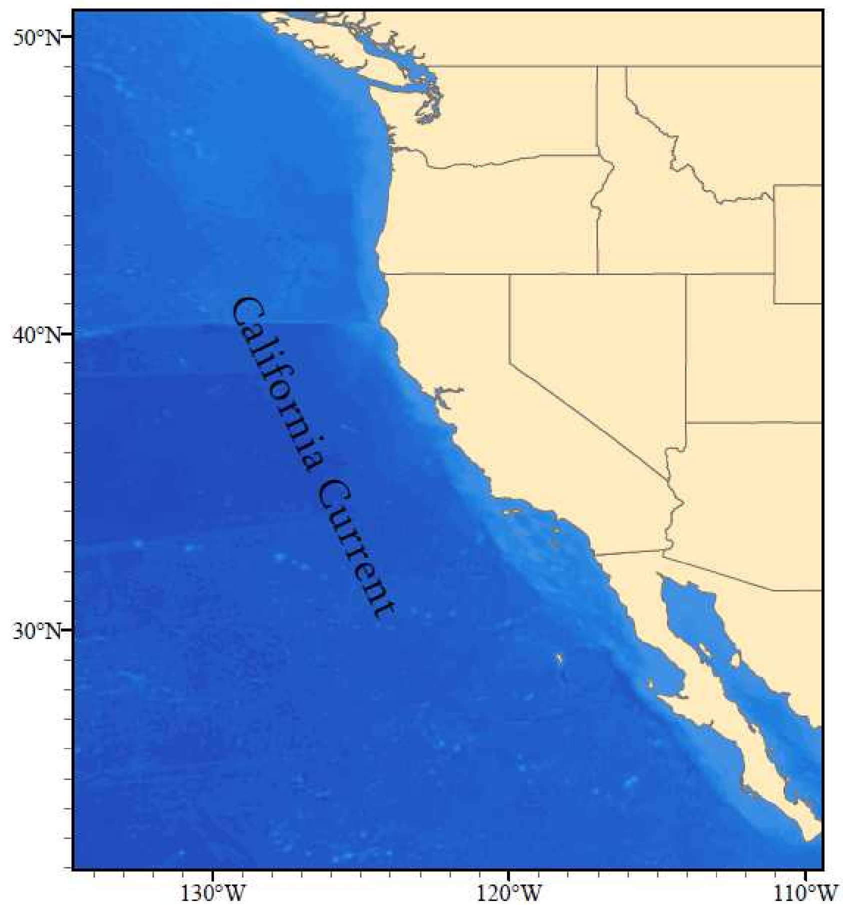
Summary of 2012 Climatic and Ecological Conditions In the California Current LME

This report is an annual summary of climate and ecosystem conditions for 2012, for public distribution, compiled by PaCOOS coordinator Rosa Runcie (email: Rosa.Runcie@noaa.gov).
Full content can be found after the Executive Summary. Previous summaries of climate and ecosystem conditions in the California Current can be found at http://pacoos.org/



CLIMATE CONDITIONS IN BRIEF

- **El Niño Southern Oscillation (ENSO):** La Niña persisted from 2011 into 2012 and transitioned to ENSO-neutral conditions in May 2012. These conditions continued through July and August 2012. From September to December 2012, the Pacific Ocean exhibited borderline ENSO-neutral/weak El Niño conditions.
- **The Oceanic Niño Index (ONI):** The ONI was negative at the start of 2012 and remained weakly negative through May 2012. However, in June, the ONI values became neutral (0.0), and remained in neutral conditions through the summer months. The ONI was strongly negative during winter 2012.
- **Pacific Decadal Oscillation (PDO):** The PDO was weakly negative and variable from January 2012 through spring 2012 but intensified in the summer by August when extremely negative values were reached (-1.93). The PDO was strongly negative during winter 2012.
- **Upwelling Index (UI):** UI values were positive from March through October from 27°N to 36°N. The UI and UI anomalies were positive during the July – September quarter at 36° and 42°N. Fourth quarter index values were relatively low and about average at 42°N and to the south. At 27°N indices

increased in October. UI values were negative at 51°N during November and December and the anomaly was negative in November.

- **Water Temperature and Salinity at Newport Hydrographic Line, Oregon:** The year began with colder-than-average deep waters over the inner-middle shelf. However, since upwelling was delayed and did not strengthen until early July, the deep waters (which ultimately upwell to the surface) had average temperatures (7.6°C) and salinity (33.74 average). The ocean was colder than normal during winter with the second coldest value in 17 years.
- **Trinidad Head Line, California Observations:** Observations along the Trinidad Head Line (THL) indicated that coastal waters off northern California were affected by mild upwelling in late 2011 which lead into a dry winter marked by limited freshening of coastal surface waters. Following a brief period of upwelling in February and March, late-arriving storms brought southerly winds and rain, causing downwelling and freshening of nearshore waters in spring 2012. Storm activity continued to affect waters off northern California through the spring and into the summer, with southerly wind and rain events occurring in July. The copepod assemblage at station Trinidad Head 2 exhibited relatively low densities of 'northern neritic' species into spring 2012.
- **Bodega Line, California Summary:** During 2012, quasi-monthly sampling of the Bodega Line continued. The line was established in September 2008 to monitor short-term and long-term effects of climate variability on the shelf ecosystem in the region. The initial focus was on the biodiversity and abundance of copepods and the associated water column structure. This has been expanded to include bird observations and acidification parameters. In 2012, phytoplankton biodiversity and abundance data were added. During the upwelling season, inner stations on the line were occupied almost weekly, yielding a high-frequency time series of the phytoplankton community.
- **Spring 2012 CalCOFI Observations:** During the fall 2012 CalCOFI cruise the core of the California Current was well offshore, running parallel to the coastline toward the southeast. The Davidson Current, flowing poleward along the coast, was well established as is typical for this time of the year. Off Point Conception low temperatures and high concentrations of chlorophyll *a* (Chl *a*) were observed. These features were driven by upwelling off Point Conception.

ECOSYSTEM CONDITIONS IN BRIEF

- **California Current Ecosystem Indicators:**
  1. **<u>Oregon Copepods</u>:** The abundance (biomass) of northern copepod species was at a record high through the first half of 2012 but declined in June/July due to the delayed upwelling; however biomass became anomalously high in August and September. In 2012, the northern copepod biomass was the highest in 17 years and the copepod community composition index was the fourth highest.
  2. **<u>Central-Northern California Juvenile Rockfish:</u>** The midwater trawl survey for juvenile rockfish and other pelagic nekton along the central California coast in late spring (May-June) showed that the species and assemblages that tend to do better with cool, high transport conditions, including juvenile rockfish, market squid and krill, were more productive in 2011 and 2012. Market squid and krill were at above average levels in 2011, and very high levels in 2012.
  3. **<u>Coastwide Coastal Pelagics:</u>**

     <u>Pacific Sardine:</u>

     Summer trawl sardine survey off the West Coast of Vancouver Island (WCVI), 2012 update: Regional estimates of sardine catch density and seasonal biomass in the WCVI core survey region from night sampling in 2006 and 2008 to 2010 (no survey was conducted in 2007) show a declining trend, whereas the 2011 estimates are approximately double the 2010 estimates. Compared to observations from previous survey years, overall catch densities in 2012 were considerably lower and no sardines were caught in the northwest and southeast sub-regions. The low densities may be the result of unfavorable oceanographic conditions off the WCVI for sardines during the survey period.

4. **Salmon:** Spring Chinook salmon (*Oncorhynchus tshawytscha*) catches in the June salmon surveys were the second highest in 15 years. These fish migrate northwards quickly en route to the coastal Gulf of Alaska, and by June are at the northern end of the survey area (and already off Vancouver Island). Thus they may not have experienced the warm temperatures which first appeared on 15 June. Coho salmon (*Oncorhynchus kisutch*), on the other hand (which are more resident in local waters), would have experienced high sea surface temperatures (SST) throughout much of summer, which may explain why catches in September were poor, ranking 10th of 15 years.

- **Marine Birds and Mammals:**
  Marine Birds: In the southern California study region, auklets (*Ptychoramphus aleuticus*) are most abundant during winter surveys. The auklet population declined from the late 1980s through the late 1990s, but was relatively stable thereafter. Between years, relative abundance peaked in the springs of 1990 and 2005, as well as during the summers of 2005 through 2007. In 2012, however, there was nothing unusual in the relative abundance of auklets in any season.

  In contrast to the resident auklets, shearwaters (*Puffinus griseus*) are most abundant in the study region during the summer, with lower relative abundance in the spring. During both seasons, the relative abundance of shearwaters declined. In 2012, numbers were substantially reduced from a recent peak in both spring and summer in 2010. While relative abundance generally increased during 1996-2002, overall shearwater abundance appears to be declining in this region.

PACIFIC COAST FISHERIES MANAGEMENT SUMMARIES IN BRIEF

- **Highly Migratory Species (tunas, sharks, billfishes):** The Pacific Fisheries Management Council recommended continuing bilateral negotiations with Canada on the US-Canada Albacore Treaty. They noted that any discussion should address the Canadian catch in US waters; that any new fishing regime should be based on pre-1998 levels of Canadian catch and effort in US waters; and that problems regarding access to Canadian ports by US vessels should be resolved.
- **Coastal Pelagics:**
  Pacific Sardine: The Pacific Fisheries Management Council adopted a coastwide harvest guideline (HG) of 109,409 mt for the 2012 Pacific sardine fishery. Subtracting a Tribal Set-Aside of up to 9,000 mt and an exempted fishing permit set aside of up to 3,000 mt provides at least 97,409 mt for the non-tribal general fishery.

CLIMATE CONDITIONS

El Niño Southern Oscillation (ENSO):
Source: **http://www.cdc.noaa.gov/people/klaus.wolter/MEI/mei.html, http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/**

A mature La Niña continued during January 2012, as below-average sea surface temperatures (SST) persisted across the equatorial Pacific Ocean. In February, La Niña weakened as near-to-above average sea surface temperatures emerged in the eastern equatorial Pacific Ocean. La Niña continued to weaken during March, as below-average SSTs persisted primarily in the central Pacific Ocean.

ENSO-neutral conditions prevailed in May 2012, following the dissipation of La Niña in April as below-average SSTs weakened across most of the equatorial Pacific Ocean and above-average SSTs persisted in the east. During June 2012, ENSO-neutral conditions continued as reflected in both the oceanic and atmospheric anomalies.

These ENSO-neutral conditions continued during July and August 2012 despite above-average sea surface temperatures across the eastern Pacific Ocean. September to December 2012, the Pacific Ocean exhibited borderline ENSO-neutral/weak El Niño conditions. During December, equatorial SST anomalies were positive in the western Pacific Ocean, near zero in the central Pacific Ocean, and slightly negative in much of the eastern Pacific Ocean.

