Eastern Pacific Ocean Conference
2015 Program Schedule

Stanford Sierra Conference Center, Fallen Leaf Lake, South Lake Tahoe

Sunday, September 20

3:00 p.m.	Check-in
3:00-5:00 p.m.	Boating, hiking, activities
6:30-8:00 p.m.	Dinner, *Dining Room*
8:00-9:00 p.m.	Fireside Chat with Dr. David Checkley, *Cathedral Room*
9:00-11:00p.m.	Reception on the Old Lodge Deck

Monday, September 21

7:00 a.m.-8:30 a.m. Breakfast, *Dining Room*

8:30 a.m.-12:10 p.m. **Oral Session 1: Hot and Strange Times in the California Current System – A Look at 2014-2015 from All Angles.**
Session Chairs: Nathan Mantua (nmantua@u.washington.edu) and Mike Jacox (michael.jacox@noaa.gov)
Cathedral Room

8:30-8:40 a.m.	*Welcome*
8:40-9:00 a.m.	Andrew Leising, *Just how different was 2014-2015? The CalCOFI:SOTCC perspective.*
9:00-9:20 a.m.	Paul Fiedler (given by N. Mantua), *How the 2014-2015 Blob differs from El Niño*
9:20-9:40 a.m.	Nathan Mantua, *Persistent record-high temperatures in the North Pacific in 2014/2015: a climate hypothesis*
9:40-10:00 a.m.	Ralf Goericke, *The 2014/15 Warm Anomaly in the southern California Current System*

(10:00-10:20 a.m. Coffee Break, *Fountain Deck*)

10:20-10:30 a.m.	*Poster Previews*
10:30-10:50 a.m.	Mercedes Pozo Buil, *Dynamics controlling the persistence of the 2013/14 and 2014/15 record warm anomalies in the North Pacific*
10:50-11:10 a.m.	Jennifer Fisher, *Changes to the hydrography and zooplankton in the northern California Current in response to 'the blob'*
11:10-11:30 a.m.	Jan Newton, *How the Blob affected Puget Sound*
11:30-11:50 a.m.	Jonathan Fram, *Huge Northeast Pacific Ocean*

	Dataset Available Soon from the Ocean Observatories Initiative: Opportunities and Caveats
11:50-12:10 p.m.	Morgaine McKibben , *Climactic regulation of DA along the Oregon coast*

12:10-1:30 p.m. Lunch, *Dining Room*
1:00-4:00 p.m. Boating, hiking, activities

4:00-5:30 p.m. **Oral Session 2: Role of Submesoscale and Mesoscale Processes in Structuring Ecosystem Dynamics in the Eastern Pacific Ocean.** Session Chairs: Jennifer Fisher (jennifer.fisher@noaa.gov), Christine Cass (Christine.Cass@humboldt.edu), and Fanny Chenillat (fchenillat@ucsd.edu) *Cathedral Room*

4:00-4:10 p.m.	*Welcome and Poster Preview*
4:10-4:30 p.m.	Fanny Chenillat, *Biogeochemical properties of eddies in the California Current System*
4:30-4:50 p.m.	Sung Yong Kim, *Role of submesoscale and mesoscale processes in structuring ecosystem dynamics in the eastern Pacific Ocean*
4:50-5:10 p.m.	Rachel Simons, *Linking Physical Dynamics and High Concentrations of Small Pelagic Fish in the Santa Barbara Channel Eddy*
5:10-5:30 p.m.	Fei Chai, *Future changes of nutrient dynamics and biological productivity in California Current System*

5:30-6:00 p.m. Social Time at the Fountain
6:00-7:00 p.m. Dinner, *Dining Room*

7:00-8:00 p.m. Invited Talk by Frank Schwing, NOAA, *(Cathedral Room)* *The Future of Ocean Science in the U.S.: A Perspective from Inside the Crucible*

8:00-10:00 p.m. Poster Session, *Angora Room*
10:00-11:00 p.m. Social Time at the Fountain

Tuesday, September 22

7:00a.m.-8:30 a.m.	Breakfast, *Dining Room*
8:50 a.m.-12:00 p.m.	**Oral Session 3: The Future is Now: Hypoxia and Ocean Acidification in the Eastern Pacific.** Session Chairs: Erika McPhee-Shaw (Erika.McPhee-Shaw@wwu.edu) and Kerry Nickols (knickols@csumb.edu) *Cathedral Room*

8:50-9:00 a.m.	*Welcome*
9:00-9:20 a.m.	Alice Ren, *Observations and Biogeochemical Model Results of Dissolved Oxygen off of Central California*
9:20-9:40 a.m.	Alan Devol, *Expansion of the oxygen deficient zone of the eastern tropical North Pacific and implications for marine denitirification.*
9:40-10:00 a.m.	Samantha Siedlecki, *Ocean Acidification of the Pacific Northwest coastal waters: A modeling study*
10:00-10:20 a.m.	Erika McPhee-Shaw, *Wind-driven variations in near-bottom dissolved oxygen over the Central California continental shelf*

(10:20-10:40 a.m. Coffee Break, *Fountain Deck*)

10:40-11:00 a.m.	Jason Jacobsen, *Cross-shelf and Temporal Variability of pH, Aragonite Saturation, and Dissolved Oxygen in Northern California: A Local Perspective on a Global Issue*
11:00-11:20 a.m.	Amanda Netburn, *Effects of midwater hypoxia on mesopelagic fish metabolism in the southern California Current Ecosystem*
11:20-11:40 a.m.	Toby Garfield (for Sam McClatchie), *Ichthyoplankton and corrosive waters off southern California*
11:40-12:00 p.m.	Discussion

12:00-1:00 p.m.	Lunch, *Dining Room*
1:00-3:30 p.m.	Boating, hiking, activities
3:30-6:40 p.m.	**Oral Session 4: Predictability of Biology Across Different Space-Time-Trophic Scales** Session Chairs: Clarissa Anderson (monkeyfringe@gmail.com) and Art Miller (ajmiller@ucsd.edu) *Cathedral Room*

3:30-3:40 p.m.	*Welcome*
3:40-4:00 p.m.	Mike Jacox, *An Optimal Upwelling Window for*

	Primary Producers in the California Current System
4:00-4:20 p.m.	Clarissa Anderson, *Even closer towards an operational HAB forecasting system for coastal California*
4:20-4:40 p.m.	Carol Blanchette, *Regional ocean circulation as a major driver of mussel recruitment around Santa Cruz Island, CA*
4:40-5:00 p.m.	Steven Morgan, *Surfzone hydrodynamics as a key determinant of spatial variation in marine communities*

(5:00-5:20 p.m. Coffee Break, *Fountain Deck*)

5:20-5:40 p.m.	Brian Wells, *Evaluating and using numerical ocean and biological model products to assess habitat, salmon survival, and forage dynamics along the coastal California Current system.*
5:40-6:00 p.m.	Al Hermann, *Biophysical uncertainty in the Northeast Pacific as a function of space, time, and trophic scale*
6:00-6:20 p.m.	Kylie Scales, *Optimising habitat-based models for marine top predators - the effects of spatial and temporal resolution on model inference*
6:20-6:40 p.m.	Jerome Fiechter, *A new perspective on sea lion habitat utilization of foraging success in the California Current: results from a fully coupled end-to-end ecosystem model.*

6:40-8:00 p.m.	Dinner, *Dining Room*
8:00-11:00 p.m.	Band/Dancing

Wednesday, September 23

7:00-8:30 a.m.	Breakfast, *Dining Room*
8:30 a.m.-10:50 a.m.	**Oral Session 5: General Session.** Session Chair: Al Hermann (albert.j.hermann@noaa.gov) *Cathedral Room*

8:40-8:50 a.m.	*Welcome*
8:50-9:10 a.m.	Parker MacCready, *Development of the LiveOcean Daily Forecast Model*
9:10-9:30 a.m.	Riley Brady, *Quantifying Natural and Anthropogenic Variation in California Current Upwelling*

(9:30-09:50 a.m. Coffee Break, *Fountain Deck*)

09:50-10:10 a.m.	David Rivas, *A historical HAB in the northern Gulf of California in early 2015*

10:10-10:30 a.m.	Nikolay Nezlin, *Depth and magnitude of subsurface chlorophyll maximum in southern California coastal ocean*
10:30-10:50 a.m.	The Last Talk: Noel Pelland! *Eddy Circulation, Heat and Salt Balances, and Ocean Metabolism: Seagliders at Ocean Station Papa*

10:50a.m.-12:00 p.m. Business Meeting, *Cathedral Room*
12:00-1:00 p.m. Lunch, *Dining Room*

Poster Presenters:

Session 1: Hot and Strange Times in the California Current System – A Look at 2014-2015 from All Angles.
1. Carol Blanchette, *Rapid population declines in sea stars across southern California associated with sea star wasting disease and warm temperature anomalies*
2. Eric Bjorkstedt, *Response of mid-shelf copepod community off northern California to warming event of 2014-2015 in context of environmental conditions and transport.*
3. Alexander Kurapov, *The West Coast Ocean Forecast System and the 2014 warm anomaly*
4. Roxanne Robertson, *Community Composition of Euphausiids Along the Trinidad Head Line - An overview of the time series and how the warm waters of 2014-15 affected local krill populations*

Session 2: Role of Submesoscale and Mesoscale Processes in Structuring Ecosystem Dynamics in the Eastern Pacific Ocean.
5. Christine Cass, *Seasonal and taxonomic variability in lipid and calorie content of copepods off northern California*
6. Stuart Bishop, *Mesoscale variability in the California Undercurrent from the Sea of Cortez to Vancouver Island*

Session 3: The Future is Now: Hypoxia and Ocean Acidification in the Eastern Pacific.
7. Laura Bianucci, *Hypoxia and acidification in Puget Sound: development of FVCOM-ICM model*
8. Kerry Nickols, *Physical contributions to spatial variability of carbon system parameters within a Central California kelp forest*

Session 4: Predictability of Biology Across Different Space-Time-Trophic Scales
9. Jorge Cruz Rico, *A numerical modeling analysis of the phytoplankton and nutrients dynamics for Todos Santos Bay and northwestern Baja California*
10. Xiuning Du, *Egg production rates of the copepod Calanus marshallae in relation to phytoplankton biomass and species composition in the coastal upwelling zone off Oregon, USA.*
11. Julie Keister, *The Strait of Juan de Fuca zooplankton time series*

