California Department of Public Health
Marine Biotoxin Monitoring Program

2021 Annual Mussel Quarantine

This information is provided for the preparation of press releases, answering inquiries from the public, and other purposes related to shellfish poisoning and the annual mussel quarantine. Questions and requests for additional information about the quarantine may be directed to the California Department of Public Health (CDPH), Environmental Management Branch [Vanessa Zubkousky-White, Coordinator, Biotoxin Monitoring Program, at (510) 412-4635]. Questions about human shellfish poisoning cases may be directed to the Infectious Diseases Branch at (510) 620-3434.

I. Introduction

The annual quarantine on sport-harvested mussels is normally in effect from May 1 through October 31. Occasionally the annual quarantine will begin sooner than May 1 due to significant increases in toxin levels earlier in the year. Similarly, a biotoxin event may persist beyond the end of October, resulting in an extension of the annual quarantine for one or more counties. The annual mussel quarantine applies to the entire coastline of California, including all bays, inlets, and harbors. The main purpose of the quarantine is to protect the public from the toxins that cause paralytic shellfish poisoning (PSP) and domoic acid poisoning, also known as amnesic shellfish poisoning. Both of these syndromes are associated with consumption of bivalve (two-shelled) mollusks, such as mussels, clams, oysters, and scallops, which feed by filtering tiny particles from the water. Domoic acid has also been found at levels of concern in the viscera and flesh of crustaceans like crab and small finfish like anchovies and sardines.

The mussel quarantine restrictions and recommendations apply only to shellfish collected by sport harvesters. Mussels and other bivalve mollusks harvested by state-certified shellfish growers and sold commercially in markets and restaurants should pose no risk of PSP and domoic acid poisoning to consumers as they are closely monitored and tested. Since the PSP outbreak in 1980 included illnesses from consumption of commercially harvested oysters, commercial shellfish producers have been required to submit specimens weekly from all commercial harvest areas for PSP assay by CDPH. Bivalve mollusks imported into California are similarly monitored for biotoxins by the producer states.

Shellfish toxin levels do not rise and fall in predictable cycles and can increase rapidly. Prevention of human illnesses requires strict enforcement of the annual quarantine, combined with year-round surveillance, public education, occasional special health advisories and commercial closures as needed.

II. Reporting of Suspected PSP and Domoic Acid Poisoning in Humans

PSP and domoic acid poisoning are immediately reportable to the local health authority (Title 17, California Code of Regulations, Sections 2500). Even suspected cases should be reported immediately by telephone to the local health department and to the nearest poison control center. Local health departments should interview patients regarding shellfish exposure and report these cases promptly to the Infectious Diseases Branch at (510) 620-3434.

III. Paralytic Shellfish Poisoning (PSP)

A. The Ecology and History of PSP in California

The source of the PSP toxins in bivalve mollusks is a dinoflagellate known as *Alexandrium catenella*. Unfortunately, unlike some parts of the world where visible blooms of *Alexandrium* occur, it is highly unusual to experience a 'red tide' of this dinoflagellate along the California coast. Because the PSP toxins produced by *Alexandrium* are so potent, it takes very few cells in the water to create a public health risk from shellfish consumption. Therefore visual cues of ocean color are not reliable indicators of safe or unsafe conditions for shellfish harvesting and consumption. Shellfish can develop extremely hazardous levels of toxin within a few days without any visible warning. Conversely, the majority of red tides observed along the California coast are associated with nontoxic species of dinoflagellates. Elevated levels of the PSP toxins have historically been detected in mussels, oysters, scallop viscera, clams, abalone jingles, and gooseneck barnacles. Red abalone, crab, and shrimp have not been the source of any cases of PSP in California, although the latter two crustaceans could potentially accumulate PSP toxins in the internal organs. In California, PSP toxins are detected in shellfish most commonly during the warm spring, summer, and early fall months, although episodes of high toxicity in shellfish have occurred during the winter months also.

B. PSP in Humans

Symptoms of PSP poisoning can occur within a few minutes to a few hours of consumption of contaminated seafood. Symptoms may begin with tingling and numbness of the lips, tongue, and fingertips, followed by slurred speech, difficulty in swallowing, disturbed balance, and lack of muscular coordination. Respiratory failure and death may occur without proper medical care. Treatment is supportive, including mechanical ventilation for severe cases; there is no known antidote to the toxin. Symptoms tend to resolve completely within a few days. Diagnosis is based on clinical presentation, compatible food history, and detection of elevated saxitoxin from the suspected seafood. Persons experiencing PSP symptoms should immediately seek medical treatment.