Multivariate ENSO Index (MEI) values from 2007 through December 2012 are shown in Figure 2.

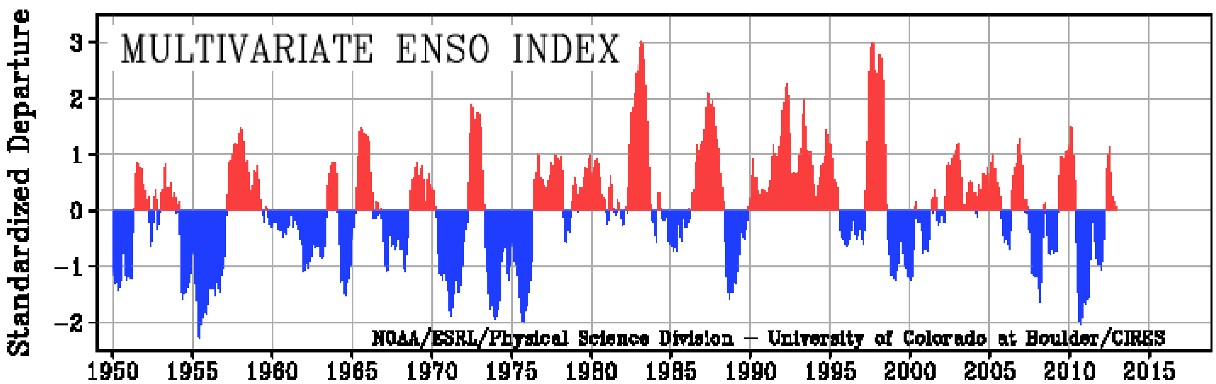


Figure 1. NOAA Physical Sciences Division attempts to monitor ENSO by basing the Multivariate ENSO Index (MEI) on the six main observed variables over the Pacific. These six variables are: sea-level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky.

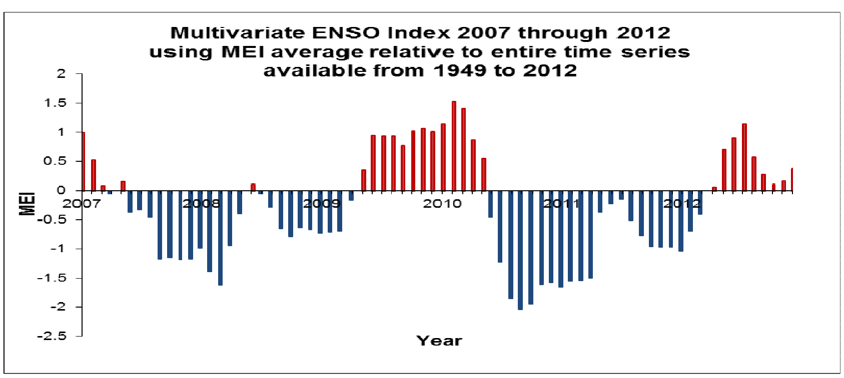


Figure 2. Multivariate ENSO Index from 2007 through December 2012. Mean used from bimonthly MEI values from the entire MEI Index time series, starting with December 2005/January 2006 through November 2012/December 2012 (http://www.esrl.noaa.gov/psd/enso/mei/table.html).

Pacific Decadal Oscillation (PDO), Oceanic Niño Index (ONI) and SST at NOAA Buoy 46050, Newport Oregon:

Source: Bill Peterson, NOAA, NMFS

The Pacific Decadal Oscillation (PDO) has been negative and cold ocean conditions have prevailed for most months from September 2007 through all of 2012. This run of negative values was interrupted by a brief and moderate El Niño event from Aug 2009-May 2010, but otherwise the PDO has been strongly negative over a period of more than five years. If the PDO were the only indicator of ocean conditions for the northern California Current, this situation would be noteworthy. However, local conditions off Newport, Oregon did not mirror the PDO in 2012; the spring transition was very late, occurring around May 2nd, three weeks later than the long-term average; moreover, winds were light and variable through May and June, and sea surface temperature values were several degrees warmer than 'normal' from mid-June through July. The significance of these observations is that the PDO alone does not necessarily reflect local conditions because values during much of 2012 were among the most negative of any in the past 100 years, yet sea surface temperatures were elevated.

The PDO was strongly negative through 2012, reaching a maximum value of -2.21 in September. The most recent value available (-0.59, for November 2012) suggests that the negative phase is weakening. Summer values (cumulated over May-September, Figure 3, -6.43), were the 4th most negative since 1960 (-7.63 in 2008, -6.43 in 2011 and -6.36 in 1962).

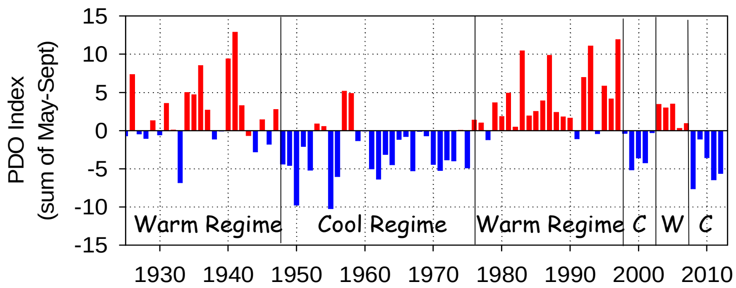


Figure 3. Time series of the PDO showing values summed over May through September of each year. Note the extremely low values in recent years, not seen since the mid-1950s.

The Oceanic Niño Index (ONI):

Source: Bill Peterson, NOAA, NMFS

The ONI values increased steadily starting in December 2011 and were positive starting in June 2012; as of November 2012 the ONI index was + 0.83 but the index fell to a slightly negative value in December 2012 of -0.09 (Figure 4) suggesting that El Niño conditions were waning. ENSO-neutral conditions are now likely through the Northern Hemisphere winter 2012-13 and into spring 2013.

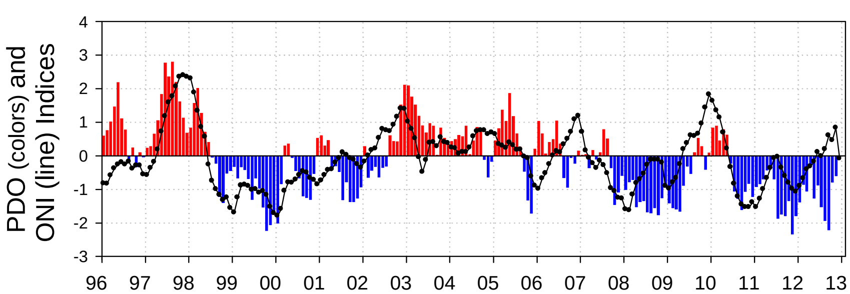


Figure 4. Time series of monthly values of the Oceanic Nino Index (ONI) and Pacific Decadal Oscillation, from 1996 to present. Note that the December 2012 value of the ONI fell to a slightly negative value (-0.09) from a strongly positive value in December (+0.83).

Sea Surface Temperatures (SST):

Source: Bill Peterson, NOAA, NMFS

At the NOAA Buoy 46050, 20 miles offshore of Newport, Oregon, daily values of SST show positive (warm) temperature anomalies in June and July, with temperature anomalies around +3°C in mid-July (Figure 5). The monthly average anomaly was + 2°C for July, at a time when the PDO value was – 1.52. SST at one of the core hydrographic stations (Newport Hydrographic (NH) 05, five miles offshore of Newport) was also above-average over the May-September period, with a peak SST of 15.9°C observed on 25 June, which was the 12th warmest of 450 measurements made at this location since 1996.

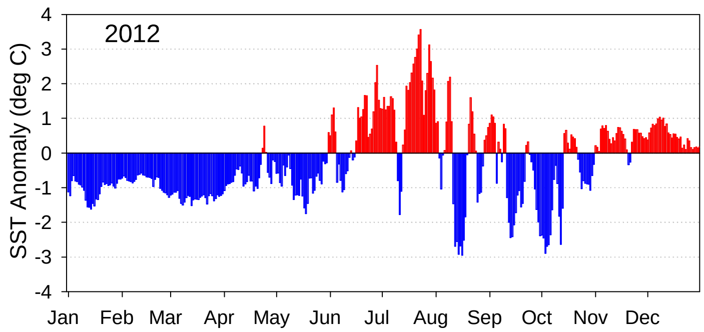


Figure 5. Daily SST anomalies at NOAA Buoy 46050, off Newport, Oregon showing the extended period of warm water observed during the summer of 2012. Both June and July were considerable warmer than normal.

Mixed Layer Temperatures:

Source: Bill Peterson, NOAA, NMFS

Mixed layer temperatures (MLT) refer to temperatures averaged over the upper 20 m of the water column, that part of the water column that is mixed by the wind in summer. When these values were calculated for station NH05, despite warm SST in 2012 (and 2007 and 2009 – see Figure 6 upper panel), anomalies of MLT during the upwelling season were below average (i.e., cooler than 'normal') for the past seven years (Figure 6 lower panel). Winter MLTs however were the same as winter SST, likely because the entire water column is well-mixed by intense winter storms. These observations create a problem for interpreting ocean conditions with respect to a juvenile salmon – do they respond to SST or to MLT? It is known that juvenile salmon live in the upper parts of the water column in depths < 20 m, but exactly where in the upper layer is not known with certainty.

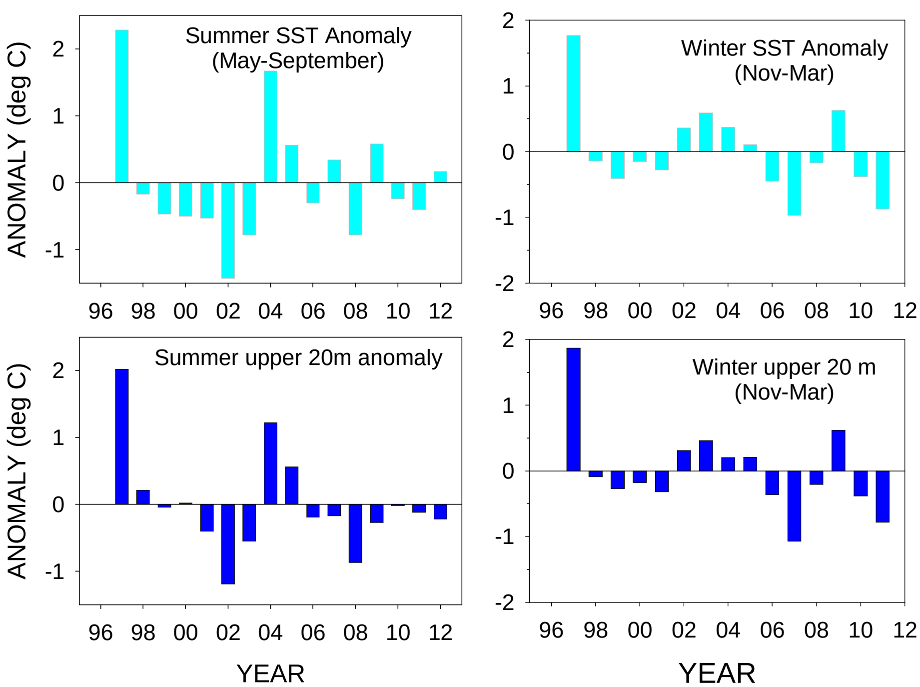


Figure 6. Temperatures at station NH05 (five miles offshore of Newport) shown as SST anomalies (top panels) in summer and winter, and anomalies averaged over the upper 20 m of the water column. Note that although SSTs were slightly warmer than average (+0.17°C) the upper 20 m were cooler than average (-0.22°C).

