55th Eastern Pacific Ocean Conference

23-26 September 2008

Stanford Sierra Camp, Fallen Leaf Lake, California

MEETING PROGRAM

EPOC President: Jan Newton

EPOC Treasurer: Stephen Pierce

Conference Co-chairs: Eric Bjorkstedt and Chris Edwards

Agenda at-a-glance

Tuesday, 23 September 2008

after 3:00	Arrival and check-in. Take a walk, cast a fly, or gather at the Camp Bar.
6:30 – 8:00	Dinner (available and included in registration package)
8:00 – 11:00	Informal mixer at Fountain.

Wednesday, 24 September 2008

7:15 – 8:15	Breakfast
8:15 – 12:00	Morning Session: Harmful algal blooms (and their benign cousins)
12:00 – 4:00	Lunch and Free Time*
4:00 – 5:30	Afternoon Session: General Contributions I
5:30 – 6:30	Free Time*
6:30 – 8:00	Dinner
8:15 – 10:00	Poster Session

Thursday, 25 September 2008

7:15 – 8:15	Breakfast
8:15 – 12:00	Morning Session: Climate change at regional scales: prediction, detection, and consequences
12:00 – 4:00	Lunch and Free Time*
4:00 – 5:45	Afternoon Session: General Contributions II
5:45 – 6:30	EPOC Business Meeting
6:30 – 8:00	Dinner
8:15 – 9:00	Fireside Chat: "Lake Tahoe: Five decades of change" Dr. Charles R. Goldman, U California, Davis

Friday, 26 September 2008

7:15 – 8:15	Breakfast
8:15 – 12:00	Morning Session: Oceanographic insights and/or products for societal use
12:00	EPOC 2008 closes; Lunch (available and included in registration package)

*** Boating will be available in the afternoons (weather permitting). The Fountain will be open during afternoons and during the evenings, so long as there are some EPOCians hanging out. There are great hiking opportunities nearby, fishing in the lake (get a license!), and perhaps even some Kokanee salmon spawning in one of the Tahoe tributaries. Drag a fellow oceanographer out there with you while you're at it.**

Wednesday, 24 September 2008, Morning session

Harmful algal blooms (and their benign cousins)

Session Chairs: Pete Strutton and John Ryan

Moderator: Pete Strutton

8:30 *The green from the moon: tidal mechanisms for inner shelf phytoplankton production in the Southern California Bight*
Presenter: Drew Lucas

8:45 *Coastal algal blooms in the Southern California Bight*
Presenter: Hey-Jin Kim

9:00 *Phytoplankton blooms in the central and southern California coastal zone: SeaWiFS ocean color data analysis*
Presenter: Nikolay P. Nezlin

9:15 *A dinoflagellate red tide incubator in the California Current System*
Presenter: John P. Ryan

9:30 *Diarrhetic shellfish toxins linked to local* Dinophysis *populations in the California coastal waters of Monterey Bay*
Presenter: Cristy M. Sorenson

10:00 Follow-up questions & discussion

10:15 BREAK

Moderator: John Ryan

10:30 *MOCHA: Monitoring Oregon Coastal Harmful Algae*
Presenter: Pete Strutton

10:45 *Climatology of algal blooms along the Oregon Coast: an emphasis on harmful species*
Presenter: Jacquline Tweddle

11:00 *Climate variability and paralytic shellfish toxins in Puget Sound shellfish: temperature and timing matter*
Presenter: Stephanie Moore

11:15 *Dinoflagellate cyst composition, production, distribution, and sedimentary flux in the Strait of Georgia, BC, Canada*
Presenter: Vera Pospelova

11:30 *Forecasting HABs in the Chesapeake Bay: a model for regional downscaling*
Presenter: Clarissa Anderson

11:45 Follow-up questions & discussion

Wednesday, 24 September, Afternoon Session

General Session I

Moderator: Chris Edwards

4:15 *Multi-nutrient limitation in the Coastal Gulf of Alaska: seasonal and interannual variability*
Presenter: Jerome Fiechter

4:30 *Modeling the phytoplankton community structure in the California Current System*
Presenter: Nicole Goebel

4:45 *Observations from an eddy in the Western Gulf of Alaska*
Presenter: Peter Rovegno

5:00 *Application of fully multivariate 4D-variational data assimilation in the California Current System*
Presenter: Gregoire Broquet

5:15 Follow-up questions & discussion

Thursday, 25 September 2008, Morning Session

Climate change at regional scales: prediction, detection, and consequences

Session Chairs: Emanuele Di Lorenzo and Nicholas Bond

Moderator: Emanuele Di Lorenzo

8:30 *Global climate model evaluation and application on regional scales*
Presenter: John Fyfe

9:00 *On using IPCC model simulations to project changes in climate for marine ecosystems of the eastern North Pacific*
Presenter: Nicholas Bond

9:15 *Linking regional and basin scale climate variability in the Pacific*
Presenter: Emanuele Di Lorenzo

9:30 *Decadal climate variability of the North Pacific: Past and future*
Presenter: Jason Furtado

9:45 *The past and future of coastal and open ocean upwelling in the NE Pacific*
Presenter: Todd Mitchell

10:00 Follow-up questions & discussion

10:15 BREAK

Moderator: Nicholas Bond

10:30 *Interannual variability and modeling of upwelling-driven shelf hypoxia off the central Oregon coast*
Presenter: Jack Barth

10:45 *Comparisons of chlorophyll interannual variability between the Humboldt and California Current Systems*
Presenter: Andrew Thomas

11:00 *Long- and short-term factors affecting seabird population trends in the California Current System, 1985-2006*
Presenter: David Ainley

11:15 *Consequences of changes in mixed layer structure on copepod foraging and production*
Presenter: Andrew Leising

11:30 Follow-up questions & discussion

Thursday, 25 September, Afternoon Session

General Contributions II

Moderator: Eric Bjorkstedt

4:15 *Simulations and observations of circulation in the Oregon Coastal Transition Zone during the 2002-2003 downwelling season*
Presenter: Scott Springer

4:30 *Why isn't hypoxia everywhere? Modulation of hypoxia risk by meso-scale flow-topography interactions*
Presenter: Francis Chan

4:45 *The California Coastal Boundary Layer: Investigating the interaction between coastline features and nearshore velocity*
Presenter: Kerry Nickols

5:00 *Circulation, water temperature, and larval settlement over the inner continental shelf of the Channel Islands, California*
Presenter: Melanie Fewings

5:15 *A Lagrangian view of larval dispersal from a ROMS model of the central California coastal ocean*
Presenter: Patrick Drake

5:30 Follow up questions & discussion

Friday, 26 September 2008, Morning session

Oceanographic insights and/or products for societal use

Session Chairs: Steven Bograd, Loo Botsford, Jan Newton, Steve Ramp

Moderator: Loo Botsford

8:30 *COAST: CSU Council on Ocean Affairs Science and Technology*
Presenter: Toby Garfield

8:45 *CeNCOOS: Responding to our ocean*
Presenter: Heather Kerkering

9:00 *Insights into Hood Canal hypoxia from NANOOS real-time data*
Presenter: Jan Newton

9:15 *Understanding fish kill dynamics in Hood Canal*
Presenter: Allen Devol

9:30 *Fate and transport of San Francisco Bay outflow*
Presenter: John Largier

9:45 *Pilot real-time forecast model of coastal ocean circulation off Oregon*
Presenter: Alexander Kurapov

10:00 Follow-up questions and discussion

10:15 BREAK

Moderator: Steven Bograd

10:30 *Recent high-frequency variability in the PDO and ocean conditions in the northern California Current: Forecasting impacts on ecosystem structure and salmon survival*
Presenter: Bill Peterson

10:45 *On the accuracy of trajectory estimations from HF radar-derived surface currents*
Presenter: Jeff Paduan

11:00 *Incorporating oceanographic observations into descriptions of larval connectivity for marine reserve design*
Presenter: Will White

11:15 *Comparison of a wind-driven Mixed Layer Conveyor model with observations of fluorescence and nitrate from a mooring*
Presenter: Loo Botsford

11:30 *Insights for stock assessment and seabird ecology from an environmentally forced individual-based model of rockfish early life history stages*
Presenter: Eric Bjorkstedt

11:45 Follow-up questions & discussion

Harmful algal blooms (and their benign cousins)

8:30 *The green from the moon: tidal mechanisms for inner shelf phytoplankton production in the Southern California Bight*
Andrew J. Lucas (SIO), Christopher L. Dupont (J. Craig Venter Institute), Peter J.S. Franks (SIO), Vera Tai (SIO), Brian Palenik (SIO)

Notes: Satellite and in situ observations indicate a persistent and strong cross-shore gradient in surface chlorophyll a concentration and phytoplankton biomass over the narrow continental shelf of the Southern California Bight. We show that this gradient is associated with elevated primary productivity and increased nitrate-fueled production in surface waters inshore of the shelf-break. Those incubations, in conjunction with associated assays—including particulate carbon to nitrogen ratios, carbon to chlorophyll ratios, HPLC pigment analysis, and flow cytometry—are consistent in indicating that the inner shelf production is supported by shoaling isopleths of nitrate and diapycnal nitrate flux. Simultaneous observations from a mid- to inner shelf moored ADCP array, autonomous profiling CTDs equipped with fluorometers, and synoptic cross-shelf CTD/F/NO3 sections indicate that the inner shelf is subject to strong baroclinic tidal forcing. This baroclinic tidal forcing causes three phenomena that we hypothesize maintain the cross-shore gradient in phytoplankton production: 1) significant energy from the baroclinic tide is extracted in the mixed bottom boundary layer, which is shallow and coincident with the nutricline and chlorophyll maximum over the inner shelf; 2) the onshore flux of baroclinic energy leads to a pycnocline set-up that is analogous to surface wave set-up and is responsible for a ~20 m shoaling of the nutricline over the 15km wide shelf; and 3) shoaling, breaking and eventual dissipation of high-frequency internal waves associated with the baroclinic tide over the inner shelf acts as an active nutrient pump during periods of strong internal wave activity. While the inner shelf of the southern California Bight is relatively unique in that wind forcing and continental run-off are not important during much of the year, we expect that the role of the baroclinic tide in fueling new production is often important in other narrow shelf settings, particularly in the absence of wind forcing or between wind events.

8:45 *Coastal algal blooms in the Southern California Bight*
Hey-Jin Kim (MBARI), Arthur J. Miller (SIO), John McGowan (SIO), Melissa L. Carter (SIO)

Notes: Surface chlorophyll measured at the Scripps Pier in the Southern California Bight for eighteen years (1983 - 2000) reveals that the spring bloom occurs with irregular timing and intensity each year, unlike sea-surface temperature (SST), which is dominated by a regular seasonal cycle. In the 1990's, the spring bloom occurred earlier in the year and with larger amplitudes compared to those of the 1980's. Seasonal anomalies of the chlorophyll have no significant correlation with local winds, offshore winds, or upwelling index anomalies. Consequently, classical coastal upwelling may not be the process that drives chlorophyll variations in the nearshore SCB. The interannual variations of the Pier SST and chlorophyll is not correlated with tropical El Niño or La Niña conditions over the entire observing period, but a few strong El Niño and La Niña events have significant impacts on the Pier data. The annual mean Pier chlorophyll concentration exhibits a clear increasing trend with no concomitant trend evident in the Pier SST over these two decades.

