

## Summary of 2009 Physical and Ecological Conditions In the California Current LME

Summary of climate and ecosystem conditions for 2009 for public distribution, compiled by PaCOOS coordinator Rosa Runcie (email: [Rosa.Runcie@noaa.gov](mailto: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 2009

- **El Niño Southern Oscillation (ENSO):** The sea surface temperature (SST) in the equatorial Pacific was in a cold phase from December 2008 - March 2009, and in a warm phase from June – December 2009. The above-normal SST in the east-central Pacific strengthened significantly in October 2009, and the 3-month-running mean SST was 1°C above-normal in September-November 2009, indicating a moderate strength El Niño in 2010.
- **Pacific Decadal Oscillation (PDO):** The PDO was negative for 23 months from September 2007 through April 2009. Thereafter it became less negative and became weakly positive in August, then more strongly positive in September, before weakening in October. Negative anomalies were again widespread in the east during November. In early December negative SST anomaly continued along the coast and the region of negative SST anomaly has expanded westward into the area of formerly persistent positive SST anomaly.
- **Upwelling Index (UI):** Upwelling along the west coast of North America was mostly above-normal during the winter 2008/09 and spring 2009. Upwelling north of 36°N became weaker than normal during late spring and summer 2009. During September-November, however, upwelling was mostly above-normal. Continuous, sustained upwelling was never established; rather, upwelling was interrupted by five major relaxation events that caused downwelling at the coast.
- **Pacific SST and Heat Content (HC) Variability:** Negative SST anomalies dominated the Northeast Pacific coinciding with a negative PDO pattern during the winter 2008/2009 and spring 2009. In the summer 2009, the PDO phase returned to near-zero and the SST anomalies changed to positive values. Negative HC anomalies in the Northeast Pacific (upper 300m temperature average) also coincided with the negative PDO pattern.
- **Newport, Oregon and Trinidad Head, California Survey Line Observations for 2009:** Deep water at the Newport Hydrographic Line, OR was warmer and fresher than the most recent two “cool years” of 2007-2008. Trinidad Head Survey Line conditions on the shelf were warmer during 2009 than in 2008, both at depth and surface.
- **CalCOFI Observations for 2009:** Conditions off Southern California in 2009 appeared to follow the cool PDO pattern observed since 1999, with relatively cool conditions in the mixed layer and a shallow nitracline. These conditions, however, did not lead to higher nutrient or phytoplankton concentrations in the upper mixed layer, nor to higher zooplankton volumes.

### ECOSYSTEM CONDITIONS IN 2009

- **California Current Ecosystem Indicators:**
  1. **Copepods:** Monthly averaged values of copepod species richness, measured off Newport, OR, continue to track the negative PDO and SST anomalies closely. During 2009, moderately low species-richness values off Oregon were moderately low, indicating the continued influence of more northern water masses (and copepods); species richness was not as low as during 2008.
  2. **Juvenile Rockfish:** The annual Spring midwater trawl survey for juvenile rockfish and other pelagic nekton along Central CA showed trends of increasing abundance for fish species and assemblages that tend to prosper in cool and productive conditions, including juvenile rockfish, Pacific hake, market squid and krill.

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3. **Coastal Pelagics:**

**Pacific Sardine:** The latest sardine biomass estimate (702,204 mt) was slightly higher than estimated in the previous assessment, but the overall population trend has declined since 2000. The Pacific sardine harvest guideline (HG) established for the U.S. fishery in calendar year 2010 (72,039 mt) was 8 percent higher than the 2009 HG (66,932 mt).

**Pacific Mackerel:** The Pacific Fisheries Management Council (PFMC, "Council") recommended an acceptable biological catch (ABC) of 55,408 mt and a HG for the Pacific mackerel directed fishery of 40,000 mt for the fishery season from July 1, 2009 through June 30, 2010.

**Market Squid:** The 2009-2010 market squid season began in April; as of January 12, 2010 the commercial fishery has landed about 68,000 mt, which is greater than 3X higher than the 17,838 mt landed in 2008-09.

**Jumbo Squid:** In 2009, few squid were observed in the Pacific Northwest through the summer, however beginning in August very large numbers appeared in commercial and recreational fisheries, as well as in various resource surveys and beach strandings. Jumbo squid were frequently encountered in shallow and nearshore waters in Fall 2009, including major incursions into the Strait of Juan de Fuca in September and Port Hardy harbor (Vancouver Island, British Columbia) in October. An early December beach stranding near Seaside, Oregon, indicated that some squid remained in the Pacific Northwest through nearly the end of 2009. From November through December of 2009, squid were more abundant off of northern and central California than further north, consistent with the proposed general southward migration during winter.

4. **Salmon:** In 2009, good returns of coho were reported in the Columbia, Umpqua and Trinity Rivers. At the Bonneville fish way, 270 km from the mouth of the Columbia River, the coho counts were twice the 10-year average. However, coho returns at Gold Ray Dam on the Rogue River in southern Oregon were the lowest of the last ten years and about a third of last year's run. Chinook returns to the Klamath and Trinity Rivers in northern California and to the Columbia River have been fair to average. Many West Coast Spring Chinook runs were lower than expected, but later Chinook runs approached average levels. In general, Chinook returns to the Sacramento - San Joaquin drainage have been as low as the last two poor years, with hatcheries getting just enough to reach their propagation goals.

5. **Pacific Hake:** The Pacific hake population has been dominated by the exceptionally large 1999 year class for the last several years. Fishing mortality in 2008 was the highest on record and well in excess of the management target. Stock biomass estimates in 2009 were at the lowest level on record.

- **Highly Migratory Species (tuna, sharks, billfishes):** **Thresher Sharks:** In 2008, the Council evaluated the need to limit the sport take of common thresher sharks. Concerns were raised by the Council that the established Harvest Guidelines (HG) might be exceeded and that the majority of this catch was occurring during the spring thresher shark pupping season. The Council decided not to make changes to thresher shark regulations for the 2009-2010 management cycle.

**Tuna and Swordfish Management:** In June 2009, the Council made recommendations to the U.S. delegation to the Northern Committee, a subsidiary body of the Western and Central Pacific Fisheries Commission (WCPFC) to maintain progress in developing biological reference points for North Pacific albacore; to resolve stock structure issues for North Pacific striped marlin and, once resolved, to conduct an assessment for all stocks.

- **Marine Birds and Mammals:**

**Marine Birds:** 2009 opened with bad news regarding the west coast Brown Pelican population. The appearance of hundreds of injured and dead birds during late 2008 and into 2009 along the entire west coast indicated a major stranding event in progress. A consensus opinion supports the hypothesis that delayed migrations out of the northwest during the Fall, and the rapid onset of severe winter weather

conditions weakened and sickened many animals, resulting in a widespread stranding event as the birds attempted to migrate out of the region during inclement weather.

Other significant stranding events occurred throughout 2009: (1) Bird stranding in the central region of the U.S. west coast during April involved mostly the stranding of Brandt's cormorants. The birds appear to have been affected by high winds. (2) A major stranding of marine birds event was observed in Oregon during the Fall, and has been attributed to a surfactant-like substance produced by a bloom of the dinoflagellate, *Akashiwo sanguinea*. (3) Central California witnessed a substantial Fall bloom of species of the diatom genus *Pseudo-nitzschia*, and significant concentrations of domoic acid in coastal waters. Data on the overall impact of this event on bird strandings and deaths in the region are still being tallied.

Marine Mammals: The "Ecosystem survey of *Delphinus* sp. off the Californias" survey was completed between 7 September and 6 December, 2009. This survey was designed to further understand the distribution, abundance, stock structure, morphology, reproduction, health and ecology of short- and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*, respectively). Preliminary cetacean sightings can be found within this report. More information can be found at <http://swfsc.noaa.gov/prd-delphinus.aspx>.

- **Harmful Algal Blooms:**

Summaries are provided in this report for two toxin-producing phytoplankton species *Pseudo-nitzschia* and *Alexandrium* activity. Reports from Washington, Oregon and California showed no unusual events in the first quarter of 2009.

Washington: PSP concentrations in California mussels exceeded the regulatory limit at Second Beach La Push in mid-January and September 2009. Domoic acid concentrations in razor clams increased in early August 2009 but remained below the regulatory limit along the entire Washington's outer coast, from the mouth of the Columbia River to the Strait of Juan de Fuca.

Oregon: After the first quarter the Oregon Department of Agriculture and the Oregon Department of Fish and Wildlife announced shellfish safety closures due either to elevated levels of paralytic shellfish poisoning (PSP) or paralytic shellfish toxins (PSTs). The 2009 closures occurred in June (north and central coast), July (entire Oregon coast), September (entire Oregon Coast), October (entire Oregon coast) and December (north Oregon coast). Domoic acid results tested below the alert level along the entire Oregon Coast.

California: In 2009, at least 259 California sea lions strandings occurred in California with suspected domoic acid toxicity. Seasonally, the majority (51.3%) of the strandings occurred in September and October. Geographically, the majority (54.8%) of the strandings occurred in San Luis Obispo County. Of the strandings (76.4%) were adult females.

## PHYSICAL CONDITIONS IN 2009

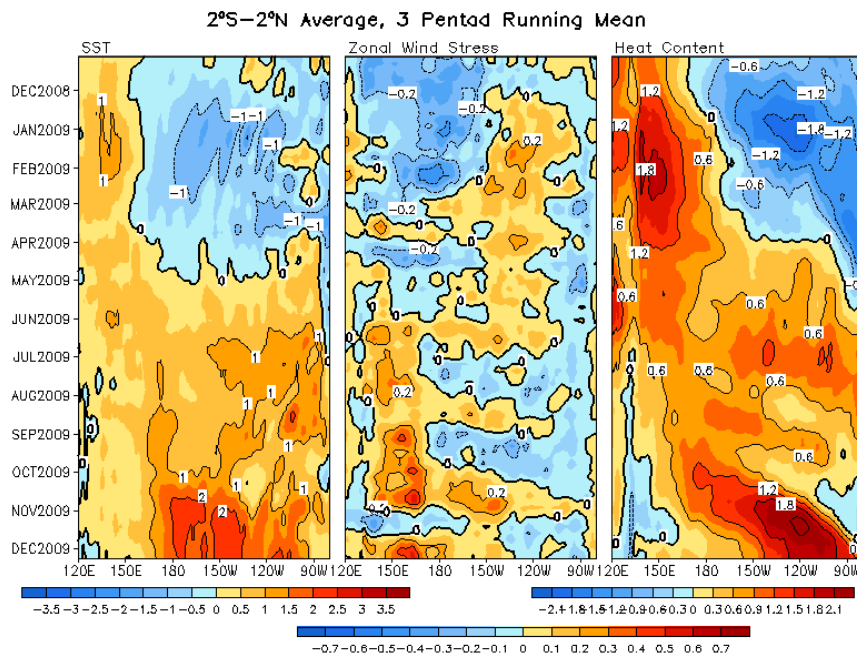
### El Niño Southern Oscillation (ENSO):

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> “Monthly Ocean Briefing” PPTs

The evolutions of the equatorial sea surface temperature (SST), zonal wind stress, and heat content (upper 300m temperature average) anomalies in 2009 are shown in Figure 1. The SST in the equatorial Pacific was in a cold phase (NINO3.4 SST < -0.5°C) from December 2008 - March 2009, and in a warm phase (NINO3.4 SST > +0.5°C) from June – December 2009. The above-normal SST in the east-central Pacific strengthened significantly in October 2009, and the 3-month-running mean NINO3.4 SST was 1°C above-normal in September–November 2009, indicating a moderate strength of El Niño. Consistent with the positive SST anomalies the positive zonal wind stress anomalies persisted in the western Pacific and positive heat content anomalies persisted across the equatorial Pacific. Intraseasonal variability dominated zonal wind stress anomalies in the central Pacific, and forced three episodes of downwelling and upwelling oceanic Kelvin waves that were evident in heat content anomalies since June 2009. Therefore, the 2009/10 El Niño developed and strengthened by a series of westerly wind burst events.



