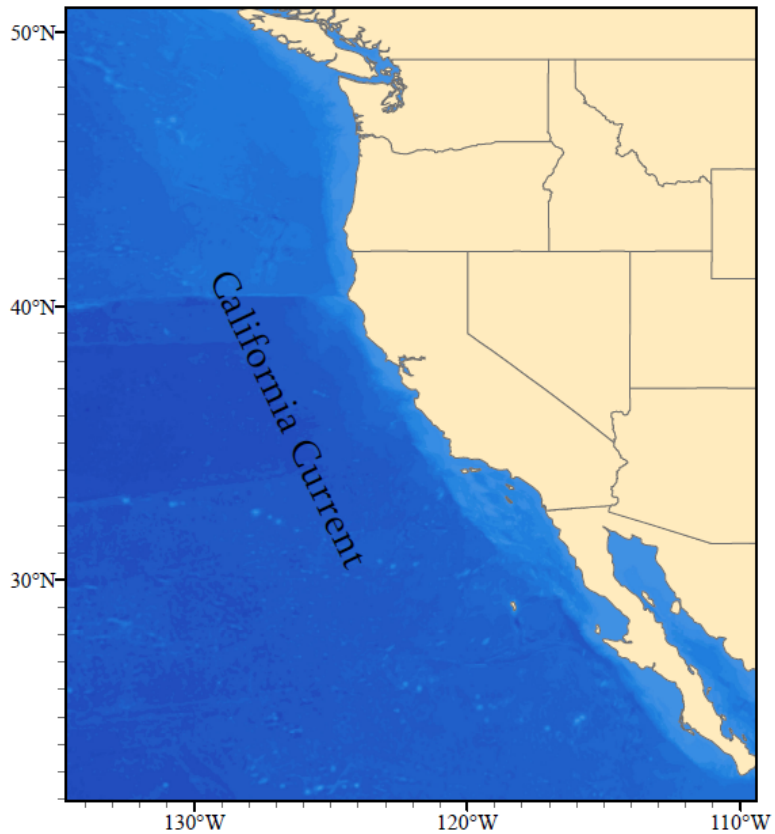
# Summary of 2010 Physical and Ecological Conditions In the California Current LME

**This report is a 2010 summary of climate and ecosystem conditions for 2010 for public distribution, compiled by PaCOOS coordinator Rosa Runcie (email: Rosa.Runcie@noaa.gov).**
**Full content can be found after the Executive Summary. Previous quarterly summaries of climate and ecosystem conditions in the California Current can be found at http://pacoos.org/**




**PHYSICAL CONDITIONS IN 2010 Executive Summary**

- **El Niño Southern Oscillation (ENSO):** SST was above-normal in the central and eastern equatorial Pacific during the winter 2009/10 at the peak phase of the El Niño. Heat content (HC) anomalies eastward across the equatorial Pacific. HC anomalies decreased rapidly in the central equatorial Pacific in April-May 2010 due to upwelling oceanic Kelvin waves signaling the start of La Niña conditions. During June-July, negative SST anomalies expanded westward, and covered the area east of 150°E. Surface wind anomalies persisted from August to December with westerly (easterly) anomalies west (east) of 150°W. Consistently, HC anomalies also persisted with positive (negative) anomalies west (east) of 180°W. ENSO forecast models expect the La Niña to peak during November-January, and to continue into the 2011 Spring.
- **Pacific Decadal Oscillation (PDO) and Upwelling Index (UI):** The PDO was in a weak positive phase during January – May 2010, consistent with the El Niño conditions in the tropical Pacific. The PDO decreased to be below -1 during July-October 2010 and consistent with the negative PDO phase, upwelling along the North America west coast was mostly above-normal. However, upwelling was weakly suppressed during September-October 2010 despite the strong negative PDO phase. During November 2010, normal downwelling was weakened, consistent with the impacts of La Niña conditions.

- **Madden Julian Oscillation (MJO):** Mid-December 2009 to mid-January 2010, the MJO index indicated eastward propagation and strengthening. During the last week in January and early February, the enhanced phase of the MJO remained generally stationary across the west-central Pacific. El Niño conditions contributed to the strong amplitude and non-steady behavior of the MJO index during the January to March period. Weak MJO activity was evident in late March - early April and May 2010. July to September, the MJO index indicated incoherent MJO activity. No significant MJO activity occurred during the months of October, November and December 2010.
- **Newport, Oregon Survey Line Observations for 2010:** Ocean conditions off central Oregon in 2010 were characterized as "warm in winter/spring" but "cold in summer/fall". There were three extended upwelling events off Newport in 2010: mid-May through mid June, three weeks in July and mid-August to mid-September. Temperature and salinity in May-September, 2010 was slightly warmer and fresher than other years. Early spring temperatures resembled spring 1997 (El Niño), but conditions changed in late spring to cooler temperatures; in fact the summer months were the coldest of the 14 year time series.
- **Monterey, California Conditions in 2010:** Mooring data from Monterey Bay show the weak 2009 El Niño as well as the 2010 La Niña events. In particular cooler and saltier surface waters with higher than average chlorophyll were apparent in the summer of 2010 while an increase in the deep chlorophyll layer was evident in the fall of 2009 and winter of 2010.
- **CalCOFI Observations for 2010:** The 2009-2010 El Niño was evident in local sea levels in the fall of 2009, reached its peak in late 2009 and by the spring of 2010 sea levels had returned to normal values. Despite the clear sea level signal of the El Niño event, no noticeable effects on mixed layer temperature or nitracline depth were observed; values of both properties were close to their long-term means. Mixed layer salinity, which is not expected to be affected by ENSO, also was similar to long-term averages. Spatial patterns in zooplankton displacement volume anomalies suggest that recent trends of declining zooplankton displacement in the CalCOFI study area are due to trends of increasing zooplankton biomass in the offshore areas, declining biomass in the California Current regions and stable biomass in the Southern California Bight; this pattern continues to hold, with smaller average anomalies, in data from the past 12 months.

**ECOSYSTEM CONDITIONS IN 2010 Executive Summary**

- **California Current Ecosystem Indicators:**
    1. **Copepods:** Shelf waters in the northern portion of the California current warmed earlier in the Fall of 2009 than in 2008 and were warmer from the Fall 2009 into the 2010 Spring than the previous winter. The timing of salinity changes followed a similar pattern, but there is less evidence that shelf waters consistently become unusually fresh in 2009-2010. These environmental signals coincided with a shift in the copepod assemblage towards species with southern affinities. The presence of southern species is typical in winter, but relatively high abundances of southern species and near absence of northern species in early 2010 was unusual.
    2. **Juvenile Rockfish:** The annual midwater trawl survey for juvenile rockfish and other pelagic nekton along the Central California coast in May-June showed increasing abundance for the species and assemblages that favor cool and productive conditions, including juvenile rockfish, juvenile Pacific hake, market squid and krill.
    3. **Coastal Pelagics:**
    Small Pelagic Fish Spawning: In 2009, the concentration of sardine eggs off southern California indicated that the location of the spawning ground was similar to 2006-2008 when the distribution of sardine spawning was almost entirely restricted to latitudes south of Point Conception in CA. By contrast, in 2010 the distribution of sardine spawning was similar to 2004, being well north of Point Conception. The early years of the time series show sardine spawning at latitudes from San Diego to San Francisco. Anchovy spawning in spring 2009

was concentrated in the southern California bight, while in 2010 very few anchovy eggs were found in the bight or elsewhere off California. Jack mackerel eggs were broadly distributed in spring 2009, but with higher densities in the southern bight.

Pacific Sardine: In 2010, the U.S. coast-wide harvest allocation, as adopted by the Pacific Fishery Management Council, was completely taken. This is the third consecutive year that the sardine allocation was reached. Sardine is currently California's second largest fishery by volume and fifth in ex-vessel value. Statewide landings as of November 2010 were 65.5 million pounds (29,708 metric tons) with an ex-vessel value of over $3.9 million. This represents a 21% decline in volume, and a 30 percent drop in revenue from 2009 and a 48 percent decrease in volume from the high of 2008, in which landings were estimated at 127.4 million pounds (57,803 metric tons) with an ex-vessel value of approximately $7.6 million.

Pacific Mackerel: No information reported.

Market Squid: Market squid is California's largest and most valuable commercial fishery. In 2009, ca. 93,000 metric tons was landed having an ex-vessel value of $56.5 million. In 2010, 71,000 metric tons were landed by November, with four months remaining of the season-year.

Humboldt Squid: Relatively few squid were encountered or observed in 2010. Despite a significant number of coastal research cruises that included focused efforts to collect squid from May through November of 2010, squid were encountered in only one off central California (Arena Canyon, north of Point Reyes) in mid-September. A modest number of squid were caught by recreational fishermen in various parts of central California between late September and early November, however catches by recreational anglers have ceased since mid- November.

**Salmon:** Central California Rivers had generally improved river conditions during 2010 and some Central Valley hatcheries are reporting salmonid returns exceeding those of 2009. However, all runs appear severely depleted and 2010 escapement totals are added to the 2007-2009 sequence of consistently low salmon returns. California coastal Coho Slamon escapement remained weak in 2010. Salmon in the Northeastern Pacific (Northern CA, OR, and WA) were unusually abundant during 2010. This is reflected in robust salmon returns to natal rivers (escapement) north of about 40°N. Chinook salmon bycatch by trawl fisheries in the northern Gulf of Alaska have also been the highest (50,000) since the current series of observations began in 2000.

Combined Columbia River salmonid escapement, monitored at the Bonneville fishway 240 km upstream, was about 1.8 million. Fall-run Chinook Salmon had the largest run at about 470,000 fish. Returns of fall-run Chinook, steelhead and sockeye were 125%, 104% and 409% of their respective ten-year averages.

- **Highly Migratory Species (tuna, sharks, billfishes):** The International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean met in July 2010 and created conservation recommendations for several species of importance to Council fisheries. Species included: Pacific bluefin tuna, albacore tuna, striped marlin, and swordfish. A shark working group was also established to conduct assessments and other studies.
- **Marine Birds and Mammals:**
  Marine Birds: 2010 was an exceptionally productive year for most seabirds on the Farallones. Those species that were able to take advantage of exceptionally high zooplankton production and abundant juvenile rockfish fared well. Cassin's Auklets far surpassed their previous best year and Common Murres, Pigeon Guillemots, Rhinoceros Auklets, Pelagic Cormorants and Ashy Storm-petrels also exhibited very high productivity. In contrast, Brandt's Cormorants again suffered very low reproductive success and Western Gulls had their poorest year on record. It seems that an overall depletion in the abundance of anchovies and other larger forage fish species resulted in poor foraging conditions, reduced breeding success and reduced breeding effort for these species. The continuing

poor performance of Brandt's Cormorants and the increasing unpredictability of prey resources in particular are of great concern.

Marine Mammals: Female gray whales and their calves are generally observed migrating northward along the California coast in April, but coastal observers in 2010 sighted fewer whales than expected. It is not known if the low counts are due to decline in the abundances of Gray whales or a change in their behavior that makes sightings more difficult.

- **Harmful Algal Blooms:**

  Summaries are provided in this report for two toxin-producing phytoplankton species *Pseudo-nitzscha* and *Alexandrium* activity.

  Washington: In June 2010, PSP in shellfish reached record levels along the Washington outer coast since monitoring began in the 1950's. Paralytic Shellfish Poisoning (PSP) exceeded the action level of 80µg/100g in razor clams at Long Beach on 1/19 at 82µg/100g. *Alexandrium* spp. were commonly observed in water samples from March through early November along the entire Washington outer coast and estuaries. The highest levels of *Alexandrium catenella* were found at La Push, coinciding with the high levels of PSP in shellfish tissue on the north coast. These were the highest *Alexandrium* spp. cell counts on the outer coast since ORHAB monitoring began in 2000.

  Blooms of *Pseudo-nitzschia* spp. occurred in June, 2010 along the outer WA coast. The greatest concentration was found at Long Beach at 306,000 cells/L of 89/11 large/small cell type. The 3rd week of June the bloom spread from Long Beach to Kalaloch. The highest cell counts were found at Long Beach. Very low levels of particulate Domoic Acid (DA) were detected in sea water and DA levels in razor clams remained relatively unchanged.

  Oregon: *Pseudo-nitzschia* and *Alexandrium* persisted along much of the coast during the spring and summer and increased in phycotoxins concentrations in bivalve tissue resulted in two shellfish closures during the year. Other harmful algae encountered during 2010 include *Chochlodinium sp., Akashiwo sanguinea* and *Dinophysis spp.*

  California: Through March 2010, most of the northern California coast remained in winter mode, with lots of detritus and few cells. South of Pt. Conception, several sites experienced diatom blooms, including *Pseudo-nitzschia* which increased at a number of southern California locations. *Alexandrium* was observed only at Imperial Beach Pier in southern San Diego County. In April, phytoplankton observations and toxin monitoring showed that *Pseudo-nitzschia* was detected along the entire southern California coast, but with no indication of domoic acid toxin buildup in shellfish. In May, low levels of *Alexandrium* produced PSP-toxins were found in Humboldt Bay and at Trinidad Head. *Pseudo-nitzschia*-produced domoic acid was detected at double health alert levels (40 ppm) in mussels from structures offshore of Santa Barbara. In October and November, PSP toxins were not detected in any shellfish samples in Northern California, and domoic acid was not detected in any shellfish samples collected along the southern or northern California coast.

# PHYSICAL CONDITIONS IN 2010

## El Niño Southern Oscillation (ENSO):

***Source : Yan Xue (Climate Prediction Center, NOAA, [Yan.Xue@noaa.gov](mailto:Yan.Xue@noaa.gov)),***
***[http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory](http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory)***
***[http://www.cpc.ncep.noaa.gov/products/GODAS](http://www.cpc.ncep.noaa.gov/products/GODAS) "Monthly Ocean Briefing" PPTs***

SST was more than 2°C above-normal in the central and eastern equatorial Pacific during the winter 2009/10 (December-January-February) at the peak phase of the El Niño (Figure 1). SST anomalies were largely persistent, but surface wind anomalies had strong intraseasonal variability characterized by two westerly wind burst (WWB) events in December 2009 and February 2010. Associated with the two WWB events were two episodes of downwelling oceanic Kelvin waves which propagated positive heat content (HC) anomalies eastward across the equatorial Pacific in about 2 months. HC anomalies decreased rapidly in the central equatorial Pacific in April-May 2010 due to upwelling oceanic Kelvin waves and forced ocean responses by easterly wind anomalies in May 2010. During the period, positive SST anomalies dissipated quickly in spring, and transitioned into negative anomalies in June 2010. During June-July, negative SST anomalies expanded westward, and covered the area east of 150°E. The 3-month-running mean NINO3.4 SST was 1°C below-normal in July-September 2010, indicating a moderate strength La Niña. Surface wind anomalies persisted from August to December with westerly anomalies west of 150°W and easterly anomalies east of 150°W. Consistently, HC anomalies also persisted with positive anomalies west of 180°W and negative anomalies east of 180°W. ENSO forecast models expect the La Niña to peak during November 2010-January 2011, and to continue into the Northern Hemisphere spring 2011.

