# 61st ANNUAL EASTERN PACIFIC OCEAN CONFERENCE

# EPOC 2014 PROGRAM

Timberline Lodge, Mt. Hood, OR
17 - 20 September 2014

Co-chairs: Jennifer Fisher, Ata Suanda
EPOC President: Eric Bjorkstedt
EPOC Treasurer: Noel Pelland

Please contact Jennifer (jennifer.fisher@oregonstate.edu) with any questions

## EPOC 2014 PROGRAM - AT A GLANCE

**Wednesday, 17 September**

16$^{00}$ - on Arrival & check-in

18$^{00}$ Dinner in the dining room/ Ram's Head (included in lodging package)

19$^{30}$ Welcoming ceremony (back patio)

20$^{00}$ Fireside Chat, **Dr. Dick Feely** (Barlow Room, included with registration)

**Thursday, 18 September**

7$^{30}$ - 8$^{15}$ Breakfast in the Cascade dining room (included in lodging package)

8$^{20}$ - 12$^{10}$ Morning Session (Ullman Hall*, 10$^{20}$-10$^{35}$ coffee break): ***Contextualizing a changing ocean: insights on dissolved oxygen and ocean acidification measurements*** (Chairs: Erika McPhee-Shaw, Kerry Nickols, Noel Pelland)

12$^{10}$ - 14$^{40}$ Lunch and afternoon free time (lunch included in lodging package)

14$^{40}$ - 18$^{00}$ Afternoon Session (16$^{15}$ snacks served): ***Modeling Eastern Pacific Ocean circulation and its interactions with biogeochemistry, ecosystem and fisheries*** (Chairs: Yi Chao, Parker MacCready, Chris Edwards)

18$^{00}$ - 19$^{30}$ Free time

19$^{30}$ - 21$^{30}$ Poster Session & hors d'oeuvre reception, Ullman Hall (included with registration)

**Friday, 19 September**

7$^{30}$ - 8$^{15}$ Breakfast in the Cascade dining room (included in lodging package)

8$^{20}$ - 12$^{00}$ Morning Session (10$^{10}$-10$^{25}$ coffee break): ***General Session*** (Chairs: Ruth Musgrave and Jennifer Fisher)

12$^{00}$ - 15$^{00}$ Lunch and afternoon free time (lunch included in lodging package)

15$^{00}$ - 18$^{00}$ Afternoon Session (16$^{10}$ snacks served): ***Characteristics and causes of regional structure and variability in the California Current*** (Chairs: Eric Bjorkstedt and Christine Cass)

18$^{00}$ - 19$^{30}$ Free time

19$^{30}$ - 23$^{00}$ Banquet & Entertainment, Ullman Hall (included with the registration)

**Saturday, 20 September**

7$^{30}$ - 8$^{25}$ Breakfast in the Cascade dining room (included in lodging package)

8$^{30}$ - 12$^{00}$ Morning Session (10$^{15}$-10$^{45}$ coffee break and check-out): ***The land-sea interface: connecting terrestrial hydrology with coastal ecosystems*** (Chairs: Clarissa Anderson and Sarah Giddings)

12$^{00}$ - 13$^{00}$ Business meeting and lunch (included with the registration)

*EPOC closes*

**unless otherwise noted, most of the conference will be held in Ullman Hall*

**EPOC 2014 PROGRAM - Thursday, 18 September talks**

**Morning Session:** ***Contextualizing a changing ocean: insights on dissolved oxygen and ocean acidification measurements***
Chairs: Erika McPhee-Shaw, Kerry Nickols, Noel Pelland

8$^{20}$ **Eric Bjorkestedt (EPOC President):** Introductory remarks

8$^{25}$ **Session and Poster introductions**

8$^{40}$ **Nina Bednarsek (PMEL):** Vulnerability and adaptation strategies of pteropods in the California Current Ecosystem

9$^{00}$ ***Mercedes Pozo (GATECH):** Decadal prediction of hypoxia along the US West Coast

9$^{20}$ **Richard A. Feely (PMEL):** Attribution of ocean acidification, upwelling and respiration along the Washington-Oregon-California Continental Shelf Margin

9$^{40}$ ***Kate Adams (CEOAS):** What's driving intraseasonal cross-shelf variability of near-bottom hypoxia: shelf or slope processes?

10$^{00}$ **Timothy Nelson (SPU):** Fluctuations in pH and oxygen concentrations near macroalgal blooms at multiple temporal scales

10$^{20}$ - 10$^{35}$ *BREAK*

10$^{35}$ **Allan Devol (UW):** Interpretation of N-loading and oxygen drawdown in Hood Canal, Puget Sound, WA

10$^{55}$ **John Mickett (APL):** What caused the exceptionally high dissolved oxygen and low temperature anomalies this past winter/spring in Hood Canal (Puget Sound)?

11$^{15}$ **Jan Newton (UW):** Ocean acidification in coastal and inland waters of Washington

11$^{35}$ **Kerry Nickols (Stanford):** Spatial variability of carbon system parameters associated with kelp forests in an upwelling system

11$^{55}$ **Session Synthesis**

12$^{10}$ - 14$^{40}$ *BREAK - lunch & afternoon free time*

* indicates students

**EPOC 2014 PROGRAM - Thursday, 18 September talks CONTINUED**

**Afternoon Session:** ***Modeling Eastern Pacific Ocean circulation and its interactions with biogeochemistry, ecosystem and fisheries***
Chairs: Yi Chao, Parker MacCready, Chris Edwards

14$^{40}$ **Session and Poster introductions**

14$^{55}$ **Edward Myers (NOAA):** Coast Operational Forecast System: Planning and Strategy Towards a Data-Assimilating Regional Coastal Ocean Forecast System

15$^{15}$ **Albert J. Hermann (JISAO):** Sources of predictability (and unpredictability) in the Pacific Northwest

15$^{35}$ **Paul Mattern (UCSC):** Optimization and intercomparison of biogeochemical ocean models of the US west coast

15$^{55}$ **Yi Chao (UCLA):** A Real-Time Nowcast/Forecast System for the California Coastal Ocean

16$^{15}$ - 16$^{25}$ *BREAK*

16$^{25}$ **Antonio M. Baptista (CMOP):** The Columbia River as a river-dominated bioreactor: a data-informed in silico exploration

16$^{45}$ **Nancy Soontiens (UBC):** Finding NEMO in the Strait of Georgia: A regional ocean modeling effort

17$^{05}$ **Fanny Chenillat (Scripps):** Planktonic ecosystem dynamics of a coastal cyclonic eddy in the Southern California Bight

17$^{25}$ **Sung Yong Kim (KAIST):** Evaluation of directly wind-coherent near-inertial surface currents off Oregon using a statistical parameterization and analytical models

17$^{45}$ **Session Synthesis**

18$^{00}$ - 19$^{30}$ *BREAK*

19$^{30}$ - 21$^{30}$ *Poster Session with hors d'oeuvre reception (Ullman Hall)*

* indicates students

**EPOC 2014 PROGRAM - Friday, 19 September talks**

**Morning Session:** *General Session*
Chairs: Ruth Musgrave and Jennifer Fisher

8$^{20}$ **Poster introductions**

8$^{30}$ **Emanuele Di Lorenzo (Georgia Tech):** Unprecedented warming in the North Pacific anticipates strong El Niño in 2014/15

8$^{50}$ **Sally Warner (OSU):** The role of mixing in regulating sea surface temperature in the eastern equatorial Pacific during El Niño and La Niña

9$^{10}$ **Amy Waterhouse (Scripps):** Variability in the timescales of mixing due to internal wave breaking in a coastal submarine canyon

9$^{30}$ **Matthew Alford (Scripps):** Nonlinear internal waves and turbulence on the Washington coast

9$^{50}$ *__Robert Arthur (Stanford):__ Transport and mixing by breaking internal waves on slopes

10$^{10}$ - 10$^{25}$ *BREAK*

10$^{25}$ *__Leif Rasmuson (OIMB):__ In situ observations of Dungeness crab, Cancer magister, megalopae used to estimate transport distances by internal waves

10$^{45}$ **Maria Aristizabal (UConn):** Near-shore velocity and temperature variability in the Santa Barbara Channel, California

11$^{05}$ **Xiuning Du (OSU):** Interannual variations in phytoplankton community structure in the northern California Current during the upwelling seasons of 2001-2010

11$^{25}$ **Ben Raanan (MLML):** Observations of benthic-interior exchange events over the continental shelf of Monterey Bay, California

11$^{45}$ **Session Synthesis**

12$^{00}$ - 15$^{00}$ *BREAK - lunch & afternoon free time*

* indicates students

**EPOC 2014 PROGRAM - Friday, 19 September talks CONTINUED**

**Afternoon Session:** ***Characteristics and causes of regional structure and variability in the California Current***

Chairs: Eric Bjorkstedt and Christine Cass

1500 **Session and Poster introductions**

1510 **Steve Ramp (Soliton):** The heat budget in a three-dimensional upwelling center off Point Año Nuevo, CA

1530 **Jeffrey Paduan (NPS):** Patterns of Upwelling and Relaxations around Monterey Bay based on Long-Term Observations of Surface Currents

1550 *__Zelalem Engida (UVic):__ Remote vs Local Wind Forcing of Coastal Upwelling

1610 - 1625 *BREAK*

1625 **Bill Peterson (NOAA):** Large-scale forcing of species composition of plankton in the Oregon upwelling zone: PDO or NPGO?

1645 **Eric Bjorkstedt (NOAA):** Coherence and variability of mid-shelf copepod assemblages in the northern California Current

1705 **Marisa Litz (OSU):** Seasonal variability in the composition and biochemistry of the copepod community within the Northern California Current

1725 **Christine Cass (HSU):** Latitudinal and temporal variability in lipid and energy content of the northern Pacific euphausiids *Euphausia pacifica* and *Thysanoessa spinifera*

1745 **Session Synthesis**

1800 - 1930 *BREAK*

1930 - 2300 *Banquet dinner with live entertainment (Ullman Hall)*

* indicates students

**EPOC 2014 PROGRAM - Saturday, 20 September talks**

**Morning Session:** ***The land-sea interface: connecting terrestrial hydrology with coastal ecosystems***
Chairs: Clarissa Anderson and Sarah Giddings

8$^{30}$ **Poster introductions**

8$^{35}$ **Sarah Giddings (SIO, UCSD):** The land-sea interface: an introduction

8$^{55}$ **Anna Pfeiffer-Herbert (OSU):** Biophysical mechanisms for primary production in the near-field Columbia River plume: Do river plumes matter in coastal upwelling systems?

9$^{15}$ **Stefan Talke (PSU):** Long term trends in Columbia River Flow since 1850

9$^{35}$ *__Lumas Helaire (PSU):__ Evolution of Columbia River Hydraulics Over the Past 150 Years

9$^{55}$ **Leonel Romero (UCSB):** Inner Shelf Dispersion and Dilution of Creek Runoff

10$^{15}$ - 10$^{45}$ *BREAK- check out*

10$^{45}$ *__Megan Williams (UC Berkeley):__ The edge of the Eastern Pacific: tidally discontinuous hydrodynamics in California's bar-built estuaries

11$^{05}$ **Curtiss Davis (OSU):** Imaging the San Francisco Bay and Estuary with the Hyperspectral Imager for the Coastal Ocean (HICO)

11$^{25}$ **Richard Dugdale (RTC, SFSU):** Effect of drought conditions on the San Francisco Bay/Delta nutrients and primary productivity from field and satellite measurements

11$^{45}$ **Session Synthesis**

12$^{00}$ - 13$^{00}$ *Lunch & business meeting (Ullman Hall)*

* indicates students

**EPOC 2014 PROGRAM - Thursday, 18 September POSTER Session**

***Contextualizing a changing ocean: insights on dissolved oxygen and ocean acidification measurements***

- **Jennifer Fisher (CIMRS, OSU)**: Differential changes in pteropod abundance across the Oregon shelf and slope
- ***Rachel Golda (OHSU)**: Using an autonomous pHstat/chemostat system to determine the effect of ocean acidification on harmful algal blooms
- **Debby Ianson (Institute of Ocean Sciences, Sidney, BC)**: What causes the high inorganic carbon inventories in the Strait of Georgia?
- **Julie Keister (UW)**: Testing the effects of ocean acidification on copepod and krill populations
- **Drew Lucas (SIO, UCSD)**: Rapid profiling measurements of dissolved oxygen: advection versus in situ processes
- **Nikolay P. Nezlin (Southern California Coastal Water Research Project)**: Assessment of the impact of wastewater discharge on dissolved oxygen over the southern California shelf
- **Samantha A. Siedlecki (UW, JISAO):** Ocean Acidification of the coastal Gulf of Alaska waters: A modeling study

