EPOC 2013 Program and Abstract Booklet

60th Annual Eastern Pacific Ocean Conference

Fallen Leaf Lake, California
2013

September 16th - 19th

Co-Chairs: Ryan Rykaczewski & Kerry Nickols

EPOC President: Eric Bjorkstedt

EPOC Treasurer: Noel Pelland

Direct questions regarding the Program to Ryan at ryk@sc.edu.

EPOC 2013 Program Summary

Monday, September 16th

15:00	Arrival and registration
18:30	Dinner
20:00	Jam session with s'mores

Tuesday, September 17th

07:30	Breakfast
08:20	EPOC opening introductions
08:30-11:15	Morning session 1: *Characteristics and causes of regional structure and variability in the California Current* (Eric Bjorkstedt and Andrew Thomas) with a coffee break 09:55-10:15
11:15-12:15	Morning session 2: *General session* (Parker MacCready and Kerry Nickols)
12:15-16:00	Lunch and afternoon free time
16:00-18:00	Afternoon session: *Submarine canyons* (Erika McPhee-Shaw, Eric Kunze, and Susan Allen)
18:00-19:00	Dinner
19:00-20:00	Fireside chat with Dr. Jim Kitchell
20:00-22:00	Poster session

Wednesday, September 18th

07:30	Breakfast
08:40-12:00	Morning session: *Region-wide perspective on HABs* (Kristen Davis, Raphael Kudela, and Drew Lucas) with a 10:05-10:25 coffee break
12:00-15:30	Lunch and afternoon free time
15:30-18:30	Afternoon session (16:55-17:15 break): *Interdisciplinary nearshore processes* (Falk Fedderson and Melissa Omand)
18:30-19:30	Dinner
20:00-22:00	Banquet and entertainment

Thursday, September 19th

07:30	Breakfast
09:00-11:00	Morning session (10:00-10:20 break): *General session* (Co-Chairs: Parker MacCready and Kerry Nickols) with a 10:00-10:20 coffee break
11:00-12:00	Business meeting
12:00	Lunch and departure

EPOC 2013 Presentation Schedule

** indicates student*

Tuesday, September 17th Talks

Morning session 1: *Characteristics and causes of regional structure and variability in the California Current*
Co-Chairs: Eric Bjorkstedt and Andrew Thomas

08:30 **Eric Bjorkstedt** (EPOC President): Introduction

08:35 ***Andrew Davis** and E. Di Lorenzo
Large-scale vs. regional-scale controls of CCS transports

08:55 Nicholas Foukal and **Andrew Thomas**
Seasonal biogeography and phenology of satellite-measured chlorophyll in the California Current System

09:15 **Yi Chao**, J. Farrara, and H. Zhang
California Current and variability as revealed by a regional ocean modeling system with data assimilation and hindcast/nowcast/forecast capabilities

09:35 **Ariane Verdy**, R. Sodowsky, and M. Mazloff
Spatio-temporal variability of ocean carbon in the California Current System

09:55-10:15 **BREAK**

10:15 **Rachel Fontana**, M. L. Elliott, J. L. Largier, and J. Jahncke
Zooplankton composition in a strong, persistent upwelling region: What can it tell us?

10:35 **Isaac Schroeder**, J. Santora, S. Bograd, B. K. Wells, J. Fiechter, and C. Edwards
Combining long-term observations and a data assimilative ROMS model to evaluate climate-driven variability in California Current krill dynamics

10:55 **Discussion**

Morning session 2: *General session*
Co-Chairs: Parker MacCready and Kerry Nickols

11:15 ***Daniel Ellis**, L. Washburn, C. Ohlmann, O. Schofield, and M. Moline
Quantifying effectiveness of autonomous underwater gliders as virtual moorings in the Santa Barbara Channel

11:35 **Sung Yong Kim** and P. M. Kosro
Observations of near-inertial surface currents off Oregon: Decorrelation time and length scales

11:55 **Martin Scherwath**, R. Dewey, and S. Mihaly
An update from Oceans Networks Canada: VENUS and NEPTUNE observatories

12:15-16:00 **BREAK**: lunch and afternoon free time

Afternoon session: *Submarine canyons*
Co-Chairs: Erika McPhee-Shaw, Eric Kunze, and Susan Allen

16:00 **Erika McPhee-Shaw**: Introduction

16:05 ***Jessica Spurgin** and S. E. Allen
Does upwelling occur in or around downwelling submarine canyons?

16:25 K. Le Souef and **Susan E. Allen**
Internal tidal resonance in the Gully, results from a laboratory model

16:45 **Erika McPhee-Shaw**, E. Kunze, J. Girton, and C. Collins
Monterey Submarine Canyon pumps oxygen into the abyss

17:05 **Discussion**

18:00-19:00 **BREAK**—Dinner

19:00 **Dr. Jim Kitchell's Fireside Chat**

Tuesday, September 17th Poster Session

20:00-22:00 **Poster session**

Characteristics and causes of regional structure and variability in the California Current

Christine Cass and J. Taatjes
Energy content of California Current zooplankton collected off of Trinidad Head, California

Sung Yong Kim and B. D. Cornuelle
Coastal ocean climatology in the Southern California Bight: Multivariate regression

Andrew Thomas, R. Mendelssohn, and R. Weatherbee
Background trends in California Current surface chlorophyll concentrations: a state-space view

Interdisciplinary nearshore processes

Jeffrey Paduan and M. S. Cook
Trajectory statistics from HF radar data: Some examples and some concerns

General session

Yi Chao, J. Farrara, H. Zhang, M. Messié, F. Chavez, L. Dewitt, E. Danner, D. Dugdale, E. Ateljevich, and J. Zhang
San Francisco Bay circulation and variability as simulated by a semi-implicit Eulerian-Lagrangian finite-element unstructured grid model

Albert J. Hermann, S. Siedlecki, and N. Bond
Live immersive exploration of biophysical forecasts for the Pacific Northwest

D. Huff, **Brian Wells**, J. Fiechter, I. Schroeder, D. Jackson, and C. Edwards
A biophysical habitat model for juvenile Chinook salmon in coastal central California

***Shane Mallory**, J. R. Jacobsen, H. A. Clyma, A. J. Blair, C. Barbour, W. Z. Jones, Jr., Z. E. Meadow, J. Nelson, J. Taatjes, R. C. Woodbury, C. J. Cass, and J. C. Borgeld
Persistence of ebb tidal fronts at the entrance of Humboldt Bay, California

***Noel Pelland**, C. C. Eriksen, S. R. Emerson, and M. T. Cronin
The seaglider time series at Ocean Station P, 2008-10: Application to estimates of ocean metabolism and near-surface budgets of heat and salt

***Bridget N. Seegers**, R. Kudela, D. Caron, G. Roberston, and B. Jones
Glider observations from "an ecosystem wide nutrient enrichment experiment" aka the Orange County Sanitation District shallow nearshore outfall pipe diversion.

J. Tyburczy, B. Peterson, J. Abell, and **Eric Bjorkstedt**
Big Krill Kill: investigating a mass mortality of euphasiids in Oregon and Northern California

Wednesday, September 18th Talks

Morning session: *Region-wide perspective on HABs*
Co-Chairs: Kristen Davis, Raphael Kudela, and Drew Lucas

08:40 **Drew Lucas**: Introduction

08:45 **Melissa Carter**, J. McGowan, M. Hilbern, and E. Vu
Scales of variability in coastal phytoplankton populations

09:05 **Drew Lucas** and R. Pinkel
The phenomenology of diatom HAB events over the inner shelf: what on earth do small spatial and temporal scales actually look like?