Harmful algal blooms (and their benign cousins)

9:00 *Phytoplankton blooms in the central and southern California coastal zone: SeaWiFS ocean color data analysis*
Nikolay P. Nezlin (SCCWRP), Paul M. DiGiacomo (NOAA), Burton H. Jones (USC), Richard P. Stumpf (NOAA)

Notes: The frequency of occurrence of phytoplankton blooms in the central and southern California coastal zone was assessed using >10 years of SeaWiFS ocean color observations (1997-2007). Blooms events were estimated on the basis of remotely-sensed chlorophyll (CHL) anomalies, defined as the observations when the difference between CHL and the CHL median during the 60-day preceding period exceeded 1 mg m^-3. In the central California, the period of bloom events occurred from spring to autumn and coincided with seasonal upwelling. In the Southern California Bight (SCB) bloom events were most frequent in spring (February-April). No correlation was found between the upwelling index, calculated as an offshore Ekman drift, and the frequency of upwelling events, estimated on the basis of remotely-sensed sea surface temperature (SST) measured by AVHRR infrared satellite sensors. In terms of SST, upwelling events associated with spring transition were pronounced in the central California and the northern part of SCB; further to the south upwelling events were less evident. Maximum frequency of upwelling events occurred in 2003 and 2005, resulting in intensive phytoplankton blooms throughout SCB. The blooms in 2005 were more intensive then in 2003, seemingly resulting from the combined effect of upwelling and rainwater discharge. Blooms were most frequent in semi-encloses regions like Santa Barbara Channel, Santa Monica Bay and San Pedro Shelf. Maximum bloom frequency mostly coincided with spring upwelling; however, in proximity of freshwater outfalls (Santa Clara, Los Angeles/San Gabriel, Santa Ana and Tijuana Rivers) blooms were observed all year round. Highest bloom intensity in the semi-encloses regions can be partly explained by sluggish circulation and long residence time, resulting in more persistent CHL (including CDOM) response to upwelling and freshwater discharge events.

9:15 *A dinoflagellate red tide incubator in the California Current System*
John P. Ryan (MBARI), James F. R. Gower (Institute of Ocean Sciences), Stephanie A. King (IOS), W. Paul Bissett (Florida Environmental Research Institute), Andrew M. Fischer (MBARI), Raphael M. Kudela (UCSC), Zbigniew Kolber (MBARI), Fernanda Mazzillo (UCSC), Erich V. Rienecker (MBARI), Kenneth S. Johnson (MBARI), Francisco P. Chavez (MBARI)

Notes: Novel remote sensing methods and in situ observations reveal that intense phytoplankton blooms occur frequently in Monterey Bay, California. Blooms can contain surface chlorophyll concentrations two orders of magnitude above average and occupy approximately 3 to 80 km^2. They occur primarily during August - November and can persist for more than a month. Maximum bloom frequency and mean intensity are in shallow (less than 25 m depth) water of the northeastern bay, in coincidence with the warmest surface water, low wind stress, and retention of shallow waters. These conditions favor dinoflagellates, which can vertically migrate to acquire nutrients in the thermocline and aggregate as "red tide" near the surface. High-resolution mapping and sampling in the bloom area indicate that concentration of dinoflagellate blooms can occur in frontal zones. This bloom area receives nutrients from natural oceanographic processes and land-sea exchanges. Such coastal bloom incubation areas may disproportionately influence regional bloom ecology.

9:30 *Diarrhetic shellfish toxins linked to local* Dinophysis *populations in the California coastal waters of Monterey Bay*
Cristy M. Sorenson, Mary Silver (UCSC)

Notes: *Dinophysis*, including species known to produce DSP elsewhere, have been recognized for many decades in this region and, indeed, throughout much of California. Our goal was to determine the annual cycle for the local dominant *Dinophysis* species, *D. acuminata* and *D. fortii*, and to discover whether there is a correlation between their abundance and DSP toxins in CA mussels, *Mytilus californianus*, in the bay. Using weekly water and mussel samples for 16 months at the Santa Cruz Municipal Wharf in Monterey Bay, we found a significant association between *Dinophysis* abundance and DSP toxins in mussels. Peak densities of *D. acuminata* and *D. forti*i occurred during the summer months when the majority of DSP toxins were detected in the CA mussel samples. A significant correlation between D. fortii cell numbers and okadaic acid (OA) concentrations in mussels during the 2004-2005 sampling period indicates this species may be the OA source. The correlation coefficient weakened with the addition of *D. acuminata*, suggesting that *D. acuminata* may have little to no role in OA production in Monterey Bay. Since DSP toxins are lipophilic, we also correlated toxin levels in mussels not just with the cell densities on the week the mussels were harvested but also with densities averaged over the prior several weeks. Results of these correlations indicate toxins in mussels were mostly strongly related to cell averages obtained over the prior several weeks, rather than on the week of collection. This result will help us predict the retention time of DSP toxicity in mussels. Although none of the CA mussel samples contained toxin levels that exceed the regulatory limit set by Canada, (1.0 μg per gram of digestive gland for any combination of OA/DTX-1), DSP may potentially be a health threat during peak *Dinophysis* events in Monterey Bay, and possibly more broadly in California.

10:30 *MOCHA: Monitoring Oregon Coastal Harmful Algae*
Pete Strutton (OSU), Jacqui Tweddle (OSU), Michelle Wood (U Oregon), Allison Poole (U Oregon), Bill Peterson (NOAA/NMFS/NWFSC), Linda O'Higgins (NOAA/NMFS/NWFSC), Dave Foley (NOAA CoastWatch), Matt Hunter (ODFW), Zach Forster (ODFW), Deb Cannon (ODA)

Notes: With funding from NOAA OHH and MERHAB, we have been combining satellite and in situ data to further our knowledge of the oceanographic conditions that lead to HABs and their interaction with the Oregon coast. The principal phytoplankton genera of interest are *Pseudonitzschia* and *Alexandrium* which can cause domoic acid or saxitoxin accumulation, respectively, in coastal shellfish, primarily razor clams, thus presenting a human health hazard. This presentation will summarize our results thus far. Using historical data on the levels of toxins in shellfish at approximately 20 locations along the Oregon coast, we have identified hot spots of frequent contamination. We have quantified a link between El Nino events and saxitoxin occurrence. Cluster analysis has identified regions of the coast that are subject to shellfish closures at the same time (or not), thus potentially streamlining the process of identifying 'at risk' locations. A new satellite product for bloom identification has been developed and disseminated. Satellite analyses have provided insight into the relationship between bloom development, nearshore winds and landfall of toxic blooms.

10:45 *Climatology of algal blooms along the Oregon Coast: An emphasis on harmful species*
JF Tweddle (COAS, OSU), P Strutton (COAS, OSU), D Foley (NOAA CoastWatch), Z Forster (ODFW), M Wood (U Oregon), M Hunter (ODFW), D Cannon (ODA)

Notes: Harmful algal blooms (HABs) have economic and human health impacts on communities along Oregon's coast. Here satellite chlorophyll, sea surface temperature and wind data, in conjunction with in situ cell counts and toxin analyses, are used to investigate the climatology of algal blooms along the Oregon coast. Latitudinal differences in the onset of upwelling, and of bloom initiation, peak concentrations, and bloom demise can be seen from the satellite data. Annual cycles in toxin concentrations confirm that HABs are most prevalent during and towards the end of the upwelling season, but domoic acid also shows a April-May peak at most locations, before upwelling is generally established, which corresponds to the timing of the spring bloom in adjacent stratified waters. This work provides the basis for more focused ocean and shellfish sampling on the Oregon coast, and improved public health protection.

11:00 *Climate variability and paralytic shellfish toxins in Puget Sound shellfish: Temperature and timing matter*
Stephanie Moore (NOAA/NMFS/NWFSC), Nathan Mantua (U Washington), Vera Trainer (NOAA/NMFS/NWFSC), Barbara Hickey (U Washington)

Notes: The influence of large-scale climate variations on oceanographic properties and paralytic shellfish toxins (PSTs) in Puget Sound are investigated using continuous profile data at 16 stations from 1993, records of sea surface temperature and salinity from 1951, and observations of shellfish toxicity from 1957. In Puget Sound, PSTs are produced by the harmful dinoflagellate species *Alexandrium catenella* and can accumulate in filter-feeding shellfish. Puget Sound's oceanographic properties have significant correlations with El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) variations in winter. Warm winter temperature anomalies during the El Niño phase of ENSO do not persist for long enough to overlap with the annual time period that shellfish accumulate PSTs in Puget Sound, which is typically from July through November. Consequently, we find no robust relationship between ENSO and PSTs. In contrast, warm winter temperature anomalies during the warm phase of PDO persist for 4 to 5 seasons or more with re-emergence the following year. We hypothesize that the greater persistence of PDO variations widens the window of favorable growth conditions for *A. catenella* based on the number of days that sea surface temperatures exceed 13°C annually, resulting in shellfish acquiring higher concentrations of PSTs during warm phases.

11:15 *Dinoflagellate cyst composition, production, distribution, and sedimentary flux in the Strait of Georgia, BC, Canada*
Pospelova, V., Esenkulova, S. (U Victoria)

Notes: Dinoflagellates are one of the most abundant and diverse groups of the phytoplankton in coastal and estuarine waters. Many dinoflagellates produce resting cysts that are preserved in the sediments, thus encoding information on the dinoflagellate populations over time, which in turn are influenced by environmental factors. It is now well accepted that dinoflagellate cysts have great potentials to serve as indicators of modern and paleoenvironmental conditions. Successful cyst-based environmental reconstructions require studies of modern dinoflagellate cyst production and distribution as a function of environmental variables.We present results of the ongoing extensive study of diversity and seasonality of dinoflagellate production in the coastal and estuarine waters of British Colombia. Surface sediment and trap samples from the Strait of Georgia are studied in this work. The deployment of the sediment trap took place from 1996 to 1999 resulting in the collection of high-resolution (biweekly) sequence of sediments, whereas the surface sediments represent ~2-10 years of deposition. The spatial and temporal cyst sedimentary flux provides estimates of the variation in cyst production in the Strait of Georgia. A statistical analysis demonstrates that cyst distributions are influenced by the offshore proximity, distance to Vancouver Harbor, spring sea surface salinity, and productivity. Identification of species composition in the sediment trap reveals valuable information on the duration and intensity of blooms of cyst-producing dinoflagellates, including toxic species such as *Alexandrium minutum*, *Protoceratium reticulatum*, and *Gonyaulax spinifera*. The 1997-98 El-Niño resulted in the significant, up to a few °C, upward shift of the sea-surface temperature, and it is detectable in the dinoflagellate cyst record.

11:30 *Forecasting HABs in the Chesapeake Bay: A model for regional downscaling*
Clarissa Anderson (UCSC), Christopher Brown (NOAA/NESDIS/CICS), Raghu Murtugudde (U Maryland), Raleigh Hood (Horn Point Laboratory, U Maryland), Wen Long (Horn Point Laboratory, U Maryland), Peter Tango (USGS), Mathew Sapiano, (NOAA/NESDIS/CICS), Anne Thessen (Marine Biological Laboratory)

Notes: Recent downscaling efforts for the Chesapeake Bay have led to an open source, hydrodynamic model currently being applied to empirical habitat models for various harmful algal bloom taxa. I will discuss the development of statistical models for predicting potentially toxic *Pseudo-nitzschia* spp. blooms in the Bay and present hindcasts and forecasts of bloom probabilities using ChesROMS. Environmental parameters significantly associated with toxigenic diatom blooms in the Bay have also been shown to be important for these blooms off the coast of central California. Future work will focus on applying similar empirical methods to a wide array of regional California HAB data to assess forecasting capabilities in the CA Current.