**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 (Reynolds et al. 2002), heat contents from the NCEP GODAS (Behringer and Xue 2004), and zonal wind stresses from the NCEP Reanalysis 2 (Kanamitsu et al. 2002). 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)), Jerrold Norton (NOAA,

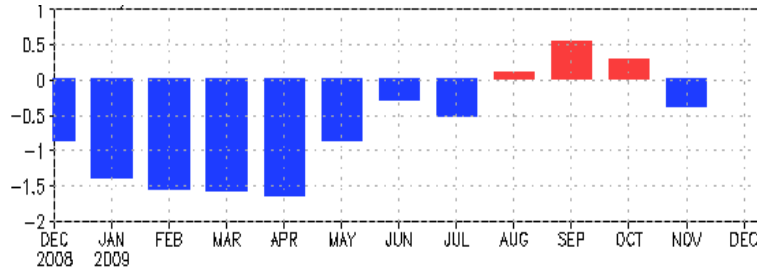
[Jerrold.G.Norton@noaa.gov](mailto:Jerrold.G.Norton@noaa.gov)) <http://jisao.washington.edu/pdo/>, and Bill Peterson (NOAA, NMFS)

<http://www.cpc.ncep.noaa.gov/products/GODAS> “Monthly Ocean Briefing” PPTs

Monthly standardized Pacific Decadal Oscillation (PDO) index downloaded from

<http://jisao.washington.edu/pdo> is shown in Figure. 2. The negative PDO phase, which lasted 23 months from September 2007 to July 2009, switched to a weak positive phase during August–October 2009

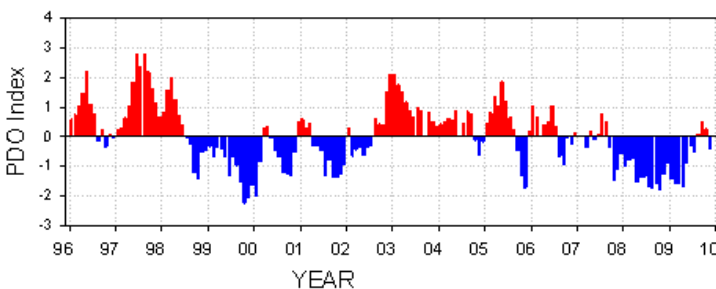
([ftp://ftp.atmos.washington.edu/mantua/pnw\\_impacts/INDICES/PDO.latest](ftp://ftp.atmos.washington.edu/mantua/pnw_impacts/INDICES/PDO.latest)). The PDO phase switched from negative to weakly positive in August, then more strongly positive in September, before in October.



**Figure 2.** Monthly standardized PDO index (bar) in 2009. The PDO index was downloaded from University of Washington at <http://jisao.washington.edu/pdo>.

It appears that the PDO is in a transitional state. Since it is a decadal index, there is no way of predicting which way it will tend from currently available monthly or annual means. Major changes in the northeast Pacific ocean ecosystems are correlated with PDO phase changes. The present transitional PDO state will likely bring a corresponding transitional or mixed state in California Current productivity and associated ecosystems. Since the PDO value is dependent on all the sea surface temperatures (SST) of the Pacific Ocean north of 20°N, it is possible for local areas to have transient SST patterns that do not follow canonical PDO patterns. The ocean 1000 km west of the continental United States was dominated by negative SST anomalies from February through May 2009, consistent with the negative PDO pattern. In June, as the negative PDO phase weakened, the SST situation changed and positive SST anomalies were most common off the coast and across the temperate northeastern Pacific to the date line ([http://coastwatch.pfel.noaa.gov/el\\_nino.html](http://coastwatch.pfel.noaa.gov/el_nino.html)). Negative anomalies were again widespread in the east during November, consistent with weakening of the possibly transient positive PDO pattern. The large offshore pool of positive SST anomaly, characteristic of PDO negative phase, persisted through October 2009, when it began to weaken. In early December negative SST anomaly has continued along the coast and these areas of negative SST anomaly have expanded westward into the area of formerly persistent positive SST anomaly (<http://www.osdpd.noaa.gov/ml/ocean/sst/anomaly.html>). Cooling of the persistent offshore warm pool may indicate change to positive PDO patterns.

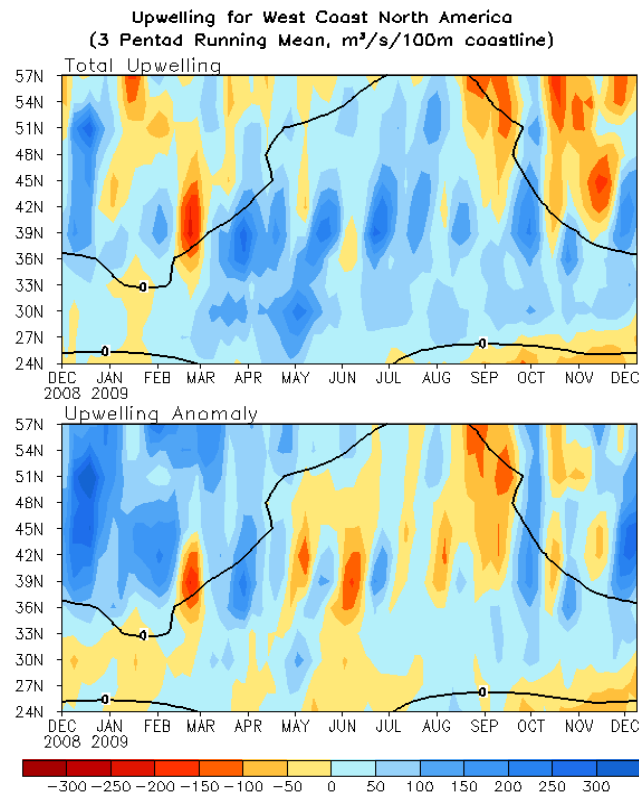
Comparing PDO behavior over the past 13 years (Figure 3), the most negative value occurred in winter 2008–2009 (Nov–Feb), the second most negative value in winter 1999–00 and the third most negative values during 2008–09.



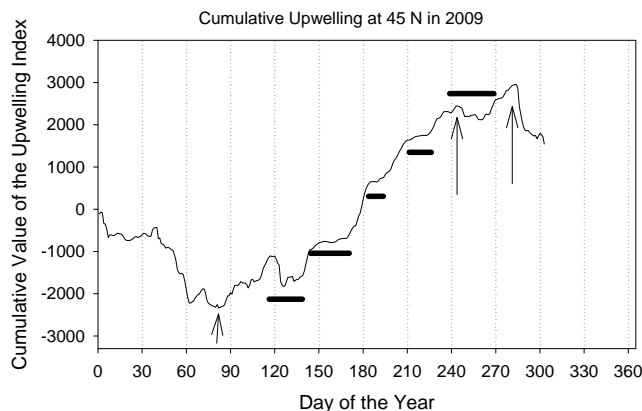
**Figure 3.** Monthly time series of the PDO at the NOAA Buoy 46050 located off Newport, OR. Note that the 2-year run of strongly negative PDO values has come to an end.

Consistent with the negative PDO phase, upwelling along the west coast of North America was mostly above-normal during the winter 2008/09 and spring 2009 (Figure 4). In 2009, upwelling was initiated early in the year (day 82; 23 March and continued into September and October). However, upwelling was never established for any lengthy periods, rather the process was interrupted by five major events when upwelling relaxed causing downwelling at the coast, as indicated by the short horizontal bars in Figure 4. The first downwelling event (early April) did not result in anomalously warm water (see Figure 2), however the other four events resulted on onshore transport of very warm water, clearly seen in the SST time series (Figure 2). These warm water “downwelling” events occurred in mid-June, mid-July, and throughout much of August, and September. When the El Niño conditions developed in the tropical Pacific in June 2009, upwelling became mostly below-normal north of 36°N during late spring and summer 2009. During September–November, however, upwelling was mostly above-normal along the west coast of North America.

Although it was easy to determine when upwelling began (23 March, day 82) the end data is more ambiguous; one could select 1 September (Figure 5) however the warm period that persisted through much of September was interrupted by a strong upwelling event that lasted for three weeks (from 19 Sep to 10 Oct). After this date, upwelling ceased. Thus 10 Oct could be selected as the end of the upwelling season.



**Figure 4.** 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/el\\_nino.cgi](http://coastwatch.pfel.noaa.gov/cgi-bin/el_nino.cgi)). (a) Total upwelling, (b) anomalous upwelling relative to the 1982-2004 climatology. Area below (above) black line indicates climatological upwelling (downwelling) season.



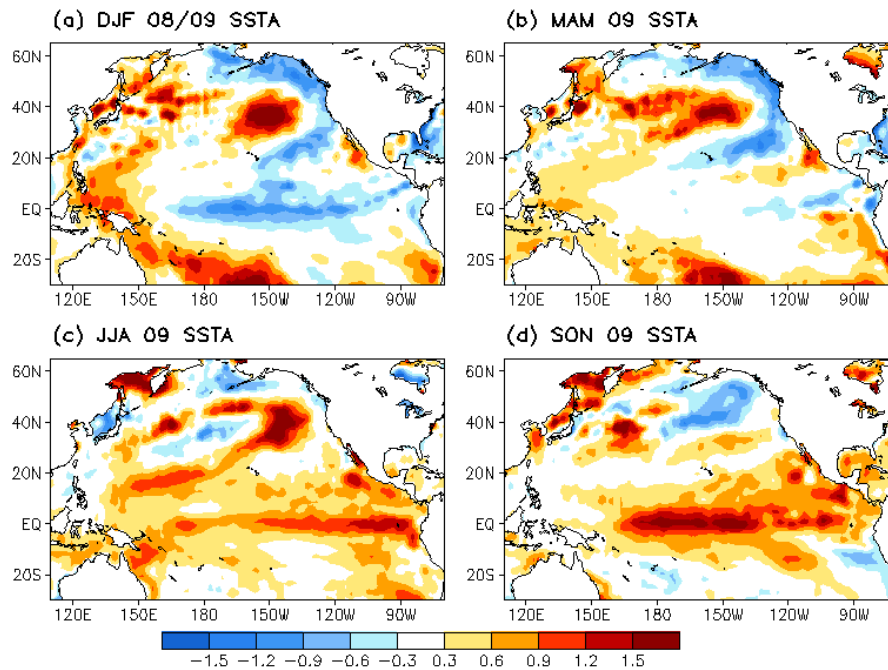
**Figure 5.** Cumulative upwelling at 45N for the year 2009 through October. Note that upwelling began on day 82 (23 March; the first vertical arrow) but the end date was not as clearly demarcated. Day 244 is 1 Sep (vertical arrow); day 283 is 10 Oct (the other vertical arrow). Upwelling was punctuated by five major periods of relaxation (compare to SST in Figure 4).

### Pacific SST Variability:

Source : Yan Xue (Climate Prediction Center, NOAA, [Yan.Xue@noaa.gov](mailto:Yan.Xue@noaa.gov)), <http://www.cpc.ncep.noaa.gov/products/GODAS/> “Annual Ocean Review” PPTs

The seasonal evolution of SST anomalies in the Pacific Ocean in 2009 is shown in Figure 6. The SST anomalies in the North Pacific were dominated by a negative PDO pattern during the winter 2008/2009 and spring 2009, characterized by a horseshoe pattern of positive SST anomalies that extended from the equatorial western Pacific to the multitudes in both hemispheres and negative SST anomalies along the western coast of North America. During summer 2009, the PDO phase returned to near-normal (Figure. 2) and the El Niño conditions developed in the tropical Pacific. During fall 2009, the El Niño conditions intensified, while the

PDO phase remained near-normal (Figure. 4).

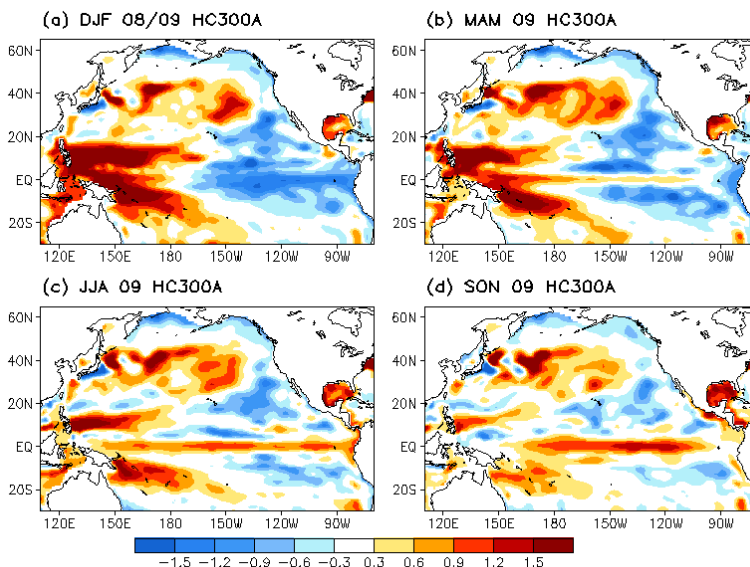


**Figure 6.** Seasonal mean SST anomalies for December 2008 to February 2009, March to May 2009, June to August 2009 and September to November 2009. SSTs are the monthly fields interpolated from the weekly 1° Optimum Interpolation (OI) analyses of Reynolds et al. (2002). All anomalies are defined as departures from the 1971-2000 climatology (Xue et al., 2003).

