

MARINE BIOTOXIN MONITORING PROGRAM

ANNUAL REPORT

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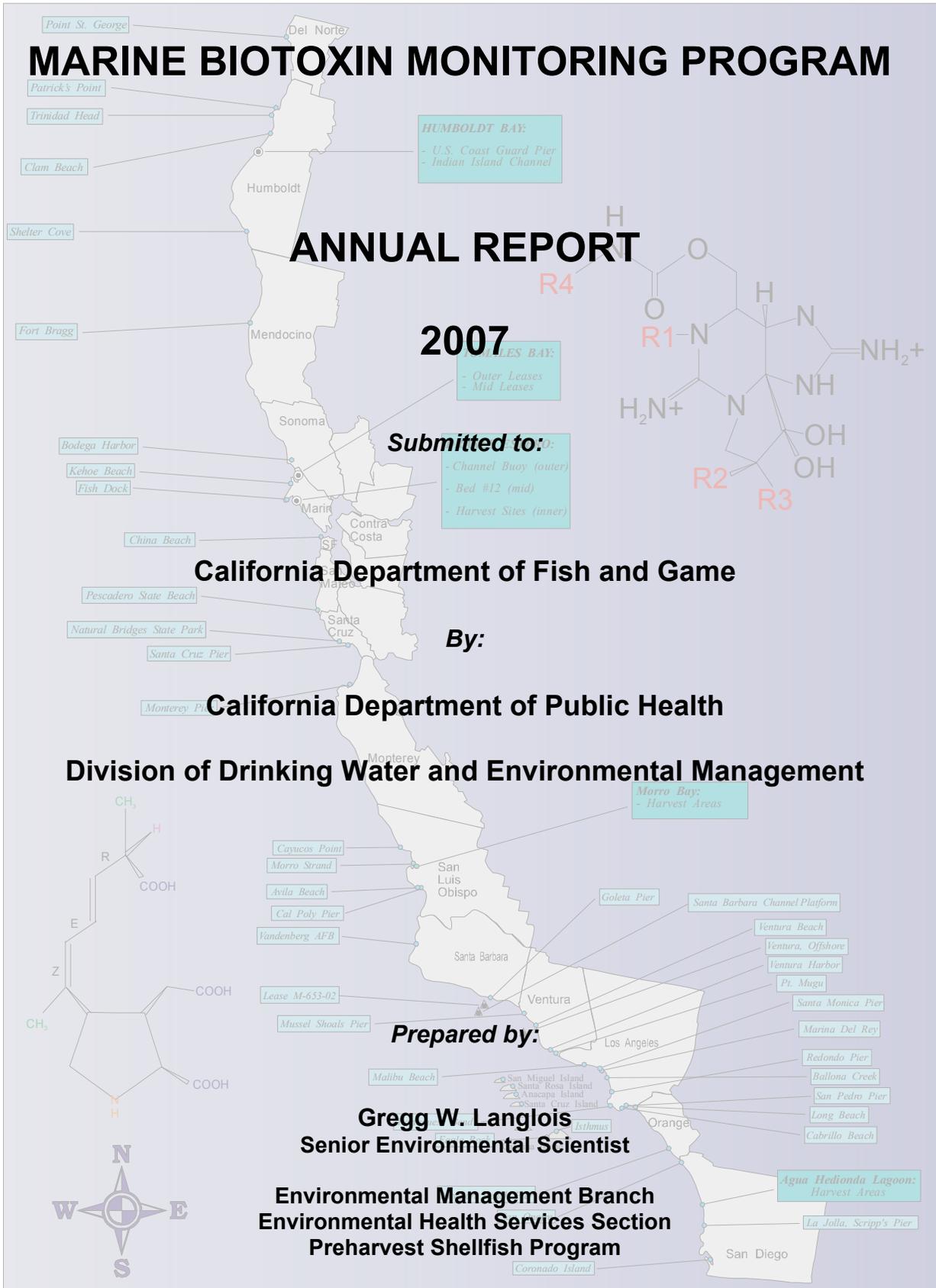
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The California Department of Public Health's Marine Biotoxin Monitoring Program would also like to acknowledge the dedicated work of the staff of the Department's Microbial Diseases Laboratory and the Food and Drug Laboratory for their efforts in conducting PSP assays and domoic acid analyses, respectively. Due to the unpredictable nature of marine biotoxin activity, the laboratories are often called upon to respond immediately to the influx of samples that result from these events. It is due to their efforts that we are able to provide rapid feedback to field samplers and notify the public of potential health risks.

Shellfish toxicity data is generated on a regular basis by the California Department of Public Health's Marine Biotoxin Monitoring Program thanks to the continuing efforts of our program participants. Additionally, volunteers are collecting phytoplankton samples on a routine basis and increase their frequency during periods of concern, providing near real-time observations of the occurrence of toxin producing species. As with all such endeavors, our success in protecting the public is due in large part to the numerous people who contribute their time and effort to collect samples at representative sites along the coast. The monthly listing of our program participants, provided in each monthly report, illustrates the diversity of groups and individuals that contribute to these efforts.

The California Department of Public Health expresses its sincere appreciation to our program participants for all of their efforts. It is through their active participation that the Department is able to protect and improve the health of all Californians.

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INTRODUCTION

California has a long history of paralytic shellfish poisoning (PSP), dating back to the time of the coastal Native American tribes. According to Meyer (1928) it was a common procedure for the coastal Pomo tribe to place sentries to watch for luminescence in the waves, having apparently established a link between bioluminescence and mussel poisoning, both of which are caused by dinoflagellates in the phytoplankton. The long-standing concern of California's public health officials for protecting the public from PSP has been warranted, as there have been 542 reported illnesses including 39 deaths attributable to this toxin since 1927 (Price et al., 1991).

In the fall of 1991 another natural toxin was identified along the California coastline. Domoic acid, a neurotoxin of lower potency than the PSP toxins, has become of equal concern because the blooms of diatoms that produce this toxin have been of greater frequency and longer duration than most PSP events over the past 10 years. In addition, domoic acid has had dramatic impacts on marine mammal and seabird populations along the coast, raising the public's awareness of marine biotoxins in general.

Because PSP toxicity represents a serious ongoing public health threat that requires year-round attention, the California Department of Public Health (CDPH) has implemented a prevention program that has traditionally been comprised of five basic elements: (1) a coastal shellfish monitoring program; (2) monitoring of commercial shellfish product; (3) an annual statewide quarantine on sport-harvested mussels (from May 1 through October 31); (4) mandatory reporting of disease cases; and (5) public information and education activities. In response to the occurrence of a new toxin, domoic acid, in the fall of 1991, CDPH added a sixth element to the Marine Biotoxin Monitoring Program: phytoplankton monitoring. This latter monitoring effort was the first volunteer-based phytoplankton monitoring program in the U.S. This annual report describes the shellfish sampling element of the program for PSP toxins and domoic acid and the phytoplankton monitoring results during 2007. A summary is also provided for quarantine and health advisory activities.

Paralytic Shellfish Poisoning

PSP is an acute, sometimes fatal form of food poisoning that is associated with the consumption of bivalve molluscs that have fed on the toxin-producing dinoflagellate *Alexandrium catenella* (formerly *Protogonyaulax catenella* and *Gonyaulax catenella*). Eating shellfish that contain PSP toxins leads to an acute disturbance of the nervous system within a few minutes to a few hours. The PSP toxins are sodium channel blockers and thus inhibit neural transmission. Symptoms begin with tingling and numbness of the lips, tongue, and fingertips, followed by disturbed balance, lack of muscular coordination, slurred speech and difficulty in swallowing. In severe poisoning, complete muscular paralysis and death from asphyxiation can occur if breathing is not maintained by artificial means. There is no known antidote to the poison. Symptoms tend to resolve entirely in a day or two under proper medical care. Persons who

suspect they or others are experiencing PSP symptoms should immediately seek medical treatment.

The type and severity of symptoms depends on the amount of toxic shellfish consumed as well as the specific toxicity of the shellfish. Price et al. (1991) summarize the range of toxin dose responses as follows: 200 to 500 micrograms (μg) per 100 grams (g) of shellfish tissue will cause at least minor symptoms, 500 to 2000 μg will cause moderate to severe symptoms, and toxin concentrations greater than 2000 μg will produce serious to lethal effects. It should be noted that exceptions exist and serious health effects have also been documented at much lower concentrations (100 to 400 μg). The federal alert level for PSP toxicity is 80 $\mu\text{g}/100$ g of shellfish tissue, and the detection limit for the PSP bioassay is approximately 40 $\mu\text{g}/100$ g.

Alexandrium is normally absent or constitutes a minor component of the marine phytoplankton community along the California coast. Under favorable environmental conditions this dinoflagellate may undergo periods of rapid population growth, frequently referred to as a "bloom". The term "bloom" or "red tide" is misleading with respect to *Alexandrium* and the resultant PSP toxicity in shellfish. Visible blooms of *Alexandrium* are rarely seen along the California coast. Conversely, elevated levels of PSP toxins in shellfish can result from the presence of relatively low numbers of *Alexandrium* in the water.

The source of the dinoflagellates that provide the "seed" for such blooms is in question, but two likely scenarios are possible. First, resting cysts of *Alexandrium* in local sediments can, under favorable conditions, produce vegetative cells that can then reproduce both sexually and asexually, resulting in localized "hot spots" of PSP toxicity in shellfish. Second, this dinoflagellate may be transported in offshore warm water masses that can move onshore under certain environmental conditions. This advection process could potentially result in either a quick spike in PSP toxicity if the number of transported cells is high, or it may simply provide the cells necessary for a bloom to initiate. Regardless of the origins of the toxin-producing dinoflagellates, the general pattern has been for these blooms to be detected first along the open coast, occasionally followed by transport into bays and estuaries. The degree to which coastal phytoplankton blooms intrude into bays and estuaries is likely influenced in part by the orientation of the bay relative to coastal currents and by the extent of tidal mixing and transport that occurs inside the bay.

Domoic Acid

In October of 1991 the presence of another marine biotoxin was confirmed in California's coastal waters. Domoic acid toxicity, which can result in the condition called amnesic shellfish poisoning (ASP), was identified as the cause of death in a large number of brown pelicans and Brandt's cormorants in the Santa Cruz area of Monterey Bay. The birds had been feeding on schools of anchovies in the bay, which in turn had been feeding on a bloom of the diatom *Pseudo-nitzschia australis* (formerly *Nitzschia pseudoseriata*).

The only documented domoic acid event prior to 1991 was a serious episode in Prince Edward Island, eastern Canada, in 1987 in which three people died and over 100 people were made ill from the consumption of toxic mussels. Domoic acid is a neuroexcitatory amino acid that causes over-stimulation of certain nerves cells in the brain, with potentially permanent or fatal effects. Case studies of the Canadian episode indicated that the most common symptoms were gastrointestinal, followed by neurologic symptoms including headaches, loss of balance and/or dizziness, memory loss, varying degrees of confusion, disorientation, changes in the level of consciousness, and in some cases seizures (Teitelbaum, 1990; Perl et al., 1990).