***Modeling Eastern Pacific Ocean circulation and its interactions with biogeochemistry, ecosystem and fisheries***

- **Yi Chao (UCLA)**: Development of an unstructured grid model for the San Francisco Bay and Estuary to enable reanalysis
- **Wei Cheng (UW, JISAO)**: Projections of Ocean Properties along the Washington Coast Related to Environmental Health
- **Cheryl S. Harrison (CEOAS, OSU)**: Physical-biogeochemical interactions and oxygen drawdown in upwelling systems
- **Alexander L.Kurapov (OSU)**: Coastal ocean variability in the US Pacific Northwest region influenced by the 2009-2010 El Niño
- **Parker MacCready (UW)**: Creating a Regional Daily Forecast Model for Ocean Acidification
- **Ariane Verdy (SIO, UCSD)**: Coupled physical-biogeochemical state estimation of the California Current System

* indicates students

**EPOC 2014 PROGRAM - Thursday, 18 September POSTER Session CONTINUED**

***General Session***

- **Susan Allen (UBC)**: Software Collaboration Tools and the Salish Sea MEOPAR Project
- *__William M. Fairchild (HSU):__ Small-scale spatial variability of mussel biotoxins off of northern Humboldt County, California
- **Tohru Ikeya (University of Tokyo)**: Resolving phytoplankton formation processes at oceanic front in spatial and time domains
- **Joseph Jurisa (CEOAS, OSU)**: Evolution of frontal mixing in the tidal Columbia River plume
- **Brent Krontmiller (CGRB)**: Center for Genome Research and Biocomputing at Oregon State University
- *__Bryce Melzer (Cal State Monterey Bay, NPS)__: Methodology comparison on determination of global mixed layer depth and heat content from temperature profiles
- *__Ruth Musgrave (SIO, UCSD)__: Tidally driven turbulence over topography at the Mendocino Escarpment: Observations and modeling
- *__Noel Pelland (UW)__: Vertical and Horizontal Transport Processes at Ocean Station P Inferred Using Inverse Methods
- **Adelaide Rhodes (CGRB)**: Center for Genome Research and Biocomputing at Oregon State University
- **David Rivas (CICESE)**: Towards a systematic and multidisciplinary research for Todos Santos Bay and northern Baja California: an update
- **Michael Vardaro (OSU)**: The Ocean Observatories Initiative in the Northeast Pacific: A New Community Resource

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

- **Ryan McCabe (UW, JISAO)**: Seasonal cross-shelf flow structure, upwelling relaxation, and the along-shelf pressure gradient in the northern California Current System
- **Hally Stone (UW)**: Interannual temperature and salinity variability in the Pacific Northwest Coastal Ocean

* indicates students

## EPOC 2014 PROGRAM - Thursday, 18 September POSTER Session CONTINUED

***The land-sea interface: connecting terrestrial hydrology with coastal ecosystems***

- **Jeremy Krogh (Univ of Victoria)**: High resolution spatio-temporal patterns of surface CDOM in the Strait of Georgia, British Columbia, Canada

- **Todd Mitchell (UW):** Do River Outflows Hopelessly Contaminate Satellite Chlorophyll Estimates?

- ***Ben Moore-Maley (UBC)**: Effects of Fraser River carbonate chemistry on pH and aragonite saturation state in the Strait of Georgia

- **Ata Suanda (SIO)**: The role of transient rip currents in driving exchange between the surfzone and inner shelf

## EPOC 2014 PROGRAM - Additional EPOC scientists

Clarissa Anderson (UCSC)
Michael Banks (OSU)
Brian Beckman (NOAA)
*Hannah Brassmassery (HSU)
Mike Cook (NPS)
*Alexander Hay (HSU)
Mike Kosro (OSU)
Douglas Latornell (UBC)
* Matthew McCammon (HSU)
Art Miller (Scripps)
Chris Mooers (PSU)
George Robertson (Orange County Sanitation District)
Joe Tyburczy (CA Sea Grant)

* indicates students

Thursday morning session

***Contextualizing a changing ocean: insights on dissolved oxygen and ocean acidification measurements***

Session chairs: Erika McPhee-Shaw, Kerry Nickols, Noel Pelland

8$^{40}$ **Nina Bednaršek (NOAA, Pacific Marine Environmental Laboratory)** Richard A. Feely (NOAA, PMEL), Mark Ohman (SIO), Jonathan Reum (NOAA, NWFSC), Bill Peterson (NOAA, NWFSC), Jennifer Menkel (OSU), Simone R. Alin (NOAA, PMEL), Burke Hales (CEOAS, OSU), Samantha Siedlecki (UW, JISAO), Al Hermann (UW, JISAO)

*Vulnerability and adaptation strategies of pteropods in the California Current Ecosystem*

The ocean uptake of anthropogenic CO2 has shoaled the aragonite saturation horizon in the California Current Ecosystem, but only a few studies to date have demonstrated widespread biological impacts of ocean acidification under present-day conditions. Pteropods are especially important for their role in carbon flux and energy transfer in pelagic ecosystems. In the California Current Ecosystem, conditions are becoming increasing unfavorable for sustaining shell maintenance because of enhanced dissolution. Our results show a strong positive correlation between the proportion of pteropods with severe dissolution and the percentage of the water column that is undersaturated with respect to aragonite. From this relationship, we are able to determine the extent of dissolution for the pre-industrial era, 2011, and 2050. Our calculations show that dissolution has increased by 30% since the beginning of the industrial era, and could increase to 70% by 2050. Although dissolution is occurring in most of the investigated pteropod species, some species have changed their daily vertical distribution pattern by migrating to upper supersaturated waters to avoid corrosive waters, a potential indication of an adaptation strategy to ocean acidification. Preliminary analyses of calcification and respiration rates demonstrate that part of the coastal pteropod population is already under increased effect of ocean acidification and hypoxia.

9$^{00}$ *__Mercedes Pozo Buil (School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GATECH)__, Emanuele Di Lorenzo (GATECH), Steven J. Bograd (NOAA, SWFSC, Environmental Research Division)

*Decadal prediction of hypoxia along the US West Coast*

Coastal hypoxia events along the US West Coast are strongly controlled by changes in local upwelling winds. However, the long-term statistics of coastal hypoxia are affected by changes in the oxygen content of the subsurface water masses that feed into the coastal upwelling. Here we diagnose the role of subsurface circulation dynamics in modulating the low-frequency variations of oxygen content of upwelling water masses along the US West Coast. Using the ECMWF ORA-S3 and SODA reanalysis products we develop a subsurface salinity proxy to track the advection dynamics of oxygen on isopycnal 26.5. We show that this salinity proxy tracks the dominant decadal fluctuations of subsurface oxygen observed in long-term records in the California Current, Oregon Shelf and Gulf of Alaska. Further analysis of the salinity proxy reveals that the coastal low-frequency fluctuations of oxygen originate in the subtropical gyre and propagate downstream into the US west coast upwelling system through the mean gyre circulation. The anomalies in the subtropical gyre lead the ones in the coastal ocean by approximately 8-10 years, and can be used to develop a decadal prediction model of coastal

hypoxia. Although more in depth analysis are needed to establish the robustness of this forecast model, the current sign of the anomalies in the gyre predicts strong hypoxic conditions by 2020.

**Richard A. Feely (NOAA Pacific Marine Environmental Laboratory)**, Simone R. Alin (NOAA PMEL), Burke Hales (College of Earth, Ocean and Atmospheric Sciences, Oregon State University), Adrienne Sutton (NOAA PMEL), Lauren W. Juranek (CEOAS, OSU), and Dana Greeley (NOAA PMEL)

*Attribution of ocean acidification, upwelling and respiration along the Washington-Oregon-California Continental Shelf Margin*

The Washington-Oregon-California continental shelf region is exposed to conditions of low aragonite saturation state during the late spring/early summer upwelling season. Along this continental margin, ocean acidification, upwelling, biological productivity, and respiration processes in subsurface waters are major contributors to the variability in dissolved inorganic carbon (DIC), pH, and aragonite saturation state. The persistence of water with aragonite saturation state <1 on the continental shelf off Washington and Oregon has been previously identified and could have profound ecological consequences for benthic and pelagic calcifying organisms such as mussels, oysters, abalone, echinoderms, and pteropods. During the late summer months of 2011, 2012 and 2013, we studied the extent of acidification conditions employing shipboard cruises and profiling gliders. We conducted several large-scale chemical and hydrographic surveys of the region in order to better understand the relationships among these natural and human-induced processes and their effects on aragonite saturation. Our results show that in the upwelled waters 14-28% of the overall acidification experienced over the continental shelf during the summer upwelling season is derived from anthropogenic CO2, 9-20% is derived from local respiration processes, and the remaining 59-74% is derived from the natural process of upwelling itself. These processes combine to maintain corrosive undersaturated waters at depths ranging from 20 to 200 m over most of the continental shelf region during the late summer months.

*__Kate Adams (College of Earth, Ocean and Atmospheric Sciences, Oregon State University)__ and Jack Barth (CEOAS, OSU)

*What's driving intraseasonal cross-shelf variability of near-bottom hypoxia: shelf or slope processes?*

Potential mechanisms responsible for observed intraseasonal variability of continental-shelf, near-bottom dissolved oxygen (DO) concentrations include local shelf and larger-scale slope processes. We investigate the importance of these processes across the continental margin. DO, density, spice and geostrophic velocity fields are analyzed from 275 underwater Slocum glider cross-shelf sections (2006-2013) along the Newport-Hydrographic line (44.65°N) The preponderance of hypoxic measurements is observed on the mid shelf (70 – 80 m isobaths) where the shelf is the flattest. This agrees with previous studies that established the Oregon mid shelf as a vulnerable location for persistent, seasonal hypoxia. Cross-shelf variability on intraseasonal time scales (weekly to monthly) is investigated using 10 sequential glider lines from late summer 2011. The cross-sectional hypoxic area in these glider lines reaches up to 1.32 km2. The vertical extent of hypoxia above the bottom (15-25 m at 80-m isobath) falls within the calculated bottom mixed layer height. Regression analysis shows that inner shelf (50

m) near-bottom DO levels are influenced about equally by source water DO concentrations and shelf processes. Hypoxia is also observed on the outer-shelf and slope down to the 200-m isobath. We present observational evidence that this outer-shelf hypoxia is a result of shelf processes.

10$_{00}$ **Timothy A. Nelson (Blakely Island Field Station, Seattle Pacific University)**, Kathy L. Van Alstyne (Shannon Point Marine Center, Western Washington), Sue-Ann Gifford (Shannon Point Marine Center, WW)

*Fluctuations in pH and oxygen concentrations near macroalgal blooms at multiple temporal scales*

Macroalgal blooms are often associated with hypoxic and anoxic conditions. We determined the impact of benthic blooms on water quality by anchoring data sondes ~20 cm from the seafloor at 4 pairs of locations in the Salish Sea for periods ranging from 3 to 48 months. The paired sites were initially chosen to represent bloom and non-bloom locations, but the unpredictability of the blooms led to only one pair consistently showing a macroalgal bloom versus no macrophytes. Oxygen saturation and pH peaked during daylight low tides and reached minima just before sunrise. Values ranged from anoxic to oxygen supersaturated and from pH 6.7 to 9.5 over a single 24 hour period. Spring tides corresponded to greater daily variance in pH and oxygen presumably due to greater benthic photosynthesis with extreme low tides during daylight. Mean daily pH and oxygen saturation dropped over the summer, while during the winter the mean gradually rose. Winter daily variances in pH and oxygen were substantially lower than summer beginning at the autumnal equinox. Anoxia occurred at sites with restricted water flow, while hypoxia was non-existent at sites with good circulation. We conclude that benthic photosynthesis and respiration substantially shift pH and oxygen concentrations.

10$_{35}$ **Allan Devol, (University of Washington, Oceanography)**, Jan Newton (UW, Applied Physics Laboratory), Wendi Ruef (UW, Oceanography)

*Interpretation of N-loading and oxygen drawdown in Hood Canal, Puget Sound, WA*

Hood Canal is a silled fjord that is part of Puget Sound in Washington State. This bathymetry promotes hypoxia in the deep waters and occasional fish kills. Recently these fish kills appear to have become more frequent possibly due to anthropogenic nitrogen inputs. We used high frequency vertical profiles from an autonomous buoy to determine mean summertime distributions for T, S, O2 and NO3, which we used to evaluate the natural versus anthropogenic contributions to hypoxia. The Nitrogen loading from natural estuarine circulation was estimated from a Knudsen salt balance and via stoichiometry new production was calculated. Distributions revealed that the 1% light level extended well below the mixed layer resulting in a two layer euphotic zone. Because half the production took place in the lower euphotic zone oxygen production did not escape to the atmosphere and this production did not contribute to oxygen drawdown. Thus, when N-loading to the upper euphotic zone (the mixed layer) was compared to anthropogenic loading it was twice as important as when compared to the total N-loading from estuarine circulation.

