Northwest Fisheries Science Center and Washington Sea Grant Program

RED TIDES

West Coast newsletter on marine biotoxins and harmful algal blooms

This second edition of the *Red Tides* newsletter is published jointly by the Northwest Fisheries Science Center and Washington Sea Grant Program to address the problem of harmful algal blooms (HABs) on the West Coast. The "cost" of HABs is highlighted in this issue, including economic impacts on human health, coastal fisheries, and environmental quality. As this issue goes to press, human illness and hospitalization in Washington state and Alaska, sea lion deaths in California, and widespread closures of shellfish areas in Puget Sound, Washington are being reported, all because of HABs. Research can help find ways to mitigate these problems. However, our work has just begun.

The cost of harmful algal blooms on the West Coast

When you hear the words "harmful algal bloom," do you think of physical harm caused to people, such as illness or even death? These are the extreme harms, but there are many other, less visible harms caused by toxic algal blooms. In this issue of *Red Tides*, we examine one very important harm: the economic loss to the fisheries in coastal regions, including recreational, commercial and subsistence operations. The articles demonstrate how far-reaching and devastating West Coast toxic blooms can be.

What is a harmful algal bloom?

An algal bloom occurs when a single microscopic algal species multiplies until it dominates the microscopic plant (phytoplankton) community, reaching such high concentrations that the water becomes colored. These blooms often are referred to as "red tides" but can also appear green, yellow or brown. Most harmful algal blooms (HABs) are considered harmful because the algae constituting them produce extremely potent natural poisons known as biotoxins. Some of these compounds are among the most toxic substances known to humans.

How common are HABs?

Scientists believe the incidence of HABs and the marine biotoxins produced by them has increased over the past few decades. At least one study shows an increase in frequency, duration and geographical distribution that cannot be explained entirely by improved monitoring, greater attention from the scientific community, or consumer awareness related to increased seafood consumption. However, there is not enough information available to provide a clear answer to the question. We would need decades of comprehensive shellfish sampling data in order to reach conclusions about the frequency and possibility of increasing occurrences of HABs on the West Coast. Existing data are sketchy, focusing primarily on commercial and recreational shellfish harvesting areas. Further scientific research eventually will reveal the causes and mechanisms that trigger HABs. An example of collaborative research with a goal of determining the causes of HABs is the Olympic Region Harmful Algal Bloom (ORHAB) project (see West Coast Research, this issue), a program led by the Northwest Fisheries Science Center.

Autumn 2000

Toxins and toxic algae

Paralytic shellfish poisoning (PSP) is caused when humans eat shellfish or crabs that have accumulated toxins by filter feeding toxic algae. The toxins include saxitoxin and gonyautoxin derivatives, produced by single-celled plankton (algae) called dinoflagellates. The closure level (seafood cannot be harvested when toxin measurements are at or above this level) for PSP is 80 µg/100 g shellfish or crab meat. Domoic acid poisoning, also called amnesic shellfish poisoning (ASP), is caused when humans eat shellfish, such as razor clams, or crabs, such as Dungeness crabs, that have ingested plankton that produce a toxin.The toxin, domoic acid, is produced by a species of single-celled plankton called a diatom. The closure level for domoic acid is 20 parts per million (ppm).

HABs and human health

Aside from the impact of HABs on local and regional economies, the significant health impacts of PSP are believed to be vastly under-reported. Since 1980, at least 183 cases of HAB-toxin related illness and three deaths have been reported in the four West Coast states (primarily in Alaska, but also in Washington, Oregon and California). In August 2000, five people were hospitalized in Washington state after eating mussels tainted with PSP. Symptoms of PSP in humans include numbness and tingling of the lips, tongue, face and extremities, difficulty talking, breathing and swallowing, and lack of muscle coordination. There is no known antidote for the biotoxin that causes PSP and treatment is restricted to artificial respiration in life-threatening situations.

