Pacific Estuarine Research Society

37th Annual Meeting
Hallmark Resort Inn
Newport, OR

April 3-5, 2014

PACIFIC ESTUARINE RESEARCH SOCIETY

About PERS:

The annual PERS Meeting is the premier regional event in the Pacific Northwest where scientists, resource managers, students, and stakeholders converge to deliver presentations, engage in discussion, and express their views on a diverse portfolio of research issues in the estuarine and coastal environments of Alaska, British Columbia, Washington, Oregon, and northern California. The PERS Meeting is typically an energetic and lively conference that is regularly attended by about 100-150 dedicated practitioners who congregate with friends and colleagues to reconnect, exchange ideas, and revitalize the collective research community. PERS operates as an affiliate society of the Coastal and Estuarine Research Federation (CERF), which is a non-profit, non-partisan organization dedicated to advancing the understanding and stewardship of estuaries and coastal ecosystems worldwide. For more information about PERS and CERF, please see their respective websites: http://www.pers-erf.org/ & http://www.erf.org/

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Acknowledgements:

The Oregon Sea Grant Program made a generous financial contribution to the PERS / 2014 Conference. Funds received from Oregon Sea Grant are used to support student travel and participation during the conference.

Program

37th Annual Meeting
Pacific Estuarine Research Society

Hallmark Inn & Resort
Newport, OR

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PERS 2014 Conference Organizing Team

Anthony D'Andrea
Steven Rumrill
Brett Dumbauld
Jude Apple
Elizabeth Perotti
Ted DeWitt
Gary Williams
Jeannie Gilbert

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SCHEDULE AT A GLANCE

Thursday, April 3rd

8:30-11:00am	***Optional Field Trip – Eelgrass restoration site on Yaquina Bay – led by Steve Rumrill***
5:00-9:00pm	**Registration and *Opening Mixer at the Rogue Brewery***

Friday, April 4th – Hallmark Resort - Salon Room

7:30 – 8:15	***Registration, Student Judge Check-in & Poster Setup***
8:15 – 8:45	***Welcome & Meeting Logistics***
8:45 – 10:00	***Oral Presentations 1 – Wetlands and Wetland Restoration***
10:00 – 10:30	***Poster Preview Blitz***
10:30 – 11:00	***Coffee Break & Poster Session, Lower Lobby***
11:00 – 12:00	***Oral Presentations 2 – Mapping, Monitoring, and Climate Change Vulnerability***
12:00 – 1:30	***Lunch – on your own***
1:30 – 2:30	***Oral Presentations 3 – Fish & Nekton ecology***
2:30 – 3:15	***Coffee Break & Poster Session, Lower Lobby***
3:15 – 4:45	***Oral Presentations 4 – Burrowing Shrimp, Larval Ecology, Plankton Dynamics***
5:00 – 6:00	***PERS Business Meeting***
6:00 – 9:00	***Banquet, Sunset Room*** Keynote Speaker – Dan Bottom, NOAA Fisheries "Oregon Experiments in Estuary Conservation: Is Salmon Management Good Estuary Management?"

Saturday, April 5th – Hallmark Resort - Salon Room

7:30 – 8:15	***Registration and Student Judge Check-In***
8:15 – 9:15	***Plenary Talk – Sarah Ann Woodin & David Wethey, University of South Carolina*** "Biogeography of Ecosystem Engineers: Community Ramifications"
9:15 – 9:45	***Oral Presentations 5 – Macroalgae and Fouling Communities***
9:45 – 10:45	***Coffee Break & Poster Session, Lower Lobby***
10:45 – 12:00	***Oral Presentations 6 – Seagrass Dynamics***
12:15 – 1:30	***Lunch – on your own***
1:30 – 2:30	***Oral Presentations 7 – Benthic Ecology***
2:30 – 3:30	***Student Awards, Acknowledgements & Closing Remarks***

MEETING NOTES

Location of Major Venues for PERS 2014 Meeting

Some restaurant suggestions near the Hallmark Resort

There are numerous restaurant choices in Newport depending on the cuisine and budget. Many of the restaurants are located in the two major tourist destinations in town: Nye Beach and the Newport Bay Front. Some suggestions from these areas are listed below but the list is far from comprehensive. Both www.yelp.com and www.urbanspoon.com have more extensive restaurant lists and reviews for Newport.

<u>Nye Beach – Eclectic beach community walking distance from the Hallmark Resort</u>

1. *Georgie's Beachside Grill* – located in the Hallmark
2. *Deep End Café* – seafood restaurant
3. *Mundo Café* – eclectic atmosphere, NW themed menu, vegan and gluten-free options, live music every night
4. *Panini Bakery* – coffee house/bakery with hand-made sandwiches and pizza. Not open late (7pm) and only takes cash (no credit/debit cards)
5. *Nana's Irish Pub* – Irish food in a relaxed atmosphere. Live music on Sat nights
6. *Nye Beach Café* – small local café which is a favorite among locals. Breakfast and lunch only

<u>Newport Bayfront – the working bay front is the major tourist destination in Newport</u>

7. *Asiatico* – sushi
8. *Noodle Café* - Asian
9. *M & P Authentic Thai* – Thai
10. *Ocean Bleu at Gino's* – local seafood
11. *Panini's Wood Fire Oven* – best pizza in Newport. Like the bakery, it is cash only
12. *Local Ocean* – locally sourced seafood. Probably the best seafood restaurant in town. Very busy so be prepared to wait for a table during dinner and lunch rushes.

PERS 2014 Annual Meeting Program Schedule

Thursday, April 3rd

8:30-11:00am **Optional Field Trip – Eelgrass restoration site on Yaquina Bay led by Steve Rumrill**
Meet at the Oregon Department of Fish and Wildlife (ODFW) Marine Resources Program office in the Hatfield Marine Science Center (HMSC): 2040 SE Marine Science Drive, Newport

5:00-9:00pm ***Registration and Opening Mixer at the Rogue Brewery***
6pm Tour of Brewery, Distillery, and Rogue Museum
Location: 2320 Marine Science Drive, Newport

Friday, April 4

7:30 – 8:15 **Registration, Student Judge Check-in & Poster Setup**

8:15 – 8:30 **PERS Welcome –** Gary Williams, President

8:15 – 8:45 **Meeting Logistics** – Tony D'Andrea, Meeting Chair

8:45 – 10:00 **Oral Presentations 1 – Wetlands and Wetland Restoration**
Chair: Laura Brophy

8:45 **EFFECTS OF RESTORATION IN A TIDAL WETLAND ON SALINITY, WATER TEMPERATURE AND PLANT COMMUNITY COMPOSITION**
Laura A. Brown, Laura S. Brophy, Michael J. Ewald, Stan van de Wetering

9:00 **CHANNEL MORPHOLOGY CHANGE FOLLOWING RESTORATION AT THE NI-LES'TUN UNIT OF THE BANDON MARSH NATIONAL WILDLIFE REFUGE: INITIAL RESULTS AND TOOL DEVELOPMENT**
Michael J. Ewald, Laura S. Brophy, Stan van de Wetering, Laura A. Brown