10:55 **John Mickett (University of Washington, Applied Physics Laboratory)**, Chris Krembs (Washington State Department of Ecology Marine Monitoring Unit), Jan Newton (UW, Applied Physics Laboratory), Allan Devol (UW, Oceanography), Wendi Ruef (UW, Oceanography)

*What caused the exceptionally high dissolved oxygen and low temperature anomalies this past winter/spring in Hood Canal (Puget Sound)?*

In the late winter and early spring of 2014, the basin water of Hood Canal Washington, a branch of the Puget Sound fjord, was the coldest (~1 deg. C below average) and most oxygenated (~2 mg/l above average) observed in more than a decade of largely continuous measurements from both the ORCA profiling moorings and the Washington State Department of Ecology marine sampling program. With the late summer minimum of dissolved oxygen (DO) levels in Hood Canal---and the likelihood of hypoxic conditions and resultant fish kills---largely dependent on the late winter levels of dissolved oxygen and the duration of the DO drawdown period, there is clear motivation to understand the drivers of the recent high DO levels. Preliminary investigation strongly suggests that basin water renewal events in December 2013 and February 2014, which rapidly cooled and oxygenated basin water, were driven by local weather conditions characterized by cold air outbreaks (<0 deg. C) occurring during an extended period of anomalously low precipitation (4-7 inches below climatology over 3 months). Lower than average basin density during the fall of 2013 may also have contributed to the strength of the renewal events.

11:15 **Jan Newton (University of Washington, Applied Physics Laboratory)**, Simone Alin (NOAA, PMEL), Adrienne Sutton (NOAA, PMEL), Dick Feely (NOAA, PMEL), John Mickett (UW), Allan Devol (UW)

*Ocean acidification in coastal and inland waters of Washington*

While the ocean acidification signal in open ocean waters has been studied more comprehensively, we are only now getting such time series from moorings and cruises in the coastal and inland waters for the Eastern Pacific. We present such observations from the Salish Sea, Puget Sound, and Washington coast. Larger variability is the obvious difference between these locations and the open ocean. Also, the role of local bathymetry may be important in dispersing but retaining low pH signals from upwelling. Events such as spring blooms and upwelling are obvious in the records. In this presentation, we summarize the main patterns of variation, note new regional observing assets and plans, and highlight analyses that will be conducted to further our understanding of drivers of the ocean acidification signal in coastal waters.

11:35 **Kerry J. Nickols (Hopkins Marine Station, Stanford University)**, David Koweek (Stanford), Paul Leary (Hopkins), Sarah Lummis (Hopkins), Steve Y Litvin (Hopkins), David A. Mucciarone (Hopkins), Robert B. Dunbar (Hopkins)

*Spatial variability of carbon system parameters associated with kelp forests in an upwelling system*

Kelp forests are among the most productive coastal ecosystems, yet little is known about their biogeochemistry and carbonate system variability. We present a weekly time-series of water column properties (temperature, salinity, total alkalinity, and dissolved inorganic carbon (DIC)) within and around a Central California kelp forest including wave exposed and protected sites. During the study period (July 2013-August 2014), Conductivity, Temperature, Depth casts and coupled water samples revealed strong seasonal cycles in the physical and chemical water column structure. During the winter, the water column was well-mixed with low kelp abundance, and vertical DIC gradients were typically absent. During the upwelling season, when kelp growth was high and the water column was stratified, vertical DIC gradients sometimes exceeded 200 μmol/kg. These vertical gradients were strongest in the protected side of the kelp forest and weaker on the wave-exposed side. pCO2 was generally highest in the wave exposed side of the forest, with lower aragonite saturation state, which was particularly pronounced during the upwelling season. Understanding the relationships between physical processes (i.e., wave exposure, stratification) and biological processes (production/respiration, calcification/dissolution) in controlling carbon system dynamics is an important step to predicting responses of nearshore habitats to climate change and ocean acidification.

Poster **Jennifer Fisher (Cooperative Institute for Marine Resources Studies, Oregon State University)**, Bill Peterson (NOAA Northwest Fisheries Science Center), Jay Peterson (CIMRS, OSU), Hongsheng Bi (University of Maryland, Center for Environmental Science)

*Differential changes in pteropod abundance across the Oregon shelf and slope*

Waters which upwell nearshore in the northern California Current have low pH and aragonite saturation values < 1.0 which may impair the ability of the planktonic snail *Limacina helicina* to produce aragonite or may lead to shell dissolution, resulting in mortality. Here, we present data on the abundance of *L. helicina* over 17 years from two stations located on the continental shelf and slope that are exposed to upwelled waters differentially. Over the 17 year time span, the seasonal peak abundance of *L. helicina* followed a negative trend in the nearshore coastal upwelling zone where waters are corrosive. In contrast, the seasonal peak abundance increased offshore where aragonite saturation values are generally >> 1 year round. Further, the long term trend nearshore in the coastal upwelling region was variable while the long term trend offshore was inversely correlated with the North Pacific Gyre Oscillation.

Poster *__Rachel Golda (Oregon Health & Science University)__, Joseph Needoba (OHSU), Tawnya Peterson (OHSU), Jacqueline Hayes (University of Fresno)

*Using an autonomous pHstat/chemostat system to determine the effect of ocean acidification on harmful algal blooms*

Algal culturing and laboratory physiology experiments for ocean acidification research require precise control of experimental conditions, particularly those pertaining to aquatic carbonate chemistry and pH. Algal chemostats customized for this application are an effective approach for laboratory experiments; however design and construction are often prohibitively expensive or require extensive electronics and software development. We have designed and constructed a novel, cost-effective pHstat/chemostat for studying the effects of pH on marine microbiota. This design includes an in situ pH sensor and regulates pH using interchangeable LabVIEW©

controlled reagent or gas mediated pH-modification manifolds, both of which feature flow regulation by solenoid valves. Effective pH control with an error range of +/-0.10 pH units was achieved with the gas manifold. The liquid manifold exhibited an even smaller error range of +/- 0.03 pH units. For the liquid manifold we derived a mathematical relationship between the size of the pH perturbation, concentration of the reagents and the rebound time of the system. We applied this pHstat to test the stress response of the toxic alga *Alexandrium catenella* to variable pH. This has the potential to provide much needed information about marine microbiota in estuarine and ocean ecosystems as OA increases in severity.

Poster **Debby Ianson (Institute of Ocean Sciences, Sidney, BC)**, Susan E. Allen, Ben. Moore-Maley, Sophia Johannessen, Robbie MacDonald

*What causes the high inorganic carbon inventories in the Strait of Georgia?*

There are few measurements of the carbonate system in the Strait of Georgia (SoG). The assumption has been that waters entering the Salish Sea from the outer coast through the Juan de Fuca Strait (at depths around 100 m) are carbon-rich due to upwelling on the outer coast. We present inorganic carbon data from 16 cruises in the Juan de Fuca Strait and SoG from the years 2003-2013 (but mostly in 2011 - 2013) and investigate seasonal patterns. These data show that the incoming waters during summer (assumed to contain an upwelling signal) are indeed rich in carbon, but that the water in the Strait has higher carbon and lower pH at the same density, while oxygen in the incoming waters is lower at times. The result is that aragonite saturation horizons in the SoG are shallow relative to the outer coast in all seasons and reach the surface during the winter months. We discuss the high carbon, low pH subsurface water in the SoG in the context of productivity and residence times and investigate the potential influence of dissolved organic matter supplied by the Fraser River as well as local anthropogenic inputs on the inorganic carbon system in the SoG.

Poster **Julie Keister (University of Washington, Oceanography)**, Anna McLaskey (UW, Oceanography), Paul McElhany (NOAA NWFSC)

*Testing the effects of ocean acidification on copepod and krill populations*

The response of crustacean zooplankton to elevated pCO2 remains poorly understood due to the limited number of labs conducting ocean acidification work on these species; their future adaptability is completely unknown. In my lab, we are conducting experiments on the sensitivity of two critical food web species—the copepod *Calanus pacificus* 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 finding overall decreased growth and survival with elevated pCO2, but a compelling variability among broods that indicates potentially large parental variance. The heritability is not yet determined. Here, I present preliminary results of several different experiments we have conducted, in the context of the conditions the organisms currently experience in the field. Multi-generation experiments are a goal of our work, but are experimentally impossible for most zooplankton taxa, and are challenging even on ‘lab rat’ species due to the technical challenges of maintaining controlled conditions for the months to years necessary to culture zooplankton through multiple generations. Field comparisons or genomics may be viable approaches to the problem—I welcome discussion of how adaptability

to future conditions can be tested on these challenging organisms.

Poster **Drew Lucas (Scripps Institution of Oceanography, UCSD)**, Kudela, Raphe (University of California, Santa Cruz)

*Rapid profiling measurements of dissolved oxygen: advection versus in situ processes*

Advances in rapid response oxygen sensors have allowed for the characterization of dissolved oxygen variability on small spatiotemporal scales. These observations can be used to test the ability of measured oxygen dynamics to predict in situ productivity and estimate the impact of hypoxic and low oxygen conditions. Utilizing a dataset spanning coastal, high productivity waters and open ocean oligotrophic regions from both within and outside of the Eastern Pacific region, results from more than 50,000 autonomous vehicle profiles indicate the critical importance of advection on in situ measurements of dissolved oxygen. These results imply far stronger oxygen variability at depth (and, occasionally, on isopycnals) on time scales at or shorter than one day than was previously understood. Implications for hypoxia, low oxygen conditions, and the utilization of high frequency oxygen changes as a proxy for phytoplankton productivity are discussed.

Poster **Nikolay P. Nezlin (Southern California Coastal Water Research Project)**, Ashley J. Booth (Environmental Monitoring Division, City of Los Angeles, CA), Chris Beegan (California State Water Board, Division of Water Quality), Curtis Cash (Environmental Monitoring Division, LA, CA), Joseph R. Gully (Los Angeles County Sanitation District, CA), Michael J. Mengel (Orange County Sanitation District, CA), George L. Robertson (Orange County Sanitation District), Alex Steele (LA County Sanitation District), Stephen B. Weisberg (Southern California Coastal Water Research Project)

*Assessment of the impact of wastewater discharge on dissolved oxygen over the southern California shelf*

Assessment of the effects of wastewater discharge on dissolved oxygen (DO) around major submerged ocean outfalls in southern California included: 1) identification of the area affected by effluent wastewater, 2) selection of reference sampling sites representing ‘natural’ conditions, and 3) comparison between DO profiles in the reference and plume-affected zones. Wastewater-affected areas were detected using Colored Dissolved Organic Matter (CDOM) as an effluent plume tracer. Reference sites were selected from within a fixed distance from the outfalls excluding the sites affected by the effluent. Reference DO profiles in the density space were calculated, taking into account DO variability between the reference stations. Comparison between plume and reference DO profiles included assessment of low-oxygen water entrained by rising effluent plume using water temperature as a tracer. ‘DO outranges’ (10% decreases in DO, consistent with the California State Water Quality regulations) were found at a small number (11%) of effluent plume stations, with about one-half of them resulting from physical entrainment of deep, low-oxygen water into the sub-pycnocline layer.

Poster **Samantha A. Siedlecki (UW, JISAO)**, Jeremy Mathis (NOAA, PMEL), Al Hermann (UW, JISAO), Ken Coyle (University of AK Fairbanks), Wiley Evans (NOAA, PMEL)

*Ocean Acidification of the coastal Gulf of Alaska waters: A modeling study*

A regional model of the coastal Gulf of Alaska is combined with the empirical relationships between the carbonate system, nitrate and temperature (Evans et al, 2013) to simulate the carbonate chemistry in this region. A model hindcast for 2009 is compared to local observations of nitrate, and aragonite saturation from the Seward Line. Challenges of this approach are discussed. Spatial patterns and seasonality are discussed. The importance of winds, freshwater runoff, and local biological processes to determining these spatial patterns will be analyzed.

---

Thursday Afternoon Session

***Modeling Eastern Pacific Ocean Circulation and its Interactions with Biogeochemistry, Ecosystem and Fisheries***

Session chairs: Yi Chao, Parker MacCready, Chris Edwards

14$_{55}$ **Edward Myers (NOAA/NOS/OCS Coast Survey Development Laboratory)**, Frank Aikman (NOAA/NOS/OCS), Aijun Zhang (NOAA/NOS/OCS), Eric Bayler (NOAA/NESDIS)

*NOAA's West Coast Operational Forecast System: Planning and Strategy Towards a Data-Assimilating Regional Coastal Ocean Forecast System*

NOAA's National Ocean Service (NOS) plans to develop an operational forecast system for the coastal and shelf waters of the U.S. West Coast. This West Coast Operational Forecast System (WCOFS) will use a three-dimensional hydrodynamic model to compute water levels, currents, temperature and salinity over a region encompassing the Washington, Oregon and California coastal waters. To best represent the complex ocean physics in this region, innovative modeling approaches that assimilate observed data into the numerical models will be used. Bringing this data assimilative capability into NOS' operational forecast systems will enable WCOFS and future systems to be more accurate through a well-posed combination of ocean model physics and adjustments based on real-time observations. Improved accuracy translates to significant, measurable impacts that will help the region better address marine navigation and under-keel clearance issues, emergency response, fisheries, ecological forecasting, coastal storm resilience, and other applications. This project presents a unique opportunity to build upon local knowledge of the region, state of the art data assimilation methodologies, and shared regional data resources to bridge modeling capabilities from the global ocean to a regional scale and further enable future estuarine-scale and port-scale models to provide the best available information to local end users.