09:25 **Raphael Kudela**, T. Schraga, C. Mioni, and M. Peacock
San Francisco Bay acts as a reservoir and mixing bowl for both marine and freshwater harmful algal toxins

09:45 **John Largier**
Oceanographic variability provides pulsed HAB habitat

10:05-10:25 **BREAK**

10:25 **Clarissa Anderson**, C. Edwards, N. Goebel, and R. Kudela
Forecasting the terrestrial influence on domoic acid production: a mechanistic approach

10:45 **Sarah Giddings**, P. MacCready, N. S. Banas, K. A. Davis, S. A. Siedlecki, B. M. Hickey, V. L. Trainer, and R. Kudela
Using bio-physical numerical simulations to test transport pathways and predict harmful algal blooms along the U.S. Pacific Northwest coast

11:05 **Kristen Davis**, N. Banas, P. MacCready, S. Giddings, S. Siedlecki, and B. Hickey
Influence of outflow from the Strait of Juan de Fuca on coastal productivity in the Pacific Northwest

11:25 **Discussion**

12:00-15:30 **BREAK—**lunch and afternoon free time

Afternoon session: *Interdisciplinary nearshore processes*
Co-Chairs: Falk Fedderson and Melissa Omand

15:30 **Falk Fedderson**: Introduction

15:35 ***Nirnimesh Kumar**, G. Voulgaris, J.C. Warner, and J. H. List
Offshore transport around a cuspate foreland system due to wind, wave and tidal forcing

15:55 ***Ata Suanda** and J. A. Barth
Internal tides on the Oregon inner shelf

16:15 **Leonel Romero**, Y. Uchiyama, J. C. Ohlmann, J. C. McWilliams, and D. A. Siegel
Simulations of nearshore particle-pair dispersion in Southern California

16:35 ***Kai Hally-Rosendahl**, F. Feddersen, and R. T. Guza
Cross-shore exchange between the surfzone and inner-shelf

16:55-17:15 **BREAK**

17:15 ***Fernanda Henderikx Freitas**, D. A. Siegel, S. Halewood, and E. Stassinos
Variability of phytoplankton and particles in the inner-shelf Santa Barbara Channel on scales of hours to seasons

17:35 ***Atsushi Fujimura**, A. Reniers, C. Paris, A. Shanks, J. MacMahan, and S. Morgan
A biophysical model of effects of beach morphology and wave conditions on surf zone larval transport

17:55 **Geno Pawlak**, L. Molina, J. Wells, S. Monismith, and M. Merrifield
Cross-shore thermal exchange on a tropical fore-reef

18:15 **Discussion**

18:30 **Adjourn for dinner and banquet**

Thursday, September 19th Talks

Morning session: *General session*
Co-Chairs: Parker MacCready and Kerry Nickols

09:00 D. Rivas, I. Rypina, D. Kirwan, and **Sherry Scott**
Identifying and analyzing 3D Lagrangian coherent structures in fluid flows

09:20 **Parker MacCready**
An energy budget for NE Pacific coastal and inland waters

09:40 **David Rivas**, A. Domínguez, and T. Baumgartner
Dynamical downscaling of IPCC global models in the Mexican eastern Pacific Ocean

10:00-10:20 **BREAK**

10:20 **Eric Bjorkstedt**
"Everywhere" conditions: mimicking momentum boundary conditions to integrate low-frequency, remote forcing in 2-D models of coastal upwelling

10:40 **Richard Dugdale**, E. Danner, E. Ateljevich, F. Chai, Y. Chao, F. Chavez, and F. Wilkerson
Modeling salmon from ocean to estuary to freshwater and back: the SESAME project

11:00 **Adjourn for business meeting, lunch, and departure**

EPOC 2013 Abstracts

(organized by session and time; * *indicates student*)

Characteristics and causes of regional structure and variability in the California Current

Tuesday morning

Co-Chairs: Eric Bjorkstedt and Andrew Thomas

Tues. 08:35

*__Andrew Murphy Davis__ and E. Di Lorenzo
School of Earth and Atmospheric Science, Georgia Institute of Technology

Large-scale vs. regional-scale controls of CCS transports

Large-scale climate forcing associated with atmospheric variability of the Aleutian Low and coastally-trapped waves of tropical origin have been invoked to explain low-frequency changes in the non-eddy resolved circulation of the California Current. Using an ensemble of eddy-resolving ocean model hindcasts over the period 1950-2008 we revisit the large-scale theory by examining the role of mesoscale dynamics and regional atmospheric forcing in driving two main features of the CCS: the meridional flow and the eddy field. We find that a large fraction of changes in meridional transport and mesoscale eddies, especially the anticyclones, respond deterministically to changes in a regional cross-shelf gradient in the wind stress curl. After developing a temporal forcing index of this wind pattern, we are able to build a linear diagnostic model to predict the low-frequency evolution of both the CCS meridional transport and eddy counts. Although the wind stress curl gradient pattern shares some variance with large-scale variation in the Aleutian Low, the strong regional wind-forcing signature implies a reduced role for tropical and basin-scale climate signals in defining CCS alongshore (*e.g.* meridional flow) and cross-shelf (*e.g.* mesoscale eddy) transport dynamics.

Tues. 08:55

Nicholas Foukal and **Andrew Thomas**

University of Maine

Seasonal biogeography and phenology of satellite-measured chlorophyll in the California Current System

Thirteen years (1998-2010) of satellite-measured chlorophyll concentrations partition biogeographic regions in the California Current System (CCS) based on seasonal variability. Climatologically, multivariate clustering divides the CCS into four regions. These are i) a northern and ii) a southern coastal region with summer and spring seasonal maxima, respectively, separated at the Southern California Bight (SCB), representing upwelling areas, iii) an offshore region 30-45˚N with winter maxima representing subtropical conditions and iv) a region between this and the upwelling zones that extends over the entire latitudinal range of the study area with very weak seasonality representing multiple ecosystems including Pacific subarctic and tropical conditions. Clustering of the

seasonal cycles separated into years finds the same four clusters and quantifies interannual variability. Interannual variability largely reflects changes in the seasonal cycle consistent with major forcing events previously documented in the CCS, including 1998, an El Niño year, and delayed upwelling in 2005. Interannual shifts between the weak and summer minimum in subtropical regions appear linked to winter wind mixing. Thirteen-year seasonal stability is strongest along the Pacific Northwest and southern Baja California coasts and weakest in, and offshore of, the SBC. Phenology trends over the study period within the two upwelling clusters are weak but present, suggesting delaying and shortening duration northern (summer) upwelling and delaying southern (spring) upwelling.

Tues. 09:15

Yi Chao, J. Farrara, and H. Zhang
University of California, Los Angeles

California Current and variability as revealed by a regional ocean modeling system with data assimilation and hindcast/nowcast/forecast Capabilities

This talk will report the progress of developing a California Current modeling and data assimilation system using a Regional Ocean Modeling System (ROMS) and 3-dimensional variational (3DVAR) data assimilation method. Results from both the nowcast/forecast operation during recent years and a 10-year (2004-present) hindcast experiment will be presented. Interactions between the California Current and the Pacific climate variability associated with PDO and NPGO as simulated by a Pacific basin-wide ROMS are described. Both in situ and satellite observations are used to validate the ROMS-3DVAR nowcast/forecast and hindcast. Circulation and variability are analyzed focusing on southern California bight as well as the central and northern California coastal ocean.

Tues. 09:35

Ariane Verdy, R. Sodowsky, and M. Mazloff

Scripps Institution of Oceanography, University of California, San Diego

Spatio-temporal variability of ocean carbon in the California Current System

The physical and biological mechanisms influencing variability in the carbon system are investigated in a model-observations synthesis of the California coastal ocean. The synthesis is produced by assimilating remote and in situ observations in a coupled physical-biogeochemical ocean model using the 4D-Var method. It provides a quantitative basis for analyzing the underlying physics and biology controlling ocean biogeochemistry in order to understand how it responds to climate variability. Changes in the concentration of dissolved inorganic carbon (DIC) in the mixed layer are attributed mainly to entrainment of thermocline waters near the coast, biological production and remineralization offshore, and horizontal advection throughout the domain. The relative importance of these mechanisms in setting the mean budget, seasonal cycle, and interannual variability are quantified. Spatial and temporal variability in air-sea fluxes of carbon dioxide, seawater pH, and calcium carbonate saturation state are also investigated and compared to observations.