Economic consequences of red tides

HABs have adverse economic impacts on the aquaculture industry, human health, coastal economies and subsistence shellfish harvesters. For example:

- The threat of "red tide" has prompted routine closures of both commercial and recreational shellfish harvesting as well as finfish aquaculture operations in some coastal states. Past closures have resulted in large-scale financial losses for the industry and bankruptcies in some cases.
- HAB occurrences affect consumer perceptions of the safety of *uncontaminated* shellfish. This reduces the demand for shellfish in general and affects the fishing and aquaculture industries even where there is no algal contamination.
- HABs may have significant impacts on coastal economies. The uncertainty associated with toxic algal outbreaks adversely affects investment in coastal aquaculture.
- Bans on recreational harvests affect local economies by reducing the amount of money harvesters spend in local communities.
- HABs impede subsistence and ceremonial harvesting by native American coastal tribes. Some tribes and low-income coastal communities depend on shellfish as a source of nutrition, therefore they may experience a higher number of health effects associated with HABs.

The Need for Economic Analysis

Although some attempts have been made to estimate the economic impact of certain red tide events, these studies haven't gone far enough. Researchers have calculated direct costs to the aquaculture industry but these represent a low estimate of the true cost of HABs, which should include the health costs associated with toxic outbreaks, impacts on demand for uncontaminated shellfish and impacts on recreational shellfish harvesting and on the coastal economy. Estimating both the overall economic impact of HABs, and the costs of preventing and/or managing them calls for an integrated assessment approach that would

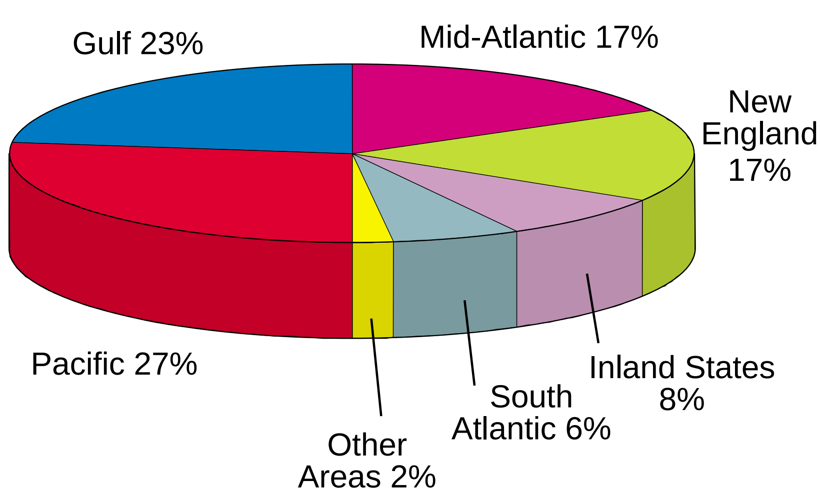
- examine the economic impact of HABs on consumers, the shellfish industry and both coastal and regional economies;
- evaluate of the costs and benefits of reducing coastal pollution and other human-related activities that may exacerbate the HAB problem; and
- weigh the costs and benefits of increased monitoring and surveillance that could potentially reduce the number of shellfish harvesting closures.

Pacific seafood is big business

The Pacific coastal region is home to perhaps the most important fishery in the United States, both in terms of the quantity of seafood harvested and the dollar value of that catch. The region leads in both the number of seafood processing plants (Figure 1) and also in the number of people employed (about 33% of all individuals employed in the seafood industry nationwide).

The Pacific region accounts for 63% of the total pounds of seafood landed in the U.S. and 41% of the total value of seafood products. The 1998 value of the region's salmon harvest was $257 million and the value of harvested crabs and clams was $608 million. In the United States, crustacean and molluscan shellfish account for about $1.4 billion per year or about 62% of the seafood market. All bivalve shellfish, and crabs such as Dungeness crab, are at risk of containing toxins from blooms of various harmful algae. Clearly, HABs can have a major impact on the economy of the Pacific region fishery and fisheries across the U.S.

Figure 1.
Distribution of seafood processing plants



Economic impact on commercial oyster farms

Washington's oyster industry is valued annually at more than $40 million

The 1997 PSP blooms in Washington state severely impacted the oyster harvest in Puget Sound and in the coastal estuaries of Willapa Bay and Grays Harbor. One unusual aspect of the blooms was that they occurred in November and December. The small farms in closed areas suffered great financial losses. A Puget Sound-area farmer of clams and oysters said that he was forced to close for eight weeks, causing him to miss Thanksgiving, Christmas, and New Year's sales, and estimated his losses to be $5,000 per week.

