in the conventional mouse bioassay for DSP toxins. However, recent evidence suggests that YTXs should be excluded from the DSP toxins group, because unlike okadaic acid (OA) and dinophysistoxin-1 (DTX-1), YTXs do not cause either diarrhea or inhibition of protein phosphatases. In spite of the increasing number of molecular studies focused on the toxicity of YTX, the precise mechanism of action is currently unknown. Since the discovery of YTX, almost forty new analogues isolated from both mussels and dinoflagellates have been characterized by NMR or LC-MS/MS techniques. These studies indicate a wide variability in the profile and the relative abundance of YTXs in both, bivalves and dinoflagellates. This review covers current knowledge on the origin, producer organisms and vectors, chemical structures, metabolism, biosynthetic origin, toxicological properties, potential risks to human health and advances in detection methods of YTXs.

Pulido, O.M. **Domoic acid toxicologic pathology: a review.** *Marine Drugs* 6(2): 180-219, 2008. O/A

**Notes:** Domoic acid was identified as the toxin responsible for an outbreak of human poisoning that occurred in Canada in 1987 following consumption of contaminated blue mussels [*Mytilus edulis*]. The poisoning was characterized by a constellation of clinical symptoms and signs. Among the most prominent features described was memory impairment which led to the name Amnesic Shellfish Poisoning [ASP]. Domoic acid is produced by certain marine organisms, such as the red alga *Chondria armata* and planktonic diatom of the genus *Pseudo-nitzschia*. Since 1987, monitoring programs have been successful in preventing other human incidents of ASP. However, there are documented cases of domoic acid intoxication in wild animals and outbreaks of coastal water contamination in many regions world-wide. Hence domoic acid continues to pose a global risk to the health and safety of humans and wildlife. Several mechanisms have been implicated as mediators for the effects of domoic acid. Of particular importance is the role played by glutamate receptors as mediators of excitatory neurotransmission and the demonstration of a wide distribution of these receptors outside the central nervous system, prompting the attention to other tissues as potential target sites. The aim of this document is to provide a comprehensive review of ASP, DOM induced pathology including ultrastructural changes associated to subchronic oral exposure, and discussion of key proposed mechanisms of cell/tissue injury involved in DOM induced brain pathology and considerations relevant to food safety and human health.

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Noguchi, T. and Arakawa, O. **Tetrodotoxin - distribution and accumulation in aquatic organisms, and cases of human intoxication.** *Marine Drugs* 6(2): 220-242, 2008. O/A

**Notes:** Many pufferfish of the family Tetraodontidae possess a potent neurotoxin, tetrodotoxin (TTX). In marine pufferfish species, toxicity is generally high in the liver and ovary, whereas in brackish water and freshwater species, toxicity is higher in the skin. In 1964, the toxin of the California newt was identified as TTX as well, and since then TTX has been detected in a variety of other organisms. TTX is produced primarily by marine bacteria, and pufferfish accumulate TTX via the food chain that begins with these bacteria. Consequently, pufferfish become non-toxic when they are fed TTX-free diets in an environment in which the invasion of TTX-bearing organisms is completely shut off. Although some researchers claim that the TTX of amphibians is endogenous, we believe that it also has an exogenous origin, i.e., from organisms consumed as food. TTX-bearing animals are equipped with a high tolerance to TTX, and thus retain or accumulate TTX possibly as a biologic defense substance. There have been many cases of human intoxication due to the ingestion of TTX-bearing pufferfish, mainly in Japan, China, and Taiwan, and several victims have died. Several cases of TTX intoxication due to the ingestion of small gastropods, including some lethal cases, were recently reported in China and Taiwan, revealing a serious public health issue.