Tues. 10:15

Rachel Fontana[1], M. L. Elliott[2], J. L. Largier[1], and J. Jahncke[2]
[1]Bodega Marine Laboratory, University of California, Davis
[2]Point Blue Conservation Science

Zooplankton composition in a strong, persistent upwelling region: What can it tell us?

Understanding variability in zooplankton abundance and composition are critical to elucidating changes in ocean conditions. Time series of zooplankton data span the west coast of North America. Less data, however, has been collected within the strong, persistent upwelling area located from southern Oregon to north-central California. To fill this regional data gap, we investigated a zooplankton time series collected off north-central California within the Gulf of the Farallones-Cordell Bank region from 2004 to 2009. We found zooplankton abundance and composition differed significantly between the first three years (2004 to 2006) and the latter three years (2007 to 2009) of the study. These changes were mainly observed as increases in total abundance and a larger contribution to overall composition by early-life stage euphausiids and two boreal copepod species in 2007 through 2009. Zooplankton abundance and composition correlated with several environmental measurements, including alongshore wind stress, surface current flow, and in situ salinity. This signifies linkages between zooplankton and oceanographic variability at multiple temporal and spatial scales within this strong, persistent upwelling region. Understanding zooplankton variability in this productive region will assist in elucidating changes in seabird populations and may assist with future year-to-year predictions of general ecosystem health.

Tues. 10:35

Isaac Schroeder[1], J. Santora[2], S. Bograd[1], B. K. Wells[3], J. Fiechter[4], and C. Edwards[4]
[1]Environmental Research Division, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration
[2]Farallon Institute for Advanced Ecosystem Research
[3]Fisheries Ecology Division, Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration
[4]Institute of Marine Sciences, University of California, Santa Cruz

Combining long-term observations and a data assimilative ROMS model to evaluate climate-driven variability in California Current krill dynamics

The National Marine Fisheries Services “Rockfish-Recruitment and Ecosystem Assessment Survey” (RREAS) sampled 31 CTD stations within the Gulf of the Farallones and Monterey Bay region during May/June, 1990-2010. Temperature and salinity averaged from 50-100 m, the depth of the 26.1 isopycnal (proxy for nutricline), and stratification of the upper 100 m were used to estimate physical drivers of krill distribution and abundance. Years of low temperature, high salinity, shoaled 26.1 isopycnal depth and decreased stratification were conditions resulting in increased krill abundance. A data assimilative ROMS allows for the extension of these physical variables to unsampled locations and months. First the model results were evaluated using the hydrographic data sampled during the RREAS survey, for a test of spatial realism, and from the M2 mooring in Monterey Bay, to test temporal realism. The physical data from the assimilative ROMS model was highly correlated with CTD observations across the RREAS

region and temporally at the M2 mooring. The model data were then used to investigate seasonally-lagged physical indicators of krill abundance and local seabird reproductive success. This study provides an example of using ROMS to develop functional relationships between the environment and ecosystem productivity at spatial and temporal scales unachievable in the past. Further, these results set the stage for building realistic ecosystem models that extend to top predators.

Posters

Christine Cass and J. Taatjes
Department of Oceanography, Humboldt State University

Energy content of California Current zooplankton collected off of Trinidad Head, California

Most zooplankton found off of Trinidad Head, California are advected into the region. Some species have primarily boreal distributions while others are more often found in sub-tropical environments. Differences in the zooplankton community resulting from recent oceanographic conditions can have profound implications for higher trophic levels. The objective of this research is to examine differences in protein and lipid content of major zooplankton taxa in the Trinidad Head region to gain a better understanding of the energy content of boreal versus sub-tropical species and the linkage between zooplankton community structure and energy available to higher trophic levels. Zooplankton collection during May, June and July of 2013 was dominated by boreal species, including *Pseudocalanus mimus*, *Acartia longiremis*, *Metridia pacifica*, and *Euphausia pacifica*. Protein content (as % of wet mass) of *E. pacifica* adult males and females was not significantly different and averaged 7.34 ± 1.42% during this time period. Protein content of *E. pacifica* increased from May to July, with average values of 6.86, 7.35, and 7.69% for May, June and July samples, respectively. *M. pacifica* showed significantly higher protein content, at 9.29 ± 1.31%. Zooplankton collection for this project is ongoing and will continue monthly through summer of 2014.

Sung Yong Kim[1] and B. D. Cornuelle[2]
[1]Division of Ocean Systems Engineering, Korea Advanced Institute of Science and Technology
[2] Climate, Atmospheric Science and Physical Oceanography, Scripps Institution of Oceanography, University of California, San Diego

Coastal ocean climatology in the Southern California Bight: Multivariate regression

A coastal ocean climatology of temperature and salinity in the Southern California Bight is estimated from conductivity-temperature-depth (CTD) and bottle sample profiles collected from historical California Cooperative Oceanic Fisheries Investigation (CalCOFI) cruises (1950 to 2009; quarterly since 1984) off southern California and quarterly/monthly near-shore CTD surveys (within 30 km from the coast except for surfzone; 1999 to 2009) off San Diego and Los Angeles. The estimation uses multivariate linear regression to optimally separate physical processes affecting the measurements. The four-dimensional temperature and salinity fields are modeled as linear combinations of the annual cycle and five harmonics, a mean and linear trend, selected well-known climate indices -- El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), North Pacific Gyre Oscillation (NPGO) -- and the Scripps Pier temperature time series, all without time lags. Since some of the predictor indices are correlated, they are successively orthogonalized in order to reduce the ambiguity in attribution of the contributing variance of each regression basis. The data-derived climatology will provide a tool to evaluate climate signals embedded in coastal observations and to constrain realistic numerical models as boundary and initial conditions.

Andrew Thomas[1]**,** R. Mendelssohn[2], and R. Weatherbee[1]
[1]University of Maine
[2]Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration

Background trends in California Current surface chlorophyll concentrations: a state-space view

State-space models are applied to 13 years of monthly satellite-measured chlorophyll concentrations of the California Current, from British Columbia to Baja California, to isolate the slowly-varying background trend from potentially non-stationary seasonal cycles, other higher-frequency cyclical variability and an irregular noise plus measurement error signal. Temporal patterns in resulting background trends cluster into four dominant groups, three of which have increasing trends, the strongest of which extends over the coastal upwelling region from southern Oregon to Point Conception, California. Overall, statistically significant increasing trends are observed over 75% of the study area, 20% of the study area had no trend, and 5% showed decreasing chlorophyll. Location-specific trend estimation shows increases are strongest in upwelling areas along the Washington, Oregon and central California coasts, weaker in regions > 200 km offshore, and that positive trends are statistically significant over most of the California Current north of ~ 27˚N. Negative trends are evident south of ~ 31˚N off Baja California. These trends remain significant with similar spatial pattern, but lower magnitude, when the 1997-1998 El Niño period is removed from the analysis. Trend patterns are compared to local wind forcing and non-local signals, characterized by the North Pacific Gyre Oscillation and the Multivariate El Niño Index.

Submarine canyons

Tuesday afternoon

Co-Chairs: Erika McPhee-Shaw, Eric Kunze, and Susan Allen

Tues. 16:05

***Jessica Spurgin** and S. E. Allen
Department Earth, Ocean and Atmospheric Sciences, University of British Columbia

Does upwelling occur in or around downwelling submarine canyons?

Since the 1980s, researchers have been using numerical models, laboratory experiments, and actual field observations to gain a better understanding of the flow dynamics in and around submarine canyons. However, many studies have focused on upwelling canyons and they are therefore better understood than downwelling canyons. A few numerical process studies have looked at both upwelling and downwelling canyons (Klinck, 1996; She and Klinck, 2000) and particular downwelling canyons: Calvi Canyon (Skliris *et al.*, 2001) and Blanes Canyon (Ardhuin *et al.*, 1999). A number of differences are present in the specific results from these studies, but all saw net downwelling; *i.e.* no raised density surfaces. However, one observational study of Blanes Canyon (Flexas *et al.*, 2008) found evidence of upwelling occurring in the canyon. To determine the cause of this difference and other smaller differences between the downwelling canyon studies, we have simulated downwelling over a number of topographies, including Blanes Canyon topography and the simpler process-study canyons. Simulations were performed with the Massachusetts Institute of Technology general circulation model (MITgcm) at various resolutions. We will explain differences between the modelling and observational studies and answer the title question.