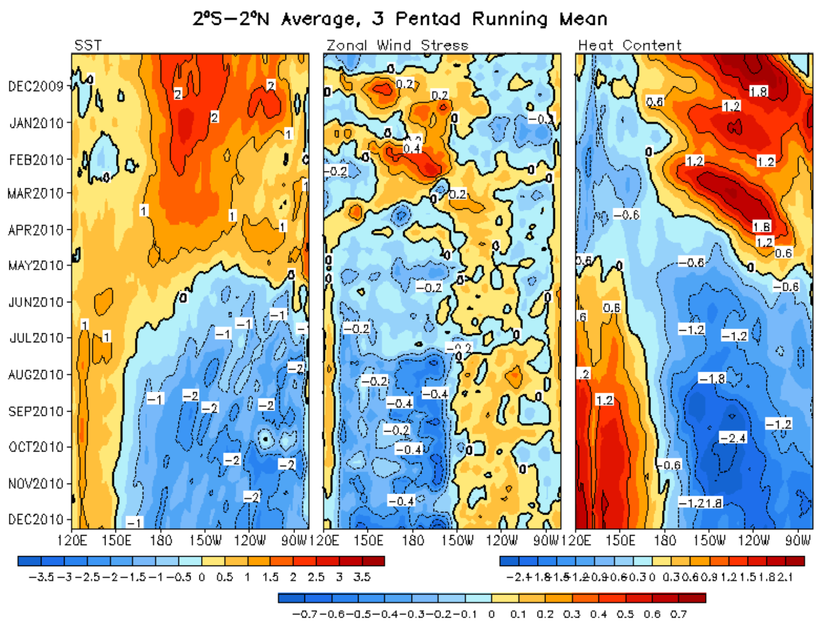



**Figure 1.** Time-longitude plots of 3-pentad-running mean of SST (left), zonal wind stress (middle) and heat content (upper 300m temperature average, right) anomalies averaged in 2°S-2°N. SSTs are from the weekly 1° Optimum Interpolation (OI) analyses of heat contents from the NCEP GODAS, and zonal wind stresses from the NCEP Reanalysis 2. Anomalies for SST, zonal wind stress and heat content were calculated for the base periods of 1971-2000, 1982-2004, and 1982-2004 respectively.

## Pacific Decadal Oscillation (PDO) and GODAS Upwelling Indices

***Source : Yan Xue (Climate Prediction Center, NOAA, [Yan.Xue@noaa.gov](mailto:Yan.Xue@noaa.gov))***
***http://www.cpc.ncep.noaa.gov/products/GODAS "Monthly Ocean Briefing" PPTs, and Jerrold Norton, NOAA (Jerrold.G.Norton@noaa.gov) http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/index.shtml***

The Pacific Decadal Oscillation (PDO) Index describes large-scale states of the North Pacific Ocean. PDO was in a weak positive phase during January – May 2010 (Figure 2), largely consistent with the El Niño conditions in the tropical Pacific. When the Index is positive, positive sea surface temperature (SST) anomalies are generally found in the eastern North Pacific with negative SST anomalies in the central North Pacific. The PDO decreased to be below -1 during July-October 2010. Consistent with the negative PDO phase, upwelling along the North America west coast was mostly above-normal during July-August 2010 (Figure 3). The Index is derived as the leading Principal Component of monthly SST anomalies north of 20°N. Monthly mean global average SST anomalies are removed to separate the PDO pattern of variability from lower frequency warming and cooling signals. The monthly Indices from late 2009 through late 2010 show two transitional periods. A five-month transitional period ended in January 2010 as the PDO Index became positive, lagging a similar sign-change in the El Niño-Southern Oscillation (ENSO) Index by six to seven months. The PDO was weakly positive for five months from January through May 2010, then tended to a strongly negative value in September 2010, nearly coincident with the change in sign of the ENSO Index. Upwelling was weakly suppressed during September-October 2010 despite the strong negative PDO phase. During November 2010, normal seasonal downwelling north of 36°N was significantly weakened, consistent with the impacts of La Niña conditions. The PDO is expected to remain negative through the northern winter and possibly through spring 2011. Many eastern north Pacific biological systems fluctuate with the PDO. Cooler water along the west coast of North America generally indicates that there are more nutrients available to phytoplankton in the photic zone. This leads to enhanced primary and secondary productivity.

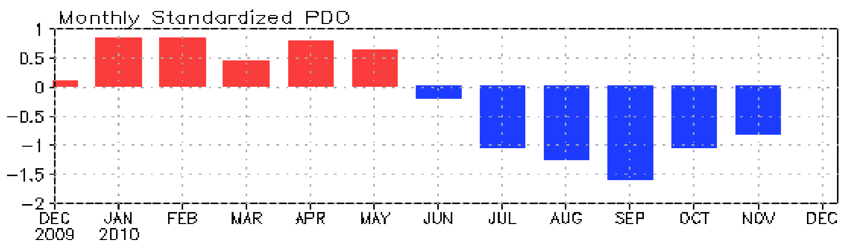



**Figure 2.** Monthly standardized Pacific Decadal Oscillation (PDO) index (bar) in 2010. The PDO index was downloaded from University of WA at **http://jisao.washington.edu/pdo**.

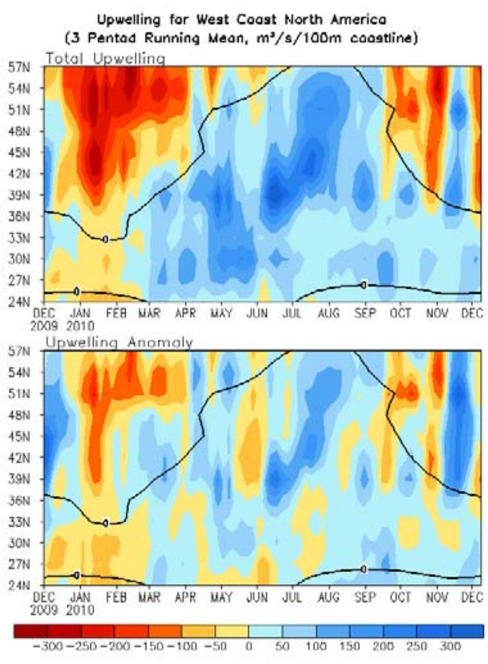



**Figure 3.** Three pentad running mean of upwelling indices derived from the vertical velocity field at 55m depth from the NCEP GODAS (Behringer and Xue 2004) for 12 standard upwelling sites that are used for the NMFS/SWFSC/ERD coastal upwelling index (http://coastwatch.pfel.noaa.gov/cgi-bin/elnino.cgi).
(a) Total upwelling, (b) anomalous upwelling relative to the 1982-2004 climatology. Area below (above) black line indicates climatological upwelling (downwelling) season.

## Madden Julian Oscillation (MJO)

***Source:*** **http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml** ***(Expert Discussions)***
**http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/ARCHIVE/** ***(summaries)***

850-hPa westerly wind anomalies increased slightly across the central and eastern Pacific during the first week in January, while easterly wind anomalies decreased across the western Pacific. Mid-January anomalies reversed sign near the Date Line with westerly anomalies present across most of the Pacific Basin. December 16, 2009 to January 24, 2010, the MJO index indicated eastward propagation and strengthening. Late January, an anticyclonic circulation was evident north of the equator across the sub-tropical Pacific. During the last week in January and early February, the enhanced phase of the MJO remained generally stationary across the west-central Pacific. El Niño conditions significantly contributed to the observed signal. Some eastward movement of the MJO index was indicated for a brief time during early-mid February before weakening dramatically. During late February and early March the MJO signal varied in amplitude indicating weak or no MJO activity. Mid-March the MJO showed some signs of strengthening but any MJO activity was weak in the latter half of the month. During late March - early April 2010 and early May 2010, weak MJO activity was evident. In early April, the MJO index indicated eastward propagation of a weak MJO signal. Mid-April 200-hPa westerly wind anomalies (5°S-5°N) developed in the eastern Pacific, and heat content anomalies decreased in the east-central Pacific in association with the upwelling phase of a Kelvin wave. Late April early May, 200-hPa westerly anomalies increased and fast eastward propagation was evident. Mid-May the MJO index indicated a decrease in eastward propagation. Late May, the MJO index showed a weak amplitude. The MJO index indicated incoherent MJO activity during the first week in July. Strong 850-hPa westerly wind anomalies and 200-hPa easterly wind anomalies were evident across the eastern Pacific. The MJO signal weakened during the first week in August and remained weak through September. During the last week in September, the MJO index again indicated an incoherent signal.

The MJO index strengthened during the first two weeks of October and weekend mid-October. Late-October the MJO index amplitude decreased with no eastward propagation and remained week the first week in November. During the second week in November the MJO index showed eastward propagation, but remained week through the end of November. The MJO index strengthened the first week of December, and indicated a re-emergence the second week. The signal during week two was consistent with background La Niña conditions. No significant MJO activity occurred during the last week in December.

## Newport, Oregon Temperature and Salinity Observations

***Source: Bill Peterson, NOAA, NMFS***

Ocean conditions off central Oregon in 2010 were characterized as “warm in winter/spring” but “cold in summer/fall”. This was due in part to a weak El Niño event that developed in mid-2009 and persisted through mid-2010 (Figure 4) and to a positive PDO pattern over the same time period. SST at the NOAA Buoy 46050 (off Newport, OR) shows that the warm anomalies were not severe, being only + 1 °C warmer than the long term average; cooling of surface waters was initiated in late June with a drop to – 1 to – 1.5 °C however slight warming commenced in September 2010, to a + 0.5 °C anomaly.

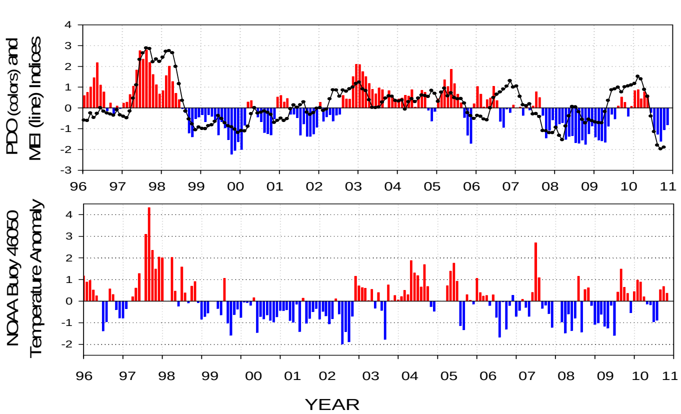



Figure 4. The upper panel, shows the time series of the Pacific Decadal Oscillation (PDO; colored bars), Multivariate ENSO Index (MEI; black line). The lower panel shows the monthly SST anomalies at NOAA Buoy 46050 located 19 miles off Newport OR.

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April (Day 92 indicated by the down-arrow in Figure 5), upwelling was weak through May and was interrupted by a weak but persistent period of southerly winds from mid-May through mid-June (indicated by the thick horizontal bar in Figure 5). The warming in September noted in Figure 6 was due to the end of the upwelling season, in mid-September (indicated by the up-arrow in Figure 5).
Taken as a whole, 2010 had a short upwelling season.

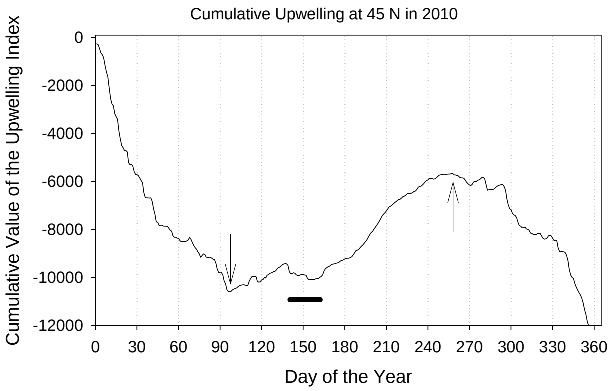



Figure 5. Cumulative values of the PFEL Upwelling Index showing that winter storms ended in early April (~ day 90, down-arrow), that upwelling was weak at the beginning of the season and was interrupted by a month of stormy weather (the horizontal bar), but was strong for only about 100 days, terminating in mid-September (~ day 255, up-arrow).

Figure 6 shows sea surface temperature (SST) anomalies at the NOAA Buoy 46050 and clearly shows that there were three extended upwelling events off Newport in 2010: mid-May through mid-June, three weeks in July and mid-August to mid-September. The latter two events were particularly strong, with -3 to -4 °C anomalies. After mid-September upwelling ceased.

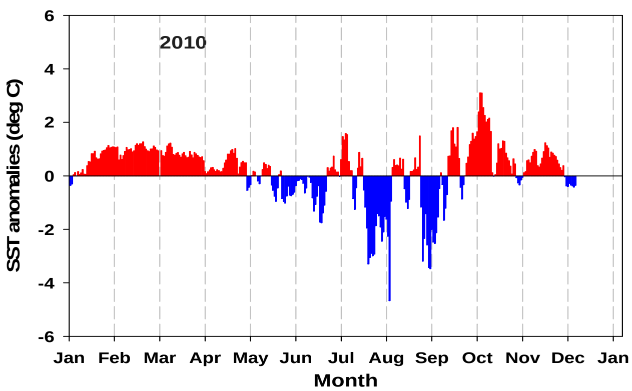
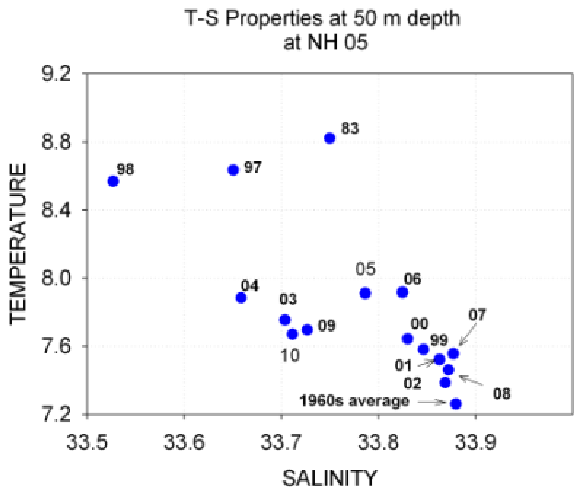
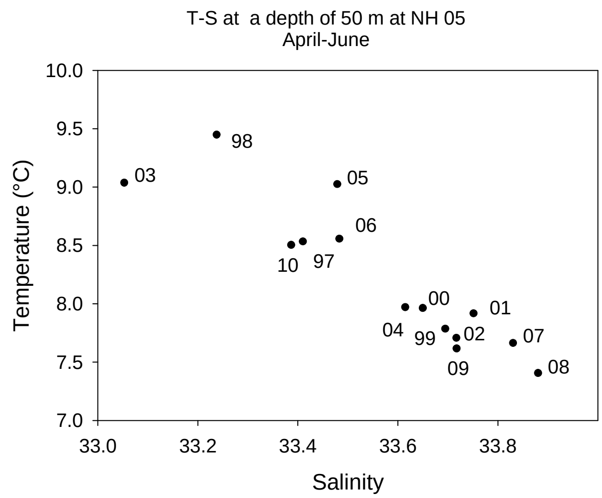



Figure 6. SST anomalies at NOAA Buoy 46050 during 2010 showing periods of downwelling (red bars) and upwelling (blue bars).