4:15 *Multi-nutrient limitation in the Coastal Gulf of Alaska: Seasonal and interannual variability*
Jerome Fiechter (UCSC), Andrew M. Moore (UCSC), Hernan G. Arango (Rutgers)

Notes: Nutrient limitation and regional ecosystem dynamics in the northwestern Coastal Gulf of Alaska (CGOA) on monthly to interannual timescales is investigated by coupling a lower trophic ecosystem model to a three-dimensional coastal ocean circulation model. By including explicit growth limitation by light, nitrate, ammonium, silicate, and iron, the ecosystem model provides an ideal framework to investigate the combined role of macro- and micro-nutrients in shaping phytoplankton community structure. Based on comparisons with available in situ and remotely-sensed observations for 1998 through 2002, the model reproduces the dominant modes of variability associated with the northwestern CGOA ecosystem dynamics. Empirical orthogonal functions (EOFs) for nutrient limitation indicate alongshelf variations in diatom growth regime, with the northeast subregion limited mainly by nitrate, and the southwest subregion limited by both nitrate and silicate. At the shelfbreak, iron limitation regulates diatom growth, and changes in dissolved iron availability in that region will likely shift the cross-shelf phytoplankton community structure between the diatom-dominated shelf population and nanophytoplankton-dominated basin population. Furthermore, the EOFs suggest that regions where nitrate, silicate, and iron most severely limit phytoplankton growth vary temporally, which implies that not only the frequency, but also the timing of cross-shelf transport events will affect seasonal and interannual CGOA ecosystem variability.

4:30 *Modeling the phytoplankton community structure in the California Current System*
N.L. Goebel (UCSC), C.A. Edwards (UCSC), J.P. Zehr (UCSC), M.J. Follows (MIT)

Notes: Observations of phytoplankton within the California Current System reveal substantial variations in community structure in different biogeographical zones and in season. Modeling such diversity is challenging with typical ecosystem models that include a single representation of only a few functional groups. We approach this problem using a relatively new ecosystem model that resolves several functional groups and includes multiple phytoplankton types within each group. This model is embedded within a realistic circulation model of the California Current System (CCS) using the Regional Ocean Modeling System. Our goal is to understand the processes that control phytoplankton functional groups and their specific roles in a larger ecosystem. The model is seeded with 78 phytoplankton types with randomly assigned physiological traits. The resultant modeled functional groups and their biogeographic zones and seasonal variability that emerge resembles that observed in the CCS. In particular, the model captures the climatological seasonal structure in the coastal phytoplankton community, the robust spring bloom of coastal diatoms, and the offshore presence of Prochlorococcus-like organisms. Interannual variability and coexistence of phytoplankton types are also features of the model output.

4:45 *Observations from an eddy in the western Gulf of Alaska*
Peter Rovegno (UCSC), Chris Edwards (UCSC), Ken Bruland (UCSC)

Notes: Mesoscale anticyclonic eddies are thought to be an important contributer to biological productivity in the northern Gulf of Alaska through the transport of iron-rich shelf water into the High-Nutrient Low-Chlorophyll (HNLC) waters of the central Gulf. Three formation regions for such eddies in the eastern Gulf of Alaska have been previously identified and studied (Yakutat, Sitka, and Haida eddies). During August-September 2007 we sampled an eddy off of Kodiak Island. Subsequent analysis of the hydrographic data and satellite altimetry suggests that this particular eddy originated off the shelf near Cook Inlet in the western Gulf of Alaska, perhaps revealing a previously unknown eddy formation region. We present details of the analysis that leads to this conclusion.

5:00 *Application of fully multivariate 4D-variational data assimilation in the California Current System*
Gregoire Broquet (UCSC), Christopher A. Edwards (UCSC), Andrew M. Moore (UCSC), Brian S. Powell (U Hawaii), Milena Veneziani (UCSC), James D. Doyle (NRL), Hernan G. Arrango (Rutgers), Javier Zavala-Garay (Rutgers)

Notes: The Incremental Strong constraint 4D Variational (IS4DVAR) data assimilation system of the Regional Ocean Model System (ROMS) is used to study the controllability of a realistic, high resolution configuration of the California Current System. The model is forced with regional COAMPS (Coupled Ocean / Atmosphere Mesoscale Prediction System) atmospheric data and with ECCO (Estimating the Circulation and Climate of the Ocean) data at the open boundaries. Climatological fields and both satellite-derived surface along with in situ observations are assimilated successfully to improve significantly many characteristics of model dynamics and forcing. The parameterization of the background error statistics is shown to be particularly critical to provide a compatible and consistent use of these different observations.

POSTER SESSION: Harmful algal blooms (and their benign cousins)

Preliminary analysis of domoic acid in Oregon coastal waters

A. Poole (U Oregon), A. M. Wood (U Oregon), B.-T. Eberhart (NOAA/NWFSC), V. L. Trainer (NOAA/NWFSC), J. Tweddle (OSU), P. Strutton (OSU), L. O'Higgins (NOAA/NWFSC), B. Peterson (NOAA/NWFSC), M. Hunter (ODFW), Z. Forster (ODFW)

Notes: We have analyzed concentrations of dissolved and particulate domoic acid (DA) in several hundred water samples collected from multiple research expeditions off the Oregon coast between June 2006 and September 2008 as part of Oceans and Human Health funded research on harmful algal blooms and in connection with the new MERHAB project MOCHA (Monitoring Oregon Coastal Harmful Algae). DA values were determined using an indirect competitive ELISA developed at the Northwest Fisheries Research Center (Marine Biotoxins group) and used routinely by ORHAB (Olympic Region Harmful Algal Bloom Research Partnership). In an effort to improve our understanding of harmful algal blooms on the Oregon coast, we examine the relationship of DA concentration in our samples with water mass structure as revealed from satellite remote sensing and the abundance and diversity of potential sources of DA in phytoplankton samples.

Generation and seasonal evolution of the Juan de Fuca Eddy - a source region of toxic Pseudo-nitzschia *to the Washington coast*

Amoreena MacFayden (U Washington), Barbara Hickey (U Washington), Vera Trainer, (NOAA/NWFSC)

Notes: The Juan de Fuca eddy is a toxic "hotspot". Domoic acid (DA) was detected in the eddy during each of six cruises over a 4-year Ecology and Oceanography in the Pacific Northwest (ECOHAB-PNW) study, although *Pseudo-nitzschia* abundance and toxin concentrations were highly variable. Our results support the hypothesis that the Juan de Fuca eddy region, and not the nearshore zone, is the primary initiation site for toxic blooms of *Pseudo-nitzschia* affecting the Washington coast. The presence of the eddy facilitates large inputs of dissolved inorganic nutrients into the region through two mechanisms: doming of California Undercurrent water within the eddy and enhanced cross-shelf advection of Juan de Fuca Strait outflow. However, no first order predictive relationships were found for either *Pseudo-nitzschia* abundance or DA concentration and environmental data from all six cruises. A prognostic, circulation model is used to model the generation and evolution of the Juan de Fuca Eddy under steady and time-variable wind-forcing and to examine subsequent retention or escape of surface waters (and plankton) residing in the eddy. Results indicate both enhanced upwelling off Cape Flattery and at the head of the Tully Canyon are important in eddy generation. When the model is forced with a sequence of alternating upwelling- and downwelling-favorable wind-forcing, the eddy increases rapidly in spatial extent as "new" eddies formed near Cape Flattery move westward into the existing eddy. Retention or escape of surface waters from the eddy is determined not only by frictional effects in the surface Ekman layer, but also by modification of the baroclinic structure of the eddy in response to prevailing wind conditions.

POSTER SESSION: Climate change at regional scales: prediction, detection, and consequences

Long term changes in the magnitude and timing of coastal upwelling in California
Marisol Garcia-Reyes, John Largier (UCD/BML)

Notes: The global increment of the surface temperature leads us to question the effect of such change in smaller scale processes like coastal upwelling, which behavior depends directly on the temperature of oceans and land. Predictions of increased geostrophic alongshore winds, due to a larger temperature difference between land and ocean, has not been fully proven, as the trends are small and the abrupt change between large warm and cold anomalies in 1997-2001 makes the interpretation of results difficult. In addition, most studies are based on the scale of the east current systems of which coastal upwelling system is only a part. These current systems present changes that are not a consequence of coastal upwelling, such as warmer or colder temperatures due to intrusion of water from other latitudes or changing depth of the thermocline due to large scale temperature anomalies. Therefore, changes in coastal upwelling should be studied with a local approach to separate it from the current system, but considering larger scale effects. Many studies focus on the magnitude of the upwelling, however, the spring transition, length of the upwelling season and high frequency variability of winds are parameters that should be analyzed at the same time as they are equally important for the ecosystem. In this work, NDBC buoys data is analyzed to investigate the long term variability of coastal upwelling. Annual, monthly and daily means of the upwelling forcing (wind stress and upwelling index) and response (sea surface temperature) are used to study the changes in magnitude, timing and synoptic variability of coastal upwelling through the 25 years of available data.

Immersive multi-scale visualization of downscaling climate models
Albert Hermann (U Washington, JISAO) , Joseph Sirott (U Washington, JISAO), Nancy Soreide (NOAA/PMEL)

Notes: Model-based downscaling of global climate change to the regional level typically involves the use of spatially nested models, from a relatively coarse global simulation to fine spatial and temporal resolution in the region of interest. Interpretation of this output is facilitated by a simultaneous examination of both large and small scale phenomena. Increasingly the output from such models (and data) can be retrieved online, e.g. through Live Access Server technology. Such technologies allow the simultaneous display of output from multiple sources (e.g. multiple models from a nested set) within a single geospatial viewer such as Google Earth. This geospatial software has the attractive ability to navigate from a large-to-fine-scale view of the globe, and to interactively re-render scenes using model output (or data) most appropriate to the user's view. Here, a portable stereo-immersive system (a "Geowall") will be used to illustrate the 3-D structure of output from an online set of downscaling physical and biological models of circulation and biology in the Coastal Gulf of Alaska. Participants will be given the opportunity to interactively choose online data, then "fly through" and examine these and other fields of interest.

POSTER SESSION: Oceanographic insights and/or products for societal use

Oceanographic connections: Surface water movement along the central and northern California coast as revealed by HF radar particle tracking

Chris Halle (UCD), John Largier (UCD/BML)

Notes: As part of the Coastal Ocean Currents Monitoring Program (COCMP), High Frequency Radar (HF-Radar) units have been in operation along most of the central and northern California coast for two years. Both standard-range (~ 2km resolution, 60 km range) and long-range (~ 5 km resolution, 200 km range) systems are used to provide hourly maps of offshore surface currents over the region from Santa Cruz to Point Arena, California. The dense array of HF-Radar Eulerian estimates provides a basis for simulating Lagrangian measurements (particle tracks). These pseudo-drifters reveal the connections between oceanographic regions (or coastal locations) in a level of detail not possible with more conventional systems. For example, a substantial fraction of the water from the Point Arena upwelling "hotspot" is entrained in a large-scale recirculation during upwelling conditions, increasing its travel time to productive marine sanctuaries in the south from a few days to over two weeks. This presentation focuses on determining the destinations of water originating near the Point Arena "hotspot", tracking a vigorous northward flow event along the coast from San Francisco Bay to Point Arena, and, predicting potential dispersal patterns for larvae originating in Bodega Bay. Future research challenges include developing realistic "interpolation" schemes to estimate the currents closest to the shore that are not measured by the radars, and establishing rigorous criteria to quantify the accuracy of particle tracks.

Spectrum analyses and divergence patterns in the Gulf of the Farallones using HF radar measured surface currents

Matt Gough (SFSU), Toby Garfield (SFSU)

Notes: An array of three high frequency (HF) radar stations have been monitoring sea surface currents in the Gulf of the Farallones off the Coast of San Francisco, California since May 2006 as part of the State Coastal Conservancy funded Coastal Ocean Currents Monitoring Program (COCMP). In a previous study we performed harmonic tidal analyses on HF radar measured surface currents in the Gulf. Here, we extend upon that study by performing rotary spectrum analyses on the surface currents and NDBC buoy 46026 winds to identify frequencies not determined by tidal harmonics. In addition to this, we examine specific time periods where surface currents demonstrate significant divergence patterns.