**Pacific Heat Content Variability:**

Source : Yan Xue (Climate Prediction Center, NOAA, [Yan.Xue@noaa.gov](mailto:Yan.Xue@noaa.gov)), <http://www.cpc.ncep.noaa.gov/products/GODAS/> “Annual Ocean Review” PPTs

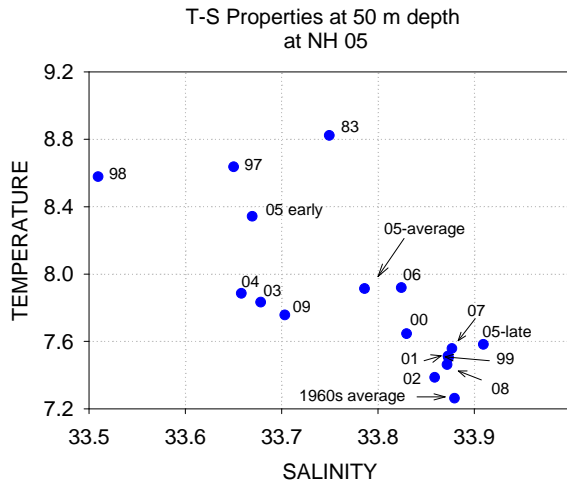
The seasonal evolution of heat content (HC) (upper 300m temperature average) anomalies in the Pacific Ocean in 2009 is shown in Figure 7. The HC anomalies in the North Pacific were dominated by a negative PDO pattern that persisted through 2009. Positive HC anomalies extended from the eastern coast of Japan to 140°W in the eastern North Pacific and negative HC anomalies occurred along the western coast of North America and south of Bering Strait. Large positive HC anomalies presented in the western tropical Pacific during the first half of 2009 and they largely dissipated in the late half of 2009 due to the developing El Niño conditions since June 2009. By fall 2009, positive HC anomalies were evident off the equatorial belt along the western coast of Central America, suggesting a propagation of coastal Kelvin waves.



**Figure 7.** Seasonal mean heat content (upper 300m temperature average) anomalies for December 2008 to February 2009, March to May 2009, June to August 2009 and September to November 2009. Heat contents are monthly fields from the NCEP GODAS (Behringer and Xue 2004).

**Newport, Oregon Temperature and Salinity Observations (Bill Peterson, NOAA, NMFS) and Trinidad Head, California Survey Line Observations for 2009 (Eric Bjorkstedt, NOAA, NMFS):**

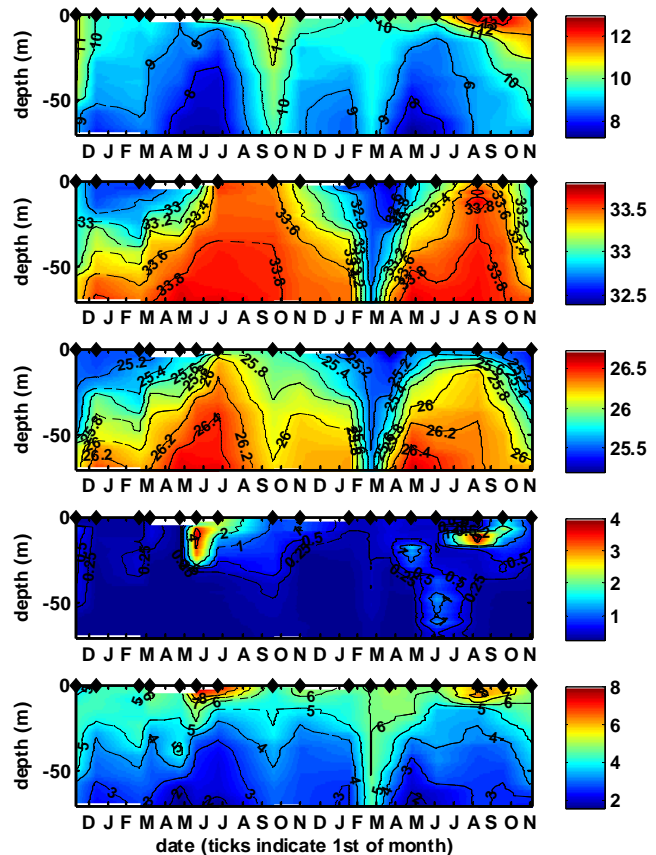
Temperature and salinity profiles are recorded every 2 weeks during the biweekly monitoring cruises off Newport, Oregon. It is clear that 2009 was quite different from the previous two “cool years” in that the deep shelf waters were cool “cool years” of 2007-2008. During the 2009 summer, deep waters were warmer and fresher than in other years (Figure 8). The presence of warm water of lower salinity is consistent with the lack weak upwelling in that it indicates that surface waters from offshore dominated the continental shelf in 2009.



**Figure 8.** T-S properties at 50 m depth averaged over May-September. This plot indicates the kind of water that will upwell if the winds are strong. It is clear that 2009 was quite different from the most recent two years in that the deep shelf waters were a bit fresher and cooler than the “cool years” of 1999-2002 and 2007-2008.

Eight observing cruises were conducted along the Trinidad Head Line in 2009. Preliminary data and analysis suggest that conditions on the shelf (e.g., station TH02 in 70 meters of water) were somewhat warmer during 2009 than in 2008, both at depth and at the surface (Figure. 9). The pattern in 2009 is influenced by observations that captured the effects of an unusual period of sustained southerly winds during late May and early June of 2009.

**Figure 9.** Observations at Station TH02 (41 3.50 N, 124 16.00 W, 75 m depth) from November 2007 through November 2009 along the Trinidad Head Line. Panels in order from top to bottom are temperature, salinity, density, estimated chl a concentration (mg/ml) based on preliminary calibrations, and dissolved oxygen. Dashed lines indicate interpolation across intervals exceeding 65 days.





## **SIO CalCOFI Annual Report**

*Source: Ralf Goericke, SIO*

The equatorial El Niño continues to affect conditions throughout the Pacific basin. Here we use San Diego sea level anomalies (SLA), which are significantly positive during strong El Niños, to ascertain the effect of the current El Niño on the region. As of October 2009, values of San Diego SLA were two standard deviations higher than average (Figure. 10 A); i.e. the equatorial El Niño is significantly affecting conditions locally.

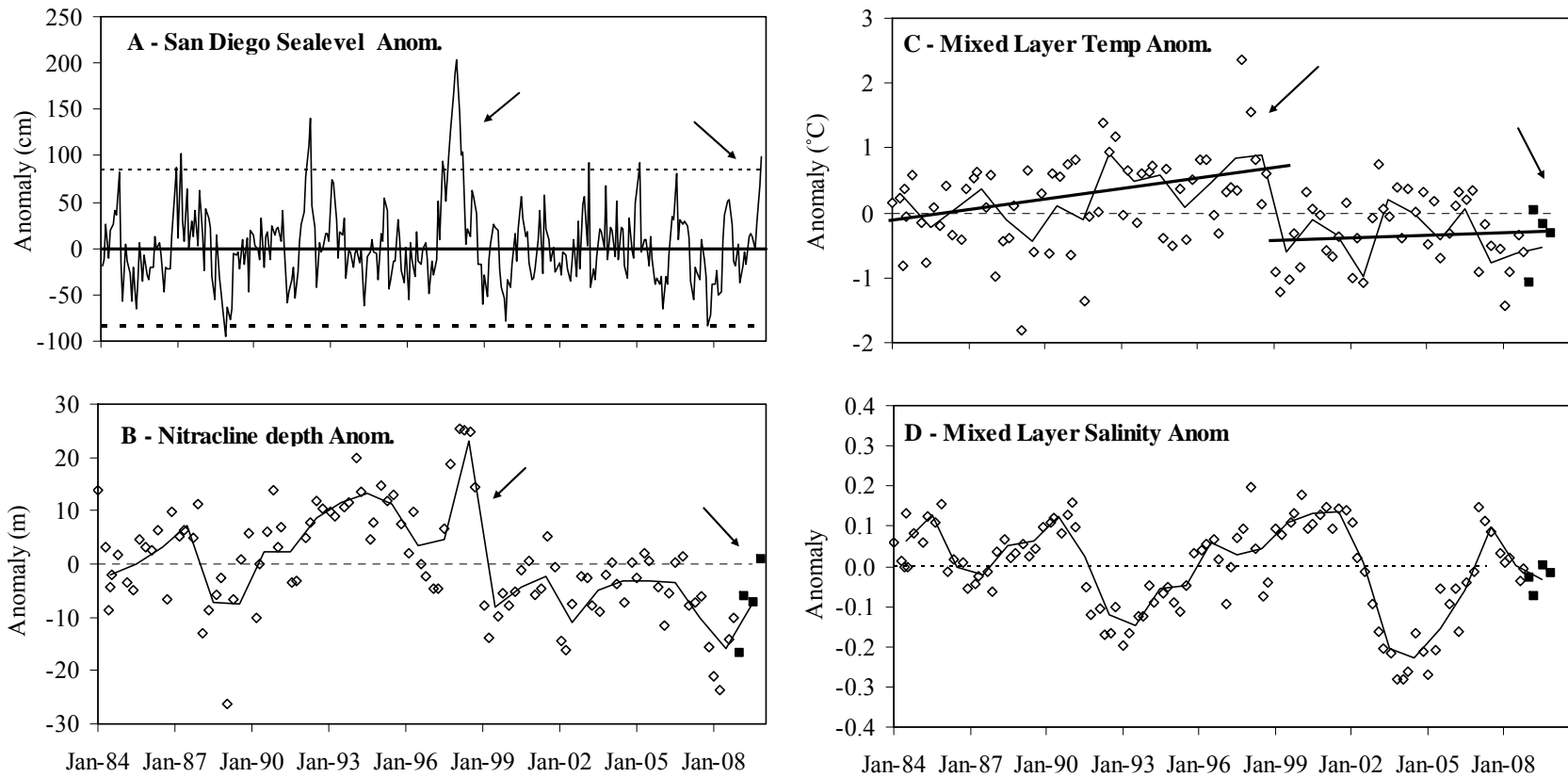
The effect of the El Niño on nitracline depth was not yet discernable by the end of 2009. During strong El Niños, nitracline depths are deeper than usual, which would result in positive nitracline depth anomalies, as was the case during the 98/99 El Niño (Figure. 10 B). Over the last year nitracline depths have returned to values similar to those observed over the last decade after the prolonged 2006 – 09 La Niña conditions when these were strongly negative (i.e. shallow nitracline depths).

Mixed layer (ML) temperatures during the second half of 2007 and the first half of 2008 were among the lowest observed since 1984 (Figure. 10 C), reflecting the basin-wide La Niña conditions. Mixed layer temperatures during 2009 were similar to those observed over the last decade (Figure. 10 C). Elevated ML temperatures, as characteristic of strong El Niños were not observed during the Nov. 2009 CalCOFI cruise. While mixed layer salinities were slightly below long-term averages (Figure. 10 D). Depictions of hydrographic conditions observed during the individual CalCOFI cruises can be found at <http://www.calcofi.net>.

Concentrations of dissolved oxygen continued to decline at depth in the Southern California Bight (data not shown). If this trend continues negative impacts on important fisheries are expected.

Except for the April 2009 cruise, standing stocks of Chl a averaged over the CalCOFI survey area were near the long-term mean, following the pattern observed in nutrient concentrations. In April, 2009, Chl a was anomalously low, likely due to a delay in the initiation of the spring bloom west and southwest of Pt. Conception.

Overall the conditions off Southern California in 2009 appeared to follow the cool PDO pattern observed since 1999, with relatively cool conditions in the mixed layer and a shallow nitracline. However, these conditions did not lead to higher nutrient or phytoplankton concentrations in the upper mixed layer, nor have they led to higher zooplankton volumes.



**Figure 10.** Time series of properties for the CalCOFI study area. In B – D averages from individual cruises are denoted with diamonds, annual averages of values are connected with solid lines. Arrows denote the times (but not necessarily the effects) of the 1998/99 and 2009/10 El Niños. **A.** Seasonally adjusted and detrended monthly San Diego sea level anomalies; shown are values of sea level, the mean value (solid horizontal line) and lines (dotted) indicating values of + and – 2 standard deviations. **B.** Nitracline depth anomalies for the CalCOFI standard grid. The nitracline is defined as the depth where concentrations of nitrate reach values of  $1\mu\text{M}$ . **C.** Mixed layer temperature anomalies; long-term trends are shown using straight lines. **D.** Mixed layer salinity anomalies.