Tues. 16:25

K. Le Souef and **Susan E. Allen**
Department Earth, Ocean and Atmospheric Sciences, University of British Columbia

Internal tidal resonance in the Gully, results from a laboratory model

Long submarine canyons such as Gaoping Canyon off Taiwan and Monterey Canyon, have been shown to have enhanced semi-diurnal tides. The Gully off the coast of Nova Scotia is a canyon of similar length and depth. However, it is a region of enhanced diurnal tides. These tides are consistent with internal wave resonance in the canyon. Using a laboratory model, we have investigated the peak resonance frequency, the breadth of the resonance curve and the structure of the flow. The methods, analysis and results from the laboratory model will be presented. The breadth of the resonance curve (or the inverse Quality factor of the resonance) is very high implying strong frictional damping in the canyon. We will discuss the origin of this friction in the laboratory and its clear analogue in the Gully. Comparison to observations and implications will conclude.

Tues. 16:45 **Erika McPhee-Shaw**[1], E. Kunze[2], J. Girton[2], and C. Collins[3]
[1]Moss Landing Marine Laboratories, San Jose State University
[2]Applied Physics Laboratory, University of Washington
[3]Moss Landing Marine Laboratories and Naval Postgraduate School

Monterey Submarine Canyon pumps oxygen into the abyss

The Monterey Submarine Canyon on the Central California continental margin has recently been discovered to host intense boundary-interior exchange and a persistent offshore transport feature around 750 to 950 m depth, caused by mixing and restratification within the canyon. Here we show that mixing and offshore transport also affect oxygen over the depth range of the oxygen minimum zone (OMZ), both within the canyon and immediately offshore. Within the main body of the canyon, dissolved oxygen levels between 600 and 1100 m were about 5 μmol kg^{-1} higher than at the same isopycnals offshore. We argue that this is due to mixing within the canyon from above and below the OMZ. The elevated oxygen signal is then pumped offshore within the same intrusion feature identified in previous work, and the anomalous signature persists as far as about 20 km from the mixing and detachment zone within the canyon. Although the anomaly is limited in offshore extent, submarine canyons are regular features along the eastern Pacific margin, and this finding may have implications for understanding the maintenance and structure of oxygen minimum zones along continental margins and near canyons, particularly important given the depletion of abyssal oxygen over recent decades.

Region-wide perspective on HABs

Wednesday morning

Co-Chairs: Kristen Davis, Raphael Kudela, and Drew Lucas

Wed. 08:45 **Melissa Carter**, J. McGowan, M. Hilbern, and E. Vu
Scripps Institution of Oceanography, University of California, San Diego

Scales of variability in coastal phytoplankton populations

Can phytoplankton spatial patterns of species abundance provide new information in understanding forcing mechanisms and scales of variability within the context of harmful algal bloom (HAB) events? Spatial correlation length scales of chlorophyll and three HAB species (*Pseudo-nitzschia spp*., *Lingulodinium polyedrum*, and *Prorocentrum micans*) were calculated along seven pier-based stations over 700 kilometers of California's coastline. These stations are part of the HAB monitoring program, conducted by the Southern California Coastal Ocean Observing System (SCCOOS), which have collected weekly samples since June 2008. The results provide context for evaluating local versus regional influences on phytoplankton dynamics and show the importance of including species data into HAB models and forecasts.

Wed. 09:05 **Drew Lucas** and R. Pinkel
Scripps Institution of Oceanography, University of California, San Diego

The phenomenology of diatom HAB events over the inner shelf: what on earth do small spatial and temporal scales actually look like?

The scientific canon of HAB outbreaks holds that biological, chemical, and physical factors combine in some particular fashion to produce optimum conditions that permit bloom events. Unfortunately, either the appropriate data are too sparsely sampled or the interacting dynamics are too nonlinear to regularly allow for effective forecast skill at any length of time into the future. Here I will present data collected from an array of autonomous profiling vehicles equipped with turbulence instrumentation and a pair of bottom-mounted, temperature-sensing fiber optic cables during a recent bloom of *Pseudo-nitzschia* off the Southern California coast. These physical data extend continuously across scales from the inertial subrange (cm) to the shelf width (km) and provide an unprecedented view of the local internal wave field. Diatom HAB events seem in principle more amenable to prediction given their presumed dependence on physically mediated nutrient delivery. These data show that physical forcing across a broad spatiotemporal range interacts to influence such nutrient dynamics, which in turn argues that detailed spectral parameterizations of the internal wave field, in particular forward energy cascades from the internal tide, are required to adequately account for the physical drivers of HAB formation in forecasting models.

Wed. 09:25

Raphael Kudela[1], T. Schraga[2], C. Mioni[3], and M. Peacock[1]
[1]Ocean Sciences Department, University of California, Santa Cruz
[2]United States Geological Survey, Menlo Park
[3]Institute of Marine Sciences, University of California, Santa Cruz

San Francisco Bay acts as a reservoir and mixing bowl for both marine and freshwater harmful algal toxins

San Francisco Bay is a nutrient-enriched estuary that has apparently resisted classic symptoms of eutrophication, such as high phytoplankton biomass and low dissolved oxygen. Increases in HABs provide perhaps the most direct metric of ecosystem health since presence of the algae and associated toxins is a clear indication of impairment. Despite the persistent nutrient enriched status of San Francisco Bay, few HABs have been reported recently for the estuary. A lack of monitoring may play a role, given the large number of potentially harmful algae present in San Francisco Bay. Here we provide an overview of results from a pilot program deploying Solid Phase Adsorption Toxin Tracking (SPATT). SPATT spatially and/or temporally integrates toxin concentrations present in the dissolved phase, and frequently identifies the presence of algal toxins missed by traditional grab sampling. We demonstrate the frequent occurrence of marine toxins interleaving with freshwater toxins along the estuarine salinity gradient, demonstrating the potential for SFB to act as a retentive reservoir for both marine and freshwater toxins, potentially magnifying the impact of HABs in this highly productive ecosystem.

Wed. 09:45

John Largier
Bodega Marine Laboratory, University of California, Davis

Oceanographic variability provides pulsed HAB habitat

During periods of calm and specifically during the fall season off northern California, pulses of stratified poleward flow provide habitat for dinoflagellate-like algal blooms along the Sonoma coast. Each event may be populated by a different taxon and some of them have harmful characteristics. In August 2011, an unusual invertebrate mortality event occurred during one such event, prompting analysis of when such an event may occur again. A forward-looking view would combine the predictability of relaxation events and stratified poleward flow with the probability of such a bloom being harmful. In this paper the oceanographic habitat determinants will be described, based on long-term data from BOON and also intensive study data from WEST. Similar phenomena can be expected in other upwelling areas.

Wed. 10:25 **Clarissa Anderson**, C. Edwards, N. Goebel, and R. Kudela

University of California, Santa Cruz

Forecasting the terrestrial influence on domoic acid production: a mechanistic approach

Several studies from the Monterey Bay suggest that the toxigenic diatom *Pseudo-nitzschia* is alternately associated with upwelling pulses and periods of river runoff. Laboratory manipulations of toxigenic species in culture have shown that production of its neurotoxin, domoic acid (DA), is in turn often a function of silicic acid limitation at different phases of *Pseudo-nitzschia* growth. Increased nutrient inputs from river runoff are expected to reduce water column Si:N ratios on time scales relevant to phytoplankton growth. We hypothesize that heavy river discharge following the first large storms of the rainy season - “first flush” events - increases the toxicity of *Pseudo-nitzschia* blooms in response to an adjustment in nutrient stoichiometry. To examine this, we developed a mechanistic model of DA production, where the growth rate follows the Michaelis-Menten form for individual nutrient limitation. Two tunable parameters determine the maximum rate of production and its rate of decline with increasing growth. Here we discuss the implications of a newly published carbon-based approach versus our simpler deterministic model. An advantage to the latter approach is its suitability for incorporation into a wide variety of NPZ-ROMS models thereby facilitating model evaluation against observations of “first flush” events in the Monterey Bay.