Session 5: General Session.
12. Ivo Pasmans, *4DVAR with ensemble error estimation in a coastal ocean model*
13. Iván Eduardo Vivas Téllez, *A Lagrangian physical-biological model to study water parcels associated with algal blooms from Southern California Bight to Todos Santos Bay.*
14. Wei Cheng, *Seasonal Circulations on the Southeast Bering Sea Shelf*
15. Kristen Davis, *Examining shoaling internal waves on a shallow shelf slope using distributed temperature sensing (DTS).*
16. Michael DeFlorio, *Western U.S. Extreme Precipitation Events and Their Relation to ENSO*
17. Morgaine McKibben, *Merging glider and ocean color data to accurately estimate phytoplankton biomass in Oregon's coastal waters*
18. William Crawford, *Climate variability in the CCS from a 31-year (1980-2010) historical analysis computed using the ROMS 4D-Var Data Assimilation System*
19. David Anderson, *Data Integration, Discovery and Visualization with the Central and Northern California Ocean Observing System Data Portal*

Eastern Pacific Ocean Conference

2015 - Abstract Book

Stanford Sierra Conference Center,
Fallen Leaf Lake, South Lake Tahoe

20-23 September 2015

Co-Chairs: Kristen Davis & Samantha Siedlecki

EPOC President: Eric Bjorkstedt

EPOC Treasurer: Noel Pelland

EPOC 2015 Abstracts
*** indicates student**

Monday, September 21, Morning Session 1: Hot and Strange Times in the California Current System – A Look at 2014-2015 from All Angles.
Session Chairs:
Nathan Mantua (nmantua@u.washington.edu) and
Mike Jacox (michael.jacox@noaa.gov)

8:40 a.m. **Andrew Leising** (NMFS SWFSC Environmental Research Division),

Just how different was 2014-2015? The CalCOFI:SOTCC perspective.

This talk aims to provide a short background on conditions in the California Current leading up to and during the recent warming event, based on information gleaned from the most recent (and in progress) CalCOFI State of the California Current (SOTCC) reports, with a particular focus on the physical oceanographic aspects. The SOTCC report is unique, in that it brings together very similarly collected basic physical data from a series of locations throughout the CCS, and thus is an excellent source for comparing the dynamics and evolution of the current anomalous event. Comparisons will also be made with the physical conditions during 2013, as that year saw some of the most oppositely anomalous conditions to the current state (2013 was a record breaking year in terms of upwelling, and also led to high oceanic productivity), and 1997-98 - the strong El Niño year which is the only period rivaling the current conditions, in terms of positive SST anomalies.

9:00 a.m. **Paul Fiedler** (Marine Mammal & Turtle Division, NOAA/NMFS Southwest Fisheries Science Center) and Nate Mantua (Fisheries Ecology Division, NOAA/NMFS Southwest Fisheries Science Center) - Talk given by N. Mantua

How the 2014-2015 Blob differs from El Niño

The warming in the eastern North Pacific that began in late 2013 and has continued into 2015 preceded a moderate El Niño warming in the tropical Pacific that began tremulously in 2014. Time series of SSTA in the California Current are loosely correlated with tropical ENSO indices; tropical and California Current warmings do not always co-occur. The Blob and El Niño events currently underway are driven by both local and remote physical forcing. Differences in mechanisms and teleconnections are discussed. The development of the recent warming in the California Current ecosystem, and its potential bottom-up biological effects, is examined in monthly anomaly fields of sea surface temperature and satellite chlorophyll.

9:20 a.m. **Nathan Mantua** (Southwest Fisheries Science Center, NOAA/NMFS) and Emanuele Di Lorenzo School of Earth and Atmospheric Sciences, Georgia Institute of Technology)

Persistent record-high temperatures in the North Pacific in 2014/2015: a climate hypothesis

The 2014-15 warm "blob" in the northeast Pacific Ocean has featured record-high sea surface temperature anomalies (> 3°C). It developed during the winter of 2013/2014 in the Gulf of Alaska and later spread along the North American coast in the following fall, winter and spring of 2014/15. Northeast Pacific SST anomalies resembled the patterns of the North Pacific Gyre Oscillation (NPGO) in 2014 and of the Pacific Decadal Oscillation (PDO) early in 2015. We suggest that the generation, persistence, and spatial evolution of the warm anomalies over the winters of 2013/14 and 2014/15 was driven by large-scale climate teleconnections between the tropics and extra-tropics that are typical of El Niño precursor dynamics. More specifically, we show that the strong atmospheric ridge that forced the warm "blob" is linked to the activity of the North Pacific Oscillation (NPO), a well know pattern of atmospheric variability that acts as a stochastic driver for ENSO. Following a strong extra-tropical NPO forcing during winter/spring, tropical El Niño conditions typically develop in the summer. Continued El Niño conditions in the subsequent fall and winter typically excite atmospheric teleconnections to the Aleutian Low (AL) that that carry the signal back to the North Pacific Ocean in ways that favor the positive phase of the Pacific Decadal Oscillation (PDO). This teleconnection dynamic from extra-tropics to tropics (winter year 0) to extra-tropics (winter year +1) is a source of significant interannual persistence of North Pacific SST anomalies as they evolve from an NPO-like (e.g. NPGO) to an AL-like pattern (e.g. PDO). Even though a strong tropical El Niño did not develop during the fall/winter of 2014/2015, we show that this tropical/extra-tropical coupling played an important role in the generation, persistence and evolution of the 2014/2015 warm "blob". Given that previous studies suggest that greenhouse forcing will energize the NPO precursor dynamics, it is important to establish if the 2014/2015 temperature extreme, and its widespread marine ecosystem impacts, will become more frequent under increasing anthropogenic climate change.

9:40 a.m. **Ralf Goericke** (Integrative Oceanography Division, Scripps Inst. of Oceanography)

The 2014/15 Warm Anomaly in the southern California Current System

The 2014/15 Warm Anomaly (WarmA) off Southern California manifested itself in the summer of 2014 as an anomalously warm surface layer in the SC Bight with low concentrations of Chl a. This layer intensified in spatial extent, covering the entire CalCOFI surface area by the winter of 2015 with temperature anomalies three StDev larger than long-term averages. Concentrations of nutrients, phytoplankton biomass and rates of primary production were extremely low during the WarmA. The evolution of the WarmA with time will be compared to the evolution of the weak and strong El Ninos observed over the last 60 years. This event provides insights in the controls of phytoplankton biomass and production in the southern California Current System. This presentation is based on data collected during the quarterly CalCOFI cruises by the CalCOFI and the CCE-LTER groups.

10:30 a.m. **Mercedes Pozo Buil*** (School of Earth & Atmospheric Sciences Georgia Institute of Technology) and Emanuele Di Lorenzo (School of Earth & Atmospheric Sciences, Georgia Institute of Technology)

Dynamics controlling the persistence of the 2013/14 and 2014/15 record warm anomalies in the North Pacific

During the winters of 2013/14 a record high sea surface temperature anomaly developed in the extra tropical NE Pacific Ocean. This anomaly persevered during the summer and fall of 2014 and reached another record high in the winter of 2014/2015, with strong impacts on marine ecosystem processes and fisheries. The initial generation and persistence of this high temperature anomaly, also referred to as the "blob" has been linked to the strong persistence of an anomalous sea level pressure ridge over the North Pacific. A closer look at the anomaly patterns reveals that while the 2013/14 anomaly was centered in the Gulf of Alaska, the 2014/15 anomaly was spread along the California Current System. While the dynamics controlling the initial generation of the 2013/14 anomalies are clear, the temporal evolution and spread of the "blob" over the CCS is still not well understood. Here we use the Regional Oceanic Modeling System (ROMS) to conduct a set of sensitivity hindcasts to explore the role of ocean circulation dynamics in shaping the warm blob. Specifically we attempt to separate the dynamics of persistence of the blob between the oceanic (e.g., mean ocean advection) and atmospheric (e.g., persistence of the anomalous ridge) contributions.

10:50 a.m. **Jennifer Fisher** (Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Oregon State University), Bill Peterson (Northwest Fisheries Science Center, Hatfield Marine Science Center), and Jay Peterson (Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Oregon State University)

Changes to the hydrography and zooplankton in the northern California Current in response to 'the blob'

The northern California Current supports a lipid-rich food chain composed of copepods, krill and small pelagic fish. Disruptions to this food chain result in reduced productivity and poor survival of pelagic and benthic fishes; major disruptions are often associated with warm ocean conditions during years of positive Pacific Decadal Oscillation (PDO) and positive El Niño events. Fortnightly measurements of hydrography and zooplankton have been sustained along the Newport Hydrographic line since 1996. These efforts have shown that the response of local hydrography and zooplankton species composition is modulated by the sign of the PDO and El Niño. Five El Niño events (1997-98, 2002-03, 2004-05, 2006-07 and 2009-10) have been sampled since 1996 where warm water and anomalously high biomass of subtropical copepods were observed at 44.6°N, regardless of the magnitude of the event at the equator or the sign of the PDO. We compare the local hydrography and species composition across 20 years of positive/negative PDO and five El Niño events in comparison to the anomalously warm event of 2014-15. During this past warm event, the shelf waters off Newport were seasonally warm (+2°C anomaly) and fresh (by 0.2 salinity units) and the biomass anomalies of warm (cold) water copepods increased (decreased) dramatically, but were not anomalously different than during other positive PDO and ENSO years. Unlike the strong El Niño of 1997/98, the deep water off the shelf was not warmer than average during this past warm event. However, copepod species richness has been the highest observed in the past 20 years, indicating source waters from further afield. In fact, seventeen copepod species, many of which have tropical affinities, have been recorded off Oregon that have not been observed at any time over at least the past 50 years, making this extreme event unlike any other.

11:10 a.m. **Jan Newton** (University of Washington), John Mickett (University of Washington), Al Devol (University of Washington), and Wendi Ruef, (University of Washington)

How the Blob affected Puget Sound

Water temperature within Puget Sound began colder than normal, a legacy from the cold fall 2013 and the very cold February 2014 conditions, but warmed the rest of the year, with unprecedented maxima in all locations except Hood Canal. These warm seawater temperatures were influenced by warm summer air temperatures, high solar radiation, and the arrival of the blob in fall. The exception, Hood Canal, was influenced by uncharacteristically cold seawater that appeared to be caused by weather-forced local deep water formation in response to the very cold February air temperatures. Even though this phenomenon occurred in February, these cold waters persisted until fall. On an annual basis, water masses in Puget Sound were warmer and saltier everywhere except Hood Canal where they were colder. This localized deep water formation dynamic also sheds light on why Hood Canal was the only Puget Sound basin with a very low annual DO deficit relative to other years, because when the deep waters were formed (very cold surface waters that became so dense they sank) they had a high oxygen content.