15$_{15}$ **Albert J. Hermann (University of Washington, JISAO)**, Samantha Siedlecki (UW, JISAO), Nicholas Bond (UW, JISAO)

*Sources of predictability (and unpredictability) in the Pacific Northwest*

Recent experience with experimental, regional, seasonal forecasts of the Pacific Northwest under J-SCOPE (the JISAO Seasonal Coastal Prediction Experiment) have naturally raised questions about what atmospheric and oceanic statistics can be expected to be forecast with any significant skill, given our present-day computational and measurement resources. The J-SCOPE model is itself driven by NOAA's Climate Forecast System (CFS). The CFS exhibits

significant predictive skill for SST, but such skill is less evident for coastal winds. For some properties (e.g. alongshore currents), we expect that coastal predictability may be improved by the spatially-averaging influence of remotely-forced coastal-trapped waves. Biological dynamics (e.g. hypoxia) may act as both low-pass filter and amplifier of physical variability. We explore these concepts using re-forecast data from NOAA's global Climate Forecast System, and the output from the J-SCOPE regional model itself.

1535 **Paul J. Mattern (UCSC, Department of Ocean Sciences)**, Christopher A. Edwards (UCSC), Jerome Fiechter (UCSC)

*Optimization and intercomparison of biogeochemical ocean models of the US west coast*

Nonlinear processes within biogeochemical ocean models result in complex, sometimes non-intuitive sensitivity to embedded rate-controlling parameters which are often large in number and poorly constrained by present laboratory and field data. Yet prior to deploying biogeochemical ocean models, it is desirable to optimize parameters so that forward simulations produce model fields that are reasonably consistent with available data. We present an intercomparison of biogeochemical ocean models of varying complexity; from a low-complexity NPZD model to the more complex NEMURO model, containing 13 biological variables and more than 30 parameters. The models are coupled to a 3-dimensional physical ocean model of the US west coast based on the Regional Ocean Modelling System (ROMS). We examine the fit of the models to chlorophyll and nutrient observations. We then assess the potential of simple parameter estimation techniques, based on evolutionary algorithm approaches, to optimize biological parameters and improve the model fit.

1555 **Yi Chao (University of California at Los Angeles)**, John Farrara (UCLA), Carrie Zhang (UCLA), Fei Chai (University of Maine)

*A Real-Time Nowcast/Forecast System for the California Coastal Ocean*

This talk will present experiences and lessons learned during the development of a regional 3-dimensional ocean nowcast/forecast system and its implementation in the California coastal ocean. The model is based on the Regional Ocean Modeling System (ROMS) with multi-domain nested configurations. A multi-scale 3-dimensional variational (3DVAR) data assimilation scheme is used to assimilate both in situ (e.g., gliders) and remotely sensed data from both satellite and land-based platforms (e.g., high-frequency (HF) radars). An ensemble modeling methodology has been tested to estimate the forecast uncertainties. Preliminary results coupling the regional circulation model with biogeochemistry/ecosystem models will be presented. Several demonstration cases using ROMS forecasts in support of decision-making by the U.S. Coast Guard during Search and Rescue operations will be discussed.

1625 **Antonio M. Baptista (Center for Coastal Margin Observation & Prediction, OHSU)**, Yvette Spitz (CMOP, OSU), Brandy Cervantes, (CMOP, OSU), Tuomas Karna (CMOP, OHSU), Clara Llebot (CMOP, OHSU), Jesse Lopez (CMOP, OHSU), J.Paul Rinehimer (CMOP, OHSU)

*The Columbia River as a river-dominated bioreactor: a data-informed in silico exploration*

CMOP investigators are studying the Columbia River estuary as a river-dominated bioreactor, where biogeochemical transformations occur disproportionately through specialized biological hotspots (lateral bays, estuarine turbidity maxima, and red water blooms). Anchoring the study is an observation network with high-resolution endurance stations, mobile platforms, and process-oriented campaigns. A family of SELFE-based interdisciplinary models has been developed iteratively, with the benefit of (a) calibration/validation against the CMOP data set, and (b) the frequent scrutiny of process-oriented investigators. Here, we take the current version of these models to provide an integrated view of circulation, sediment dynamics and net ecosystem metabolism (NEM). Mapping results onto a modern estuarine classification system, we identify four primary physical regimes (driven by river flows and tides) and characterize a bioreactor that is highly responsive to these regimes. Using NEM as a metric, we take first steps towards characterizing the seasonality and contrasting the roles of biological hotspots. Computing balances, we offer early estimates of estuarine imports and exports of nitrogen and carbon. This silico analysis—a snapshot in our iterative understanding of a complex estuary—is limited by the modeling skill, which itself depends on the prevailing physical regime. The richness and diversity of the available sensor data is used to assess strengths and weaknesses of the analysis.

1645 **Nancy Soontiens (Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia)**, Susan Allen (UBC), Doug Latornell (UBC), Kate Le Souef (UBC), Idalia Machuca (UBC)

*Finding NEMO in the Strait of Georgia: A regional ocean modeling effort*

The Strait of Georgia is a strongly stratified, semi-enclosed body of water located between Vancouver Island and the mainland of British Columbia. It is part of a larger system of waterways collectively known as the Salish Sea and is connected to the Pacific Ocean via the Strait of Juan de Fuca and Johnstone Strait. In collaboration with groups at Dalhousie University, Environment Canada and Fisheries and Oceans Canada, the Salish Sea NEMO model team is developing a three-dimensional numerical ocean model of the Salish Sea using the NEMO ocean modeling architecture. This presentation will showcase model evaluation through comparisons with observations. For example, measured tidal amplitude and phase, tidal currents from CODAR data, and water level elevation caused by storm surges will be compared with model output. Future plans for a coupled biological-chemical modeling component and data assimilation from the Ocean Networks Canada observatory system will be discussed, as well as a real-time modeling case study to coincide with an upcoming drifter deployment in the Strait of Georgia. This is a project funded by the Marine Environmental Observation Prediction and Response network (MEOPAR), a Network of Centres of Excellence of Canada.

1705 **Fanny Chenillat (Scripps Institution of Oceanography, UCSD)**, Peter S.J. Franks (SIO, UCSD), Pascal Rivière (Laboratoire des Sciences de l'Environnement Marin, France), Xavier Capet (Laboratoire d'Océanographie et du Climat, France), Bruno Blanke (Laboratoire de Physique des Océans, France)

*Planktonic ecosystem dynamics of a coastal cyclonic eddy in the Southern California Bight*

The highly productive Californian eastern boundary upwelling system exhibits high mesoscale eddy activity. Eddies that are formed at the coast move offshore, entraining and redistributing

nearshore nutrients and planktonic organisms. High planktonic biomass can be found in these eddies months after detaching from the coast. The mechanisms driving these patterns, and their ecological impacts are still poorly understood. To characterize and understand the influence of mesoscale eddies on planktonic ecosystems in the California Current System (CCS) we use a numerical approach coupling the Regional Ocean Modeling system (ROMS), at 5 km horizontal resolution, with a multiple size class planktonic ecosystem model (NEMURO). Combining Eulerian and Lagrangian analyses, we were able to follow one specific cyclonic eddy formed in the Southern California Bight as it detached from the coast and migrated offshore. Lagrangian particle tracking allowed us to identify the eddy core where high concentrations of coastal nutrients are found. The Eulerian calculations allowed us to quantify ecosystem properties and dynamics along the particle tracks. We highlight the role of this eddy in altering local planktonic ecosystem dynamics, and contrast those dynamics with the coastal upwelling source waters, and the waters encircling the eddy.

17$_{25}$ **Sung Yong Kim (Division of Ocean Systems Engineering, School of Mechanical, Aerospace & Systems Engineering, Korea Advanced Institute of Science and Technology)**, P. Michael Kosro (CEOAS, OSU), Alexander L. Kurapov (CEOAS, OSU)

*Evaluation of directly wind-coherent near-inertial surface currents off Oregon using a statistical parameterization and analytical models*

Directly wind-coherent near-inertial surface currents off the Oregon coast are investigated with a statistical parameterization of observations and outputs of a regional ocean model and three one-dimensional analytical models (e.g., slab layer, Ekman, and near-surface averaged Ekman models). The transfer functions and response functions, statistically estimated from observed wind stress at NDBC buoys and surface currents derived from shored-based high-frequency radars, enable us to isolate the directly wind-forced near-inertial surface currents. The concurrent observations of the wind and currents are crucial to evaluate the directly wind-forced currents. Thus, the wind stress and surface current fields obtained from a regional ocean model, which simulates the variability and scales of the wind and surface currents close to the observations off Oregon, are analyzed with the same statistical parameterization to derive the point-by-point transfer functions and response functions. The estimated response functions exhibit the decay time scales in a range of 3 to 5 days, and about 40% of near-inertial motions are explained by local wind stress. Among the one-dimensional analytical models, the near-surface averaged Ekman model best explains the statistically derived wind-current system than other analytical models.

Poster **Yi Chao (UCLA)**, John Farrara (UCLA), Carrie Zhang (UCLA), Joseph Zhang (VIMS), Fei Chai (University of Maine)

*Development of an unstructured grid model for the San Francisco Bay and Estuary to enable reanalysis*

An unstructured grid model based on SELFE is developed for the San Francisco bay/estuary with the goal of enabling reanalysis. As the model domain includes bays and estuaries, the complex coastline often requires an unstructured grid in the horizontal direction in order to achieve computational efficiency. We have implemented the Semi-implicit Eulerian-

Lagrangian Finite Element (SELFE) with unstructured triangular grids in the horizontal direction and a hybrid vertical coordinate combining the terrain-following and vertically-stretched with constant-depth layers. Results from both the June-July 2009 test run and a decade-long (2004-2014) reanalysis will be presented. Preliminary results coupling the SELFE model with the CoSiNE ecosystem model will be discussed.

Poster **Wei Cheng (University of Washington, JISAO)**, Nick Bond (UW, JISAO), Al Hermann (UW, JISAO)

*Projections of Ocean Properties along the Washington Coast Related to Environmental Health*

The objective of this study is to evaluate medium-term responses of the coastal waters of Washington State to forcing perturbations associated with climate change. Our research has proceeded along two lines: (1) direct analysis of the output for the region from global climate model simulations presented in IPCC AR4, and (2) dynamical downscaling using a sub-set of the climate models to drive a regional ocean circulation model. The ocean model used is the Regional Ocean Modeling System (ROMS), with 3-km horizontal resolution and 60 vertical layers. Output from the global climate models provides the initial and lateral boundary conditions as well as surface forcing variables for ROMS. The ROMS output is being examined for assessment of upper ocean properties pertaining to marine ecosystem response. Results to date suggest potentially significant changes in summer stratification, surface eddy kinetic energy, and meridional mass transport into the region in years 2030-2040 relative to years 2001-2011. The implications of these changes for the health of the regional marine ecosystem will be discussed.

Poster **Cheryl S. Harrison (CEOAS, OSU)**, Roger M. Samelson (CEOAS, OSU), Burke Hales (CEOAS, OSU), Samantha Siedlecki (JSAIO, UW)

*Physical-biogeochemical interactions and oxygen drawdown in upwelling systems*

A maximally simple coupled physical-biogeochemical box model is used to examine the processes affecting on-shelf carbon cycling and oxygen drawdown in upwelling systems. Steady states and upwelling-onset behavior are derived. Initial oxygen drawdown rate is primarily dependent on the surface production and flux of particles to depth. Linearized solutions describe the rate of particle accumulation and oxygen drawdown time as a function of the model parameters. Oxygen drawdown time is sensitive to the strength of upwelling relative to the shelf width, the subsurface sinking rate, and the initial surface particle value. The steady state potential for low oxygen at depth is explored as a function of the parameters. Higher oxygen drawdown is favored for moderate upwelling, wider shelf-widths, rapid production and fast sinking rates. Under periodic forcing, retention decreases through offshore surface transport of nutrients during heavy upwelling, extending oxygen drawdown timescales at depth.

Poster **Alexander L.Kurapov (Oregon State University)**, Scott Durski (OSU), John S. Allen (OSU), Gary D. Egbert (OSU), P. Michael Kosro (OSU), R. Kipp Shearman (OSU), Jack A. Barth (OSU)

*Coastal ocean variability in the US Pacific Northwest region influenced by the 2009-2010 El Niño*

A 2-km horizontal resolution model of the US Pacific Northwest region (35-50N, 134W-coast) has been developed to study how the coastal and interior ocean dynamics influence each other. The model is based on the Regional Ocean Modeling System (ROMS). Realistic simulations are performed for September 2008 – May 2011. Model verification against observations (including high-frequency radar surface currents, glider temperature and salinity cross-shore sections, satellite SST and SSH, mooring temperature and tide gauge SSH time series) confirms that the simulation reproduces coastal ocean variability on scales from several days to interannual. Our analysis is focused on patterns of the winter downwelling regime, in particular, the contrast of the 2009-2010 winter influenced by a moderate strength El Niño and the winters of the preceding and following years. Associated with the El Nino, the air and ocean temperatures are relatively warmer starting June 2009. Downwelling-favorable winds are stronger in winter 2009-10 and on average over the season the point separating coastal areas of predominantly downwelling and upwelling favorable winds is displaced farther south than usual. As a result, the near-surface salinity along the coasts of Northern California is relatively lower in winter 2009-10. Waters advected to the north along the slope and reaching Oregon (41-46N) are relatively fresher and warmer in winter 2009-10 than in the two adjacent non-El Nino years. The changes in composition of the source waters advected in winter toward the north influence the pattern of variability in the volume-averaged temperature and salinity over the Oregon shelf.