Upwelling Index:

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

***Pacific Fisheries Environmental Laboratory* http://www.pfeg.noaa.gov/products/PFEL/, *monthly surface pressure maps:* http://www.pfeg.noaa.gov/products/PFEL/modeled/pressure_maps/pressure_maps.html, *monthly IU values:* http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA/data_download.html, http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/upwelling.html**

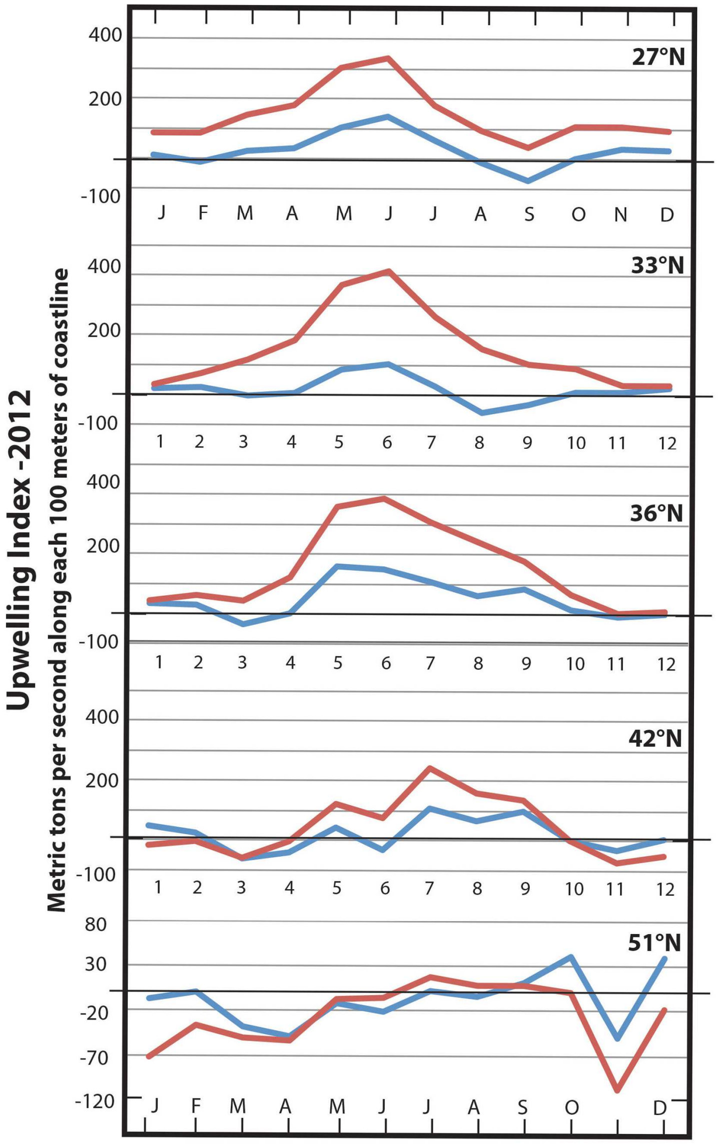


Figure 7. Plots of the ERD / SWFSC upwelling index (UI) computed from monthly mean pressure fields. The computation points are shown, from the top: 27°N, Baja California, Mexico; 33°N, Southern California Bight; 36°N, central California; 42°N, northern California Border; and 51°N, southern Canada. The red lines give the UI and the blue lines give the anomaly to the same scale. The anomaly is compared to 1948-1967 mean values. All graphs, except the bottom one (51°N), are on the same scale (-100 to 500). Values are given for each month of 2012. The UI values and anomalies were clearly positive from May until August from 27°N to 36°N. The UI and UI anomalies were positive during the July – September quarter at 36° and 42°N. Fourth quarter index values were relatively low and about average at 42°N and to the south. At 27°N, indices increased in October. UI values were negative at 51°N during November and December and the anomaly was negative in November. Alternate effects of high and low pressure systems often lead to low average UI values at 51°N.

Coastal Upwelling at 45°N:

Source: Bill Peterson, NOAA, NMFS

Upwelling began on May 2nd and ended on 12 October. It lasted 161 days (Figure 8), ranking 11th in 15 years for duration. The start date was three weeks later than the long-term average. However, after only a few days of northerly winds, upwelling ceased and did not resume until early July, after which the upwelling index pointed towards strong and nearly continuous upwelling, with only brief pauses, until October. Very warm water was found on the continental shelf on nearly all days in July (at a time when the upwelling index was suggesting strong upwelling, see Figure 5). Thus, the UI did not index local conditions during the summer of 2012.

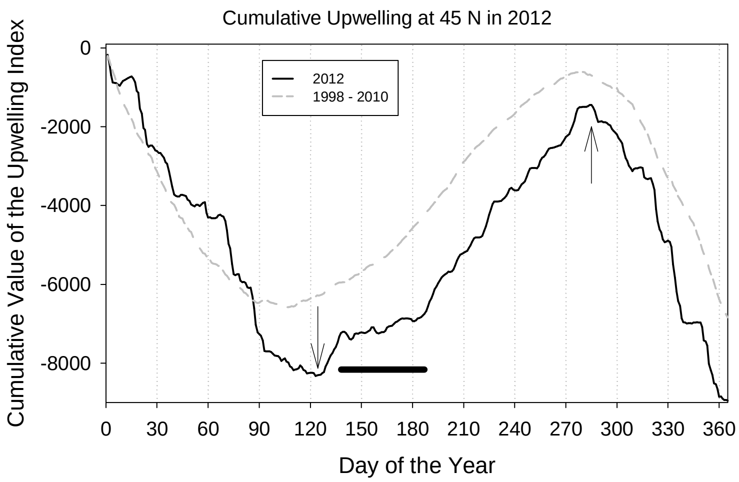


Figure 8. Cumulative values of the PFEL Upwelling Index for 2012 compared to the 1998-2010 climatology. Upwelling began late in 2012, but then had an extended 'pause' (solid horizontal line) from approximately mid-May through mid-July.

Regional Oceanic Conditions:

Source: Jerrold Norton, NOAA, ERD, SWFSC (Jerrold.G.Norton@noaa.gov)
***El Niño Watch, Advisory* http://coastwatch.pfel.noaa.gov/cgi-bin/elnino.cgi**

The ocean off the west coast of the US, from 30°N to 50°N and extending westward to 135°W, had average-to-cooler-than-average SSTs in the first half of 2012 followed by a period of average-to-warmer-than-average SSTs. However, much of the northeastern temperate and subarctic Pacific Ocean east of 150°W had cooler-than-average SSTs during 2012. Off the west coast of the US, the 10°, 12° and 14°C SST isotherms were relatively stable with respect to latitude from January through April, as the neutral-to cool SST patterns first observed in November 2011 persisted.

Seasonal warming and the formation of a coastal upwelling zone became more apparent in May, as the 10°, 12°, 14° and 16°C SST isotherms migrated about 300 km northward. In June a coastal upwelling zone extending from 38°N to 43°N was bounded by the 12°C isotherm and the coast. The areas of negative SST anomaly seen in April were reduced by June.

The July monthly mean showed a transition in coastal SST anomaly patterns. Coastal areas from 32°N to 50°N exhibited a positive anomaly to 1.5°C, and this pattern persisted through year's end. These positive anomaly patterns intensified in August, particularly in the Southern California Bight (SCB) where SST anomalies reached 2°C. A strong front formed around Point Conception at the west end of the Santa Barbara Channel (34°-34.7°N). Offshore during July, the 14° and 16°C isotherms were found about 600 km to the north of their June latitudes. The coastal upwelling zone between 35° and 45°N was marked by the boundaries of the 12°, 14°, and 16°C isotherms and the coast.

During September the positive anomalies weakened in the north and intensified in and around the SCB where temperatures exceeded 22°C. Anomalies exceeded 2°C in the SCB. October SST maps showed that the upwelling zone shifted to the north. The 14°C isotherm and coast defined a coastal upwelling zone, from 39°N to 50°N, that contained small areas of negative SST anomaly. Positive SST anomaly persisted in the SCB, and then weakened through the end of 2012. The coastal upwelling system dissipated in November and December and SST anomalies to 1.5°C occurred on the coast and up to 300 km offshore from 36°N to 43°N. Negative SST anomalies were again found north of 35°N and west of 125°W during the last two months of 2012. The 10°, 12°, 14° and 16°C isotherms were generally about 100 km farther north in December than they had been in January 2012. This northward displacement of isotherms was generally greater nearshore where weak positive anomalies persisted in December.

These ocean observations are based on smoothed Advanced Very High Resolution Radiometer (AVHRR) monthly mean SST maps found at the CoastWatch, West Coast Regional Node (http://coastwatch.pfel.noaa.gov/elnino.html). For SST anomalies, the AVHRR SST were compared to the Pathfinder + erosion (Pathero) climatology (Casey and Cornillion, 1999).

Deep-Water Temperature and Salinity along the Newport Hydrographic Line, OR:

Source: Bill Peterson, NOAA, NMFS

The year 2012 saw the continuation of a trend that began in 2009 towards slightly warmer and fresher water at depth on the continental shelf. This is an indication that upwelling has been weak and that the waters which upwell have a shallower offshore source. The April-June 2012 data were among the fresher and warmer years; July-September was cool and fresh (often referred to as 'minty' water) as was the season as a whole (May-September, Figure 9). This is also reflected in the sea surface temperature data shown in Figure 5 – slightly warmer waters prevailed through much of 2012.