Aside from Hood Canal, the annual oxygen content throughout Puget Sound was similar to 2013; with lower oxygen concentrations (higher deficits) than observed during 2009-2012 but higher oxygen concentrations (lower deficits) than observed during 2006-2008. Fewer than normal oceanic intrusions entered Puget Sound from the Strait of Juan de Fuca, likely in response to the lower than normal Fraser River summer discharge, had the effect of keeping overall oxygen concentration higher than what it might have been during the upwelling season.

The arrival of “the Blob” into Puget Sound during fall caused a quick change in many of the conditions afore noted. Oxygen in lower Hood Canal rapidly went from higher than average to hypoxia which persisted through the end of the year, a condition not seen in the 10-y record. The low river discharge, the lack of oceanic intrusions, and the lower density of the fall intrusions (due to warmer temperatures) likely contributed to the lack of flushing of lower Hood Canal, resulting in the persistence of hypoxia. Hypoxia, at the time of writing is more severe than seen historically, with anoxia in the bottom waters at Twanoh and concentrations at 1 mg/L for a 60 m deep layer at Hoodsport.

11:30 a.m. **Jonathan P. Fram** (CEOAS, Oregon State University),Edward P. Dever (CEOAS, Oregon State University), Craig M. Risien (CEOAS, Oregon State University), Christopher E. Wingard (CEOAS, Oregon State University), Michael F. Vardaro (CEOAS, Oregon State University), and John A. Barth (CEOAS, Oregon State University)

Huge Northeast Pacific Ocean Dataset Available Soon from the Ocean Observatories Initiative: Opportunities and Caveats

The Ocean Observatories Initiative (OOI) will provide new in situ measurements along the coast of Washington and Oregon. OOI includes the Endurance Array, which consists of moorings and profilers at each of three sites located off Central Oregon at 25, 80, and 600 m depth. The

Array also includes three analogous sites off Central Washington, and a network of gliders surrounding all six sites. Some components off Oregon are connected to an undersea fiber optic Cabled Array, which also includes two profilers at full ocean depth further west. OOI includes moored sensors, profilers, and gliders at Station Papa, 1600 km NW of the Endurance Array. At each location there is a broad range of physical, chemical, and biological sensors. Data will made available in near real-time upon completion of OOI's CyberInfrastructure (CI).

This contribution will show what OOI has deployed in the PNW water-column versus what was planned when OOI started six years ago. We will discuss challenges to building and operating this part of OOI. OOI offers new opportunities for long-term oceanographic research in the PNW. As an example, we will show OOI measurements of the recent "warm blob" via a live demonstration of OOI's CI.

11:50 p.m. **Morgaine McKibben*** (College of Earth, Ocean, and Atmospheric Sciences, Oregon State University) and Angelicque White (College of Earth, Ocean, and Atmospheric Sciences, Oregon State University)

Climactic regulation of DA along the Oregon coast

Domoic acid (DA), a toxin produced by some phytoplankton species of the genus Pseudo-nitzschia, accumulates in the food web. DA poses a health threat to shellfish consumers and higher trophic level wildlife such as seabirds and marine mammals. Not all species of Pseudo-nitzschia are toxigenic and those that are do not reliably produce DA. This complicates efforts to find a conclusive mechanism for DA production and develop predictive capacity for DA events. Here we provide evidence for climactic regulation of DA events along the Oregon coast, with the events being strongly related to warm phases of the Pacific Decadal Oscillation. We hypothesize that the presence of toxigenic Pseudo-nitzschia along the Oregon shelf is enhanced during the positive PDO phases. Our results enhance predictive capability for DA events in this region.

Monday, September 21, Afternoon Session 2: Role of Submesoscale and Mesoscale Processes in Structuring Ecosystem Dynamics in the Eastern Pacific Ocean.

Session Chairs:
Jennifer Fisher (jennifer.fisher@noaa.gov),
Christine Cass (Christine.Cass@humboldt.edu), and
Fanny Chenillat (fchenillat@ucsd.edu)

4:10 p.m. **Fanny Chenillat** (Scripps Institution of Oceanography, UCSD), Vincent Combes (College of Earth Ocean and Atmospheric Sciences, OSU), and

Peter J.S. Franks (Scripps Institution of Oceanography, UCSD)

Biogeochemical properties of eddies in the California Current System

The California Current System is known for its high coastal biological production, contrasting with oligotrophic offshore waters. The resulting cross-shore gradient of biological and physical properties is perturbed by strong mesoscale eddy activity. Eddies that are formed at the coast move offshore, entraining and redistributing nearshore nutrients and planktonic organisms. However, the ecosystems within eddies often differ, potentially due to the age of the eddy, the time and the location of its formation, or its nature – cyclonic eddies (CE) vs. anticyclonic eddies (ACE). To characterize and quantify the ability of mesoscale eddies to affect local and regional planktonic ecosystems in the CCS we coupled the Regional Ocean Modeling system with a planktonic ecosystem model. Over a 10-year-long climatological model solution, we identified and tracked CE and ACE. Biogeochemical properties are quantified along their trajectories. This study highlights the differential role of CE and ACE: CE efficiently transport coastal planktonic organisms and maintain local production based on recycling and local vertical nitrate inputs, whereas ACE have enhanced exchange with surrounding waters, diluting the ecosystems within them.

4:30 p.m. **Sung Yong Kim** (Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST))

Role of submesoscale and mesoscale processes in structuring ecosystem dynamics in the eastern Pacific Ocean

Two episodic events of secondary vertical circulation associated with drifting submesoscale eddies are presented with subinertial surface currents [O(1) m depth] derived from shore-based high-frequency radars (HFRs) and in-situ vertical profiles of the current and temperature within the spatial coverage of HFRs. In order to detect eddies from surface current maps, the winding-angle approach based on flow geometry is applied to the calculated stream function. A cluster of nearly-enclosed streamlines with persistent vorticity in time is identified as an eddy About 700 eddies were detected for each rotation (clockwise and counter-clockwise) from two-year surface current observations. Considering the local wind events and surface kinematic and dynamic quantities (velocity potential, stream function, divergence, vorticity, and deformation rates), the vertical movement of thermoclines are more related to drifting submesoscale eddies instead of local upwelling.

4:50 p.m. **Rachel D. Simons** (Earth Research Institute, U.C. Santa Barbara), Mary M. Nishimoto (Marine Science Institute, U.C. Santa Barbara), Libe Washburn (Geography Department, U.C. Santa Barbara)

Linking Physical Dynamics and High Concentrations of Small Pelagic Fish in the Santa Barbara Channel Eddy

The Santa Barbara Channel (SBC) eddy is a cyclonic mesoscale eddy and a dominant feature of the SBC. In June 1998 and 1999, the SBC eddy was surveyed for small pelagic fishes. In 1998, very high numbers of fishes were observed within the eddy, but not in 1999. The ocean conditions that contributed to the interannual differences of fish abundances inside the eddy are investigated using a three-dimensional Regional Ocean Modeling System (ROMS) with particle tracking. The physical dynamics and particle retention of the SBC eddy differ significantly in 1998 and 1999. In 1998, when the SBC eddy is rotating at a steady rate in space and time with vertically coherent flow, the particle retention is high and the isopycnal uplift sustained. However in 1999, when the SBC eddy is rotating unsteadily without vertically coherent flow, the particle retention is low and the isopycnal uplift fluctuates. We theorize that the steady vertically coherent rotation of the eddy in 1998 has two important impacts on the fish abundances. First, it provides a prolonged period of cold nutrient rich water uplifting into the euphotic zone, which stimulates primary productivity attracting zooplankton prey. Second, it allows the zooplankton prey to be retained inside the eddy, which attracts small pelagic fish. We conclude that biological productivity inside mesoscale eddies may be linked to the stability of their three-dimensional rotational structure and their consequent ability to retain particles.

5:10 p.m. **Fei Chai** (School of Marine Sciences, University of Maine), Peng Xiu (South China Sea Institute of Oceanology, Chinese Academy of Sciences), and Enrique N. Curchitser (Department of Environmental Sciences, Rutgers University)

Future changes of nutrient dynamics and biological productivity in California Current System

Future climate change will impact on eastern boundary upwelling ecosystems such as the California Current System (CCS). How do the warming-induced stratification and intensification of upwelling-favorable winds will affect ocean productivity in the CCS? We used a coupled and nested physical-biogeochemical model to examine and predict changes in the physical and biogeochemical fields by the end of 2050. The large global model is an earth system model (ESM) with dynamic atmosphere-ocean general circulation and marine biogeochemistry dynamics developed at NOAA's GFDL. The nested regional model was based the ROMS coupled to a biogeochemical model CoSiNE. The full model was run from 1970 to 2050 and model outputs from two periods were analyzed (1990-2009 and 2030-2049). The model has predicted increased upwelling intensity associated with stronger alongshore winds in the coastal region, and enhanced upper stratification in the open ocean. These two changes both contribute to the increased vertical nutrient flux and biological productivity in CCS. The difference of isothermal deepening between the open ocean and the coast reflecting the basin-scale adjustment creates elevated onshore nutrient transport that increase nutrient concentrations of the upwelling source water and eventually supporting higher productivity in CCS. We found this basin-scale adjustment of nutrient plays a larger contribution than the enhanced wind-generated upwelling in terms of vertical nutrient flux increase in the coastal region. Our model also predicted increasing eddy activities in the CCS that will increase vertical nutrient transport mostly in the coastal region. This study takes advantage of high-resolution models and highlights mechanisms of future productivity enhancements in the coastal upwelling ecosystems.

Monday, September 21, Evening Invited Talk

7:00 p.m. **Frank Schwing** (Office of Science and Technology, NOAA NMFS)

The Future of Ocean Science in the U.S.: A Perspective from Inside the Crucible

Washington DC is the crucible where policy is made and the science that informs policy is planned, prioritized, and funded. Ocean science conducted by NOAA and other Federal agencies, and with a variety of state, tribal, academic, and private partners, is essential to effective management of ocean and coastal resources and better investments in the Nation's ocean economy. Agencies seek efficiencies and look to avoid duplication and conflict between their science programs by fostering inter-agency cooperation, leveraging internal and external research activities, and building and strengthening partnerships. This presentation will highlight, through concept and real examples, how the Federal government is setting a course for coordinated, prioritized research that is responsive to mandates and authorities, balances basic and applied R&D investments, uses the Nation's ocean science capacity, and informs effective, efficient, and better decision-making.

Tuesday, September 22, Morning Session 3: The Future is Now: Hypoxia and Ocean Acidification in the Eastern Pacific.