Poster **Parker MacCready (University of Washington, Oceanography)**

*Creating a Regional Daily Forecast Model for Ocean Acidification*

I will relate my experiences in transitioning our regional modeling framework, developed over the last decade as a hind cast model aimed at specific science questions, into a daily forecast model meant to be used by the public. The transition involves new (for me) aspects of software architecture, especially in forging robust interactions with external data sources. We are also using a cloud computing platform to process and archive the model output, and to serve the results to the public through an interactive website.

Poster **Ariane Verdy (Scripps Institution of Oceanography, UCSD)**, Matthew Mazloff (SIO, UCSD), Brendan Carter (Princeton University), Bruce Cornuelle (SIO, UCSD)

*Coupled physical-biogeochemical state estimation of the California Current System*

We present an estimate of the physical and biogeochemical state of the southern California Current System during the period 2007 to 2010. The state estimate is produced using the adjoint of the coupled MIT ocean general circulation model and the Biogeochemistry with Light, Iron, Nutrient and Gases model (MITgcm-BLING). The adjoint method is based on optimizing a set of control parameters, here the model initial conditions and atmospheric forcing, in order to bring the model solution into consistency with remote and in situ observations (including observations of ocean pCO2, pH, oxygen, nitrate, salinity, temperature, and sea surface height). In this presentation, we will discuss the performance of the assimilation. Despite inherent nonlinearities in the coupled system, the linear adjoint model is effective in decreasing the misfit with observations over a continuous one-year assimilation window. The biogeochemical model is strongly sensitive to initial conditions, which are uncertain. We

present the fields determined by the optimization that yield an improved fit to datasets from CalCOFI, GLODAP, and SOCAT. The state estimate is well suited for simulating processes that are difficult to observe, such as coastal upwelling and mixed layer depth variability, both of which are important drivers of variability in the coastal ocean carbon system.

---

Friday Morning Session
***General Session***
Session chairs: Ruth Musgrave and Jennifer Fisher

8$_{30}$ **Emanuele Di Lorenzo (Georgia Tech)**

*Unprecedented warming in the North Pacific anticipates strong El Niño in 2014/15*

During the winter of 2013/2014, the North Pacific experienced the warmest sea surface temperature anomalies (>3°C) ever recorded in this region. The spatial structure of these anomalies resembles the one observed during the winter prior to strongest El Niños of the last century (e.g. 1982/83, 1997/98). The wind anomalies that drive this warming pattern are linked to a known extra-tropical trigger of El Niño, which typically leads the development of mature El Niño conditions by 12 months. Furthermore, similar to the development of the 1997/98 event, the equatorial Pacific is currently characterized by sustained westerly winds and strong subsurface warm anomalies (~6°C), both well known tropical triggers of El Niño. Here, we develop a physically-based statistical ENSO model that combines both extratropical and tropical precursor dynamics. This model exhibits significant hindcast skill in identifying the 1972/73, 1982/83, and 1997/98 El Niños as strong events (>2 °C), and relates them to years when both tropical and extra-tropical triggers were active and strong in the preceding winter/early spring. Furthermore, stochastic simulations of the model are in agreement with observational statistics of El Niño return times, thus supporting the random event paradigm and challenging the idea that memory is retained from one event to the next. Applied to the current situation with several precursors active, the model predicts the development of a strong 2014/2015 El Niño event.

8$_{50}$ **Sally J. Warner (Oregon State University)**, James N. Moum (OSU)

*The role of mixing in regulating sea surface temperature in the eastern equatorial Pacific during El Niño and La Niña*

At the end of the ’97-’98 El Niño, the sea surface temperature in the eastern equatorial Pacific cooled by the extraordinary amount of 6.4°C in 25 days. This rapid cooling — which is seen to some extent at the end of all El Niños — must come from below. It is known that upwelling of cold, deep water by an eastwardly propagating equatorial Kelvin wave accounts for some of this sea surface cooling, but we show that diapycnal mixing also plays an important role. In this study, a seven year time series of mixing measured with moored fast-thermistors (Chipods) deployed at 0° 140°W within the equatorial Pacific cold tongue is used to determine the sequence of events that leads to sea surface cooling following the El Niños in 2007 and 2010. Furthermore, we show that during El Niño years, diapycnal mixing, narrowband shear instabilities, turbulent heat flux, and tropical instability wave kinetic energy are all lower than

during La Niña years.

9$_{10}$ **Amy Waterhouse (Scripps Institution of Oceanography)**, Jen MacKinnon (SIO), Ruth Musgrave (SIO), Sam Kelly (SIO), Jonathan Nash (SIO)

*Variability in the timescales of mixing due to internal wave breaking in a coastal submarine canyon*

Recent results highlight the long-range propagation of low-mode internal tides up to thousands of kilometers across ocean basins. Much of the dissipation and resultant turbulent mixing may take place where waves hit the continental slope. We hypothesize that coastal canyons may be particularly efficient at dissipating incident internal tide energy. To investigate this hypothesis we conducted a two-week field experiment in Eel Canyon, off the California Coast. The variability in the observed mixing within the canyon is found to be associated with energy flux convergences within the canyon influenced from both remote and local generation sites. We determine the time scales of mixing are related to both the semidiurnal and diurnal internal tide, with enhanced turbulent mixing along the near-bottom axis of the canyon.

9$_{30}$ Shuang Zhang (SIO), **Matthew Alford (Scripps Institution of Oceanography)**, Madeleine Hamann (SIO)

*Nonlinear internal waves and turbulence on the Washington coast*

We present properties, mass transport, and mixing mechanisms of over 1,000 strong nonlinear internal waves detected in four summers/falls of moored data on the Washington continental shelf. The waves propagate onshore and appear to arise as remotely generated internal tides impinge on the shelf and steepen. Nearly all are waves of depression, with some reaching amplitudes up to 40-50 in 100 m of water. Stokes drift calculations suggest that mass transport by the waves is as great as that by wind-driven Ekman transport, giving the waves a potentially important role in the region's mass and nutrient budgets. We also examine the conditions accompanying Thorpe-scale-inferred turbulence, finding that the waves break by both shear and convective instability. Finally, we present preliminary results from our August 2014 cruise wherein we measure the waves' turbulence and examine their generation mechanism.

9$_{50}$ *__Robert S. Arthur (Environmental Fluid Mechanics Laboratory, Stanford University)__, Oliver B. Fringer (EFML, Stanford)

*Transport and mixing by breaking internal waves on slopes*

Internal waves are ubiquitous in the Eastern Pacific Ocean, where they propagate toward the coastline and interact with the nearshore slope. The resulting internal wave shoaling and breaking events affect nearshore velocity fields, leading to the transport and mixing of biologically important scalars including temperature, nutrients, larvae, sediment, and dissolved oxygen. Due to the difficulty of capturing internal wave-breaking events in the field, a high-resolution numerical model is employed to study the associated transport and mixing processes in an idealized setting. Using particle tracking, cross-shore transport is quantified as a function of initial location; maximum onshore transport is observed within upslope-propagating internal bores, while maximum offshore transport is observed in an intermediate layer near the

pycnocline. Alongshore spreading of particles is also observed due to three-dimensional flow that develops during wave breaking. Vertical mixing is quantified in terms of a change in background potential energy over the course of a breaking event. Transport and mixing results are considered for various wave and slope conditions based on the internal Iribarren number, and extended to the field based on calculations of this parameter in the nearshore along the Pacific coast of the United States.

10 25 *__Leif Rasmuson (UO, Oregon Institute of Marine Biology)__, Alan Shanks (OIMB)

*In situ observations of Dungeness crab, Cancer magister, megalopae used to estimate transport distances by internal waves*

Larvae of many coastal organisms develop offshore and must migrate to shore to settle. Two mechanisms of migration are proposed for crustacean postlarvae: onshore swimming and transport by internal waves both which are strongly influenced by larval behavior. Dungeness crab megalopae were observed *in situ* to determine if they orient their swimming direction and to determine swimming speed over ground. They were not oriented to the east, rather they swam in the direction of the current at speeds of ~9.8 cm $s^{-1}$ which should increase transport distance by internal waves. We tested the influence of these behaviors on transport by deploying a thermistor mooring for 24 days and calculating transport distances for all observed waves. Calculations were done for passive particles and particles that swam with the surface current at speeds from 0-10 cm $s^{-1}$. Of 69 observed waves none would have transported passive particles but as swimming speed of organisms increased the number of transporting waves increased dramatically. At swimming speeds of 10 cm $s^{-1}$, all waves were transporting. Megalopae of *C. magister* do not migrate ashore by swimming east rather they swim with surface currents, possibly allowing them to better exploit internal waves as a transport mechanism.

10 45 **Maria Aristizabal (Department of Marine Sciences, University of Connecticut)**

*Near-shore velocity and temperature variability in the Santa Barbara Channel, California*

The Santa Barbara Channel experiences significant near-shore temperature fluctuations that can be as large as 8 degrees in four hours during summer time. These temperatures are associated with the delivery of nutrients and larvae to the euphotic zone. The velocity and temperature variability in the diurnal and semidiurnal band in this area are linked to internal wave activity driven by wind and tidal forcing. In this study we used a wealth of existing observations of temperature and velocity that extended over 18 years. These observations are located at 24 near-shore sites along the mainland and the Northern Channel Islands. We found that the phase lag of the diurnal band temperature between sites is fairly uniform when the coherence is high, while the phase lag in the semidiurnal band is randomly distributed. This suggests that the diurnal temperature variations are mostly driven by the local winds, whereas the semidiurnal temperature variations are tidally driven and modified by the local bathymetry or by interactions with mesoscale eddies. About 45 percent of the temperature variability, in both the diurnal and semidiurnal band, can be explained by the vertical advection of temperature gradients due to a 2-layer cross-shelf flow.

11$_{05}$ **Xiuning Du (Cooperative Institute for Marine Resources Studies, Oregon State University)**, William Peterson (NOAA, NWFSC), Linda O'Higgins (CIMRS, OSU)

*Interannual variations in phytoplankton community structure in the northern California Current during the upwelling seasons of 2001-2010*

A fundamental problem in the biological oceanography of the California Current is one of determining the relative influence of local processes such as coastal upwelling vs. basin-scale processes associated with the Pacific Decadal Oscillation (PDO) on plankton community structure. Towards this end, phytoplankton species were enumerated from 72 samples collected biweekly during the upwelling season (May to August) of 2001-2010, to test for effects of interannual variations in upwelling and decadal basin-scale variability on phytoplankton community. Cluster analysis of phytoplankton community structure identified seven groups. One group was dominated by dinoflagellates while the other groups were dominated by diatoms, but with variable ratios of diatom-to-dinoflagellate abundance ranging from 4 to 847. Variations in phytoplankton community were not related to the strength of upwelling within a given year; rather, the abundance and ratios of diatom-to-dinoflagellate were related to when a sample was collected within an upwelling/downwelling cycle. Community structure was also analyzed by non-metric multidimensional scaling ordination (NMDS). An index of community structure from NMDS was correlated with the Pacific Decadal Oscillation but not with seasonally-averaged coastal upwelling strength. Thus changes in the sign of the PDO seem to be more influential in explaining the interannual variations in phytoplankton community structure than seasonally-averaged coastal upwelling.

11$_{25}$ ***Ben Raanan (Moss Landing Marine Labs, SJSU)**, Erika McPhee-Shaw (Shannon Point Marine Center, WWU), Olivia Cheriton (Pacific Coastal and Marine Science Center, USGS)

*Observations of benthic-interior exchange events over the continental shelf of Monterey Bay, California*

Physical and optical measurements taken over the mud belt on the southern continental shelf of Monterey Bay, California documented the frequent occurrence of suspended particulate matter (SPM) features, the majority of which were detached from the seafloor and centered 9–33 m above the bed. As part of the Benthic Exchange Project (NSF) field effort, an automated wave-driven profiling mooring and fixed instrumentation, including a thermistor chain and upward-looking acoustic Doppler current profiler, were deployed at the 70-m isobath offshore of Monterey, California for 4-5 weeks in the falls of 2011 and 2012. Examining the fall 2011 period of observation, Cheriton et al. [2014] provide evidence supporting a number of physical mechanisms (mainly associated with the internal tide) driving detachment and lateral advection of SPM layers. Here we illustrate the temporal and spatial variation of SPM intrusions documented throughout the month long field effort of fall 2012, and implement time series analysis and modeling methods to investigate how hydrographic and climatic phenomena influence the detachment of SPM layers and manipulate erosional forces applied to the seabed. Finally, we apply statistical modeling methods to establish predictive framework for SPM detachment based on co-occurring environmental processes.