9:15 **TRANSGRESSIVE MIGRATION OPPORTUNITIES FOR TIDAL WETLAND DEVELOPMENT UNDER THE INFLUENCE OF FUTURE CLIMATE CHANGE IN PUGET SOUND**
Brittany R. Jones, Charles A. Simenstad

9:30 **HABITAT-SPECIFIC NUTRIENT REMOVAL AND RELEASE IN OREGON SALT MARSHES**
Theodore H. DeWitt, Hillmar A. Stecher III, Laura A. Brown, Caitlin L. White, Jessica B. Moon

9:45 **HYDROLOGY IN A PEATY HIGH MARSH: HYSTERETIC FLOW AND BIOGEOCHEMICAL IMPLICATIONS**
H.A. Stecher, J.B. Moon, R.B. McKane, T. DeWitt

10:00 – 10:30 **Poster Preview Blitz (Authors present 2 minute summaries)**

10:30 – 11:00 *Coffee Break & Poster Session, Lower Lobby*

11:00 – 12:00 **Oral Presentations 2 – Mapping, Monitoring, and Climate Change Vulnerability**

Chair: Ted DeWitt

11:00 **UPDATING OREGON'S ESTUARINE WETLAND HABITAT MAPS: MODERNIZING THE FOUNDATION FOR COASTAL RESOURCE MANAGEMENT**
Laura Brophy, Laura Mattison, Randy Dana, Tanya Haddad, Andy Lanier, Cinamon Moffett

11.15 **MONITORING: WHERE, WHAT, AND HOW?**
James S. Brennan, Brenda Padgham

11.30 **ABUNDANT OR RARE? A HYBRID APPROACH FOR DETERMINING SPECIES RELATIVE ABUNDANCE AT AN ECOREGOIONAL SCALE**
Deborah Reusser, Henry Lee II, Christina Folger, Katharine Marko, Rene Graham, Marshall Hanshumaker

11:45 **TRAIT-BASED FRAMEWORK TO PREDICTING RELATIVE VULNERABILITY TO CLIMATE CHANGE IN NEAR-COASTAL SPECIES AND HABITAT**
Henry Lee II, Deborah Reusser, Christina Folger, Katharine Marko, Rene Graham, Marshall Hanshumaker

12:00 – 1:30pm *Lunch (On your own)*

1:30pm – 2:30pm **Oral Presentations 3 – Fish and Nekton Ecology**
Chair: Alison Dauble

1:30pm **LAMPREY ARE THE NEW SALMON: RIVER AND PACIFIC LAMPREY IN THE COLUMBIA RIVER ESTUARY**
Laurie Weitkamp, Susan Hinton, Paul Bentley

1:45pm **PRE-SPAWN PACIFIC HERRING DISTRIBUTION AND POPULATION ESTIMATES IN YAQUINA BAY**
Alison Dauble

2:00pm **ESTUARINE REARING AND GROWTH OF JUVENILE CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) AS INFERRED FROM OTOLITH MICROSTRUCTURE**
Pascale Goertler, Charles Simenstad, Dan Bottom

2:15pm **SEAWALLS AND SEATTLE: EFFECTS OF SEAWALL ARMORING ON SUBTIDAL FISH AND CRAB ASSEMBLAGES IN ELLIOTT BAY**
Stuart Munsch, Jeffery Cordell, Jason Toft, Charles Simenstad

2:30pm – 3:15pm *Coffee Break & Poster Session, Lower Lobby*

PERS 2014 Annual Meeting Program Schedule

3:15pm-4:45pm **Oral Presentations 4 – Burrowing Shrimp, Larval Ecology, Plankton Dynamics**

Chair: Brett Dumbauld

3:15pm **CHESS WITH THE DEVIL AND HOW DO THE PIECES MOVE: A RAPID INTERTIDAL MEGAFAUNA SURVEY METHOD APPLIED TO *UPOGEBIA PUGETTENSIS*, AND ITS INTRODUCED PARASITE, *ORTHIONE GRIFFENIS***
John W. Chapman, Cameron S. Carter

3:30pm **THE GOOD, THE BAD AND THE MUDDY: LESSONS LEARNED FROM THREE YEARS OF MAPPING BURROWING SHRIMP POPULATIONS IN YAQUINA BAY, OR.**
Katelyn Bosley, Brett Dumbauld, Lee McCoy

3:45pm **LARVAL ECOLOGY OF INTRODUCED AND NATIVE BOPYRIDAN ISOPOD PARASITES IN YAQUINA BAY, OREGON**
Ralph A. Breitenstein, John W. Chapman, Craig E. Brauer

4:00pm **A COMPARISON OF BULK ESTUARINE TURNOVER TIMESCALES TO PARTICLE TRACKING TIMESCALES USING A MODEL OF THE YAQUINA BAY ESTUARY**
Emily Lemagie, Jim Lerczak

4:15pm **DIFFERENCES IN LARVAL AVAILABILITY AND SETTLEMENT ACROSS INVERTEBRATE TAXA TO THE PUBLIC PIER IN YAQUINA BAY, OR**
Shelby R Herber, William T. Peterson, Jennifer L. Fisher, Tracy Shaw, Jay O. Peterson, Cheryl A. Morgan

4:30pm **NUTRIENT, OXYGEN AND PLANKTON DYNAMICS IN BELLINGHAM BAY AND THE CONNECTIVITY BETWEEN SURFACE ALGAL COMMUNITIES AND BOTTOM WATER HYPOXIA**
Jude Apple, Robin Kodner, Natasha Christman, Gabriela B. Zayas del Rio

5:00pm – 6:00pm **PERS Business Meeting**

6:00pm – 9:00pm **Banquet in Sunset Room, Hallmark Resort**

Keynote Address: "**Oregon Experiments in Estuary Conservation: Is Salmon Management Good Estuary Management?"**

Dan Bottom, NOAA Fisheries, Newport, OR

Saturday, April 5

7:30 – 8:15	**Registration and Student Judge Check-In**
8:15 – 9:15	***Plenary Talk:*** **Biogeography of Ecosystem Engineers: Community Ramifications** Sally Woodin & David Wethey, University of South Carolina
9:15 – 9:45	***Oral Presentations 5 – Macroalgae and Fouling Communities*** Chair: Tony D'Andrea
9:15	**EXTRACTIVE SURVEYS OF THE SUBTIDAL SEAWEEDS AND SEAGRASSES IN THREE OREGON MARINE RESERVES** Gayle I. Hansen, ODFW Marine Reserve Team
9:30	**ASSESSMENT COPPER (ANTIFOULING) PAINT TOLERANCE IN SESSILE MARINE ORGANISMS − TRANSLATING LOCAL OBSERVATIONS TO GLOBAL AND EVOLUTIONARY PERSPECTIVE** Joshua A. Mackie
9:45 – 10:45	*Coffee Break & Poster Session, Lower Lobby*
10:45 – 12:00	***Oral Presentations 6 – Seagrass Dynamics*** Chair: Steven Rumrill
10:45	**EVALUATING THE FUTURE OF PADILLA BAY'S EELGRASS HABITAT IN THE FACE OF SEA LEVEL RISE: AN ECOGEOMORPHIC FIELD AND HYBRID MODELING APPROACH** Katrina Poppe, John Rybczyk
11:00	**SEED DENSITY AND DISTRIBUTION OF NON-NATIVE (*ZOSTERA JAPONICA*) AND NATIVE (*ZOSTERA MARINA*) EELGRASSES IN SEDIMENTS OF MIXED AND MONO-SPECIFIC MEADOWS** Brooke Bannerman, Heath Bohlmann, Douglas Bulthuis, Nicole Burnett, Suzanne Shull
11:15	**UNDERSTANDING THE ECOLOGY OF A NON-ENDEMIC EELGRASS IN PACIFIC NORTHWEST ESTUARIES** Daniel Sund, Brett Dumbauld
11:30	**PREDICTING AND MEASURING CO_2 SEQUESTRATION WITHIN AN EELGRASS (*ZOSTERA MARINA*) MEADOW** Royann J. Petrell, M. Jones, T. Lesiuk, P Horgen
11:45	**EUTROPHICATION AND ACIDIFICATION IMPACTS ON SEAGRASS DO NOT EQUALLY TRANSLATE TO ITS CONSUMERS.** Fiona Tomas Nash, Begoña Martínez-Crego, Gema Hernán, Rui Santos
12:00pm – 1:30pm	*Lunch (On your own)*