Based on the rather small number of case histories available the following dose responses can be approximated while recognizing the overlap in ranges and symptoms: 27 to 75 $\mu\text{g/g}$ may result in mild to moderate symptoms (gastrointestinal), 40 to 700 $\mu\text{g/g}$ may result in moderate to severe neurologic symptoms, and domoic acid concentrations greater than 450 $\mu\text{g/g}$ may result in severe neurologic symptoms and/or death.

Phytoplankton

There were no documented human health impacts from the 1991 Monterey Bay domoic acid episode, but the severity of the Canadian outbreak made it clear that continued monitoring for domoic acid would be necessary for public health protection. Because of the cost and time involved in running separate analyses for each toxin, in addition to the prospect that other known toxins may be present along the California coast, CDPH began a volunteer-based phytoplankton monitoring program in 1993 with the technical support of the U.S. Food and Drug Administration. The intent of this program was to develop a network of volunteer samplers and field observers that would allow the early detection of potentially toxigenic blooms. Early detection is key to mobilizing and focusing additional sampling and analytical resources for plankton, shellfish, and other species in the affected region. As a result of this volunteer effort CDPH has been able to detect and track numerous harmful algal blooms, improving the capabilities for protecting public health.

2007 SAMPLING EFFORT

Paralytic Shellfish Poisoning

Shellfish samples were collected at 70 different sites along the coast of California in 2007 (Figures 1a and 1b). Several commercial growing areas had multiple sites representing different harvest areas. There were 1260 shellfish samples collected statewide for PSP toxin assay during 2007. The greatest number of samples (466) was collected at sites in Marin County (Table 1), with commercial shellfish aquaculture companies providing approximately 86% of the samples collected in this county. The majority of these (291) were contributed by Drakes Bay Oyster Company in Drakes

Estero, which samples four stations on at least a weekly basis. The large proportion of Marin County sites is a reflection of both the number of commercial growers and the frequency of occurrence of PSP toxicity in this region.

Commercial shellfish growers accounted for 68% of all samples collected in 2007, followed by various state agencies and coastal county health departments (20% and 8%, respectively; Table 2). Several other program participants, including federal agencies and volunteers, provided valuable assistance by contributing their sampling effort in 2007. The diversity of participants is a valuable component of the monitoring program (Table 3). As mentioned above, monitoring of the outer coast is a key element in California's marine biotoxin monitoring program because all toxic blooms to date have originated offshore or along the coast. Monitoring coastal shellfish resources can therefore provide an early warning of toxic conditions that may soon impact shellfish in bays and estuaries, which harbor the majority of commercial shellfish growers and recreational clam beds.

The majority of samples collected in 2007 consisted of mussels (66%), followed by cultured pacific oysters (31%; Table 4). A variety of other species of shellfish were sampled for PSP toxin analysis in 2007, including rock scallops (*Crassadoma gigantea*) and several genera of clam and crustaceans. The Marine Biotoxin Monitoring Program continues to use mussels as a primary indicator species for PSP toxins because of their ability to bioaccumulate these toxins at a faster rate than other bivalve species (Shumway, 1990). Differential uptake in mussels versus oysters during a major PSP event in 1991 was previously documented (California Department of Health Services, 1991).

Domoic Acid

There were 351 shellfish samples analyzed for domoic acid during 2007 compared to 250 samples analyzed the previous year (Table 5). Samples from 45 different sampling sites were targeted for analysis as a result of observations from the volunteer monitoring network of high numbers of *Pseudo-nitzschia spp.* The greatest number of samples was submitted from Santa Barbara County (112) and San Luis Obispo County (83).

Phytoplankton

There were 1741 phytoplankton samples collected during 2007, the largest number of annual samples submitted by the volunteer-based monitoring effort since the program began in 1993. This record number of samples was collected at 137 sampling sites representing all coastal counties (Table 6). The greatest numbers of samples were collected in San Luis Obispo (333), Marin (307), Santa Barbara (226), and Los Angeles (175) counties. Samples were collected along all coastal counties by 79 volunteers (Figures 1c and 1d). Several areas (e.g., commercial shellfish growing areas) had multiple sites that are not individually identified in the figure and some volunteers may sample sites in multiple counties.

Of the 1741 phytoplankton samples collected in 2007, 1154 (66%) contained at least one toxigenic species. Toxin-producing phytoplankton species were detected at 118 different sampling sites throughout all of the 15 coastal counties in 2007. The greatest number of samples containing toxin-producing species was collected in San Luis Obispo (258), Santa Barbara (174), Marin (147), and Los Angeles (107) counties.

2007 RESULTS

Paralytic Shellfish Poisoning Toxicity and *Alexandrium* Observations

The geographic distribution of PSP toxins in shellfish during 2007 was similar to that of 2006, although the magnitude of PSP toxicity was slightly less in 2007 (Figure 2). There were fewer samples above the alert level, distributed throughout fewer counties, than occurred in 2006. Measurable concentrations of PSP toxins were found in 244 shellfish samples from the following coastal counties: Humboldt, Marin, San Mateo, San Francisco, San Mateo, Santa Cruz, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and San Diego.

PSP toxin concentrations at or above the alert level were detected in 37 samples from Marin (29), Santa Cruz (1), San Luis Obispo (4), and Santa Barbara (3). PSP toxicity was found most frequently along the coast of Marin County during 2007. The highest single toxin concentration detected was 619 µg/100 g of shellfish meat in sentinel sea mussels from Drakes Estero (Marin County), 282 µg in sentinel mussels from the Cal Poly Pier (San Luis Obispo County), and 133 µg in mussels from an offshore aquaculture lease in Santa Barbara County.

Alexandrium was present along much of the California coastline throughout 2007. Of special note are the significant relative abundances of this dinoflagellate that were observed in January and February along most of the southern California coast. This unusual occurrence was a continuation of a pattern begun in 2006 and was associated with PSP toxin levels that exceeded the alert level by late January. PSP toxins were present at low levels in shellfish samples every month during 2007. Alert levels of the PSP toxins were present in seven different months during 2007. The temporal distribution of PSP toxins was unusual compared to the typical average annual pattern, with an early winter peak in activity and alert levels of toxins during the first three months of the year (Figure 3).

The apparent southward shift in PSP activity noted in 2006 was documented again in 2007. The PSP toxicity detected during the first three months of 2007 occurred at a number of sites between San Luis Obispo and San Diego counties, as well as farther north in Marin County. By June the activity had become focused in the Marin County area as is more typical. Low levels of these toxins were again detected predominantly in southern counties in November and December.

Following is an overview of *Alexandrium* and PSP toxin monitoring efforts during 2007. Detailed maps illustrating the weekly relative PSP toxin concentrations for each month, the monthly distribution and relative abundance of *Alexandrium* and *Pseudo-nitzschia*, and the monthly lists of program participants are provided in separate monthly reports. These reports are available at the following Internet site:

<http://www.cdph.ca.gov/healthinfo/vironhealth/water/Pages/Shellfish.aspx>

Although winter is usually a period of low risk for the presence of *Alexandrium* and the PSP toxins it produces, January 2007 became the 11th consecutive month that this dinoflagellate was observed along a significant portion of the California coast. Low numbers of *Alexandrium* were observed along several coastal counties between Marin and Ventura in the beginning of the year. The greatest relative abundance of this dinoflagellate was observed at sites between San Luis Obispo and Ventura counties. Low concentrations of PSP toxins were initially detected in mussels from several sites along the San Luis Obispo coast, increasing above the alert level to 153 µg per 100g of tissue by January 23, reaching 282 µg by January 29 (Cal Poly Pier sentinel mussels). Low levels of these toxins were also detected in mussels from Drakes Estero, the Santa Cruz Pier, offshore of Santa Barbara and in samples of lobster viscera collected along the Ventura coast and offshore near Anacapa Island.

This general pattern continued through February, with *Alexandrium* observed in low numbers throughout approximately the same range as noted for January. *Alexandrium* was also observed offshore near Santa Cruz Island and off of the Palos Verdes peninsula (Los Angeles County). Low levels of PSP toxins continued to be detected in sentinel mussels from Drakes Estero, increasing above the alert level during the first week (124 µg on February 6) before declining to low levels for the remainder of the month. Similarly, low levels of these toxins increased in sentinel mussels at the Santa Cruz Pier (106 µg, February 7), declining to low levels for the rest of the month. The high PSP toxin concentrations detected in mussels from Avila at the end of January continued through the first half of February. Farther south there was a rapid increase in these toxins by the second week of February. Within one week the toxin concentration in mussels from an offshore aquaculture lease increased from nondetectable levels (February 6) to well above the alert level (133 µg, February 14), then quickly declined to nondetectable levels by the end of the month. Low levels of the PSP toxins were also detected in mussels from an offshore oil platform during the middle of the month and in a sample of lobster viscera collected near Anacapa Island on February 21.

By March the distribution and relative abundance of *Alexandrium* was in decline at sites between Marin and San Luis Obispo counties, but increasing along the Santa Barbara coast. Low levels of these toxins were detected in mussels at Goleta Pier throughout the month. Mussels from the offshore aquaculture lease experienced another sudden increase in PSP toxicity during the second week of March. Within one week the toxin concentration in mussels increased from nondetectable levels (March 6) to above the alert level (87 µg, March 14). The PSP toxin concentration reached 99 µg by March 21 at this site before declining at the end of the month and remaining at low concentrations

through April. Low levels of the PSP toxins were also detected in mussels from Marin, Santa Cruz, Los Angeles and San Diego counties, as well as in a sample of lobster viscera collected near Santa Cruz Island on March 5. Low levels of these toxins continued to be detected at various locations in April. Sentinel mussels from the Santa Cruz Pier contained 38 μg on April 5 and mussels from northern Ventura County also contained detectable levels by the third week of April.

Alexandrium increased slightly at sites between Marin and Monterey counties in May. The frequency of *Alexandrium* observations also increased at sites between Ventura and Orange counties. *Alexandrium* continued to be observed at offshore sites, including the Santa Barbara Channel, Anacapa Island, and Catalina Island. PSP toxins were detected in sentinel mussels from the Santa Cruz Pier during the last week of May. Low levels of the PSP toxins were detected in sentinel mussels from San Luis Obispo County during the latter half of the month and in mussel samples from the aquaculture lease just offshore of Santa Barbara by the last week of May.

This dinoflagellate increased at several sites in June, with the highest relative abundance observed in a sample collected just inside Tomales Bay. *Alexandrium* was observed at sites between Marin and Santa Barbara counties and continued to be observed in significant numbers as far offshore as the Farallon Islands. *Alexandrium* was no longer observed at sites offshore of southern California as in previous months. PSP toxins were detected in sentinel mussels from the Cal Poly Pier and Santa Cruz Pier during the first and second week of June, respectively. By the third week of June these toxins were detected in shellfish samples from San Francisco and Marin counties, with elevated levels in Drakes Bay (166 μg) and Drakes Estero (91 μg). PSP toxin concentrations reached 619 μg in Drakes Estero on June 21 and then began a general pattern of decline with periodic, short-lived increases. Toxins remained above the alert level in sentinel shellfish from the mid-Estero but declined to safe levels in the outer sentinel buoy by the end of the month.