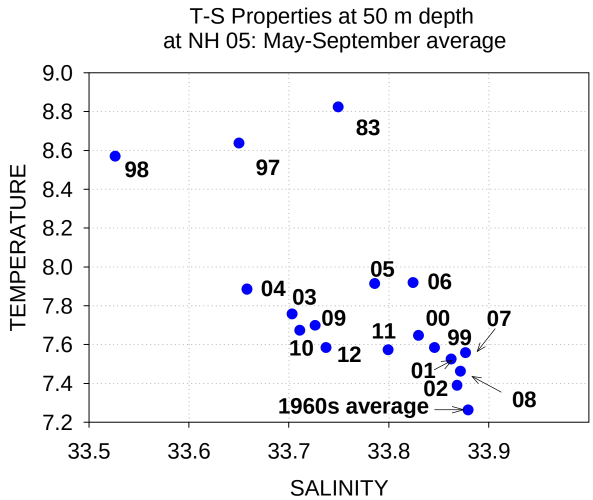


Figure 9. Temperature and salinity values measured at a depth of 50 m at station NH05, off Newport, OR over May-September. These values can be viewed as a measure of upwelling strength – e.g., cold and salty values indicate strong upwelling. The summer of 2012 was relatively cool compared to other years (averaged 7.58°C) but considerably fresher (33.738).

Summary of 2012 observations along the Trinidad Head Line (41°03.5'N):

Source: Eric P. Bjorkstedt (NOAA/NMFS/SWFSC/HSU), Jeff Abell (HSU)

Observations along the Trinidad Head Line (THL) indicated that coastal waters off northern California were affected by mild upwelling in late 2011 which lead into a dry winter marked by limited freshening of coastal surface waters. Following a brief period of upwelling in February and March, late-arriving storms brought southerly winds and rain, causing downwelling and freshening of nearshore waters in spring 2012 (Figures 10 and 11). Storm activity continued to affect waters off northern California through the spring and into the summer, with southerly wind and rain events occurring in July. Based on preliminary analyses of surface currents measured with HF radar, the region between Cape Blanco and Cape Mendocino may also have been affected by intrusion of southerly, offshore water as a consequence of or in conjunction with the observed wind forcing (data not shown).

The copepod assemblage at station Trinidad Head 2 (TH02) exhibited relatively low densities of 'northern neritic' species (and the absence of several such species) into spring 2012 (data not shown; Bjorkstedt et al. 2012, CalCOFI Reports 53: 41-76). Near-bottom temperatures at station TH02 (approximately mid-shelf, 41°03.5'N, 124°16'W, 75m depth), were within the range of previous observations (2006-2011) for much of the summer and into the fall (Figure 10), and showed the effects of upwelling, although surface waters showed the influence of late spring and summer storms (data not shown). Chlorophyll concentrations in the upper water column remained very low at TH02 throughout 2012, save for a modest bloom that developed in late summer to early fall (Figure 10); this trend was apparent along the entire line (out to approximately 50 km offshore, data not shown). Reduced upwelling might have contributed to this pattern, but preliminary analysis of samples indicates that gelatinous zooplankton were more abundant along the THL in 2012 than in past years and may have grazed phytoplankton stocks down (data not shown).

Observation cruises in 2012 were supported by NOAA/NMFS and the California Ocean Protection Council.

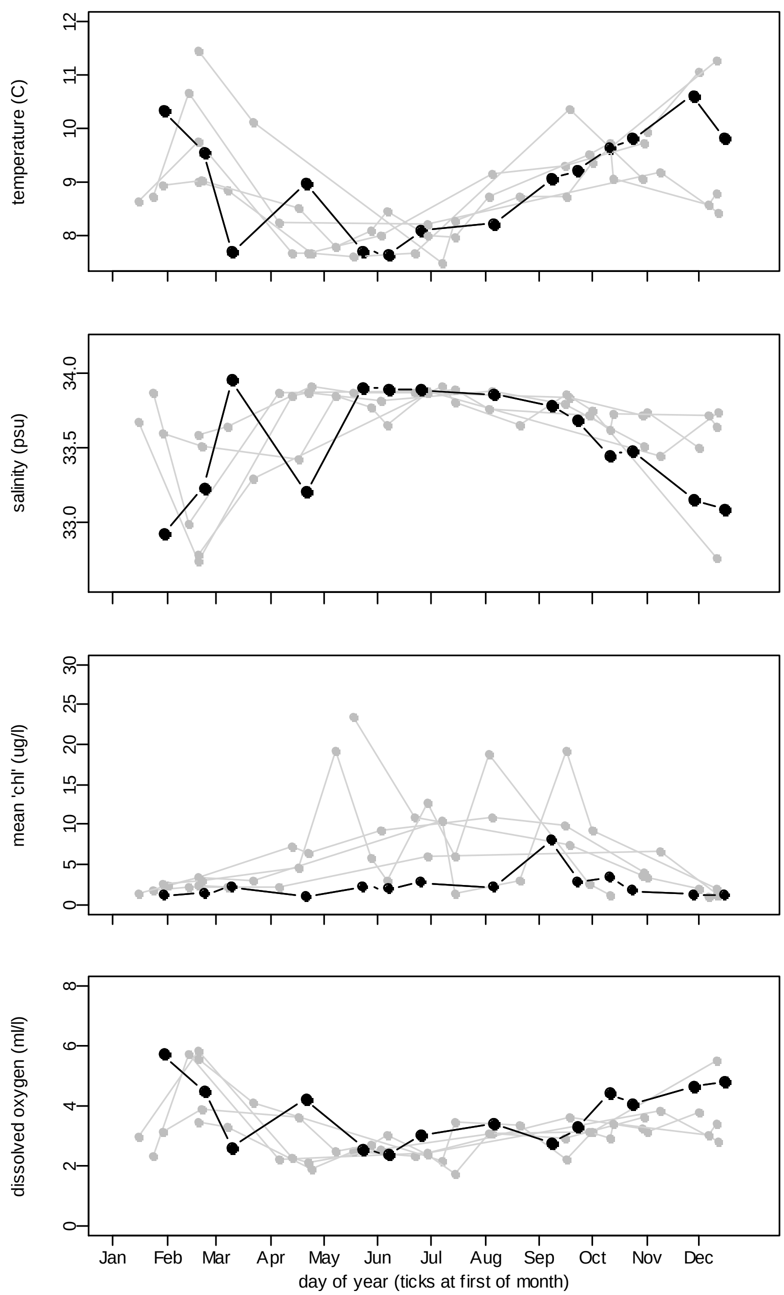


Figure 10. Annual series of observations of temperature at 60 m (top panel), salinity at 60 m (second panel), mean chlorophyll concentration (ug/l based on fluorometer) over the upper 60 m (third panel) and dissolved oxygen at 50 m (bottom panel) at station TH02 (approximately mid-shelf, 41°03.5 N, 124°16' W, 75m depth) along the Trinidad Head Line. Black circles and lines indicated observations from 2012; grey symbols/lines indicate observations from earlier years (late 2006-2011).

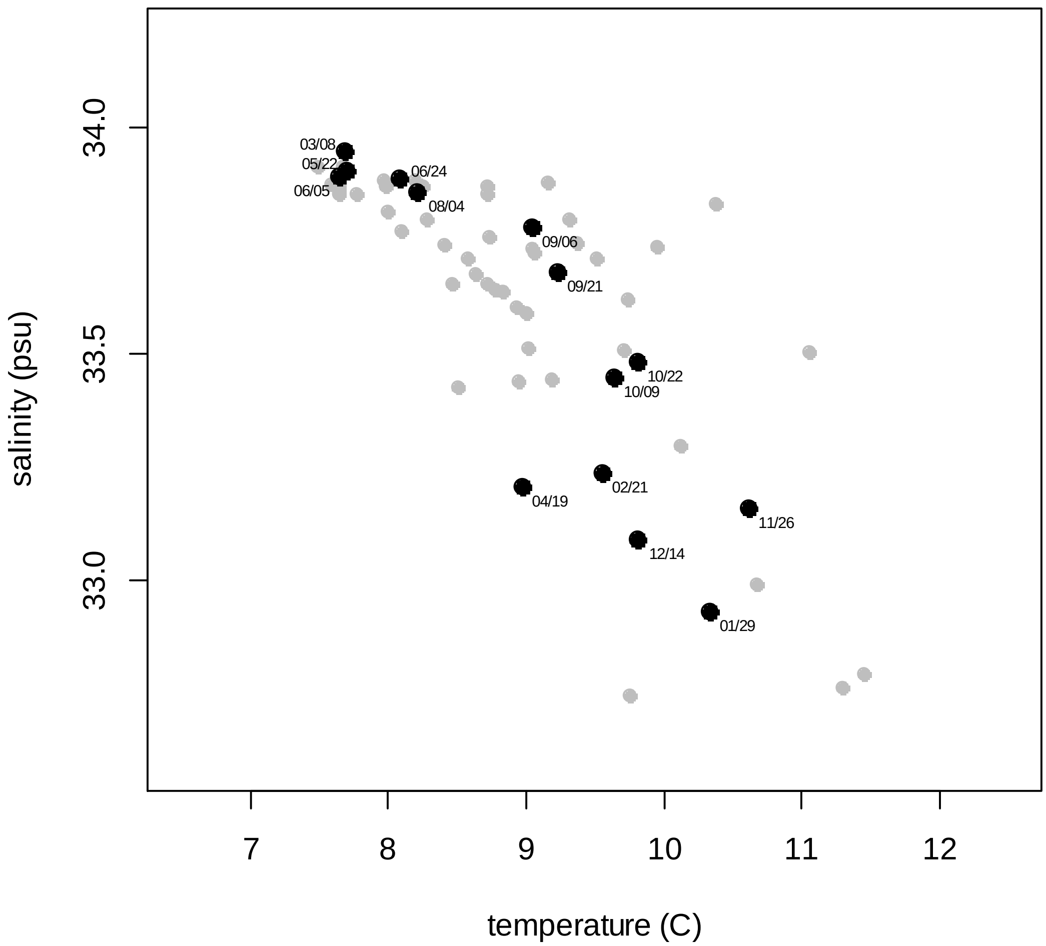


Figure 11. Temperature and salinity characteristics at 60 meters depth at station TH02 (approximately mid-shelf, 41° 03.5' N, 124° 16' W, 75m depth) along the Trinidad Head Line. Black circles indicate observations during 2012, labeled by date. Grey circles indicate observations from previous years' cruises.

Summary of 2012 operations along the Bodega Line (38.25°N):

Source: John L. Largier (UC Davis) and Steven G. Morgan

During 2012, quasi-monthly sampling of Bodega Line continued, with surveys on 14 March, 25 April, 22 May, 17 July, 22 August, 26 September, 30 October, and 19 December. The line was established in September 2008 through collaboration between Bodega Marine Laboratory (University of California Davis) and the Sonoma County Water Agency to monitor short-term and long-term effects of climate variability on the shelf ecosystem in the region. Station locations are shown in Figure 12. The initial focus was on the biodiversity and abundance of copepods and associated water column structure (in parallel with lines off Trinidad, California, and Newport, Oregon). This has been expanded to include bird observations and acidification parameters. In 2012, phytoplankton biodiversity and abundance data were added through collaboration with the Farallon Institute. During the upwelling season, inner stations on the line were occupied almost weekly, yielding a high-frequency time series of the phytoplankton community (dates in addition to monthly surveys: 21 and 28 March, 4 and 19 April, 3 May) – see Figure 13. This line was also sampled during the WEST program (Largier et al 2006). The time-series of monthly surveys is accompanied by high-frequency data on water properties from moorings off Bodega Head and on Cordell Bank, surface currents from a HF-radar network, and winds from Bodega Head and the NDBC weather buoy 46013.