Advances in use of altimeter data in coastal domains
P. Ted Strub (OSU), Corinne James (OSU)

Notes: Satellite altimeter data suffer from a number of problems within approximately 50 km of land. The actual return signal from the radar (the EMR reflected from the ocean surface) is affected when land is within 10-20 km of the satellite nadir track (the central point of the radar reflection). More importantly, a number of the "corrections" to the sea surface height (SSH) are also affected. SSH is calculated from the time taken for the radar signal to travel from the satellite to the ocean surface and back to the satellite - the "path delay." This path delay is affected by the amount of water vapor in the atmosphere and characteristics of the sea surface, mostly related to significant wave height (SWH). The SSH must also be corrected for changes in SSH caused by tidal signals and other high frequency SSH signals (caused by coastal trapped waves, internal tides, etc.) that are not well resolved by the altimeter sampling characteristics. For instance, the integrated atmospheric water vapor is estimated from an onboard, multi-frequency microwave radiometer that has a "footprint" diameter of approximately 50-100 km, eliminating use of this correction within 25-50 km of the coast. SWH, external and internal tidal signals and coastal trapped waves may all change their characteristics over short spatial scales over the continental shelf, requiring changes in estimates of these corrections as well. Thus, alternative strategies for retrieving the altimeter SSH data are needed over the continental shelf and within 50 km of land, even if a shelf is not present (islands and coastal regions with little or no shelf). We will describe the present state of the art in use of altimeter data in coastal regions, which is a topic of active research by an international community of oceanographers and radar experts that has begun to meet periodically (http://cioss.coas.oregonstate.edu/altimeter_workshop.html), with the next workshop scheduled for November in Pisa, Italy (http://www.coastalt.eu/pisaworkshop08).

Space/time evolution of low salinity events along the Oregon coast
Risien, C.M., J.A. Barth, P.M. Kosro, M.D. Levine, R.K. Shearman, W. Waldorf (OSU)

Notes: The Oregon Coastal Ocean Observing System (OrCOOS), a subregional partner of NANOOS (Northwest Association of Networked Ocean Observing Systems) brings together observations along the Oregon coast to help address issues related to, for example, ecosystem preservation and management. To this end, OrCOOS currently maintains a research mooring at NH-10, a site located 10 nautical miles off Newport, Oregon along the Newport Hydrographic line in 80 meters of water. A varying set of moored instrumentation has been deployed at this location beginning in 1997. The present NH-10 mooring, first deployed in July 2006, consists of a suite of meteorological sensors as well as 13 sensors that span the water column from 2 to 73 meters. Meteorological and oceanographic observations, including water temperature, conductivity and dissolved oxygen, are telemetered to shore every 6 hours allowing researchers the opportunity to monitor ocean conditions in near real-time (NRT). Using these and other NRT observations we identify and track a low salinity (< 30 PSU) event, in space and time, along the Oregon coast. The evolution of this event, which occurred in May 2008, is presented using in situ and remotely sensed datasets. Results confirm that the source water for this particular event is the Columbia River plume, which is thought to be ecologically important to surface feeding planktivores such as larval and juvenile fish. The freshwater feature takes approximately 10 days to reach NH-10 and is pushed onshore by downwelling favorable winds.

Web-based multimedia educational products for the Central and Northern California Ocean Observing System (CeNCOOS)
Matthew Binder (CeNCOOS)

Notes: The development and distribution of web-based multimedia educational products has been facilitated by the increasing capabilities of computers to more readily deliver, receive, and process larger quantities of rich digital media. Interactive multimedia educational programs that are produced according to sound instructional design principles have proven to be educationally valuable. Such methods stem from comprehensive research efforts on learning theory in relationship to specific instructional methodologies conducted by Robert Gagne and have since been applied to educational program design, particularly where instructional technology and multimedia are concerned. The Central and Northern California Ocean Observing System (CeNCOOS) is one of the eleven regional associations involved in on-going ocean observing activities in the United States. These regional associations comprise the Integrated Ocean Observing System, or IOOS. In addition to being committed to ocean observing science, an emerging role of these IOOS members will be to promote ocean literacy through improved education and outreach efforts. These efforts will undoubtedly involve the development of interactive multimedia educational products which can then be accessed by teachers, students, and the general public alike through the website of that particular regional IOOS member. The CeNCOOS Classroom Series Educational Product Suit, which is currently available through the Classroom link at www.cencoos.org, represents such efforts and is the result of work conducted during the 2008 Summer Internship Program at the Monterey Bay Aquarium Research Institute (MBARI).

Measuring surface currents along California's North Coast using high-frequency radar: Trials and triumphs
Shannon Stone, Greg Crawford, Laurie Roy (HSU)

Notes: The Coastal Ocean Currents Monitoring Program (COCMP) is a statewide effort to measure surface currents along the California coast. As part of this project, Humboldt State University (HSU) has been allocated four long range (LR; > 200km) high frequency radars (Codar Ocean Sensors) to measure surface currents from the California-Oregon border to Point Arena. Implementation of the radar network in this region has been problematic, owing to a sparse population density and lack of infrastructure along the California's North Coast. Despite these hurdles, HSU is now operating two LR systems and collaboratively operating a third. In this presentation, we provide an update on the status of the COCMP radar system implementation and discuss the preliminary results of surface current measurements in this poorly studied region.

Standardizing the delivery of coastal water monitoring data in the CeNCOOS (Northern and Central California) region

Dale Robinson (SFSU), Krista Kamer (SFSU), Marcel Losekoot (UCD/BML), John Graybeal (MBARI), Raphael Kudela (UCSD), John Largier (UCD/BML), Frank Shaughnessy (HSU), Toby Garfield (SFSU), Steve Ramp (CeNCOOS)

Notes:

In the field of ocean observing there are nation-wide efforts to develop integrated systems to deliver ocean-related data to end users. As envisioned, these are end-to-end systems that handle data from the point of collection, through processing and quality control, to archival and dissemination. Development of the infrastructure and standards to implement these systems is underway, but is not yet complete. For example, standards describing file format and structure for data and metadata are often generalized to increase flexibility and, although standardized vocabularies are available, standard names for data parameters are inconsistent and all of the variables measured a data provider may not be included in a single vocabulary. As a result, data files made available for distribution could vary considerable in their format, structure, vocabulary, and the quantity and quality of metadata, making collection and integration of disparate data difficult. This eventuality presents a challenge for regional ocean observing systems charged with collecting data from local data providers and making it available in compliance with national standard, and for individual data providers trying to contribute to the larger data integration effort on a limited budget. Here we describe an effort to standardize the output of water monitoring data within the CeNCOOS geographical region by defining a rigorous strategy to the format, structure, vocabulary, and metadata used for data. Knowledge sharing is included in the effort to make the approach available in the form of a set-by-step guide or "cookbook" that can be easily adopted by data providers with limited resources. Additional benefits of the data delivery strategy are scalability to allow expansion to larger geographical areas and a broader range of data, flexibility to incorporate future changes in file format, structure, and content as emerging national standards become available, and compatibility with OPeNDAP servers and common database management systems.

The Trinidad Head Line: Development of a NMFS-HSU collaboration in support of three OOS

Eric Bjorkstedt (NMFS/SWFSC, HSU), Ashok Sadrozinski (HSU), Abby Johnson (HSU), Scott Quackenbush (HSU), R. Scott Martin (HSU), Jim Howard (HSU), Churchill Grimes (NMFS/SWFSC), Jonathan Phinney (NMFS/SWFSC)

Notes:

Since early 2006, a collaborative effort between NOAA's Southwest Fisheries Science Center and Humboldt State University (HSU) has been conducting ocean observing surveys as part of the Pacific Coast Ocean Observing System (PaCOOS). To date, over a dozen,cruises have returned data on hydrographic structure, fluorescence, dissolved oxygen, zooplankton settled volumes, and distributions of larval fishes and other zooplankters in relation to hydrography along a 40 km transect lying due west of Trinidad Head, California. Looking forward, we plan to enhance the data stream by conducting monthly cruises, collecting samples and data with newly acquired CUFES, ADCP, and water sampling instruments, developing our capacity to extract information on copepods and other key taxa from zooplankton samples, integrating our findings with observations from the HF radar network that has recently been extended to the North Coast, and collaborating with colleagues to the north (Newport) and south (Bodega Marine Laboratory) to implement biological sampling protocols that will allow direct comparisons of zooplankton communities along a broad stretch of the U.S. West Coast. These data will inform work by CeNCOOS to the south and NANOOS to the north.

POSTER SESSION: General Contributions

Nutrients, CO_2, phytoplankton and productivity in the Gulf of the Farallones, CA
R. Dugdale, F.Wilkerson, A. Parker, A. Marchi J. Fuller (SFSU)

Notes: There are two major sources of nutrients for the lower trophic levels that feed the food web of the Gulf of the Farallones: 1) coastal upwelling supplying nitrate and silicate; 2) outflow from San Francisco Bay. Each of these sources is likely to be more important at different seasons and under different climate conditions. Upwelling occurs primarily in spring and summer, while major freshwater flow and outflow from San Francisco Bay dominates in winter and early spring during the rainy and snowmelt periods. The additional nutrient source from SF Bay will supplement the more traditionally considered upwelling sources and ensure plentiful nutrients to fuel the Farallones food web. The type of nutrients may influence the phytoplankton community and productivity that results. The estuarine outflow carries high ammonium concentrations that would be expected to favor dinoflagellates (such as *Alexandrium catenella* that is commonly observed nearshore) and inhibit nitrate uptake by diatoms. The upwelling is also a source of high CO_2 that may impact phytoplankton processes. We report here preliminary results of seasonal cruises to the Marin coast to investigate nutrient composition, phytoplankton communities and productivity in the Gulf of the Farallones.

A numerical modeling study of the upwelling source waters along the Oregon coast during 2005
David Rivas, Roger M. Samelson (OSU)

Notes: Year 2005 was an anomalous year in terms of the spring transition (and hence the start of the upwelling season), which occurred over one month later than average, and of the temperature, which was about 6 degree Celsius above the average. Here we study numerically the source of the upwelling waters along the Oregon coast during 2005. The model presents a spring transition and a near-shore temperature anomaly similar to those reported in the literature, and comparisons with observations show that the model reproduces most of the features observed in the sea level and velocity. The contribution to central Oregon alongshore velocity and sea level variability from remote forcing, south of the model's southern boundary, is explored using coastal-trapped wave theory. Preliminary lagrangian analysis of the path of upwelling source waters shows that part of the water parcels come from northern locations beyond the model's northern boundary, from depths below 200 m.

The thermal structure of eddies in the Gulf of Alaska

Sarkar, N. (NOAA/SWFSC), Tremblay, Y. (UCSC), Schroeder, I. (NOAA/SWFSC), Bograd, S. (NOAA/SWFSC), Costa, D. (UCSC), Simmons, S. (UCSC), Robinson, P. (UCSC), Hassrick, J. (UCSC)

Notes: Northern elephant seals (*Mirounga angustirostris*) have been tagged with temperature-depth recorders for nine years at a rookery in central California, as a part of the TOPP (Tagging of Pacific Pelagics) program. The elephant seals spend over 60% of their time foraging at sea, of which 90% of the time is spent under water. The seals that travel to the Gulf of Alaska, often encounter eddies that frequent the region. They spend weeks foraging within these eddies, where they frequently dive to a depth of ~500 m, several times a day. This yields a unique dataset of high frequency, long duration and deep temperature-depth profiles, which are used to examine the thermal structure of eddies in the Gulf of Alaska. Eddies in the Gulf of Alaska are frequently cited as significant modes of transport of heat, salt and nutrients. The temperature profiles from the elephant seals have been used to describe the thermal structure of eddies in the Gulf of Alaska and to quantify the heat content of these eddies compared to the surrounding waters. Some elephant seals return to the same eddy multiple times during a single trip, which has made it possible to describe the time evolution of several eddy thermal fields.