Alexandrium continued to be observed through July at a number of sites between Marin and San Diego counties. The relative abundance declined in some areas compared to past months. *Alexandrium* continued to be observed in significant numbers offshore of San Francisco near the Farallon Islands. The relative abundance of this dinoflagellate was highest in samples from Drakes Estero (July 9) and Ano Nuevo (July 23). The elevated concentrations of PSP toxins detected in sentinel mussels from Drakes Estero in June continued into July. PSP toxin concentrations declined to 138 μg by the third week of July and then dropped below the alert level by the last week of the month. These toxins were detected above the alert level at other sites along the Marin coast as well. Low levels of the PSP toxins persisted through most of the month at sites in San Francisco, San Mateo, and Santa Cruz counties.

By August *Alexandrium* had increased in relative abundance inside Monterey Bay as well as farther north in Humboldt and Del Norte counties. PSP toxin concentrations in sentinel mussels from Drakes Estero again increased above the alert level during the first two weeks of August. After a short decline the toxicity increased again at the end of

the month in the mid-Estero (185 µg). The PSP toxin concentration also increased at the Drakes Bay sentinel station during the last week of August (119 µg) through the first week of September, reaching 155 µg. The high concentrations of these toxins in Drakes Estero during August declined below the alert level by the first week of September and were not detectable by the latter half of the month. In a similar pattern, low levels of these toxins were detected through most of August and into the first week of September at the sentinel mussel station in outer Humboldt Bay. By the end of October these toxins were not detectable at any monitoring site.

There was a noticeable increase in *Alexandrium* cell numbers at several sites between San Luis Obispo and Ventura counties through mid-November. Low concentrations of PSP toxins were detected the first week of November at Goleta Pier. By the second week of the month these toxins were detected offshore of Santa Barbara and at sites in San Luis Obispo County. A low concentration of PSP toxins was also detected in the viscera of lobster collected near Santa Cruz Island. The relative abundance of *Alexandrium* continued to increase slightly at several sites during the first half of December, particularly in Santa Barbara. Low concentrations of PSP toxins were detected the first week of December at sites in Marin, San Mateo, San Luis Obispo and Santa Barbara counties. These low toxin levels persisted through the second or third week of the month at various sites. The highest PSP toxin concentration detected was 71 µg in a mussel sample from offshore of Santa Barbara (December 13). Low levels of PSP toxins were also detected in the viscera of lobster collected offshore of Ventura and in scallop viscera collected near Santa Cruz Island.

Domoic Acid Toxicity and *Pseudo-nitzschia* Observations

Measurable concentrations of domoic acid were found in 80 samples during 2007 (Table 8), compared to 39 positive samples in 2006. Domoic acid was detected in samples from the following coastal counties: Humboldt, Santa Cruz, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles. Concentrations of domoic acid above the alert level (20 µg per gram of shellfish meat, or 20 parts per million (ppm)) were detected in 36 of the 80 positive samples from the following four counties: San Luis Obispo, Santa Barbara, Ventura, and Los Angeles. Eight of the 36 samples above the alert level were lobster viscera from the Channel Islands. The highest level of domoic acid found in molluscan shellfish was 610 ppm in mussels from an aquaculture lease less than one mile offshore of Santa Barbara, which is the highest concentration ever detected in California.

The magnitude of domoic acid toxicity in 2007 was greater compared to 2006 but the geographic distribution was similar. The majority of positive samples came from southern California counties, with sites in Santa Barbara and Ventura counties experiencing the highest concentrations of domoic acid. As observed in recent years, there appeared to be a temporal progression of the spring bloom down the coast from San Luis Obispo to Los Angeles counties. By March there were elevated numbers of this diatom along most of the southern California coast. Domoic acid levels began increasing in March and continued through April (Figure 5), primarily along the southern

California coast between San Luis Obispo and Los Angeles counties. The highest percent compositions of this diatom were observed in April in San Luis Obispo (84%, April 5), Santa Barbara (91%, April 18 and 26), and Ventura (90%, April 23) counties.

Under some circumstances the percent composition data for *Pseudo-nitzschia* can be misleading. To adjust for the importance of cell mass, as well as sampling effort, a Relative Abundance Index (RAI) was formulated. The RAI is based on an estimate of cell mass as determined by settled cell volume (a), the percent composition of each species (b), and the sampling effort as determined by the total tow length (c):

$$\text{RAI} = (a \cdot b) / c$$

The RAI data can provide perspective on the significance of the percent composition data for *Pseudo-nitzschia* or other species of interest. Many of the observations of high percent compositions of *Pseudo-nitzschia* (Figure 6) have less importance when the RAI is determined (Figure 7). The period of maximum RAI values for *Pseudo-nitzschia* observations during 2007 (Figure 7) is in agreement with the temporal pattern of measurable domoic acid in shellfish samples (Figure 5).

As discussed earlier, detailed accounts of toxigenic phytoplankton distribution and biotoxin concentrations can be found in the monthly reports. The following is a brief account of domoic acid and *Pseudo-nitzschia* activity during 2007.

Pseudo-nitzschia was observed along the entire southern California coast in January and was common at sites between San Luis Obispo and San Diego counties. The highest relative abundances were observed at Scripps Pier (San Diego County) and consisted of both toxic and non-toxic species. Elevated levels of domoic acid were detected in a sample of lobster viscera collected near Anacapa Island on January 2 (81 ppm). The abundance of this diatom declined slightly in February at some southern California sites. The highest relative abundances were observed offshore of Palos Verdes and increased during the last two weeks of the month. Domoic acid remained absent from nearshore shellfish samples through February.

There was a significant increase in the relative abundance of *Pseudo-nitzschia* along much of the southern California coast in March. Numbers of this diatom steadily increased throughout the month along the San Luis Obispo coast. The highest relative abundances were observed offshore of Diablo Cove (March 20), followed by lower but significant levels at Avila (March 27) and Imperial Beach (San Diego County, March 13). Low levels of domoic acid were detected in mussel samples from Avila during the last two weeks of March, increasing from 3 ppm on March 20 to 14 ppm by March 27. A high concentration of this toxin (136 ppm) was detected in a sample of lobster viscera from Santa Cruz Island (March 5). Although the distribution of *Pseudo-nitzschia* increased noticeably in March between Marin and Santa Cruz, domoic acid was not detected in any shellfish samples analyzed.

The relative abundance of this diatom remained very high along the San Luis Obispo

coast throughout April, with a sudden decline in percent composition at the end of the month. Numbers of this diatom steadily increased throughout the month along the Santa Barbara coast and began increasing at sites in Los Angeles County by the end of the month. *Pseudo-nitzschia* densities were also elevated at sites in Ventura County in April. The highest relative abundances were observed at Pismo Beach Pier (April 26), followed by lower but significant levels offshore of Santa Barbara (April 26). Domoic acid concentrations increased in mussel samples from Avila through the first three weeks of April, reaching 30 ppm on April 20, then declining rapidly to 1 ppm by April 30. In contrast to the gradual increase in toxin levels in Avila, several sites onshore and offshore of Santa Barbara experienced a sudden increase in domoic acid concentrations in shellfish samples by the second week of April. Mussels from an aquaculture lease less than one mile offshore of Arroyo Burro Beach went from a nondetectable level of domoic acid to 62 ppm in seven days (April 4 to April 11). By April 24 the concentration of domoic acid in mussels at this site had reached 610 ppm, the highest level recorded to date. Toxin levels also increased throughout the month in mussels from Platform Houchin, approximately three miles offshore, reaching 66 ppm by the third week of the month. Mussels from Goleta Pier reached 180 ppm of domoic acid by April 25. Very high concentrations of this toxin were also detected in mussels in Ventura County throughout the month, with a maximum concentration of 237 ppm on April 19. Mussels collected from Portuguese Bend (Los Angeles County) on April 27 contained 26 ppm of domoic acid. None of the samples collected south of Los Angeles contained measurable amounts of this toxin. The relative abundance of *Pseudo-nitzschia* also increased inside Monterey Bay. A low level of domoic acid was detected in a sentinel mussel sample from Santa Cruz Pier on April 5.

The relative abundance of *Pseudo-nitzschia* decreased throughout May at sites between San Luis Obispo and Ventura counties. In contrast, the relative abundance of this diatom increased offshore near San Nicolas Island at the beginning of May, then at sites in Los Angeles and Orange counties by mid-month, decreasing again by the end of the month. The highest relative abundances of *Pseudo-nitzschia* were observed offshore near San Nicolas Island (May 2), offshore of the Palos Verdes peninsula (May 23), and at Port Hueneme Pier (May 8). Domoic acid concentrations in mussels remained at elevated levels at sites in Santa Barbara through mid-May and then declined to nondetectable levels by the end of the month. Elevated levels of this toxin were also detected in samples of rock crab from the Channel Islands and in samples of sardines landed in Los Angeles that were collected by the CDPH Food and Drug Branch. The relative abundance increased between Ano Nuevo (San Mateo County) and Monterey County. Low levels of domoic acid were detected in sentinel mussels from Santa Cruz Pier during the first two weeks of May (13 ppm on May 9) and at Natural Bridges (6 ppm on May 9). A very low level of domoic acid was also detected in a razor clam sample from Clam Beach in Humboldt County (1.6 ppm on May 18).

Pseudo-nitzschia numbers declined in most areas of the southern California coast in June, with the exception of San Diego County. This diatom was observed at sites along the San Diego coast for the first time since April. The highest relative abundances of *Pseudo-nitzschia* were observed offshore of Diablo Cove (June 20) and at the Imperial

Beach Pier (June 26). Domoic acid was not detected in any shellfish samples collected in June. A low concentration of this toxin was detected in a sample of lobster viscera from Anacapa Island on June 28.

Once again *Pseudo-nitzschia* numbers increased at several sites along the southern California coast in July, particularly in San Luis Obispo and San Diego counties. The highest relative abundances of *Pseudo-nitzschia* were observed offshore of Diablo Cove (July 6) and at the Imperial Beach Pier (July 3). The high numbers of this diatom observed along the San Diego coast were mostly the presumed nontoxic species in the delicatissima complex. Domoic acid was not detected in any shellfish samples collected in July. A low concentration of this toxin was detected in a sample of lobster viscera from Santa Cruz Island on July 12.

By August the numbers of *Pseudo-nitzschia* began decreasing along much of the southern California coast. The highest relative abundances of *Pseudo-nitzschia* were observed at San Simeon Pier (San Luis Obispo County) on August 24. Domoic acid was not detected in any shellfish samples collected in August. Two samples of lobster viscera were found to contain varying levels of domoic acid, however. A very high concentration of domoic acid (276 ppm) was detected in a sample from Anacapa Island (August 2) and a low concentration of this toxin was detected in a sample from San Miguel Island on August 6 (Figure 3).