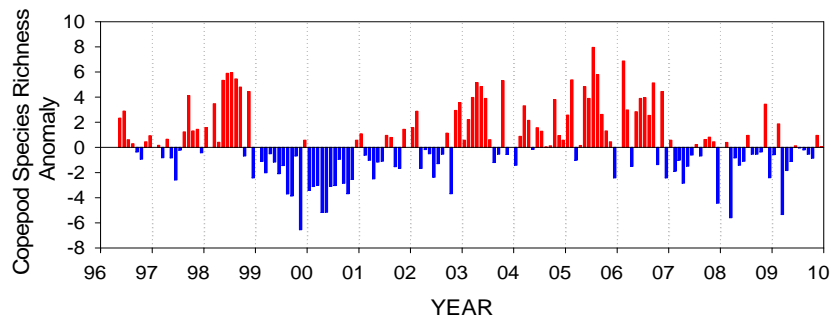
## ECOSYSTEMS

### California Current Ecosystem Indicators:

#### Copepod Biodiversity (Species Richness)

Source: *Bill Peterson, NOAA, NMFS*

Monthly averaged values of copepod species richness continue to track the PDO and SST quite closely (Figure. 3 and 11). When the PDO is negative, surface waters are cold, and the copepod community is dominated by only a few cold-water, subarctic species; however, when the PDO is positive, SSTs are warm, and the community is dominated by a greater number of warm-water, subtropical copepod species. During 2009, moderately low species-richness values were found but not as low as during 2008.



**Figure 11.** Time series of monthly averaged copepod species richness anomalies.

### Ecosystem indicators for the Central California Coast, May-June 2009:

Source: *John Field, Steve Ralston and Keith Sakuma, Fisheries Ecology Division, SWFSC*

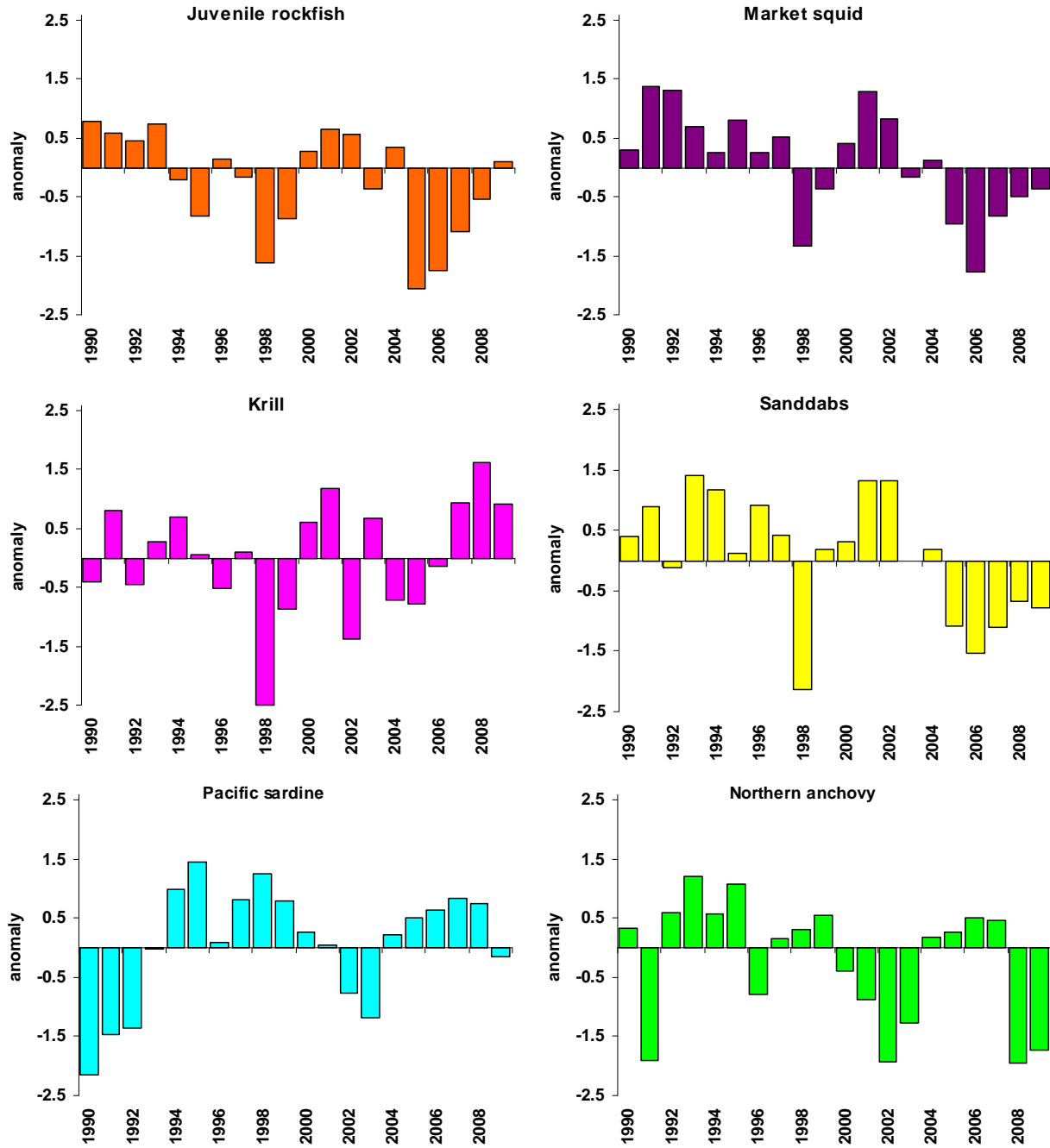
The Fisheries Ecology Division of the SWFSC has conducted an annual midwater trawl survey for juvenile rockfish and other pelagic nekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile rockfish for fisheries oceanography studies and for developing indices of year class strength for stock assessments, although many other commercially and ecologically important species are captured and enumerated as well. Results here summarize trends in the core area of the survey (Monterey to Bodega Bay) since 1990, as not all species were consistently identified in earlier years. All previous cruises took place on the NOAA ship DAVID STARR JORDAN, but in 2009 the NOAA Ship MILLER FREEMAN was utilized. The data for the 2009 survey presented here are preliminary and do not take into account possible differences in catchability between the two vessels. Additionally, this cruise has sampled a greater spatial area since 2004 (Cape Mendocino to the U.S./Mexico border); however the results presented here focus on the core survey area. Results from the expanded survey area will be developed for future reports.

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. 12). Most are considered to be well sampled, although the survey was not designed to accurately sample krill, and those numbers should be considered with caution (interpretation of acoustic data from this survey to better assess krill trends in abundance is ongoing). Trends in 2009 were of increasing abundance for the species and assemblages that tend to prosper in cool and productive conditions, including juvenile rockfish, Pacific hake, market squid and krill. However, while the trends in relative abundance for rockfish and squid have increased since record low values in the 2005-2006 period, this increase has only returned levels close to the long term mean (krill being a possible exception).

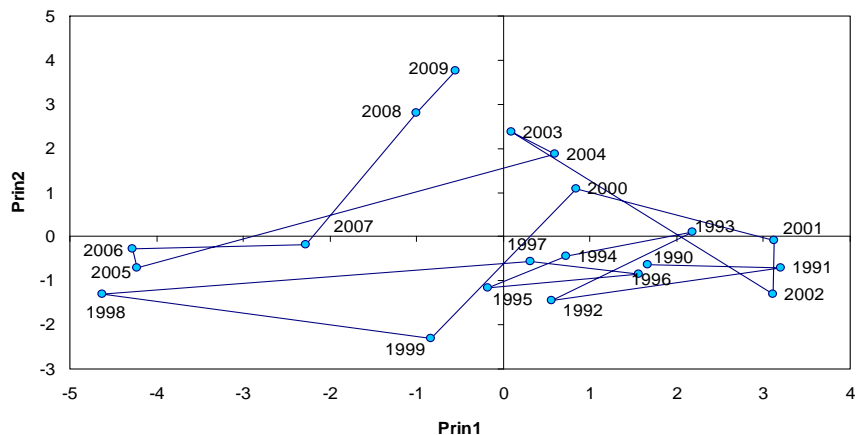
The trends observed in these six indicator species are consistent with trends across a number of other taxa within this region. When the covariances among fifteen of the most frequently encountered species are evaluated in a Principal Components Analysis (PCA), there are strong loadings for the groundfish 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 (Figure. 13) explain 39% and 14% of the variance in the data respectively (component scores and loadings were shown in the fall 2008 PaCOOS report for reference, and have changed little in the most recent analysis), and plotting the time trend of the two

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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 and the cool-phase between 1999 and 2003. As with the 2008 data, results from this year continue to represent a return to approximately long term mean conditions.



**Figure 12.** 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 are based on the entire 1983-2009 period for all groups except krill).



**Figure 13.** Principal component scores plotted in a phase graph for the most frequently encountered species sampled in the central California core area in the 1990-2009 period.

### Coastal Pelagics:

#### **Jumbo squid in the California current through 2009**

*Source: John Field (NOAA, SWFSC), William Gilly and Julia Stewart (Hopkins Marine Station, Stanford University)*

Prior to the 1997/98 El Niño the jumbo squid (*Dosidicus gigas*) was an infrequent visitor to the U.S. waters of the California Current System (CCS), yet since 2003 this species has been regularly encountered in large numbers throughout the CCS in both the U.S. and Canada, and as far north as Southeast Alaska. Although mature adults from both sexes have been encountered throughout this period and demonstrated to have viable gametes, zooplankton collections (CalCOFI quarterly cruises, among others) have provided no evidence that squid are spawning in the U.S. waters of the CCS (William Watson, SWFSC, pers. com). Similar collections from Eastern Tropical Pacific (ETP) waters clearly demonstrate spawning (Danna Staaf, pers. com). Based on a qualitative interpretation of trends in catch rates, length frequencies and maturity data, jumbo squid appear to move north or northeast from southern waters along central California during late spring and early summer, showing up in surveys and commercial fisheries off Oregon, Washington and British Columbia during the late summer and early fall. They are observed again off of California during late fall and early winter, presumably as they travel to waters of Baja California to spawn. However, precise confirmation of these movement patterns is lacking, and the distribution and timing vary from year to year, and region to region.

Patterns in 2009 were consistent with those in previous years, with squid encountered in both trawl and ROV surveys off of central California in modest numbers in spring and summer. Few squid were observed in the Pacific Northwest through the summer, however very large numbers of squid were observed in this region beginning in August in both commercial and recreational fisheries, as well as various resource surveys and beach strandings. Strandings have continued through the fall of 2009. A significant number of media reports and accounts of such strandings were widely circulated as a result, including an event near Uclelet, Vancouver Island in which a stranded squid was observed being carried off by a black bear (<http://www.westcoaster.ca/modules/AMS/article.php?storyid=7266>). During the Fall of 2009 squid were frequently encountered in shallow (inshore of the continental shelf break) and occasionally nearshore waters, including major incursions into the Strait of Juan de Fuca in September and Port Hardy harbor (Vancouver Island, British Columbia) in October. Early December a stranding near Seaside, Oregon, indicated that at least some squid have remained in the Pacific northwest through nearly the end of 2009 (<http://www.kgw.com/news/Squid-start-washing-ashore-near-Seaside-79021792.html>). From November through December of 2009, squid were again abundant off of northern and central California, consistent with the proposed general southward migration during winter.

Several hundred squid were collected from throughout the range discussed above for demographic, food habits and genetic studies. Additionally, two dozen squid were tagged with acoustic transmitters off Westport, Washington in September 2009 as part an exploratory effort by Hopkins Marine Station, NOAA Fisheries, Washington Dept. Fish and Wildlife and the Pacific Ocean Shelf Tracking (POST) Project. This pilot study assessed the species' suitability for acoustic tagging, and to determine the value of on-shelf tracking capability. Another seven squid were tagged with pop-up satellite tags off of central California as part of an ongoing effort by Hopkins Marine Station and NOAA Fisheries (supported by California Sea Grant

and the California Ocean Protection Council). Most of these tags have since reported back or have been recovered, including one tag that first reported approximately 80 miles offshore of Ensenada, Mexico 17 days after being released near Monterey Bay, California. These tagging studies will help researchers explore not only long distance movement patterns but also dynamic vertical movements, particularly in conjunction with the midwater oxygen minimum zone (OMZ). The apparent expansion of this oceanographic feature (OMZ) throughout the CCS, and more widely across the ETP, has been suggested to be an important factor behind the ongoing range expansion.