When the temperature and salinity of the deep water which had upwelled onto the shelf was examined (Figure 7), it is clear that two very disparate patterns were seen. Averaged over the climatological upwelling season of May-September (left panel in Fig 7), 2010 was slightly warmer and fresher than other years. However, when spring is examined separately (upper right panel, Figure 7), the spring resembled the spring of 1997 (an El Niño year), 2005 (the year when upwelling off Oregon was delayed until mid-July) and 2006. However, the summer months were completely different, being characterized as the coldest of the 14 year time series (CTD measurements were initiated in 1997 along the Newport Line).



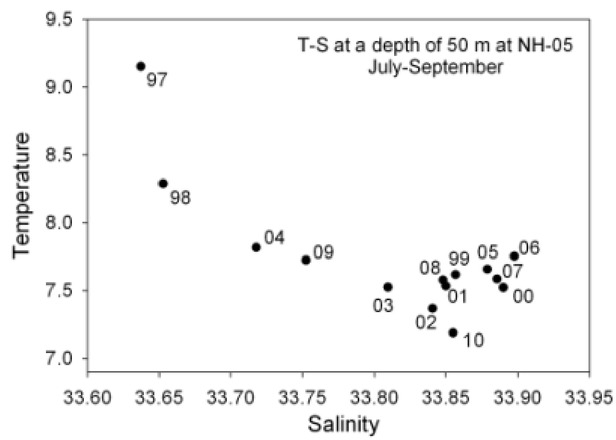




Figure 7. T-S characteristics in deep water on the continental shelf waters. The left panel shows the data averaged over May-September; the upper right panel, April-June; lower right panel July-September.

## Monterey, California Region Temperature, Salinity, Chlorophyll Observations

***Source: Francisco Chavez, Curt Collins, Baldo Marinovic, and Tim Pennington (MBARI)***

In 2010, observations were conducted within the central California portion of the California Current System (CCS) including physical, chemical, and both phytoplankton and zooplankton observations. Winter and Spring quarterly sampling as well as one summertime and two fall cruises were conducted along CalCOFI Lines 67 and 60. At all twenty standard CalCOFI stations a complete set of hydrographic observations were conducted.

Time series of surface and 100 m temperature (top), salinity (middle) and chlorophyll from the M1 mooring site in Monterey Bay, California during 2009 and 2010 compared to climatology in Figure 8. In Monterey Bay the 2009-2010 El Niño persisted from about Nov 2009 through Apr 2010. This event first became apparent as warm and fresh anomalies at 100m (right upper and middle panels, Figure 8), likely due to storm or coastal Kelvin wave passage. These anomalies were weaker but present at the surface (left upper and middle panels, Figure 8). Similarly, surface chlorophyll was near climatology during El Niño (left lower panel, Figure 8), but counter-intuitively, much higher than climatology at 100m (right lower panel, Figure 8). This positive chlorophyll anomaly likely reflects development of a strong deep chlorophyll maximum within Monterey Bay during El Niño (DCMs are typically shallow or at the surface within the Bay).

El Niño apparently flipped to La Niña during spring of 2010 when Monterey Bay surface waters became cool and salty (left upper and middle panels, Figure 8); 100m water became salty (but not anomalously cold; right upper and middle panels, Figure 8). Surface chlorophyll has been high during La Niña (left lower panel, Figure 8) whereas 100m chlorophyll has been near climatology (right lower panel).

The Monterey Bay data series have been plotted into Sep 2010. La Niña has continued to influence the atmosphere and ocean into 2011 and it will be interesting to see if impacts conform to expectation.

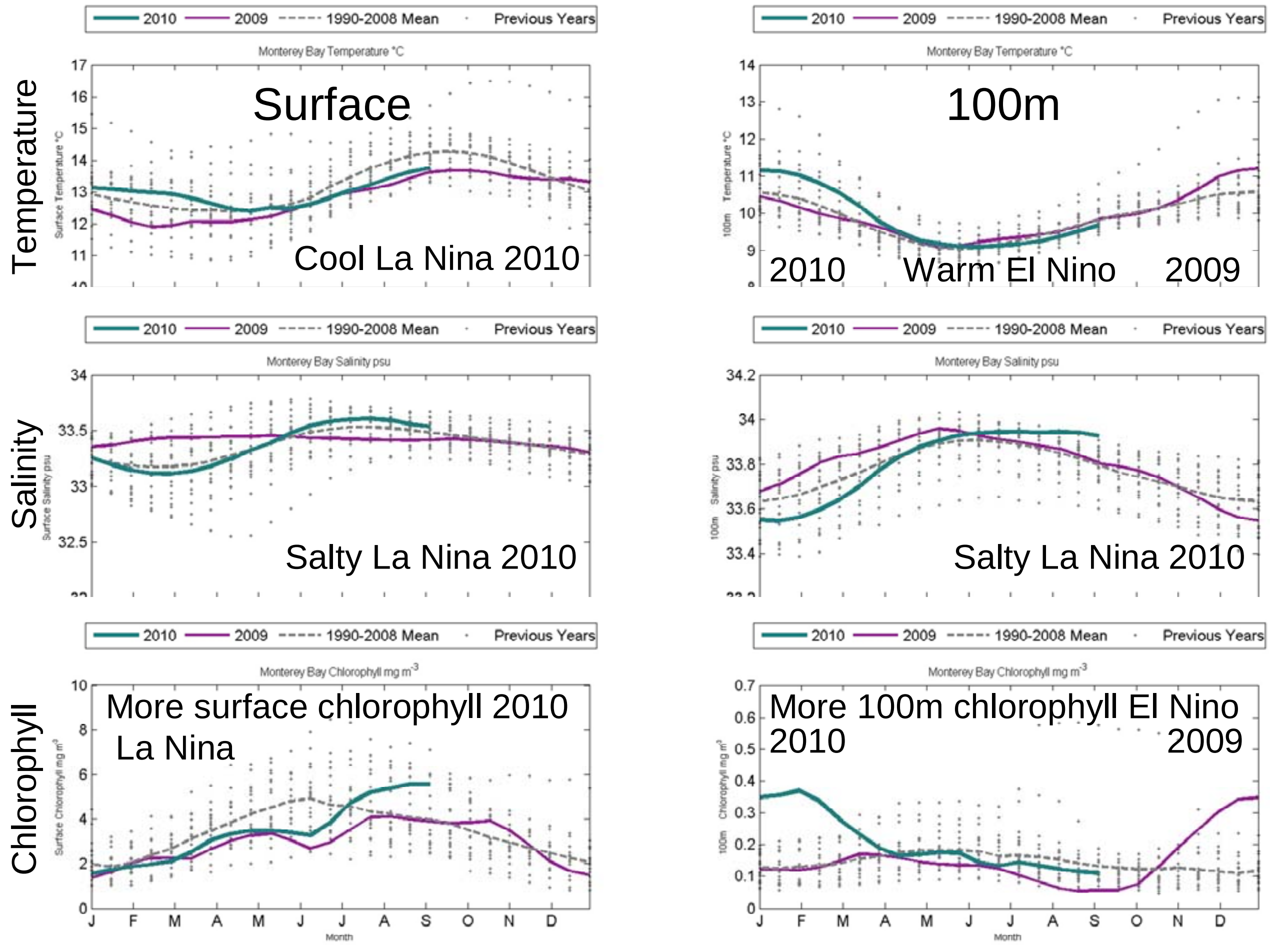



**Figure 8.** Time series of surface and 100 m temperature (top), salinity (middle) and chlorophyll (bottom) from the M1 mooring site in Monterey Bay, California during 2009 (purple) and 2010 (green) compared to climatology (dashed, dots are individual measurements).

***Source: State of the California current 2009-2010: Regional variation persists through transition from* La Niña *to El Niño (and back?). California Cooperative Oceanic Fisheries Investigations (CalCOFI) Report Vol. 51, 2010.***

The 2009-2010 El Niño started having an effect on local sea levels in the fall of 2009, reached its peak in late 2009 and by the spring of 2010 sea levels had receded to normal values (Figure 9a). Despite this clear sea level signal of the El Niño, no noticeable effects on mixed layer temperature or nitracline depth were observed (Figure 9b, c); values of both properties were close to their long-term means. Mixed layer salinity, which is not expected to be affected by ENSO, also was similar to long-term averages (Figure 9d).

Over the last year, temperatures and salinities at 200 m were slightly higher and lower, respectively, than long-term averages, similar to patterns observed during the 1997-1998 El Niño (Figure 10). However, these signals were driven by changing isopycnal depths (Figure 11) rather than changing properties on any isopycnal. In contrast to observations during the 1997-1998 El Niño, hydrographic and chemical properties did not change significantly at representative isopycnals during the 2009-2010 El Niño. Spatial patterns of isopycnal depth anomalies during the 2009-2010 El Niño were similar to those observed during 1997-1998, i.e. during the winter, deeper than normal isopycnal depths (positive anomalies), were observed primarily in the Southern California Bight (data not shown). Averaged over the CalCOFI area, these spatial patterns contributed to the persistence of overall positive anomalies in isopycnal depth after the dissipation of El Niño conditions (Figure 11).

Nitracline depths in the CalCOFI area were similar to mean values observed since 1999. Thus, nitracline depth responded significantly to the La Niña conditions of 2007-2008 but not to the El Niño conditions of 2009-2010 (Figure 9b). Concentrations of nutrients in the mixed layer were likewise similar to long-term averages (Figure 12). The slightly elevated concentrations observed during the April/May 2010 cruise were due to strong upwelling observed west and southwest of Point Conception during the cruise. Strong upwelling also contributed to the very high chl a concentrations observed during the April/May 2010 cruise (Figure 13a), a signal primarily driven by enhanced phytoplankton growth in the coastal areas. Coincident observations of extremely low zooplankton displacement volumes southwest of Pt Conception on the April/May 2010 cruise are also likely to reflect the effects of transport associated with this upwelling event (data not shown). With the exception of those observed during the winter of 2009-2010, rates of primary production were slightly above long-term averages (Figure 13b).

Zooplankton displacement volumes over the past 12 months have been similar to long-term averages for the respective months (Figure 14a). Anomalies of zooplankton displacement volumes are consistent with the long-term trend of declining values observed since 1999 (Figure 14b). Spatial patterns in zooplankton displacement volume anomalies suggest that recent trends of declining zooplankton displacement in the CalCOFI study area are due to trends of increasing zooplankton biomass in the offshore areas, declining biomass in the California Current regions and stable biomass in the Southern California Bight; this pattern continues to hold, with smaller average anomalies, in data from the past 12 months. What factors control zooplankton biomass in these different areas are currently unknown.

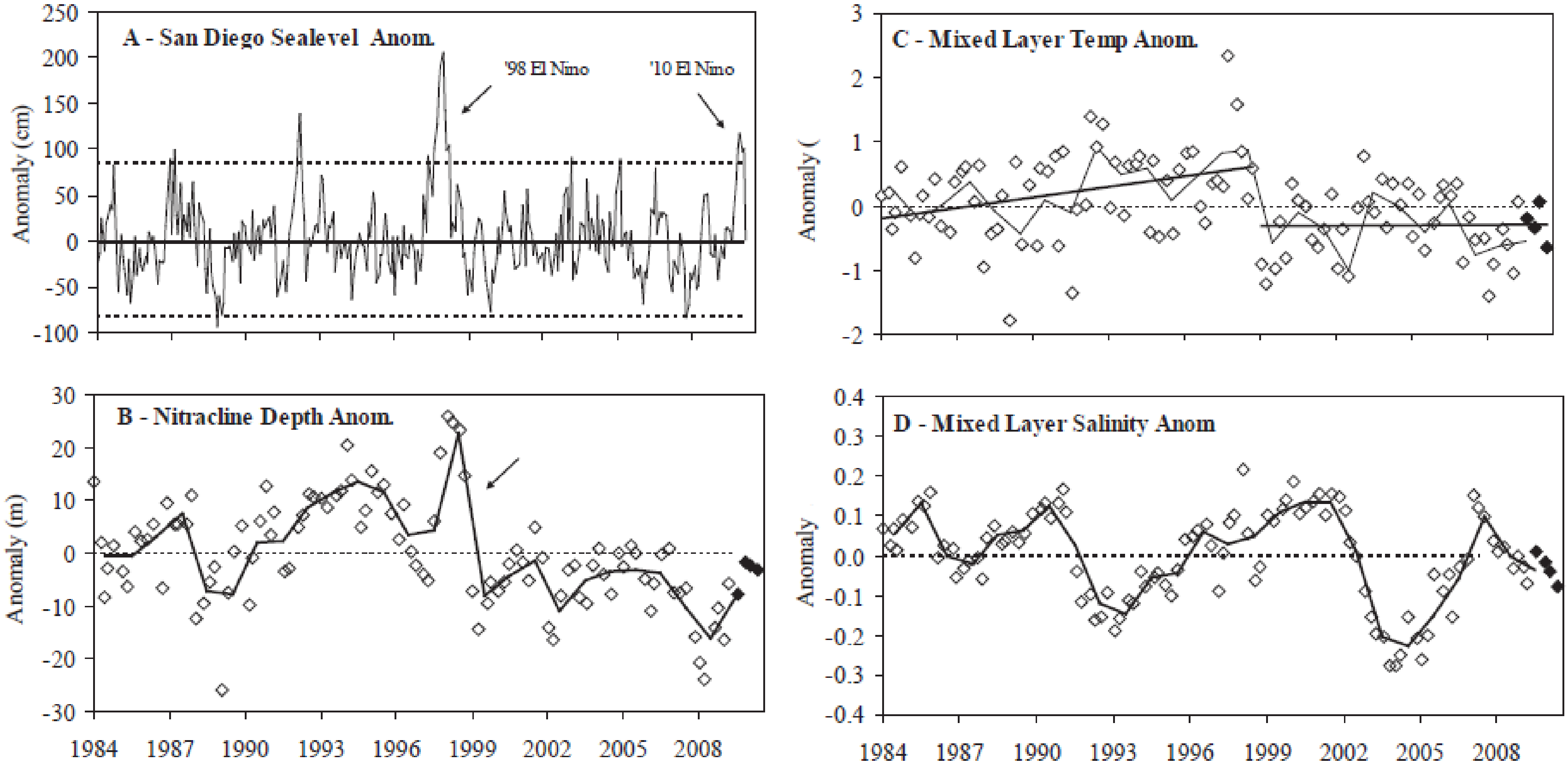



**Figure 9**. Time series of properties for the CalCOFI study area. Anomalies of detrended San Diego sea level (A), nitracline depth (B), mixed layer (ML) temperature (C), and ML Salinity (D) off Southern California. Data from the last four CalCOFI cruises are plotted as solid symbols, data from previous cruises are plotted as open diamonds. The thin solid lines represent the annual averages, the dotted lines the climatological mean, which in the case of anomolies is zero and the straight solid lines long-term trends.