Poster **Susan Allen (Dept. Earth, Ocean and Atmospheric Sciences, University of British Columbia)**, Doug Latornell (UBC), Kate Le Souef (UBC), Nancy Soontiens (UBC), Idalia Machuca (UBC)

*Software Collaboration Tools and the Salish Sea MEOPAR Project*

The open source software community has generated a number of tools for collaborative development. These tools are now mature enough to be useful in oceanographic research. We will describe the set of tools we are using in the Salish Sea MEOPAR project. This project is deploying the NEMO ocean model as a forecast model for the waters inside Vancouver Island including the Strait of Georgia, Strait of Juan de Fuca, Johnstone Strait, and Puget Sound. The collaboration tools were chosen and configured to be as lightweight as possible so as to allow us to focus on model development rather than burden us with many new technologies. The foundation is distributed version control. It is applied to not only code, but also documentation, model configurations, and analysis of model results. The top level is provided by IPython Notebooks which allow easy access to the analysis (graphs, code, summaries) of one researcher by all others, facilitating supervision, scientific evaluation and discussion. A summary of our specific tools, why they were chosen, and how they are coordinated through web services will be presented using the implementation and evaluation of tides as an example.

Poster *__William M. Fairchild,__ N. Aitken, A. Benelisha, H. Brassmassery, A. Hay, T. Johnson, J. Larrabee, M. McCammon, J. C. Borgeld, C. J. Cass (all authors affiliated with Humboldt State University)

*Small-scale spatial variability of mussel biotoxins off of northern Humboldt County, California*

Sport-harvested mussels *Mytilus californianus* are collected and tested by the California Department of Public Health to protect the public from domoic acid poisoning and paralytic shellfish poisoning (PSP). Collection quarantines are issued when these toxins rise above consumable levels (>36 µg/g), primarily during summer upwelling conditions that contribute to blooms of toxin producing *Pseudo-nitzschia* spp. We studied the spatial variability of near-shore *Pseudo-nitzschia* cells and mussel tissue biotoxin concentrations at three locations, north and south Trinidad Head (TH), CA, and north Scotty Point, CA, a headland 3 km north of TH. To compare upwelling and non-upwelling conditions, we sampled in spring (April, May) and summer (June). Spring sampling showed low ocean productivity (average fluorescence of 1.54 $mg/m^3$) compared to summer sampling (average fluorescence of 16.7 $mg/m^3$). Despite a late-June rain event weakening upwelling, *Pseudo-nitzschia* abundances and average mussel tissue PSP concentration (50 µg/g) was greatest in June. April's Scotty Point mussel sample yielded a low positive (PSP of 36 µg/g), while north and south TH mussels were not found hazardous (<36 µg/g). Initial analysis reveals that tissue-toxin can vary widely even within 3km of coastline and that mussel collectors should still be careful during the non-quarantine collection months of November-April.

Poster Jon Fram (Oregon State University), Jack Barth (OSU), Robert Collier (OSU), Edward Dever (OSU) **Michael Vardaro (OSU)**

*The Ocean Observatories Initiative in the Northeast Pacific: A New Community Resource*

The Ocean Observatories Initiative (OOI), an NSF-sponsored project to provide long-term, interactive access to the ocean, is in the final stages of constructing and installing ocean platforms and sensors in the Northeast Pacific. The OOI was designed around ocean science community proposals to address cutting-edge science and pressing societal issues. Off Oregon and Washington, two elements of OOI combine to investigate seafloor, water column, and air-sea interaction processes including hypoxia, ocean acidification, ecosystem dynamics, fluid-rock interactions at the seafloor, and plate-scale geodynamics. The Endurance Array consists of moorings over the continental margin off Newport, Oregon, and Grays Harbor, Washington, and a glider array spanning from the Strait of Juan de Fuca to Coos Bay, Oregon. The Regional Scale Nodes make use of a seafloor cable with power and internet-quality connectivity to host underwater laboratories and water-column moorings at Axial Volcano and Hydrate Ridge. The OOI platforms are designed to be in place year-round, necessitating innovation, for example to withstand strong winter storms, and host almost fifty different instrument types including physical and biogeochemical sensors. As data come on line, and after a verification phase, all the data will be freely available and are accessible via oceanobservatories.org.

Poster **Tohru Ikeya (University of Tokyo, Department of Biological Sciences and Yokohama National University)**, Kyoko Kawanobe (Aquatic Life Research Institute Inc.)

*Resolving phytoplankton formation processes at oceanic fronts in spatial and time domains*

An enhancement of high abundance of phytoplankton at spring bloom has been observed along the Kuroshio Current. Vertical sections along cruise tracks across the Kuroshio Current showed that two different mechanisms are hypothesized for the formation processes of enhanced phytoplankton abundance at oceanic fronts. One is due to typical diapycnal mixing at fronts along meandering currents. The other is disturbance by an override of warm Kuroshio water onto cold water derived from the northern part of the Kuroshio Current. A careful examination of phytoplankton composition illustrates two different mechanisms resulting in different phytoplankton composition derived from oceanic and coastal waters, respectively. An additional research sample also showed significant similarity between coastal and winter samples. These results indicate that the productivity at fronts in spring is connected spatially to coastal as well as seasonally to winter time domain. Such alternation of major phytoplanton composition should be directly affected by oceanic fluctuation of the Kuroshio Current, but also be potentially connected to inoculation at coastal as background level. These ideas will be a basis of long term oscillation of oceanic productivity.

Poster Brent Krontmiller (Center for Genome Research and Biocomputing, OSU), Shawn O'Neil, Matthew Peterson, **Adelaide Rhodes**, Chris Sullivan, Kelly Vining (all CGRB)

*Center for Genome Research and Biocomputing at Oregon State University*

This poster provides information on the core facility at Oregon State University that offers next generation sequencing services, biocomputing and bioinformatics training and confocal microscopy. A key part of the Center is the CGRB Core Facilities that provide services, technical expertise, collaborative functions and share-use equipment for molecular bioscience research at Oregon State University and to external users. The Core Facilities are a fully staffed facility that serves as a focal point for acquisition and development of new instrumentation and technologies. A professional staff of nine provides service in four areas: 1.) Genomics - DNA

sequencing, high throughput sequencing (Illumina & 454), genotyping and fragment analysis; 2.) Biocomputing and Bioinformatics - advanced computational resources for data mining, data analysis and database development; and 4.) Imaging and Image Analysis - a confocal laser scanning microscope facility for high resolution analysis of wide variety of specimens. In addition, the CGRB provides shared instrumentation, including real-time PCR, scanners, robotics and computational facilities for use by walk-in users.

Poster **Joseph Jurisa (CEOAS, OSU)**, Jonathan Nash (CEOAS, OSU)

*Evolution of frontal mixing in the tidal Columbia River plume*

The evolution of turbulent mixing in the tidal Columbia River plume and the dependencies on tidal forcing parameters are discussed. It is found that the intensity of the turbulent mixing in the frontal region is positively correlated with the normalized frontal amplitude. The frontal growth is related to the trapping of internal waves in the frontal region. This frontal trapping process is represented using the Froude numbers of the ambient water mass ahead of the front (Fra) and the ambient fluid below the plume (Frp2). Plumes where Fra/Frp2 > 1 exhibit large frontal amplitudes and elevated turbulent mixing, while plumes where Fra/Frp2 < 1 do not exhibit large frontal growth. The relevant tidal parameter for the frontal amplitude is found to be the difference in tidal duration between the current and previous ebb tide, with this diurnal inequality in tidal duration being linked to the duration it takes the tidal plume to propagate through the buoyant remnants of the previous tidal plume. The magnitude of the tidal velocity and elevation drop at the mouth of the river are found to be of only secondary importance. Implications of the tidally dependent frontal mixing on net plume mixing will also be addressed.

Poster *__Bryce Melzer (California State University, Monterey Bay & Naval Postgraduate School)__, Chenwu Fan (NPS), Peter Chu (NPS)

*Methodology comparison on determination of global mixed layer depth and heat content from temperature profiles*

The mixed layer depth (MLD) is defined as the depth at which the isothermal layer ends and the thermocline begins. The MLD determines the upper ocean heat content and largely affects climate patterns through its influence on air-sea interactions. A variety of different methods/criteria exist to identify the MLD from ocean temperature profiles. In this study, datasets of global monthly MLD were created by processing 2009 NOAA/NODC World Ocean Atlas (WOA) temperature data for each existing method, with the goal of determining the most accurate method on a global scale. The two methods of focus were the difference threshold and gradient threshold methods, of which 9 sets of criteria are tested for the former, and 3 for the latter. Analysis was done on each dataset using an established quality index computation on a scale of 0< Ii <1 to determine which set gives an optimal estimation of global MLD. Of the 12 method/criteria combinations studied, the optimal one was found to be the difference method, with a threshold temperature difference of 0.8°C and a reference depth of 10 m. Global upper heat content (MHC) was subsequently calculated, utilizing the MLD values obtained from our newly established optimal methodology.

Poster *__Ruth Musgrave (Scripps Institution of Oceanography, UCSD)__, Jen MacKinnon (SIO, UCSD), Rob Pinkel (SIO, UCSD), Jonathan Nash (OSU), Amy Waterhouse (SIO, UCSD)

*Tidally driven turbulence over topography at the Mendocino Escarpment: Observations and modeling*

The interaction of tidal flows with topography can generate a range of phenomena including radiating internal tides that propagate large distances across the ocean, and, for sub-inertial tidal constituents, trapped internal tides that propagate along topographic gradients. Close to the topographic crest large amplitude, non-linear lee waves may form and break leading to intense localized turbulence and mixing. We present detailed shipboard observations and modeling of tidal flow in the vicinity of a channel at the crest of the Mendocino Escarpment, where both radiating super-inertial and energetic trapped sub-inertial internal tides are generated, interacting non-linearly close to the crest to give rise to dramatic turbulent events once per day. High resolution modeling shows the formation of large amplitude internal tide beams at the M2 tidal frequency and its harmonics, which are advected across the ridge crest each tidal cycle giving rise to distinctive signatures in our observations. The passage of bottom trapped diurnal tides through the channel not only strongly enhances tidal volume transport but also modifies the baroclinic structure of flows, resulting in the generation of tidal lee waves only once per day when the trapped wave transport is in the same direction as that of the surface tide.

Poster *__Noel A Pelland (UW, Oceanography)__, Charles C Eriksen (UW Oceanography), Meghan F Cronin (NOAA PMEL, UW Oceanography), Steven R Emerson (UW Oceanography)

*Vertical and Horizontal Transport Processes at Ocean Station P Inferred Using Inverse Methods*

In the southern Gulf of Alaska, though the annual upper-ocean cycle is dominated by surface inputs and local storage of heat and freshwater, subsurface vertical and horizontal advection terms are thought to be important in removing excess buoyancy below the surface layer, helping to maintain the existing stratification and thus playing an important role in air-sea interaction in this region. However, these processes are not well resolved in existing measurements, in particular below the mixed layer where previous studies have found large vertical gradients. We investigate the vertical and temporal structure of horizontal and vertical transport processes at the Ocean Station Papa site using 1.5 yr of data from a combined array of Seagliders and moored instruments. Over the study period, relatively large imbalances (10-60 W $m^{-2}$) exist between monthly-average measured surface buoy heat fluxes and upper ocean heat content changes; the character of these imbalances changes over the course of the study, which may be due in part to a weak mesoscale eddy passing the site. An inverse solution based on conservation of heat, salt, and potential vorticity yields weakly sheared vertical velocities of O(~0.1) m $d^{-1}$, which can be important in the seasonal thermocline and halocline where vertical gradients are large. Inferred vertical diffusivities are minimal in the highly stratified halocline and reach 1-5x10-4 m2 $s^{-1}$ at the base of the mixed layer. Horizontal geostrophic transport is of leading order in the halocline and to a lesser extent in the seasonal thermocline. Inverse solution residuals are large, indicating that there may be significant unresolved terms that are not be included in the model - ongoing work includes exploration of the role of mean Ekman transport, and generalization of the inverse model to include this process.

Poster **David Rivas (Departamento de Oceanografía Biológica, CICESE)**, Ernesto García-Mendoza (CICESE), Paula Pérez-Brunius (CICESE), Antonio Almazán-Becerril (Unidad de Ciencias del Agua, CICY), Jorge Cruz-Rico (CICESE), Iván Vivas-Téllez (CICESE)

*Towards a systematic and multidisciplinary research for Todos Santos Bay and northern Baja California: an update*

Todos Santos Bay (TSB) in northern Baja California (BC) is a region of major economic and scientific importance in Mexico. TSB is part of the southern portion of the California Current System and is under the influence of regional phenomena like wind-driven coastal upwelling, mesoscale eddies, coastal trapped waves, and harmful algal blooms (HAB). Diverse observational and numerical efforts have been done to describe such phenomena, which include monitoring of physical and biochemical variables within the Bay and a numerical analysis of the upwelling-source waters that fill the Bay and that are associated with the occurrence of HAB. Herein we present an update of a new effort to conduct systematic research that combines quasi-continuous monitoring and multi-year numerical simulations including coupled bio-physical models to describe the regional physical-biological dynamics.