1:30pm – 2:30pm ***Oral Presentations 7 – Benthic Ecology***
Chair: Curtis Roegner

1:30pm **THE REDOUBTABLE ECOLOGICAL PERIODIC TABLE**
Steven Ferraro

1:45pm **CHANGES IN PUGET SOUND BENTHIC MACROINVERTEBRATE ASSEMBLAGES AS CHARACTERIZED WITH FUNCTIONAL FEEDING GUILDS**
Valerie Partridge, Margaret Dutch, Sandra Weakland, Kathy Welch, Clifton Herrmann

2:00pm **CAN SUBTIDAL BAY CLAMS SERVE AS SOURCE POPULATIONS FOR THE INTERTIDAL? A PRELIMINARY EVALUATION OF THE SUBTIDAL "SPAWNING STOCK HYPOTHESIS" IN TWO OREGON ESTUARIES**
Anthony F. D'Andrea, Elizabeth A. Perotti, Stacy Galleher, Cinamon L Moffett, Stacy A. Strickland, Maryna Sedoryk, Natalie Amoroso, Kamala Earl, Amy M. Hutmacher, Eva Riedlecker, Kelsey Adkisson, Jennifer Boyer

2:15pm **ACOUSTIC TELEMETRY STUDIES OF DUNGENESS CRAB IN THE COLUMBIA RIVER ESTUARY**
Curtis Roegner

2:30pm – 3:00pm **Student Awards, Acknowledgements and Closing Remarks**
Tony D'Andrea, President and Meeting Chair

POSTER PRESENTATIONS (Friday-Saturday, Alphabetical by Author)

UTILIZATION OF AN OREGON ESTUARY BY FEMALE DUNGENESS CRAB, *CANCER MAGISTER*
Justin Ainsworth, Mitch Vance

IDENTIFYING TRANSMISSION AGENTS OF SEA STAR WASTING DISEASE IN THE SUNFLOWER STAR, PYCNOPODIA HELIANTHOIDES
Robert I. Beck, Benjamin G. Miner
(Undergraduate Student Poster)

EFFECTS OF ENVIRONMENTAL AND HERBIVORE STRESS ON *ULVA LACTUCA*
Natasha Borgen, Suzie Gifford, Kathy Van Alstyne
(Undergraduate Student Poster)

FEEDING OF THE INVASIVE COPEPOD PSEUDODIAPTOMUS FORBESI ON NATURAL MICROPLANKTON ASSEMBLAGES IN THE LOWER COLUMBIA RIVER
Alyssa Bowen, Stephen Bollens, Gretchen Rollwagen-Bollens, Julie Zimmerman
(Graduate Student Poster)

PHYSICAL AND MICROBIAL DRIVERS OF HYPOXIA IN BELLINGHAM BAY
Natasha Christman, Jude Apple
(Undergraduate Student Poster)

A DECADE OF MAPPING SUBMERGED AQUATIC VEGETATION USING COLOR INFRARED AERIAL PHOTOGRAPHY: METHODS USED AND LESSONS LEARNED
Patrick Clinton, David Young, David Specht

GROWTH RATE AND MORPHOLOGY CHANGES FOR TWO CONTRASTING *SYNECHOCOCCUS* STRAINS WHEN GROWN IN BLOOM VERSUS NONBLOOM OCEAN WATER.
Larisa Crippen-Chavez, Kerri Fredrickson, Suzanne Strom
(Undergraduate Student Poster)

POTENTIAL EFFECTS OF NON-NATIVE EELGRASS ON BAY CLAM POPULATIONS IN NETARTS BAY, OREGON
Anthony D'Andrea, Elizabeth Perotti, Cinamon Moffett, and Stacy Strickland

FOUR DECADES OF SUBTIDAL CLAMS IN TILLAMOOK BAY, OR USA
Anthony F. D'Andrea, Elizabeth A. Perotti, Stacy A. Strickland, Stacy N Galleher, Kamala Earl, Maryna Sedoryk, Amy M. Hutmacher, Natalie Amoroso

FINE-SCALE POPULATION STRUCTURE AMONG CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) OF THE SILETZ RIVER IN OREGON: A PRELUDE FOR INCORPORATION OF RIVERSCAPE GENETICS.
Chanté D. Davis, Michael A. Banks
(Graduate Student Poster)

QUANTIFYING THE IMPACTS OF OYSTER AQUACULTURE ON SEAGRASS (ZOSTERA MARINA) AT THE LANDSCAPE SCALE IN WILLAPA BAY, WASHINGTON
Brett Dumbauld, Lee McCoy

USING FERRIES FOR MARINE WATER QUALITY MONITORING IN THE SALISH SEA
Carol Falkenhayn Maloy, Christopher Krembs, Suzan Pool, Julia Bos, Laura Hermanson, Sheila Helgath, Jim Thomson, Walt Deppe, Brandon Sackmann

BIOGEOGRAPHIC DISTRIBUTIONS, ABUNDANCES, AND VULNERABILITIES TO CLIMATE CHANGE OF BRACHYURAN AND LITHODID CRABS FROM THE GULF OF CALIFORNIA TO THE BEAUFORT SEA
Christina Folger, Henry Lee II, Deborah Reusser, Katie Marko, Rene Graham

MAPPING OREGON'S OCEAN AND ESTUARINE SHORELINES USING SHOREZONE MAPPING PROTOCOLS
David Fox, John Harper, Andy Lanier, Steve Rumrill

EVALUATING THE POSSIBLE FEEDBACKS BETWEEN BIVALVE AGGREGATIONS AND ALKALINITY CYCLING UNDER ACIDIFICATION CONDITIONS
Iria Gimenez Calvo, George G. Waldbusser
(Graduate Student Poster)

EMBATTLED BIVALVES: BIOGEOGRAPHIC DISTRIBUTIONS AND ABUNDANCES FROM THE BEAUFORT SEA TO THE GULF OF CALIFORNIA.
Rene Graham, Henry Lee II, Deborah A. Reusser, Christina Folger, Katharine M. Marko, Paul Valentich-Scott