The PSP bloom in Willapa Bay and Grays Harbor was felt just before Thanksgiving Day, which is the oyster industry's busiest time of the year, accounting for 40% of the business. Although the coastal bays were reopened by mid-December, sales during the Christmas season were also lost because out-of-state competitors had moved into the market. About 34 coastal shellfish farms lost approximately 50% of their sales, reducing average sales by about $8 million. Over 100 workers were laid off and many more had hours reduced.

Not only did the small oyster farms suffer in 1997, the entire industry felt the impacts of PSP. Large companies had to scale back shellfish farming in the coastal estuaries and in Puget Sound. Oyster diggers and shuckers throughout the state lost their jobs during this PSP event.

HAB blooms are not yet predictable, so no one can tell you when and where a bloom will occur. But they are sure to occur again. Progress in HAB forecasting and rapid detection will help reduce economic impacts.

HABs in Alaska

In the "last frontier" state, the most damaging harmful algal species is the dinoflagellate *Alexandrium* that causes PSP. A persistent economic and human health problem for Alaska, PSP fatalities date back to 1799 when crew members of Alexander Baranof of the Russian American Trading Company ate tainted blue mussels at Poison Cove.

In 1997 and 1998, nine illnesses and one death were reported from Kodiak Island, the Aleutian Peninsula, and the panhandle near Juneau. Although most PSP illnesses happen during summer months, the season for toxin occurrence cannot be predicted. In the spring of 1999, another death occurred on Kodiak Island, and illnesses requiring emergency attention were reported in February and June 2000. Due to under-reporting of poisoning events, the actual number of illnesses may be 10 to 30 times greater than reports indicate.

Of all states in the Pacific region, Alaska has the largest, most productive fishery in the United States, contributing 54% of the nation's total landings. With an annual revenue of approximately $3 billion, commercial fishing is second only to oil as Alaska's most important industry. The fishing supplies more than 10% of Alaska's jobs, while seafood processing accounts for 63% of employment in the manufacturing sector. Although finfish and crab fisheries are enormous in the state, PSP hinders expansion of Alaska's shellfish industry because regulatory requirements for testing increase the costs and financial risks, and prevent existing shellfish operations from maximizing income.

The cost of PSP to the commercial fishery, recreational harvesters, and the aquaculture industry is believed to exceed $10 million annually. Research is underway to develop quick, inexpensive methods by which shellfish farmers and recreational/subsistence harvesters can determine safe shellfishing times. In addition, early warning systems that will allow more effective management of seafood resources are being tested on buoys (see West Coast Research, this issue).

Dungeness crab, an important West Coast resource

Alaskan Natives are subsistence users of marine resources, but no toxin monitoring program is required to assess the quality of their harvests in a timely manner. Alaskan Natives can be 10 times more likely to contract PSP than the average resident of Kodiak. Because Alaska does not have an agency charged with monitoring the recreational/ subsistence harvests for marine toxins, sampling and testing costs must be paid by the harvester. Testing laboratories have a statutory responsibility to test commercially-harvested products first, so a subsistence harvester may wait several days for results of a sample test.

Alaska's aquaculture industry is greatly concerned that reductions in state funding will result in user fees for state toxin testing. The results to the aquaculture industry would be disastrous. A littleneck clam farmer who sells 800 lbs. of clams each week would be required to send six samples to a lab for testing, at a total cost of $750. With an estimated gross income of the harvest at $2000, the cost of testing would rise to over 37% of the income from the harvest.

Tribes and the value of early warning

Washington's coastal region is a unique area where treaty Indian tribes reside. For ceremonies, subsistence, and commercial sales, these tribes depend on the harvest of marine species such as razor clams, California mussels, littleneck clams, horse clams, butter clams, gooseneck barnacles and Dungeness crabs. Unfortunately, these species can accumulate toxins by filtering seawater. When toxins reach levels too dangerous for human consumption, tribes can face tremendous economic and quality-of-life losses.

Because of declining fish stocks in the Pacific Northwest, including rockfish and salmon, tribes are relying more heavily on shellfish than ever before. Shellfish and crustaceans are a primary source of income to many tribal members. The Quinault tribe, for example, depends on razor clams for both commercial and subsistence harvests. In September 1998, the tribe's entire harvest was lost because of record levels of domoic acid in the meats.