Picoplankton community structures in Gulf of Alaska eddies

Melissa Blakely (UCSC), Raphael Kudela (UCSC), Tawnya Peterson (Oregon Health and Science U)

Notes: Mesoscale eddies in the Gulf of Alaska can transport nutrients and biological populations from the shelf into the high nutrient, low chlorophyll (HNLC) regions offshore, thereby modifying the phytoplankton assemblage in these regions. An open question is whether these eddies originating on the shelf transport nutrients (particularly iron) into the HNLC waters, resulting in enhanced productivity of the HNLC community, or whether the eddies also transport the resident shelf community, or both, or neither (no biological response in HNLC waters). During the summer of 2007, picoplankton community structures were studied in two distinct eddies, one formed in the Yakutat region, and one formed near Kodiak in the Gulf of Alaska. We examined the role that the mesoscale eddies play in transporting nutrients and biological communities to offshore waters and examine the influence that the eddies have on the spatial and vertical picoplankton communities present in HNLC regions. We compare the source water, eddies, and HNLC waters using a combination of flow cytometry, size-fractionated chlorophyll, nutrient, and primary productivity measurements. Preliminary analysis of the Yakutat and Kodiak eddies showed that the communities were comprised of distinct groups of picoeukaryotes, *Synechococcus* spp., and heterotrophic bacteria. As expected, *Prochlorococcus* spp. were not found at any station. In this presentation we will address the question of whether the eddies are transporting nutrients, distinct phytoplankton assemblages, or both, and whether there is a subsequent biological response distinct from the surrounding HNLC waters.

Observations of wind-driven and wave-driven flows in northern Monterey Bay using Nortek Acoustic Wave and Current Profiler (AWAC)

Ata Suanda, John A. Barth (OSU)

Notes:

In July 2007, we deployed a Nortek Acoustic Wave and Current Profiler (AWAC) at an inner-shelf (15m) location in northern Monterey Bay as part of a Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) biophysical experiment. The goal of the PISCO experiment was to examine the physical processes that determine the delivery of invertebrate larvae and juvenile rockfish to communities in northern Monterey Bay. The simultaneous measurement of currents and waves is analyzed to isolate forcing mechanisms that drive cross-shelf flow and provide insight to the on/offshore transport of mass and momentum to the inner shelf. These mechanisms include wind-driven motions from large-scale and local diurnal winds as well as wave-driven motions. Small wave heights during the study period allowed time-dependent local wind-driven Ekman transport to dominate the observed flow field. Nonetheless, the more constant wave-driven transport associated with Stokes drift is significant during periods of relatively low wind stress. Spectral characteristics of the wind and wave fields were used to further distinguish wave-driven transport associated with locally generated wind waves from transport associated with swell.

The modeled impacts of wind strength on Euphausia pacifica *production over the continental shelf.*

Jeffrey Dorman, Thomas Powell (UC Berkeley)

Notes:

Variation in upwelling conditions of the California Current System (CCS) are wind-driven and affect the population biology of phytoplankton and zooplankton both directly (through nutrient and food resources) and indirectly (through advection and retention). We have linked the Regional Ocean Modeling System (ROMS) with an individual based model (POPCYCLE) to examine the impacts of various wind states on the population biology of *Euphausia pacifica*. Idealized physical forcings from ROMS drive the individual based model through three-month simulations representing the spring/summer months off the northern California shelf region. Food resources for *E. pacifica* are provided via a nutrient-phytoplankton-zooplankton-detritus model also forced by ROMS. Simulations were run with varying wind strength and varying patterns of upwelling/relaxation wind conditions. The abundance, size structure and reproductive effort of *E. pacifica* were examined in relation to the variouswind fields. The results will be used to explore potential affects on higher-trophic level organisms that rely on euphausiids as prey.

The spatial association of predators and prey at frontal features in the northern California Current: Competition, predation, or co-occurrence?

David G. Ainley (H.T. Harvey & Associates), Katie. D. Dugger (OSU), R. Glenn Ford (R.G. Ford Consulting), Steven D. Pierce (OSU), Douglas C. Reese (OSU), Richard D. Brodeur (NOAA/NWFSC), Cynthia T. Tynan (Assoc. Scientists at Woods Hole), John A. Barth (OSU)

Notes: We investigated variation in the small- to meso-scale abundance and distribution of the three most abundant seabird species in the northern California Current region during summer: sooty shearwater *Puffinus griseus*, Leach's storm-petrel *Oceanodroma leucorhoa*, and common murre *Uria aalge* during the upwelling season of 2000 and 2002. Covariates, with importance assessed using general linear and an information theoretic modeling, included physical features, such as sea-surface temperature, dynamic height and pyncnocline depth; biological factors, such as chlorophyll maximum; and foodweb factors, such as the density of three size classes of zooplankton, the density of potential piscine predators, such as adult salmon *Onchorhynchus* spp., and abundance of fish prey, such as anchovies *Engraulis mordax*. Flux-adjusted seabird density was estimated using continuously collected data; covariates were estimated using towed Seasoar and four-channel hydroacoustics arrays, as well as trawls for fish. The most important factors explaining seabird occurrence proved to include proximity, both negative and positive depending on species, to the alongshore upwelling front, the abundance of prey-sized fish, and association with certain inshore vs offshore 'biomes'. Overlap in occurrence of the murres and shearwaters with adult salmon was interpreted as co-occurrence and, perhaps, competition for prey species; a negative relationship between shearwaters and abundance of forage fish was interpreted as evidence for prey depletion by the birds and other co-occurring predators. Seabirds and adult salmon occurred at the edges of some forage fish 'hotspots' but not others, but overlapped the areas of fish concentration mainly only in the frontal region. Overall, results and other information indicated the likely value of spatially explicit data on predator and prey species abundance for improved foodweb modeling.

Seabird integration of environmental variability in time and space

Isaac D. Schroeder (NOAA/SWFSC), William J. Sydeman (Farallon Institute for Advanced Ecosystem Research), Nandita Sarkar (NOAA/SWFSC), Steven J. Bograd (NOAA/SWFSC), Franklin B. Schwing (NOAA/SWFSC)

Notes: Egg laying data from Cassin's Auklets (CAAU) and Common Murres (COMU) have been collected on the Farallon Islands since 1972. Our hypothesis is that the interannual variability in the laying dates is due to the upwelling in the region. To test this hypothesis, the laying dates have been correlated to meridional winds and sea surface temperature (SST), which are used as proxies for coastal upwelling along the California coast. CAAU laying dates are highly correlated with meridional winds over the cumulative period of January-February. In contrast, COMU laying dates have highest correlations with meridional winds in January. Laying dates for both CAAU and COMU are highly correlated to the February-March SSTs. These results suggest that preconditioning of the environment for CAAU and COMU egg-laying starts in January.

Quantifying food availability for juvenile salmon in the Klamath River Plume and nearby coastal waters
Nicholas E. Bawden (HSU), Justin W. Box (HSU), Spencer F. Hitzeroth (HSU), Alexander M. Saslow (HSU), Eric P. Bjorkstedt (NOAA/SWFSC, HSU), and Sarah A. Goldthwait (HSU)

Notes:

The survival of juvenile salmon entering the marine environment is strongly influenced by prey resources in the coastal ocean. We quantified zooplankton biomass and distribution in and around the Klamath River plume in late May 2008, during the early part of the juvenile salmon outmigration season. Hydrographic parameters were sampled using an underway system and vertical CTD profiles on station, while bongo nets (500 µm mesh) were used to collect zooplankton. Initial sampling was conducted during an upwelling relaxation event, during which the plume lay close to the coast and flowed northwest from the river mouth. During the fourth and final day of sampling, northwest winds caused the plume to move southwest, extending at least 18.5 km west of the river mouth. The river plume was characterized by a surface lens of warm (10.8 °C), low salinity (27.8 ppt) water. Typical zooplankton biomass and chlorophyll a concentrations inside the plume were approximately 20 mg dry weight m^{-3} and <1 mg m^{-3}, respectively. Peak zooplankton biomass (169 mg dry weight m^{-3}) occurred along plume edges in correspondence with elevated turbidity (60% beam transmission) and chlorophyll a (>6 mg m^{-3}). Medusae, particularly *Eutonina indicans*, were common throughout the region. Copepods, mainly *Calanus* spp., dominated the edges of the plume. Ongoing work seeks to evaluate whether zooplankton biomass in and around the plume was adequate to sustain the juvenile salmon population coming out of the Klamath River.

Comparing carbon flow through cetaceans and abiotic processes in the northern California Current
Tynan, C. T. (Assoc. Scientists at Woods Hole), Ainley , D. G. (H.T. Harvey & Associates), Barth , J. A. (OSU), Cowles , T. J. (OSU), Brodeur, R. D. (NOAA/NWFSC), Reese, D. (OSU), Ford, R. G. (RG Ford Consulting)

Notes:

Carbon budgets for shelf food webs have rarely included complete pathways for the communities of apex predators. In particular, the regionally and seasonally significant influences of large whales in shelf systems are often missing in models of carbon flux. The ecological role of whales in the trophic transfer of shelf carbon was examined during GLOBEC Northern California Current (NCC) process cruises off Oregon (41.9 - 44.7° N) during summer 2000 and 2002. Line-transect surveys of cetaceans were conducted across the shelf and slope, in conjunction with multidisciplinary investigations of the NCC. During the upwelling season, humpback whales *Megaptera novaeangliae* move onto the shelf, especially at ecological 'hotspots' such as Heceta Bank (44° N). There, they forage on high densities of euphausiid and fish prey, removing large amounts of carbon from productive coastal waters, and sequestering carbon in whale biomass. The amount of carbon that is seasonally sequestered in cetacean biomass, and ultimately exported from the shelf during the whales' migration, is comparable with the amount of carbon transported cross-shelf by a jet of the NCC. Roles of other cetacean species, and abiotic processes, in carbon flow are compared for the shelf environment. Even the reduced numbers of an endangered population of whales contributes significantly to carbon flow in a coastal shelf ecosystem.

Modeling analysis of flow dynamics in the Coastal Transition Zone off Oregon
Andrey O. Koch, Alexander L. Kurapov, John S. Allen. (OSU)

Notes:

A nested circulation model based on the Regional Oceanic Modeling System (ROMS) has been implemented to study the three-dimensional time-dependent flow over the shelf and in the Coastal Transition Zone (CTZ) off Oregon. The study period is spring-summer 2002 during the time of the GLOBEC field program. Model-data comparisons have utilized velocity measurements from mid-shelf moorings, surface velocity measurements from high-frequency (HF) radars in the area of Cape Blanco (43N), SeaSoar hydrographic sections, surface drifter trajectories, satellite SST maps, and alongtrack SSH altimetry. These comparisons have shown that the model reproduces qualitatively correctly the time-averaged flow structure and variability over the period studied, including the energetic processes associated with separation of the coastal jet off Cape Blanco. Lagrangian analysis of surface particle trajectories has provided information on how the CTZ flow is grouped in filaments and on the location of particular separation zones. Analysis of the vertical structure of the jet separating from Cape Blanco and flowing westward, in a direction perpendicular to the direction of the prevailing wind stress, has revealed alternating convergence and divergence zones in the surface currents, accompanied by subduction and upwelling.

Diagnosing physical ocean state and dynamics using CalCOFI and satellite data
Ha Joon Song (SIO), Arthur J. Miller(SIO), Bruce D. Cornuelle (SIO), Emanuele Di Lorenzo (Georgia Tech)

Notes:

Data assimilation over California Current System (CCS) was performed using California Cooperative Oceanic Fisheries Investigations (CalCOFI) *in situ* and satellite data so that the model can better estimate the ocean state and improve forecast skill with Regional Ocean Modeling System (ROMS) Incremental Strong Constraint 4DVAR (IS4DVAR). Although ROMS IS4DVAR showed some limitations, it successfully produced a better estimate of not only sea surface temperature (SST) but subsurface temperature and salinity over CCS by decreasing RMSE by 70% for temperature and 55% for salinity.