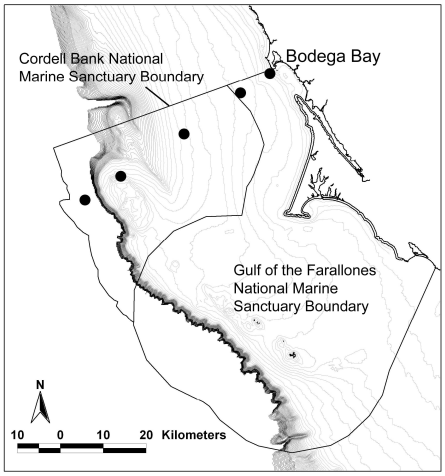


Figure 12. Location of stations along the Bodega Line, running WSW from Bodega Head and extending offshore over Cordell Bank. The line is just north of Point Reyes and characterizes the shelf ecosystem downstream of the Point Arena upwelling center.

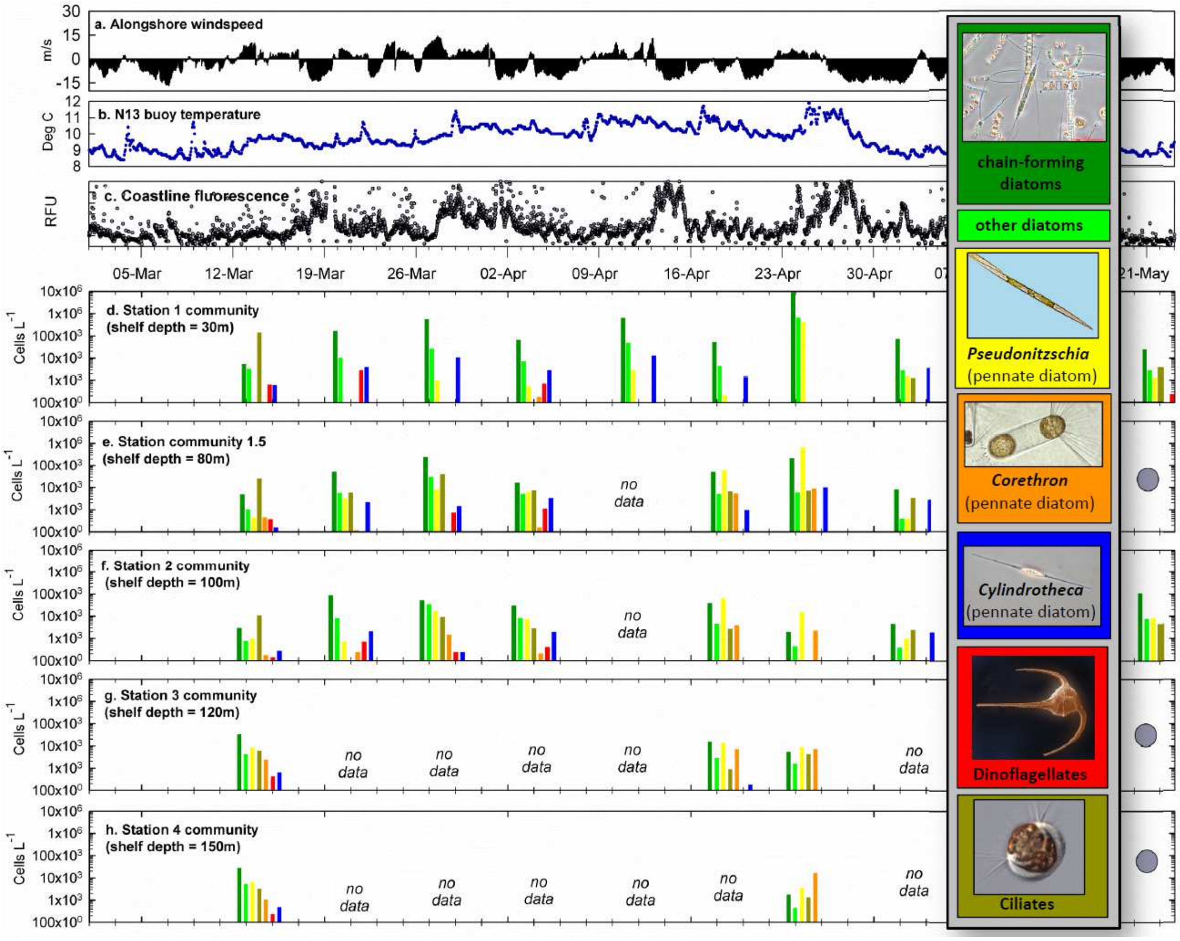


Figure 13. Preliminary phytoplankton community data for the Bodega Line in early 2012 (data provided by Adele Paquin, Farallon Institute; Coastline fluorescence data provided by Karina Nielsen). Different colored bars correspond to the taxonomic groups shown in the key on the right.

Fall 2012 Observations by the SIO CalCOFI group:
Source: Ralf Goericke, SIO
The fall 2012 CalCOFI cruise was carried out between Oct 19 and Nov 5th, 2012. The core of the California Current was well offshore during this period, running parallel to the coastline toward the southeast (Figure 14a). The Davidson Current, flowing poleward along the coast, was well established as is typical for this time of the year. Off Point Conception low temperatures and high concentrations of chlorophyll *a* (Chl *a*) (Figure 14b & d) were observed. These features were driven by upwelling off Point Conception, a conclusion corroborated by unusually high concentrations of nitrate and low concentrations of oxygen off the Point. However, the upwelling cell off the Point was small, compared to other fall cruises, based on the negative Chl *a* anomalies in large areas surrounding the Channel Islands.

In other regards properties observed during the fall CalCOFI cruise were similar to long-term averages.

1210NH State of the Current Figure

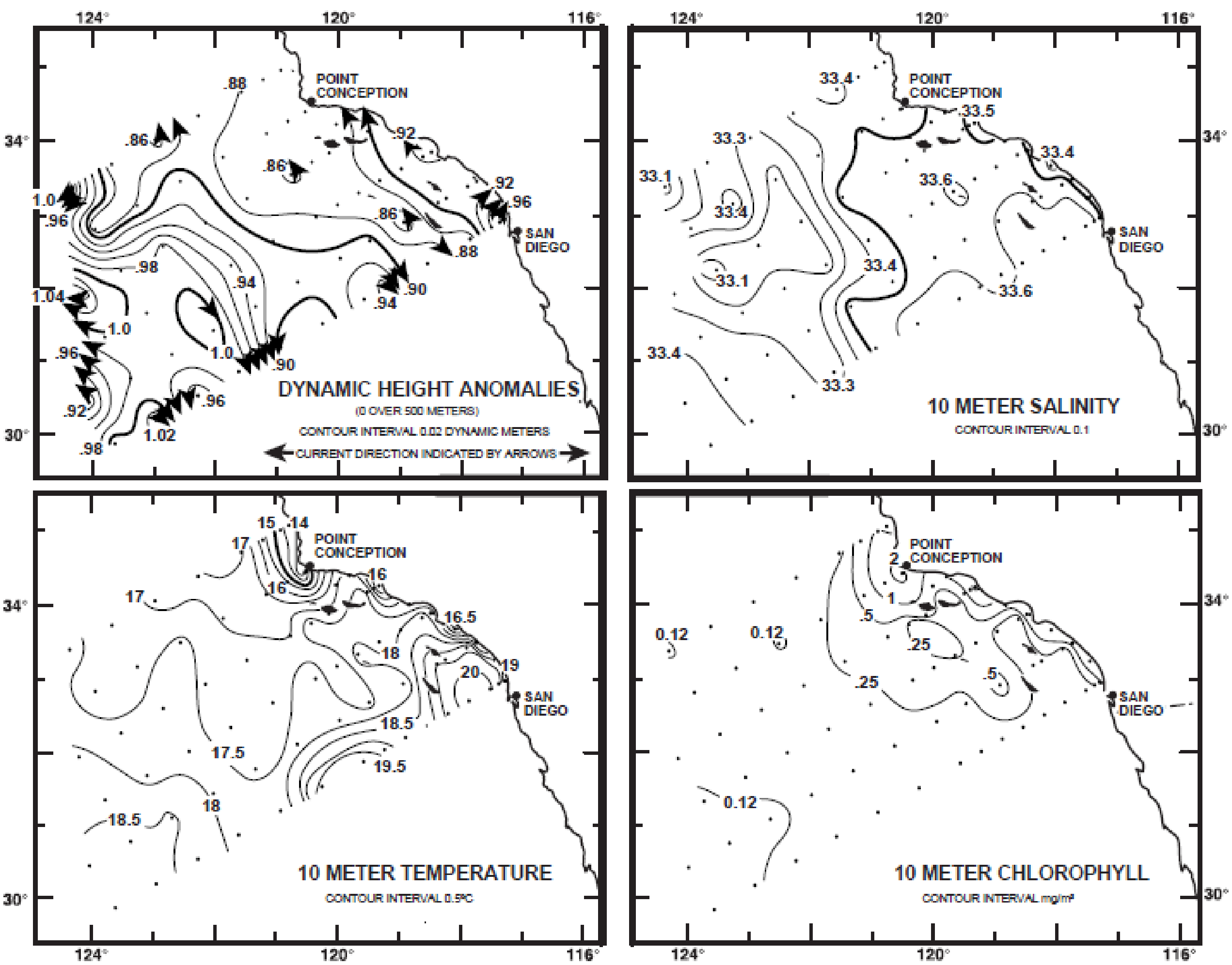


Figure 14. Hydrographic properties off Southern California in October - November 2012: **A**, dynamic height (dynamic meter), **B**, temperature (°C), **C**, salinity, and **D**, Chlorophyll a (μg/L). The latter 3 properties are for a depth of 10 m.

ECOSYSTEMS

California Current Ecosystem Indicators:

<u>Copepod Biodiversity (Species Richness)</u>:

Source: Bill Peterson, NOAA, NMFS

Copepod species richness continued to track the PDO closely (Figure 15); the average for the upwelling season (May-September) in 2012 was ~ 9 species, the same as observed from 2007-2009 and in 2011, but higher than during the cool period of 2000-2001 when the average was about 7 species.