PSP was made a reportable disease in 1927. There is some limited information about cases prior to 1927 although there could be underreporting during this time. Since 1903, 582 illnesses due to PSP have been reported in California; 39 patients have died. Over

99 percent of these illnesses have occurred during the months of May through October. The last major PSP outbreak in California occurred in July 1980 with 98 illnesses and 2 deaths. In August 1991, 11 non-fatal illnesses due to PSP, including 3 hospitalizations, were reported in persons who had eaten mussels they had collected in northern Sonoma County. In March 2018, 1 non-fatal illness due to PSP resulting in hospitalization occurred in a patient who ate mussels collected in northern Marin County. In February 2020, 1 person developed symptoms consistent with PSP after eating mussels collected in northern San Mateo County. Mussel samples collected from the area three days after the sport-harvest were negative for the presence of PSP toxin. Otherwise, no other persons were reported to have PSP in California in 2020 or 2021 to date.

C. PSP Toxins in 2020

Alexandrium was observed at sites along all coastal counties during 2020. This dinoflagellate was observed during all months in 2020 and it occurred at multiple sites along the California coast sporadically throughout the year. The highest percent composition was in June at Pacifica Pier in San Mateo County. Elevated percent composition and frequency of occurrence was in June through July at multiple sites in Monterey and San Luis Obispo counties.

Measurable concentrations of PSP toxins were found in 173 shellfish samples from the following coastal counties: Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, Monterey, and San Luis Obispo. Detection of measurable PSP toxins occurred during February through December 2020. Concentrations of PSP toxins greater than or equal to the alert level (80 µg/100 g of tissue) were detected in samples from Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, and Monterey counties. The highest concentrations detected were in mussel samples; 1,619 µg/100 g PSP toxins collected November 9 at the USCG Station in Humboldt Bay and 1,036 µg/100 g collected November 9 at Indian Island in Humboldt Bay.

D. PSP Toxins in Early 2021

Between January and February 2021, measurable concentrations of PSP toxins below the alert level have been detected in mussel samples from the following coastal counties: Mendocino, Sonoma, and Marin. Low levels of PSP toxins were also detected in razor clams in Del Norte County in February.

IV. Domoic Acid

A. The Ecology and History of Domoic Acid in California

In 1987, domoic acid was first recognized as a cause of poisoning in humans when approximately 150 persons in Canada became ill and four died after consuming toxic mussels from Prince Edward Island on the Canadian Atlantic coast. The source of the

domoic acid in this outbreak was a diatom known as *Pseudo-nitzschia pungens* forma *multiseries*. This single-celled marine algae, like dinoflagellates, is a natural food source for filter-feeding animals.

The first documented occurrence of domoic acid on the Pacific Coast of the United States was in September and October 1991 in the vicinity of Santa Cruz, on Monterey Bay. In this episode it was found to be the cause of death of several hundred brown pelicans and Brandt's cormorants. The birds were exposed to domoic acid by feeding on anchovies, which had fed on a bloom of the diatom *Pseudo-nitzschia australis*. Prior to the 1991 event, there is evidence that *Pseudo-nitzschia* was abundant in Monterey Bay in 1961 during a sooty shearwater die off, inspiring Hitchcock's film *The Birds.*

Subsequent sampling revealed elevated concentrations of domoic acid in mussels at several locations around Monterey Bay, and elevated levels also were found in razor clams sampled in Humboldt and Del Norte Counties. The high levels of domoic acid in Monterey Bay coincided with a bloom of the diatom *Pseudo-nitzschia australis*, and the toxin also was found in plankton samples containing mostly this diatom species. Low concentrations of domoic acid have subsequently been found in mussels from almost every coastal county in California.

Similar domoic acid events occurred in May 1998, the summer of 2000, and the spring of 2015 along the San Luis Obispo County coast and in Monterey Bay. These events involved illness or death in large numbers of California sea lions and, as in 1991, anchovies and sardines again appeared to be responsible for providing a pathway for toxin transport from the diatoms to the marine mammals. Volunteer phytoplankton observers were instrumental in CDPH's ability to detect and track these blooms. Intensive sampling of a variety of seafood species determined that high concentrations of domoic acid could be found in a number of bivalve shellfish, like mussels and oysters, as well as in the digestive gland of crabs, spiny lobsters, sardines and anchovies. Persistent elevated levels of domoic acid have been detected in razor clam meat from Humboldt and Del Norte counties since 2015. Domoic acid also has been found in Oregon and Washington in razor clams, mussels, and crabs.