GROWTH AND LONGEVITY IN THE RED ROCK CRAB, *CANCER PRODUCTUS*.
Scott Groth, Sylvia Yamada, Jim Heinrich

BROAD-SCALE ENVIRONMENTAL PREDICTORS OF THE INTERTIDAL ZONATION OF *Z. MARINA* AND *Z. JAPONICA* IN THE PUGET SOUND
Michael Hannam
(Graduate Student Poster)

SOME COMMON SUBTIDAL SEAWEEDS FOUND IN OREGON'S MARINE RESERVES
Gayle I. Hansen

SOME MARINE ALGAE FOUND ON JAPANESE TSUNAMI DEBRIS
Gayle I. Hansen

EFFECTS OF OCEAN ACIDIFICATION ON THE EMBRYONIC DEVELOPMENT OF *METACARCINUS MAGISTER*
Torian Jones, Nicole Casper, Shawn Arellano
(Undergraduate Student Poster)

CHARACTERIZATION OF ECOSYSTEM STRUCTURE AND FUNCTION RECOVERY WITHIN THE NOAA MOC-P MITIGATION BASIN, NEWPORT, OREGON
Nate S. Lewis, Sarah K. Henkel, Steve S. Rumrill

ASSESSING BIOGENIC HABITAT IN OREGON'S NEARSHORE OCEAN USING ROV VIDEO
Scott Marion, Bill Miller, Arlene Merems

STRESSED SEBATES: A TRAIT-BASED EVALUATION OF CLIMATE RISKS TO ROCKFISHES OF THE NORTHEASTERN PACIFIC USING THE COASTAL BIOGEOGRAPHIC RISK ANALYSIS TOOL (CBRAT)
Katharine Marko, Deborah Reusser, Henry Lee II, Christina Folger, Rene Graham

MAPPING SUBMERGED AQUATIC VEGETATION USING SINGLE-BEAM SONAR: APPLICATION FOR NATURAL RESOURCE MANAGEMENT IN WASHINGTON STATE
Peter Markos, Andrew Ryan, Cinde Donoghue

CAN OREGON MARSHES KEEP UP WITH THE RISING TIDE? A STUDY OF SHORT AND LONG TERM MARSH ACCRETION

T Chris Mochon Collura, Cheryl Brown, Theodore DeWitt, Chris Janousek

CONSEQUENCES OF SALINITY ON GROWTH AND TISSUE CHEMISTRY IN EELGRASS (*ZOSTERA MARINA)*
Joshua Morel Matos, Sylvia Yang, Emily Nebergall
(Undergraduate Student Poster)

SEDIMENT TOTAL ORGANIC CARBON: IS THIS A USEFUL INDICATOR OF SEDIMENT CONDITION FOR PACIFIC NORTHWEST ESTUARIES?
Walter Nelson, Melanie Frazier

DOES JAPANESE EELGRASS (*ZOSTERA JAPONICA*) AFFECT RECRUITMENT AND GROWTH OF MANILA CLAMS, AND THE GROWTH AND CONDITION OF PACIFIC OYSTERS?
Kim Patten, Scott Norelius, Nick Haldeman

RESPONSE OF A DEVELOPING SALISH SEA DIATOM BLOOM TO OCEAN ACIDIFICATION
Elizabeth Peña, Brandy Olson
(Undergraduate Student Poster)

LARVAL SUPPLY, SETTLEMENT, AND POST-SETTLEMENT PROCESSES AS DETERMINANTS OF THE SPATIAL DISTRIBUTION OF OLYMPIA OYSTERS (*OSTREA LURIDA*) IN COOS BAY, OR
Rose Rimler, Cate Pritchard
(Graduate Student Poster)

***IN HOSPITE* HYDROGEN PEROXIDE PRODUCTION OF TWO SYMBIOTIC ALGAE HOSTED BY *ANTHOPLEURA ELEGANTISSIMA* UNDER TEMPERATURE AND IRRADIANCE STRESS**
Jean C. Rodríguez Ramos, Brian Bingham, James Dimond
(Undergraduate Student Poster)

ARE HARVESTS OF COCKLES (*CLINOCARDIUM NUTTALLII*) FROM NETARTS BAY (OREGON) MANAGED IN A SUSTAINABLE MANNER? A REVIEW OF COMMERCIAL AND SPORT HARVESTS OVER 2008-2013
Steven Rumrill

CAN SEAGRASS PROVIDE REFUGIA FROM OCEAN ACIDIFICATION FOR ESTUARINE BIVALVES?
Stephanie Smith, George Waldbusser, Burke Hales
(Graduate Student Poster)

A SUMMARY OF RECREATIONAL CRAB CATCH AND EFFORT IN OREGON.
Mitch Vance, Justin Ainsworth

MICROSATELLITE DESIGN AND APPLICATION IN *WATERSIPORA* (BRYOZOA), A COMPLEX OF INVASIVE SPECIES
Darren Wostenberg, Michael Doan, Sean Craig, Joshua Mackie
(Graduate Student Poster)

STATUS OF THE EUROPEAN GREEN CRAB IN THE PACIFIC NORTHWEST.
Sylvia Behrens Yamada, Graham E. Gillespie

APPLICATION OF A EUTROPHIC CONDITION INDEX TO BENTHIC MACROALGAL ACCUMULATION IN PACIFIC NORTHWEST ESTUARIES
David Young, Patrick Clinton, Henry Lee II, Cheryl Brown, David Specht, David Cladwell

SEASONAL AND SPATIAL PATTERNS OF LOW-DISSOLVED OXYGEN IN BELLINGHAM BAY
Gabriela B. Zayas del Rio, Jude K. Apple
(Undergraduate Student Poster)

PERS Banquet / Keynote Address

Oregon Experiments in Estuary Conservation: Is Salmon Management Good Estuary Management?

Dan Bottom
NOAA Fisheries, Northwest Fisheries Science Center, Newport, OR

A variety of resource conservation approaches have influenced management of Oregon's estuaries, each supported by different scientific ideas and assumptions. For decades, estuary management was a focus of fishery management insofar as Oregon estuaries were deemed important to salmon production. Estuaries often were presumed a threat to salmon survival, and research and management activities were designed to identify, remove, or avoid this salmon-production "bottleneck." In the 1960s and 70s estuary protection became an explicit goal of state environmental laws and comprehensive land-use planning. In contrast to the traditional predict-and-control approach of fisheries management, Oregon's Estuarine Resources Goal assumed that estuaries are dynamic and unpredictable. The planning goal sought to conserve habitat diversity within and among estuaries as a strategy for minimizing unforeseen risks of future development.

Estuary conservation now has entered a new restoration phase in response to coastwide salmon decline and the listing of many stocks as threatened or endangered. The ultimate success of these efforts may depend on the conceptual framework that is used to guide estuary actions on behalf of salmon. In the Columbia River, the estuary restoration program has been superimposed on the existing production-based system for managing water and fish, raising questions over its ultimate success. Perhaps a better model for understanding the possibilities of estuary restoration is Oregon's Salmon River, where the U.S. Forest Service has restored >2/3 of the original estuarine wetlands previously diked or filled for grazing and other uses. The increased estuary rearing opportunities at Salmon River have expanded life history diversity in both the Chinook and coho populations. Estuary-associated life histories that were rare or absent when most of the wetlands were diked now account for a quarter to a third of the adults produced in each population. The results at Salmon River imply that salmon management can be good estuary management (and vice versa) when placed in a broader ecosystem context. Predicted effects of climate change argue strongly for conservation strategies that expand habitat opportunities and strengthen the resilience of salmon ecosystems to future disturbance.