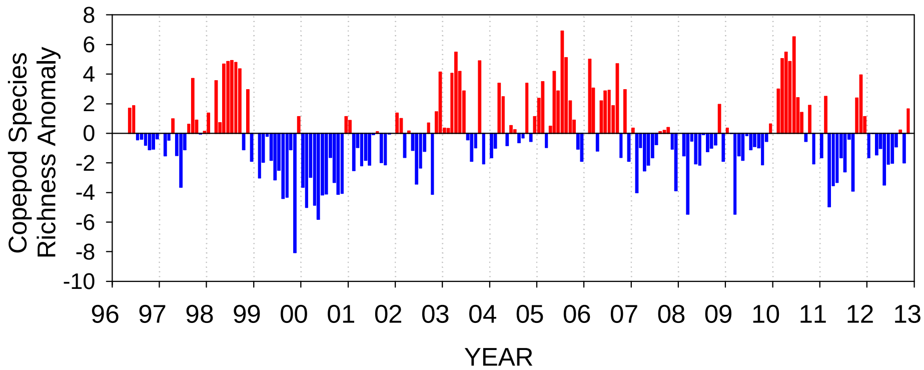


Figure 15. Monthly time series of copepod species richness anomalies. When compared to the monthly time series of the PDO (in Figure 4), it can be seen that species richness tracks the PDO closely – when the PDO is negative, the northern California Current is usually cold and fewer species of copepods are found, indicating the presence of a sub-arctic community.

Northern and Southern Copepod Biomass Anomalies. Copepods are transported to the Oregon coast, either from the north/northwest or from the west/south. Copepods that arrive from the north are cold–water species that originate from the coastal Gulf of Alaska and referred to as the "northern copepods"; those that originate from the south and offshore are called "southern copepods". A high biomass of northern species indicates a lipid- and bioenergetically-rich food chain. Positive anomalies of one or the other indicates transport of water from the north (for 'northern' copepods) or from the south (for 'southern' copepods) to the Oregon coast. During the winters of 2011 and 2012 (Jan-Mar), the biomass of northern copepods was the highest of the 17 year time series. Similarly, during the upwelling seasons (May-September, Figure 16) of the past two years, the northern copepod biomass was also the highest in 17 years suggesting strong transport from the north.

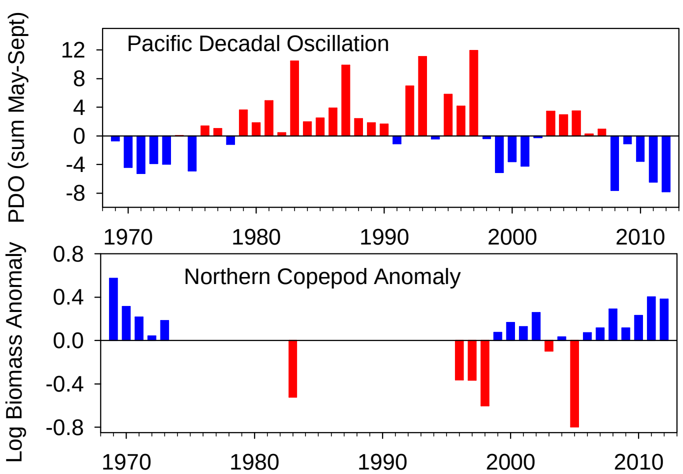


Figure 16. Time series of the May-September PDO (upper) and May-September averaged "northern copepod biomass" anomaly. Positive anomalies indicate and greater than average biomass of subarctic, northern, lipid-rich copepod species and is an indicators of good ocean conditions that are favorable for high rates of salmon growth and higher than average salmon survival. For details, see <u>www.nwfsc.noaa.gov/oceanconditions</u>.

Ecosystem indicators for the Central California Coast, May-June 2012

Source: John Field 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 micronekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile (pelagic age 0) rockfish for fisheries oceanography studies and stock assessments, while simultaneously monitoring the micronekton forage assemblage (including other juvenile fishes, krill, coastal pelagic species, and mesopelagic species) and collecting oceanographic information. The results here summarize trends in the core area since 1990, as not all species were consistently identified in earlier (1983-1989) years of the survey. From 1983 through 2008 cruises took place on the NOAA ship David Starr Jordan, but since 2009 a series of different research platforms have been utilized and the surveys have ranged in duration and spatial distribution. In 2012 the cruise took place onboard the NOAA Ship Bell M. Shimada. The data for the 2012 survey presented here are preliminary, and the analysis does not account for potential differences in catchability among vessels. Results from the expanded survey area (available from 2004 to the present) 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). Trends in 2011 and 2012 were of higher productivity for the species and assemblages that tend to do better with cool, high transport conditions, including juvenile rockfish, market squid and krill. In 2011, juvenile rockfish were more abundant then they had been since the early 2000s, and juvenile abundance remained relatively high in 2012. Market squid and krill were at above average levels in 2011, and very high levels in 2012; with market squid in particular estimated to be at the highest relative abundance in the time series. Other coastal pelagic species (adult northern anchovy and Pacific sardine) continued to be encountered at low levels, although this is likely a greater reflection of their local availability and ocean conditions rather than their coastwide or regional abundance. Notably, in 2012 the abundance of several types of gelatinous zooplankton was extraordinarily high, particularly that of several species of salps (pelagic tunicates), including *Salpa fusiformis* and *Thetys vagina*, as well as pyrosomes and heteropods. Although abundance data for these species has not been collected since 2001, a historical data set from the early years of the trawl survey will be evaluated in the near future to better quantify the relative magnitude of the observed abundance levels. The abundance was sufficiently great that the mass of gelatinous zooplankton damaged sampling gear, and resulted in some offshore trawl stations being abandoned for the first time in the 30 year history of this survey.

As with past reports (e.g., Bjorkstedt et al. 2011), the trends observed in the six indicators shown in Figure 17 are consistent with trends across a broader suite of taxa within this region, with the first and second components (of a principle components analysis of 15 of the dominant taxon) explaining approximately 36% and 16% of the variance in the data respectively. Loadings of these groups indicate strong covariance among young-of-the-year groundfish (rockfish, sanddabs and Pacific hake), cephalopods and euphausiids, which in turn tend to be negatively correlated over time with coastal pelagic and mesopelagic species. As with the 2011 results, 2012 continued to indicate a pelagic micronekton community structure to conditions similar to those seen in the early 1990s and early 2000s (Figure 18). However, the spatial patterns of abundance will also be the target of future analysis, as anecdotally these patterns may not have been typical of previous cool, productive periods. Specifically, as there was some suggestion that small gelatinous zooplankton were at greater levels of abundance in offshore waters, while more coastal waters experienced relatively greater abundance levels of krill, squid and juvenile groundfish.

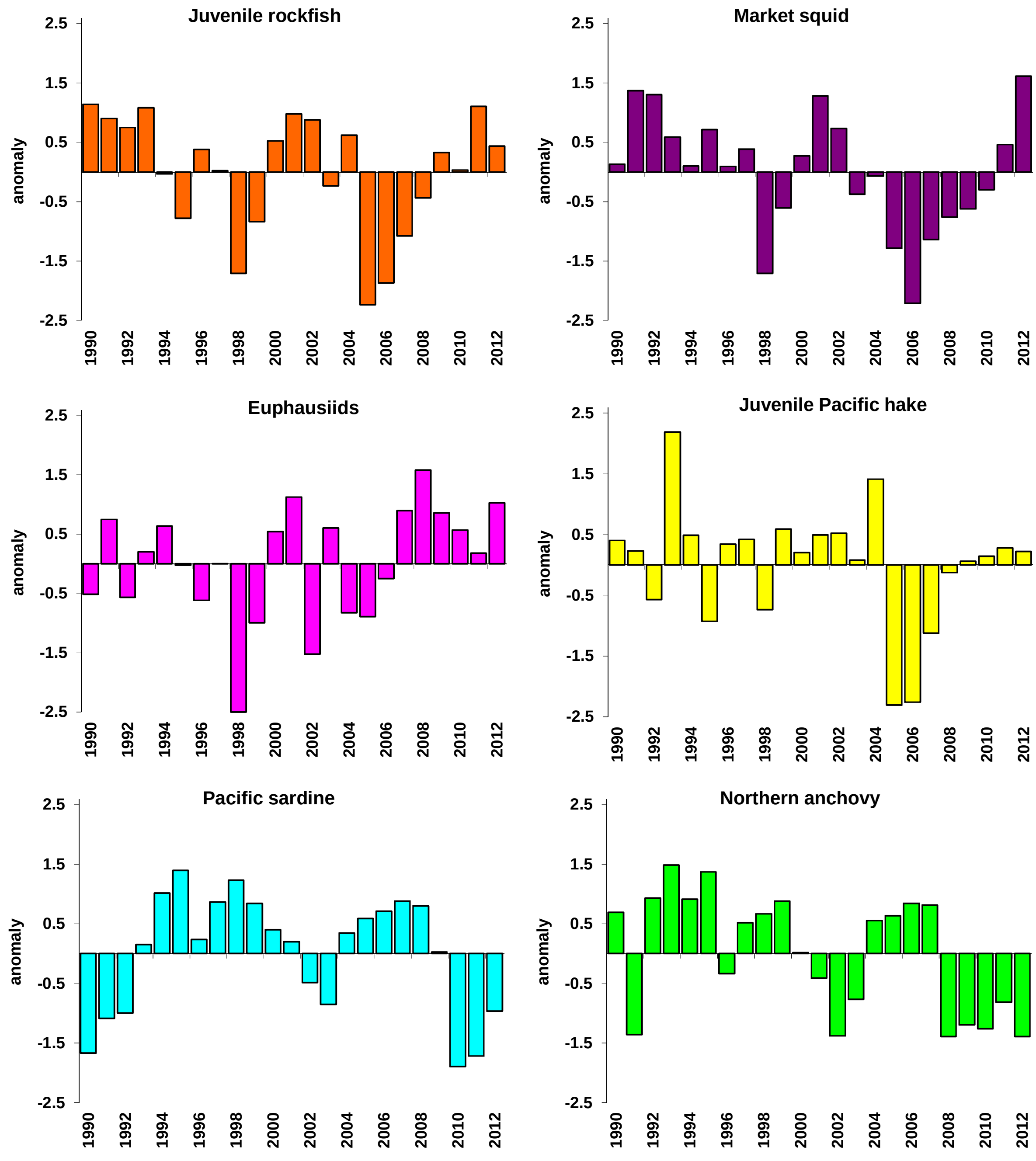


Figure 17. Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from the central California rockfish recruitment survey in the core region (1990-2012).