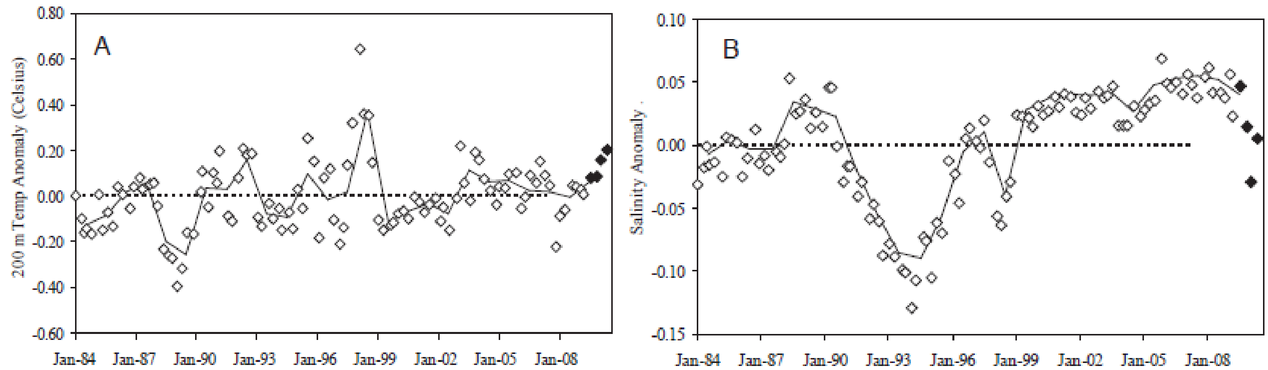



**Figure 10.** Anomalies of temperature (A) and salinity (B) at a depth of 200 m, calculated and presented as described in Figure 9.

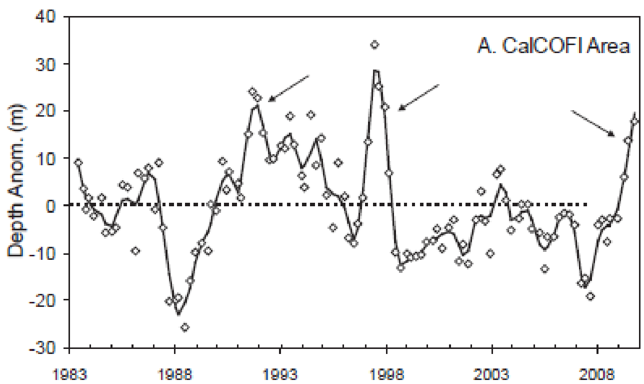



**Figure 11.** Depth anomalies of the $\sigma_t$ 26.4 isopycnal calculated and presented as described in Figure 9. Arrows indicate the last three strong El Niños.

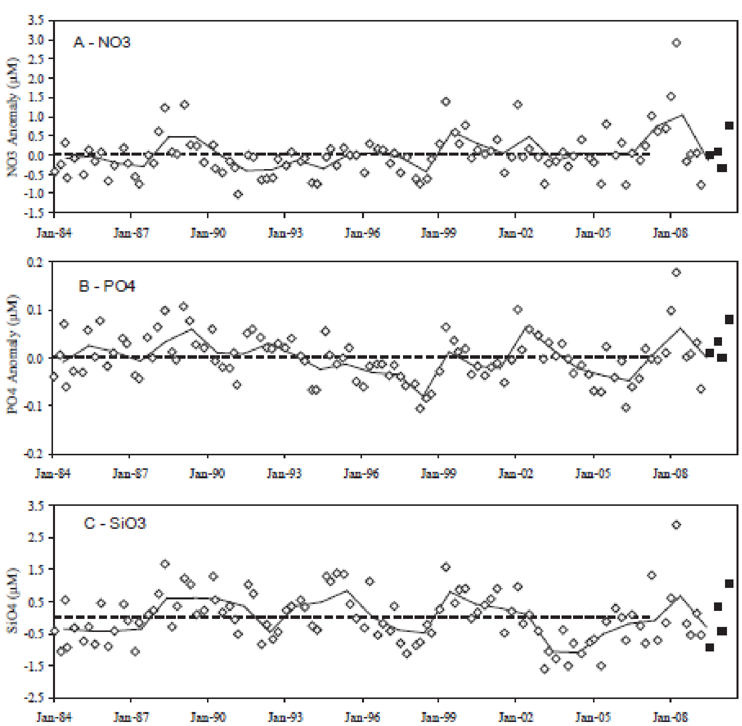



**Figure 12.** CalCOFI region anomalies for concentrations of (A) nitrate, (B) phosphate and (C) silicate in the mixed layer. Data are plotted as described in Figure 9.

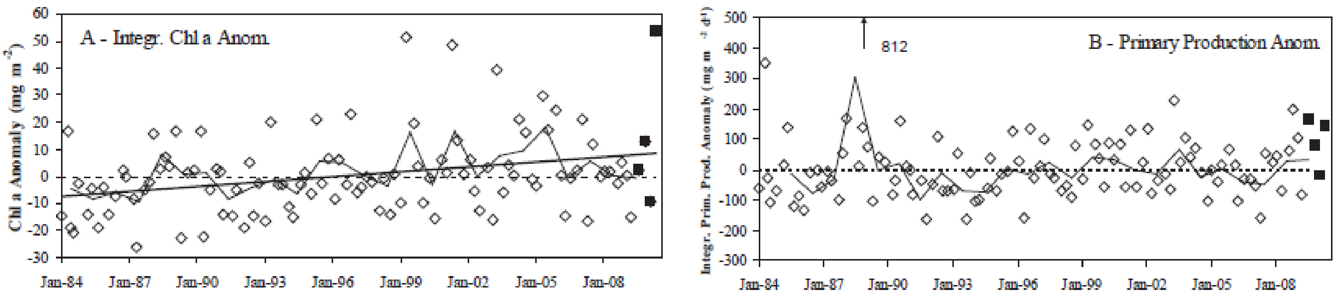



**Figure 13.** CalCOFI region averages for standing stocks of Chl a (A) and rates of primary production (B) both integrated to the bottom of the euphotic zone, plotted against time. Data and symbol codes are the same as those in Figure 10.

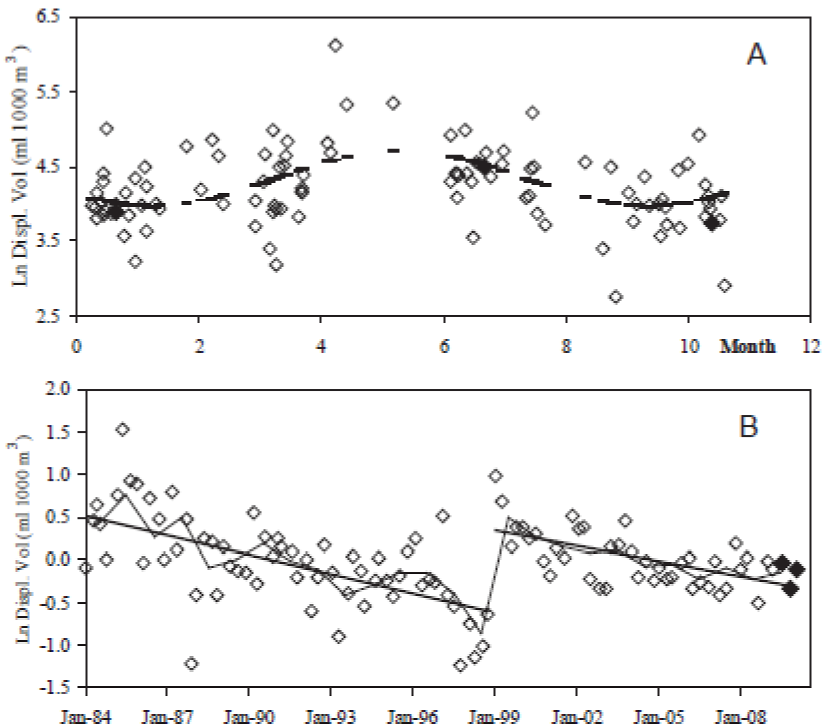



**Figure 14.** CalCOFI log cruise-mean macrozooplankton displacement volumes plotted against the month of the year (A) and time (B). Symbols are as described for Figure 9, except that data for cruise 2010-04 are not yet available. The dashed line in A is the harmonic fit to the data. Straight lines in B represent long term trends for the periods 1984 to 1998 and 1999 to 2009.

# ECOSYSTEMS IN 2010

### California Current Ecosystem Indicators:
### Copepod Biodiversity (Species Richness)

***Source: Bill Peterson, NOAA, NMFS***

Warm water conditions in shelf waters off Oregon usually result in a relatively high biomass of warm water species and a reduced biomass of cold water species. However, despite the warm conditions observed prior to June, the biomass of northern copepods averaged over the "upwelling season" (May-Sept) was quite high, ranking 4$^{th}$ highest in 15 years (Figure 15). A high northern copepod biomass is expected when the PDO has a negative value, and in 2010, the summer PDO value (May-September) was also the 4$^{th}$ most negative.

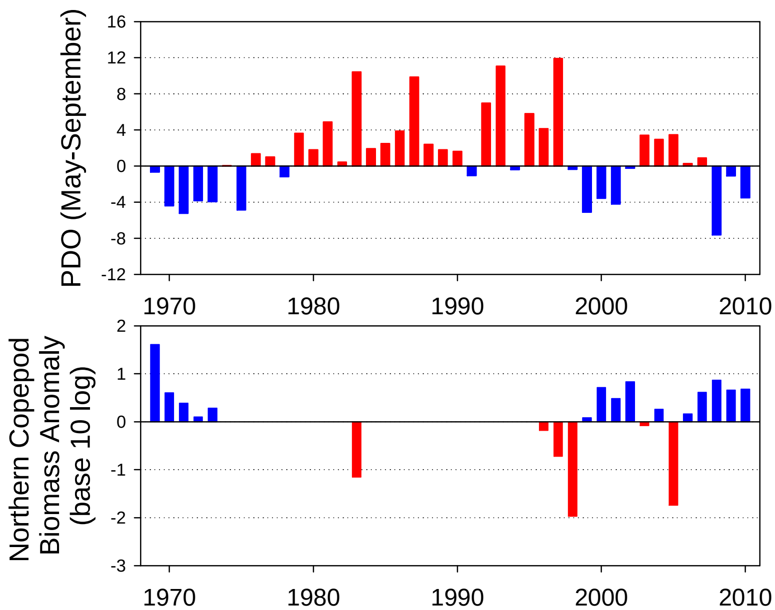



**Figure 15.** Values of the PDO (upper graph) and Northern Copepod Biomass Anomaly (lower graph) averaged over the upwelling season (May-September). Values seen in summer 2010 were the 4$^{th}$ most negative (PDO) and 4$^{th}$ highest biomass (copepods) of the recent 15 years.

***Source: Frank Schwing, NOAA, NMFS and Eric Bjorkstedt, NOAA, NMFS***

Focusing on events during spring 2009 into summer 2010, key observations (Fig. 16) include: (1) shelf waters in the northern portion of the California Current warmed earlier in the Fall of 2009 than in 2008 and were warmer from the Fall 2009 into the 2010 Spring than the previous winter. The timing of salinity changes followed a similar pattern, but there is less evidence that shelf waters consistently became unusually fresh in 2009-2010; (2) these environmental signals coincided with a shift in the copepod assemblage towards species with southern affinities. The presence of southern species is typical in winter, but the relatively high abundances of southern species and near absence of northern species in early 2010 was unusual. This pattern appears to have been quite coherent north of San Francisco and particularly north of Cape Mendocino.

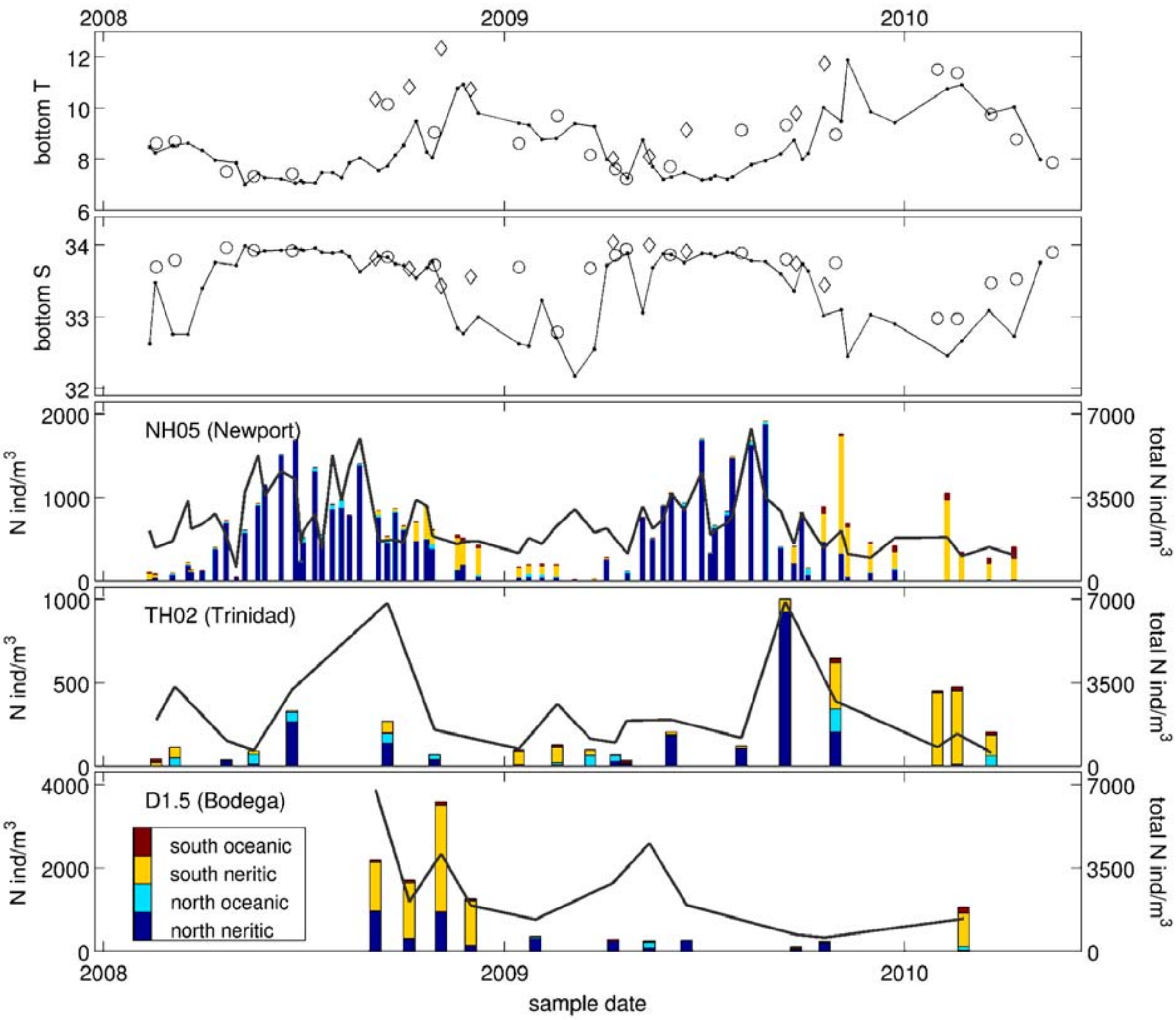



**Figure 16.** The top two panels show bottom temperature and salinity at mid-shelf stations along the Newport Hydrographic line (line), the Trinidad Head Line (open circles), and the Bodega Line (open diamonds) from 2008 through spring 2010. The bottom three panels show copepod abundance (lines) and community structure (colored bars) for mid-shelf stations on each line.