PERS Conference / Plenary Talk

Biogeography of Ecosystem Engineers: Community Ramifications

Sarah Ann Woodin and David S. Wethey
Department of Biological Sciences, University of South Carolina

The biogeographic patterns of large marine intertidal organisms on the coast of Europe have a historical record of over 100 years and due to upwelling zones individual species often have more than one northern or southern limit. This mosaic nature of the European coast allows one to test proposed mechanism and validate models at multiple locations. We will demonstrate this for two intertidal species, the foundation barnacle species *Semibalanus balanoides* on rocky shores and the ecosystem engineer *Diopatra* in sediments.

Long term trends of biogeographic change can reverse and distributions shift rapidly on short time scales as a function of extreme climatic events. The boreal barnacle *Semibalanus* illustrated this after the extreme winter of 2009-2010 when it expanded its range to the south by ~100 km, and filled in gaps in its distribution where it had not been seen in decades. In the Pacific Northwest another ecosystem engineering polychaete *Abarenicola pacifica* is illustrative of the reversal of patterns due to such oceanographic effects as the Pacific Decadal Oscillation.

Sarah Woodin

Dr. Woodin's research is focused on the analysis of processes controlling the distribution and abundance of organisms in marine sedimentary environments. Her past work has demonstrated experimentally the relative roles of direct and indirect competition, disturbance, predation (partial and complete), biogenic structural heterogeneity, and biogenic halogenated compounds. She is particularly interested in the importance of biogenic disturbance to recruitment and roles of large infauna as community drivers. Her emphasis has been on experimental field manipulations of shallow water marine sedimentary assemblages with parallel laboratory experiments and on the development of tools with which to detect behaviors of infauna remotely.

Dr. Woodin's current research centers on the following three areas:

1. remote sensing of the frequency and intensity of biogenic disruption by ecological engineers using pressure signals generated by hydraulic activities,
2. the effect of hydraulic activities on community structure in sediments, and
3. the importance of global climate change to the biogeography of large infauna who are ecosystem engineers.

The ability to detect activities of large infauna remotely is a major breakthrough in sediment research in that it allows one to ask questions about rates and experimental outcomes non-destructively, opening the door to an array of manipulations and allowing the determination of pore-water flux rates. In the global change project she is looking at mechanisms driving changes in range limits as well as behavioral indicators of stress in large infauna at range limits. These projects are funded by NSF and NASA. Her field studies are currently being carried out on the Atlantic and Pacific coasts of North America and the Atlantic coast of Europe.

David Wethey

Dr. Wethey's research interests include biogeography, population dynamics, predator-prey and competitive interactions, conservation genetics, and the mechanisms by which organisms escape the physics of their habitats. He uses a combination of field and laboratory experiments and modeling to examine these processes. His work on population dynamics involves the application of difference and differential equation models to age structured populations, including barnacles, annelids, copepods, and fish. His work on animal behavior has used non-invasive field and laboratory methods including medical ultrasound and low frequency pressure transients to detect activities of animals living within sediments. His work on biogeography has used field experiments and biophysical modeling to determine the mechanisms responsible for setting geographic limits of species. His field studies are currently being carried out on the Atlantic and Pacific coasts of North America, the Pacific coast of Asia, and the Atlantic coast of Europe.

Dr. Wethey’s current research projects include

1. field, remote sensing, modeling and forecasting studies of the mechanisms responsible for setting the geographic limits of intertidal barnacles, mussels, and infauna;

2. field and laboratory studies of the subsurface activities of infaunal worms and clams, and their effects on porewater geochemistry, nutrient cycling, and bacterial populations.

Abstracts for Contributed Presentations and Posters:

UTILIZATION OF AN OREGON ESTUARY BY FEMALE DUNGENESS CRAB, *CANCER MAGISTER*

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Dungeness crab, *Cancer magister*, utilize estuarine habitats throughout all benthic life stages. From newly-settled juveniles to mature adults, estuaries provide the prey and refuge that lead to higher growth rates and lower mortality. Understanding the spatial and temporal trends in Oregon's Dungeness crab populations is necessary for managing the popular recreational and economically important commercial fisheries. We implemented a trap sampling program to characterize the relative abundance, species composition, size frequency, and other traits of crab populations in Yaquina Bay. From May 2007 to April 2013, 100 sampling trips were completed, with a total of 3,151 pot-pulls, capturing and assessing 8,241 female Dungeness crab. Relative abundance of all female crabs was highest in the late-summer to early-fall before dropping during the winter and spring. Furthermore, sexually mature female Dungeness crabs (110-135 mm carapace width) were relatively scarce in estuaries throughout the study period. Overall, the female crabs captured were composed of sexually immature (~100 mm CW) and very large old individuals (~145 mm CW). Females belonging to the one or two instars between these two modes were relatively infrequent, and ovigerous females were not captured at all. The results show that either sexually mature female crab avoid estuaries, or that sexually immature and very large females differentially prefer them. The results from our study were compared with published growth increment estimates, life-history models, and other unpublished trapping data.

NUTRIENT, OXYGEN AND PLANKTON DYNAMICS IN BELLINGHAM BAY AND THE CONNECTIVITY BETWEEN SURFACE ALGAL COMMUNITIES AND BOTTOM WATER HYPOXIA

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Coastal eutrophication and bottom water hypoxia are stressors in many coastal and marine ecosystems, including the fjords and embayments of the Salish Sea. Recent work by researchers at Western Washington University and Northwest Indian College has identified a relatively large area (>10km^2) of low dissolved oxygen (DO) in bottom waters of Bellingham Bay (Bellingham, WA) that returns predictably each summer. Direct measurements of water column respiration indicate that incoming oceanic deep water exhibits rates of oxygen consumption that are relatively low (~100µg O_2 $L^{-1}d^{-1}$) when compared to other estuarine ecosystems. Manipulative experiments reveal that rates of respiration in bottom waters of Bellingham Bay tend to be limited by carbon rather than temperature and respond quickly to additions of organic matter. This observation was corroborated by changes in bottom water respiration and DO in

response to export of *Pseudo nitzschia* from surface blooms. Our research reveals a temporal coupling between algal biomass and bottom water hypoxia – and that this response to organic matter inputs is relatively rapid and short lived. Nutrient inputs to Bellingham Bay, which have been linked to algal productivity, are variable throughout the year and shift seasonally between marine and freshwater sources. Examination of the vertical structure of the water column has revealed that low DO water masses in Bellingham Bay are highly dynamic and appear to respond to upwelling events and high volumes of tidal flushing characteristic of many west coast estuaries.