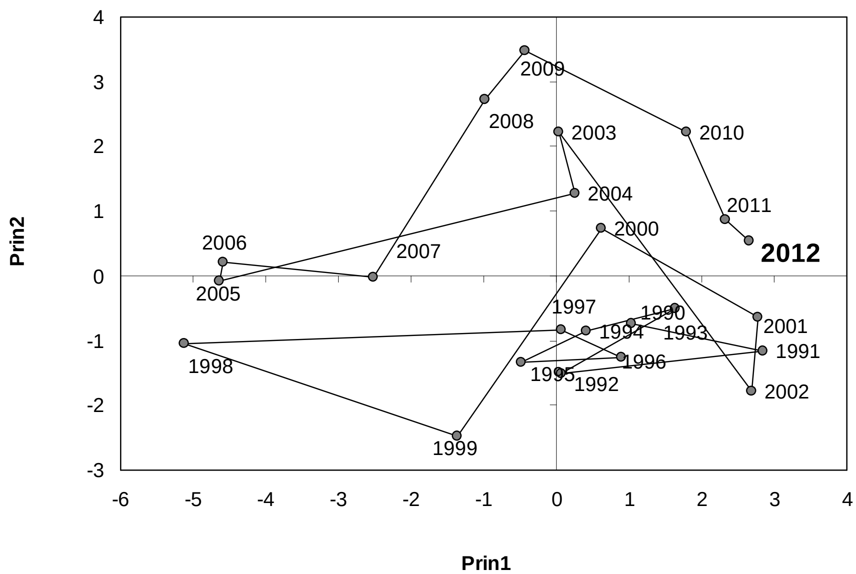


Figure 18. Principal component scores plotted in a phase graph for the fourteen most frequently encountered species groups sampled in the central California core area in the 1990-2012 period.

Summer trawl sardine survey off the west coast of Vancouver Island (WCVI), 2012 update

Source: Linnea Flostrand, Vanessa Hodes, Jennifer Boldt, and Jake Schweigert, Fisheries and Oceans Canada, Nanaimo, BC (Pacific Biological Station, 3190 Hammond Bay Rd. Nanaimo, BC V9T 6N7).

Survey background

The summer west coast of Vancouver Island surface trawl survey is conducted to collect information on sardine: 1) regional distribution, 2) abundance, 3) size and age structure, 4) species associations (sardine diet and predation), and 5) oceanographic conditions. Surveys have been conducted most summers since 1992 (McFarlane and MacDougall 2001, DFO 2012). Fishing is done by a mid water trawl towed near the surface (e.g. <30 m) using floats on the headlines at average speeds approximating 4.5 to 5.5 knots. Since 2006, sampling has been conducted at night (Schweigert et al 2009; DFO 2012).

The 2012 survey was conducted between July 18 and August 2 and sampling sites were based on intersections of a regional grid (~5x5 km) extending approximately 2 to 57 km from shore with a range in latitude of 50.7-48.5° extending southward to 10km from the US border (Figure 19). The region was further subdivided into 8 sub-regional strata to aid in the planning of sampling coverage across the region and for future exploration of possible stratification schemes for calculating estimates. Assignment of sampling stations was done by applying proportional probabilities to strata so that each would receive approximately equal sampling intensity. For planning purposes, it was expected that ~70 unique stations would be sampled within a previously defined “core” region (designated initially for the 2011 season).

Biomass estimates for the region have been calculated using mean sardine catch densities (metric ton /km^3) extrapolated over regional or sub-regional surface volume estimates (Schweigert and McFarlane 2001; Schweigert et al 2009; DFO 2012). For each tow, a catch density estimate is calculated as the total weight of sardine divided by an estimate of the volume of water swept while fishing. The volume of water is determined by multiplying the length and width dimensions of the trawl net mouth by the effective fishing distance covered during the tow (distance over ground between end of net deployment and beginning of net retrieval). The core area of the survey region is approximately 16,740 km^2 and catch densities are assumed to represent sardine distributions in the top 30m of the region, therefore the region’s surface volume is estimated at ~ 502.2 km^3 (Figure 19, Flostrand et al 2011).

WCVI survey sardine catch density and length observations

In 2012, a total of 88 trawl tows were made (Figure 19). Four trawl stations were sampled within inlets and 4 stations were sampled seaward of the core region. Replicate sampling was conducted at 13 different stations inside the core region. The incorporation of replicate sampling was to collect information on temporal variation during the survey period representing a time difference of approximately 1 week. The first set of replicate observations had a lower proportion of positive sardine tows but the mean density and variance were greater than that observed in the second set of replicate observations. Excluding inlet sampling, 67 different stations were sampled within the core region and 71 different stations were sampled with the inclusion of the seaward stations.

Compared to observations from previous survey years, overall catch densities in 2012 were considerably lower and no sardines were caught in the northwest and southeast sub-regions (Figures 19 and 20). The low densities may be the result of unfavorable oceanographic conditions off the WCVI for sardines during the survey period.

Randomly selected fresh length samples were taken from 32 tows (100-140 fish per sample sex combined). For pooled (unweighted) sample data, the range in fork length for most sardines was 19-26 cm, with a mean of 22.9 cm and a peak mode at ~21-22 cm and a secondary mode at ~ 23-24 cm (Figure 21).

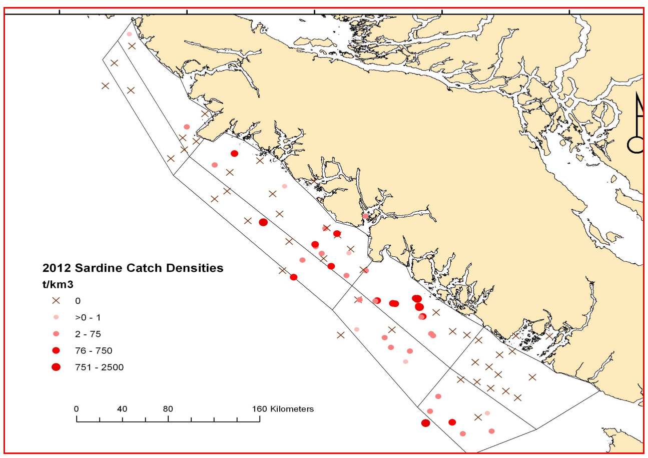


Figure 19. West coast of Vancouver Island 2012 night surface trawl locations and approximate Pacific sardine (*Sardinops sagax*) catch densities for night sampling, occurring between July 18- August 2.

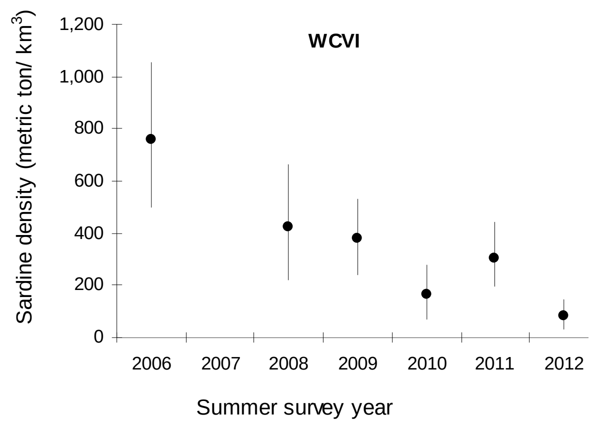


Figure 20: West coast of Vancouver Island 2006-2012 night survey average sardine trawl catch density estimates and 90% bootstrap confidence intervals (in metric tons per km^3). No 2007 survey.

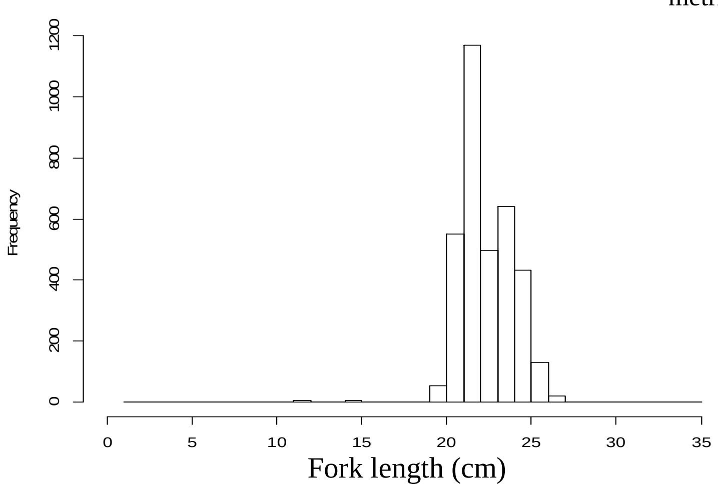


Figure 21. Fork length frequency distributions representing fresh sardines collected in 2012 from the WCVI summer surface trawl survey between July 18 and August 2.

Catches of Spring Chinook salmon:

Source: Bill Peterson, NOAA, NMFS

Trawl surveys have been carried out for 15 years, since 1998, using a Nordic 264 rope trawl fished in the upper 20 m of the water column. Catches of spring Chinook salmon in June 2012 were very high, ranking 2nd among all surveys (Figure 22); catches of coho salmon in September of 2012 were low, ranking 10th of 15 years.

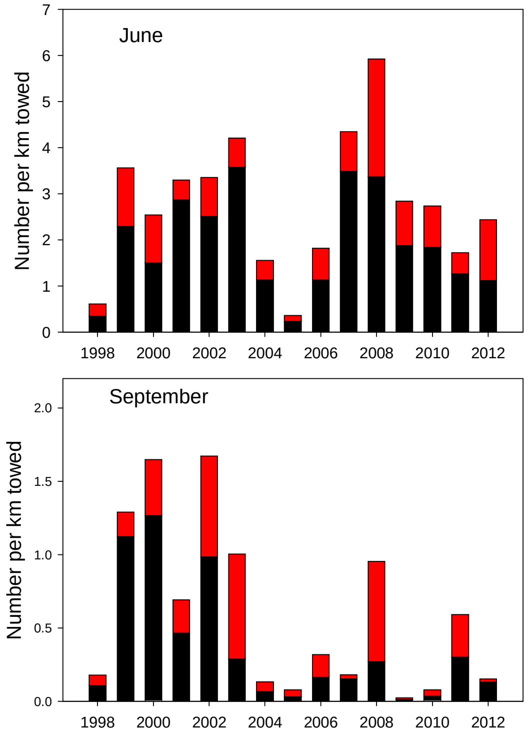


Figure 22. Catches of juvenile salmonids in pelagic trawl surveys carried out in June (upper) and September (lower) in coastal waters off Washington and Oregon. Black indicates juvenile coho salmon (*Oncorhynchus kisutch*) and red juvenile Chinook salmon (*Oncorhynchus tshawytscha*).

West coast Chinook salmon 2012:

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

Ocean catches of Chinook salmon headed for the Sacramento in California and other west coast river drainages indicated good west coast river runs. Half to one fish per rod was typical daily catch aboard recreational Commercial Passenger Fishing Vessels departing central and northern California ports. However, there were places and periods, more frequently in northern California, during 2012 when recreational anglers took daily limits of two Chinook, near port, early in the day. Recreational anglers out of Oregon and Washington ports reported about one Chinook or coho per rod per day during spring and summer. Due to high abundance of Chinook salmon in the coastal ocean and good fishing conditions for northern California commercial fisheries, diminishing market demand forced reduction in prices paid at dockside. This in turn caused temporary reductions in commercial fishing effort.