The seasonal pattern of occurrence of *Pseudo-nitzschia* and domoic acid has changed significantly since monitoring began in 1991. The initial event in Monterey Bay occurred in the fall and phytoplankton monitoring in the years immediately following this event confirmed this seasonal pattern of increase in *Pseudo-nitzschia*. There was very little domoic acid toxicity detected through the remainder of the 90's, although there was a large scale marine mammal mortality event due to domoic acid in 1998 as noted above. During 2000 there was a noticeable increase in domoic acid activity in Monterey Bay and along the San Luis Obispo County coast during the summer months, extending into November at some locations. In 2002 there was an early spring increase in *Pseudo-nitzschia* and domoic acid concentrations. This event began in Monterey Bay in February and appeared to 'move' down the coast between San Luis Obispo and Los Angeles Counties through June. This spring bloom pattern persisted through most of the remainder of the decade, although a smaller fall event occurred in 2009 and a winter

event occurred in Santa Barbara County in 2011. In 2015, domoic acid was detected in shellfish from Del Norte County to Los Angeles County when a large bloom of *Pseudo-nitzschia* persisted off the west coast of North America from California to Alaska. In 2017 domoic acid was again detected over a large range of the coast with elevated levels in mussels from Del Norte, Monterey, Santa Barbara, Ventura, and Los Angeles counties. The changing seasonality and distribution of *Pseudo-nitzschia*, and subsequently of domoic acid concentrations in seafood, reinforces the need for a rigorous monitoring program throughout the year to ensure public health protection.

Extensive phytoplankton sampling is being conducted to investigate the spatial and temporal distribution of the diatoms associated with domoic acid production. Extensive blooms of the diatoms that produce domoic acid have been detected and followed along most coastal counties since this program began.

These environmental observations provide an early warning to potentially toxic blooms, allowing CDPH to respond quickly with intensified sampling and toxin analysis in the affected area.

B. Domoic Acid Poisoning (Amnesic Shellfish Poisoning) in Humans

Within 24 hours of eating contaminated shellfish, patients develop gastrointestinal symptoms such as diarrhea, vomiting, and abdominal pain, followed by headache, memory loss, and disorientation. In severe cases, domoic acid poisoning can cause cardiovascular instability, seizures, coma, and death. Survivors may experience anterograde short-term memory loss (i.e., inability to recall the recent past). Diagnosis is based on clinical presentation, compatible food history, and detection of domoic acid from the suspected seafood. As with PSP, medical therapy consists of supportive care; there is no known antidote to the toxin, and persons experiencing symptoms should receive immediate medical attention.

Domoic acid poisoning in humans associated with the consumption of shellfish harvested in California has not been reported.

C. Domoic Acid in 2020

Pseudo-nitzschia was observed at sites along all coastal counties during 2020. This diatom was observed during every month in 2020. The highest percent composition occurred in December at Pier 15 in San Francisco County. Elevated percent composition and frequency of occurrence was during December in Marin and San Francisco counties and May in San Mateo County.

Measurable concentrations of domoic acid were found in 9 shellfish samples, not including 108 razor clam samples, from the following coastal counties: Santa Cruz in May, and Humboldt and Mendocino in October and November. Razor clam samples from Del Norte and Humboldt Counties had measurable concentrations of domoic acid throughout 2020. Concentrations of domoic acid above the alert level (20 µg/g of shellfish

meat, or 20 parts per million [ppm]) reached 180 ppm in razor clams from Del Norte County.

More information on crab monitoring data from 2020 and associated health advisories is available at the following link:
https://www.cdph.ca.gov/Programs/CEH/DFDCS/Pages/FDBPrograms/FoodSafetyProgram/DomoicAcid.aspx

V. Special Risks from Various Kinds of Seafood

The greatest hazard for PSP and domoic acid poisoning is from the consumption of mussels (see also discussion below on razor clams) because: (1) they concentrate the toxins more quickly and to higher levels than do other shellfish, (2) they generally occur along the open coast where they are directly affected by oceanic blooms, and (3) they are eaten whole without removal of digestive organs. The digestive organs of crustaceans such as lobster and crab, as well as of small finfish like sardine and anchovy, can also contain dangerous levels of domoic acid, as can the flesh. Other contaminants can also be concentrated in the viscera, so the public is advised to avoid consuming the internal organs of any seafood species.