SEED DENSITY AND DISTRIBUTION OF NON-NATIVE (*ZOSTERA JAPONICA*) AND NATIVE (*ZOSTERA MARINA*) EELGRASSES IN SEDIMENTS OF MIXED AND MONO-SPECIFIC MEADOWS

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The non-native eelgrass, *Zostera japonica*, was introduced to the Pacific Northwest in the 1930's. Over time, *Z. japonica* has expanded its range and is increasingly found intermixed with the native eelgrass, *Zostera marina*. In Padilla Bay, Washington *Z. marina* grows on extensive intertidal and subtidal flats and covers more than 3000 hectares. *Z. japonica* initially became established in Padilla Bay on high intertidal flats that had been bare of macro-vegetation. Mapping of eelgrasses over the last 20 years indicates that *Z. japonica* has expanded its range in Padilla Bay and is increasingly found intermixed with *Z. marina* in the mid-intertidal areas. We investigated the density and distribution of seeds of these two species in the sediments in intermixed and mono-specific stands in Padilla Bay, Washington. In November of 2013, we collected 280 sediment cores from 56 sample sites along three 3.3 km transects from shore to about -1.0 m MLLW. Seeds were extracted, counted and compared to existing plant density and distribution data. *Z. marina* and *Z. japonica* seeds were found to be well distributed throughout the intertidal zone including areas of low plant density. Mean total seed density for *Z. marina* was 1,396/m^2 in areas dominated by *Z. marina* and 285/m^2 in areas dominated by *Z. japonica* or lacking vegetative cover, and ranged from 0-5761 seeds/m^2. Mean total seed density for *Z. japonica* was 17,622/m^2 in areas dominated by *Z. japonica* and 5,365/m^2 in areas dominated by *Z. marina* or lacking vegetative cover, and ranged from 0-75,850 seeds/m^2.

IDENTIFYING TRANSMISSION AGENTS OF SEA STAR WASTING DISEASE IN THE SUNFLOWER STAR, PYCNOPODIA HELIANTHOIDES

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Sea star wasting disease, also known as a wasting syndrome, is characterized by a series of symptoms where the affected sea star wastes away, ultimately leading to death. Reports of dead and dying sea stars of multiple species along the Western Pacific Coast of North America began in summer 2013 and have spread from San Diego to Alaska. Researchers and citizen scientists within the Puget Sound and British Columbia have documented mass mortalities in the sunflower star, *Pycnopodia helianthoides*, which appears especially vulnerable to wasting

disease. Little is known about these expanding mass mortalities despite similar occurrences in the past. It has yet to be confirmed whether the disease is truly pathogenic or simply environmental. Within a controlled laboratory, we tested virulence of wasting disease in *P. helianthoides* by exposing presumably healthy individuals 1) to direct contact with an affected *P. helianthoides*, 2) to indirect contact via water from a site with affected sea stars, or 3) to contact with water from a control site. Direct contact produced the most rapid transmission of symptoms consistent with wasting disease resulting in 100% mortality within 15 days whereas indirect and control treatments showed only 33.3% mortality after two months. We conclude that the cause of wasting disease is primarily due to pathogens passed most effectively by direct contact between sea stars.

EFFECTS OF ENVIRONMENTAL AND HERBIVORE STRESS ON *ULVA LACTUCA*

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Marine plants and herbivores live in a constantly changing environment where they are exposed to a variety of dynamic stresses. While the interactive effect of stress and herbivory on growth, survival and reproduction is well documented in terrestrial plants, less is known about the mechanism of stress response in marine plants and its possible impact on intertidal ecology. This study explored how two short-term environmental stresses, desiccation and low salinity, affected susceptibility to grazing, and how the additive pressures of these stresses and herbivory affected dimethylsulfonionpropionate (DMSP) levels and growth in *Ulva lactuca*, an intertidal macroalga that can form large blooms in optimal conditions. DMSP, which is found in high concentrations in *U. lactuca*, is a natural product that is found in marine algae and functions in stress tolerance and activated defenses. While environmental stress did not have a significant effect on growth or susceptibility to grazing, lower levels of DMSP were found in the desiccated *U. lactuca*. However, over the course of the experiment, the DMSP levels in desiccated *U. lactuca* recovered to initial levels.

THE GOOD, THE BAD AND THE MUDDY: LESSONS LEARNED FROM THREE YEARS OF MAPPING BURROWING SHRIMP POPULATIONS IN YAQUINA BAY, OR.

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The burrowing shrimps, *Neotrypaea californiensis* and *Upogebia pugettensis* comprise a significant portion of intertidal habitat in west coast estuaries. Significant declines of both species have been observed over the last decade, raising some concern over the long-term sustainability of these shrimp populations. From 2011 – 2013, surveys of both *Neotrypaea* and *Upogebia* populations in Yaquina Bay, Oregon have been conducted to estimate population abundance and obtain age structure information for development of a population dynamics model. The 2011 survey was conducted using simple random sampling of 100 locations on shrimp beds where burrow information was collected. An inverse distance weighted (IDW)

interpolation was used to estimate population total with bootstrapping of IDW totals to estimate variance. Validation of the interpolation indicated poor accuracy in estimation with the IDW model. In subsequent years, increased sample size and a Generalized Random Tessellation Stratified sampling design were used to improve model predictions. Our data showed a considerable increase in population abundance from 2011 to 2012 resulting from a significant recruitment event in 2010. We were also able to quantify fine scale variability within the shrimp beds by exploring spatial autocorrelation of the data. The methods developed in this study provide a statistically based and easily implemented method for improving estimates of population abundance for intertidal benthic invertebrates.

OREGON EXPERIMENTS IN ESTUARY CONSERVATION: IS SALMON MANAGEMENT GOOD ESTUARY MANAGEMENT?

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A variety of resource conservation approaches have influenced management of Oregon's estuaries, each supported by different scientific ideas and assumptions. For decades, estuary management was a focus of fishery management insofar as Oregon estuaries were deemed important to salmon production. Estuaries often were presumed a threat to salmon survival, and research and management activities were designed to identify, remove, or avoid this salmon-production "bottleneck." In the 1960s and 70s estuary protection became an explicit goal of state environmental laws and comprehensive land-use planning. In contrast to the traditional predict-and-control approach of fisheries management, Oregon's Estuarine Resources Goal assumed that estuaries are dynamic and unpredictable. The planning goal sought to conserve habitat diversity within and among estuaries as a strategy for minimizing unforeseen risks of future development.

Estuary conservation now has entered a new restoration phase in response to coast-wide salmon decline and the listing of many stocks as threatened or endangered. The ultimate success of these efforts may depend on the conceptual framework that is used to guide estuary actions on behalf of salmon. In the Columbia River, the estuary restoration program has been superimposed on the existing production-based system for managing water and fish, raising questions over its ultimate success. Perhaps a better model for understanding the possibilities of estuary restoration is Oregon's Salmon River, where the U.S. Forest Service has restored >2/3 of the original estuarine wetlands previously diked or filled for grazing and other uses. The increased estuary rearing opportunities at Salmon River have expanded life history diversity in both the Chinook and coho populations. Estuary-associated life histories that were rare or absent when most of the wetlands were diked now account for a quarter to a third of the adults produced in each population. The results at Salmon River imply that salmon management can be good estuary management (and vice versa) when placed in a broader ecosystem context. Predicted effects of climate change argue strongly for conservation strategies that expand habitat opportunities and strengthen the resilience of salmon ecosystems to future disturbance.