---

Friday Afternoon Session

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

Session chairs: Eric Bjorkstedt and Christine Cass

1510 **Steve R. Ramp (Soliton Ocean Services)**, Igor Shulman (NRLSSC, Stennis Space Center), Fred L. Bahr (MBARI), Russ E. Davis (SIO, UCSD), Qing Wang (Naval Postgraduate School), Jim Doyle (NRLMRY)

*The heat budget in a three-dimensional upwelling center off Point Año Nuevo, CA*

A Combination of novel autonomous observations and numerical models for the ocean and atmosphere are used to estimate terms of the heat budget in the three-dimensional upwelling center located off Point Año Nuevo, CA during the ONR 2006 Adaptive Sampling and Prediction (ASAP) experiment. The Navy's COAMPS model was used in conjunction with a time series of aircraft over-flights and ocean buoy data to estimate the daily-averaged heat fluxes into the sea surface. The NRL NCOM model, which assimilated thousands of glider TS profiles and aircraft SST data, was used to estimate the fluxes through the sides of the control volume. Upwelling, relaxation, and transition events were examined during August 1-15, 2006. The eddy or fluctuating heat fluxes through the sides of the ASAP control volume were found to be three orders of magnitude larger than the transport heat flux and one power of ten larger than the net surface flux. The alongshore eddy fluxes through the ends of the volume were nearly balanced, and thus the thermal variability within the volume was controlled primarily by the u'T' term through the offshore side. Most of the time this across-shore eddy flux was established by horizontal circulation processes: An offshore jet transported heat out of the control volume during the upwelling event while onshore jets moved heat into the volume during the relaxations. Classical two-dimensional Ekman overturning was generally not observed but appeared sometimes near the end of extended upwelling events.

1530 **Jeffrey D. Paduan (Naval Postgraduate School)**, Mario V. Tapia (Santa Clara University),

Michael S. Cook (NPS)

*Patterns of Upwelling and Relaxations around Monterey Bay based on Long-Term Observations of Surface Currents*

The conditional averaging approach used to elucidate the horizontal structure of upwelling that was taken in the M.S. thesis of Enriquez (2004) is expanded in this study. Surface current mapping data from the five-year period of 2006 through 2010 is used for the area in and around Monterey Bay, California. The data are derived from the network of coastal high frequency (HF) radar stations that has been built up along the coasts of California and Oregon. The canonical, recurring pattern of upwelling currents is contrasted with the pattern observed during relaxation wind conditions as well as the pattern that results from seasonal averaging without regard to wind conditions. The reproducible yet heterogeneous patterns that emerge from conditional averaging based on winds suggest that the currents that spin-up under upwelling winds are strongly tied to the coastal morphology.

1550 *__Zelalem Engida (University of Victoria, School of Earth and Ocean Sciences)__, Adam Monahan (UVic), Debby Ianson (DFO Canada and UVic)

*Remote vs Local Wind Forcing of Coastal Upwelling*

Summertime upwelling winds along North America west coast are weaker and intermittent in the north compared to those in the south. Ekman theory would suggest that coastal productivity along this coast would increase from north to south. However, observations indicate the opposite. One potential mechanism to explain this contradiction between theory and observations is large-scale upwelling in the northern coastal regions resulting from coastally-trapped waves forced by winds in areas where the winds are much stronger and persistent. To investigate the connection between coastal currents and surface winds, twenty years of hourly current meter data from a mooring off of the west coast of Vancouver Island and wind stresses calculated from ten buoys located between 40°N and 52°N along the coast are analyzed. Results show that during summer there are no connections between local winds and currents on any frequency, while wind stresses from remote southern buoys seem to be coherent with the currents at periods ~10-30 days. Calculations of phase propagation speeds gave results within the range of speeds of a class of coastally-trapped waves. During winter, there is no coherence between the wind stresses, at any of the buoys, and currents. Results obtained with current shears will also be discussed.

1625 **Bill Peterson (NOAA, NWFSC)**, Jennifer Fisher (OSU, CIMRS), Jay Peterson (OSU, CIMRS), Xiuning Du (OSU, CIMRS)

*Large-scale forcing of species composition of plankton in the Oregon upwelling zone: PDO or NPGO?*

Through fair weather and foul, the Peterson lab has gone to sea fortnightly since 1996, mostly on small research vessels (length 12-17 m), to study seasonal and inter-annual variations in the physical forcing and pelagic ecosystem response of plankton in the coastal upwelling zone along the Newport Hydrographic Line. Standard measurements include CTD profiles, sampling for nutrients, chlorophyll and phytoplankton species composition, and plankton net tows for

zooplankton, krill and ichthyoplankton. Two types of zooplankton are seen: 'northern' species (whose origin is the coastal Gulf of Alaska) and 'southern' species (whose origins either oceanic waters offshore of Oregon or coastal waters from southern California). From a food chain perspective, the northern species are lipid-rich whereas southern are lipid-depleted, thus bioenergetically speaking, very different food chains can be found off Oregon. The relative contribution of 'northern' vs. 'southern' species is driven largely by variations in large scale circulation of the northeast Pacific which are associated with the PDO and the NPGO. The burning question is, to what degree can we attribute patterns in our time series to the PDO vs the NPGO because at the present time, the two oscillations are nearly in phase.

1645 **Eric Bjorkstedt (NOAA, SWFSC and Humboldt State University)**, Bill Peterson (NOAA, NWFSC)

*Coherence and variability of mid-shelf copepod assemblages in the northern California Current*

We applied non-metric, multidimensional scaling (NMDS) to characterize temporal and taxonomic variability within copepod assemblages at mid-shelf stations along the Newport Hydrographic Line (NHL; 44.63°N) and the Trinidad Head Line (THL; 41.06°N), and use results from this analysis as the basis for examining patterns and variation in these assemblages in the context of local and regional forcing, hydrographic conditions and indices of transport. From 2008 through early 2014, taxa with offshore and southern (warm) biogeographic affinities have been consistently more prevalent off northern California than off Oregon, and this latitudinal contrast persists over the course of typically coherent seasonal shifts in the copepod assemblages throughout the region over the course of the year. Moreover, the composition of copepod assemblages off northern California appears to be more variable during summer months, than the predominantly cold-water assemblage observed during the upwelling season off Oregon, yet, the copepod assemblage off Oregon appears to be more variable during winter—particularly from year to year—than the assemblage off northern California. Copepod assemblages in both areas exhibited responses to the 2009-2010 El Niño, but recovery of northern taxa off northern California from the 2009-2010 El Niño lagged well behind that observed off Oregon.

1705 Miller, Jessica A. (OSU, HMSC), William Peterson (NOAA, NWFSC), Louise Copeman CEOAS, OSU), Cheryl A. Morgan (CIMRS, OSU), **Marisa N. C. Litz (Oregon State University, Hatfield Marine Science Center)**

*Seasonal variability in the composition and biochemistry of the copepod community within the Northern California Current*

In the Northern California Current, the copepod community oscillates seasonally between a diverse assemblage dominated by warm-water species and a less diverse assemblage of lipid-rich, boreal species. It is hypothesized that larval fish experience enhanced growth when the boreal copepod community dominates due to its enhanced lipid content. To test this hypothesis, we characterized variation in lipid and FA composition of the copepod community collected approximately biweekly for 18 months five miles off Newport, Oregon. There was a strong seasonal pattern with an increase in total lipids and the proportion of wax esters within the copepod community during upwelling. There was clear delineation between the FAs present

within the warm-water and boreal copepod communities. We compared variation in the species, lipid, and FA composition of the copepod community with daily growth variation in young-of-the year northern anchovy (*Engraulis mordax*). Anchovy growth was significantly related to the copepod species (r = -0.68) and FA composition. Growth increased as the proportion of 16:1w7 increased (diatom indicator: r = 0.818) and decreased as 18:4w3 (flagellate indicator: r = -0.664) increased. The biochemical composition of the copepod community oscillated seasonally with the species composition and was significantly related to growth variation of larval fish.

17$_{25}$ **Cass, Christine J. (Department of Oceanography, Humboldt State University)**

*Latitudinal and temporal variability in lipid and energy content of the northern Pacific euphausiids Euphausia pacifica and Thysanoessa spinifera*

*Euphausia pacifica* and *Thysanoessa spinifera* are important food sources for many species in the Northern California Current (NCC), including blue whales and coho salmon. To better understand their role in food webs, this study examined seasonal variability in lipid and total energy content of the two species, as well as differences between individuals collected in different regions of the NCC. Euphausiids were collected from May 2013-May 2014 off the coasts of Trinidad, CA (TH; 41°N latitude) and Newport, OR (NHL; 44°N). Lipid content of *E. pacifica* peaked at both locations from late August to early April, although lipid content was on average 50% higher at NHL than at TH during that time (7-9% v. 5-8% dry mass (DM), respectively). As *T. spinifera* was absent for most of the winter, temporal variability could not be assessed. However, individuals from NHL showed 3-5 times higher lipid content than those collected at TH during similar times of year (12-26% v. 4-6%DM, respectively). Such differences could indicate a mismatch in phenology between the two locations, or reflect substantial differences in available prey. Total energy content of both species was often higher at NHL, suggesting NHL euphausiids provide a higher-energy food source to their predators.

Poster **Ryan M. McCabe (UW, JISAO)**, Barbara M. Hickey (UW, Oceanography), Edward P. Dever (CEOAS, OSU), Parker MacCready (UW, Oceanography)

*Seasonal cross-shelf flow structure, upwelling relaxation, and the along-shelf pressure gradient in the northern California Current System*

Observations are used to investigate the seasonal change in vertical structure of cross-shelf circulation at a mid-shelf location in the northern California Current System. A streamwise-normal coordinate system is employed to eliminate meander-induced biases in the cross-shelf flow that are unaccounted for with an alternative, commonly-applied approach. The resulting flow develops an organized pattern midway through the upwelling season. Under upwelling-favorable conditions an onshore return layer occurs just beneath the offshore surface flow, and a third offshore-directed layer exists at depth. Both subsurface layers strengthen in time. Mechanisms to explain the mean structure are evaluated, and it is suggested that the timing of the development and strengthening of both the interior return flow and the offshore near-bottom layer are consistent with the seasonally-changing direction and magnitude of the large-scale along-shelf sea-level gradient. The change to a poleward sea-level gradient initiates a seasonal relaxation of upwelled isopycnals that likely leads to the near-bottom flow. Late-

season enhancement of the interior return flow is related to along-shelf winds but appears to form as a consequence of offshore transport in the near-bottom layer and the need to satisfy coastal mass balance. Shallow return flows have important consequences, potentially decreasing nutrient delivery during upwelling-favorable conditions.

Poster **Hally B. Stone (UW, School of Oceanography)**, Neil S Banas, (UW, JISAO), Barbara M. Hickey (UW, Oceanography), Parker MacCready (UW, Oceanography)

*Interannual temperature and salinity variability in the Pacific Northwest Coastal Ocean*

The Pacific Northwest coast is an unusually productive area with a strong river influence and highly variable upwelling-favorable and downwelling-favorable winds. A new ROMS hindcast model of this region makes possible a study of interannual variability. This study of the interannual temperature and salinity variability on the Pacific Northwest coast was conducted using a coastal hindcast model (43°N - 50°N) spanning 2002-2009 from the University of Washington Coastal Modeling Group in combination with multi-year observations of physical water properties from several sources. The resolution of the model over the shelf and slope is 1.5 km. Observational sources include sea surface temperature from satellite data, bottom temperature from NOAA West Coast Groundfish Bottom Trawl Surveys, and data from the RISE and ECOHAB PNW studies. Analysis of hindcast model results was used to assess the relative importance of rivers and local wind forcing, as well as source water variability, including the Poleward Undercurrent, in explaining these interannual variations over the shelf and slope. Results will be discussed in the context of previously studied relationships between the North Pacific Gyre Oscillation, the Pacific Decadal Oscillation, and ecologically significant variables such as oxygen, pH, and nutrients.

---

Saturday Morning Session
***The land-sea interface: connecting terrestrial hydrology with coastal ecosystems***
Session chairs: Clarissa Anderson and Sarah Giddings

8$_{35}$ **Sarah N. Giddings (Scripps Institution of Oceanography, UCSD)**, Kristen A Davis (Univ of California, Irvine), Parker MacCready (UW, Oceanography), Barbara M Hickey (UW, Oceanography), Neil S Banas (UW, JISAO), Samantha A Siedlecki (UW, JISAO), Clarissa Anderson (UCSC)

*The land-sea interface: an introduction*

Connectivity between the coastal ocean, estuaries, and rivers impacts the physics, chemistry, and biology of these systems. First we will introduce this session broadly and the speakers to follow including the broad range of scales over which they are addressing coupled land-sea questions. Then, we will briefly discuss an example of these connections using realistic hindcast ROMS simulations coupled with a bio-geochemical model of the Pacific Northwest including the Salish Sea and Columbia River estuaries and the coastal ocean off of the Washington and Oregon coasts. Outflow from two major river plumes, the Salish Sea and the Columbia River, contribute significant buoyancy to the coast and interact with one another. Model dye releases and numerical experiments are used to quantify the influence of winds and river flow on the interaction of these plumes both within the estuaries and on the shelf. The

plumes influence the delivery of buoyancy, nutrients, productivity, and oxygen to the shelf demonstrating the importance of capturing the hydrologic-coastal connection.