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Ramsdell, J.S. and Zabka, T.S. **In utero domoic acid toxicity: a fetal basis to adult disease in the California sea lion (*Zalophus californianus*).** *Marine Drugs* 6(2): 262-290, 2008. O/A

**Notes:** California sea lions have been a repeated subject of investigation for early life toxicity, which has been documented to occur with increasing frequency from late February through mid-May in association with organochlorine (PCB and DDT) poisoning and infectious disease in the 1970's and domoic acid poisoning in the last decade. The mass early life mortality events result from the concentrated breeding grounds and synchronization of reproduction over a 28 day post partum estrus cycle and 11 month *in utero* phase. This physiological synchronization is triggered by a decreasing photoperiod of 11.48 h/day that occurs approximately 90 days after conception at the major California breeding grounds. The photoperiod trigger activates implantation of embryos to proceed with development for the next 242 days until birth. Embryonic diapause is a selectable trait thought to optimize timing for food utilization and male migratory patterns; yet from the toxicological perspective presented here also serves to synchronize developmental toxicity of pulsed environmental events such as domoic acid poisoning. Research studies in laboratory animals have defined age-dependent neurotoxic effects during development and windows of susceptibility to domoic acid exposure. This review will evaluate experimental domoic acid neurotoxicity in developing rodents and, aided by comparative allometric projections, will analyze potential prenatal toxicity and exposure susceptibility in the California sea lion. This analysis should provide a useful tool to forecast fetal toxicity and understand the impact of fetal toxicity on adult disease of the California sea lion.

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Deeds, J.R., Landsberg, J.H., Etheridge, S.M., Pitcher, G.C., and Watt Longan, S. **Non-traditional vectors for paralytic shellfish poisoning.** *Marine Drugs* 6(2): 308-348, 2008. **O/A**

**Notes:** Paralytic shellfish poisoning (PSP), due to saxitoxin and related compounds, typically results from the consumption of filter-feeding molluscan shellfish that concentrate toxins from marine dinoflagellates. In addition to these microalgal sources, saxitoxin and related compounds, referred to in this review as STXs, are also produced in freshwater cyanobacteria and have been associated with calcareous red macroalgae. STXs are transferred and bioaccumulate throughout aquatic food webs, and can be vectored to terrestrial biota, including humans. Fisheries closures and human intoxications due to STXs have been documented in several non-traditional (i.e. non-filter-feeding) vectors. These include, but are not limited to, marine gastropods, both carnivorous and grazing, crustacea, and fish that acquire STXs through toxin transfer. Often due to spatial, temporal, or a species disconnection from the primary source of STXs (bloom forming dinoflagellates), monitoring and management of such non-traditional PSP vectors has been challenging. A brief literature review is provided for filter feeding (traditional) and nonfilter feeding (non-traditional) vectors of STXs with specific reference to human effects. We include several case studies pertaining to management actions to prevent PSP, as well as food poisoning incidents from STX(s) accumulation in non-traditional PSP vectors.

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Wang, D.-Z. **Neurotoxins from marine dinoflagellates: A brief review.** *Marine Drugs* 6(2): 349-371, 2008. **O/A**

**Notes:** Dinoflagellates are not only important marine primary producers and grazers, but also the major causative agents of harmful algal blooms. It has been reported that many dinoflagellate species can produce various natural toxins. These toxins can be extremely toxic and many of them are effective at far lower dosages than conventional chemical agents. Consumption of seafood contaminated by algal toxins results in various seafood poisoning syndromes: paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning (NSP), amnesic shellfish poisoning (ASP), diarrhetic shellfish poisoning (DSP), ciguatera fish poisoning (CFP) and azaspiracid shellfish poisoning (AZP). Most of these poisonings are caused by neurotoxins which present themselves with highly specific effects on the nervous system of animals, including humans, by interfering with nerve impulse transmission. Neurotoxins are a varied group of compounds, both chemically and pharmacologically. They vary in both chemical structure and mechanism of action, and produce very distinct biological effects, which provides a potential application of these toxins in pharmacology and toxicology. This review summarizes the origin, structure and clinical symptoms of PSP, NSP, CFP, AZP, yessotoxin and palytoxin produced by marine dinoflagellates, as well as their molecular mechanisms of action on voltage-gated ion channels.

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