Session Chairs:
Erika McPhee-Shaw (Erika.McPhee-Shaw@wwu.edu) and
Kerry Nickols (knickols@csumb.edu)

9:00 a.m. **Alice Ren*** (Department of Marine Sciences, University of Maine),Fei Chai (Department of Marine Sciences, University of Maine), David M. Anderson (CeNCOOS), Fred Bahr (CeNCOOS), Yi Chao (Department of Atmospheric and Oceanic Sciences, UCLA), and Francisco Chavez (MBARI)

Observations and Biogeochemical Model Results of Dissolved Oxygen off of Central California

A potential threat of climate change is global decrease in dissolved oxygen at depth due to increased stratification. Regionally, the California Current has experienced dissolved oxygen declines since the late 1980s with observations from Oregon and the Southern California Bight. Here, observations of dissolved oxygen were gathered from Monterey Bay and CalCOFI Line 67 to create a data set spanning the past sixty years. Preliminary analysis suggests that oxygen declines in the past few decades are greatest around the 26.8 sigma-theta isopycnal (depth 350-400 m), and that there is a decadal trend in dissolved oxygen, similar to that of the tropical eastern Pacific, when taking into account observations from the 1950s and 1960s. The observations along Line 67 were compared with model output from the Pacific basin ROMS-CoSiNE biogeochemical model to first, evaluate the model and second, investigate mechanisms to explain changing oxygen dynamics. The model results help to identify the changes in dissolved oxygen attributable to decadal variability and those related to climate change.

9:20 a.m. **Allan Devol** (Oceanography, University of Washington), Rachel Horak (American Society of Microbiology, Washington D.C.)

Expansion of the oxygen deficient zone of the eastern tropical North Pacific and implications for marine denitirification.

The Eastern Tropical North Pacific (ETNP) contains a large region of anoxic water that hosts widespread water column N loss (denitrification). There is some disagreement on whether anoxic zones are currently expanding, and long-term studies of water column denitrification within the anoxic zone are lacking. In this study, we compared, water column O2, and dissolved inorganic nitrogen (DIN) data from the ETNP in 2012 to data from the same transect in 1972, 1994, and 2007. We show that low oxygen conditions have expanded into shallower isopycnals from 1972 to 2012 and geochemical markers for cumulative N loss indicate denitrification was highest in 2012. Oxygen and N loss changes in the world's largest oxygen minimum zone for 2012 could not fully be explained by Pacific Decadal Oscillation.

9:40 a.m.

Samantha Siedlecki (JISAO, UW), Parker MacCready (Oceanography, UW), Ryan M. McCabe (JISAO, UW), Simone R. Alin (PMEL, NOAA), Richard A. Feely (PMEL, NOAA), and Jan Newton (APL, UW)

Ocean Acidification of the Pacific Northwest coastal waters: A modeling study

Total inorganic carbon and alkalinity is incorporated into a regional bio-physical model to examine inorganic carbon variability along the Washington and Oregon continental margin. Results are compared to output from an existing oxygen model (Siedlecki et al., 2015) combined with observationally-based empirical relationships between carbon system parameters, oxygen, and temperature (Alin et al., in prep). Model hindcasts for 2007 and 2013 are also validated against local observations of dissolved oxygen, pH, and the saturation state of aragonite. Challenges and benefits of each approach are discussed. The model suggests that the volume of hypoxic and undersaturated water present over the continental shelf increases over the upwelling season, occupying more of the water column later in the upwelling season. This would result in increasingly stressful conditions for biota over most of the water column as the upwelling season progresses. Spatial variability in the volume of undersaturated water in the region will also be discussed.

10:00 a.m.

Erika McPhee-Shaw (Western Washington University, Shannon Point Marine Center), Olivia Cheriton (U S Geological Survey, Pacific Coastal and Marine Sciences Center), Jeffrey Sevadjian and Ben Raanan (Monterey Bay Aquarium Research Institute)
*Work done at Moss Landing Marine Laboratories

Wind-driven variations in near-bottom dissolved oxygen over the Central California continental shelf

A moored autonomous profiler at the 70-m on the shelf near Monterey, California collected hourly profiles of oxygen during spring upwelling and two 4-week-long fall deployments. Oxygen measurements were ancillary to studies of the physics of shelf boundary-interior exchange, however they provide valuable insight into the dynamics of mid- and outer shelf oxygen, and into the offshore source for pulses of low dissolved-oxygen water observed for many years on the region's inner

shelf. During spring upwelling, relatively low oxygen waters consistently filled outer shelf waters, with concentrations below potentially harmful threshold levels (~4.6 mg L-1, 2.9 ml L-1) persisting for ~7 days and extending upward as far as 20 m depth. During fall deployments, wind reversals and upwelling/downwelling adjustments were common and low-oxygen conditions were more episodic. Distinct pulses of dense water brought sub-threshold oxygen levels up to depths of 40 to 50 m on four separate occasions, each persisting approximately 4 to 6 days. In no case did we observe hypoxic levels, consistent with previous studies finding generally higher oxygen on the shelves of Central California compared to those in the northern part of the eastern boundary current. The height to which low-oxygen water extended was strongly related to isopycnal movement, which varied on upwelling/relaxation time scales (4 to 6 days) as well as at semidiurnal and diurnal time scales.

10:40 a.m. **Jasen Jacobsen*** (Oceanography, Humboldt State University), Jeffery Abell (Oceanography, Humboldt State University), Eric Bjorkstedt (Fisheries Oceanography, Humboldt State University), Frank Shaughenessy (Botany, Humboldt State University)

Cross-shelf and Temporal Variability of pH, Aragonite Saturation, and Dissolved Oxygen in Northern California: A Local Perspective on a Global Issue

We characterize cross-shelf and temporal variability of pH and aragonite saturation (ΩA) from 2010 to 2015 off northern California based on data from 72 offshore cruises conducted along the Trinidad Head Line (THL) and a time-series station at Trinidad Head Wharf (THW). Along THL, dissolved inorganic carbon, alkalinity, and hydrographic data were determined at discrete depths along five stations spanning the continental shelf and upper continental slope. At THW pH and hydrographic data were measured continuously in ~5m water depth since 2006. Following upwelling events during late spring/early summer the aragonite saturation horizon (ΩA=1) reaches as shallow as 30m indicating the bottom water over the entire shelf is periodically under-saturated. pH observations at THW are consistent with this offshore data in terms of the timing of exposure to aragonite corrosive water, but they indicate the aragonite saturation horizon breaches the surface on a regular basis at shore. Since 2006, 87 corrosive events were observed near-shore (determined as any daily period with an average pH below 7.75). Most events persisted for less than a week, but events up to 36 days were observed. Between March and July, THW experienced corrosive conditions 30.8% of the time observed. These events often coincide with low dissolved oxygen conditions.

11:00 a.m. **Amanda Netburn*** (Scripps Institution of Oceanography, University of

California San Diego), Martin Tresguerres (Scripps Institution of Oceanography, University of California San Diego)

Effects of midwater hypoxia on mesopelagic fish metabolism in the southern California Current Ecosystem

The mesopelagic fish assemblage is diverse and abundant, includes essential forage species, and is vital for transporting carbon to the deep sea. Hypoxic mesopelagic waters likely limit the depths of mesopelagic fauna in this region, and continued deoxygenation of California Current (CC) waters could have deleterious effects on fishes already living at the edge of their hypoxia-tolerance thresholds. We measured activities of key enzymes in the aerobic and anaerobic respiratory pathways to ask: (1) Are there detectable changes in total metabolic activity and relative contributions of aerobic and anaerobic respiration across the relatively small-scale gradient in hypoxic layer depths and intensity encountered within the southern CC? (2) Is there evidence for an ethanol production anaerobic pathway in these fishes? (3) Do migrating and non-migrating fishes respond differently to changes in midwater oxygen concentrations? This is the first study we know of to compare metabolic activities of these species across variable conditions within a single region. We speculate on the implications of our findings for pelagic ecosystems in a future deoxygenated ocean.

11:20 a.m. **Toby Garfield**, Sam McClatchie, Andrew R. Thompson and William Watson (Southwest Fisheries Science Center, NOAA Fisheries)

Ichthyoplankton and corrosive waters off southern California

The influence of equatorial water in the southern California region has been increasing over the last three decades, associated with strengthening of the California Undercurrent. These waters contain lower oxygen and higher acidity, but their influence is mediated by the seasonal and inter-annual variability of currents and water masses. The CalCOFI program has consistently sampled the southern California region since 1951, identifying the ichthyoplankton assemblages to species. The mesopelagic fish larvae are the best represented group in these samples. We use the mesopelagic ichthyoplankton assemblages collected by CalCOFI at three locations representative of the core of the California Current, the core of the California Undercurrent and the oligotrophic central gyre waters to determine how increasing equatorial influence is reflected by the mesopelagic fish community. We discovered different temporal patterns and variability of ichthyoplankton at the three representative locations within the region. Warm and cool water associated mesopelagic ichthyoplankton assemblages also show different responses, indicating that spatial averaging over many species may fail to resolve biotic responses to complex oceanographic variability.

Tuesday, September 22, Afternoon Session 4: Predictability of Biology Across Different Space-Time-Trophic Scales

Session Chairs:
Clarissa Anderson (monkeyfringe@gmail.com) and
Art Miller (ajmiller@ucsd.edu)

3:40 p.m. **Michael G. Jacox** (Institute of Marine Sciences, University of California Santa Cruz and Environmental Research Division, Southwest Fisheries Science Center, NOAA), Steven J. Bograd (Environmental Research Division, Southwest Fisheries Science Center, NOAA), and Elliott L. Hazen (Environmental Research Division, Southwest Fisheries Science Center, NOAA)

An Optimal Upwelling Window for Primary Producers in the California Current System

Upwelling variability and trends in Eastern Boundary Currents (EBCs) have been topics of considerable study in recent years, broadly motivated by a desire to understand potential changes in these highly productive regions. However, translating changes in upwelling to changes in ecosystem productivity is not straightforward. Ideal conditions must balance nutrient availability with physical processes (such as mixing, advection, and subduction) that can adversely affect biological populations. Here, we use a regional ocean model and satellite data to characterize an "optimal upwelling window", describing the parameter space for winds and nitrate that is most conducive to high chlorophyll concentrations. These results are key to projecting ecosystem responses to environmental change, as shifts in upwelling and water column properties relative to optimal conditions may influence biology in unexpected but predictable ways (e.g., decreased productivity with more upwelled nutrient).