A resource survey that year by the tribes and Washington Department of Fish and Wildlife indicated that the large, adult clam population (over 3 inches shell length) greatly exceeded numbers calculated in previous years. On the four beaches that constitute the Quinault harvest areas, this survey indicated that approximately 250,000 of these clams should have been harvested for commercial sales. At about four clams per pound, that constituted a great economic loss to this tribe.

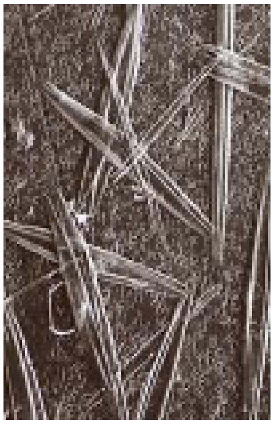
The situation did not improve in 1999. Because natural die-offs of clam populations occur about every five years, and possibly because of unfavorable 1998 El Niño conditions, the Quinault clam harvest was substantially reduced in 1999 for a second year in a row.

The Quileute Tribe in La Push, Washington also suffered great monetary losses during the 1998 domoic acid episode. Toxin levels in Dungeness crab were above the regulatory limit. Crabbers had a choice of eviscerating the crabs (removing the guts) or closing down the fishery entirely. They chose to eviscerate, which greatly decreased the market value of the crabs. This commercial industry lost 50% of the money typically earned. If this toxic episode had been predicted, tribal fishers could have sought an alternative buyer (for eviscerated product), and shellfish managers could have opened the razor clam harvest prior to the toxic event, saving money for a depressed tribal economy.

Shellfish managers need access to quick screening tools for the analysis of toxins and toxic species in both shellfish and seawater. Such screening assays would not only protect humans from exposure to toxins but also would make monitoring more cost effective. Screening assays are currently being developed and tested in the field as a collaboration between the Quileute tribe, the National Ocean Service, and the Northwest Fisheries Science Center.

Razor clam digging on a Washington state beach in 1932

Domoic acid impact on the recreational razor clam fishery



A scanning electron microscope image of *Pseudo-nitzschia*, the diatom that can produce domoic acid

Washington is known for its wide sandy beaches and large populations of the Pacific razor clam, *Siliqua patula*. This very tasty mollusk is one of the West Coast's most popular shellfish for recreational harvest.

The razor clam industry started as a commercial fishery in the late 1800s and evolved into one of the state's largest recreational shellfisheries. During peak spring tides, up to 60,000 diggers have been counted on the 60 miles of sandy coastal beaches in central and southern Washington state. Over the years, disease and increased tribal harvest in off-reservation areas, within the tribes' usual and accustomed fishing areas, has reduced the number of clams available to the recreational fishery by up to 50%.

In the 1960s and 70s, up to a million digger trips were made each year to harvest razor clams on the open coastal beaches in Washington. This harvest provided business for restaurants, motels and RV parks where "clam cleaning sheds" attracted diggers to share stories of how they caught their limit of the "wily razor clam."

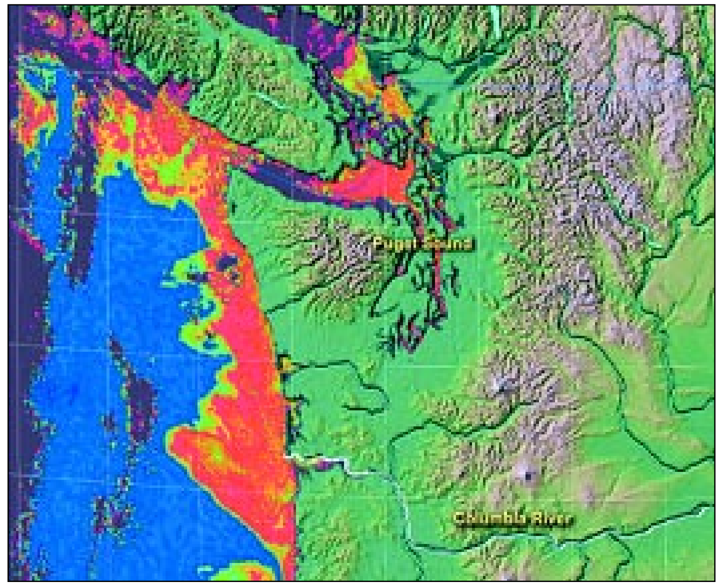
In 1991, domoic acid was discovered in razor clams during a routine test for PSP. Domoic acid is a natural toxin produced by a microscopic organism, *Pseudo-nitzschia*. The toxin can accumulate in digestive tissues of shellfish and in the meat of razor clams. While it does not hurt shellfish, people who eat domoic acid-laden meat can become sick, suffer short-term memory loss, and occasionally die. An emergency closure of the Long Beach peninsula in the fall of 1991 affected thousands of diggers and coastal businesses. Domoic acid levels continued to increase and spread to other beaches, resulting in the closure of all five major clamming beaches. The closures lasted into the following spring, causing an estimated revenue loss of $5 million to $8 million, based on estimates of $25 per day per digger.