The relative abundance of *Pseudo-nitzschia* continued to decline at most locations along the California coast in September. There was a noticeable increase in the relative abundance of this diatom offshore of Los Angeles and Orange counties in October. This diatom quickly increased in abundance offshore of Palos Verdes, with the percent composition increasing from 1% (October 11) to 15% (October 16) in just five days. By October 30 *Pseudo-nitzschia* had declined to 1% at this site. A similar pattern was observed for this diatom offshore of Newport Harbor, although cell numbers were lower than those observed offshore of Palos Verdes. Low levels of domoic acid were detected in shellfish samples from an aquaculture lease located less than one mile offshore of Santa Barbara during the second and third week of October and again during the second week of November.

There was a noticeable decrease in the relative abundance of this diatom in November and December at most sites along the coast. A high concentration of this toxin (57 ppm) was detected in a sample of lobster viscera collected near Anacapa Island on November 1. Domoic acid was not detected in any shellfish samples analyzed in December.

2007 PSP QUARANTINES AND RELATED HEALTH ADVISORIES

The State Public Health Officer issued the annual quarantine on the sportharvesting of mussels on April 20, 12 days in advance of the usual May 1 start date. This early start to the annual mussel quarantine was the result of elevated levels of domoic acid in

shellfish samples. The annual mussel quarantine applies only to sport-harvested mussels along the entire California coastline, including all bays and estuaries. Routine biotoxin monitoring is maintained throughout this period. The annual quarantine does not affect the certified commercial shellfish growing areas in California. Shellfish sold by certified harvesters and dealers are subject to frequent mandatory testing.

On April 27 the State Public Health Officer issued a health advisory that warned consumers to avoid eating sport-harvested species of any bivalve (two-shelled) shellfish, sardines and anchovies or the organs, or viscera, of sport-harvested or commercially sold lobster or crab taken from the coast of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and Orange counties. The health advisory was issued because CDPH detected elevated levels of domoic acid in finfish and shellfish from this region.

The annual quarantine on the sport-harvesting of mussels was rescinded on midnight, October 31, as scheduled. There were no reported human illnesses or deaths due to PSP or domoic acid poisoning in 2007.

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TABLES 1 – 8

Table 1. Total number of shellfish samples collected per coastal county in 2007 for PSP assay.

COUNTY	# SAMPLES
Del Norte	11
Humboldt	113
Mendocino	6
Sonoma	1
Marin	466
San Francisco	6
San Mateo	12
Santa Cruz	59
Monterey	1
San Luis Obispo	266
Santa Barbara	182
Ventura	34
Los Angeles	33
Orange	6
San Diego	64
TOTAL	1260

Table 2. Number of shellfish samples collected by program participants, per coastal County, in 2007 for PSP assay.

COUNTY (North to South)	COMMERCIAL GROWERS	COUNTY AGENCIES	STATE AGENCIES	FEDERAL AGENCIES	OTHER PARTICIPANTS	TOTAL
Del Norte	--	11	--	--	--	11
Humboldt	104	7	2	--	--	113
Mendocino	--	6	--	--	--	6
Sonoma	--	--	--	--	1	1
Marin	403	--	63	--	--	466
Contra Costa	--	--	--	--	--	--
San Francisco	--	6	--	--	--	6
San Mateo	--	12	--	--	--	12
Santa Cruz	--	7	52	--	--	59
Monterey	--	--	--	--	1	1
San Luis Obispo	198	--	66	--	2	266
Santa Barbara	124	--	51	5	2	182
Ventura	--	18	--	4	12	34
Los Angeles	--	33	--	--	--	33
Orange	--	--	--	--	6	6
San Diego	34	--	13	--	17	64
TOTAL =	863	100	247	9	41	1260

Table 3. Program participants by county that submitted shellfish samples in 2007 for PSP assay.

COUNTY	AGENCY
Del Norte	Del Norte County Health Department
Humboldt	Coast Seafoods Company
	Humboldt County Environmental Health Department
	Humboldt State University Marine Lab
Mendocino	Mendocino County Environmental Health Department
Sonoma	CDPH Volunteer
Marin	Cove Mussel Company
	Drakes Bay Oyster Company
	CDPH Marine Biotoxin Monitoring Program
	Hog Island Oyster Company
	Bernal Brothers
	Marin Oyster Company
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
San Francisco	San Francisco County Health Department
San Mateo	San Mateo County Environmental Health Department
Santa Cruz	Santa Cruz County Environmental Health Department
	University of California Santa Cruz
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
Monterey	Monterey Abalone Company
San Luis Obispo	CDPH Volunteer
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
	Tomales Bay Oyster Company
	Williams Shellfish Company
Santa Barbara	Central Coast Shellfish Company
	University of California Santa Barbara
	Vandenberg Air Force Base, Environmental Health Services
	Santa Barbara Mariculture Company
	CDPH Volunteer
Ventura	Ventura County Environmental Health Department
	CDPH Volunteer
	Naval Air Station, Pt. Mugu
Los Angeles	Los Angeles County Health Department

Orange	Orange County Health Care Agency
San Diego	Carlsbad Aquafarm, Inc.
	CDPH Volunteer
	Scripps Institute of Oceanography

Table 4. Number and species of samples collected in 2007 for PSP assay.

SAMPLE TYPE	# SAMPLES
Bay Mussels ¹ :	
Sentinel	48
Wild	25
Cultured	236
Total Bay Mussels	309
Sea Mussels ² :	
Sentinel	355
Wild	159
Total Sea Mussels	514
Mixed Bay and Sea Mussels	10
Total Mussels	833
Pacific Oysters ³	
Cultured	391
Rock Scallops	2
Other ⁴	34
TOTAL	1260

¹ *Mytilus galloprovincialis* or *M. trussulus*

² *Mytilus californianus*

³ *Crassostrea gigas*

⁴ Razor clam, Washington clam, Littleneck clam, Pismo clam, Rock crab, Spiny Lobster

Table 5. Total number of shellfish samples analyzed for domoic acid, per coastal county, in 2007.

COUNTY	# SAMPLES
Del Norte	2
Humboldt	18
Mendocino	1
Sonoma	1
Marin	25
San Francisco	0
San Mateo	2
Santa Cruz	60
Monterey	1
San Luis Obispo	83
Santa Barbara	112
Ventura	21
Los Angeles	13
Orange	0
San Diego	12
TOTAL	351

Table 6. Total number of phytoplankton samples collected per coastal county in 2007.

COUNTY	# SAMPLES
Del Norte	11
Humboldt	60
Mendocino	0
Sonoma	13
Marin	307
Contra Costa	5
San Francisco	71
San Mateo	92
Santa Cruz	109
Monterey	101
San Luis Obispo	333
Santa Barbara	226
Ventura	76
Los Angeles	175
Orange	42
San Diego	120
TOTAL	1741

Table 7. Date and location of shellfish samples containing detectable levels of PSP toxins during 2007.

DATE	COUNTY	SAMPLE TYPE	SAMPLE SITE	PSP TOXINS (ug/100 g)
JANUARY				
01/02/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	38
01/02/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	37
01/02/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	36
01/10/07	Santa Barbara	Lobster, Spiny, Viscera	Santa Barbara Channel	33
01/18/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P2	36
01/22/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	42
01/23/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	153
01/25/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	49
01/29/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	282
01/30/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	41
01/30/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	63
01/30/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	48
01/30/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	43
01/30/07	San Luis Obispo	Pacific Oyster, Cultured	Morro Bay, Lease M-614-01 P1	36
01/31/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	71
01/31/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	38
01/31/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	37
FEBRUARY				
02/02/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P2	41
02/03/07	San Luis Obispo	Sea Mussel, Wild	Cayucos Point	39
02/06/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	124
02/06/07	Marin	Sea Mussel, Sentinel	Morro Bay, Lease M-614-01 P1	37
02/06/07	Marin	Pacific Oyster, Cultured	Morro Bay, Lease M-614-01 P1	54
02/06/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #6	39
02/06/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	38
02/06/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	227
02/07/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	106
02/08/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	131

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02/08/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	44
02/08/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	44
02/08/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	44
02/12/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	46
02/13/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	37
02/13/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	62
02/13/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	35
02/14/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	58
02/14/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	46
02/14/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	133
02/14/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., Plt Houchin	41
02/14/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	46
02/20/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	40
02/20/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	43
02/20/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., Plt Houchin	38
02/20/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	57
02/20/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	41
02/21/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	72
02/21/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	45
02/21/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	73
02/21/07	Santa Barbara	Lobster, Spiny, Viscera	S.B. Channel, Mid, N Anacapa Is.	35
02/27/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	47
02/27/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	37
02/27/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Lease M-614-01 P1	40
02/27/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	54
02/28/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	42
MARCH				
03/01/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	48
03/05/07	Ventura	Lobster, Spiny, Viscera	Santa Cruz Island	36
03/06/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	36
03/06/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	36
03/06/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	36

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03/06/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	46
03/07/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., Plt Houchin	41
03/07/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	44
03/12/07	San Diego	Sea Mussel, Wild	La Jolla, Scripps Pier	38
03/14/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	87
03/14/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	40
03/14/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	41
03/15/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., M-653-02	53
03/16/07	Los Angeles	Sea Mussel, Wild	Malibu Beach	37
03/21/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	99
03/21/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	42
03/21/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	40
03/21/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	39
03/28/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	37
03/28/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	46
03/28/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	36
03/28/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	39
APRIL				
04/03/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	44
04/03/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	35
04/05/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	38
04/11/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	37
04/19/07	Ventura	Sea Mussel, Wild	Mussel Shoals, Oil Piers	36
04/24/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	39
04/29/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	38
MAY				
05/14/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	45
05/21/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	56
05/23/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	43
05/29/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	45
JUNE				
06/04/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	38

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06/13/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	40
06/18/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	55
06/18/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	166
06/19/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	91
06/19/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	67
06/19/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	48
06/19/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #22	40
06/19/07	San Francisco	Bay Mussel, Wild	China Beach	47
06/20/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	41
06/21/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	117
06/21/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #22	68
06/21/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	469
06/21/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	619
06/22/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	565
06/25/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	121
06/25/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	108
06/25/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	68
06/25/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	214
06/25/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	154
06/26/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	213
06/27/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	126
06/27/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	41
06/28/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	60
06/28/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	42
06/28/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	142
06/29/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	319
JULY				
07/02/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	66
07/02/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	70
07/02/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	40
07/02/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	56
07/02/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	44