4:00 p.m. **Clarissa Anderson** (Institute of Marine Sciences, University of California Santa Cruz), Raphael M. Kudela (Ocean Sciences Department, University of California Santa Cruz), David M. Anderson (Central and Northern California Ocean Observing System), Fred L. Bahr (Central and Northern California Ocean Observing System), Dale H. Robinson (NOAA Coast Watch), Richard P. Stumpf (NOAA National Ocean Service).

Even closer towards an operational HAB forecasting system for coastal California

After completion of a one-year feasibility demonstration, we are closer

to our goal of achieving an operational harmful algal bloom (HAB) forecasting system in coastal California. This effort builds on years of proof-of-concept studies in various hot spots off the U.S. West Coast. Our application system predicts the spatial likelihood of Pseudo-nitzschia blooms and dangerous levels of domoic acid (DA) using a unique blend of numerical models, ecological forecast models of target phytoplankton species, and satellite ocean color imagery. Daily predictions (nowcasts and forecast maps) that merge reconstructed satellite fields from DINEOF with physical fields from ROMS model output are run routinely at the Central and Northern California Ocean Observing System (CeNCOOS) and posted on their public website. Over the next two years, this application system will be moved to developmental computers at NOAA's National Centers for Coastal Ocean Science (NCCOS) and National Weather Service (NWS) to be incorporated into NOAA's operational HAB forecasting system and HAB Bulletin. Data from the first 1.5 years of routine model runs capture two of the largest domoic acid events on record, coincident with the "warm blob", with unprecedented advisories for sardine and anchovy fisheries in the Monterey Bay region. Historical stranding data are compared with model hindcast runs, and marine mammals appear to be good sentinels of the offshore onset of a DA event at large spatial scales.

4:20 p.m. **Carol Blanchette** (Marine Science Institute, University of California, Santa Barbara)

Regional ocean circulation as a major driver of mussel recruitment around Santa Cruz Island, CA

We measured mussel recruitment at 5 sites around Santa Cruz Island, CA from 1996-2009. The spatial patterns of recruitment were consistent through time, with the lowest recruitment at the two westernmost sites. The temporal patterns of recruitment at all sites followed a strong seasonal cycle, with most recruitment in the period from June-October, correlated with the warmest water in the seasonal temperature cycle. Across all sites, there was little to no recruitment of mussels in 1999 and 2008, both strong La Nina years. We used a ROMS with particle tracking to simulate mussel larval dispersal and recruitment. By releasing particles throughout the southern CA coastline and tracking them for a range of PLDs for mussels, the temporal and spatial patterns of recruitment around the Island were most closely reproduced by particles released from the mainland coast south of the Santa Barbara Channel. These southern mainland particle releases also showed a dramatic reduction in recruitment during the 1999 La Nina year corresponding to the field data. Our results show that regional ocean circulation as opposed to local nearshore circulation may be a major driver of invertebrate recruitment.

4:40 p.m. **Steven Morgan** (Environmental Science and Policy, Bodega Marine Laboratory, University of California Davis), Alan Shanks (Oregon Institute of Marine Biology, University of Oregon), Jamie MacMahan (Department of Oceanography, Naval Postgraduate School) Ad Reniers (Rosenstiel School of Marine and Atmospheric Science)

Surfzone hydrodynamics as a key determinant of spatial variation in marine communities

We proposed that surfzone hydrodynamics plays a key role in regulating subsides of food and larvae to nearshore communities in upwelling regimes. We tested this hypothesis by comparing entire zooplankton communities inside and outside of the surf zone daily while monitoring physical conditions for one month each at two shores with different surf zones. Opposite cross-shore distributions of zooplankton occurred at the two sites: zooplankters were more abundant inside the wide surf zone at a moderately sloping shore with a system of rip currents, and they were more abundant outside the narrow surf zone at a steep shore where water exchange was reduced by half. Modeled larvae recruited onshore in two ways: benthic streaming near the bottom when winds are calm and wind-driven transport of surface-dwelling larvae to the turbulent surf zone followed by sinking to the bottom boundary layer. Recruitment varied predictably with surfzone hydrodynamics regulating communities coastwide.

5:20 p.m. **Brian Wells** (NOAA, Southwest Fisheries Science Center, Fisheries Ecology Division), David Duff (NOAA, Southwest Fisheries Science Center, Fisheries Ecology Division and Institute of Marine Sciences, UCSC), Jerome Fiechter (Institute of Marine Sciences, UCSC), and Isaac Schroeder (NOAA, Southwest Fisheries Science Center, Environmental Research Division and Institute of Marine Sciences, UCSC), and Jarrod Santora (University of California at Santa Cruz, Center for Stock Assessment Research)

Evaluating and using numerical ocean and biological model products to assess habitat, salmon survival, and forage dynamics along the coastal California Current system.

We overview our work using output from numerical ocean and biological models to assess influences of environmental conditions on variability in population and community dynamics along coastal California Current System (CCS). Evaluation of models demonstrates that physical and biological outputs are coherent with empirical data at appropriate spatial and temporal scales and are suitable for quantifying ecosystem dynamics on California shelf waters. We address a variety of ecological hypotheses by confronting model output with biophysical observations. We elucidate mechanisms connecting spatial and temporal upwelling dynamics to observed krill and forage fish abundances. We use model output to estimate interannual variability of biophysical habitat of juvenile Chinook salmon collected from shipboard surveys. We then use results to elucidate mechanisms influencing region-specific survival of Chinook salmon populations along CCS.

5:40 p.m. **Albert J. Hermann** (JISAO, University of Washington), Georgina Gibson (IARC, University of Alaska-Fairbanks), Samantha Siedlecki (JISAO, University of Washington), Tam Nguyen (JISAO, University of Washington)

Biophysical uncertainty in the Northeast Pacific as a function of space, time, and trophic scale

Predictive skill is a strong function of scale. With notable exceptions (e.g. local tides), we typically anticipate better skill at predicting the broad features of the ocean, as compared with its spatial, temporal, or biological details. Indeed, for some fisheries management applications it is precisely those broad features which are of greatest interest. While field measurements of the ocean across a wide range of space and time scales are limited, we have ready access to multi-scale synthetic datasets from dynamical biophysical models. As in weather forecasting, we can utilize multiple forecast realizations of a particular domain to get a sense of the uncertainty (the lack of predictability) of projected futures at various scales. Here we examine multiple downscaling realizations of biophysical dynamics for the Bering Sea and the Pacific Northwest, to estimate how the "cone of uncertainty" - that is, the growth in variance among projected futures - is affected by spatial, temporal, and trophic aggregation. Specifically we examine: three multi-decadal projections of the Bering Sea, each driven by a separate global CMIP model projection; six seasonal projections of the Pacific Northwest, each driven by a separate global realization of the NCEP Climate Forecast System. Finally, we consider how EOF analysis might be utilized to derive the most predictable aggregates for a region.

6:00 p.m. **Kylie L. Scales**, Elliott L. Hazen, Michael G. Jacox, and Steven J. Bograd (Environmental Research Division, Southwest Fisheries Science Center, NOAA)

Optimising habitat-based models for marine top predators - the effects of spatial and temporal resolution on model inference

Predicting the responses of marine top predators to dynamic oceanographic conditions requires habitat-based models that sufficiently capture environmental preferences. Spatial resolution and temporal averaging of environmental data layers is a key aspect of model construction. The utility of surfaces contemporaneous to animal movement (e.g. daily, weekly), versus synoptic products (monthly, seasonal, climatological) is currently under debate, as is the optimal spatial resolution. Using movement simulations with built-in environmental preferences (correlated random walks, multi-state hidden Markov-type models) together with modeled (Regional Oceanographic Modeling System, ROMS) and remotely-sensed (MODIS-Aqua) datasets, we explored the effects of degrading environmental surfaces (3km – 1 degree, daily – climatological) on model inference. Results indicate that models using seasonal or climatological data fields can overfit environmental preferences. We also observed a divergence between the 'best' models selected using common methods and those that accurately reproduced preferences. These findings have implications for management, particularly in forecasting climate-mediated ecosystem changes.

6:20 p.m.

Jerome Fiechter (Institute of Marine Sciences, University of California, Santa Cruz), Luis Huckstadt (Dept. of Ecology and Evolutionary Biology, University of California, Santa Cruz), Kenneth Rose (Dept. of Oceanography and Coastal Sciences, Louisiana State University), Daniel Costa (Dept. of Ecology and Evolutionary Biology, University of California, Santa Cruz), Enrique Curchitser (Institute of Marine and Coastal Sciences, Rutgers University), Katherine Hedstrom (Institute of Marine Science, University of Alaska, Fairbanks), Christopher Edwards (Dept. of Ocean Sciences, University of California; Santa Cruz), Andrew Moore (Dept. of Ocean Sciences, University of California; Santa Cruz).

A new perspective on sea lion habitat utilization of foraging success in the California Current: results from a fully coupled end-to-end ecosystem model.

We present results from a fully coupled end-to-end ecosystem model for the California Current Large Marine Ecosystem that describe the impact of environmental variability on habitat utilization and foraging success of California sea lions. The ecosystem model consists of a nutrient-phytoplankton-zooplankton model (NEMURO) embedded in a regional ocean circulation model (ROMS), and both coupled with a multi-species individual-based model (IBM) for forage fish (sardine and anchovy) and California sea lions. For sea lions, bioenergetics and behavioral attributes are specified using available TOPP (Tagging Of Pacific Predators) data on their foraging patterns and diet in the California

Current. Sardine and anchovy are specifically included in the model as they represent important prey sources for California sea lions and exhibit significant interannual and decadal variability in population abundances. Output from a 20-year run (1989-2008) of the model shows how different physical and biological processes (e.g., temperature, prey availability) control habitat utilization and foraging success of California sea lions on seasonal and interannual time scales. A principal component analysis of simulated California sea lion foraging patterns indicates that the dominant mode of variability is an inshore-offshore shift in habitat utilization associated with years of cooler-warmer coastal temperatures (a behavior consistent with male sea lion tracking data collected in 2004 vs. 2005). We also illustrate how variability in forage fish distribution affects sea lions diet composition, with a more anchovy (sardine) dominated diet during periods of cooler (warmer) ocean conditions. While specifically focusing on sea lion habitat utilization and foraging success, our modeling framework has the ability to provide new and unique perspectives on trophic interactions in the California Current, or other regions (e.g., southern ocean) where similar end-to-end ecosystem models may be implemented.