Less obvious economic impacts can be just as important to the overall picture.

- Short-notice emergency closures have sometimes left clam diggers disappointed and frustrated given the long-distances they travel, non-refunded lodging costs, and their disbelief of authority figures. In the 1999-2000 season alone, razor clam beaches were closed multiple times with only a couple of days' notice.
- Because few other recreational activities exist in Washington's coastal area, clam harvesting closures reduced income from tourist dollars.

Some of the problems discussed in this newsletter are the subjects of active West Coast research projects. Here is a brief overview of some of these projects.

- August 2000 launched the five-year Olympic Region Harmful Algal Bloom (ORHAB) monitoring project off the coast of Washington state. This is a multidisciplinary, multi-agency partnership to investigate the origins of open-coast blooms of domoic acid-producing algae, and assess the environmental conditions under which they occur and are transported to coastal shellfish. The major partners are: Battelle Marine Laboratory, Northwest Fisheries Science Center, Olympic Coast National Marine Sanctuary, Pacific Shellfish Institute, Quinault Indian Nation, Saigene Corporation, University of Washington, Washington Departments of Fish and Wildlife, Health, and Ecology. This project is sponsored by the Center for Coastal Monitoring and Assessment, NOAA.
- Also during August, field testing began on a prototype buoy monitoring system for the detection of toxic algal species. The instrument, called the Environmental Sample Processor, or ESP, will collect discrete water samples autonomously, concentrate microorganisms within those samples onto filter disks, and automate application of preservatives, DNA (or other molecular probes) to enable identification and quantification of species captured.
- A project on Kodiak Island, Alaska, will use molecular probe technology and advanced seawater toxin detection techniques to determine whether there is a correlation between the abundance of the toxic dinoflagellate, *Alexandrium*, and the toxicity of shellfish (*Mytilus edulus*). The plan is to develop the DNA probe method that can be used by shellfish farmers and recreational/subsistence harvesters to determine safe shellfish harvesting times. This project is funded by the Alaska Science and Technology Foundation.
- A three-year study funded by Washington Sea Grant Program is looking at whether unicellular or multicellular organisms have the ability to measure time. "Clocks" within the cell control fundamental biochemical and molecular events that dictate survival. For a unicellular alga, survival may mean replicating itself, swimming deeper to harvest more nutrients or, in the case of *Heterosigma carterae*, releasing a multiple-function toxin. *Heterosigma* causes severe problems to farmed fish globally in both temperate and sub-tropic regions.



Red indicates areas of highest chlorophyll. Satellite imagery is being tested as a forecasting tool in the ORHAB project.

Center for Environmental Visualization, University of Washington
SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE

How can you help researchers study HABs?

Evidence that marine biotoxins can have a dramatic impact on wildlife, including sea birds and marine mammals, has raised concern among scientists who research and monitor wildlife populations. Domoic acid was discovered on the U.S. West Coast in 1991 because of the death of hundreds of brown pelicans and cormorants. These birds had been feasting on anchovies in Monterey Bay, which had fed on a bloom of the diatom *Pseudo-nitzschia australis*, a phytoplankton species capable of producing domoic acid.

In 1998, and again in 2000, this scenario was repeated in Monterey Bay where a large number of dead or ill sea lions was linked to their consumption of anchovies tainted with domoic acid.