### **Salmon:**

*Source: Jerrold Norton, NOAA (Jerrold.G.Norton@noaa.gov)*

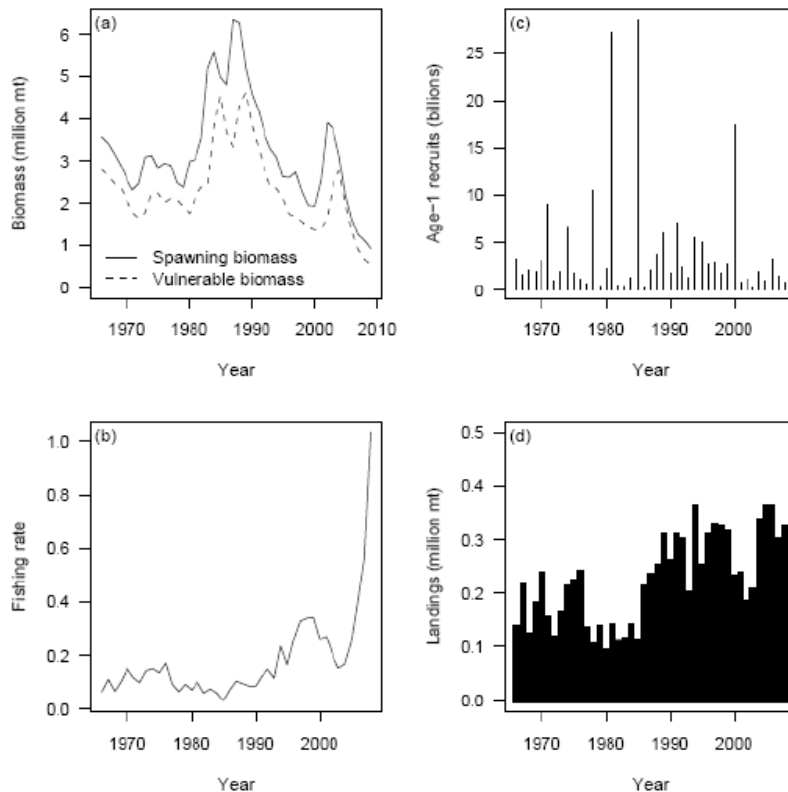
Generalities about salmonid stocks on the west coast of the continental United States are difficult because each species in each river has different adaptations and all stocks face variable natural and anthropogenic survival obstacles at several life-history stages. On the positive side, several habitat enhancement efforts were successful in 2009, restoring presently small populations of anadromous trout (mainly steelhead) and salmon.

Good returns of coho were reported in the Columbia, Umpqua and Trinity Rivers. At the Willamette Falls fish passage-way, 42 km upstream from the Willamette River's confluence with the Columbia River, the total passage of Coho has been the best of the last eight years. At the Bonneville fish way, 270 km from the mouth of the Columbia River, the Coho counts were twice the 10-year average. However, Coho returns at Gold Ray Dam on the Rogue River in Oregon were the lowest of the last ten years and about a third of last year's run. Chinook returns to the Klamath and Trinity Rivers in northern California and to the Columbia River have been fair to average. Many West Coast Spring Chinook runs were lower than expected, but later Chinook runs approached average levels. In general, Chinook returns to the Sacramento - San Joaquin drainage have been as low as the last two poor years, with hatcheries getting just enough to reach their propagation goals. At Butte Creek, off the upper Sacramento River, fall Chinook returns are reported to be less than 70% of 2008. Good steelhead runs were reported in several California and Oregon Rivers. Counted Steelhead returns to the Columbia River have been twice the 10-year average, including over 171,000 non-hatchery steelhead. Sockeye salmon counts at the Bonneville fish way were twice the 10-year average for a second consecutive successful year.

### **Canadian Assessment of Pacific Hake in U.S. and Canadian Waters in 2009:**

*Source: Fisheries and Oceans Canada [http://www.dfo-mpo.gc.ca/CSAS/Csas/Publications/ScRS/2009/2009\\_002\\_E.pdf](http://www.dfo-mpo.gc.ca/CSAS/Csas/Publications/ScRS/2009/2009_002_E.pdf)*

Estimates of the vulnerable Pacific hake biomass, spawning stock biomass, fishing mortality rates, age-1 recruits at the posterior mode and historical landings are summarized in Figure 14. During the late 1960s and 1970s, annual landings averaged 169,000 t and the corresponding fishing mortalities were less than 0.18 per year. During the 1980s catches increased from 90,000 t to just over 300,000 tons and the fishing mortality rates during this period averaged less than 0.11 per year. Two exceptionally strong cohorts (1980, 1984) were responsible for a large increase in the vulnerable biomass during this time period. The vulnerable biomass peaked in the mid 1980s and declined steadily to a low of 1.35 million tons in 2000. During this time period, there were no significant recruitment events, annual landings increased from 110,000 tons in 1985 to nearly 312,000 tons in 1999, and the fishing mortality rate increased to 0.34. The 1999 year class was also exceptional in numbers, as a result the vulnerable biomass more than doubled from 1.35 million tons in 2000 to 2.75 million tons in 2004. Catches declined as this year class recruited to the fishery, resulting a reduction in fishing mortality to 0.15 in 2003. Catches increase again, reaching 360,000 t in 2005 and 2006, causing another sharp increase in fishing mortality. The 1999 year class passed through the fishery and has not been replaced with another exceptional year class. Vulnerable and spawning biomass reached their historical minima following the 2008 fishery, and fishing mortality continued to spike in 2008, reaching an extremely high value well in excess of the estimated F (maximum sustainable yield, nearly 3 times F).



**Figure 14.** Maximum likelihood estimates of vulnerable and spawning biomass (panel a), fishing mortality (b), age-1 recruits (c) and the observed historical landings (d) for U.S. and Canadian fisheries combined.

### Highly Migratory Species (HMS):

#### Thresher sharks:

**Source:** *Review of Selected California Fisheries for 2008: Coastal Pelagic Finfish, Market Squid, Ocean Salmon, Groundfish, California Spiny Lobster, Spot Prawn, White Seabass, Kelp Bass, Thresher Shark, Skates and Rays, Kelleys Whelk, and Sea Cucumber.* CDFG, CalCOFI & Dale Sweetnam

**Commercial Fishery:** The common thresher shark, *Alopias vulpinus*, is the most common commercially landed shark in California. Although primarily targeted using large-mesh drift gillnets (73% of total) and hook-and-line gear (6%), they are also caught incidentally with small mesh gillnets (21%) and occasionally by harpoon. Commercial landings declined 28% in 2008 to 147 t (round weight) from 204 t in 2007. Much of the commercial fishing for thresher shark occurs in the Southern California Bight, with the highest average proportion of landings over the last ten years occurring in the San Diego port complex. In 2008, however, the greatest amount of landings occurred in the Santa Barbara port complex, followed by San Diego and then Los Angeles/Orange County.

**Recreational Fishery:** California sportfishing regulations impose a two fish per day per angler limit on thresher sharks. In recent years, interest in thresher shark has increased as other sportfishing species have become more heavily regulated, and some fishing areas are closed to protect other fish species.

**Fishery Management:** In 2008, the Council evaluated the need to limit the sport take of common thresher sharks. Recreational catch had been increasing, due to the sportfishing public becoming more educated on how to target them. Concerns were raised that the HG might be exceeded and the majority of this catch was occurring during the spring thresher shark pupping season, and many of the fish caught appeared to be pregnant females. Additionally, although many thresher shark anglers practice catch and release fishing methods, a preliminary study indicated that thresher sharks caught by foul-hooking by the tail had poor survival rates when released. On further examination of the recent California Recreational Fisheries Survey (CRFS) data, estimates of recreational thresher shark catches were found not to be causing cumulative landings to exceed the HG (Figure 12). Further, an analysis of bag limits showed that few anglers caught their limit and a change in the bag limit would likely have little effect on recreational catch. The Council

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decided not to make changes to thresher shark regulations for the 2009-2010 management cycle, but did make a number of recommendations including: 1) continuing outreach to fishermen regarding best practices to increase survival of released animals, 2) improving data collection on thresher sharks (especially for private access marinas, and in commercial hook-and-line and non-HMS fisheries), 3) initiating a new stock assessment, incorporating data from Mexico, 4) better estimating the number and condition of released fish, 5) to further investigate recreational gear modifications to increase survival, and 6) to better identify thresher shark nursery areas.

#### Council makes recommendations on HMS management:

*Source: Pacific Council News (Volume 33, No. 2) [www.pcouncil.org](http://www.pcouncil.org)*

In June, the Council made recommendations to the U.S. delegation to the Northern Committee, a subsidiary body of the Western and Central Pacific Fisheries Commission (WCPFC) responsible for developing management measures for highly migratory species stocks occurring principally north of 20°N latitude. This body has identified as their responsibility the North Pacific stocks of albacore, tuna, bluefin tuna, and swordfish. The Council's recommendations were to maintain progress in developing biological reference points for North Pacific albacore; resolve stock structure issues for North Pacific striped marlin and, once resolved, conduct an assessment for all stocks; recommend the Northern Committee seek management authority for striped marlin from the WCPFC; address any conservation recommendations for North Pacific swordfish proposed by the Plenary of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean; and conduct an assessment of Northern bluefin tuna as soon as possible to resolve uncertainties in the last assessment.

*Source: Decisions of the Pacific Fishery Management Council October 31 – November 5, 2009 [www.pcouncil.org](http://www.pcouncil.org)*

The Council also provided the following guidance to the Highly Migratory Species Management Team (HMSMT): (1) to comprehensively review the list of management unit and monitored species in the HMS fishery management plan (FMP) to consider re-classification as in the fishery or ecosystem component species, (2) to conduct a vulnerability analysis on shortfin mako, common thresher, and blue shark, (3) to revise the list of alternatives for applying the international exception. The alternatives would then include applying the international exception to all HMS FMP management unit species (MUS), or applying it to all MUS except for shortfin mako and common thresher shark.

#### **Marine Bird Strandings Along the West Coast:**

*Source: David Caron (Professor, Department of Biological Sciences, USC)*

2009 opened with bad news regarding the west coast Brown Pelican population. The appearance of hundreds of injured and dead birds during late 2008 and into 2009 along the entire west coast indicated a major stranding event in progress. An initial hypothesis for the cause of the incident was domoic acid poisoning because this issue had caused sickness and mass mortality of these birds in previous years. However, only a few animals tested positive for very low concentrations of domoic acid, and symptoms and injuries sustained by the birds were more consistent with exposure and frostbite than poisoning. A consensus opinion now supports the hypothesis that delayed migrations out of the northwest during the Fall, and the rapid onset of severe winter weather conditions weakened and sickened many animals, resulting in a widespread stranding event as the birds attempted to migrate out of the region during inclement weather.

Other significant stranding events occurred throughout 2009. Bird stranding in the central region of the U.S. west coast during April involved mostly the stranding of Brandt's cormorants. The birds appear to have been affected by high winds. Additionally, a major stranding of marine birds event was observed in Oregon during the Fall, and has been attributed to a surfactant-like substance produced by a bloom of the dinoflagellate, *Akashiwo sanguinea*. This surfactant has been shown to reduce the natural waterproofing of the birds' feathers leading to exposure to cold. This event was similar to a stranding event that occurred off central California during 2007 when a large number of birds displaying similar symptoms stranded in conjunction with surfactants attributed to the growth of the dinoflagellate. Finally, Central California witnessed a substantial Fall bloom of species of the diatom genus *Pseudo-nitzschia*, and significant concentrations of



domoic acid in coastal waters. Data on the overall impact of this event on bird strandings and deaths in the region are still being tallied.