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07/03/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	66
07/03/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	36
07/03/07	San Mateo	Sea Mussel, Wild	Pescadero State Beach	40
07/03/07	San Francisco	Sea Mussel, Wild	China Beach	47
07/05/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	34
07/05/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	95
07/05/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	65
07/06/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	47
07/08/07	Marin	Pacific Oyster, Cultured	Tomales Bay, Lease #M430-02	36
07/09/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	60
07/09/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	46
07/09/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	41
07/10/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #38	38
07/10/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	83
07/10/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	251
07/11/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	34
07/12/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	128
07/12/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	46
07/12/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	41
07/13/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	242
07/13/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	52
07/13/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	44
07/13/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #8	35
07/13/07	Marin	Pacific Oyster, Cultured	Tomales Bay, Lease #M430-11	42
07/16/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	56
07/16/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	180
07/16/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	138
07/16/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	41
07/17/07	San Mateo	Sea Mussel, Wild	Pescadero State Beach	36
07/18/07	Marin	Sea Mussel, Wild	Kehoe Beach	121
07/18/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	55
07/19/07	Marin	Sea Mussel, Wild	Tomales Bay, Lease #M430-11	39

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07/19/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	55
07/19/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	42
07/19/07	Marin	Bay Mussel, Wild	Tomales Bay, Lease #M430-11	40
07/23/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	75
07/23/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	38
07/24/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	42
07/26/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	50
07/30/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	41
07/30/07	San Francisco	Sea Mussel, Wild	China Beach	40
07/31/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	42
07/31/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #11	42
AUGUST				
08/02/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	36
08/02/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	49
08/02/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	47
08/06/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	37
08/06/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	56
08/06/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	36
08/07/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	94
08/07/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	126
08/07/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	38
08/07/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #9	39
08/07/07	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Uscg Station	37
08/09/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	66
08/09/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	45
08/13/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	44
08/13/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	39
08/14/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	37
08/14/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	61
08/14/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	101
08/14/07	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Uscg Station	37
08/16/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	45

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08/16/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	41
08/20/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	50
08/21/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	59
08/21/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	38
08/23/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	35
08/23/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	40
08/27/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	47
08/27/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	119
08/28/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #8	36
08/28/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	50
08/28/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Bed #12	185
08/28/07	Marin	Sea Mussel, Sentinel	Drakes Estero, Channel Buoy	65
08/28/07	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Uscg Station	37
08/29/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	40
08/30/07	Marin	Pacific Oyster, Cultured	Drakes Estero, Bed #12	40
08/30/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	46
08/30/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	50
SEPTEMBER				
09/04/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	43
09/04/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	57
09/04/07	Marin	Pacific Oyster, Cultured	Drakes Bay, Fish Dock	36
09/04/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	155
09/04/07	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Uscg Station	37
09/05/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	36
09/06/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	40
09/06/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	46
09/06/07	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Uscg Station	34
09/10/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	60
09/11/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	35
09/11/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	35
09/13/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	35
09/13/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	36

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09/17/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	47
09/24/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	40
09/30/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	37
OCTOBER				
10/09/07	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	35
NOVEMBER				
11/07/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	36
11/12/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Wq Station #11a	39
11/13/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	38
11/13/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	70
11/14/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	39
11/18/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Wq Station #11a	36
11/24/07	Ventura	Lobster, Spiny, Viscera	Santa Cruz Island	35
11/27/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	39
DECEMBER				
12/03/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	46
12/04/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	43
12/05/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	42
12/06/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	57
12/10/07	Ventura	Sea Mussel, Wild	Mussel Shoals, Oil Piers	38
12/10/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	36
12/10/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Wq Station #11a	40
12/11/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	52
12/11/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	41
12/12/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	45
12/13/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	71
12/13/07	Ventura	Rock Scallop Viscera	Santa Cruz Island	43
12/13/07	Ventura	Lobster, Spiny, Viscera	Ventura Harbor	37
12/16/07	San Luis Obispo	Bay Mussel, Cultured	Morro Bay, Wq Station #11a	35
12/17/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	43
12/17/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	42
12/18/07	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	37

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12/19/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	47
12/19/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	48
12/21/07	San Mateo	Sea Mussel, Sentinel	Pescadero State Beach	36

Table 8. Date and location of shellfish samples containing detectable levels of domoic acid during 2007.

DATE	COUNTY	SAMPLE TYPE	SAMPLE SITE	DA (ppm)
JANUARY				
01/02/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	81
FEBRUARY				
MARCH				
03/05/07	Ventura	Lobster, Spiny, Viscera	Santa Cruz Island	136
03/15/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., M-653-02	3.3
03/14/07	Ventura	Lobster, Spiny, Viscera	Santa Cruz Island	28
03/20/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	3.5
03/27/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	14
APRIL				
04/03/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	14
04/03/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	13
04/04/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	23
04/05/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	10
04/06/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Avila Beach	4.4
04/09/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	16
04/11/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	11
04/11/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	62
04/11/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	24
04/11/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	57
04/14/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., Plt Houchin	51
04/15/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., Plt Houchin	86
04/15/07	Santa Barbara	Bay Mussel, Wild	Santa Barbara Ch., Plt Houchin	86
04/19/07	Ventura	Sea Mussel, Wild	Mussel Shoals, Oil Piers	237
04/19/07	Ventura	Sea Mussel, Wild	Ventura Beach	77
04/18/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	83
04/24/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	610

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04/25/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	6
04/20/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	30
04/22/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	25
04/25/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	180
04/26/07	Ventura	Sardine, Whole	Ventura Harbor	52
04/29/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	59
04/29/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	54
04/27/07	Los Angeles	Bay Mussel, Wild	Portuguese Bend	26
04/26/07	Ventura	Sea Mussel, Wild	Mussel Shoals, Oil Piers	89
04/26/07	Los Angeles	Sea Mussel, Wild	Ballona Creek	19
MAY				
05/01/07	Los Angeles	Sardine, Whole	Long Beach Breakwater	23
05/01/07	Los Angeles	Sardine, Whole	Long Beach Breakwater	13
05/02/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	3.3
05/04/07	Los Angeles	Sea Mussel, Wild	Portuguese Bend	2
05/08/07	Ventura	Sea Mussel, Wild	Mussel Shoals, Oil Piers	1.5
05/08/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	53
05/08/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	44
05/03/07	Santa Barbara	Crab, Brown Rock, Viscera	Santa Rosa Island	36
05/03/07	Santa Barbara	Crab, Brown Rock, Viscera	Santa Rosa Island	10
05/03/07	Santa Barbara	Crab, Brown Rock, Viscera	Santa Rosa Island	110
05/03/07	Santa Barbara	Crab, Brown Rock, Viscera	Santa Rosa Island	9.5
05/03/07	Santa Barbara	Crab, Brown Rock, Viscera	Santa Rosa Island	3.8
05/08/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	77
05/09/07	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	13
05/09/07	Santa Cruz	Sea Mussel, Wild	Natural Bridges	6.3
05/15/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	10
05/14/07	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	1.5
05/16/07	Santa Barbara	Sea Mussel, Wild	Goleta Pier	3.6
05/18/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	4.7
05/18/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	3.7
05/21/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	3.4

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05/21/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	5.8
05/18/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.6
05/18/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.8
05/18/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.4
05/18/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	2.5
05/18/07	Santa Barbara	Crab, Red Rock	Santa Rosa Island	12
05/18/07	Santa Barbara	Crab, Red Rock	Santa Rosa Island	43
05/18/07	Santa Barbara	Crab, Red Rock	Santa Rosa Island	23
05/18/07	Santa Barbara	Crab, Red Rock	Santa Rosa Island	24
05/24/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	2.7
JUNE				
06/28/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	17
JULY				
07/11/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	1.3
07/12/07	Ventura	Lobster, Spiny, Viscera	Santa Cruz Island	7
07/15/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.4
07/15/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.6
07/15/07	Humboldt	Clam, Razor	Clam Beach, Mckinleyville	1.6
AUGUST				
08/02/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	32
08/02/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	276
08/06/07	Santa Barbara	Lobster, Spiny, Viscera	San Miguel Island	9.4
SEPTEMBER				
09/29/07	Ventura	Lobster, Spiny, Viscera	Ventura Harbor	25
09/30/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	269
OCTOBER				
10/09/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	1.7
10/09/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	1.7
10/09/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	2.9
10/16/07	Santa Barbara	Bay Mussel, Sentinel	Santa Barbara Ch., M-653-02	3.9
10/16/07	Santa Barbara	Pacific Oyster, Cultured	Santa Barbara Ch., M-653-02	3.7

NOVEMBER				
11/05/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	1.2
11/05/07	Santa Barbara	Bay Mussel, Cultured	Santa Barbara Ch., M-653-02	1.2
11/01/07	Ventura	Lobster, Spiny, Viscera	Ventura, Anacapa Is., Mid	57
DECEMBER				

FIGURES 1 – 13.

Figure 1a. Locations of shellfish sampling stations during 2007 (Del Norte to Monterey counties).

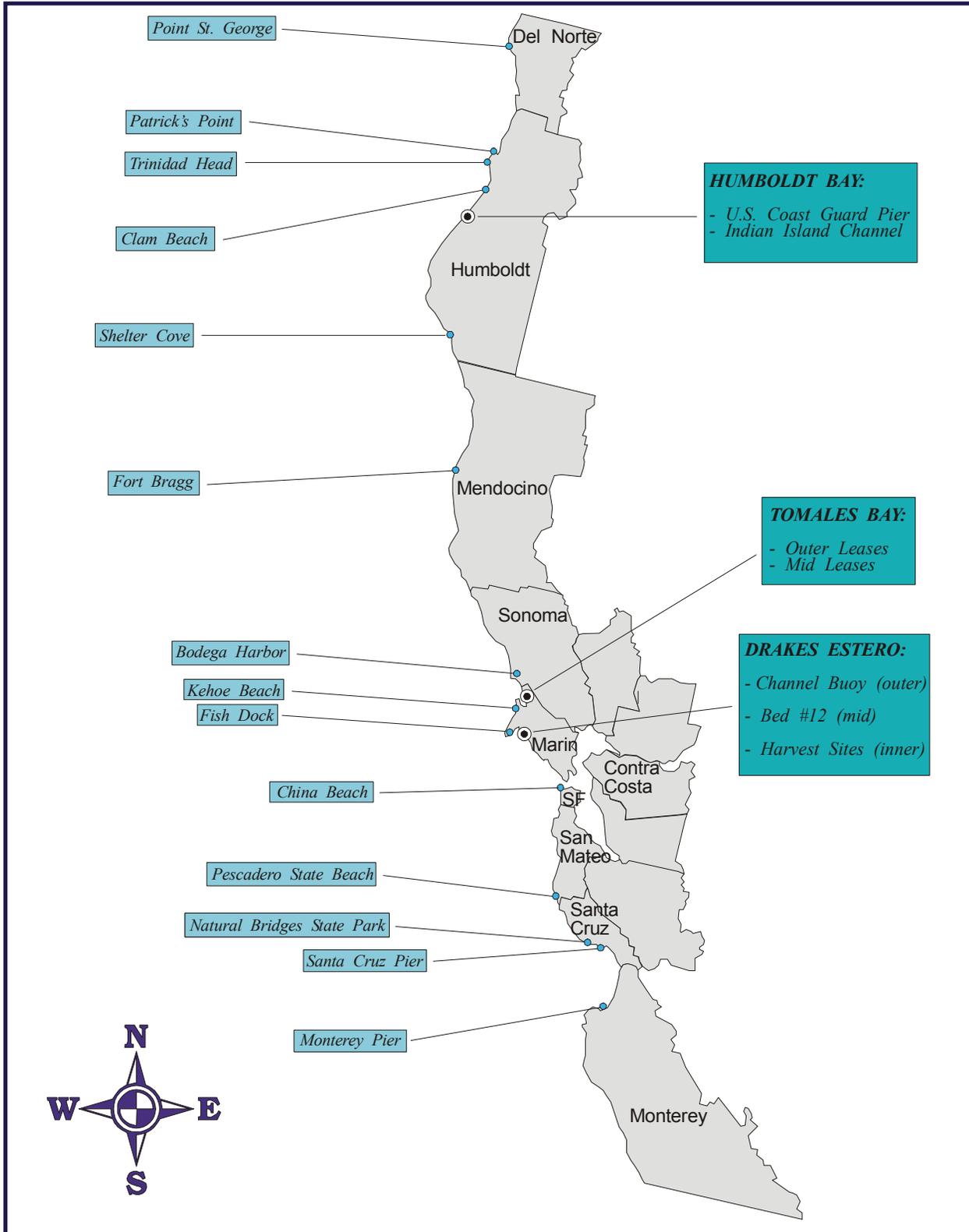


Figure 1b. Locations of shellfish sampling stations during 2007 (San Luis Obispo to San Diego counties).