**Juvenile Rockfish:**

Ecosystem indicators for the Central California Coast, May-June 2010:

***Source: John Field, Steve Ralston and Keith Sakuma (Fisheries Ecology Division, SWFSC/NMFS/NOAA)***

The Fisheries Ecology Division of the SWFSC has conducted an annual midwater trawl survey for juvenile rockfish and other pelagic nekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile rockfish for fisheries oceanography studies and for developing indices of year class strength for stock assessments, although many other commercially and ecologically important species are captured and enumerated as well. The results here summarize trends in the core area since 1990, as not all species were consistently identified in earlier years. Most cruises have taken place on the NOAA ship David Starr Jordan, but in 2009 the cruise took place on the NOAA Ship Miller Freeman and the 2010 cruise took place on the F/V Frosti (a chartered commercial fishing vessel). A total of 136 midwater trawls and 235 CTD casts, as well as zooplankton samples, seabird and mammal observations, and continuous underway data collections were conducted in 2010; the data presented here are preliminary. Although this survey has sampled a greater spatial area from 2004 onward (roughly Cape Mendocino to the U.S./Mexico border), the results presented here focus on the core survey area (corresponding to the region just south of Monterey Bay to just north of Point Reyes, CA) as the length of the time series leads to more informative insights. Results from the expanded survey area will be developed for future reports.

The standardized anomalies from the log of mean catch rates are shown by year for six key forage species and assemblages that are sampled in this survey (Figure 17). Most are considered to be well sampled, although the survey was not designed to accurately sample krill, and those numbers should be considered preliminary. Interpretation of acoustic data from this survey to better assess krill trends in abundance is ongoing. Trends in 2009 and 2010 were of increasing abundance for the species and assemblages that tend to do better with cool and productive conditions, including juvenile rockfish, juvenile Pacific hake, market squid and krill. However, while the trend in relative abundance for rockfish and squid has been increasing since record low values in the 2005-2006 period, this increase has been only to levels close to the long term mean. Krill appear to be the exception, with very high catches in recent years. By contrast, the coastal pelagic forage species (adult life history stages of northern anchovy and Pacific sardine) typically observed in greater numbers during warmer, less productive periods were at low levels in 2009 and 2010, either as a result of lower abundance, a more offshore or southerly distribution, or both. Humboldt squid, encountered regularly since 2004, were not encountered in either trawl or jigging operations this year. As with the 2009 data, results from this year continue to represent a return to cool, high productivity conditions similar to the 1999 to 2003 period for many groups, while others are at moderate levels that approximate long term mean conditions.

The trends observed in these six ecosystem indicators are consistent with trends across a number of other taxa within this region. When the covariance among fifteen of the most frequently encountered species and species groups are evaluated in a Principal Components Analysis (PCA) (Figure 18), there are strong loadings for the groundfish young-of-the-year taxa (rockfish, Pacific hake, rex sole and sanddabs) as well as cephalopods, and euphausiids, with slightly weaker (and inverse) loadings for Pacific sardine, northern anchovy, and several species of mesopelagic fishes. The first and second components explain 39% and 14% of the variance in the data respectively, and plotting trends of the two components against each other, some patterns seem to emerge. In particular, the clupeoid-mesopelagic group was prominent during the 1998 El Niño and during the anomalous 2005-2007 years, while the groundfish group prospered during the early 1990s, the cool-phase between 1999 and 2003, and the most recent period from 2009 through 2010.

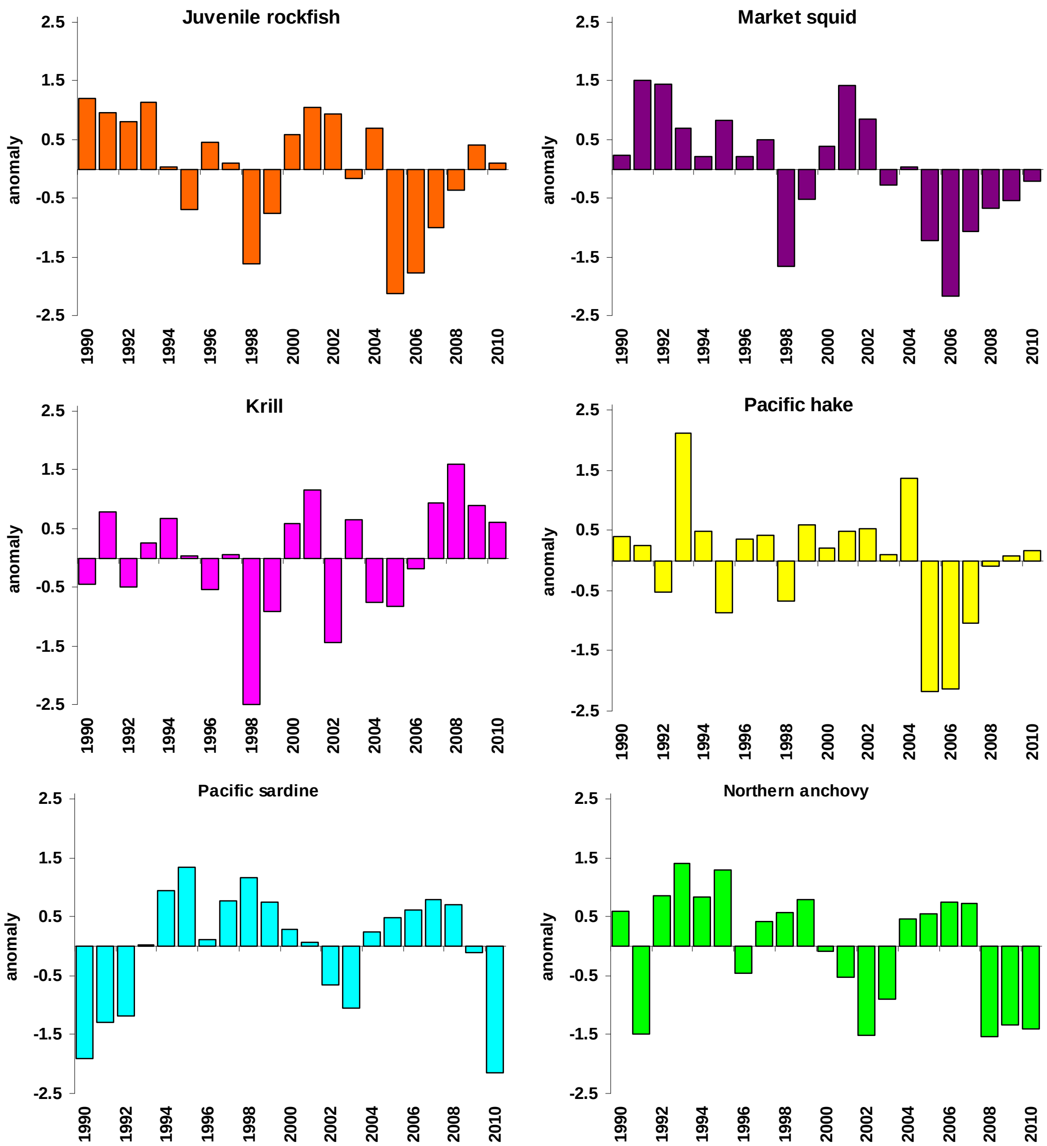



**Figure 17.** Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from the central California rockfish recruitment survey in the core region (anomalies based on the 1990-2010 period only).

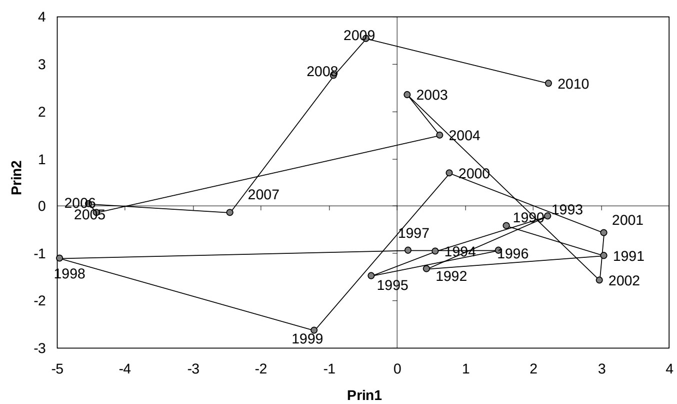



**Figure 18.** Principal component scores plotted in a phase graph for the fourteen most frequently encountered species groups sampled in the central California core area in the 1990-2010 period.

## Coastal Pelagics:

### Small Pelagic Fish Spawning

***Source: State of the California current 2009-2010: Regional variation persists through transition from* La Niña *to El Niño (and back?). California Cooperative Oceanic Fisheries Investigations (CalCOFI) Report Vol. 51, 2010.***

The spatial distribution of sardine (*Sardine sagax*) eggs with respect to sea surface temperature varies substantially from year to year in the CCS (Figure 19). In 2009, the concentration of sardine eggs off southern California indicated that the spawning ground was similar to 2006-2008 when the distribution of sardine spawning was almost entirely restricted to latitudes south of Point Conception. By contrast, in 2010 the distribution of sardine spawning was similar to 2004, being well north of Point Conception. The early part of the time series shows sardine spawning at latitudes from San Diego to San Francisco. Northerly extension of sardine spawning out of the southern California Bight to along the central California coast does not appear to be consistently related to variation in temperature. Qualitative examination of sardine egg distributions suggests that 5 of 8 anomalously warm years (1998, 2000, 2003, 2004 and 2010) showed northern extension of sardine spawning; the remaining 3 years (1997, 2005, 2006) were ambiguous or contradicted the expected pattern (Figure 19).

Spawning grounds of northern anchovy (*Engraulis mordax*) and jack mackerel (*Trachurus symmetricus*) also exhibit substantial variation over time as indicated by the spatial distribution of their eggs (Figure 19). In spring 2009, anchovy eggs appeared to be concentrated in the Southern California Bight, and in spring 2010, anchovy eggs were nearly absent from the study region (Figure 19). These patterns contrast sharply with the broader extent of anchovy spawning grounds observed in 2005-2008 (Figure 19). In spring 2009, jack mackerel eggs were broadly distributed throughout the southwestern area of the survey at low densities, showed an unusual degree of overlap with the distribution of sardine eggs, and occurred in high densities inshore of the sardine spawning grounds in the southern portion of the survey region (Figure 19). The latter pattern was also observed in 2000, and substantial overlap between sardine and jack mackerel spawning also occurred in 2005, 2007, and 2008. Jack mackerel eggs occurred only south of Point Conception in 2010.

These patterns need to be quantified for all three species, but pose possible challenges to three commonly held views. Specifically, these data suggest that sardine spawning does not necessarily shift northwards in warmer years, that anchovy spawning is not always associated with coastal upwelling areas, and that jack mackerel do not always spawn further offshore than sardine.

Based on analysis of data and samples from the 2009 survey, estimated daily egg production rates suggest a slight increase in 2009, coincident with overall warmer temperatures than the preceding year (Figure 20). The relationship between year-to-year changes in sea surface temperature and changes in estimated daily egg production rates remained consistent over the period 1994 to 2009, with the exception of 1997 and 2002. Given that the spawning biomass of Pacific sardine is positively related to the daily egg production, in particular if the number of oocytes per biomass weight remains constant, estimated daily egg production rates suggest that spawning biomass of Pacific sardines is presently at relative low levels compared to recent historical estimates (Figure 20). The extent of spawning south of San Diego depends on the local environmental conditions and will not be known until information from Mexican surveys, i.e. IMECOCAL becomes available for recent years. To update previous reports, we note that analysis of CUFES samples collected during IMECOCAL survey 0804 suggests that little sardine spawning occurred in the IMECOCAL area in April 2008.

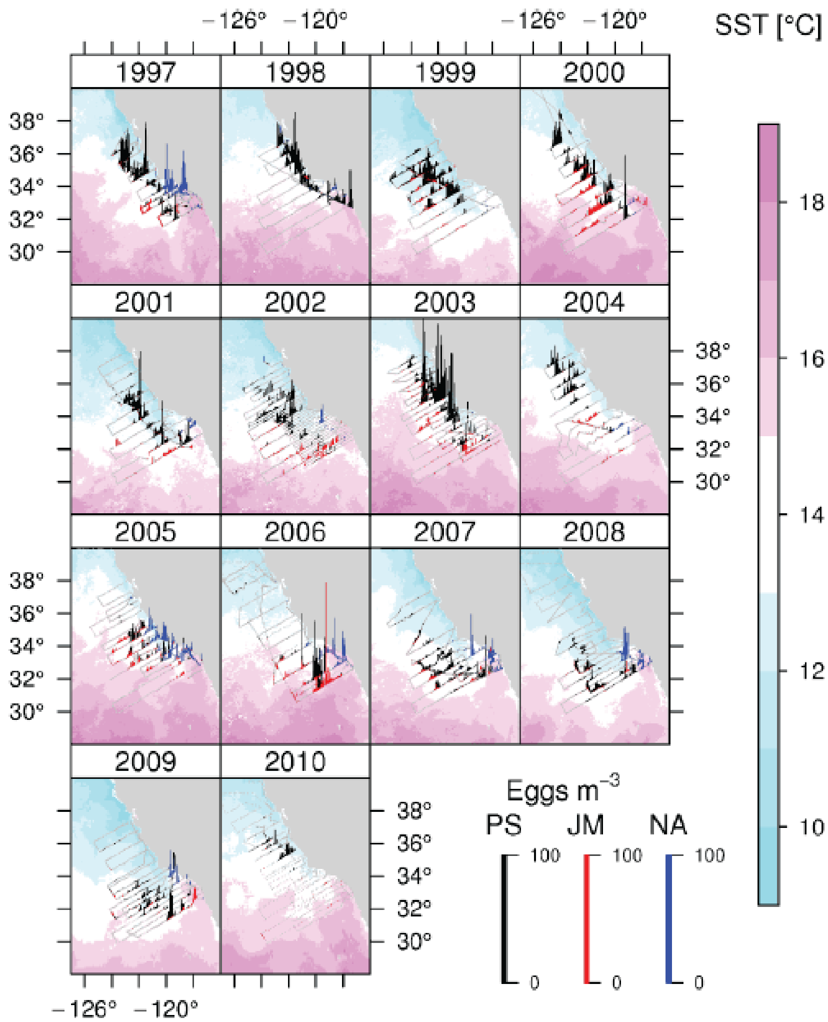



**Figure 19.** Density of eggs of Pacific sardine, northern anchovy and jack mackerel collected with CUFES (all on the same scale) overlaid on satellite SST derived from a monthly composite of April AVHRR Pathfinder imagery (1997-2008) and a blended SST product (2009-2010). PS = Pacific sardine (*Sardinops sagax*), JM = jack mackerel (*Trachurus symmetricus*), and NA = northern anchovy (*Engraulis mordax*).

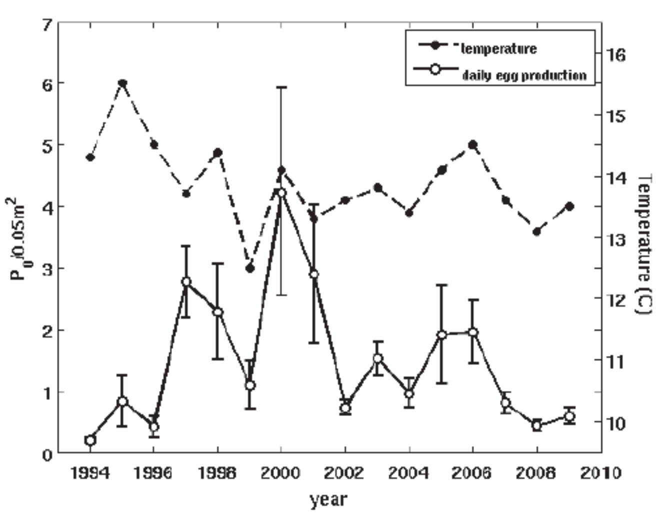



**Figure 20.** Daily egg production/0.05m$^2$ of Pacific sardine (open circles, solid line; error bars indicate +-1 SE) and averages SST (°C) (closed circles, dashed line) during March-April DEPM-CalCOFI cruises from 1994-2009.