NEPTUNE Canada Regional Cabled Observatory: Transforming ocean science

Mairi M.R. Best, Brian D. Bornhold, Chris R. Barnes (NEPTUNE Canada, U. Victoria)

Notes:

NEPTUNE Canada is installing a regional cabled ocean observatory across the northern Juan de Fuca Plate in the northeastern Pacific. When completed in 2009, this system will provide the continuous power and bandwidth to collect integrated data on physical, chemical, geological, and biological gradients at temporal resolutions relevant to the dynamics of the earth-ocean system. The similar adjacent US OOI Regional Scale Nodes should be operational by 2014. At inshore Folger Passage, Barkley Sound, understanding controls on biological productivity will help evaluate the effects that marine processes have on fish and marine mammals. Experiments around Barkley Canyon will allow quantification of changes in biological and chemical activity associated with nutrient and cross-shelf sediment transport around the shelf/slope break and through the canyon to the deep sea. There and north along the mid-continental slope, exposed and shallowly buried gas hydrates allow monitoring of changes in their distribution, structure, and venting, particularly related to earthquakes, slope failures and regional plate motions. Circulation obviation retrofit kits (CORKs) at mid-plate ODP 1026-7 will monitor in realtime changes in crustal temperature and pressure, particularly as they relate to events such as earthquakes, hydrothermal convection or regional plate strain. At Endeavour Ridge, complex interactions among volcanic, tectonic, hydrothermal and biological processes will be quantified at the western edge of the Juan de Fuca plate. Across the network, high resolution seismic information will elucidate tectonic processes such as earthquakes, and a tsunami system will allow determination of open ocean tsunami amplitude, propagation direction, and speed. The infrastructure has further capacity to allow experiments to expand from this initial suite. NEPTUNE Canada will transform our understanding of biological, chemical, physical, and geological processes across an entire tectonic plate from the shelf to the deep sea (17-2700m). Real-time continuous monitoring and archiving allows scientists to capture the temporal nature, characteristics, and linkages of these natural processes in a way never before possible.

8:30 *Global climate model evaluation and application on regional scales*
John C. Fyfe (Environment Canada)

Notes: One of the primary sources of information on possible future states is global climate model simulated-data, which in some cases has been downscaled using techniques, either statistical or dynamical, to enhance regional detail. It is critically important therefore to periodically evaluate the capabilities and limitations of the global climate models - as was recently done in Chapter 8 of WGI Fourth Assessment Report of the IPCC. In this presentation I will describe some of the key findings of Chapter 8 (Climate models and their evaluation) - as for example those dealing with the simulation of mean ocean temperature and salinity structures, Pacific Decadal Variability, and the El Nino-Southern Oscillation. Time permitting I will also describe two recent applications of global climate model simulated-data relevant to the Eastern Pacific Ocean: the first concerning a human-induced shift in North Pacific circulation and the second concerning an anthropogenic speed-up of oceanic planetary waves.

9:00 *On using IPCC model simulations to project changes in climate for marine ecosystems of the eastern North Pacific*
Nicholas A. Bond (U Washington/JISAO), James E. Overland (NOAA/PMEL), Muyin Wang (U Washington/JISAO)

Notes: In preparation for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, an international group of modeling centers carried out sets of global climate simulations. A total of 23 different coupled atmosphere-ocean general circulation models were employed under common emission scenarios. The objective of of the future states of marine ecosystems of the eastern North Pacific. Our method relies on critical evaluation of the models' 20th century hindcasts of variables pertaining to the ecosystems of interest. The first step has been to determine the degree to which each available model was able to replicate the spatial pattern, temporal scale and magnitude of variance associated with the leading mode of variability in North Pacific SST, i.e., the Pacific Decadal Oscillation (PDO). The subset of 12 models successful at replicating the PDO were then examined further using a technique known as Bayesian Model Averaging (BMA). This technique provides weighted ensemble means and estimates of uncertainties in the models' predictions for individual parameters in specific regions. The parameters considered here are upwelling in the California Current System (considered indirectly through SLP patterns) and the latitude of the West Wind Drift/sub-arctic front in the eastern North Pacific.

9:15 *Linking regional and basin scale climate variability in the Pacific*
Emanuele Di Lorenzo (Georgia Tech), Niklas Schneider (U Hawaii)

Notes: Climate change predictions from large-scale coupled ocean-land- atmosphere models (e.g. IPCC) are potentially useful to predict the climate statistics of the regional and coastal oceans. However, it is still unclear how to downscale the large-scale climate models to regional scales. Although large-scale coupled climate model predictions show similarity in their basin scale patterns of climate change and variability, at the regional scale these patterns show important differences and are largely resolved. This talk presents an improved dynamical framework of Pacific Climate Variability that allows us to connect the regional and basin scales processes. Such a framework is based on linking large-scale modes of climate variability observed over the last 50 year with regional processes of physical and ecosystem variability. Using this dynamical framework it is possible to test the degree of realism of the coupled climate models during the modern period and evaluate how climate predictions at the basin scale may project on ocean regional scales in the future.

9:30 *Decadal climate variability of the North Pacific: Past and future*
Jason Furtado, Emanuele Di Lorenzo (Georgia Tech)

Notes: Recent studies show that decadal climate and ecosystem variations in the North Pacific are largely explained by the first two dominant modes of ocean-atmosphere covariability evident in sea level pressure (SLP) and oceanic variables like sea surface height (SSH) and sea surface temperature (SST). The first covariability mode tracks changes in the Aleutian Low and is associated in the ocean with the well-known Pacific Decadal Oscillation (PDO). The second covariability mode tracks variability in the North Pacific Oscillation (NPO) - a dipole structure in SLP with opposite signed loadings over the Bering Sea and also north of Hawaii. The oceanic expression of the NPO is the recently identified North Pacific Gyre Oscillation (NPGO) - a decadal mode of climate variability that reflects changes in the strength of the central and eastern branches of the subtropical gyre. The NPGO is also linked to previously unexplained fluctuations of salinity, nutrient and chlorophyll fluctuations in the Northeast Pacific. Additionally, recently noted shifts in the state of the dominant modes of SLP and SST in the North Pacific makes understanding how these modes may continue to change important for climate projections.Using a set of ten coupled climate models from the Intergovernmental Panel on Climate Change (IPCC), we (1) assess the degree of realism of the IPCC models in reproducing the first two modes of ocean-atmosphere covariability in the North Pacific during the twentieth century (1900-1999), (2) explore how this covariability is projected to change in the future (2001-2100) under warming scenarios and (3) evaluate changes in the dominance and frequency of these modes and the possible impacts on future climate in the North Pacific as a result of those changes.

9:45 *The past and future of coastal and open ocean upwelling in the NE Pacific*
Todd Mitchell, Phil Mote, Nate Mantua, Eric Salathe (U Washington)

Notes: Dominant patterns of alongshore wind stress and offshore wind stress curl between the Queen Charlotte Islands and Baja are documented in QuikSCAT winds for 2000-2007 and in-situ pseudostress (ICOADS) for 1960-2006. The analysis captures the seasonal intensification of the upwelling-favorable winds along Big Sur in April-May-June, and along the Washington and Oregon coasts in June-July-August, as well as year-to-year fluctuations in these phenomena. To identify the large-scale circulation patterns that control varability in the coastal winds, sea-level pressure proxy timeseries for these patterns are generated from the NCEP-NCAR reanalysis for 1948-2007. Simulated changes in the large-scale circulation patterns from 1950 through 2100 are then examined in 19 IPCC AR4 global climate model simulations. Consistent with our earlier study using 2 global models, coastal upwelling in climate model simulations appears to be relatively insensitive to greenhouse gas forcing. Regional climate model simulations over the NE Pacific region will be used to establish the connection between large-scale climate change and the local winds, following the observational analysis. The regional model is based on the Weather Research and Forecast (WRF) model and is run at 36-km resolution forced by the ECHAM5 global climate model output for the A1B scenario (1970-2070).

10:30 *Interannual variability and modeling of upwelling-driven shelf hypoxia off the central Oregon coast*
John A. Barth, F. Chan, Stephen D. Pierce, R. Kipp Shearman, Anatoli Y. Erofeev, Laura Rubiano-Gomez Justin Brodersen (OSU)

Notes: Near-bottom waters over the inner shelf (< 50 m water depth) off central Oregon have been increasingly hypoxic (dissolved oxygen < 1.4 ml/l) over the last 8 years, including the appearance of anoxia in summer 2006. Through a combination of ship sampling, moorings and autonomous underwater vehicle gliders, we have been measuring dissolved oxygen with increasing temporal and spatial coverage. For longer term context, we use historical observations along the Newport Hydrographic Line sampled since the 1960s. The appearance of near-bottom, inner-shelf hypoxia is driven by upwelling of low-oxygen and nutrient-rich sourcewater onto the continental shelf, followed by the decay of organic matter raining down from surface phytoplankton blooms. Hypoxia in this region is not driven by input of nutrients from freshwater runoff. The severity of inner-shelf hypoxia varies year-to-year due to changes in upwelling sourcewater properties and the characteristics of wind-driven upwelling. We use a regression model to link observed inner-shelf, near-bottom oxygen levels with offshore sourcewater dissolved oxygen levels and two measures of wind forcing. Wind forcing is represented as both the cumulative seasonal upwelling and an exponentially weighted sum of winds over the last 30 days. The model shows that 94% of the variability of inner-shelf, near-bottom dissolved oxygen levels is explained by a nearly equal combination of changes in sourcewater dissolved oxygen and wind forcing. Long-term records of dissolved oxygen in upwelling source waters off central Oregon show a decrease consistent with other recent estimates of oxygen declines in the eastern North Pacific.

10:45 *Consequences of changes in mixed layer structure on copepod foraging and production*
Andrew Leising (NOAA), James Pierson (UMCES), Bruce Frost (U Washington)

Notes: Over the past 3 years, we have conducted 9 short 2-3 day cruises during different seasons investigating the foraging behavior and collocation of copepods relative their prey (~chl) and other water column properties within the upper surface layers during the night. These studies were conducted within a relatively enclosed fjord (Dabob Bay, WA) which acts as a sort of "mesocosm," having species and water column properties similar to many coastal ocean conditions. We found that the copepod Calanus pacificus is often not found at maximum abundance within the layer of highest food. Instead, we have found evidence that this species conducts short-term (1/2-2 hr) forays between the layers with high food, and deeper, food-poor layers. Our hypothesis is that these copepods feed within a high-food layer, and then move into the colder, deeper, food-poor layer to digest, returning again to the high-food layer after some refractory period. Here, we use an individual-based model of this behavior in order to investigate the effects of possible long-term and regional-scale changes in vertical water column structure on the feeding and production of these copepods. The results of this modeling will be discussed, along with the potential impacts of these changes on the availability of copepods as prey for surface-foraging predators.

11:00 *Comparisons of chlorophyll interannual variability between the Humboldt and California Current Systems*
Andrew Thomas (U Maine), Peter Brickley (U Maine), Ryan Weatherbee (U Maine)

Notes:

Large-scale variability in interannual patterns of chlorophyll are compared between the two Pacific eastern boundary current upwelling systems, the California Current (CCS) and the Humboldt Current (HCS) using 10 years of daily SeaWiFS satellite ocean color data at 4km resolution composited to monthly means. EOFs extract the dominant coherent signals. In both systems, the strongest non-seasonal signals in the time series are large negative anomalies during the 1997-98 El Nino period, strongest off Peru in the HCS during southern hemisphere summer and off Oregon and Washington in the CCS during fall and spring. Thereafter, the CCS shows stronger interannual variability than the HCS. Strong signals in the CCS are dominated by large positive anomalies in 2002 and 2006, and negative anomalies at the higher latitudes in early 2005. In the HCS, largest anomalies after the El Nino period are positive events in spring 1999 and the summers of 2001-02 and 2005-06. Using 100km cross-shelf chlorophyll means that sample the main upwelling region at each latitude, and removing the seasonal signal, anomaly time series are compared first to local wind forcing and then to 3 Pacific basin scale climate indices of non-local forcing; the PDO, MEI and NPGO. In each system, strong latitudinal regionality is evident in the linkage between chlorophyll variability and both local (wind) and non-local (basin-scale index) forcing. The dominant overall picture is of closer linkages to all forcing at both highest and lowest latitudes in each system, weaker at mid latitudes. Lastly, we examine the 10-year chlorophyll anomaly record for evidence of systematic trends.