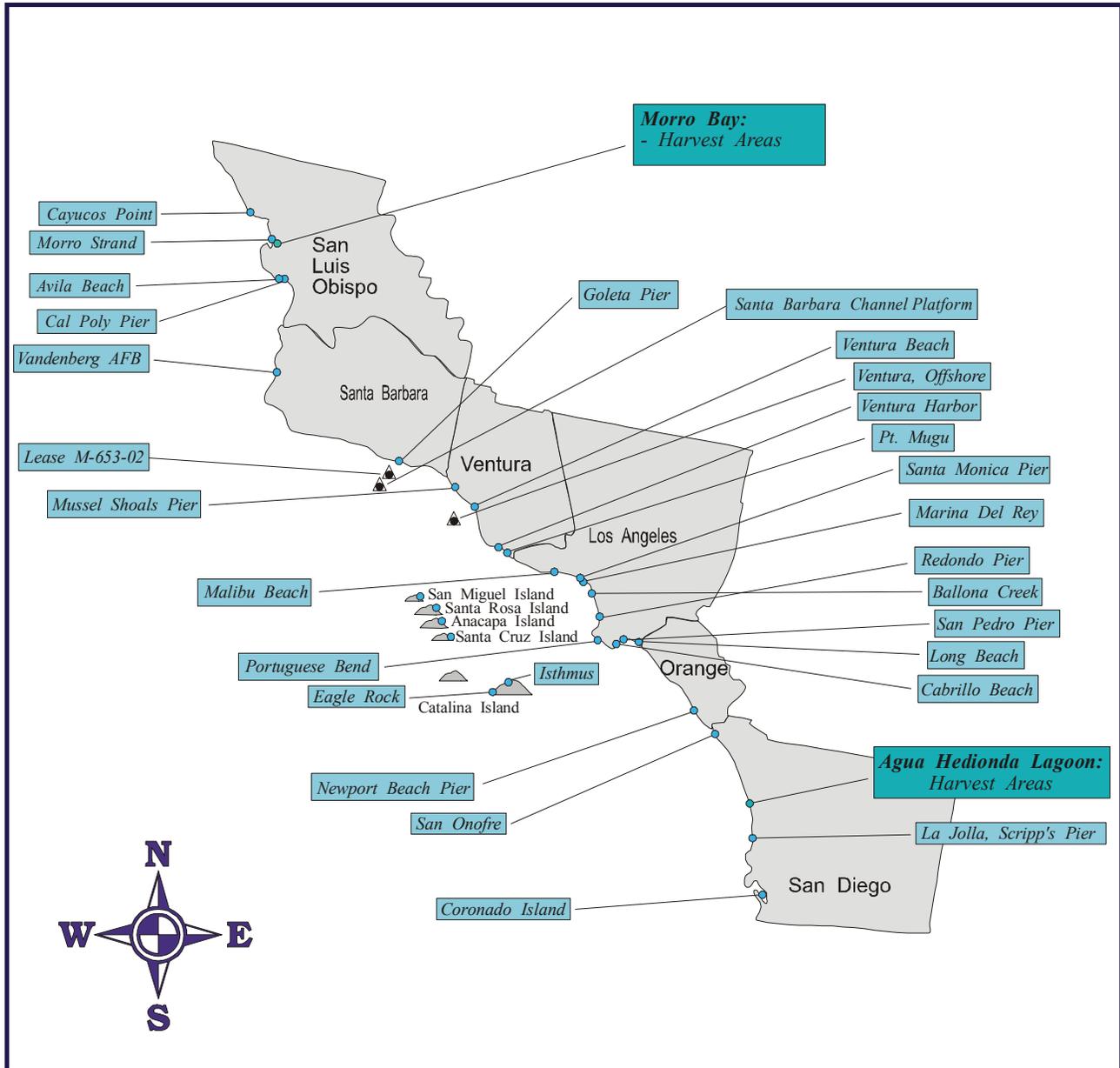


Figure 1c. Locations of phytoplankton sampling stations during 2007 (Del Norte to Monterey counties).

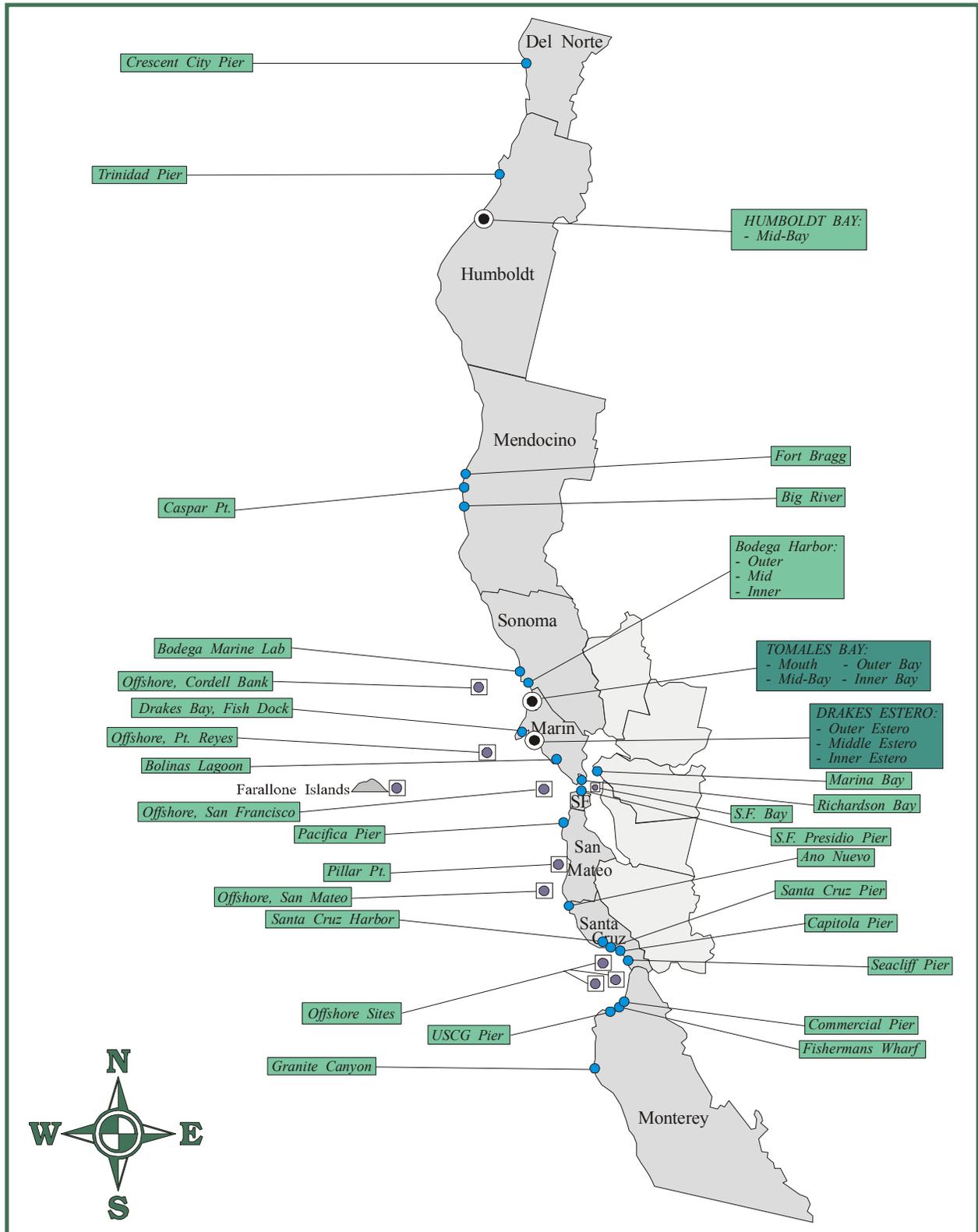


Figure 1d. Locations of phytoplankton sampling stations during 2007 (San Luis Obispo to San Diego counties).