Although state monitoring programs and biotoxin researchers are always on the alert, they cannot be everywhere at once. People who frequent the shoreline and coastal waters for recreation can provide the first observational data of a potential biotoxin event.

To find out how you can help, call your state monitoring program. The following is a partial listing of contacts.

British Columbia

Canada Dept. of Fisheries and Oceans
604.666.3169
Marine Mammal Coordinator
250.756.7236 (Ed Lochbaum)

Alaska

Alaska Dept. of Health
800.731.1312
Marine Mammal Stranding Coordinator 907.586.7824 (Kaja Brix)

Washington

Washington Dept. of Health
800.562.5632
Marine Mammal Stranding Coordinator (Northwest Region)
206.526.6733 (Brent Norberg)

Oregon

Oregon Dept. of Agriculture
503.986.4728
Oregon State Police (Stranding Reports) 800.452.7888

California

California Dept. of Health Services
800.553.4133
Venura Couny: Dept. of Animal Regulation 805.388.4341
St. Luis Obispo to Monterey County: Marine Mammal Center 415.289.seal
Monterey to Santa Cruz County: Moss Landing Marine Lab 831.755.8650
Santa Cruz to San Mateo County: Long Marine Lab 831.459.2883
San Mateo to Medicino County: Calif. Academy Of Science 415.750.7176
Mendicino County: Calif. Dept. of Fish and Game 707.964.9078
Humboldt County to Del Norte: Humboldt State Univ. Vertebrate Museum 707.826.4872

Hawaii

808.586.4725 (Food)
808.586.4586 (Epidemiology)

**biotoxin hotlines*

Alaska

- In June 2000, a man ate 8-10 cooked littleneck clams, drank the clam “juice” and also ate Dungeness crab from an area north of Sitka. Six hours later, he went to the emergency room with symptoms of PSP. Both crab and clam samples showed low levels of PSP, ranging from 32-45 µg/100g.
- A 35-year-old Kodiak man suffered from PSP after eating butter clams harvested near Port Lions on Kodiak Island in February 2000. Two clam samples from the area contained 115 and 134 µg PSP/100 g shellfish, respectively. The man was airlifted to the nearest hospital for treatment and was released the following morning.
- In July 1999, all-time high levels of PSP in geoducks were measured at Vallenar Bay west of Ketchikan, with 1818 µg/100g in the viscera (digestive organs), 71 µg/100g in the meat.

British Columbia

- There were three suspected PSP illnesses in B.C. in 1999, including a woman who consumed butter clams harvested along the central coast, and two individuals who consumed small swimming scallops.
- The highest concentration of PSP in a 1999 sample was 3900 µg/100g in a mussel monitoring sample from Useless Inlet, Barkley Sound, collected on September 20.
- Low levels of domoic acid were found in samples of razor clams, mussels, butter clams, and manila clams. Only one mussel sample from Nuchatlitz Inlet in October 1999 exceeded the action level.
- The Harmful Algal Monitoring Program (HAMP) for the 1999 plankton season observed a bloom of *Cochlodinium* sp., previously not known to be a problem on the Pacific coast of Canada, which caused mortalities to farmed fish in Kyuquot and Quatsino sounds.

Washington

- In late August 2000, an outbreak of PSP at levels greater than 13,700 µg/100g in South Puget mussels resulted in the illness of nine people. Of the five that were hospitalized, three people were placed on respirators.
- In June and July, 1999, a PSP bloom blanketed coastal waters from the Canadian border to Carr Inlet in south Puget Sound, and from Neah Bay on Washington’s coast, east to Anacortes. PSP levels in many areas exceeded 1000 µg/100g.
- Information on public shellfishing sites in Washington is available at *www.doh.wa.gov/ehp/sf/sf10maps.htm*

A net filled with razor clams

Oregon

- PSP toxicity in mussels was observed beginning in late June 1999 on the north and central Oregon coasts. Levels ranged from 42-229 µg/100g on July 19. Levels returned to <45 µg/100g by mid-August.
- In October 1998, record levels of domoic acid in razor clams were 220-308 ppm. In February and March 1999, domoic acid levels still ranged from 28-52 ppm. During the first week of June 1999, levels had dropped to between 13-16 ppm. This illustrates the long retention time of domoic acid in razor clams.