11:15 *Long- and short-term factors affecting seabird population trends in the California Current System, 1985-2006*
David G. Ainley (H.T. Harvey and Associates) and K. David Hyrenbach (Hawaii Pacific University)

Notes:

We analyzed trends in abundance of the most abundant marine bird species in the northern California Current System (CCS) during the upwelling season (May-June) over a 22-year period, 1986-2007. Data were collected during cruises that ranged from Bodega Bay (38.32° N) to Cypress Point (35.58° N), and from the coast to beyond the continental slope (3000-m isobath). We related variation in species' abundance (number km-2), with three seasonal lags — Late Winter, Early Spring, and Late Spring — to indices during a period of major fluctuations in El Niño-Southern Oscillation (ENSO) and the longer-term Pacific Decadal Oscillation (PDO). Included, to address different temporal/spatial scales, were a Multivariate ENSO Index, PDO, coastal upwelling indices and local sea-surface temperature. Cyclical trends were apparent in Black-footed Albatross, as were decreasing trends for Sooty Shearwater, Ashy Storm-petrel, Pigeon Guillemot, Rhinoceros Auklet, Cassin's Auklet, and Western Gull. Although abundance variation for these species was explained by ocean factors, no long-term pattern was evident for eight other focal species. We hypothesize that decreasing trends, and even some of the short-term variability, especially for high-energy diving species (most of the above), was related to documented changes in ocean productivity. In addition, increasing trophic competition from baleen whales, which rediscovered the study area where not long ago they had been harassed by whalers, may have been involved as were changes in nesting grounds related to the 'restoration' of nesting grounds. Overall, our study points to the complexity of factors that unequally affect the population structure of a marine 'community'.

4:15 *Simulations and observations of circulation in the Oregon Coastal Transition Zone during the 2002-2003 downwelling season*
S. R. Springer (OSU), J. S. Allen (OSU), R. M. Samelson (OSU), A. L. Kurapov (OSU), G. D. Egbert (OSU), R. N. Miller (OSU), Sergio de Rada (NRL)

Notes:

Circulation in the region offshore of Oregon from October 1, 2002 to May 1, 2003 is the subject of a one-way nested grid model simulation. The nested model obtains initial conditions and boundary conditions from a larger scale California Current model and is forced by wind stress from a regional mesoscale model, rainfall and heat fluxes calculated from a coarse resolution atmospheric model, and observed coastal river flows. At the beginning of the period, an upwelling circulation established by predominantly southward winds during the previous summer is in place. The upper ocean is dominated by a shallow (<30 m) thermocline, except near the coast where upwelling brings cold water to the surface, and the resulting offshore density gradient supports a southward surface jet. Vigorous cyclonic storms in December deepen, freshen, and cool the mixed layer. Comparison with measurements along the Newport hydrographic line (44.65 N) show that the model-simulated changes in the mixed layer are realistic. Northward wind stress near the coast establishes a downwelling circulation, which is characterized by a northward surface jet, a density front over the midshelf (~50 m depth), and a well-mixed water column over the inner shelf. Onshore Ekman transport holds freshwater input by rain-swollen rivers near the coast. When the wind reverses to southward for several days in early February, offshore Ekman transport spreads this freshwater feature seaward where it is mixed away. High resolution hydrographic observations support the model representation of this event. During the mid to late winter, wind stress switches between strongly downwelling-favorable and weakly upwelling-favorable intervals of approximately 10-14 day duration. Comparison with moored current meters on the outer and midshelf shows that the model reproduces the corresponding reversals of the depth-averaged alongshore currents, although the simulated northward currents during downwelling events are somewhat weak. Observed inner shelf velocities have higher frequency fluctuations that are not well represented in the simulation. Sensitivity studies demonstrate the importance of both surface rainfall and coastal river freshwater input to stratification in the upper ocean in wintertime.

4:30 *Why isn't hypoxia everywhere? Modulation of hypoxia risk by meso-scale flow-topography interactions*
Francis Chan (OSU), J. A. Barth (OSU), J. Lubchenco (OSU), A. Kirincich (WHOI), M. Wolf (OSU), K. Page-Albins (OSU)

Notes: The development of shelf hypoxia and/or anoxia is a common feature of many but not all eastern boundary current systems. In the northern and southern California Current System, recent studies have identified the novel emergence of inner-shelf anoxia and the shoaling of the hypoxia horizon in slope and shelf waters, respectively. Broad-scale changes in the oxygen content of offshore sourcewaters and the characteristics of climate-dependent wind forcing have been implicated as two important causative factor in the intensification of shelf oxygen deficits. The expression of shelf hypoxia has nevertheless varied greatly along the coast and suggests that shelf processes over finer-spatial scales may be important in modulating the risk of hypoxia/anoxia. Along the central Oregon coast, a marked transition from a narrow to a broad continental shelf interacts with alongshore currents to form contrasting regions of advective flushing and surface primary production. Using data from shallow shelf moorings and repeated cross-shelf cruise transects, we examined the role that such meso-scale flow-topography interactions may have in controlling the risk and intensity of hypoxia events. We find strong evidence that differences in alongshore flows between regions of contrasting shelf width can exert key controls on the expression of hypoxia/anoxia. The results of respiration rate studies further suggest that bottom respiration are decoupled from alongshore variations in surface production at the <100 km scale, and implicates physical differences in shelf circulation as a dominant factor for modulating the effects of inter-annual shifts in climate forcing on hypoxia formation along the coast.

4:45 *The California Coastal Boundary Layer: Investigating the interaction between coastline features and nearshore velocity*
K. Nichols (BML/UCD), B. Gaylord (BML/UCD), J. L. Largier (BML/UCD)

Notes: Nearshore flow is one of the most understudied issues in physical oceanography, despite having important implications for larval recruitment, movement of pollutants, and other ecological processes. The interaction of the coastline and alongshore flow creates a nearshore velocity gradient, referred to as the Coastal Boundary Layer (CBL). Here, we examine the presence of a CBL at five sites on the South and Central California coast through transects of nearshore velocity data from Acoustic Doppler Current Profilers and CODAR. We find the presence of a CBL whose characteristics reflect interactions of flow with the shoreline and bottom slope near to the shore. For all sites, velocity is polarized in the alongshore direction. In addition, mean alongshore velocity of stations closer to shore (5-10 m isobath) are an order of magnitude smaller than mean velocity of stations farther offshore (20-25 m isobath). Alongshore velocity profiles at each site follow a logarithmic relationship with distance from shore. An approach similar to small-scale hydrodynamic boundary layer theory is used to describe the relationship between CBL velocity profiles and shoreline properties. These predictable slower nearshore flows may be responsible for decreased alongshore transport and increased local retention of certain waterborne constituents, such as larvae and pollutants.

5:00 *Circulation, water temperature, and larval settlement over the inner continental shelf of the Channel Islands, California*
Melanie R. Fewings (UCSB), Libe Washburn (UCSB), Chris Gotschalk (UCSB), Carol Blanchette (UCSB), and Jennifer Caselle (UCSB)

Notes: We use seven-year-long time series of water velocity, water temperature, salinity, and wind stress in 15 m water depth to describe the circulation and water temperature over the inner continental shelf of the Channel Islands in the Santa Barbara Basin in California. The Santa Barbara Basin is strongly influenced by the California Current upwelling system. In turn, the water circulation in the Santa Barbara Basin influences the local marine ecosystem by affecting the water temperature and the supply of nutrients and larval fish. The Santa Barbara Channel area of the Basin is also a bio-geographic boundary: it is the northern limit of the ranges of many coastal species that have southern distributions. Larvae, nutrients, and pollutants traveling from the coast to the open ocean must somehow pass through the inner shelf. To date, the water circulation over the inner continental shelf has not been well understood, particularly in the area of the Channel Islands, where the circulation has never before been described. Due to the shallowness of the water, the inner shelf has different physical dynamics than either the surfzone or the middle and outer continental shelf. We discuss the relative importance of upwelling-favorable along-shelf winds and of cross-shelf winds as forcing mechanisms for coastal upwelling circulations over the inner continental shelf; test whether the cross-shelf wind stress and surface gravity waves are important for cross-shelf circulation in the Santa Barbara Basin; and describe the subtidal patterns of water temperature and velocity around the Channel Islands. Cross-shelf circulation and the movement of water masses into and out of the Basin have implications for settlement and recruitment of many coastal species, including the economically important kelp rockfish, kelp bass, and sea urchin. Understanding the circulation of the Santa Barbara Basin and its inner shelves is a precursor to determining the source locations of the planktonic larvae. That information on source locations is essential for the design, siting, and assessment of existing and future marine protected areas in California and elsewhere.

5:15 *A Lagrangian view of larval dispersal from a ROMS model of the central California coastal ocean*
Patrick T. Drake, Chris A. Edwards (UCSC)

Notes:

Larval supply is considered an important factor influencing marine population distributions and dynamics, yet owing to the complexity of the circulation, the dispersal of larvae in the real ocean is a poorly quantified process. In this study, we use a high-resolution implementation of the Regional Ocean Modeling System of the central California coastal region to investigate the dispersal of millions of passive particles. The particles are neutrally buoyant, released over of the inner shelf, and intended to simulate the larvae of many near-shore fish and crustaceans species. Particles are released daily for one year along a ~400 km stretch of coastline, tracked for 16-days and reprocessed to simulate an instantaneous point-source release. From the particle trajectories, we calculate the Lagrangian diffusivity and integral time-scale in both the alongshore and across-shore directions. Alongshore estimates of both quantities are similar to existing meridional estimates for the California Current. We then review a three-parameter solution to the two-dimensional advection-diffusion equation, appropriate near an idealized coastal boundary, as a model of coastal dispersal. This simple, Gaussian solution is the continuous equivalent of Taylor's classic theory of Lagrangian turbulent diffusion. Here we employ the model using the Lagrangian diffusivity measured directly from the trajectories. When compared to the observations, the advection-diffusion model exaggerates the spreading rate, resulting in lower-than-observed particle concentrations, and misrepresents the particle distribution at the coast, which is found to be a non-Gaussian, Laplace distribution.

Oceanographic insights and/or products for societal use

8:30 *COAST: CSU Council on Ocean Affairs Science and Technology*
Toby Garfield, Krista Kamer, Dale Robinson (SFSU)

Notes: The California State University System (CSU) has formed the Council on Ocean Affairs, Science and Technology (COAST) to promote multi-campus collaborations in addressing the environmental and societal impacts to the California coast. The CSU is the largest educational institution in the United States and trains the majority of California's elementary and high school teachers. COAST aims to develop and provide coherent content for science teachers as well as use state-wide distribution of CSU campuses to implement large-scale observing measurements and related products.

8:45 *CeNCOOS: Responding to our ocean*
Heather Kerkering (CeNCOOS), Steve Ramp (CeNCOOS), Tom Wadsworth (CeNCOOS), Matthew Binder (CeNCOOS)

Notes: In the past year alone, the oceans of central and northern California experienced a major oil spill, unprecedented harmful algal blooms, and the collapse of the salmon population. With the oceans in constant turmoil, facing both short and long term threats to our resources and economy, the value of an integrated ocean observing system cannot be overstated. The Central and Northern California Ocean Observing System (CeNCOOS) responded to these events, and others, by providing leadership in coordination and development of decision-making tools. Our response strategies, future plans and priorities, and successful products, including a new interactive classroom tool, will be highlighted and shared.