FEEDING OF THE INVASIVE COPEPOD PSEUDODIAPTOMUS FORBESI ON NATURAL MICROPLANKTON ASSEMBLAGES IN THE LOWER COLUMBIA RIVER

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Invasive species are increasingly common, but still poorly understood disturbances to aquatic ecosystems. We conducted laboratory grazing experiments with the invasive copepod *Pseudodiaptomus forbesi* and natural assemblages of microplankton collected in the fall of 2010 and 2012 at three sites in the lower Columbia River: Astoria, OR; Vancouver, WA; and Bonneville Reservoir. We examined prey preferences and diet composition of this copepod on microplankton to better understand predator-prey dynamics throughout this system as well as the potential for competition with native copepods. Significant differences in copepod grazing among sites included a greater preference for flagellates ($p=0.025$) and cyanobacteria ($p=0.027$) in Astoria than Bonneville, and a greater preference for dinoflagellates ($p=0.014$) in Bonneville than Vancouver. Also, flagellates ($p=0.003$) were ingested at a significantly higher rate in Bonneville than Vancouver. Overall, *P. forbesi* selectivity trended toward smaller, motile prey (especially in Bonneville) with an additional preference for cyanobacteria in Astoria. Potential competition between *P. forbesi* and native copepods may be site-specific and dependent on zooplankton community assemblages as well as availability of preferred prey items.

LARVAL ECOLOGY OF INTRODUCED AND NATIVE BOPYRIDAN ISOPOD PARASITES IN YAQUINA BAY, OREGON

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This is the first systematic study of marine bopyrid isopod parasite larval ecology. Dramatic declines and extinctions of the native burrowing shrimp *Upogebia pugettensis* are directly associated with intense infestations and effective castration by the introduced Asian bopyrid, *Orthione griffenis*. The great ecological importance of *Upogebia* therefore places the ecology of this host-parasite interaction among the major conservation issues for eastern Pacific estuaries. Difficulties of identifying the pelagic bopyid microniscan and cryptoniscan larvae prevented research on their ecology. We found a trapping method to capture and identify cryptoniscans. The known cryptoniscan stage permitted identification of the microniscan stage and our survey of *Orthione* larval stages in Yaquina Bay over diel, tidal, lunar and annual cycles. *Orthione* epicarid larvae emerge from their *Upogebia* hosts and emigrate into the open coastal waters where they settle on to copepod hosts, *Acartia longiremis* or *Acartia hudsonica* and metamorphose into microniscans. The non-reproductive microniscans metamorphose into cryptoniscans which return to their estuarine hosts from spring through fall. In addition to its new final host and its new oceanographic system, the intermediate hosts of *O. griffenis* are also new. Atypical for introduced eastern Pacific species, the *Orthione* life cycle is not completed in estuaries. We also surveyed cryptoniscans of the native bopyrid Ione cornuta in the course of these investigations. *Ione cornuta* larvae also mature in the coastal ocean and return to Yaquina Bay in pulses which we found primarily in the later summer and fall.

MONITORING: WHERE, WHAT, AND HOW?

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Monitoring comes in many forms and may be used for a variety of purposes. Unfortunately, there appears to be a lack of consensus and well-established guidelines (and funding) for monitoring marine systems, particularly restoration monitoring. This presentation will review some of the available guidelines for monitoring and identify key elements and challenges. A case example of a bulkhead removal and shoreline restoration project will be used to illustrate the monitoring approach used in this case, along with some discussion of the impending challenges associated with the new Shoreline Master Programs being adopted in Washington State.

UPDATING OREGON'S ESTUARINE WETLAND HABITAT MAPS: MODERNIZING THE FOUNDATION FOR COASTAL RESOURCE MANAGEMENT

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Oregon's estuarine wetlands provide valued ecosystem services such as food web support, sediment detention, carbon sequestration, and fish and wildlife habitat. However, since European settlement, Oregon has lost about 70% of emergent tidal wetlands and over 90% of once-prevalent tidal swamps (shrub/forested tidal wetlands). To provide guidance for tidal wetland restoration and conservation efforts, resource managers need accurate mapping of tidal wetlands. The last major statewide effort to map these resources was in the early 1980s; since then, a wealth of new data has become available. Our team is using new data to generate updated mapping of Oregon's tidal wetlands and shorelands, including diked former tidal wetlands, and to classify these resources according to the Coastal and Marine Ecological Classification Standard (CMECS). A major goal is to improve the accuracy of mapping for upslope and up-estuary limits of tidal wetlands, which have not been well-defined or accurately mapped in previous efforts. We determined this upslope boundary using digital elevation models derived from LIDAR, along with tide height modeling from NOAA tide stations. The products of this study modernize the informational foundation for Oregon's estuary management program, allowing state and local governments to make better estuary planning and management decisions.

EFFECTS OF RESTORATION IN A TIDAL WETLAND ON SALINITY, WATER TEMPERATURE AND PLANT COMMUNITY COMPOSITION

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Numerous restoration projects have taken place in the Pacific Northwest in response to the overwhelming decline of tidal wetlands in Oregon, as well as the growing knowledge of the ecosystem services provided by these wetlands. One of the largest tidal restoration projects in Oregon is the 418 acre Ni-les'tun Unit of Bandon Marsh NWR, with goals of restoring habitat for native plants, fish and other wildlife. At the Ni-les'tun Unit and a reference site in Bandon Marsh NWR, salinity, water temperature, and plant communities were monitored a year prior to restoration and two years after restoration (Before-After-Control-Impact design). Prior to restoration, salinity was lower, water temperatures were higher, and invasive species dominated the restoration site. After restoration, salinity and temperature at the restoration site converged with those at the reference site. Plant richness and total percent plant cover was lower after restoration, most likely due to non-native species' intolerance of the newly restored salinity regime. Native plant species increased in areas of highest salinity, and are likely to increase across the rest of the site as non-native species continue to die back due to the restored salinity regime. By monitoring controlling factors as well as biotic responses before and after a restoration event, we can holistically determine the effectiveness of the restoration in meeting project goals.

CHESS WITH THE DEVIL AND HOW DO THE PIECES MOVE: A RAPID INTERTIDAL MEGAFAUNA SURVEY METHOD APPLIED TO *UPOGEBIA PUGETTENSIS*, AND ITS INTRODUCED PARASITE, *ORTHIONE GRIFFENIS*

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Declines or extinctions of the native northeast Pacific intertidal blue mud shrimp, *Upogebia pugettensis* over the species range are directly associated with intense infestations by the introduced Asian bopyrid isopod parasite, *Orthione griffenis*. Single point sampling sites and anecdotal records poorly resolve how this interaction is occurring over the species ranges. The meta-population dynamics of these two species within estuaries and among geographical regions can only be resolved from large scale surveys. However, these surveys are proceeding slowly or, in most cases, have not begun. This knowledge gap partially results from the large efforts and major field and computational resources that conventional grid or random point survey methods require. We tested a new method in Alsea Bay, Oregon, in which shrimp bed perimeters and areas are algebraically defined previous to direct sampling of the enclosed populations. This new method is intuitive, reduces field logistics and requires minimum field and computational resources. The Alsea Bay *U. pugettensis* populations are sufficiently abundant to remain "ecosystem engineers". However, they are intensely infested by *Orthione* that cause significant reproductive losses and they appear to be declining along with all other known *Upogebia* populations in Oregon estuaries.