### **Marine Mammals:**

*Source: Susan Chivers, Chief Scientist for SWFSC-PRD's 2009 research cruise*

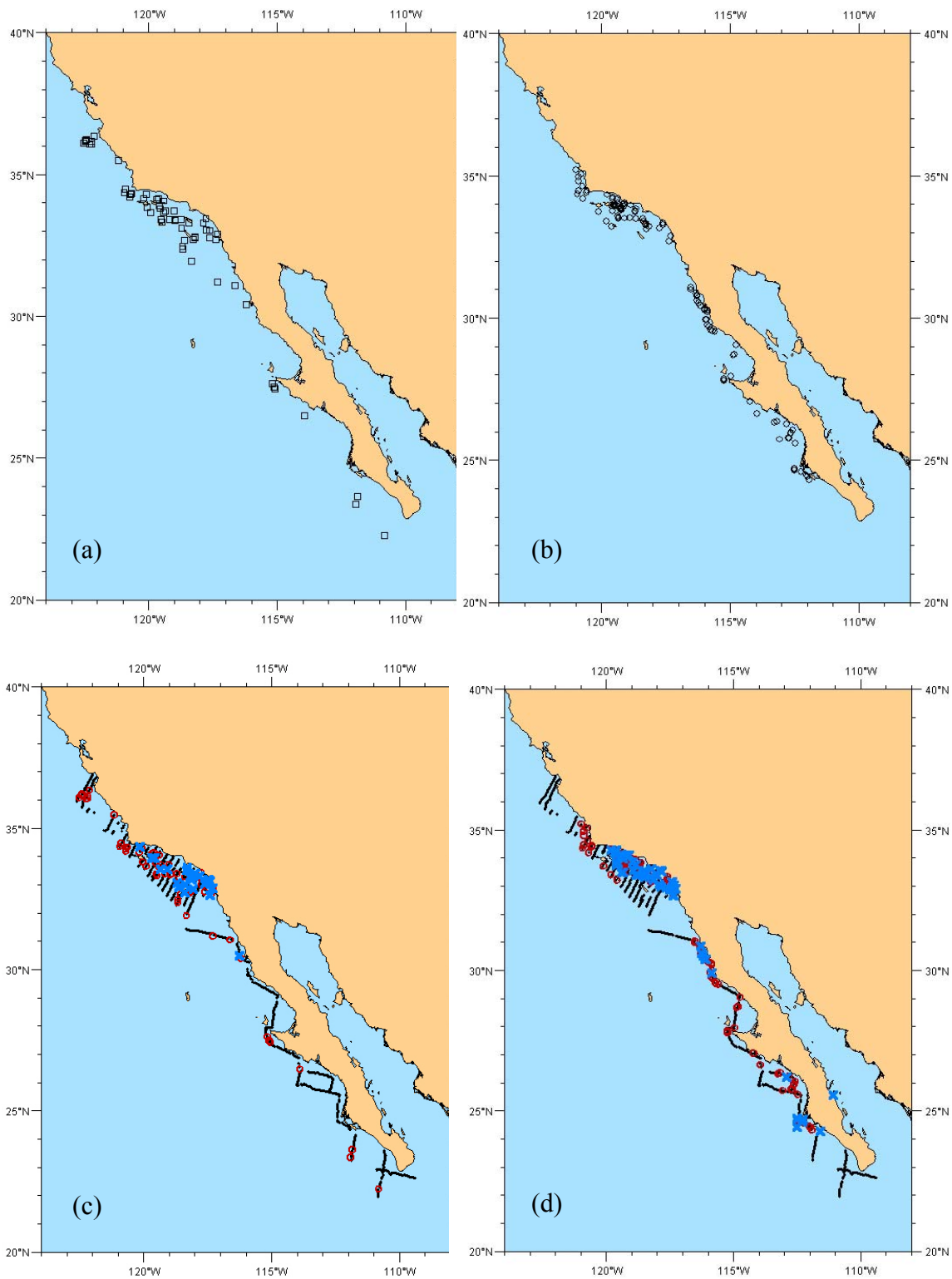
A 3-month survey of common dolphins was conducted by NOAA Fisheries Southwest Fisheries Science Center's Protected Resources Division during the Fall of 2009. This survey, "Ecosystem survey of *Delphinus* sp. off the Californias," was designed to further understand the distribution, abundance, stock structure, morphology, reproduction, health and ecology of short- and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*, respectively). Both species are important members of the California Current ecosystem, but long-beaked common dolphins inhabit coastal waters in this ecosystem making them more vulnerable to a wide range of anthropogenic impacts (e.g. commercial and recreational fisheries, habitat degradation due to pollution and ocean noise). Exposure to these potential threats together with widely variable abundance estimates, uncertainty about transboundary stock boundaries and recent increases in stranding rates prompted this multi-disciplinary, ecosystem-based study to focus primarily on long-beaked common dolphins. A complimentary suite of data was collected simultaneously from short-beaked common dolphins to compare and contrast the ecology of these apparently closely related, sympatric species. Data collected included sightings along pre-determined tracklines, biopsy samples, photographs, and oceanographic data (Table 1). Sightings summaries are presented in Table 2. Completed line transect effort, common dolphin sightings by species and aerial photographs taken are shown in Figure 15 with oceanographic sampling stations shown in Figure 16. Results from this study will provide essential information to develop better conservation and management plans for these species, and improve our ability to meet the goals of the Marine Mammal Protection Act by providing appropriate stock units for the required annual stock assessment reports and reproductive rate estimates for both common dolphin species. The survey was conducted from central California, USA to the southern tip of Baja California, Mexico in collaboration with Mexican colleagues at Investigación y Conservación de Mamíferos Marinos Instituto Nacional de Ecología (INE) and Universidad Autónoma de Baja California Sur (UABCS). Field data collections were completed between 7 September and 6 December 2009 aboard the NOAA ship McArthur II with aerial support provided by NOAA-48, a Twin Otter aircraft. More information can be found at <http://swfsc.noaa.gov/prd-delphinus.aspx>.

**Table 1.** Summary of data collected. Anticipated analyses for each data set are noted in brackets.

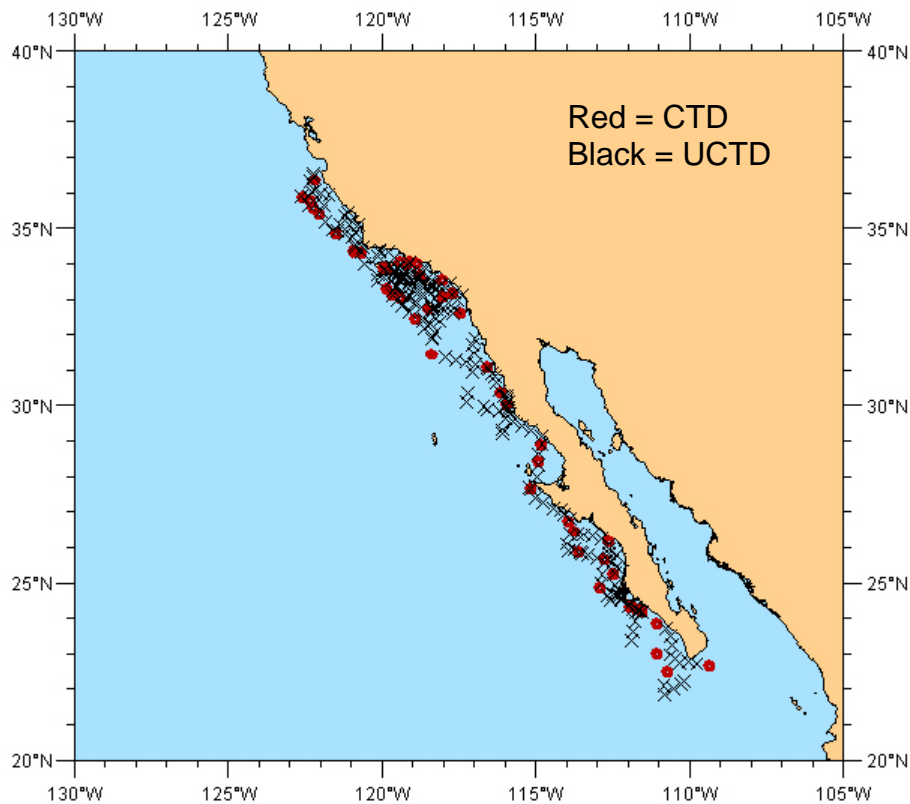
<b>Data set [Analyses]</b>	<b>Total</b>	<b><i>D.</i> <i>capensis</i></b>	<b><i>D.</i> <i>delphis</i></b>
Line transect effort [Abundance]	3.3k nmi; 911 Sightings	147	117
Biopsy [Stock ID, Pregnancy, Contaminants, Stable isotopes, Fatty acids]	1458 (13 spp.)	679	661
Photos from the ship - # of sightings [Morphology]	199	67	40
Photos from the plane - # of sightings [Morphology, Calf Production]	155	61	24
Oceanography – # of stations: CTD/UCTD or XBT/surface chlorophyll [Habitat characterization]	74/392/410		
Oceanography – # of stations: mid-tropic sampling (e.g. squid jigging, and bongo and IKMT net tows) [Habitat characterization]	64/65		
Oceanography - # of stations [Distribution and quantification of species responsible for harmful algal blooms]	289		

**Table 2.** Summary of cetacean sightings.

<b>Species</b>	<b>Number of sightings</b>
<i>Delphinus capensis</i>	147
<i>Delphinus delphis</i>	117
<i>Balaenoptera physalus</i>	74
<i>Delphinus sp.</i>	74
<i>Balaenoptera sp.</i>	55
<i>Lagenorhynchus obliquidens</i>	54
<i>Grampus griseus</i>	51
<i>Balaenoptera musculus</i>	50
<i>Tursiops truncatus</i>	38
<i>Megaptera novaeangliae</i>	36
<i>Lissodelphis borealis</i>	18
<i>Balaenoptera acutorostrata</i>	12
<i>Physeter macrocephalus</i>	12
<i>Globicephala macrorhynchus</i>	11
<i>Phocoenoides dalli</i>	10
<i>Phocoena phocoena</i>	9
<i>Stenella attenuata (offshore)</i>	8
<i>Balaenoptera borealis/edeni</i>	7
<i>Orcinus orca</i>	6
<i>Stenella longirostris orientalis</i>	6
<i>Ziphius cavirostris</i>	5
<i>Berardius bairdii</i>	4
<i>Stenella coeruleoalba</i>	3
<i>Steno bredanensis</i>	2
<i>Stenella attenuata (unid subsp.)</i>	1
<b>Sub Total</b>	<b>810</b>
<b>Unidentified categories</b>	
unid. small delphinid	49
unid. dolphin	19
unid. large whale	16
unid. medium delphinid	8
unid. cetacean	4
unid. whale	3
unid. porpoise	1
unid. ziphiid whale	1
<b>Total</b>	<b>911</b>



**Figure 15.** Visual sightings of short-beaked common dolphins (a) and long-beaked common dolphins (b) recorded in the study area. Completed survey effort (black lines) with sightings of dolphins (red) with the locations of aerial photographs taken (blue) for short-beaked common dolphins (c) and long-beaked common dolphins (d).



**Figure 16.** Location of CTD, and Underway-CTD/XBT sampling stations; see legend for key.

### 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 called paralytic shellfish poisoning (PSP), and *Pseudo-nitzschia* is the diatom that produces domoic acid.

### Washington HAB Summary

Source: Anthony Odell, University of Washington, Olympic Natural Resources Center), Stephanie Moore (NOAA, NWFSC) and Vera Trainer (NOAA, NWFSC)

Washington Department of Health <http://ww4.doh.wa.gov/gis/mogifs/biotoxin.htm>

Washington's Olympic Region Harmful Algal Bloom (ORHAB) partnership monitors nine regular sites along Washington's outer coast (Figure 17) 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. multiseriata*, *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.

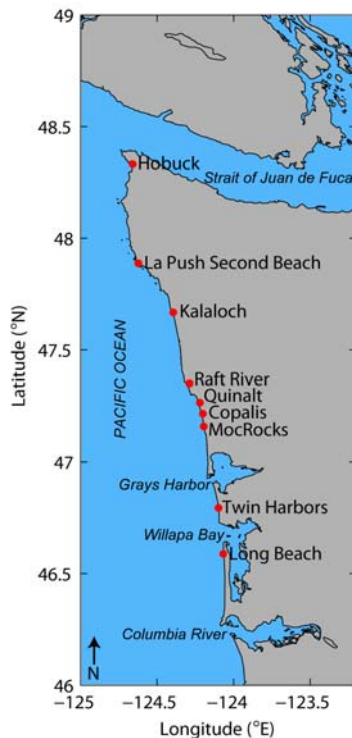
Three significant blooms of *Pseudo-nitzschia* spp. occurred in 2009 along the outer Washington coast. The first bloom occurred in April when cell abundances exceeded the event response action level of 50,000 cells/L for the larger *Pseudo-nitzschia* cell type (Figure 18). The highest cell abundances occurred at Kalaloch Beach at 108,000 cells/L and 60% of cells were the large *Pseudo-nitzschia* cell type (Figure 18). Domoic acid was not detected in water samples or shellfish. The second bloom occurred in May and spanned the entire outer Washington coast, but cell abundances did not exceed event response action levels for large or small cell types. The May bloom primarily consisted of the smaller *Pseudo-nitzschia* cell type (96% of cells at the peak of the bloom) and was denser along the south coast of Washington compared to the north. The highest cell abundances occurred at Twin Harbors at 654,000 cells/L (Figure 18). Concentrations of domoic acid in razor

clams rose very slightly from no detectable amounts to range of <1-2 ppm, but remained well below the regulatory limit of 20 ppm. The third bloom occurred in late July and early August. The highest cell abundances occurred on the central coast at MocRocks Beach at 429,000 cells/L and 78% of cells were the large *Pseudo-nitzschia* cell type (Figure 18). *Pseudo-nitzschia* spp. accounted for roughly 35% of the total phytoplankton community during this bloom. *Pseudo-nitzschia* cell abundances well exceeded the event response threshold of 50,000 cells/L for the larger cell type. Concentrations of domoic acid in razor clams increased rapidly in early August reaching 8 ppm, but had declined to background levels of  $\leq 3$  ppm by the end of November.