## Pacific Sardine:

***Source: 2010 California Pacific Sardine Fishery Update. 11th Annual Trinational Sardine Forum, Victoria, CA November 16-18, 2010. Dale Sweetnam, Briana Brady, and Mandy Lewis, California Department of Fish and Game.***

The Pacific sardine, *Sardinops sagax*, has been a major component of California's commercial fisheries. The historic sardine fishery existed from the early 1900's, crashed in the 1940s, and saw resurgence in the late 1980s. The 2010 California Coastal Pelagic Species limited entry fleet consists of 65 permits on 58 vessels; 35 of those permitted vessels landed sardine.

Through October 2010, sardine is currently California's second largest fishery by volume and fifth in ex-vessel value. Statewide landings as of November 7, 2010 were 65,495,000 pounds (29,708 metric tons) with an ex-vessel value of over $3.9 million. This represents a 21% decline in volume, and a 30 percent drop in revenue over 2009 in which sardine was California's second largest fishery by volume, 82.8 million pounds (37,543 metric tons), and sixth in ex-vessel value at $5.6 million. This also represents a 48 percent decrease in volume from the high in 2008, in which landings were estimated at 127.4 million pounds (57,803 metric tons) with an ex-vessel value of approximately $7.6 million. The average price for sardine was $0.06 per pound, a slight drop from the $0.07 per pound in 2009. Landings occurred mainly in the San Pedro-Terminal Island and Monterey-Moss Landing port complexes.

In 2010, the coast-wide allocation or harvest guideline (HG), as adopted by the Pacific Fishery Management Council (PFMC), was completely taken. This is the third time since its resurgence that the sardine HG had been achieved. In November 2009, the Council adopted a total HG of 72,039 metric tons for the 2010 Pacific sardine fishery, which extends from California to Washington. A research set aside of 5,000 tons used for an Experimental Fishing Permit (EFP) to do coast-wide aerial surveys and evaluate survey methodologies (photographic, acoustic, and LIDAR) in the fall dropped the HG to 67,039. This HG was allocated in three parts based on an annual (Jan 1 – Dec 31) management cycle. The 1st allocation (Jan 1 – June 30) lasted 162 days. This was markedly longer than the 2nd (July 1 – Sept 14) and 3rd (Sept 15 – Dec 31) allocations which lasted 21 and 9 days, respectively. Increased fishing efforts, such as vessels making multiple landings per day, were observed during all allocation periods. Fishing effort continued during weekends, a period normally not fished. The 2009 fishery behavior was characteristic of a "derby" style fishery, leading to a temporary shortening of the directed fishery. The directed Pacific sardine fishery was officially closed by NOAA Fisheries on September 24, 2010.

Fishery dependent sampling in 2010 indicates that the average lengths of sardines from Monterey and San Pedro were not significantly different. In addition, sardines from both areas were significantly smaller than from the same areas in 2009. The majority of landings in 2010 came from southern California (87%). This is dramatically different from 2009 in which 64% of the landings came from Monterey and Moss Landing.

On November 7, 2010, the Council adopted a HG of 50,026 metric tons for the 2011 Pacific sardine fishery based on a biomass estimate of 537,173 metric tons and the harvest control rule in the Coastal Pelagic Species Fishery Management Plan. This HG also incorporates a 4,200 metric ton set-aside allocated for dedicated Pacific sardine research consisting of an aerial survey in Oregon and Washington, and a hybrid survey in California depending on survey results this fall.

## Market Squid:

***Source: Dale Sweetnam, California Department of Fish and Game***

Market squid is California's most valuable fishery both in volume and value. The Market Squid Fishery Management Plan, which was adopted by the Fish and Game Commission in 2004, established management measures to ensure the sustainability of this resource, including a harvest limit, weekend closures to allow for periods of uninterrupted spawning, a limit on light wattage since lights are used to attract the squid and a restricted access program, which limits the number of vessels participating in the fishery.

DFG biologists monitoring the commercial squid fishery report that 2010 squid catches off California were once again very high in the fishing season starting April 1, 2010. Statewide, over 157 million pounds (71,309 metric tons) have been landed by November this season (April 1, 2010 to March 31, 2011). Over 200 million pounds (93,371 metric tons) of market squid were landed in 2009 with an ex-vessel value of $56.4 million.

In southern California squid have been captured in widespread areas surrounding the Northern and Southern Channel Islands, offshore banks, and coastal areas from La Jolla to Pt. Conception. In northern California, squid were landed from Pt. Sur to Half Moon Bay.

**Humboldt Squid**:

**Humboldt squid in the California Current through 2010**

***Source: John Field[1], William Gilly[2] and Julia Stewart[2]***
***1 NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA***
***2 Hopkins Marine Station, Stanford University, Pacific Grove, CA***

Although the Humboldt, or jumbo, squid (*Dosidicus gigas*) has been regularly encountered in large numbers throughout the CCS (from Mexico to Canada) over the past decade, relatively few squid were encountered or observed in 2010. No squid were encountered in the FED/SWFSC juvenile rockfish survey for the first time since the first encounter in 2005, and only minor squid catches were reported by the midwater-trawl fishery for Pacific hake in 2010, following a year (2009) in which incidental catches were extremely high. Similarly, only modest numbers of squid were seen in the Monterey Bay Aquarium Research Institute (MBARI) ROV surveys in 2010, with virtually no sightings in spring and summer months, and only modest numbers of squid in the fall. Despite a significant number of coastal research cruises that included focused efforts to collect squid from May through November of 2010, squid were encountered in only one survey off central California (Arena Canyon, north of Point Reyes) in mid-September. A modest number of squid were caught by recreational fishermen in various parts of central California between late September and early November. However the infrequent reports of catches by recreational anglers have ceased since mid- November. There were few event-driven media reports of squid in either fisheries catches or beach strandings in 2010 (excluding the first two months of the year). In fact the media reports that did come out during the year noted the conspicuous absence of Humboldt squid in California Current waters, in sharp contrast to 2009.

The cause of this decline in squid encounters is unclear, but is likely to relate to ocean conditions. Specifically, 2010 saw a relatively strong, but short-lived, El Niño event during early winter 2010 that impacted the southern California Current System and Gulf of California, followed by a rapid return to cool (La Niña) conditions by late spring throughout most of the California Current. Preliminary analysis of the few squid specimens that were sampled in 2010 suggests that they may have been slightly smaller than in recent years, which could be consistent with observations of fully mature squid of extremely small size in the southern Gulf of California during 2010. Statoliths are being analyzed from both locations to investigate potential changes in growth and maturation rates associated with the oceanic anomalies like those of 2010.

**Salmon:**

***Source: Jerrold Norton, NOAA (Jerrold.G.Norton@noaa.gov)***
***http://www.alaskafisheries.noaa.gov/npfmc/current_issues/bycatch/ChinookESAletter1210.pdf, http://www.psc.org/FraserPnl/Escapement/Sockeye_Escapement.pdf, http://www.fpc.org/adultsalmon/AdultCumulativeTable.asp***

Central California Rivers had generally improved river conditions during 2010 and some Central Valley hatcheries are reporting salmonid returns exceeding those of 2009. However, all runs appear severely depleted and 2010 escapement totals are added to the 2007--2009 sequence of consistently low salmon returns. California coastal Coho Salmon escapement remained weak in 2010.

Salmon presence in the Northeastern Pacific has been unusually high during 2010. This is reflected in robust salmon returns to natal rivers (escapement) north of about 40°N. Chinook salmon bycatch by trawl fisheries in the northern Gulf of Alaska have also been the highest (50,000) since the current series of observations began in 2000. The previous high trawl bycatch of Chinook was about 40,000 fish in 2007. Coded wire tags showed that some of the trawl bycatch was from the ESA-listed lower Columbia and upper Willamette River Chinook populations of Washington and Oregon. Increasing demand of wild salmon supported prices as landings in Alaska salmon fisheries of Sockeye, Coho and Chum Salmon together were more than a million fish greater than the ten year combined average. Canadian west coast salmon fisheries also had unusually successful seasons in 2010. Between the end of June and the beginning of October and estimated 16 million sockeye salmon entered the Fraser River, just north of the Washington border.

Combined Columbia River salmonid escapement, monitored at the Bonneville fishway 240 km upstream, was about 1.8 million. Fall-run Chinook Salmon had the largest run at about 470,000 fish. This was followed by Steelhead and Sockeye Salmon. Each had total escapement of about 400,000. These three species were at 125%, 104% and 409% of the respective ten-year average returns. The count of precocious males (jacks) was about average for each of the three species. Sockeye returns were as notable in the Columbia River, as they were in the Fraser River, 300 km to the north. Columbia River spring run Chinook returned at 146% of the ten-year average in 2010. This larger than average Columbia spring Chinook run was predicted on the basis of the 2009 jack total that was 385% of the ten-year average. Recreational salmonid fishing in Oregon coastal rivers was mixed, rating fair overall. A fair to good winter steelhead recreational fishing season is underway along Oregon Rivers and is expected to improve through winter.

Shorter river systems near the northern California border are having relatively good returns of larger than average Chinook Salmon and Steelhead Trout. Thirty to 60 pound Chinook Salmon have been common at the Rowdy Creek Hatchery off the Smith River.

**Highly Migratory Species (HMS):**

***Source: Pacific Council News www.pcouncil.org***

The International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean met in July (ISC 10) and created conservation recommendations for several species of importance to Council fisheries: (1) Pacific bluefin tuna: The rate of fishing mortality is increasing, and should be decreased to less than its 2002-2004 levels, particularly for juvenile age classes. The next assessment is planned in 2012; (2) Albacore tuna: An assessment was last conducted in 2006. Fishing mortality should not be increased; a full assessment is planned for 2011; (3) Striped marlin: The last assessment was completed in 2007. Fishing mortality should be reduced from 2001-2003 levels; (4) Swordfish: the western-central and eastern Pacific Ocean stocks are healthy and above the level required to sustain recent catches; (5) Sharks: ISC10 established a Shark Working Group to conduct stock assessments and other studies. It will first work on assessments of blue and shortfin mako sharks.

**Marine Birds:**

**Status of Seabirds on Southeast Farallon Island During the 2010 Breeding Season:**

***Source:* P.M. Warzybok and R.W. Bradley*, Jaime Jahncke, Point Reyes Bird Observatory (PRBO)***

Reproductive Performance and Population Status. Seabirds on Southeast Farallon Island (SEFI) had their greatest reproductive performance since 2004 with most species exhibiting higher productivity in 2010 relative to last season. Cassin's Auklets, Common Murres, Pigeon Guillemots, Rhinoceros Auklets, Tufted Puffins and Pelagic Cormorants all had exceptionally high productivity (Figure 21). Brandt's Cormorants had low productivity but increased over the previous two seasons and Ashy Storm-petrels were equal to last year. The only species to have a decline in productivity were Western Gulls, which suffered the lowest productivity ever recorded on SEFI (Figure 21). Population size was estimated for all species except Ashy Strom-petrels and Rhinoceros Auklets and is presented in Figure 22. Breeding population sizes were higher than the 2009 estimates for all species except Cassin's Auklets. Population increases ranged from 8% for Tufted Puffin (TUPU) to 300% for Brandt's Cormorants (BRCO) when compared to last season.

Cassin's Auklets exhibited unprecedented productivity this season. The number of chicks fledged per breeding pair was more than double the long-term mean productivity and the highest ever recorded for this species anywhere within its range. This exceptionally high productivity was likely due to extremely abundant prey resources (primarily euphausiids) and a very high rate of double brooding. Auklet populations declined considerably since the early 1970's (Figure 22). The current population is now less than one-quarter of the population estimate made in 1972 and less than half the population estimated during 1989. The burrow counts for 2010 were 10% lower than in 2009, indicating a continuing downward trend for this population. Recent analyses of the trends in burrow density in our index plots indicate an overall population decline of 2.4% per year since 1991;

Reproductive success of Common Murre (COMU) was also among the highest observed for this colony. This is a sharp contrast to the 2009 season when productivity was among the lowest in the time series. There were no cases of egg or chick abandonment this season and chicks appeared to be growing quickly and fledging in good condition. Historically, the Common Murre population on the Farallones was estimated to be between 400,000 and 1 million birds, but egg collecting, oiling, gill net entanglement and human disturbance drastically reduced these numbers. However, murres have recovered substantially since the islands became a refuge and SEFI is currently the largest colony in California.

Pigeon Guillemot (PIGU) numbers have also been increasing of the last decade based on morning raft counts and were the highest ever recorded during 2010. Occupancy of monitored PIGU crevices was high in 2010 (75%) when compared to previous years suggesting a greater breeding effort in concordance with the increased population estimate. It is difficult to contrast these results with historic estimates since our methods have changed, but the current population is likely the highest it has been since PRBO began monitoring this species in the 1970’s.

Rhinoceros Auklets (RHAU) and Pigeon Guillemots also had increased breeding success. For RHAU, 2010 was the highest reproductive performance in over 20 years and third highest on record. Pigeon Guillemots had their greatest success since 2004 and many sites were able to fledge both chicks in the brood. As with all the alcids, fledging success was exceptionally high and chicks were leaving the nest site in good condition.

Brandt’s Cormorants suffered low reproductive success again in 2010, their third consecutive year of poor productivity (Figure 21). Although there was a greater breeding effort during 2010, the overall population remained low; roughly 25% of the population from 2007. It is likely that much of the apparent decline was a result of birds either skipping breeding due to unfavorable conditions or moving to a different colony. However, significant adult mortality also likely plays some role. In contrast, Pelagic Cormorants had very good productivity, the highest since 2004 and were well above the long-term mean. The 2010 estimate was roughly 20% higher than last season, though still less than half the number of birds breeding in 2004. The lack of anchovies and other larger forage fish likely caused reduced breeding effort and success for Brandt’s Cormorants. Pelagic Cormorants may have been able to exploit different prey resources, such as juvenile rockfish and sculpin, which may not have been available for Brandt’s due to differences in their foraging habits. In contrast to the Farallones and other central California colonies, Brandt’s Cormorants nesting farther north (northern California and Oregon) or south seemed to have moderate to high breeding success, suggesting that localized prey depletion may still be affecting this region.

Productivity of Western Gulls further declined during 2010 and was the lowest ever observed (Figure 21). High rates of intraspecific predation and high chick mortality coupled with low food availability likely led to the overall poor success. As mentioned above, prey may have been abundant in the area but simply not readily accessible to surface feeders.

Approximately 50% of the world population of Ashy Storm-petrels breeds on the Farallones, but little is known about their true population status. Ashy Storm-petrels are difficult to census, but appear to have been increasing at the Farallones

Tufted Puffins are surveyed during two week-long surveys, one in May during the pre-breeding and early egg laying period and a second during August when puffins are feeding chicks. Population estimates are based on the overall number of active sites observed during these surveys. 2010 had the greatest number of active nest sites ever observed for this species on the Farallones and was approximately 8% higher than during 2009.