8:55 **Anna Pfeiffer-Herbert (CEOAS, OSU)**, Fredrick Prahl (CEOAS, OSU), Tawyna Peterson (IEH, OHSU) Jim Lerczak (CEOAS, OSU), Burke Hales (CEOAS, OSU)

*Biophysical mechanisms for primary production in the near-field Columbia River plume: Do river plumes matter in coastal upwelling systems?*

Freshwater plumes emerging from large rivers are dramatic sites of interaction between land-based aquatic systems and the coastal ocean. The Columbia River (CR) is a major freshwater source to the Eastern Pacific coastal zone. The CR plume is unusual among large river plumes for having relatively low nitrogen concentrations, particularly compared to the nutrient-rich water supplied by coastal upwelling. What it does provide, however, is a large freshwater flux that imparts buoyancy-driven circulation and affects the background wind-driven coastal circulation. In this study, we investigate the influence of the near-field CR plume on coastal primary production. Repeated transects of the CR plume with an undulating towed vehicle revealed a persistent patch of warm, high oxygen surface water north of the estuary mouth. We hypothesize that the temperature and oxygen anomalies are signatures of a retained water mass that has undergone surface heating and primary production. We will discuss physical mechanisms for retention and enhanced productivity in the vicinity of the near-field plume and use a box model approach to assess the importance of primary production in plume-associated patches in relation to local and regional productivity during the summertime upwelling season.

9:15 **Stefan A. Talke (Civil and Environmental Engineering, Portland State University)**, David A. Jay (PSU), Lumas Helaire (PSU)

*Long term trends in Columbia River Flow since 1850*

Using archival newspaper accounts, primary-source documents, tide data, and river stage data, we construct a 160 year record of freshwater output from the Columbia River basin to the coastal ocean. Virgin flow estimates show that spring freshets are strongly influenced by the Pacific decadal oscillation, with the magnitude of the 10 year flood event shifting by 20% over decadal time scales. Anthropogenic effects are large: Flow regulation and water diversion has reduced the once-in-10 year spring freshet by nearly 50%, while winter flood magnitudes have increased. Spring freshets now typically peak in May, rather than June. These changes imply both a change in the magnitude and timing of sediment flux and nutrients to the coastal ocean. Similar changes are observed in SF Bay. Numerical simulations of the 19th century Columbia reveal that estuarine circulation and plume development have altered due to river, tidal, and bathymetry change. For example, the historical Columbia bar bathymetry caused the plume to hook southwards, while water escaping over the bar and in a secondary channel caused bifurcation and dispersion that altered plume growth. These considerations help identify and quantify the historical footprint of anthropogenic activities and climate variability on the coastal zone.

9:35 *__Lumas Helaire (Portland State University)__, Stefan A. Talke (PSU), Andrew Mahedy (PSU)

*Evolution of Columbia River Hydraulics Over the Past 150 Years*

Over the past 150 years the flow characteristics of the Lover Columbia River (LCR) has changed drastically. Among the numerous changes to the system are the following:

- Construction of the North Jetty and South Jetty at the mouth of the river
- Dredging and deepening of the main river channel
- Filling of tidal wetlands
- Isolation of tidal wetlands by the installation of dikes and levees

To begin to address the impact of some of these changes a Delft3D hydrodynamic model of the Lower Columbia River with the bathymetry of the late 19th century has been developed. The model has been calibrated and validated with recently discovered 19th century tidal logs [Talke and Jay, 2013]. With this model we can begin to better understand the flow characteristics of the LCR in the late 19th century. We can begin to answer some of the following questions:

- How has tidal propagation changed as a result of the physical changes to the river channel?
- What was the LCR inundation profile in the late 19th century
- How has salinity intrusion evolved over the past 150 years?

9$_{55}$ **Leonel Romero (Earth Research Institute, UCSB)**, Yusuke Uchiyama (Kobe University), David A. Siegel (ERI, UCSB), James C. McWilliams (UCLA)

*Inner Shelf Dispersion and Dilution of Creek Runoff*

Runoff from coastal streams can provide inorganic nutrients, organic matter, and sediments to coastal ecosystems. Similarly, pollutants from stormwater runoff can have direct impacts to society. The objective is to characterize dispersion and dilution of freshwater runoff from small creeks. We present numerical simulations of stormwater runoff in the Santa Barbara Channel near Mohawk reef. This study is unique by focusing on the far-field of small-scale rivers discharging into a turbulent submesoscale flow (as opposed to quiescent). We present the results corresponding to two wet seasons with relatively large discharge rates, including statistical analyses of freshwater fraction and passive tracer concentration. Runoff events are typically short-lived, lasting for 12 hr to about 2 days. Freshwater plumes are generally trapped near coast, dispersing along-shelf roughly 10 faster than cross-shelf. Surface winds are generally non-stationary, modulating the cross-shelf extent of the freshwater plumes, where offshore winds lead to offshore spreading of the plume (and vice versa). Numerical experiments are used to assess the sensitivity of the results to changes on the hydrological fluxes and wind forcing. The results will be used to develop simple rules describing the dilution field of freshwater runoff as a function of a few environmental parameters.

10$_{45}$ *__Megan E. Williams (Department of Civil & Environmental Engineering, UC Berkeley)__, Mark T. Stacey (UC Berkeley)

*The edge of the Eastern Pacific: tidally discontinuous hydrodynamics in California's bar-built estuaries.*

California's coastal range watersheds drain to the Eastern Pacific via small, bar-built estuaries with intermittent connections to the ocean. Their inlets may completely close as a result of nearshore sand transport, and remain constricted while open to tidal influence. Extensive field measurements in the highly salt-stratified Pescadero estuary in Northern California show that

the shallow mouth causes these estuaries to experience discontinuous tidal forcing. While the ocean and estuary are fully connected with near equal water levels, tidal velocities are slow but infragravity motions in the nearshore cause large velocity oscillations. As the ocean tide falls, infragravity forcing is cut off because the estuarine mouth is perched above the low tide ocean water level, and ebbing velocities are set by bed friction. This oscillation between ocean-forced conditions and frictionally-controlled conditions characterizes and sets the hydrodynamics and salt dynamics in these estuaries. Additional wave setup of the lagoon emphasizes the dependence of these estuaries on nearshore ocean conditions, but the diurnal or semidiurnal retreat of the ocean below the mouth cuts off this nearshore influence. The salt field responds to this discontinuous forcing, being transported upstream on the flood and becoming trapped in deep pools of the estuary on ebb.

11$_{05}$ **Curtiss O. Davis (CEOAS, OSU)**, Jasmine Nahorniak (CEOAS, OSU), Nicholas Tufillaro (CEOAS, OSU)

*Imaging the San Francisco Bay and Estuary with the Hyperspectral Imager for the Coastal Ocean (HICO)*

The Hyperspectral Imager for the Coastal Ocean (HICO) is the first spaceborne imaging spectrometer designed to sample the coastal ocean. HICO images selected coastal regions at 92 m spatial resolution with full spectral coverage (88 channels covering 400 to 900 nm) and a high signal-to-noise ratio to resolve the complexity of the coastal ocean. Here we use HICO to study the San Francisco Bay and Delta Ecosystem (SFE). We have just initiated a three year NASA Interdisciplinary Science Project to understand the effects of humans on hydrology and ecological structure and function of the SFE. Our goal is to use satellite data and models validated using in situ data to develop an integrated system for understanding the dynamics of SFE. We are using MERIS, HICO and Landsat Data for this study. Here we give a brief overview of the SFE Project and highlight the results with HICO showing the complex mixing patterns and limited productivity of the bay itself and a strong bloom at the edge of the SFE plume after it leaves the estuary.

11$_{25}$ **Richard Dugdale (Romberg Tiburon Center, SFSU)**, Frances Wilkerson (RTC, SFSU), Curtiss Davis (CEOAS, OSU), Pat Glibert (University of Maryland), Sarah Blaser (RTC, SFSU), Ned Antell (RTC, SFSU)

*Effect of drought conditions on the San Francisco Bay/Delta nutrients and primary productivity from field and satellite measurements*

California experienced an extreme drought condition in 2014, following a dry year in 2013. To investigate the effects of such extreme conditions on the lower trophic levels of the pelagic food web of the San Francisco Bay/Delta ecosystem, cruises were made beginning in March, 2014. Nutrient concentrations were elevated throughout the area to levels not seen in recent history and phytoplankton blooms, rare in spring in this system, were observed. One of these cruises coincided with the initial field measurement phase of our three year NASA Interdisciplinary Science Project. We encountered an area of elevated chlorophyll inside the Bay near the Golden Gate. From temperature and salinity values, the origin of this chlorophyll must have originated in upwelled water in the nearby coastal ocean. Upwelling favorable winds had blown for some weeks along the California coast. We report a preliminary analysis of the

origin and fate of this high phytoplankton abundance using in situ and remote sensing, including HICO hyperspectral images.

Poster **Jeremy Krogh (University of Victoria, Ocean Networks Canada)**, Akash R Sastri (UVic)

*High resolution spatio-temporal patterns of surface CDOM in the Strait of Georgia, British Columbia, Canada*

Ocean Networks Canada's coastal cabled observatory, VENUS, includes a suite of oceanographic and meteorological instruments aboard the BC Ferries vessel Queen of Alberni. This ferry transits the Strait of Georgia (SoG) eight times a day between Nanaimo and South Vancouver, BC (~50 km). Two additional ferry routes transiting between: 1) Nanaimo and North Vancouver; and 2) Victoria and South Vancouver will also be instrumented by the fall of 2014. Underway sea surface measurements (every 10 seconds) include temperature, salinity, oxygen, chlorophyll a, colored dissolved organic matter (CDOM) and turbidity as well as standard meteorological measurements. All data are freely available online (oceannetworks.ca) in near real time. This data set is unique for its high spatio-temporal resolution and the dynamical nature of the Fraser plume edge crossed by the ferry. Variation of CDOM in the SoG is closely described by salinity since the dominant source of CDOM is Fraser River freshwater discharge. Concentrations of CDOM increase from late winter and peaks several weeks prior to the freshet (early June). Thereafter, CDOM input and sea surface concentrations decline. This poster examines the relationship of river discharge, seasonal irradiance and biological activity to patterns of CDOM, both inside and outside of the river plume.

Poster **Todd Mitchell (University of Washington)**

*Do River Outflows Hopelessly Contaminate Satellite Chlorophyll Estimates?*

It's a widely held belief that river outflows contaminate satellite chlorophyll estimates to the degree that satellite chlorophyll are useless near river mouths. Is this really true? Daily Columbia River outflows at Beaver Oregon, approximately 40 miles upriver, from 1979 - 2013 are compared with SeaWiFS and MODIS Aqua chlorophyll estimates to document their correlation. The relationship of river outflow with MODIS Aqua colored dissolved organic material (CDOM) is also examined.

Poster *Ben Moore-Maley (University of British Columbia), **Susan Allen (UBC)**, Debby Ianson (DFO Canada)

*Effects of Fraser River carbonate chemistry on pH and aragonite saturation state in the Strait of Georgia*

Evaluating the carbonate chemistry of the Fraser River is required in order to model the seasonal dynamics of SoG pH and aragonite saturation state. However, even for a well-studied river like the Fraser, details of carbon chemistry are difficult to constrain. Data from recent publications, and from Environment Canada (EC) and Fisheries and Oceans Canada sampling programs are used to evaluate the seasonal carbonate chemistry of the river. River pH varies from approximately 7.4 in winter to 8.0 in summer according to EC buoy observations near the

river mouth, and river TA varies from approximately 6.0 meq/kg at peak flow to 1.3 meq/kg at low flow according to EC sampling throughout the river. SoG pH and aragonite saturation state sensitivity to river chemistry are evaluated using a one-dimensional bio-chem-physical model with varied river pH and TA values. The impact of the expected variation and of the lack of accuracy in our knowledge of this well-studied river will be presented.

Poster **Ata Suanda (Scripps Institution of Oceanography)**, Falk Feddersen (SIO)

*The role of transient rip currents in driving exchange between the surfzone and inner shelf*

The transport and mixing of tracers across the nearshore region to the continental shelf is an important problem in coastal oceanography. Potential tracers include anthropogenic terrestrial pollutants and intertidal invertebrate larvae. On beaches with alongshore-uniform topography, two distinct wave-driven mechanisms are responsible for promoting cross-shelf exchange: offshore-directed Eulerian currents associated with the Stokes' drift return flow and transient rip currents. While Stokes' drift is constantly present in shoreward-propagating waves, transient rip currents are sporadic and originate from surfzone eddies generated by the finite-crest length wave-breaking due to directionally spread waves. Here, the Boussinesq, wave-resolving model, funwaveC, is used to examine the efficiency of these two processes in driving cross-shelf exchange. We show that the transient rip currents exiting the surfzone significantly increases the efficiency and offshore extent of wave-driven exchange. Numerical experiments conducted across a broad range of surfzone parameters (beach slope, wave height, period, & directional spread) are used to determine the a non-dimensional scaling for rip current exchange on the inner-shelf and the properties setting the time-scales, length-scales, and magnitude of transient rip currents.