Wednesday, September 23, Morning Session 5: General Session
Session Chair:
Al Hermann (albert.j.hermann@noaa.gov)

8:50 a.m. **Parker MacCready** (School of Oceanography, University of Washington), Ryan McCabe (JISAO, University of Washington), Samantha Siedlecki (JISAO, University of Washington), Neil Banas (University of Strathclyde, Scotland)

Development of the LiveOcean Daily Forecast Model

LiveOcean is a daily forecast model of the NE Pacific (OR, WA, BC) and Salish Sea, focused on making short term Ocean Acidification forecasts for shellfish growers. The steps, both scientific and practical, in creating such a system are described, including funding, choice of model forcing fields, computational resources, validation, and dissemination of results to stakeholders. Particular attention is given to the modular software architecture for a system that can be continuously tested and improved while still creating daily forecasts.

9:10 a.m. **Riley Brady*** (Marine Science Program, University of South Carolina), Ryan Rykaczewski (Biological Sciences, University of South Carolina), Michael Alexander (Physical Sciences Division, NOAA Earth System Research Laboratory)

Quantifying Natural and Anthropogenic Variation in California Current Upwelling

Upwelling in the California Current sustains a highly productive ecosystem and is largely mediated by the cross-shore atmospheric pressure gradient that develops during the boreal summer. This pressure gradient may be intensified through increased warming of the continent relative to the Pacific Ocean, resulting in accelerated alongshore winds and amplified coastal upwelling (a concept known as the Bakun Hypothesis). Past efforts to investigate the Bakun Hypothesis have utilized multi-model "ensembles-of-opportunity" to examine the response of upwelling to climate change. However, attempts to distinguish anthropogenic changes relative to natural climate variability are limited, largely because model divergences in an ensemble-of-opportunity are the result of both natural variability and inter-model variability (i.e. the differing response of each model to identical radiative forcing). In these multi-model ensembles, the impacts of these two phenomena are inseparable. To address this concern, modeling centers are developing "large ensembles" consisting of numerous, independent model runs separated only by round-off differences in their initial atmospheric state. Differences between these runs are void of inter-model variability, allowing disparities between runs to be attributed entirely to natural variability within the system. Using output from the CESM1 Large Ensemble, I consider the influence of anthropogenic activity—relative to natural climate variability—on the spatial extent, seasonality, and amplitude of upwelling. Here, I explore the intensity and timescale over which the anthropogenic signal emerges from the background noise of natural climate variability.

09:50 a.m. **David Rivas** (Departamento de Oceanografía Biológica, CICESE), Anahí Bermúdez-Romero (Departamento de Oceanografía Biológica, CICESE), Ernesto García-Mendoza (Departamento de Oceanografía Biológica, CICESE), Mary C. Ruiz de la Torre (Facultad de Ciencias Marinas, UABC)

A historical HAB in the northern Gulf of California in early 2015

An intense harmful algal bloom (HAB) occurred in the northern portion of the Gulf of California in January-March 2015. This unusual HAB caused the death of thousands of sea birds and numerous sea mammals, and severely affected the local economy. Herein we describe the biological aspects of this historical HAB and the environmental conditions associated with it.

10:10 a.m. **Nikolay P. Nezlin** (Southern California Coastal Water Research Project, SCCWRP), Dario Diehl (SCCWRP), Karen McLaughlin (SCCWRP)

Depth and magnitude of subsurface chlorophyll maximum in southern California coastal ocean

Routine water-quality monitoring near major southern California ocean wastewater outfalls provides an excellent platform to analyze spatial and temporal (seasonal and interannual) variations in subsurface chlorophyll maximum layer (SCML) and environmental factors affecting its depth and magnitude. An extensive chlorophyll fluorescence dataset, collected between 1998 and 2014 using Conductivity-Temperature-Depth (CTD+) profilers, was calibrated using discrete chlorophyll measurements obtained from bottle samples using standard methods. Characteristics of spatio-temporal variations of SCML depth and magnitude were analyzed using statistical methods based on empirical orthogonal functions allowing missing values. For three regions examined: Ventura/Santa Monica Bay; Palos Verdes/San Pedro Shelf; and San Diego, the depth and magnitude of SCML demonstrated specific features of spatial, temporal and interannual dynamics related to water column stratification and transparency. Specifically, during the most recent five-year period (2010-2014) SCML in all three regions gradually deepened and decreased in magnitude, seemingly resulting from declining intensity of the North Pacific gyre circulation (NPGO index) and increasing transport of warm water from equatorial Pacific (ENSO cycle).

10:30 a.m. **Noel Pelland**

Eddy Circulation, Heat and Salt Balances, and Ocean Metabolism: Seagliders at Ocean Station Papa

Seagliders were deployed at Ocean Station Papa (OSP; 50N, 145W) in the southern Gulf of Alaska, augmenting a NOAA Ocean Climate Stations surface fluxes mooring and moored ADCP, from 8 June 2008 to 21 January 2010. Seagliders provided increased resolution of the three-dimensional temperature, salinity, and dissolved oxygen field surrounding the mooring, resolving horizontal gradients at scales relevant to local advection, the latter of which had never before been measured at or near OSP with persistence longer than a few months. Results indicate that Seaglider surveys took place during a period of anomalous circulation at OSP, likely due to a passing small anticyclonic eddy only intermittently apparent in satellite altimetry. Dissolved oxygen characteristics suggest that this eddy originated to the south or west, suggesting generation within the ocean interior. Analysis of the heat and salt balances estimated large upwelling, responsible for offsetting the surface input of heat, and horizontal input of fresh water, contrary to typical descriptions at OSP but consistent with a passing anticyclone. In the dissolved oxygen budget, estimates of respiration were formed in the region deeper than the surface layer and shallower than the permanent pycnocline, giving a net apparent oxygen utilization of ~1.1 mol O_2 m^{-2} yr^{-1} (0.8 mol C m^{-2} yr^{-1}). Given previously estimated rates of net community productivity of C in the surface layer in summer, this rate indicates that 30-50% of the organic carbon exported from the euphotic zone during each growing season is respired before it can reach the deep ocean. Overall, these results demonstrate the feasibility of autonomous vehicle surveys of this type to capably resolve monthly and seasonal features of upper-ocean tracer balances in this climatically and ecologically important region of the northeast Pacific Ocean.

2015 Poster Presenters:

Session 1: Hot and Strange Times in the California Current System – A Look at 2014-2015 from All Angles.

1. **Carol Blanchette** (Marine Science Institute, University of California, Santa Barbara)

   Rapid population declines in sea stars across southern California associated with sea star wasting disease and warm temperature anomalies

   Sea-star wasting disease (SSWD) is a general description for a set of symptoms that are found in sea stars, and generally lead to rapid mortality. In most reported cases of SSWD, the incidence and progression of disease appear to be highly temperature sensitive. Since June 2013, SSWD has affected at least 20 species of sea stars, and spread across the Pacific Coast of North America, making it the largest known marine wildlife epizootic to date. Our observations indicate that SSWD spread rapidly from northwest (near Point Conception) to southeast (near San Diego) across southern California in the winter of 2013-2014, leading to mass mortality of intertidal Pisaster ochraceus and subtidal sea stars in the genus Pisaster. The onset and spread of SSWD across southern California was correlated with a period of unusually warm temperature anomalies. The most rapid mortality happened between January-April 2014, when water temperatures were approximately 2 degrees (C) above the seasonal average. The rapid spread of disease concurrent with warm temperature anomalies suggests that temperature may play an important role in facilitating disease transmission.

2. **Eric P. Bjorkstedt,** (NOAA National Marine Fisheries Service, Southwest Fisheries Science Center), Roxanne Robertson (CIMEC, Humboldt State University), and William T. Peterson (National Marine Fisheries Service, Northwest Fisheries Science Center)

   Response of the mid-shelf copepod community off northern California to the warming event of 2014-2015.

   The copepod community observed off northern California experienced strong shifts in community composition related to changes in hydrographic conditions associated with the unusual warming observed in the northeast Pacific during 2014. Early in 2014, the biomass of copepods with northern biogeographical affinities was similar to that observed in previous years, but began to decline in mid- to late summer as upwelling weakened and mid-shelf bottom waters began to depart from the seasonal climatology by becoming slightly warmer, fresher, and more oxygenated than normal. The biomass of northern copepods dropped dramatically in Fall 2014 with the cessation of upwelling and the arrival of 'blob' waters marked by strong warming over the shelf. Conversely, the biomass of southern copepods increased during the late summer and fall and remained consistently high through the end of 2014. This pattern of depressed biomass of northern copepods and elevated biomass of southern copepods has persisted through Spring 2015. The decline of northern taxa is especially apparent when northern neritic species (including the normally abundant *Pseudocalanus mimus*) are considered seperately, with strong negative biomass anomalies for the nearshore neritic assemblage persisting into and through Spring 2015. Copepod species richness has been consistently high relative to previous years during summer and fall 2014, and again in early 2015. During this period, several species of southern or offshore copepods have been observed for the first time in the Trinidad Head Line record.

3. **Alexander Kurapov** (CEOAS/OSU), P. M. Kosro (CEOAS/OSU), J. Barth (CEOAS/OSU), E. Bayler (JCSDA/NOAA), E. Myers (NOS/NOAA).

The West Coast Ocean Forecast System and the 2014 warm anomaly

The West Coast Ocean Forecast System (WCOFS) is being developed in partnership between CEOAS (OSU) and NOAA. It will be designed to provide forecasts of oceanic conditions along the entire West Coast, at the 2-km resolution. As the initial step in the system development, we analyze the outputs of the model without data assimilation, run for a period of 2009-2014. The model compares well against satellite SST and high-frequency (HF) radar surface currents, reproduces well coastal ocean variability on temporal scales from days to interannual, and shows the signature of the undercurrent. Our current analyses involve contrasting the "warm blob" 2014 year to previous years using WCOFS and available observations.