California

- In late June and early July 2000, sea lion mortalities due to domoic acid poisoning were observed on the central California coast. Researchers now suspect that these poisonings may occur more frequently than previously believed.
- The highest levels of domoic acid recorded in mussels since 1991 were measured at 15 ppm at Cayucos and 29 ppm at Cambria (between Morro Bay and San Simeon) in July 2000.
- The maximum concentration of PSP detected in California in 1999 was 750 µg/100g inside Drakes Estero in September.
- Consumers of Washington clams, also known as butter clams, were cautioned to eat only the white meat of this shellfish. By discarding the dark part of the siphon and the viscera, the consumer can reduce the risk of ingesting toxins.

Coming Events

Symposium on Harmful Marine Algae in the U.S., December 5-9, 2000, Marine Biological Laboratory in Woods Hole, Massachusetts

This is the first of a series of biannual meetings to provide a forum for scientific exchange and technical communication on all aspects of marine HAB research in the United States. Each of these meetings will include special theme sessions or mini-symposia. For this first meeting, the highlighted theme will be integrated, multidisciplinary projects within regions, such as the ECOHAB regional studies.

The format will include oral presentations, poster sessions, and discussion groups. Technical demonstrations and workshops are also planned, including: Cell Detection; Toxin Detection; Data Visualization; and Subcellular Localization Techniques. The number of participants will be limited, with preference given to scientists working on United States marine and estuarine HAB issues.

For further information:
http://www.redtide.whoi.edu/hab/symposium/default.html
Judy Kleindinst
508.289.2745
jkleindinst@whoi.edu.

PICES Ninth Annual Meeting, October 20-28, 2000, Hakodate, Hoddaido, Japan.

During the North Pacific Marine Science Organization, PICES Ninth Annual Meeting in October, the North Pacific HAB Working Group (WG15) will convene. The goal of the WG15 is to assess the HAB situation in the North Pacific, to identify the main gaps in the present knowledge, and to outline possible development of collaborative investigations.

For further information about the PICES meeting, visit the Web site: *http://pices.ios.bc.ca/*

For information about WG15 contact Tatiana Orlova at *orlovat@chat.ru*

7th Canadian Workshop on Harmful Marine Algae, May 23-25, 2001, Pacific Biological Station, Nanaimo, BC, Canada

The 7th Canadian Workshop on Harmful Marine Algae will be held in Nanaimo, the central city of Vancouver Island on the west coast of British Columbia. Captain George Vancouver first recorded PSP on this coastline in 1793 when members of his expeditionary crew succumbed to the toxin after a meal of bivalves harvested at Poison Cove. The legacy of PSP occurrence on this coast remains with us today.

There is no registration fee for this workshop, so reserve your place on the distribution list by pre-registering as soon as possible. Participants are invited to submit provisional titles and subject categories (taxonomy, chemistry, ecology, toxicology, physiology, monitoring, mitigation, etc.) for oral and poster presentations.

Deadline for submission of titles, Dec. 15, 2000; abstracts, Feb. 2, 2001.

For further information:
J.N.C. (Ian) Whyte
Tel.: 1.250.756.7007
Fax: 1.250.756.7053
E-mail: *whytei@pac.dfo-mpo.gc.ca*

You can keep up to date on West Coast HAB issues through the NWFSC's Web site (http://*www.nwfsc.noaa.gov/hab*) featuring recent HAB findings from a variety of West Coast researchers, state reports on sampling and HAB occurrences, and links to many other relevant sites.

We acknowledge the following colleagues for their contributions to this newsletter: Dan Ayres, Nancy Blanton, Deb Cannon, Andrea Copping, Frank Cox, Gregg Langlois, Ramanan Laxminarayan, Mitch Lesoing, Terry Nosho, Mike Ostaz, Ray Ralonde, Joe Rhodes, Robyn Ricks, Klaus Schallie, Chris Scholin, Joe Schumacker, Doug Simons, Barbara Stein

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If you'd like to be on our mailing list or share your ideas for future newsletter articles, contact:

Jack Wekell, Ph.D.
John.C.Wekell@noca.gov
206.860.3388

Vera Trainer, Ph.D.
Vera.L.Trainer@noaa.gov
206.860.6788

Northwest Fisheries Science Center
2725 Montlake Blvd E.
Seattle, WA 98112