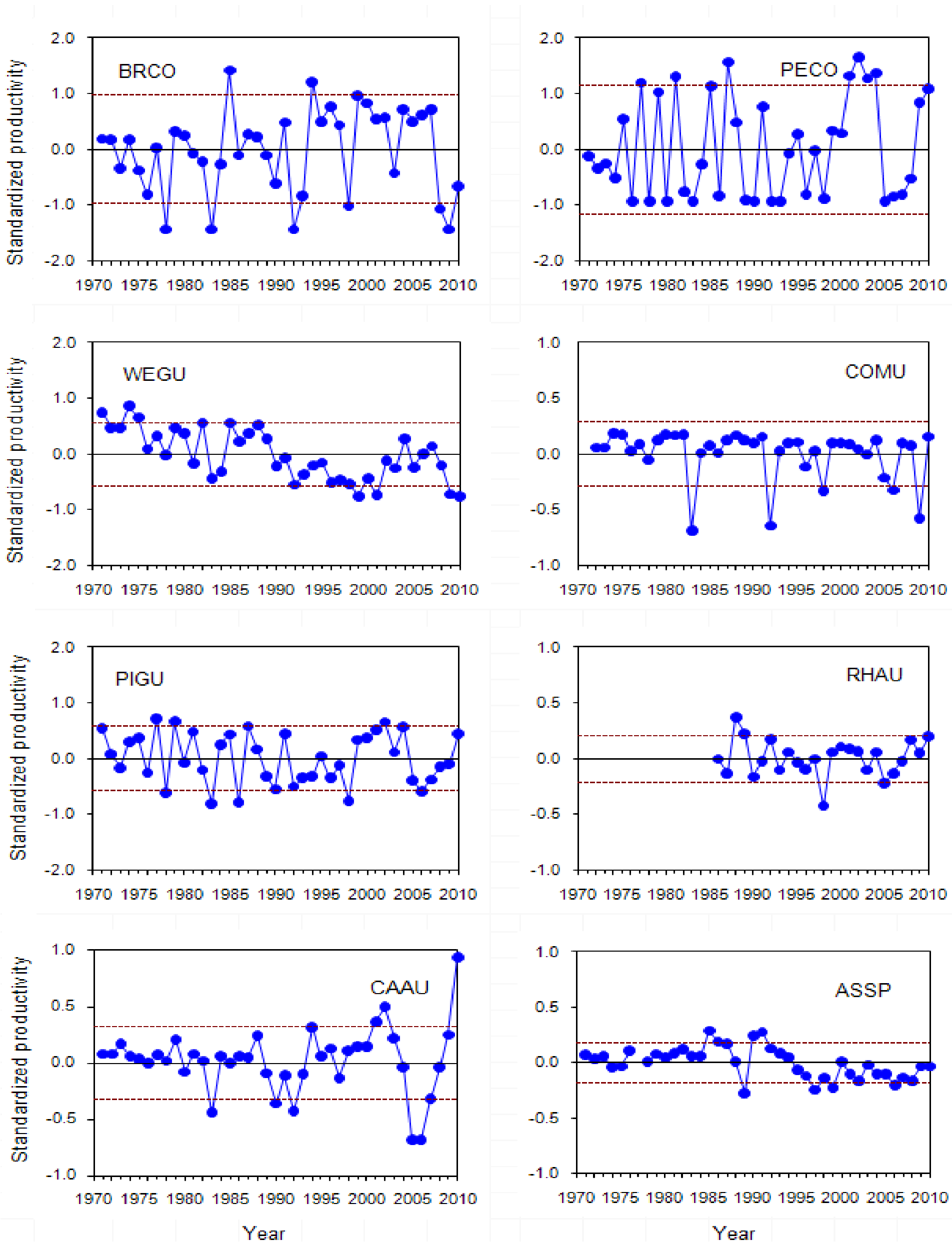



Figure 21. Standardized productivity anomalies (annual productivity – long term mean) for 8 species of seabirds on SEFI, 1971-2010. The dashed lines represent the 80% confidence interval for the long term mean.

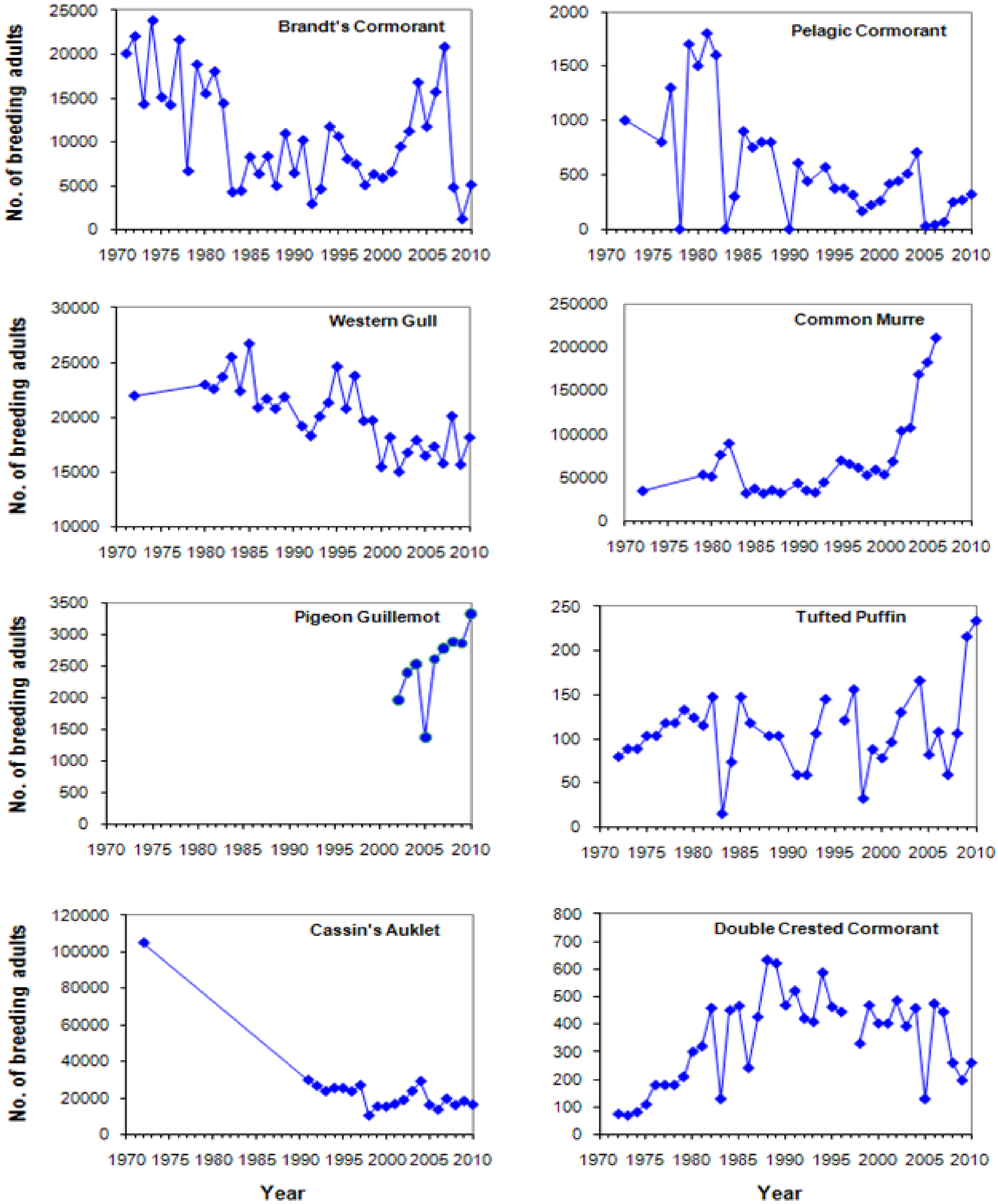



Figure 22. Population trends for 8 species of seabirds on Southeast Farallon Island, 1972-2010. Populations were determined by counting either individuals or nests on all visible areas on SEFI and West End. Please note the different scales on the Y-axis. PIGU evening raft counts done prior to 2002 are not comparable to current methods and are not displayed. COMU whole colony estimates not made after 2006.

**Marine Mammals:**
***Source: SWFSC, Gray Whale Studies***
**http://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=211&id=9036**
***El Niño Watch, Advisory, Biological Observations*** **http://coastwatch.pfel.noaa.gov/cgi-bin/elnino.cgi**

Each winter, the entire Eastern Pacific (or California) population of gray whales migrates from its primary feeding grounds in the Arctic to the lagoons and near-shore areas of Baja California, Mexico to breed, bear and nurse their young, and cavort before returning to the Arctic. Southwest Fisheries Science Center (SWFSC) monitors this migration each year, conducting shore-based surveys from two sites on the California coast. Southbound migration monitoring occurs from the Granite Canyon Marine Laboratory and northbound migration monitoring occurs from Piedras Blancas.

Counts of northbound cows and calves have revealed surprising variability in calf production for this population. Estimates of gray whale calf abundance from 1994-2006 are shown in Figure 23. It appears that the number of calves born each year is related to environmental conditions in the Arctic that limit prey populations and/or the availability of prey to reproductive females. It's hypothesized that the timing of the melt of sea ice in the Arctic may control access to primary feeding grounds for newly pregnant females and thus impact the probability that existing pregnancies will be carried to term.

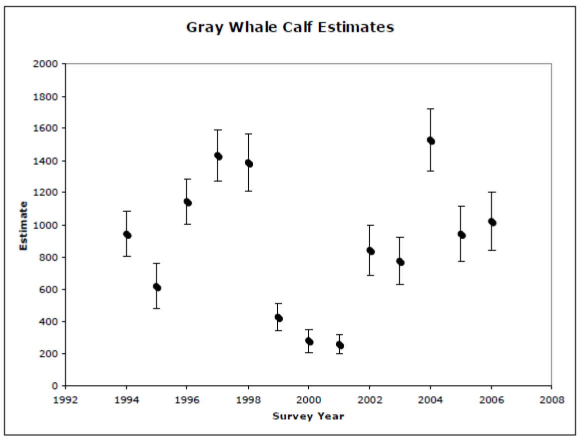



**Figure 23.** Estimates of northbound gray whale calves based on counts from the Piedras Blancas Light Station. Vertical bars around the points indicate the uncertainty in the estimate.

Female gray whales and their calves are generally observed migrating northward along the California coast in April, but coastal observers in 2010 sighted fewer whales than expected. There either appears to be a change in whales' behavior that makes them more difficult to locate or there may be fewer Gray whales than expected.

**Harmful Algal Blooms:**

This section provides a summary of two toxin-producing phytoplankton species *Pseudo-nitzschia* and *Alexandrium* activity. *Alexandrium* is the dinoflagellate that produces a toxin (saxitoxin) responsible for paralytic shellfish poisoning (PSP), and *Pseudo-nitzschia* is the diatom that produces domoic acid, the neurotoxin that causes amnesic shellfish poisoning (ASP).

**Washington HAB Summary**
***Source: Anthony Odell, University of Washington, Olympic Natural Resources Center), Stephanie Moore (NOAA, NMFS) and Vera Trainer (NOAA, NMFS)***
***Washington Department of Health*** http://ww4.doh.wa.gov/gis/mogifs/biotoxin.htm,
http://www.wdfw.wa.gov/fish/shelfish/razorclm/season.htm

Washington's Olympic Region Harmful Algal Bloom (ORHAB) partnership monitors nine sites along Washington's outer coast (Figure 24) for the presence of several harmful phytoplankton species including *Pseudo-nitzschia* spp., *Alexandrium* spp., and *Dinophysis* spp. The smaller *Pseudo-nitzschia* cell type commonly includes *P. delicatissima, P. pseudo-delicatissima, P. cuspidata, P. calliantha* and the larger cell type commonly includes *P. australis, P. multiseries, P. pungens*, *P. heimii*, *P. fraudulenta*. When action levels for the 2 cell sizes are exceeded (50,000 cells/L for the larger cell type; 1,000,000 cells/L for the smaller cell type), toxin testing in seawater and shellfish is initiated.

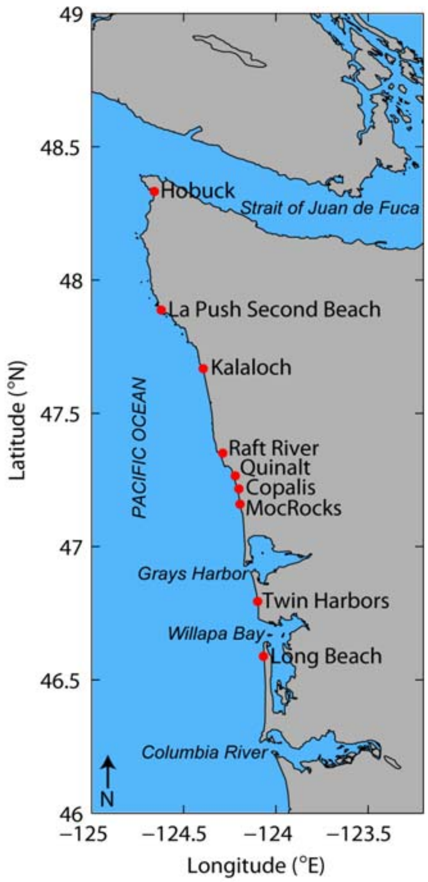



**Figure 24.** ORHAB monitoring locations on the outer coast of Washington State.

In June of 2010, PSP in shellfish reached record levels along the Washington outer coast since monitoring began in the 1950's. California mussels tested by the Washington Department of Health from Second Beach, La Push taken on June 1st were found to contain lethal doses of PSP at 3601µg/100g tissue. Very high levels of PSP in California mussels were also found at Neah Bay (1518µg/100g, 6/7), Makah Bay (1718µg/100g, on 6/7), Cape Alava (1675µg/100g, on 6/6), and Ruby Beach (731µg/100g, on 6/3). PSP exceeded the action level of 80µg/100g in razor clams at Long Beach on 1/19 at 82µg/100g. PSP was elevated, but did not exceed the closure limit at Twin Harbors (58µg/100g, on 1/26 in razor clams), Quinault Beach (79µg/100g, on 6/8 in blue mussels), and Willapa spits (78µg/100g, on 7/12 in razor clams). *Alexandrium* spp. were commonly observed in water samples from March through early November along the entire Washington outer coast and estuaries. The highest levels of *Alexandrium catenella* were found at La Push, Second beach on 6/1 at 53,000 cells/L, coinciding with the high levels of PSP in shellfish tissue on the north coast. These were the highest *Alexandrium* spp. cell counts on the outer coast since ORHAB monitoring began in 2000.

A bloom (or blooms) of *Pseudo-nitzschia* spp. occurred in June, 2010 along the outer WA coast. The bloom first occurred at the southern beaches in the first week of June and exceeded the event response action level of 50,000 cells/L of for the larger cell type. The greatest concentration was found at Long Beach at 306,000 cells/L of 89/11 large/small cell type. Very low levels (43ng/L) of particulate domoic acid were detected in sea water analyzed by ORHAB collaborators using a monoclonal antibody ELISA. DA levels in razor clams remained relatively unchanged according to WDOH. As cell counts dropped significantly along the rest of the coast, cell counts increased rapidly to 167,000 cells/L 34/66 large/small cell type at Neah Bay on 6/16. Particulate DA was not detected in sea water from Neah Bay using the monoclonal ELISA. The third bloom or third portion of the bloom occurred in the 3rd week of June spreading from Long Beach to Kalaloch. The highest cell counts were found at Long Beach on 6/21 at 235,000 cells/L of 94/6 large/small cell type. Again, very low levels (19ng/L) of particulate DA were detected in sea water and DA levels in razor clams remained relatively unchanged.