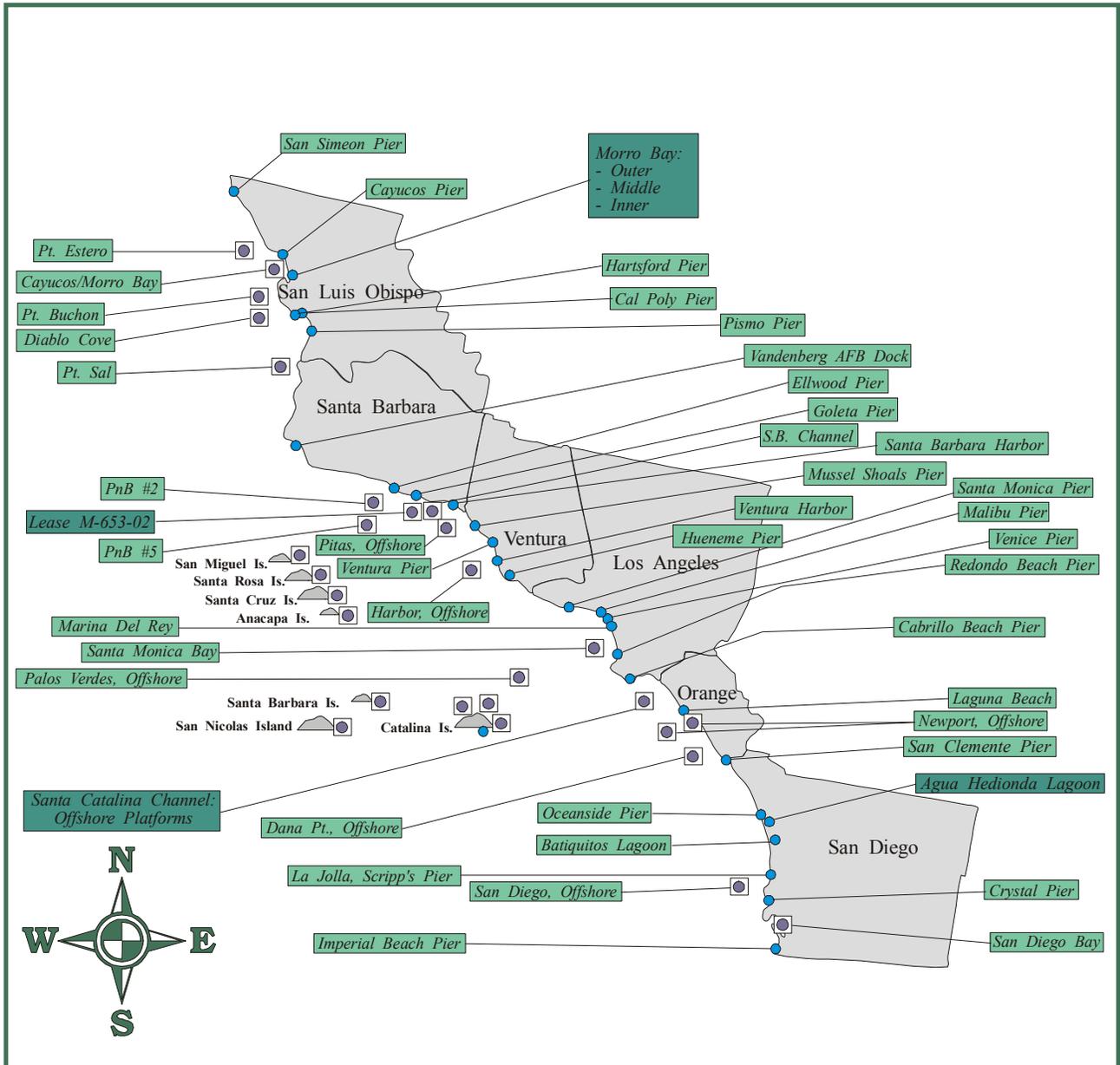


Figure 2. Annual PSP toxin levels in California shellfish from 1991 through 2007.

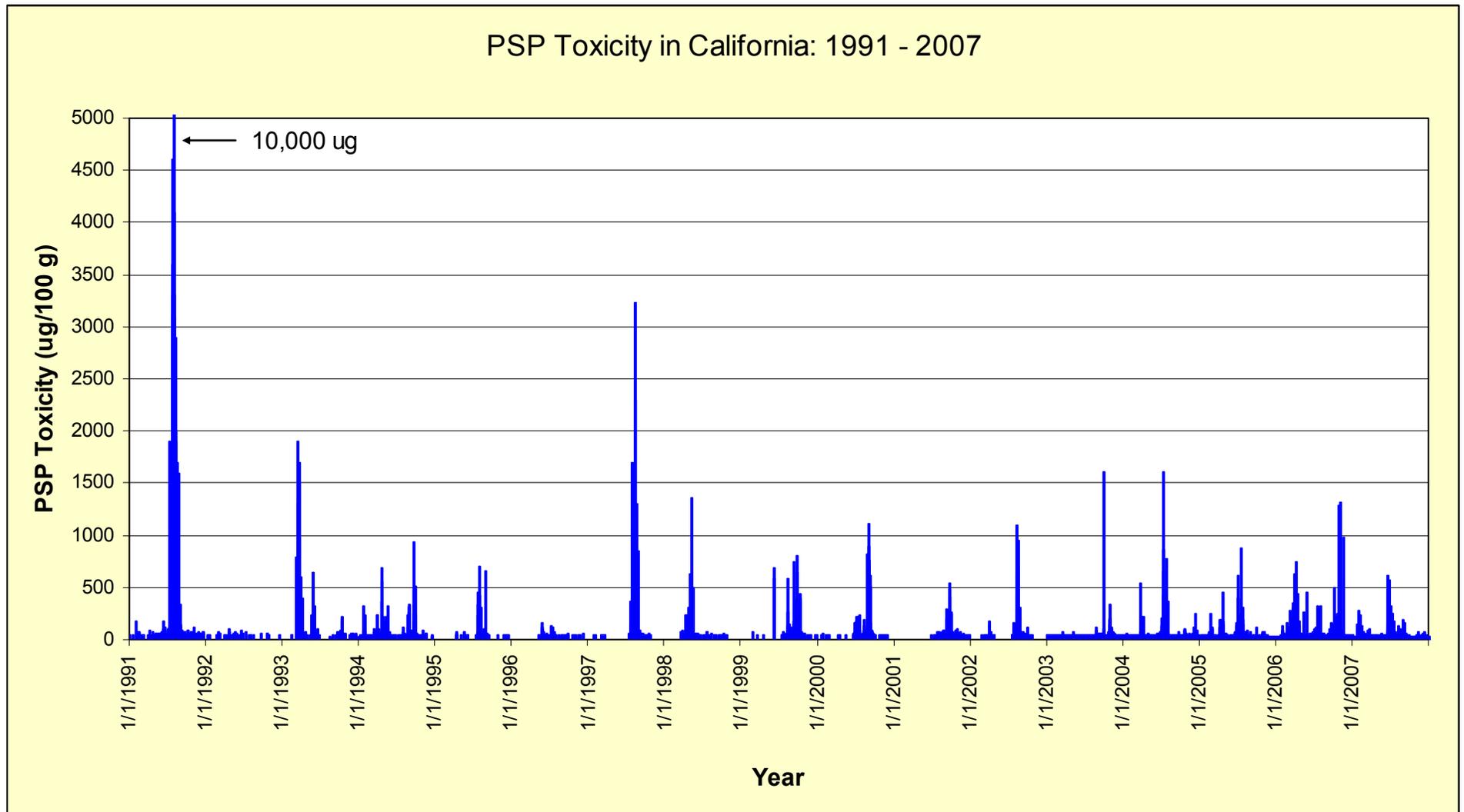


Figure 3. PSP toxin concentration and temporal distribution in California shellfish during 2007.

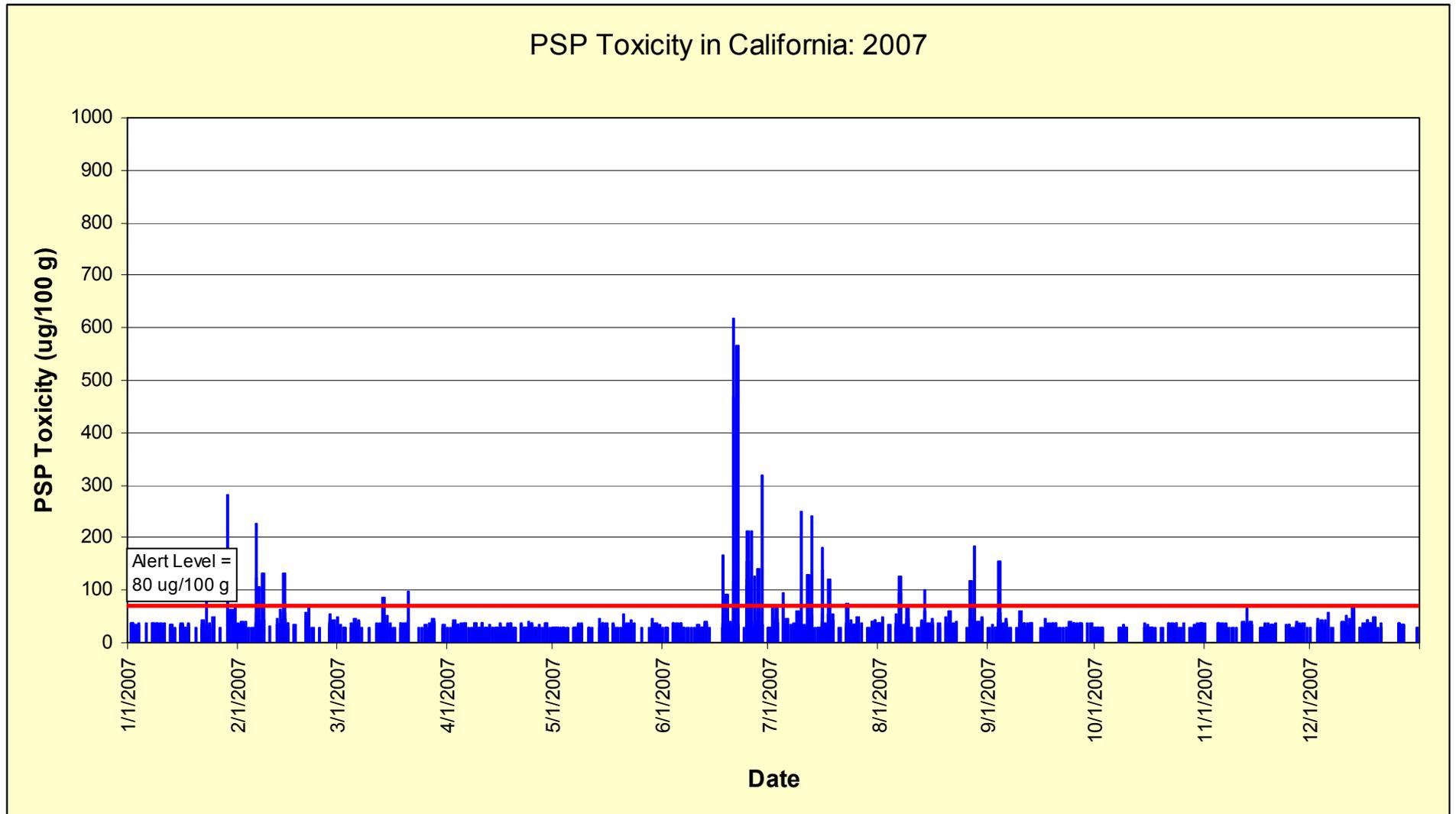


Figure 4. Temporal distribution and percent composition of *Alexandrium* spp. during 2007.