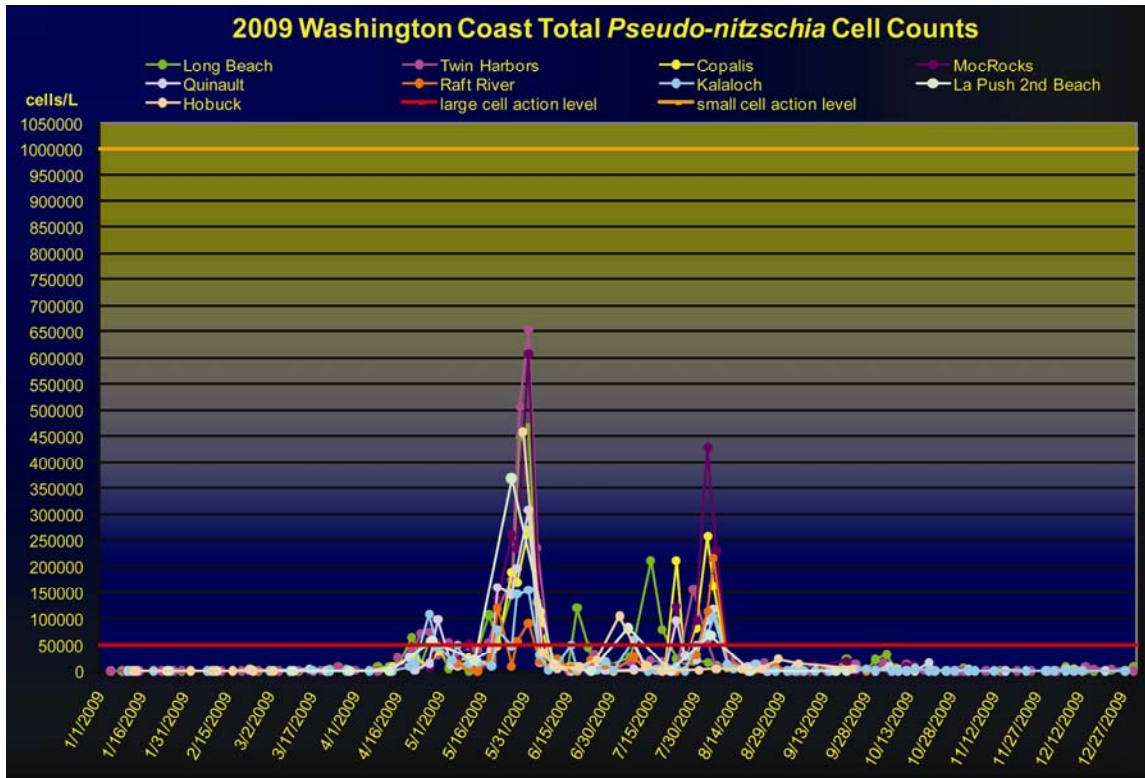
*Alexandrium* spp. were commonly observed throughout the year along the entire Washington outer coast. The highest cell abundances of *Alexandrium catenella* occurred at Kalaloch Beach at 12,000 cells/L on September 10, 2009. Concentrations of PSP in California mussels reached 205  $\mu\text{g STX-eq } 100 \text{ g}^{-1}$  shellfish meat on September 21, 2009 – more than twice the regulatory limit of 80  $\mu\text{g STX-eq } 100 \text{ g}^{-1}$ . There was also a very large bloom of *Alexandrium cf. fundyense* (based on morphological features – positive species identification is still ongoing) at Twin Harbors in early August at 304,000 cells/L. This morphotype of *Alexandrium* was dominant in the phytoplankton assemblage during the bloom.

*Dinophysis* spp. were commonly observed during the summer months and were most abundant during August and September. The highest cell abundances were 16,000 cells/L at Twin Harbors on August 6, 2009 and at Kalaloch on September 10, 2009. The most commonly observed species was *D. acuminata*.

There was a very significant bloom of *Akashiwo sanguinea* from August to November along the entire outer coast. This bloom was at least partly responsible for a large bird die off on the Washington coast and possibly affected the respiratory health of surfers. *Akashiwo sanguinea* cell abundances peaked in early September and again in mid-October. The September bloom was mainly observed along the northern and central Washington coast. The highest cell abundances were 1,553,000 cells/L at Quinalt Beach on September 10, 2009. In contrast, the October bloom was densest along the southern Washington coast and the highest cell abundances were 1,485,000 cells/L at Long Beach on October 26, 2009. *Akashiwo sanguinea* was dominant in the phytoplankton assemblage in near shore samples along the northern Washington coast and co-dominant with *Attheya armatus* in surf zone samples from the entire Washington coast.



**Figure 17:** ORHAB monitoring locations on the outer coast of Washington State for 2009.



**Figure 18:** Total *Pseudo-nitzschia* spp. cell abundances at ORHAB monitoring locations on the outer coast of Washington State for 2009. The large and small event response action levels are also shown.

### Oregon HAB Summary

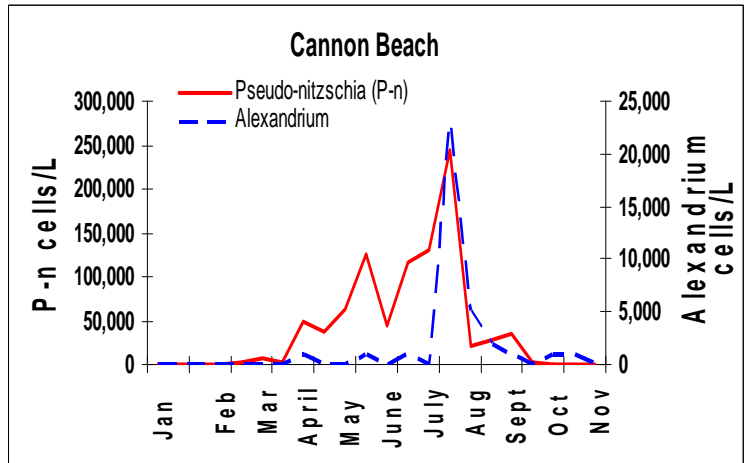
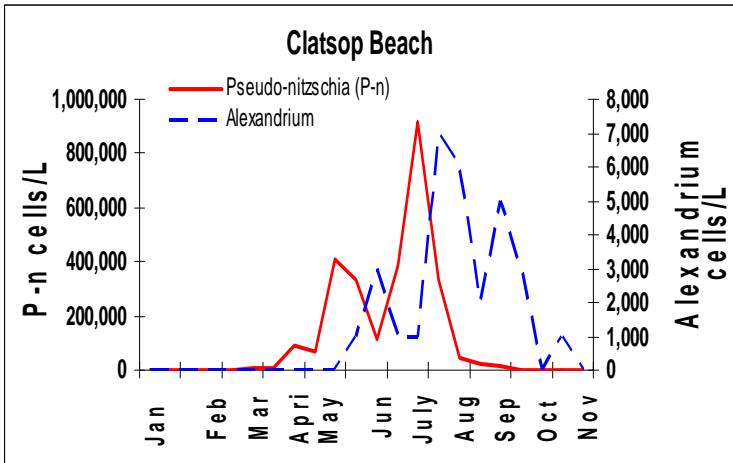
**Source: Oregon Department of Fish and Wildlife** <http://www.dfw.state.or.us/MRP/shellfish/razorclams/plankton.asp>

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

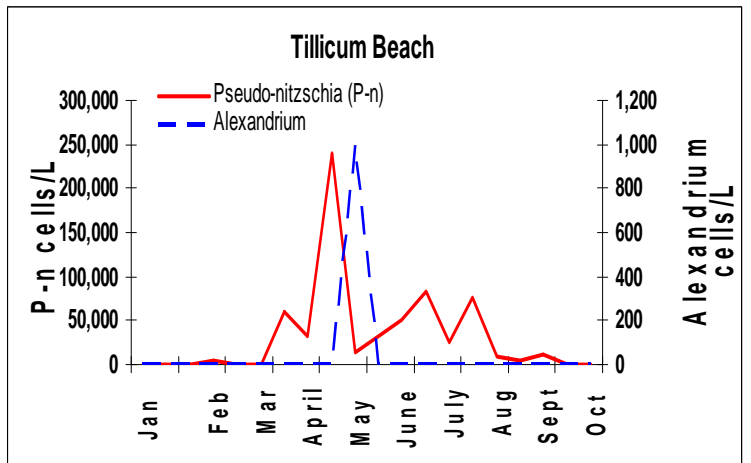
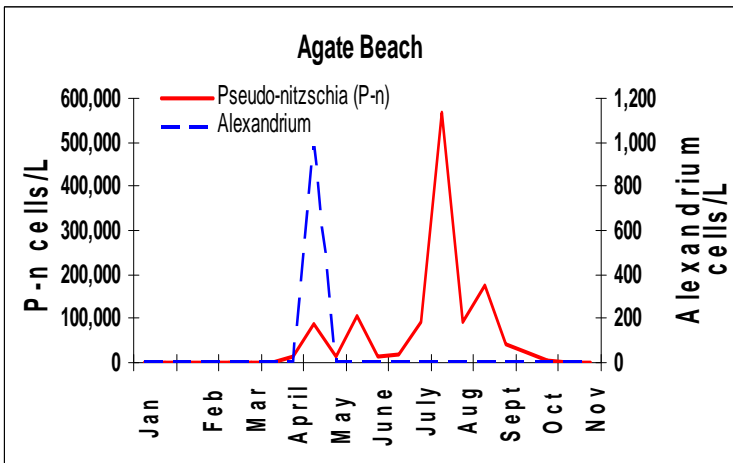
Oregon’s “Monitoring Oregon’s Coastal Harmful Algae (MOCHA) project” monitors ten sites along the coast of Oregon. These include three along Clatsop Beach, one on Cannon Beach, two on the central coast and four sites on the south coast. March sampling indicated a very abundant and diverse phytoplankton community although *Pseudo-nitzschia* and *Alexandrium* cell counts remained low through much of the spring (Figure. 19). In May there was an increase of larger *Pseudo-nitzschia* cells with the highest concentration along the north coast (411,000 cells/L). Cell counts of *Pseudo-nitzschia* continued to increase through July peaking at 915,000cell/L along Clatsop Beach. Approximately 60 % of these fit the larger P-n *aust./fraud./multi.* cell type. *Pseudo-nitzschia* counts along the central and south coast also began increasing at this time with maximum cell densities over 900,000 cells/L at Agate beach (Figure. 19). By September cell counts at all test sites had declined and remained low through the fall.

*Alexandrium* was first seen in shore-side samples in May along the central coast and by June it was present in net tow samples coast wide. As nearshore waters began to warm *Alexandrium* also became very common in 10x concentrated whole water samples. Peak *Alexandrium* counts reached 23,000 cells/L at Cannon Beach the first week of August (Figure 19). *Alexandrium* was most often encountered at Clatsop Beach however it persisted the longest at the south coast test site in Gold Beach. Other harmful algae encountered during 2009 include *Chaetoceros convolutus*, *Chochlodinium polykrikoides*, *Akashiwo sanguinea* and *Dinophysis spp.*

### North Coast



### Central Coast



### South Coast

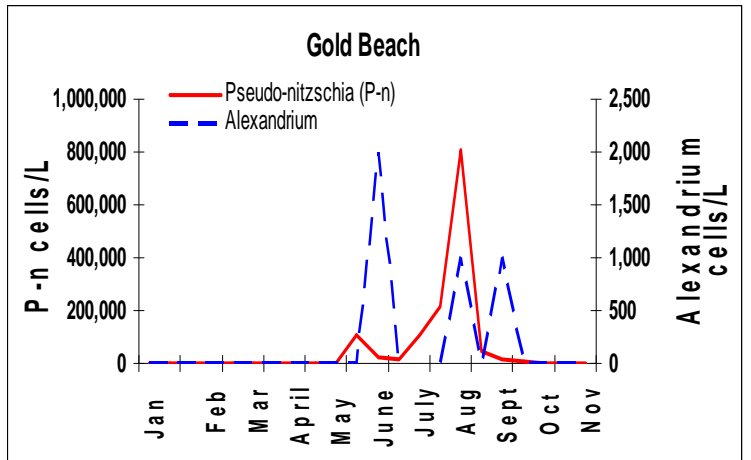
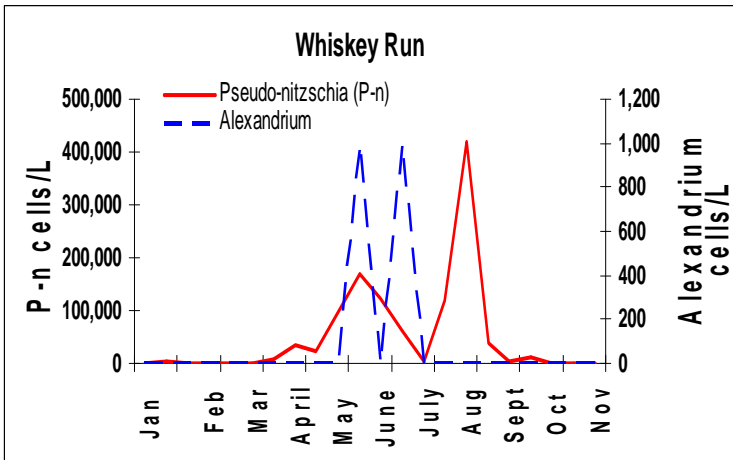


Figure 19. Cells per liter of *Pseudo-nitzschia* and *Alexandrium* during 2009 along the Oregon Coast.