4. **Roxanne Robertson** (Cooperative Fisheries Oceanography Research Team, Humboldt State University) and Eric Bjorkstedt (Fisheries Ecology Division, National Marine Fisheries Service)

Community composition of euphausiids off northern California: An overview of the Trinidad Head Line time series and responses to the 2014-2015 warming event

Euphausiids, in particular *Euphausia pacifica* and *Thysanoessa spinifera*, a play a key role in the transfer of energy and nutrients to higher trophic levels in the California Current Ecosystem (CCE). We have analyzed plankton samples collected along the Trinidad Head Line (41° 3.50′ N) from late 2006 through summer 2015 to examine structure and variability in the euphausiid community in waters over the shelf and upper slope off northern California. Our analysis confirms that the coastal euphausiid community off northern California is dominated by *Euphausia pacifica* and *Thysanoessa spinifera,* which were present all months of the year, with peak densities observed from late spring through early winter. Several other species were also observed, some of which were relatively common (*Nematoscelis difficilis, Thysanoessa gregaria, Stylocheiron spp*., and *Thysanoessa inspinata*). We applied non-metric multidimensional scaling (NMDS) to estimates of euphausiid density for these more common species, diffferentiated also by life history stage (furcilia, juvenile, adult), which revealed both spatial (cross-shelf) structuring as well as variability at seasonal and longer time scales. These analyses reveal cross-shelf structure euphausiid community is more spatially structured during the spring through fall, when immature *E. pacifica* and *T. spinifera* enrich the coastal assemblage, and less so in winter, when densities decline in shelf waters and the community includes a greater proportion of oceanic species. Metrics of euphausiid community composition were significantly correlated with local conditions indexed by near-bottom water temperature at a mid-shelf station (a useful indicator of cumulative upwelling). Seasonal community composition was found to correlate significantly with PDO one month prior and MEI 8 months prior. The initial response of the euphausiid community to the warming event of 2014 appears to reflect a substantial decline in *T. spinifera* during the onset of warming and subsequent arrival of 'warm blob' waters in October 2014 that has persisted through summer 2015. This shift in the euphausiid community was partly countered by persistently high abundances of *E. pacifica* and increases in immature *E. pacifica* and *N. difficilis* in early 2015. The arrival of the warm blob brought the sub-tropical krill *Euphausia recurva* to waters off northern California; adult and larval stages of this species were observed at low densities from January until March 2015. These observations suggest a variety of responses to the warming event, ranging from patterns dominated by transport and changes in water masses off northern California (*E. recurva*) to those that may also reflect different responses to changes in local productivity or other ecological conditions (e.g., the contrasting patterns observed for *T. spinifera* and *E. pacifica*).

Session 2: Role of Submesoscale and Mesoscale Processes in Structuring Ecosystem Dynamics in the Eastern Pacific Ocean.

5. **Christine Cass** (Department of Oceanography, Humboldt State University)

Seasonal and taxonomic variability in lipid and calorie content of copepods off northern California

Northern California Current (NCC) copepod community structure is heavily influenced by oceanographic circulation patterns. During southward transport, species usually found at higher latitudes ("boreal") are advected into the region, while northward currents bring species more common to southern California ("subtropical"). The purpose of this research was to determine whether the geographic affinity of copepod species influenced their lipid and total energy content. Total lipid, protein and calorie densities of NCC copepods were assessed during fall 2013 to spring 2014 off Trinidad Head, California. Most copepods had higher protein content in October-November, and lower protein during January-April, while lipid content showed the opposite trend. Total calorie density was most strongly influenced by protein content. No significant differences were observed based on geographic affinity, suggesting the importance of local conditions rather than species composition on energy accumulation.

Session 3: The Future is Now: Hypoxia and Ocean Acidification in the Eastern Pacific.

6. **Laura Bianucci** (Coastal Sciences Division, Pacific Northwest National Laboratory), Wen Long (Coastal Sciences Division, Pacific Northwest National Laboratory), Tarang Khangaonkar (Coastal Sciences Division, Pacific Northwest National Laboratory), Greg Pelletier (Washington State Department of Ecology), Mindy Roberts (Washington State Department of Ecology)

Hypoxia and acidification in Puget Sound: development of FVCOM-ICM model

Estuaries and coastal waters are driven by a complex combination of forcings. They exchange heat and mass with a warming atmosphere that has ever-increasing levels of carbon dioxide. Through the land, they receive inputs of many water sources (e.g., rivers, wastewater treatment plants, storm water systems), each with different degrees of organic matter and/or pollution. Furthermore, coastal zones are affected by a changing open ocean. The latter is of particular significance in regions such as the Northeast Pacific Ocean, where monitoring programs indicate that oxygen and pH are already declining. As these waters enter the Juan de Fuca Strait and eventually reach Puget Sound, there are concerns of increased hypoxia and acidification in the region. Our goal is to improve our understanding of the drivers of hypoxia and ocean acidification in Puget Sound. We aim to evaluate the role of the various sources and sinks of inorganic carbon and oxygen, and quantify the role of local, regional and remote forcing in order to inform future regulations for the Puget Sound area. For this purpose, we introduced sediment diagenesis and a carbonate-system module to our existing model of the Salish Sea, which already included oxygen. The physical model is the Finite Volume Community Ocean Model (FVCOM), which we coupled to the water-quality model CE-QUAL-ICM. Here, we will introduce the latest developments of our FVCOM-ICM model, its performance and our future plans.

7. **Kerry Nickols** (California State University Monterey Bay), D. Koweek (Stanford University), P. Leary (Hopkins Marine Station, Stanford University), S.Y. Litvin (Hopkins Marine Station, Stanford University), S. Lummis (University of California, Santa Cruz), D.A. Mucciarone (Stanford University), and R.B. Dunbar (Stanford University).

Physical contributions to spatial variability of carbon system parameters within a Central California kelp forest

The biogeochemical environment of kelp forests is influenced by a combination of regional processes, such as upwelling, that deliver offshore waters into the forest as well as local processes, such as production, respiration, and local-scale hydrodynamics, that modify the local water chemistry. We monitored water column properties weekly (temperature, salinity, total alkalinity, and dissolved inorganic carbon (DIC)) within and around a Central California kelp forest from July 2013-August 2014 in conjunction with continuous monitoring of water column velocity using Acoustic Doppler Current Profilers (ADCPs). Sampling included sites that were wave-exposed and protected. Satellite-derived estimates of kelp biomass were also available in this area over variable time intervals. While benthic DIC varied spatially throughout the year, surface DIC was more seasonally influenced, with higher variability of DIC between sites recorded during the upwelling season. Within the kelp forest, velocities near the bottom at the more wave-exposed site were generally isometric, with similar magnitudes in the along- and cross- dimensions, or had higher cross-shore velocities. Strong cross-shore velocities may promote exchange with offshore bottom waters and limit retention of forest waters. Velocities near the bottom on the wave-protected side of the forest were polarized in the alongshore dimension, which may promote retention of forest waters. At the surface, currents became increasingly polarized with increases in kelp canopy biomass; as kelp canopy biomass decreased in late fall and winter, current velocities were isometric, increasing cross-shore exchange. This study demonstrates the complexity of kelp forest biogeochemistry that arises from the interconnectedness of the kelp forest itself and the local-scale hydrodynamics.

Session 4: Predictability of Biology Across Different Space-Time-Trophic Scales

8. **Jorge Cruz Rico*** and David Rivas (Oceanografia Biologica, Centro de Investigación Científica y de Educación Superior de Ensenada)

A numerical modeling analysis of the phytoplankton and nutrients dynamics for Todos Santos Bay and northwestern Baja California

A tridimensional physical-biological numerical model is implemented for the Todos Santos Bay and the northwest of Baja California to investigate the mechanics and ecological processes associated with the regional plankton dynamics. An NPZD (Nitrate, Phytoplankton, Zooplankton, and Detritus) ecosystem simple model is used to describe the distribution and evolution of the lower trophic levels in the area of study. The model adequately reproduces the spatial distribution of the concentration of chlorophyll for the different seasons of the year. In general, the distribution of the subsurface chlorophyll maximum (SCM) depends primarily on the seasonal circulation patterns, the total solar irradiance, and the vertical flux of nutrients. Interannual variability shows two extreme years in the analyzed period: 2006 and 2007. Year 2006 was an anomalous warm year, with a weak upwelling activity and low chlorophyll concentrations compared to year 2011. These anomalies are related to the activity of the Pacific Decadal Oscillation, the El Niño+3, and the regional Outgoing Longwave Radiation. Thus, in spite of the simplicity of the NPZD model, both temporal and spatial patterns of distribution of chlorophyll and nutrients are generally reproduced.

9. **Xiuning Du** (Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, OSU) and William Peterson (NOAA-Fisheries, Northwest Fisheries Science Center, Hatfield Marine Science Center)

Egg production rates of the copepod Calanus marshallae in relation to phytoplankton biomass and species composition in the coastal upwelling zone off Oregon, USA.

Study of copepod egg production in situ behaviors under dynamic effects of phytoplankton is one of many ways to look into interactions between the two classic food-web lower trophic levels. We analyzed egg production rates (EPR; eggs female-1 day-1) of the copepod Calanus marshallae in response to corresponding phytoplankton biomass, species composition and community structure. Female C. marshallae and phytoplankton water samples were collected biweekly at an inner-shelf

station off Newport, Oregon USA for four years, 2011-2014, during which a total of 1213 female C. marshallae were incubated in 63 experiments. EPRs in spring (Apr-May, average of 40.2) were significantly higher than summer (Jun-Oct; 26.4). EPRs were intermediate in winter (Jan-Feb; 32.5). Total chlorophyll a (Chl a) concentration and diatom abundance both were significantly higher in summer while no seasonal differences were found in abundance of dinoflagellates, ciliates or Cryptophytes. Relationships between EPR and potential food variables (phytoplankton and ciliates) were significant by season: a hyperbolic functional response was found between EPR and total Chl a in winter-spring and summer, separately, and between EPR and ciliate abundance in winter-spring; a linear model fit best for correlating EPR with diatom abundance in summer.

10. **Julie Keister** (School of Oceanography, University of Washington), Anna McLaskey (School of Oceanography, University of Washington), Brady Olson (Shannon Point Marine Center, Western Washington University); Brooke Love (Shannon Point Marine Center, Western Washington University); Katherina Schoo (Shannon Point Marine Center, Western Washington University); Paul McElhany (NWFSC, NOAA),

The Strait of Juan de Fuca zooplankton time series

The ability of crustacean zooplankton to tolerate elevated pCO2 remains poorly understood due to the limited number of labs conducting ocean acidification work on these species; their future adaptability is almost completely unknown. In my lab, we are conducting experiments on the sensitivity of several critical food web species—the copepods Calanus pacificus and Acartia hudsonica, and euphausiid Euphausia pacifica—to pH and pCO2 levels currently experienced in our region (Puget Sound, WA) as well as future predicted levels. We are testing hypotheses that 1) direct, physiological effects of low pH are reflected in zooplankton early life growth and survival, and 2) effects of elevated CO2 affect the metabolism and reproduction of adult zooplankton indirectly through changes in phytoplankton size and quality (lipid composition). To date, we have observed highly species and life-stage specific responses that preclude any generalization of taxonomic response to ocean acidification. I will present highlights and implications of some of these studies.

Session 5: General Session.