Wed. 10:45 **Sarah Giddings**[1], P. MacCready[1], N. S. Banas[2], K. A. Davis[3], S. A. Siedlecki[2], B. M. Hickey[1], V. L. Trainer[4], and R. Kudela[5]
[1]School of Oceanography, University of Washington
[2]Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
[3]Department of Civil and Environmental Engineering, University of California, Irvine
[4]Northwest Fisheries Science Center. National Oceanic and Atmospheric Administration
[5]Ocean Sciences Department, University of California, Santa Cruz

Using bio-physical numerical simulations to test transport pathways and predict harmful algal blooms along the U.S. Pacific Northwest coast

As part of a joint hydrodynamic and ecosystem modeling project to understand the transport of harmful algal blooms (HABs) in the Pacific Northwest (PNW) we present realistic hindcast simulations of the coastal ocean along the Washington and Oregon shelf. We use particle tracking to examine transport pathways between known source regions for HABs and the coast. We focus on the genus *Pseudo-nitzschia* (PN) of which several species in the PNW are known to produce the neurotoxin domoic acid. In particular, we examine the Juan de Fuca Eddy and Heceta Bank source regions, retentive areas with high nutrients that encourage HAB formation. As previous studies have shown, specific wind forcing drives transport pathways between these retentive regions and the coast. The physical transport pathways alone exhibit strong seasonal and interannual patterns that enhance our predictive capabilities. However, when transport predications are compared to actual beach HAB events (as measured by high PN cell count) many false positives occur. We show that incorporating phytoplankton biomass results from a coupled biogeochemical model reduces the false positives and thus further improves our HAB predictions. Nevertheless, enhanced information about PN growth and toxicity production in the PNW is desired to further improve these predictions.

Wed. 11:05

Kristen Davis[1], N. Banas[2], P. MacCready[3], S. Giddings[3], S. Siedlecki[2], and B. Hickey[3]

[1]Department of Civil and Environmental Engineering, University of California, Irvine
[2]Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
[3]School of Oceanography, University of Washington

Influence of outflow from the Strait of Juan de Fuca on coastal productivity in the Pacific Northwest

In the Pacific Northwest, coastal waters are strongly influenced by outflow from the Strait of Juan de Fuca, fed by the Fraser River and the rivers of Puget Sound. These rivers act as a conduit for land-derived nutrients and the estuarine exchange driven by the freshwater flow entrains ocean-derived nutrients into the coastal euphotic zone and can influence the development of harmful algal blooms. Here, we examine the role of outflow from the Strait of Juan de Fuca in shaping regional patterns of phytoplankton biomass and productivity using an ecosystem model coupled to a high-resolution circulation model of the Washington and Oregon coasts. We present hindcasts of years 2005, 2006, and 2007 to examine the origin (river vs. upwelling) and fate of nitrogen flux from the Strait of Juan de Fuca. Results from this study highlight the important role of estuarine circulation at the mouth of the Strait in the biological productivity of the Washington shelf.

Interdisciplinary nearshore processes

Wednesday afternoon

Co-Chairs: Falk Fedderson and Melissa Omand

Wed. 15:35

***Nirnimesh Kumar**[1], G. Voulgaris[1], J.C. Warner[2], and J. H. List[2]
[1]Department of Earth and Ocean Sciences, University of South Carolina
[2]Coastal and Marine Geology Program, United States Geological Survey

Offshore transport around a cuspate foreland system due to wind, wave and tidal forcing

In this study, a combination of field measurements and a modeling system is used to identify the role of a cuspate foreland in modifying wind, wave and tidally driven circulation and material transport. Field observations of flow and wave parameters were obtained in the surf/inner-shelf region around Cape Hatteras, NC. These measurements are augmented by model simulations from a nested configuration of the COAWST modeling system. Simulated wave parameters and velocity profiles closely agree with measurements. Model results reveal that the flow pattern around Cape Hatteras point is regulated by the presence of a sub-aqueous shoal complex and shoreline orientation change. For southwestward winds, the east side responds to the wind stress, while eddy formation occurs on the leeward side (south side) of the cape. This pattern is reversed for northeastward winds. In both these wind conditions, flow is directed away from the cape. Strongest offshore flows occur during southeastward winds. The shallow shoal complex modifies wave propagation by refraction and dissipation, manifested in form of wave sheltering of the leeward side. Finally, tidal residual flows are found to be substantially weaker than subtidal flows over the study area, suggesting a dominant contribution of wind over tidal forcing for material transport.

Wed. 15:55

***Ata Suanda** and J. A. Barth

College of Earth, Ocean, and Atmospheric Sciences, Oregon State University

Internal tides on the Oregon inner shelf

During the summer upwelling season, tidal-band internal oscillations are a large, but intermittent part of the central Oregon inner-shelf temperature and velocity signals. These nonlinear oscillations potentially contribute to the mixing and transport of nutrients, larval invertebrates and pollutants across the inner shelf. In this work, six years of velocity and density observations from inner-shelf sites to the north of- and directly on- a large submarine bank capture the intermittency and non-homogeneous nature of internal tides. Over the inner shelf, internal tides are organized into events, 2 – 15 day periods of highly-energetic and persistent wave behavior. During events, the northern mooring location, in a region of simple topography, shows a coherent and unidirectional internal tidal wave field. In contrast, the on-bank site has less coherence, with shorter events and multi-directional waves. The duration of an event is related to the persistence of shelf

stratification, and the relation to regional upwelling/downwelling is explored. The amount of energy within an event is highly variable, suggesting the influence of remotely generated tides shoaling onto the Oregon shelf. Both the temporal and spatial variability of internal tides need to be considered when used in interdisciplinary studies which hypothesize a relationship between internal tidal strength and biogeochemical or environmental variables.

Wed. 16:15

Leonel Romero[1], Y. Uchiyama[2], J. C. Ohlmann[1], J. C. McWilliams[3], and D. A. Siegel[1]
[1]Earth Research Institute, University of California, Santa Barbara
[2]Department of Civil Engineering, Kobe University
[3]Institute of Geophysics and Planetary Physics, University of California, Los Angeles

Simulations of nearshore particle-pair dispersion in Southern California

Knowledge of dispersion in nearshore oceans is important for many applications including the transport and fate of pollutants and the dynamics of nearshore ecosystems. We present two-particle dispersion statistics calculated from high-resolution numerical simulations of the Southern California Bight. The relative dispersion is analyzed with respect to the coastal geometry, bathymetry, eddy kinetic energy, and the relative magnitudes of strain and vorticity. Headlands are more energetic and dispersive than bays. Relative diffusivity estimates are smaller and more anisotropic close to shore. Farther from shore, the relative diffusivity increases and becomes less anisotropic, approaching isotropy ~10 km from the coast. The degree of anisotropy of the relative diffusivity is qualitatively consistent with that for eddy kinetic energy. The total relative diffusivity as a function of pair separation distance R is consistent with available drifter observations and is on average proportional to $R^{5/4}$. An analysis of the relative vorticity field shows that structures of large vorticity are preferably elongated and aligned with the coastline nearshore, which may limit cross-shelf dispersion. The results provide useful information for the design of sub-grid scale mixing parameterizations as well as quantifying the transport and dispersal of dissolved pollutants and biological propagules.