There were large blooms of *Dinophysis* spp. in 2010 along Washington's outer coast and estuaries. *Dinophysis* spp. were commonly observed in water samples from May through September. The highest counts were found at Copalis Beach at 76,000 cells/L on 8/26. These were the highest *Dinophysis* spp. cell counts on the outer coast since ORHAB monitoring began in 2000. In areas that close shellfish harvesting based on cell counts in other areas of the nation and abroad, 300-500 cells/L is generally the closure cell count limit. The most commonly observed species were *D. acuminata* and *D. fortii* (considered the most potentially toxic). Shellfish samples from the affected beaches were sent to the FDA, but have yet to be analyzed.

*Akashiwo sanguinea* and *Cochlodinium* sp. were present throughout the late spring and summer generally along the central and northern coast, but never dominant in the phytoplankton assemblage. *Attheya Armatus* was generally the dominant phytoplankton species throughout the year. *Asterionellopsis* spp. were also frequently dominant or co-dominant.

**Oregon HAB Summary**

***Source: Oregon Department of Fish and Wildlife*** http://www.dfw.state.or.us/MRP/shellfish/harmful_algae.asp

***Source: Zach Forster, Oregon Department of Fish and Wildlife***

Oregon's "Monitoring Oregon's Coastal Harmful Algae (MOCHA) project" samples ten sites along the coast of Oregon for the presence of harmful algae. These sites include three along Clatsop Beach, one on Cannon Beach, two on the central coast and four sites on the south coast (Figure 25). *Pseudo-nitzschia* (P-n) and *Alexandrium* persisted along much of the coast during the spring and summer (Fig. 26) and increases in phycotoxins in bivalve tissue resulted in two shellfish closures during the year. Other harmful algae encountered during 2010 include *Chochlodinium sp., Akashiwo sanguinea* and *Dinophysis spp.*

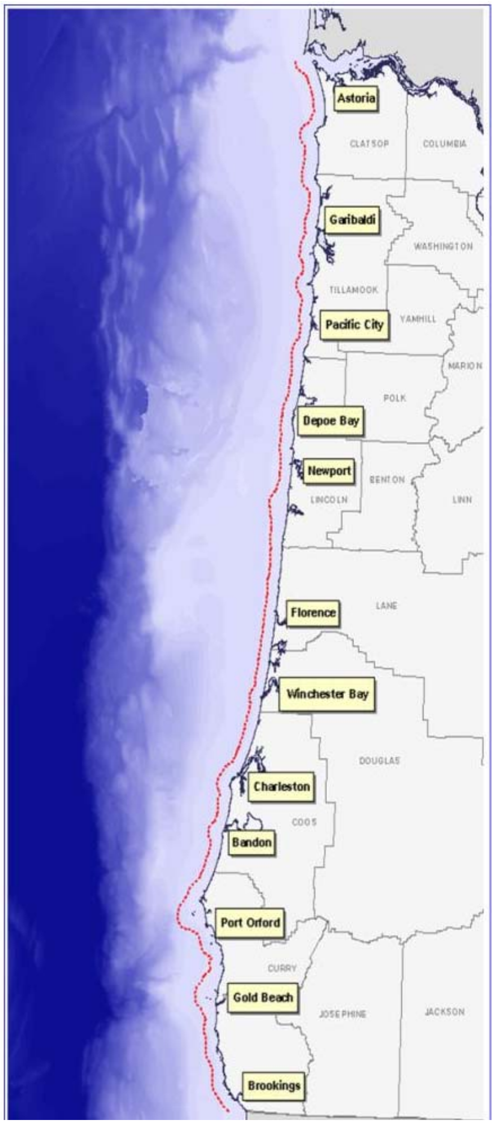



**Figure 25.** Oregon's HAB monitoring sites along the Oregon coast.

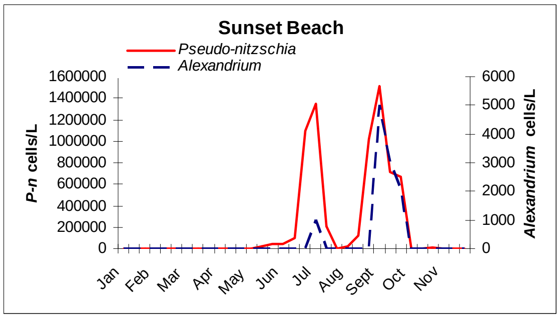
The first major bloom of P-n was detected in May along the south coast. Gold Beach was the first sample site to see an increase of P-n (320,000 cells/L) of which about 70% fit into the larger *P. aust./fraud.* sub-type. When similar increases were seen at Whiskey Run (384,000 cells/L) and Bastendorff Beach (413,000 cell/L) by late May the harvest of razor clams was closed from Bandon north to Coos Bay due to elevated levels of domoic acid (26 ppm). Cell counts remained above the alert level (50,000 cells/L) through June. A bloom of the smaller *P. deli./p-deli.* subtype was seen in late July with cell counts nearing 550,000 cells/L. Concentrations of domoic acid in razor clams decreased to 12ppm by the end of August. A third bloom of the larger type P-n was recorded in September, however no significant changes in domoic acid levels were observed.

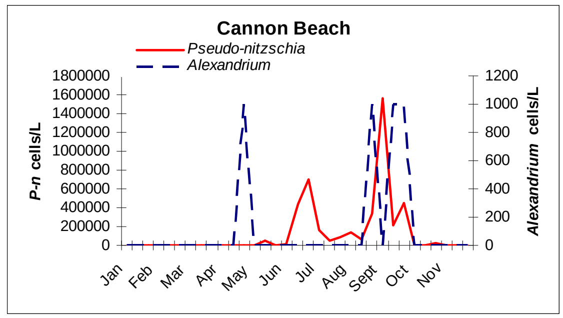
Central coast sample sites also experienced an increase of larger type P-n cells in May. Cell counts as high as 268,000 cells/L at Agate Beach and 157,000 cells/L at Tillicum Beach were a precursor to elevated domoic acid tissue toxin results (48 ppm) by late June. As a result the northern boundary of the razor clam closure was extended to include all beaches from Bandon, north to Tillamook Head. P-n cell counts remained above alert levels through much of the summer. Domoic acid levels continued to increase in razor clam tissue with a peak of 119 ppm near the end of August. By September, domoic acid levels began to decline and eventually returned below closure levels by the end of the month. Shortly after the reopening of razor clam harvest, another very large bloom of P-n hit this region of the coast. Cell counts of the larger type P-n reached 2,300,000 cells/L at Agate Beach which is the single highest recorded value since the monitoring project began in 2006. Remarkably, no observed increases in toxin levels were seen in shellfish tissue samples.

Along the northern coast there were two significant blooms of P-n that occurred during spring and summer. Cell counts during each of these events peaked at over 1,000,000 cells/L however tissue toxin testing showed only small fluctuations of domoic acid in clams and mussels.

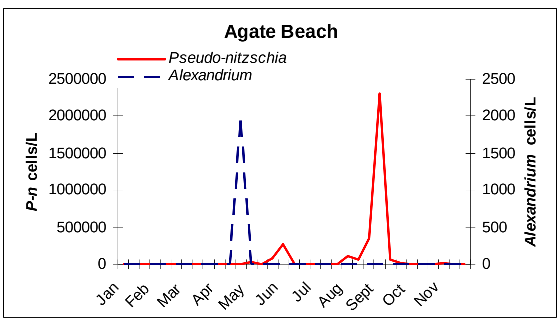
*Alexandrium* was commonly seen in low levels at most test sites throughout the spring. However, no significant increases in paralytic shellfish toxins (PST) were recorded during this time. The greatest concentration of *Alexandrium* was observed on the north coast during the latter part of August with cell counts as high as 5,000 cells/L recorded at multiple sample sites. This bloom resulted in a month long closure of all mussel harvesting from the Columbia River south to Cascade Head due to elevated levels of PST. There were no significant increases in PST levels observed in razor clams.

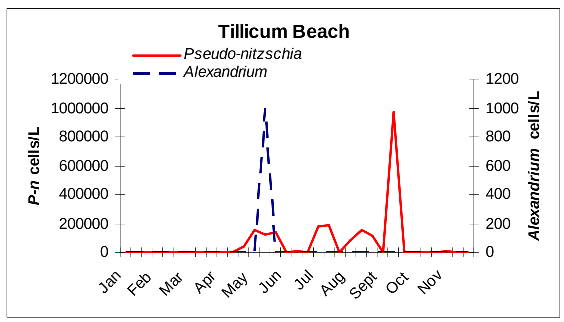
## North Coast



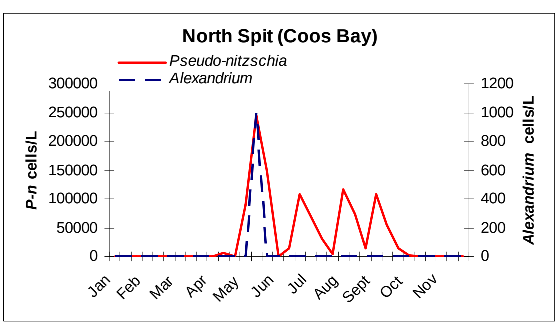




## Central Coast




## South Coast



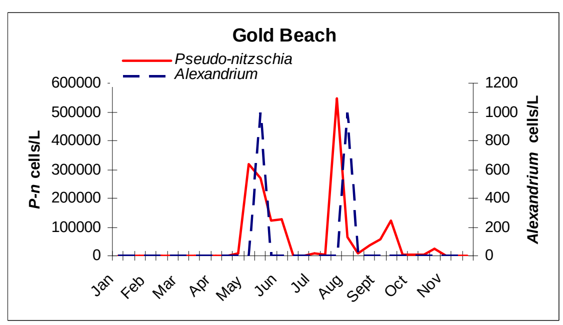




**Figure 26.** Cells per liter of *Pseudo-nitzschia* and *Alexandrium* during 2010 along the Oregon Coast.

**California HAB Summary**

***Source: Gregg W. Langlois, CA Department of Public Health***

**http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Shellfish.aspx**

Phytoplankton observations and toxin monitoring for the first quarter of 2010 showed that several sites were experiencing diatom blooms south of Pt. Conception. Most of the north coast remains in winter mode, with lots of detritus and few cells. The exception is Humboldt Bay, where in mid-March an increase in the diversity and numbers of phytoplankton (with low levels of PSP toxins detected in sentinel mussels) was observed. *Pseudo-nitzschia* had been increasing at several southern California locations, but mussel samples in Morro Bay, Santa Barbara and San Diego remain negative for domoic acid based on field-screening results. *Alexandrium* were observed at just one location (Imperial Beach Pier in southern San Diego County). Domoic acid and PSP toxins were not detected in any samples during January and February.

Phytoplankton observations and toxin monitoring during April detected *Pseudo-nitzschia* along the entire southern California coast and at most sampling locations between Sonoma and Monterey counties, as well as Del Norte and Humboldt counties, but with no indication of domoic acid toxin buildup in shellfish. *Alexandrium* was observed at San Luis Obispo, Ventura, and San Diego counties. Paralytic Shellfish Poisoning (PS) toxins were not detected in any southern California shellfish samples collected in April. Northern California mussel samples collected from Humboldt Bay and Drakes Estero indicated low concentrations of PSP.

In May, *Alexandrium* dinoflagellates were observed offshore of Marin and San Mateo counties (38°N). Low levels of *Alexandrium* produced PSP-toxins occurred inside Humboldt Bay and at Trinidad Head (41°N). *Pseudo-nitzschia* diatoms (PN) increased to bloom levels in Monterey Bay and at several Santa Barbara sites. Domoic acid was detected in shellfish in both regions, and at double health alert levels (40 ppm) in mussels from structures offshore of Santa Barbara.

In late August-early September, *Alexandrium* was observed at a greater number of sampling stations but low concentrations of the paralytic shellfish poisoning (PSP) toxins were detected in shellfish samples from offshore of Santa Barbara.

*Pseudo-nitzschia* cells were abundant inside Monterey Bay, along the San Luis Obispo coast, at one Santa Barbara site, and at one location inside Santa Monica Bay. But low concentrations of domoic acid (DA) were detected in shellfish samples from offshore of Santa Barbara. Sentinel mussels from the Santa Cruz Pier had nondetectable or very low concentrations of domoic acid. There was no clear pattern of increase despite the persistent high densities of *Pseudo-nitzschia* in this region.

Late September, Late September, *Pseudo-nitzschia* and DA values from the Santa Cruz Wharf showed particulate DA at 1935 ng/L, dissolved DA at 14.89 ug/L, a resurgence of DA at the Wharf after 3 weeks of zero values (Figure 27).

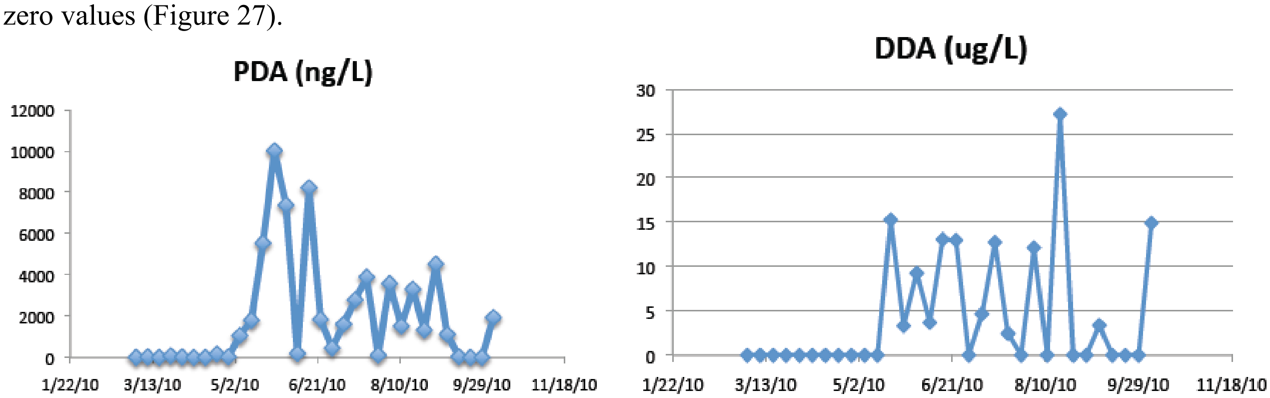



**Figure 27.** The graphs above show data for the spring-summer-fall bloom from Santa Cruz Wharf.

In October and November, low numbers of *Alexandrium* were detected at sites between San Luis Obispo and Santa Barbara counties and at one location in San Diego County. In October, low levels of PSP toxins were detected in shellfish from Santa Barbara and Ventura counties. In October and November, PSP toxins were not detected in any shellfish samples in Northern California. *Pseudo-nitzschia* was observed along the entire southern California coast during October. Domoic acid was not detected in any shellfish samples collected along the southern or northern California coast in October or November.

A new map layer of toxigenic phytoplankton distribution can be viewed at:

http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Toxmap.aspx