Oceanographic insights and/or products for societal use

9:00 *Insights into Hood Canal hypoxia from NANOOS real-time data*
Jan Newton, Al Devol, Wendi Ruef, Corinne Bassin (U Washington)

Notes: Hood Canal (Washington State), a classic fjord estuary with a shallow sill and sluggish circulation, is connected to the Eastern Pacific Ocean via the Strait of Juan de Fuca. While known to be prone to hypoxia, an increasing persistence and occurrence of low dissolved oxygen concentrations in Hood Canal observed during the 1990-2000's and repetitive fish kills during the 2000s galvanized interest to better understand the drivers of the hypoxia. These include natural factors (e.g., climate, ocean, and freshwater dynamics), as well as human factors (e.g., carbon and nutrient loadings from a variety of sources). The Hood Canal Dissolved Oxygen Program-Integrated Assessment and Modeling study has used observations and models to quantitatively evaluate the causes for the increasing hypoxia. After 3 years of study it is apparent that while natural factors appear to be dominant, the role of human loads of nitrogen is significant in the lower reaches of Hood Canal. Use of real-time current and water property data from moorings was instrumental in helping to discern effects from the diverse factors.

9:15 *Understanding fish kill dynamics in Hood Canal*
Allan Devol, Jan Newton, Mitsuhiro Kawasi (U Washington)

Notes: Hood Canal (Washington State) is a classic fjord estuary with a shallow sill and sluggish circulation. Recent increases in summer bottom water hypoxia have led to a comprehensive scientific study to support management initiated corrective actions. As part of this program, 4 autonomous moored profiling systems (ORCA buoys) have been deployed in Hood Canal. Each system collects high frequency (bi-hourly) profiles of chemical, physical, and biological variables using meteorological sensors and an underwater instrument package. A major fish kill occurred in southern Hood Canal on September 19, 2006. Moored profiler data suggest this fish kill was caused by the combination of the gradual summer depletion of deep-water oxygen, followed by the annual intrusion of dense Pacific Ocean water, which displaced the oxygen poor water to just under the pycnocline. Finally an upwelling-favorable wind event moved the surface water layer northwards resulting in outcrops of low oxygen water at the surface. Within 12 hours the surface oxygen concentration decreased to ~0.6 mg/L. The event lasted ~ 24 hours and ended abruptly. These data provide insights into the mechanisms of the fish kills and also provide fisheries managers with real-time data to help mitigate such events.

9:30 *Fate and transport of San Francisco Bay outflow*
John Largier, Megan Sheridan, Chris Halle (BML/UCD)

Notes: The outflow of water from San Francisco Bay transports biogenic material, suspended sediment and a variety of contaminants. These constituents play important roles in the Gulf of Farallones at times and places determined by the flow patterns, which result from an interaction of tidal and buoyancy forcing with circulation in receiving waters. In particular, there are two primary transport patterns: (i) southward and offshore during wind-driven upwelling, and (ii) northward and onshore during calm periods and during winter storms. Our focus is on the latter, when bay contaminants may impact nearshore and shoreline communities along the coasts of Pt Reyes peninsula (National Seashore & National Recreation Area). Further delivery of nutrients and phytoplankton to Drakes Bay may play a key role in bay-gulf coupling. The influence of Bay outflow may extend a hundred miles beyond Point Reyes at times, as far as Point Arena. Time-series data on temperature and salinity show alternating outflow and upwelling effects, while HF radar surface current maps and drifters show transport pathways. These results and new insights have been used in MPA assessment, oil spill review, and nascent EBM efforts in the National Parks.

9:45 *Pilot real-time forecast model of coastal ocean circulation off Oregon*
A. Kurapov, S. Y. Erofeeva (OSU)

Notes: A pilot real-time forecast model has been set-up to provide daily updates of 3-day ocean circulation forecasts over the shelf and in the eddy-dominated coastal transition zone (CTZ) off Oregon. The Regional Ocean Modeling System (ROMS) has been utilized. The model domain extends between 41-47N south-to-north and 300 km in the offshore direction. To provide forcing fields, an atmospheric forecast updates are obtained from the mesoscale North American Model (NAM, run by NOAA). Open boundary inputs are provided from the forecasting Navy Coastal Ocean Model of California Current System (NCOM-CCS, run at NRL by I. Shulman et al.). The entire forecast system, including collection of forcing fields, model runs, and data distribution, is operated automatically, supported by computer scripts, with outputs posted online (www-hce.coas.oregonstate.edu/~orcoss/NCTZ/SSCforecast.html). The outputs are also delivered to our colleagues from the Oregon Coastal Ocean Observing System (OrCOOS, orcoos.org) who have added value to our product providing web-based interactive analysis and visualization tools. Our model-generated time series compares favorably to near-real time OrCOOS observations (mid-shelf mooring velocities, HF radar surface currents) as well as SST satellite composite maps, describing correctly variability both on the shelf and in the CTZ, including an energetic flow separation off the Cape Blanco. Hindcast model runs have been utilized to provide additional verification, using observations from 2001 COAST and 2002 GLOBEC field programs, to test algorithms for surface and 3D particle tracking, and to study processes in CTZ with focus on the subsurface currents and vertical structure of the CTZ jet. A variational data assimilation method, using tangent linear and adjoint codes developed at OSU, has been tested with with eventual goal to include the assimilation capability in the real time model.

10:30 *Recent high-frequency variability in the PDO and ocean conditions in the northern California Current: Forecasting impacts on ecosystem structure and salmon survival*
William Peterson (NOAA/NWFSC)

Notes: Recently, the northeast Pacific has experienced high-frequency variability in the PDO pattern: cool phase from 1999-2002; warm phase from late 2002-2006; cool from 2006 to present. Thus nature has handed us a natural experiment that allows us to determine in what ways and how quickly marine organisms respond to strong climate variability. We use our 13 year time series of hydrography and zooplankton collected off Newport OR and our 11 year time series of hydrography, zooplankton and pelagic fish collected off Washington and Oregon to investigate the response of the pelagic marine ecosystem to recent changes in state of the north Pacific. Ecosystem indicators have been developed from these time series as metrics to describe interannual variability in ocean conditions, and to forecast recruitment variability of salmon in Pacific Northwest waters. We communicate our results through a web site; the site includes information on the status of the northern California Current ecosystem on a seasonal basis, and provides a one-year lead forecast of returns of coho salmon and a two-year lead forecast of Chinook returns, based on the "stoplight" approach. Our ability to manage fishery resources in the future will depend in part on our ability to forecast the impact of changing ocean conditions as a result of global climate change. We suggest that use of a complete set of ecosystem observations, from physics to fish, will become a requirement if we are to understand fully how variations in physical climate forcing will affect fisheries and marine ecosystem productivity.

10:45 *On the accuracy of trajectory estimations from HF radar-derived surface currents*
Jeffrey D. Paduan, Michael S. Cook, Francisco Almeida, George Wright (NPS)

Notes: Remotely sensed current maps from shore-based HF radar systems are being used to investigate surface particle pathways. These trajectory computations have potential utility in a wide range of applications and scientific questions, including oil spill mitigation, search and rescue, and larval transport statistics. The typical and data-specific errors in the HF radar-derived currents themselves are the subject of ongoing investigations. Those Eulerian errors must, in turn, be propagated into uncertainties in the Lagrangian trajectories. This presentation will outline recent error analyses. The techniques used include direct comparison of HF radar- and surface drifting buoy-derived velocities and trajectories for the region offshore central California between the Gulf of the Farallones and Monterey Bay.

11:00 *Incorporating oceanographic observations into descriptions of larval connectivity for marine reserve design*
J. Wilson White, Louis W. Botsford, Alan Hastings, John L. Largier (UCD)

Notes: Patterns of larval connectivity are essential to metapopulation persistence in marine reserve networks, so spatially explicit population models are often used to guide the reserve design process. Ideally, such models would describe larval connectivity using a dispersal matrix derived from circulation models and ocean observations, or genetic/geochemical estimates of larval movement. In practice, modelers have assumed that dispersal is a spatially homogenous advection-diffusion process. This makes it possible to derive several simple rules for reserve design: the minimum number and width of reserves, optimal reserve spacing, and the relationship between conventional fishery management and reserve performance. However, the generality of these results in more complex flow regimes has been questioned. We relaxed the assumption of spatial homogeneity, taking advantage of biological and oceanographic data collected in the vicinity of Pt. Reyes, California (drifter tracks, CODAR, collections of larvae and settlers) to generate three stereotypical, non-homogeneous larval dispersal patterns for eastern boundary current systems. Models using these alternative dispersal pathways reveal that in addition to the rules-of-thumb derived from simpler models (which generally hold true), it is usually advantageous to place reserves in larval retention zones. Additionally, some dispersal patterns are more likely to produce a network of independent, self-sustaining reserves, while others tend to produce networks with interdependent, non-self-sustaining reserves. This distinction implies that the species within a reserve network will respond differently to habitat destruction. As more reserves are implemented, linking population models to the latest circulation models and ocean observations will sharpen our efforts to monitor reserve effectiveness.

11:15 *Comparison of a wind-driven Mixed Layer Conveyor model with observations of fluorescence and nitrate from a mooring*
Loo Botsford (UCD), Matt Holland (UCD), John Largier (UCD, BML), Ed Dever (OSU), Alan Hastings (UCD)

Notes: With increasing emphasis on Ecosystem Based Management, policy analysis and the interpretation of the responses will depend increasingly on our perception of primary production. There have been a number of modeling efforts that combine NPZ and physical circulation models to represent production in coastal upwelling systems, but few direct comparisons with data reflecting nutrients, phytoplankton and zooplankton. Here we compare predictions from a very simple physical and NPZ model to fluorometer and nitrate measurements at a mooring during the 2001 field season of WEST (Wind Events and Shelf Transport). The model is the essentially 1-dimensional Mixed Layer Conveyor (MLC) model developed in WEST. It is driven by cross-shelf velocity from Ekman transport based on local winds, and mixed layer depth varying with time lagged wind stress. Both model N and nitrate observations, and model P and fluorescence are highly correlated over periods of tens of days. The intervening errant periods have not all been completely explained, but likely involve circulation conditions during which the transport paths of upwelled parcels become two-, rather than one-dimensional. While this comparison lends credibility to MLC calculations, the ultimate effect on higher trophic level marine resources depends on the ultimate fate of this production, observed here at a very early stage.

11:30 *Insights for stock assessment and seabird ecology from an environmentally forced individual-based model of rockfish early life history stages*
Eric Bjorkstedt (NMFS/SWFSC, HSU), Steve Ralston (NMFS/SWFSC)

Notes:

Recruitment variability to populations of winter-spawning rockfish derives primarily from highly variable survival through the larval stage, presumably as a consequence of environmental and ecological conditions coincident with early life history. We developed a mechanistic modeling framework that explicitly accommodates short-term variability and ecological dynamics to predict the probability of survival-to-age as a function of the date an individual enters the plankton. Our approach embeds models for plankton production and the growth and transport of larval and juvenile rockfish in a simple model of the wind-forced cross-shelf circulation, so that the fate of individual larvae integrates environmental conditions encountered over the course of pelagic life. The physical-biological model is based on a 1-D "mixed layer conveyor" model of a coastal upwelling system, augmented to incorporate the dynamics of downwelling fronts and phenomenological consequences of vertical mixing (enrichment) and stratification (retention of productivity in surface waters) related to wind forcing. Predictions of recruitment success are obtained by integrating the joint probability of (1) survival conditional on birth date, and (2) entering the plankton on a given date, where the latter is based on the distribution of spawning over time. Comparison to recruitment indices taken from stock assessments indicates that the model performs best for species-specific spawning seasons coincident with those reported in the literature. In contrast, recruitment indices based on fixed-time surveys (e.g., oceanographic surveys, diver surveys, and seabird diets) are best predicted for (hypothetical) spawning seasons consistently centered in March, regardless of species, which suggests that, at least for some rockfish species, such data are a biased measure of reproductive success.