The consumer cannot distinguish toxic mussels from harmless ones. Moreover, cooking cannot be relied upon to destroy the toxins because they are relatively heat stable. The safest guideline for consumers is: Do not eat mussels taken by recreational sport-harvesters from California coastal waters during the annual quarantine months of May through October. During other months, call the CDPH "Biotoxin Information Line" at 1-800-553-4133 for an up-to-date, recorded message of any special health advisories.

While clams can develop hazardous levels of PSP toxin, they are placed under quarantine only in localized areas when tests reveal the presence of elevated toxin levels in mussels in the vicinity of clam beds or in clams themselves. In clams, the toxin is concentrated primarily in the digestive organs (dark meat), hence, these portions from all types of clams should always be discarded; only the white meat should be eaten.

A special hazard is presented by the Washington or butter clam (*Saxidomus* spp.). They may concentrate the PSP toxins in the neck or siphon (the tube-like part of the clam that sticks out between the shells). It has been found that PSP toxin in the necks of Washington clams may persist for a year or more after an outbreak of PSP.

Northern razor clams (*Siliqua patula*) have been found to present a special risk for domoic acid poisoning because they concentrate this toxin in the white meat of the foot and siphon, parts that normally are preferred for human consumption. Razor clams are able to retain this toxin for extended periods, just as the Washington clam retains the PSP toxins.

Scallops from California waters may also become toxic. This is true for both the adductor muscles (the "scallop" or white meat that is ordinarily eaten) and the digestive organs (the darkish soft tissue of a scallop left after the white adductor muscle has been removed). In

August 1980, a man died of PSP after eating only the digestive organs of a single rock scallop (*Hinnites giganteus*) taken by a sport-diver on the Sonoma County coast. Subsequent investigations revealed that a lower, but still hazardous, concentration of the toxin also may occur in scallop adductor muscles during a PSP episode. The digestive organs of scallops should never be eaten as they may remain toxic year-round. It is unknown how long PSP toxins may persist in the white meat of scallop adductor muscles.

VI. Groups at Special Risk of Shellfish Poisoning

In addition to recreational harvesters, immigrants from countries with no history of marine toxins, as well as people from areas with no routine toxin monitoring, are particularly at risk of consuming toxic shellfish. This risk is magnified when there is a cultural history of harvesting shellfish for subsistence or ceremonial purposes. CDPH has a number of alternative language quarantine signs available to county health departments and community-based outreach organizations upon request.

VIII. Infectious Disease Hazards

Bivalve shellfish should never be taken from waters contaminated by sewage or other pollutants because they also can concentrate disease-producing bacteria and enteroviruses, such as Hepatitis A virus, in their digestive organs.

IX. Public Information Available

CDPH has developed a “Frequently Asked Questions” (FAQ) for the annual mussel quarantine that can be found online at:
https://www.cdph.ca.gov/Programs/CEH/DRSEM/Pages/EMB/Shellfish/Annual-Mussel-Quarantine.aspx

EMB maintains a toll-free "Biotoxin Information Line" with recorded updates on shellfish biotoxins and quarantines at 1-800-553-4133.

EMB also maintains an interactive map of the recreational bivalve shellfish health advisories.
https://experience.arcgis.com/experience/394836318cfe4f7494e1c09097a43559/

An information leaflet entitled "Natural Marine Toxins" is produced by CDPH and the University of California Cooperative Extension. This leaflet is available at the following web site:
https://www.cdph.ca.gov/Programs/CEH/DRSEM/CDPH%20Document%20Library/EMB/Shellfish/Natural_Marine_Toxins.pdf

Press releases are prepared by CDPH to announce the annual mussel quarantine and any health advisories issued. These can be found online at:
https://www.cdph.ca.gov/Programs/OPA/Pages/Shellfish-Advisories.aspx

Monthly reports issued by CDPH are available that include summary information and maps of PSP toxicity and toxigenic phytoplankton distributions along the coast. The monthly and annual reports can be found online at the link below or by contacting redtide@cdph.ca.gov:
https://www.cdph.ca.gov/Programs/CEH/DRSEM/Pages/EMB/Shellfish/Marine-Biotoxin-Monitoring-Program.aspx