Wed. 16:35

***Kai Hally-Rosendahl**, F. Feddersen, and R. T. Guza
Scripps Institution of Oceanography, University of California, San Diego

Cross-shore exchange between the surfzone and inner-shelf

Cross-shore exchange between the surfzone and inner-shelf was observed using temperature and Rhodamine WT dye tracer at the approximately alongshore-uniform Imperial Beach, California. A case study, with dye continuously released near the shoreline for 4.5 hours, is presented. Obliquely incident waves (Hs = 0.7 m) drove an alongshore current, creating a shore-parallel dye plume. Dye and temperature were measured near the bed with a cross-shore array, near the surface with two jetskis, and over the vertical with an alongshore-towed vertical array and CTD+F casts. Within the warm, dye-rich surfzone (0-2 m depth), dye and temperature were vertically well-mixed. Inner-shelf (4-6 m depth) dye and temperature were alongshore-patchy in roughly 50 m-wide bands, and elevated dye co-occurred with elevated temperature, consistent with ejection of warm, dye-rich surfzone water by transient rip currents. Inner-shelf dye concentrations

were approximately depth-uniform in the upper 3 m, where thermal stratification was weak. Below 3 m, dye and temperature vertical gradients were linearly related, suggesting that thermal stratification limited vertical dye mixing immediately outside the wave-breaking boundary. These observations highlight the important role that transient rip ejections can play in surfzone inner-shelf exchange, and indicate the importance of inner-shelf stratification immediately seaward of the well-mixed surfzone.

Wed. 17:15

***Fernanda Henderikx Freitas**[1], D. A. Siegel[1], S. Halewood[2], and E. Stassinos[2]
[1]Department of Geography, University of California, Santa Barbara
[2]Earth Research Institute, University of California, Santa Barbara

Variability of phytoplankton and particles in the inner-shelf Santa Barbara Channel on scales of hours to seasons

The distribution of phytoplankton and suspended particles in inner-shelf waters are determined by a combination of planktonic and benthic ecosystem, physical oceanographic, and land-ocean exchange processes; all interacting over a wide range of time and space scales. In order to understand the controls on particle and phytoplankton distributions in the narrow, dynamic and productive inner-shelf Santa Barbara Channel, we used a glider to obtain highly resolved (~0.5 Hz, ~100 m horizontally, ~1 m vertically) measurements of temperature, salinity, chlorophyll and CDOM fluorescence, spectral backscatter and dissolved oxygen over a 4-km long cross-shelf section off of the Mohawk Kelp Forest, with water depths between 20 and 70 m. Here we present results based on more than 400 cross-shelf snapshots of optical properties acquired within one year and covering a variety of oceanographic scenarios, including pre- and post-phytoplankton blooms, upwelling and relaxation events, the development of intermediate boundary layers in great detail, and a runoff episode. Empirical orthogonal function and harmonic analyses were used to summarize the extensive data into their main modes of variability and correspondent physical forcings. Data allowed characterization of spatial gradients of subsurface chlorophyll fluorescence and particle backscatter on supra-inertial to sub-inertial time scales, with important ecological implications.

Wed. 17:35

***Atsushi Fujimura**[1], A. Reniers[1], C. Paris[1], A. Shanks[2], J. MacMahan[3], and S. Morgan[4]
[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami
[2]Oregon Institute of Marine Biology, Oregon University
[3]Department of Oceanography, Naval Postgraduate School
[4]Bodega Marine Laboratory, University of California, Davis

A biophysical model of effects of beach morphology and wave conditions on surf zone larval transport

Onshore larval migration in the intertidal zone is the last stage of larval transport; however, the mechanism of larval delivery through the surf zone is not understood. We examined the effects of physical and biological factors on nearshore larval transport by using bio-physical coupling model. Surf zone hydrodynamics with different physical regimes were simulated by Delft3D. The modeled physical data were transferred to an individual based model as a biological module. Preliminary results showed that the larval delivery is higher at

a more dissipative beach than at a reflective beach. The results also indicated that larval transport at the relatively steep beach is less dependent on the important parameters for the gradually sloping beach such as larval buoyancy and turbulent-dependent sinking behavior, but more controlled by the complex beach configuration and morphology. Furthermore, there was a negative correlation between onshore larval delivery and wave height. The model results are consistent with the data collected at the beaches along the California coast.

Wed. 17:55

Geno Pawlak[1], L. Molina[2], J. Wells[2], S. Monismith[3], and M. Merrifield[4]
[1]Department of Mechanical and Aerospace Engineering, University of California, San Diego
[2]Department of Ocean and Resources Engineering, University of Hawaii at Manoa
[3]Department of Civil and Environmental Engineering, Stanford University
[4]Department of Oceanography, University of Hawaii at Manoa

Cross-shore thermal exchange on a tropical fore-reef

Observations of the velocity structure at the Kilo Nalu Observatory on the south shore of Oahu, Hawaii show that thermally driven baroclinic exchange is a dominant mechanism for cross-shore transport for this tropical forereef environment. Estimates of the exchange and depth-averaged fluxes are comparable and show that the average residence time for the zone shoreward of the 12m isobath is generally less than one day. Cross-shore wind stress modifies the cross-shore exchange but surface heat flux is identified as the primary forcing mechanism from the phase relationships and buoyancy balance for the annually averaged diurnal structure. Dynamic flow regimes are characterized based on a 2D theoretical framework and the observations of the thermal structure are shown to be in the unsteady temperature regime while the momentum balance is dominated by turbulent stress divergence. While the thermally driven exchange has a robust diurnal profile in the long-term, there is high temporal variability on shorter timescales. Ensemble averaged diurnal profiles indicate that the exchange is strongly modulated by surface heat flux, wind speed/direction and along-shore velocity direction. Analysis of the thermal balance in the nearshore region indicates that the cross-shore exchange accounts for roughly one-third of the advective transport.

Poster

Jeffrey D. Paduan and M. S. Cook
Department of Oceanography, Naval Postgraduate School

Trajectory statistics from HF radar data: Some examples and some concerns

Surface current data from high frequency (HF) radar instruments have been extended over longer times and larger domains in the past decade, particularly along the U.S. western and northeastern coastlines. With those data have come increased calls for statistical information based on estimated surface particle trajectories. Example drivers include the description of source waters for critical sites along the coastline such as marine protected areas, desalination plant intakes, or intertidal larvae settlement habitat. When estimating trajectories, the choices to be made and the limitation that are imposed are common between gridded HF radar data and circulation model output. While example trajectory statistical analyses have been presented from both observations and model results, the errors in those results and the assumptions that underlay them are seldom discussed. This presentation is intended to highlight some of those results and to pair them with a discussion of the inherent assumptions that will need further discussion and validation going forward.

General session

Tuesday and Thursday mornings

Co-Chairs: Parker MacCready and Kerry Nickols

Tues. 11:15

***Daniel Ellis**[1], L. Washburn[1], C. Ohlmann[1], O. Schofield[2], and M. Moline[3]
[1]Marine Science Institute, University of California, Santa Barbra
[2]Institute of Marine and Coastal Sciences, Rutgers University
[3]University of Delaware

Quantifying effectiveness of autonomous underwater gliders as virtual moorings in the Santa Barbara Channel

Autonomous underwater vehicles (AUVs) like gliders are typically used to obtain vertical cross sections of water properties along transects. Another, less common, application is the use of gliders as virtual moorings. Gliders appear to offer many advantages compared with conventional moorings, but extensive evaluation of gliders as mooring substitutes has not been done. During August 2012, two gliders sampled in a box pattern around a conventional mooring in 26 m water depth off of Pt. Sal, California for 2 and 4 days, respectively. Two box patterns were used, one 500m on a side and the other 1 km on a side. Temperature and velocity data from the gliders and moorings are compared using linear regressions and contouring techniques. Linear regressions show good agreement between glider and mooring temperatures ($r^2 > 0.93$, $p < 0.001$). Significant correlations are also found between ADCP-derived velocities from the gliders and the mooring; along-shore velocities exhibit higher correlation ($r^2 = 0.30$, $p < 0.001$) compared with cross-shore velocities ($r^2 = 0.65$, $p < 0.001$). Glider versus glider comparisons are similar to glider versus mooring comparisons in the along-shore ($r^2 = 0.28$, $p < 0.001$) and cross-shore ($r^2 = 0.51$, $p < 0.001$) directions. Additional comparisons of gliders and moorings are planned.