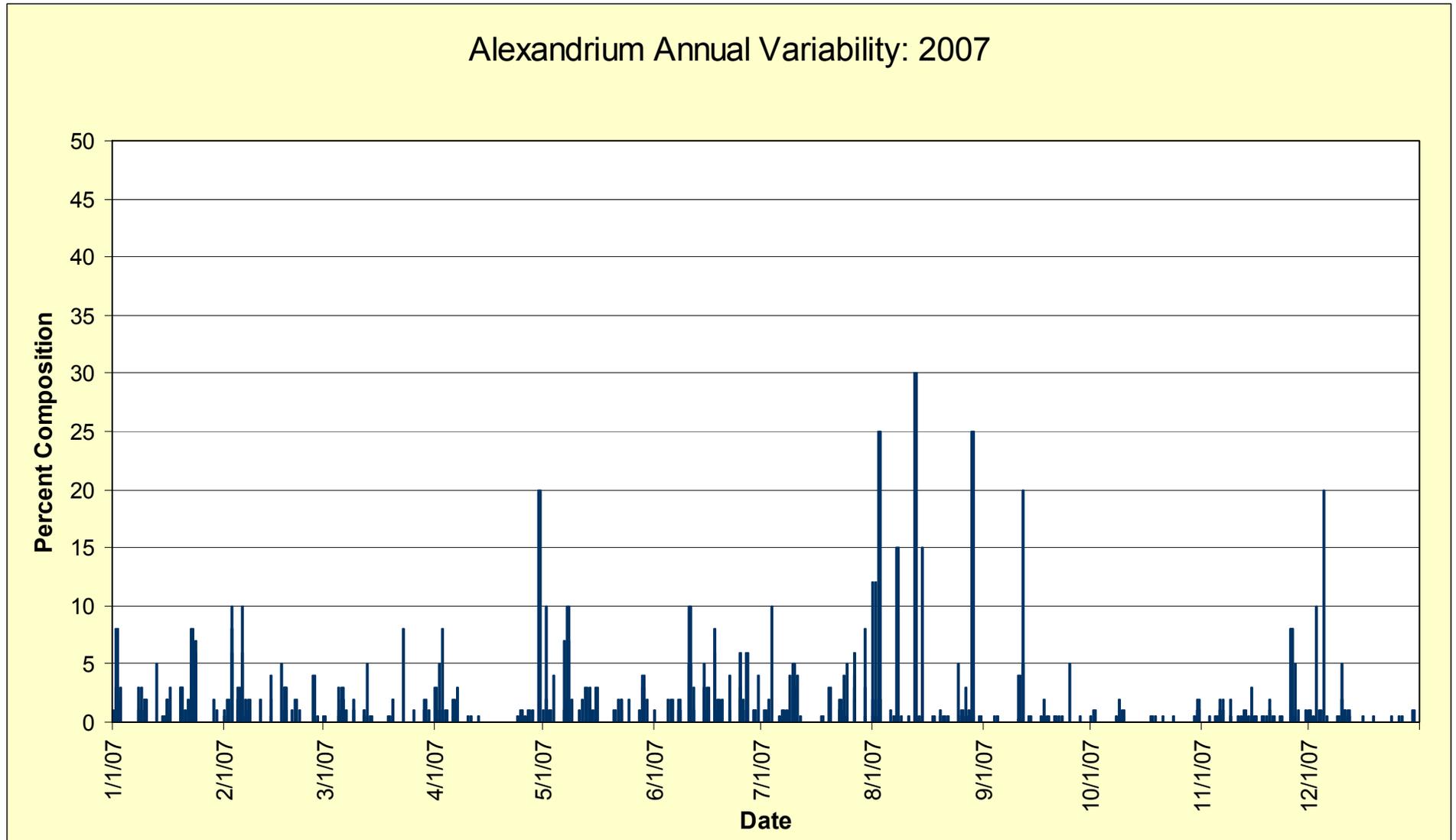


Figure 5. Domoic acid concentration and temporal distribution in California during 2007.

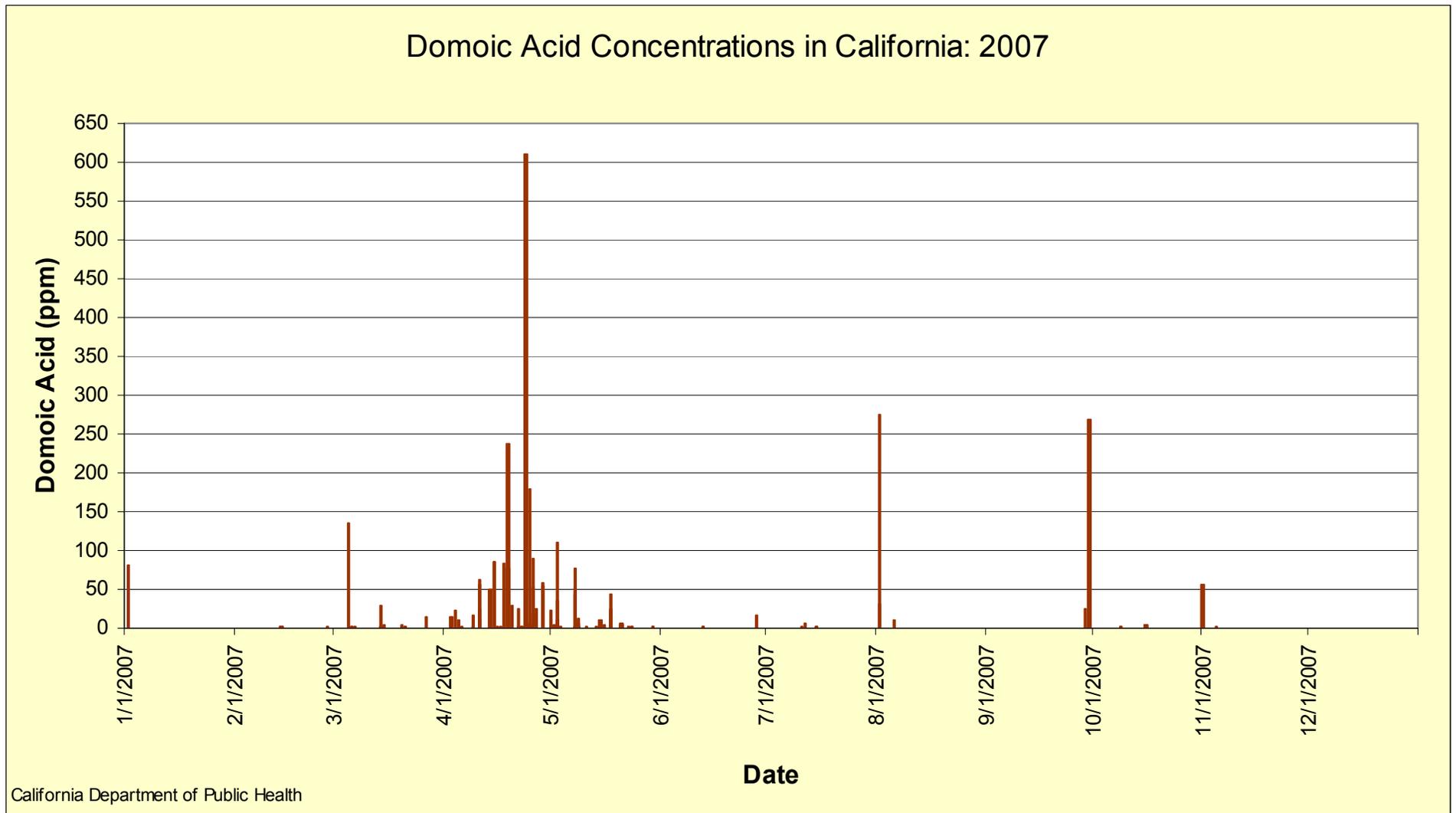


Figure 6. Temporal distribution and percent composition of *Pseudo-nitzschia* spp. during 2007.

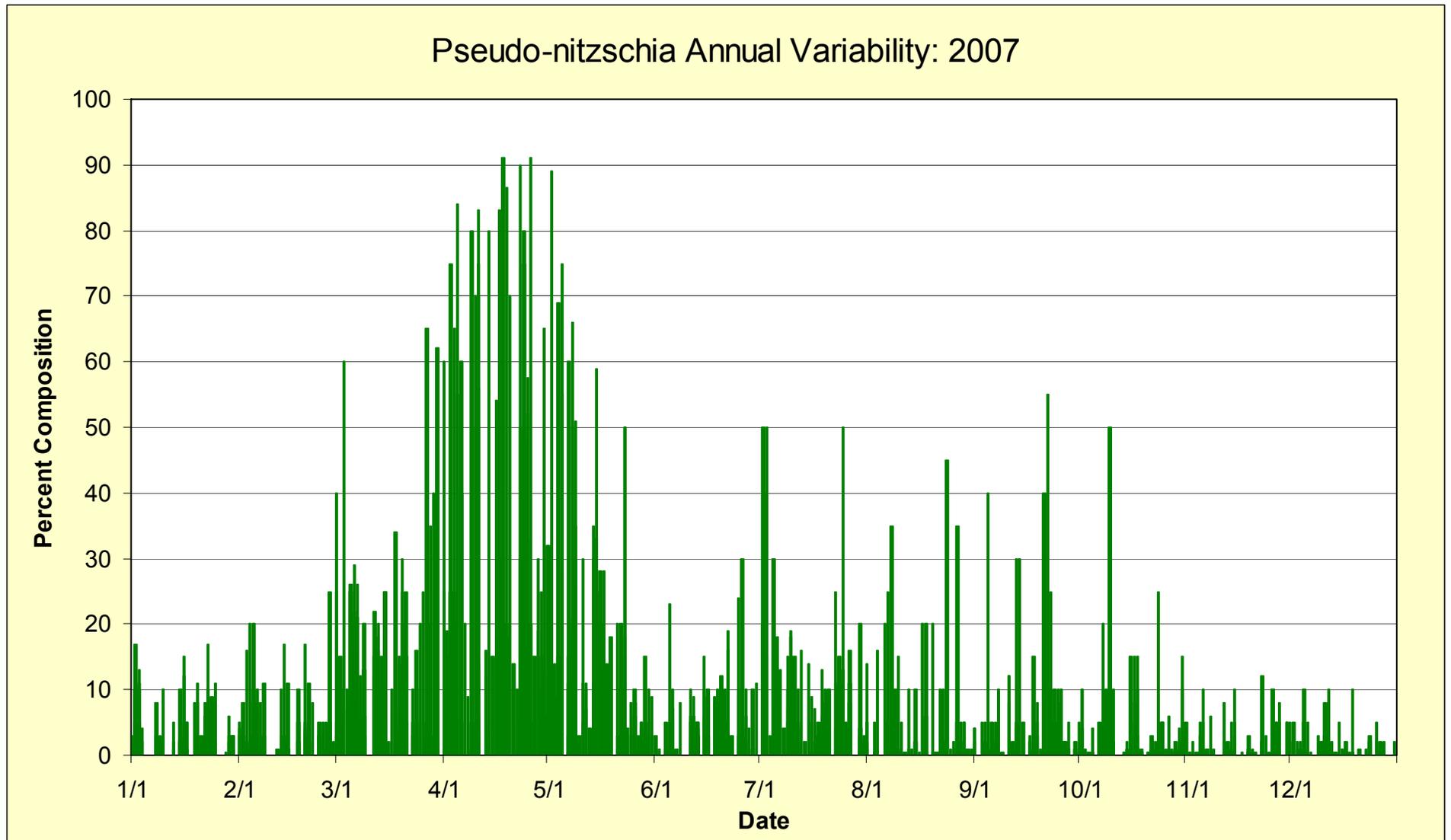


Figure 7. Temporal distribution and relative abundance index (RAI) of *Pseudo-nitzschia* spp. during 2007.