## California HAB Summary

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

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

### Summary of *Alexandrium* Relative Abundance and PSP Concentrations:

#### Northern California

*Alexandrium* was either absent or present in very low numbers at a small number of sampling stations through May 2009. The distribution of *Alexandrium* increased noticeably between Bodega Bay and Monterey Bay in June. PSP toxins were detected in shellfish samples from Marin County sites for the first time in 2009. By August *Alexandrium* was observed at most locations between Del Norte and Santa Cruz counties. By the second week of August a sample from Anchor Bay (Mendocino County) was found to contain PSP toxins above the alert level of 80 ug/100 g (147 ug/100 g, August 10) (Figure. 20). By the third week of August there were alert levels of the PSP toxins at sites in Sonoma and Marin counties, persisting through the end of the month. Toxin concentrations exceeded 600 ug/100 g in sentinel mussels from Bodega Harbor and Drakes Estero, reaching a maximum of 966 ug/100 g in the mid-Estero on August 20 (Figure. 20). PSP toxicity increased from below the alert level to well above within one day (46 ug on August 18 and 432 ug on August 19, respectively). In a rare occurrence, these toxins were detected inside Tomales Bay throughout the month, exceeding the alert level by August 23. Elevated levels of the PSP toxins have not been detected inside Tomales Bay since 2002.

There was a general decline in the relative abundance of this dinoflagellate at sites in Mendocino and Sonoma counties by September. The high concentrations of PSP toxins detected in shellfish samples during the latter half of August inside Drakes Estero persisted through the first week of September, then declined. In contrast, PSP toxicity increased significantly inside Humboldt Bay and farther northward in Del Norte County in September. The highest concentration detected was 916 ug/100 g in a sentinel mussel sample from outer Humboldt Bay. In a rare occurrence, low levels of these toxins were detected in oyster samples from the North Bay area well inside Humboldt Bay. PSP toxin levels declined inside Humboldt Bay in October but remained high in samples from Del Norte County. Toxin levels began decreasing in November and fell below the alert level in Del Norte County by the end of the month.

#### Southern California

Low numbers of *Alexandrium* were observed at various sites along the southern California coast in 2009. The higher frequency of occurrence was at sites along the San Luis Obispo County coast. PSP toxicity was only detected in low concentrations in San Luis Obispo and San Diego counties. Low concentrations of the PSP toxins were detected in mussels from Agua Hedionda Lagoon (San Diego) during the first three weeks of March (Figure. 20). This is the fourth consecutive year that low to moderate levels of these toxins have been detected inside this lagoon in northern San Diego County. PSP toxins has not previously been detected in shellfish from this site since 1999.

*Alexandrium* was also observed at all sampling locations along the San Luis Obispo coast and at two locations in Santa Barbara during September. Low concentrations of the PSP toxins were detected in shellfish samples collected from inside Morro Bay through from September through the beginning of December.

### Summary of *Pseudo-nitzschia* Relative Abundance and Domoic Acid Concentrations:

#### Northern California

There was a significant increase in *Pseudo-nitzschia* at sites in Monterey Bay through the middle of May, declining but remaining common at the end of May. The highest relative abundance was observed at the Santa Cruz Pier. Domoic acid was detected at two sites in Monterey Bay. Low levels of domoic acid were detected in several mussel samples from the Santa Cruz Pier through May 22. The highest concentration detected was 9 ppm on May 13.

There was another, more dramatic increase in the relative abundance of *Pseudo-nitzschia* at sites inside Monterey Bay and offshore of San Mateo County during October. Domoic acid increased from <2.5 ppm on October 14 to 29 ppm on October 21 in sentinel mussels collected by U.C. Santa Cruz at the Santa Cruz Pier.



The concentration of this toxin declined slightly by October 28 (19 ppm) (Figure. 20). *Pseudo-nitzschia* densities oscillated through November and December at shore-based sampling stations. Domoic acid concentrations likewise varied, reaching 59 ppm in sentinel mussels at the Santa Cruz Pier on November 20.

#### *Southern California*

*Pseudo-nitzschia* was observed throughout the year at numerous sites along the southern California coast during 2009, with a significant increase in relative abundance occurring during March. The highest percent composition was observed in samples from various locations in Santa Barbara County, reaching 70% of all genera observed at Ellwood Pier by March 31. A similar pattern was observed in Ventura County, where *Pseudo-nitzschia* increased to 50% by the end of the month. Although the percent composition of this diatom was lower in samples from offshore of Palos Verdes (Los Angeles County) and did not exceed 35%, the cell density was much higher, resulting in the highest recorded relative abundance for *Pseudo-nitzschia* during March (March 5 and March 10). A moderate concentration of domoic acid (11 ppm) was detected in a mussel sample from an aquaculture lease just offshore of Santa Barbara on March 18. By March 31 the concentration of this toxin had increased to 51 ppm at this site and the area was closed to harvest.

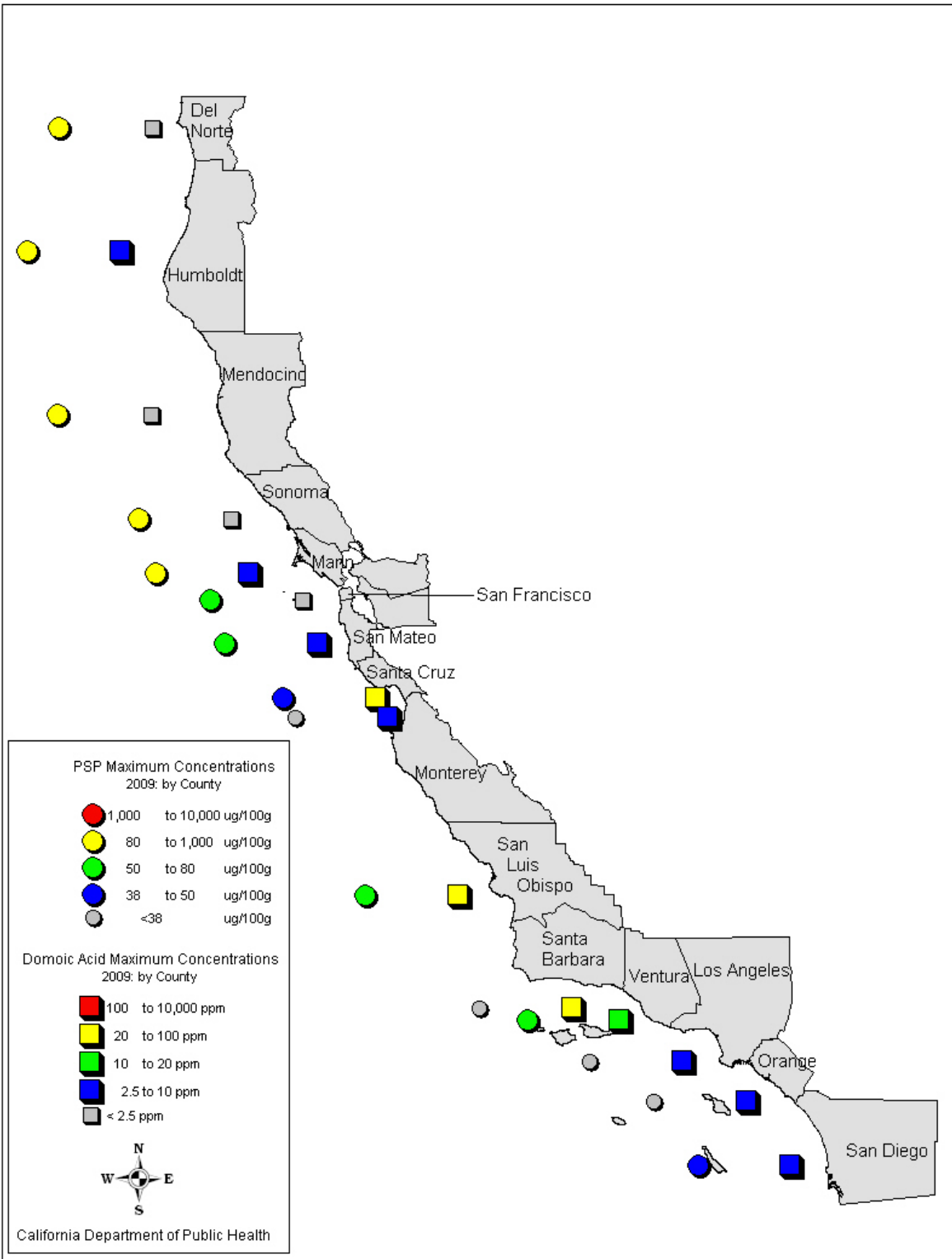
*Pseudo-nitzschia* remained abundant at sites along the coast of Santa Barbara and Ventura counties through April. *Pseudo-nitzschia* was also abundant at sites offshore of these counties and accounted for 95 percent of the species composition in a sample on the west side of Anacapa Island (April 22). The pattern of increase observed in March reversed at the beginning of April as the relative abundance of *Pseudo-nitzschia* declined at many sites but remained common. A second increase in this diatom occurred at sites in Santa Barbara and Ventura counties towards the latter part of April. Low concentrations of domoic acid (3 to 6 ppm) were detected in mussels from sampling stations in Ventura County at the beginning of April. A moderate concentration (12 ppm) of this toxin was detected in mussels from Goleta Pier on April 1 (Figure 20). By the second week of April there was no domoic acid detected in any samples along the southern California coast, consistent with the decline in overall numbers of *Pseudo-nitzschia*. During the last week of the month, as cell numbers again increased, domoic acid was detected in mussels from Goleta Pier (11 ppm on April 29) and the offshore aquaculture lease (34 ppm on April 28).

*Pseudo-nitzschia* density was reduced at sites between Santa Barbara and San Diego counties in May, although this diatom remained common between Santa Barbara and Los Angeles. Toxin levels declined at Santa Barbara sites compared to results from the end of April, reaching a maximum of 11 ppm in mussels from an offshore aquaculture lease on May 5. Domoic acid remained at low levels through May 19, when it declined and remained below the detection limit. A mussel sample from Los Angeles County contained 3 ppm of domoic acid on May 5, declining below the detection limit by May 19.

There were high relative abundances of what appeared to be the nontoxic *Pseudo-nitzschia* species in the *delicatissima* complex along the southern California coast in July and August. These distinctions are considered tentative given the difficulty in identifying species of this diatom with light microscopy. In September *Pseudo-nitzschia* disappearing from all samples south of Santa Barbara but increased at sites along the San Luis Obispo coast. There also appeared to be a shift from the nontoxic *Pseudo-nitzschia* species in the *delicatissima* complex to the toxic species in the *seriata* complex. Low levels of domoic acid were detected in shellfish samples collected from two locations in Morro Bay during September.

The high relative abundances of *Pseudo-nitzschia* observed along the San Luis Obispo coast in September continued through the first week of October. Cell numbers of *Pseudo-nitzschia* declined through the remainder of the month at most of the San Luis Obispo sites. Low levels of domoic acid were detected in shellfish samples collected from two locations in Morro Bay during the second week of the month. By October 20 the level of domoic acid reached 20 ppm in mussels from the outer bay (Figure 20). The highest domoic acid concentration detected further inside the bay was 17 ppm in sentinel mussels (October 20).

There was also an increase in domoic acid concentrations further south in Morro Bay in late November, reaching 14 ppm in sentinel mussels at an aquaculture site.



**Figure 20.** Paralytic Shellfish Poisoning (PSP) and Domoic Acid concentrations by county. Samples were collected from different sites along the coast of California from Del Norte County to San Diego County.