Tues. 11:35

Sung Yong Kim[1] and P. M. Kosro[2]
[1]Division of Ocean Systems Engineering, Korea Advanced Institute of Science and Technology
[2]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University

Observations of near-inertial surface currents off Oregon: Decorrelation time and length scales

High-resolution (km in space and hourly in time) surface currents observed by an array of high-frequency radars off Oregon are analyzed to quantify the decorrelation time and length scales of their near-inertial motions. The near-inertial surface currents are dominantly clockwise with amplitudes of 9–12 cm/s. However, they appear asymmetric and elliptical as a result of counterclockwise inertial motions with magnitudes in a range of 2–5 cm/s. The decorrelation time and length scales are computed from the decay slope of the near-inertial peak and the spatial coherence in the near-inertial frequency band, respectively. Decorrelation time scales of clockwise near-inertial motions increase from 2 days nearshore (within 30 km from the coast) to 6 days offshore, and their length

scales increase from 30 to 90 km seaward possibly due to coastal inhibition. The local spatial coherence has an exponentially decaying structure for both clockwise and counterclockwise rotations, and their phases propagate northwestward (offshore) for clockwise and northeastward (onshore) for counterclockwise rotations.

Tues. 11:55

Martin Scherwath, R. Dewey, and S. Mihaly
University of Victoria/Ocean Networks Canada

An update from Oceans Networks Canada: VENUS and NEPTUNE observatories

The VENUS and NEPTUNE Canada ocean observatories are now operated jointly under the single organization, Ocean Networks Canada. These observatories cover a wide range of marine provinces from the mouth of the Fraser River in the Salish Sea, out across the continental shelf and slope to the Endeavour Ridge hot vent fields, and even into the Canadian Arctic. Data has been flowing since 2006, and we continue to add new components, activate new experiments, and broaden the research opportunities. The presentation will high-light some of the recent additions, including CODAR, Ferry systems, gliders, and a buoy profiler system, and some review of regional signals across the network including up-welling and pathways from off-shore to in-shore. We will also provide an update on our experiences in operating an advanced cabled observatory, including both the successes and challenges.

Thurs. 09:00

D. Rivas[1], I. Rypina[2], D. Kirwan[3], and **Sherry Scott**[4]
[1]Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico
[2]Woods Hole Oceanographic Institution
[3]University of Delaware
[4]Marquette University

Identifying and analyzing 3D Lagrangian coherent structures in fluid flows

In this presentation, we discuss a method for identifying and analyzing the 3D Lagrangian coherent structures (LCS) present in ocean flows. The relatively new method uses a mathematical - dynamical systems and ergodic theory- approach for analyzing fluid flows and employs harmonic analysis/wavelet theory tools for obtaining multi-scale information. We consider the effects of these 3D structures on transport in the flow - with special attention to the possible additional insights gleaned from investigating the vertical motion in the flow. Such 3D LCS have implications for the transport and mixing of nutrients in coastal upwelling locations, harmful algae bloom events and nearshore processes.

Thurs. 09:20 **Parker MacCready**
School of Oceanography, University of Washington

An energy budget for NE Pacific coastal and inland waters

Terms for the mechanical energy budget of the NE Pacific shelf and the adjoining Salish Sea are calculated from a realistic hindcast numerical simulation. Terms from the ROMS history, average, and diagnostic files are used to form closed budgets for all flux divergence terms in KE and PE equations. The fields give a compact, but spatially and temporally explicit way to compare the influence of tides, wind, rivers, eddies, and coastal trapped waves on the energy fields. Energy storage terms are also calculated, split up into barotropic and baroclinic terms, as well as tidal and subtidal. Available Potential Energy of the subtidal density field is calculated as the energy required to go from a state of flattened density surfaces to an observed state. It is calculated for a number of different volumes, allowing exploration of the relative size of different physical energy reservoirs. There is a very large amount of APE stored in the density structure of the inland waters, a result that is consistent with the relative constancy of the estuarine exchange flow throughout the year. Volume integration of these energy terms allows comparison of the relative size of phenomena such as internal tides and upwelling.

Thurs. 09:40 **David Rivas**[1], A. Domínguez[2], and T. Baumgartner[1]
[1]Department de Oceanografía Biológica, Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico
[2]Department de Oceanografía Física, Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico

Dynamical downscaling of IPCC global models in the Mexican eastern Pacific Ocean

Regional climate change scenarios are analyzed for the Mexican Eastern Pacific Ocean. Such scenarios are obtained by downscaling IPCC global models with a regional three-dimensional regional model. Two global models from the Coupled Model Intercomparison Project Phase 3 (CMIP3) were selected by applying criteria reported in the literature, and the downscaled scenarios are compared to the corresponding 20th Century-Climate Experiments. These results are also to be compared to those obtained by using the CMIP5 version of the selected global models.

Thurs. 10:20 **Eric Bjorkstedt**
Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration and Department of Fisheries Biology, Humboldt State University

"Everywhere" conditions: mimicking momentum boundary conditions to integrate low-frequency, remote forcing in 2-D models of coastal upwelling

Sea level anomaly (SLa) reflects in part the effects of local (wind) forcing and alongshore transport related to larger-scale processes. Persistent changes in SLa are useful indicators of ecosystem productivity in coastal upwelling systems, and must be accounted for in modeling drivers of recruitment variability in marine populations. Simple 2-D models of coastal upwelling capture high-frequency responses to local wind forcing, yet the typical structure of these models—a narrow channel with periodic northern and southern boundaries—precludes conventional application of boundary conditions to integrate low-frequency variability in alongshore flow related to basin-scale processes. By nudging the alongshore momentum field towards a quasi-climatology indexed to SLa, it is possible to integrate low-frequency remote forcing in a 2-D model. Nudging is concentrated in current 'cores' so that the system remains responsive to local wind forcing; the strength of this response is inversely related to how strongly the model solution is nudged towards the alongshore momentum quasi-climatology. Incorporating opposing "California Current" and "California Undercurrent" modes in the quasi-climatology appears to be essential to avoid upwelling from unrealistic depths. Idealized and realistically forced simulations demonstrate changes in cross-shelf isocline structure and modulation of ecosystem responses to local wind forcing consistent with field observations.

Thurs. 10:40

Richard Dugdale[1], E. Danner[2], E. Ateljevich[3], F. Chai[4], Y. Chao[5], F. Chavez[6], and F. Wilkerson[1]
[1]Romberg Tiburon Center, San Francisco State University
[2]Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration
[3]California Department of Water Resources
[4]School of Marine Sciences, University of Maine
[5]Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles
[6]Monterey Bay Aquarium Research Institute

Modeling salmon from ocean to estuary to freshwater and back: the SESAME project

This NASA funded modeling project SESAME (Salmon Ecosystem Simulation and Management Evaluation) couples stream and estuarine models with a basin-scale ocean model to simultaneously model the entire early life history (freshwater, estuarine, and coastal ocean habitats) of the Chinook salmon migrating through the San Francisco Bay estuary system. It requires the coupling of a diverse set of numerical models, from ROMS models of the coastal ocean, to the SELFE (Semi-implicit Eulerian Lagrangian Finite Element) model adapted to the San Francisco Estuary and Delta. The different scales of the models presented challenges that already have been met, connecting the coastal ocean with the bay system. Calibration of the combined models has begun using data from fixed observing stations within the Bay. The CoSINE model is embedded as the lower trophic level ecosystem model. Although well-tested in basin-wide and coastal models, the CoSINE model has not previously been applied to estuarine or freshwater systems. Salmon life cycle models including Dynamic Energy Budget (DEB) model are being developed for juvenile and adult stages of the Chinook salmon. The overall model structure, the diverse habitats existing within the Bay and the Sacramento River that challenge the modelers, and some early results will be presented.