The spring run Chinook in Butte Creek, a tributary to the Sacramento River, may be the largest run of naturally spawning spring run Chinook in California. Post-season carcass counts suggest that the Butte Creek run was near 16,000 fish. This is the best escapement since 2001 and 2005 when total counts were 18,050 and 16,400, respectively. Spring Chinook escapement improved several fold on upper Battle Creek. Wild and hatchery spring Chinook returns into the Trinity River and its tributaries were relatively good during 2011 and 2012. This year and last were also relatively good years for spring Chinook escapement to the Umpqua River in Oregon where the cumulative counts of over 16,000 fish were the best since 2003. By mid-July a total of

7,725 spring run Chinook salmon had returned to Cole River hatchery on the upper Rogue River. Total count of spring Chinook on the Feather River off the Sacramento was 1,831 and 1,655 in 2011 and 2012. The spring run reached 1,934 on the Umatilla River in Oregon. Cumulative spring and summer Chinook runs at Bonneville Dam on the Columbia River were about equal to the 10-year average.

The escapements of fall and winter run Chinook into the Sacramento and Klamath-Trinity basins have been the best of the last five or six years. The recent trend appears to be toward stronger Chinook salmon runs, but breeding stocks remain small compared to historical assessments. Returns to the Shasta River, a Klamath tributary, reached 27,657, which far exceeded 2011 and 35-year average values. The Klamath-Trinity system hosted an escapement run that was considerably better than 2011 and possibly a modern record. Chinook returns to the Stanislaus River, a tributary to the San Joaquin, numbered 7,019 as compared to about 4,300 annually from 2003 through 2005. On the Russian River, the 6,400 Chinook returns were about 200 more than next highest recent total in 2003. In 1922, 47,500 Chinook were harvested from the Russian River by commercial fishers. Conditions on the Eel River appear to be improving and an estimated 20,000 Chinook entered the river in fall and winter of 2012; this is near estimated historical returns. A weak run of fall Chinook was seen on the North Umpqua River, but it was the best since 2003. Early seine surveys at mile eight on the Rogue River indicated 80% of ten-year averages for fall Chinook. In Alaska, fall Chinook salmon populations have been in decline over the past several seasons. Parts of western Alaska have been designated disaster areas by the Secretary of Commerce because of curtailed catches. These notes come from a wide range of sources and run counts are preliminary. Additional information is available at the Pacific Fisheries Management Council's web site: http://www.pcouncil.org/salmon/stock-assessment-and-fishery-evaluation-safe-documents/review-of-2012-ocean-salmon-fisheries/.

Auklets and shearwaters as indicators of ecosystem change off southern California:

Source: William J. Sydeman and Sarah Ann Thompson (Farallon Institute, Petaluma, CA)

Climate variability is known to affect the structure and productivity of marine ecosystems (McGowan et al. 1998). Top marine predators may respond to this variation through changes in their relative abundance. In particular, seabirds, as conspicuous and highly mobile organisms living at the interface of the atmosphere and the ocean, have been put forth as useful indicators to spatial and temporal variability in marine ecosystems. Surveys of marine birds have been conducted in conjunction with seasonal CalCOFI/CCE-LTER cruises since May 1987 (Veit et al. 1996). The resulting database now contains 90 surveys over 26 years, including information on seabird distribution and abundance through August 2012. Here, patterns of variability are illustrated in the relative abundance of two species, the Sooty Shearwater (*Puffinus griseus*) and Cassin's Auklet (*Ptychoramphus aleuticus*) expressed as natural log of density (ln [birds km^{-2} + 1]). The planktivorous auklet is a resident species of the California Current, breeding locally on the Channel Islands as well as Southeast Farallon Island, ~400km to the north of the study region (Abraham and Sydeman 2004). The omnivorous shearwater breeds in Chile and New Zealand and on other sub-Antarctic islands, and migrates to the California Current during the austral winter. Both species prey upon euphausiid crustaceans, icthyoplankton, and small pelagic fish and squid.

In the southern California study region, auklets are most abundant during winter surveys (January-February). The auklet population declined from the late 1980s through the late 1990s, but was relatively stable thereafter (Figure 23, upper panel). Between years, relative abundance peaked in the springs of 1990 and 2005, as well as during the summers of 2005 through 2007. These peaks may be related to poor food availability for auklet reproduction in these years. When there are inadequate food supplies to support reproductive activities, the auklets may remain at sea in search of food, resulting in short-term increases in relative abundance (Sydeman et al. 2006). In 2012, however, there was nothing unusual in the relative abundance of auklets in any season.

In contrast to the resident auklets, shearwaters are most abundant in the study region during the summer (July-August), with lower relative abundance in spring (April-May). During both seasons, the relative abundance of shearwaters declined (Figure 23, lower panel). In 2012, numbers were substantially reduced from a recent peak in both spring and summer in 2010. While relative abundance general increased during 1996-2002, overall the population numbers appear to have been declining. As with the auklet, these changes in shearwater abundance may be related to short or long-term changes in food availability. Alternatively, population decreases elsewhere could be affecting counts; shearwaters have been declining on some New Zealand islands (Scott et al. 2008). The decline in shearwater density in the CalCOFI/CCE-LTER region corresponds in time with a substantial decline in the relative abundance of larval anchovies (*Engraulis mordax*), though whether these trends are connected is unclear. Determining the relationship between these seabirds and potential prey populations is currently the focus of ongoing research and will be the topic of an upcoming paper.

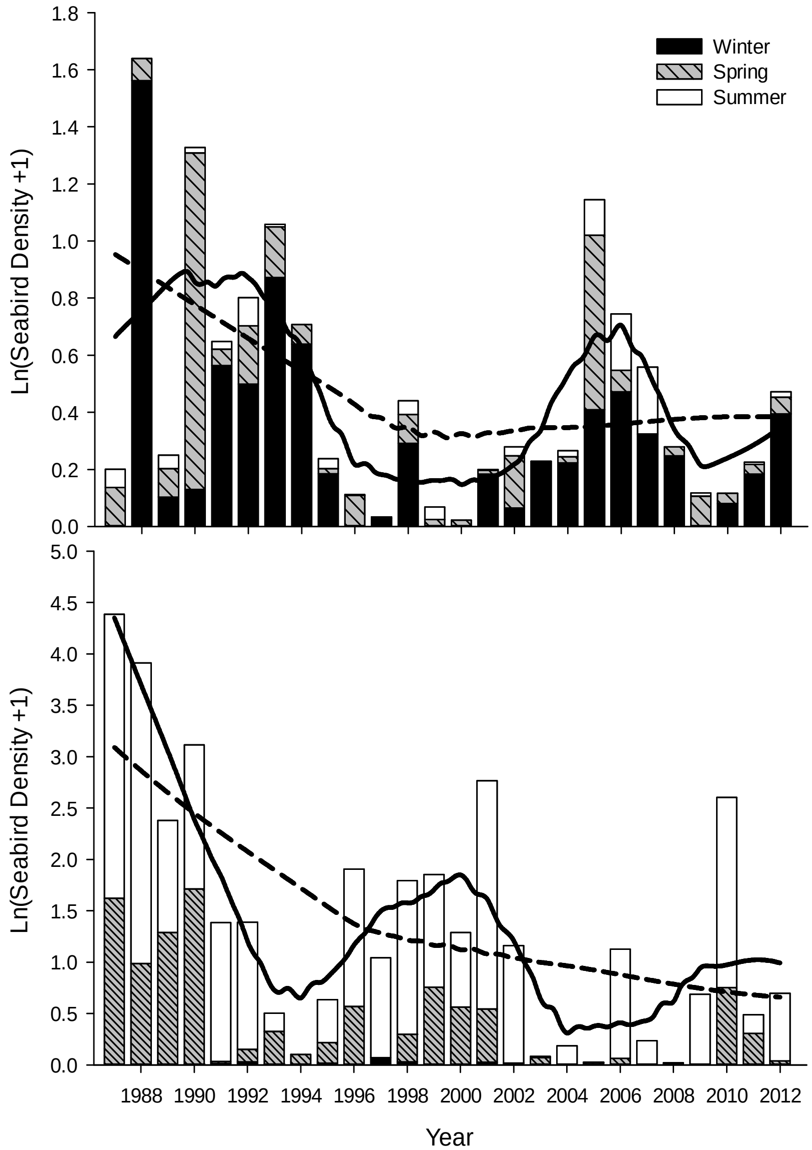


Figure 23. Changes in Cassin's auklet (*Ptychoramphus aleuticus*) (resident, top graph) and Sooty shearwater (*Puffinus griseus*) (migrant, bottom graph) relative abundance (natural log of birds km^{-2}) on 90 CalCOFI/CCE-LTER surveys, May 1987 - July 2012. Stacked bars denote seasonal density estimates, with 2 locally weighted regression (LOWESS) smoothing lines (bandwidths of 0.3 and 0.8) shown based on the summed annual values.

PACIFIC COAST FISHERIES MANAGEMENT SUMMARIES AND RECOMMENDATIONS

Highly Migratory Species (tuna, sharks, billfishes):

The Pacific Fisheries Management Council recommended continuing bilateral negotiations with Canada on the US-Canada Albacore Treaty. They noted that any discussion should address the Canadian catch in US waters; that any new fishing regime should be based on pre-1998 levels of Canadian catch and effort in US waters; and that problems regarding access to Canadian ports by US vessels should be resolved.

In its recommendations to the Western and Central Pacific Fisheries Commission, which coordinates international management of highly migratory species, the Council recommended that the US not agree to conservation measures that disadvantage the US vessels or their access to fair share of the internationally allowed harvest. Further, any agreed-to measures must be equitably enforced by all participating countries and include bycatch and artisanal fisheries.

Coastal Pelagics:

Fourth Quarter 2012 Summary, CA Pacific mackerel and Pacific sardine fisheries:

Monthly CPS landings tables can be found on the web at www.dfg.ca.gov/marine/cpshms/landings.asp.

On November 4, 2011 the Pacific Fisheries Management Council adopted a coastwide harvest guideline (HG) of 109,409 mt for the 2012 Pacific sardine fishery. Subtracting a Tribal Set-Aside of up to 9,000 mt and an exempted fishing permit (EFP) set aside of up to 3,000 mt provides at least 97,409 mt for the non-tribal general fishery which is allocated seasonally as follows:

Coastwide HG = 109,409 mt Tribal set aside = 9,000 mt EFP set aside = 3,000 mt Adjusted HG = 97,409 mt				
	Period 1	Period 2	Period 3	Total
	Jan 1 - June 30	July 1 - Sept 14	Sept 15 - Dec 31	
Seasonal Allocation (mt)	34,093	38,964	24,352	97,409
Incidental Set Aside (mt)	1,000	1,000	1,000	3,000
Adjusted Allocation (mt)	33,093	37,964	23,352	94,409

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