11. **Ivo Pasmans*** (College of Earth, Ocean and Atmospheric Sciences, Oregon State University), Alexander Kurapov (College of Earth, Ocean and Atmospheric Sciences, Oregon State University)

4DVAR with ensemble error estimation in a coastal ocean model

High biochemical activity can be found in and close to upwelled water masses and river plumes. Accurate forecasting near the fronts bounding these regions is challenging as small errors in the front location result, due to the presents of sharp gradients, in large model errors. Ocean prediction systems with traditional 4DVAR data assimilation assume that the model error covariance at the beginning of each assimilation window is independent of time and location. Consequently, it is expected that these systems underestimate model error in frontal regions leading to insufficient assimilation of observations. To include the dynamics of these regions into the model error covariance we have developed and tested a methodology in which this covariance is based on a localized ensemble of model forecasts. The method has been tested with a ROMS model of the coastal region offshore Oregon/Washington using our own AVRORA 4DVAR code. We find that the spatial structure of the ensemble covariance differs from the traditional one and that with the ensemble covariance more accurate T,S-relations and subsurface temperature forecast are produced. Furthermore, we find that the extent of the river plume depends on the covariance used.

12. **Iván Vivas-Téllez*** (Departamento de Oceanografía Biológica, CICESE) and David Rivas (Departamento de Oceanografía Biológica, CICESE)

A Lagrangian physical-biological model to study water parcels associated with algal blooms from Southern California Bight to Todos Santos Bay.

Lagrangian ocean circulation and biological dynamics are numerically studied in Todos Santos Bay during the spring of 2007. This period is particularly interesting after an intense toxic algal bloom occurred in April 2007 in this area, which was associated with the wind-driven upwelling in the region. High resolution, numerical model simulations were carried out to study dynamical features along of the Southern California Bight (SCB), the coast of the northern Baja California (BC), and the interior of Todos Santos Bay (TSB). These simulations are used in a three-dimensional Lagrangian (particle tracking) analysis which provides information about the origin and distribution of the waters present in the Bay during the occurrence of the toxic bloom. After the selection of trajectories of particles showing coherent patterns, a Nitrate-Phytoplankton-Zooplankton-Detritus (NPZD) lower trophic model is implemented to study the influence of the environmental conditions that occur during the particle advection, solving the NPZD equations at every time-varying position of the advected particles. The model is also modified for phytoplankton growth as a function of the environmental temperature to somehow emulate the life cycle of Pseudo-nitzschia. The analysis of the trajectories shows that particles mainly come from two regions: from the north, in the southern portion of SCB and from regions west of the TSB. Knowing the regional circulation patterns and their phytoplankton dynamics can help to understand and even predict the origin and destination of the harmful algal blooms that occur in TSB and its surroundings.

13. **Wei Cheng** (Univ of Washington), Carol Ladd (NOAA/PMEL), Albert Hermann (Univ of Washington), and Phyllis Stabeno (NOAA/PMEL)

Seasonal Circulations on the Southeast Bering Sea Shelf

The ocean circulation in the area north of the Unimak Pass is examined using a multi-year (2007-2012) integration of the Regional Ocean Modeling System (ROMS). This area is located at the eastern rim of the Bering Canyon where flow through the relatively shallow Unimak Pass meets and interacts with the Aleutian North Slope Current. As a result, the circulation there is influenced by local as well as remote wind forcings, ocean bathymetry, tides, and exhibits high spatial and temporal variability on multiple scales. The simulation suggests that on seasonal time scales, flow entering the area from the Unimak Pass and the slope region roughly balances the eastward transport onto the shelf plus the strong northwestward flow. Unimak Pass throughflow and the northwestward flow have stronger seasonal variations than the eastward transports, and of the latter, the further inshore component has larger seasonal changes than the transport from the slope region. Such seasonality of the modeled transports is consistent with observations. We will place these results in the context of shelf-wide Bering Sea circulation and discuss their biological and fishery implications.

14. **Kristen Davis** (University of California, Irvine)

Examining shoaling internal waves on a shallow shelf slope using distributed temperature sensing (DTS).

Shoaling internal waves are an important process affecting physical variability and water properties on continental shelves around the world. Here we examine observations collected in June 2014 designed to track the evolution of internal waves across a shallow fore reef and onto the Dongsha Atoll reef flat. Data from a Fiber Optic Distributed Temperature Sensing (DTS) system, which measures temperature continuously in time and space along an optical fiber provides a continuous 2-dimensional view of temperature and internal wave dynamics. Our data show that internal wave activity on the fore reef is characterized by intrusions of low temperature water (as much as 8°C cooler) and are generally associated with a decrease in near bed oxygen and pH and an increase in near bed salinity. This unique view of cross-shelf temperature structure has made it possible to capture a highly resolved time series of internal wave dynamics on the inner shelf, including internal wave reflection and bolus formation and dissipation.

15. **Michael DeFlorio** (UCSD-SIO), David Pierce (UCSD-SIO), Daniel Cayan (UCSD-SIO), and Arthur Miller (UCSD-SIO)

Quantifying Predictability Limits, Uncertainties, Mechanisms, and Regional Impacts of Pacific Decadal Climate Variability

Water resources and management over the western United States are heavily impacted by both local climate variability and the teleconnected responses of precipitation to the El Nino–Southern Oscillation (ENSO) and Pacific decadal oscillation (PDO). In this work, regional precipitation patterns over the western United States and linkages to ENSO and the PDO are analyzed using output from a Community Climate System Model version 4 (CCSM4) preindustrial control run and observations, with emphasis on extreme precipitation events. CCSM4 produces realistic zonal gradients in precipitation intensity and duration over the western United States, with higher values on the windward side of the Cascade Mountains and Sierra Nevada and lower values on the leeward. Compared to its predecessor CCSM3, CCSM4 shows an improved teleconnected signal of both ENSO and the PDO to large-scale circulation patterns over the Pacific–North America region and also to the spatial pattern and other aspects of western U.S. precipitation. We also find that CCSM4 has substantially less precipitation duration bias than is present in CCSM3. Both the overall and extreme intensity of wintertime precipitation over the western United States show statistically significant linkages with ENSO and PDO in CCSM4. Our study increases understanding of the large-scale drivers of extreme rainfall over the western U.S., which is vital for policymakers and water resource managers in this region.

16. **Morgaine McKibben*** and Angelicque White (College of Earth, Ocean and Atmospheric Sciences, Oregon State University)

Merging glider and ocean color data to accurately estimate phytoplankton biomass in Oregon's coastal waters

Long-term deployments of vertically-profiling platforms are becoming more common, providing a data-rich source of in situ ocean parameters ideal for pairing with satellite remote sensing data, particularly in areas with persistent cloud coverage. Regional development of methods that couple satellite and in situ data in ways that maximize the descriptive power of each is one of the crucial next steps in oceanographic research. For example, subsurface chlorophyll-a (chl-a) maxima often occur below the first optical depth (FOD), the maximum depth covered by satellite chl-a. In these cases, the sensors effectively miss a majority of phytoplankton biomass. Here we develop methods to merge 5 years of Slocum glider profiles and ocean color data in Oregon's coastal waters in order to quantify the occurrence of chl-a within the full euphotic zone and to improve biomass estimations in this region. This work includes two primary goals. First, the relative accuracy, precision, and uncertainty of the datasets are assessed, including comparison of vertical glider profiles of chl-a concentration, corrected to account for non-photochemical quenching, to satellite retrievals. Secondly, we have characterized the vertical distribution of chl-a and scattering and determined the seasonality and frequency of chl-a features below the FOD. We will discuss results of this study relative to physical and chemical forcing within the region.

17. **William Crawford*** (Ocean Sciences, University of California, Santa Cruz), Andrew Moore (Ocean Sciences, University of California, Santa Cruz), Michael G. Jacox (Institute of Marine Sciences, University of California, Santa Cruz, Environmental Research Division, Southwest Fisheries Science Center, NOAA, Monterey, CA), Emilie Neveu (Inria, Grenoble, France), Christopher A. Edwards (Ocean Sciences, University of California, Santa Cruz), Jérôme Fiechter (Institute of Marine Sciences, University of California, Santa Cruz)

Climate variability in the CCS from a 31-year (1980-2010) historical analysis computed using the ROMS 4D-Var Data Assimilation System

Climate variability in the California Current System (CCS) is investigated using circulation estimates based on a 31-year (1980-2010) historical analysis of the CCS calculated using the Regional Ocean Modeling System (ROMS) 4-dimensional variational (4D-Var) data assimilation system. The leading 3-dimensional multivariate empirical orthogonal functions (3D EOFs) of the CCS circulation were computed and provide a complete view of low-frequency circulation variability within the CCS. The leading 3D EOFs are found to capture much of the variability in the CCS associated with the El Nino Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO). Variability in the coastal circulation on time scales associated with ENSO and the NPGO was quantified by computing the co-varying power between time series of climate indices and time series of the circulation using wavelet analysis. Cross-wavelet spectra reveal the nature of the variability in the coastal circulation associated with ENSO and the NPGO and indicate significant latitudinal dependence. The coastal circulation response to ENSO varies considerably from event to event, while for the NPGO the coastal circulation response is most pronounced during the 1990s and is apparently tied to coastal promontories. A similar analysis of circulation estimates computed from a forward run of the model using similar forcing and boundary conditions, but without data assimilation, indicates that 4D-Var has a significant impact on estimates of the CCS circulation and variability.

18. **David M. Anderson** (Central and Northern California Ocean Observing System, Monterey Bay Aquarium Research Institute), Robert Bochenek (Axiom Data Science), Jennifer L. Patterson (Central and Northern California Ocean Observing System, Monterey Bay Aquarium Research Institute), and Leslie K. Rosenfeld (Central and Northern California Ocean Observing System, Monterey Bay Aquarium Research Institute).

Data Integration, Discovery and Visualization with the Central and Northern California Ocean Observing System Data Portal

The Central and Northern California Ocean Observing System collaborative transitioned to a new data portal in 2013, expanding access to a diverse collection of ocean observations, now-casts, and forecasts for the Central and Northern California Coast. The data portal (data.cencoos.org) provides catalog and map based access to real-time and historical observations, with data visualization and sub-set/download capabilities. Observations from twenty two sensor types from 835 stations are streamed continuously and made available via the portal along with seven satellite data sets. The newest data streams are the Trinidad glider line (11/2014) and the Hog Island ocean acidification sensor (12/2014). Now-casts and forecasts from regional ocean circulation and atmospheric model simulations are also provided. The observations and simulations available from the portal are used by scientists, ocean industries including fishing and marine transportation, and the public, and are used for search and rescue, environmental response and restoration, and environmental monitoring and assessment. The portal data visualization interface reveals the increase in salinity in California's estuaries related to ongoing drought, the unusually warm waters circulating in the north Pacific in 2014-15 (nicknamed 'the blob') and the harmful algal bloom in June 2015 that resulted in mariculture warnings and closures in central California.