Posters

Yi Chao[1], J. Farrara[1], H. Zhang[1], M. Messié[2], F. Chavez[2], L. Dewitt[3], E. Danner[3], D. Dugdale[4], E. Ateljevich[5], and J. Zhang[6]
[1]University of California, Los Angeles
[2]Monterey Bay Aquarium Research Institute
[3]National Oceanic and Atmospheric Administration
[4]San Francisco State University
[5]California Department of Water Resources
[6]Virginia Institute of Marine Science

San Francisco Bay circulation and variability as simulated by a semi-implicit Eulerian-Lagrangian finite-element unstructured grid model

This poster will report the progress of developing a San Francisco Bay modelling system using a 3-dimensional Semi-implicit Eulerian-Lagrangian Finite-Element (SELFE) Unstructured Grid Model. In contrast to the traditional bay/estuary modeling, the lateral boundary condition for SELFE is provided by a 3-dimensional tide resolving Regional Ocean Modeling System (ROMS) over the California coast. Preliminary results from the June-July 2009 model simulation will be presented. The model performance for both water level and temperature/salinity fluctuations will be presented. Potentials of using this model for both hindcast and nowcast/forecast studies will be discussed.

Albert J. Hermann, S. Siedlecki, and N. Bond
Joint Institute for the Study of the Atmosphere and Ocean, University of Washington

Live immersive exploration of biophysical forecasts for the Pacific Northwest

The effective visualization of large multivariate datasets is a continuing challenge to oceanographers. In this live demonstration, we will use stereo-immersive 3D software and hardware (interactive 3D projection) to display output from a regional forecast model of the Pacific Northwest (PNW), and compare it with online climatologies such as those from the World Ocean Atlas. Our regional model is used to downscale 9-month projections from NOAA's global Climate Forecast System to 2.5-km horizontal resolution, and includes forecasts of alongshore transport, upwelling, and anoxia for the PNW. The performance (forecast skill) of this model in the past year will be discussed.

D. Huff[1], **Brian Wells[1]**, J. Fiechter[2], I. Schroeder[1], D. Jackson[1], and C. Edwards[2]
[1]Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration
[2]Department of Ocean Sciences, University of California, Santa Cruz

A biophysical habitat model for juvenile Chinook salmon in coastal central California

Chinook salmon originating from central California waters are the primary contributor to the California fishery. Previous work by Woodson *et al.* (2013, *Marine Ecology Progress Series*) and Wells *et al.* (2013, *Marine Ecology Progress Series*) demonstrates that within the first few months of ocean residency a significant amount of mortality occurs. So great is this mortality event

that variability in the adult population numbers has been linked to the condition of the ocean at entry and the likelihood of encountering prey. What remains to be understood is how the spatial distribution and temporal dynamics of the coastal system affect the probability of appropriate habitat and prey resources becoming available to newly emigrated fish. Here, we use biophysical coupled model output to evaluate the physical (*e.g.*, advection, temperature, salinity, and turbulence) and biological aspects (*e.g.*, PON, diatoms, zooplankton) of the system to quantify habitat. Once built, we use the models to interpret how spatial variability in physical habitat and biological resources may have contributed to recent booms (*e.g.*, 2003) and busts (*e.g.*, 2007) of the stock. The successful completion of this study will allow for the development of appropriately quantified ecosystem indicators of salmon production, examination of biophysical data at a resolution before unachievable for this type of study, and the potential to evaluate the effects of current and future climate variability on the stock.

***Shane Mallory,** J. R. Jacobsen, H. A. Clyma, A. J. Blair, C. Barbour, W. Z. Jones, Jr., Z. E. Meadow, J. Nelson, J. Taatjes, R. C. Woodbury, C. J. Cass, and J. C. Borgeld
Department of Oceanography, Humboldt State University

Persistence of ebb tidal fronts at the entrance of Humboldt Bay, California

Humboldt Bay, CA ebb tidal circulation is dominated by water exiting from the two major sub-bays: North Bay and South Bay. In May 2013, North and South Bays were sampled to identify differences in water originating from the two sub-bays. These properties were utilized to characterize ebb flow interactions of water exiting Humboldt Bay through the entrance channel. CTD tows across visual tidal fronts in the bay entrance revealed strong temperature and chlorophyll gradients across fronts with three times higher chlorophyll concentrations in North Bay waters and higher temperatures in South Bay waters (~3 ˚C). The South Bay waters also demonstrated higher salinities than North Bay waters (approximately 33.86 and 33.82 psu respectively). The smaller South Bay supplied a warmer thermally-stratified surface layer with a cooler, lower-oxygen bottom layer. A longer and deeper channel to the larger North Bay supplied a more well-mixed water column that took longer to exit than South Bay waters. The temperature difference between North Bay and South Bay waters resulted in a density gradient across fronts that inhibited water masses from mixing as the tide ebbed.

***Noel Pelland**[1], C. C. Eriksen[1], S. R. Emerson[2], and M. T. Cronin[1,2]
[1]School of Oceanography, University of Washington
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The seaglider time series at Ocean Station P, 2008-10: Application to estimates of ocean metabolism and near-surface budgets of heat and salt

From 2007 onward, Ocean Station Papa, in the southern Gulf of Alaska (GoA), has been the site of a multidisciplinary mooring fielded by NOAA to study air-sea interaction. From June 2008-February 2010 this mooring was joined by orbiting Seagliders, which augmented the mooring by providing horizontal spatial gradient information as well as increased depth capability and resolution. We present an overview of early results from this time series, with emphasis on observations of lateral exchange and biogeochemical processes in the GoA. Seagliders observed geostrophic currents that suggest a weak anticyclonic eddy passed by the array; this is supported by subsurface observations of warm, saline water that is typically carried by coastally-generated anticyclones. Results are also applied to a budget of surface oxygen, which allows inference of summer rates of net biological oxygen production (related to carbon export) that are consistent with previous estimates. Ongoing analysis includes assessment of respiration of oxygen below the mixed layer and inference of vertical diffusion as a residual in scalar tracer budgets. These observations help to improve our understanding of the importance of horizontal advection of tracers in the GoA, and are an important precursor to future glider deployments associated with the NSF Ocean Observatories Initiative Station Papa node.

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Glider observations from "an ecosystem wide nutrient enrichment experiment" aka the Orange County Sanitation District shallow nearshore outfall pipe diversion

The Orange County Sanitation District (OCSD) normally discharges an average of 5.3 x 10^8 L/day from their outfall located 7 km offshore at 60 m depth. In September 2012, OCSD began a 3-week diversion of their effluent to a shallower (20 m) outfall located 2 km from shore. Due to the effluent's low salinity and therefore lower density it was expected that the discharged effluent would rise to the surface with reduced dilution and bring nutrients into the well-lit shallow waters with a significant potential to stimulate algal blooms. Three gliders deployed on transects near the outfall pipes resulted in good spatial and temporal coverage before, during, and after the diversion event. The system responded with an increase in phytoplankton, but the overall response was less than expected and spatially was very patchy. The observational glider data showed the outfall plume had a patchy distribution and was often mixed throughout the surface. It seems at least in part the plume distribution was influenced by warm summer conditions that minimized the density difference of the cooler and low salinity outfall waters and surrounding ocean waters that could allow for mixing. The system returned to "normal" within 72 hours of the diversion's end.

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Big Krill Kill: investigating a mass mortality of euphasiids in Oregon and Northern California

Between 15 and 21 June 2013, mass stranding and mortality of *Thysanoessa spinifera* was observed on beaches spanning 650 km from Pacific City, Oregon to Bodega Bay, California. This stranding was coincident with unusually low dissolved oxygen levels including mild hypoxia in the nearshore waters of the region. The densest strandings were observed immediately following an unseasonable storm with southwesterly, downwelling-favorable winds. One possible scenario is that the krill were shallow in the nearshore water column (possibly due to diel vertical migration and/or a mating swarm, and likely exacerbated by hypoxia) where they were more susceptible to onshore transport, especially via near-surface downwelling currents.