PHYSICAL AND MICROBIAL DRIVERS OF HYPOXIA IN BELLINGHAM BAY

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Bottom water hypoxia is a feature of many coastal embayments and fjords in the Salish Sea. Ongoing research in Bellingham Bay (Bellingham, WA USA) by Northwest Indian College and Western Washington University has identified a seasonally recurring area of low dissolved oxygen near the center of the bay. Similar to other regions of the Salish Sea, hypoxia in Bellingham Bay may be a naturally occurring phenomenon, yet the extent of eutrophication and anthropogenic nutrient loading's influence on patterns of hypoxia is poorly understood. The present study has continued an established monitoring program documenting the range, duration and severity of hypoxia in Bellingham Bay, while adding an experimental component investigating factors that regulate respiration of heterotrophic bacterioplankton. Profiles of water column parameters and sample collection were performed on six regularly scheduled cruises. Dissolved oxygen concentrations below the hypoxic threshold were observed in bottom waters in the center of Bellingham Bay for most of the summer, although the layer of hypoxic water appeared to migrate upwards into the water column in late July. Manipulative experiments were conducted on collected water samples to investigate effects of temperature and organic carbon on water column respiration. These experiments revealed that temperature had a negligible effect on water column respiration, while organic carbon stimulated oxygen consumption and was thus identified as a possible limiting factor. The study's findings broaden our knowledge of factors regulating oxygen dynamics in coastal embayments of the Salish Sea and provide further insight into the potential effects of anthropogenic stressors and climate change on Salish Sea water quality.

A DECADE OF MAPPING SUBMERGED AQUATIC VEGETATION USING COLOR INFRARED AERIAL PHOTOGRAPHY: METHODS USED AND LESSONS LEARNED

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Annual color infrared aerial photographs acquired annually between 1997 and 2007 were used to classify distributions of intertidal and shallow subtidal native eelgrass *Zostera marina* and non-indigenous dwarf eelgrass *Z. japonica* in lower Yaquina estuary, Oregon. The use of digitally orthorectified aerial photography acquired at extreme low tides enabled very high resolution imagery from 15 to 25 centimeter ground pixels. The use of false-color infrared film enabled a high contrast between submerged aquatic vegetation beds and bare substrate not visible in true color film. The initial success of this remote sensing method inspired similar efforts in nine other Pacific Northwest estuaries from Willapa Bay, WA to Humboldt Bay, CA. Innovative techniques developed during the course of the project included a flight planning tool and a hybrid image classification methodology. The decadal study enabled the mapping of spatio-temporal patterns in the distribution of intertidal vegetation including an exponential expansion of the distribution of non-indigenous dwarf eelgrass *Z. japonica* in Yaquina Bay. The methods developed in this study are applicable for use with four band digital aerial photography.

GROWTH RATE AND MORPHOLOGY CHANGES FOR TWO CONTRASTING *SYNECHOCOCCUS* STRAINS WHEN GROWN IN BLOOM VERSUS NONBLOOM OCEAN WATER.

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The picocyanobacteria group *Synechococcus* is important in marine plankton communities since it can be responsible for a large percentage of total photosynthesis in this ecosystem. *Synechococcus* exhibit variable growth rates and morphologies in laboratory culture. We hypothesize that this is due to allelochemicals that are present in the local seawater used to make culture media; these chemicals may be produced by other plankton which become abundant during spring and summer blooms in the Salish Sea. *Synechococcus* strains CC9311 (coastal isolate) and WH8102 (open ocean isolate) were grown in nutrient-enriched (SN) media that used as its basis two different types of autoclaved filtered seawater. Both types of seawater were collected at the same site, but one was exposed to bright light in the laboratory, promoting a diatom bloom, while the other was stored in darkness. After filtration, media preparation, and inoculation with *Synechococcus*, fluorescence was measured daily for 14 days to determine population growth rate, while cell morphology samples were taken every 2-3 days. Preliminary data suggest that both strains of *Synechococcus* had a higher growth rate in media prepared from bloom water than from non-bloom water.

POTENTIAL EFFECTS OF NON-NATIVE EELGRASS ON BAY CLAM POPULATIONS IN NETARTS BAY, OREGON

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The non-native eelgrass *Zostera japonica* was introduced in the 1930s to the Pacific Northwest and has since become well established in many estuaries. Several of these estuaries have expansive native *Zostera marina* beds and support large recreational and commercial shellfish species . However, there is limited information about the impacts of *Z. japonica* expansion on ecosystem structure and function. In 2013, the Shellfish and Estuarine Assessment of Coastal Oregon (SEACOR) project of the Oregon Department of Fish and Wildlife conducted a bay clam population and estuarine habitat study in Netarts Bay. This estuary is a popular recreational clamming destination and also supports commercial mariculture operations. Both rapid and detailed assessment methods were applied extensively across the study area in grid and random stratified points with respect to tidal elevation. Post hoc, we identified four bed types in the bay (*Z. marina*, *Z. japonica*, mixed eelgrass species, and non-vegetated beds), and explored patterns in the related benthic invertebrate communities. *Z. japonica* is widely distributed in the bay with an overlapping distribution with *Z. marina*. We found a significant relationship between bed type and community composition. Additionally, some species of recreationally-targeted bay clams in the upper intertidal were significantly associated with bed types which included *Z. japonica*. Notably, native littleneck (*Leukoma staminea*) clams were more prevalent in mixed eelgrass beds. These survey results enhance our understanding of distribution and potential effects of *Z. japonica* but highlight the need for further research on the interactions of this non-native eelgrass species on bay clam populations.

CAN SUBTIDAL BAY CLAMS SERVE AS SOURCE POPULATIONS FOR THE INTERTIDAL? A PRELIMINARY EVALUATION OF THE SUBTIDAL "SPAWNING STOCK HYPOTHESIS" IN TWO OREGON ESTUARIES

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Subtidal habitats, which are protected from many intertidal predators and are always submerged, are often assumed to harbor large bay clam populations that serve as spawning stock for intertidal populations. The Shellfish and Estuarine Habitat Assessment of Coastal Oregon (SEACOR) project conducted extensive surveys of bay clam populations in subtidal and intertidal habitats of two Oregon estuaries. Tillamook Bay (2010-2012) is Oregon's second largest outer coast estuary, is fed by 5 major rivers, and supports more than 70% of the state's commercial bay clam fishery. In contrast, Netarts Bay (2013-2014) also serves as an important recreational clamming destination, but has little freshwater influence, comparatively small commercial harvest, and an intertidal Shellfish Preserve. Using a stratified-random design (tide flat x tide height), bay clam (*Clinocardium nuttallii*, *Tresus capax*, *Saxidomus gigantea*, *Leukoma staminea*) population and habitat data were collected for the main intertidal flats and subtidal channels. In Tillamook Bay, 2 of the 3 main subtidal channels supported high densities of all target species except littleneck clams, which were also not abundant in the intertidal. Cockle and gaper clams were 2.7-3X more abundant and butter clams were 1.5X more abundant in the subtidal than the intertidal. These data support a spawning stock hypothesis in Tillamook Bay. Alternatively, the only abundant species in subtidal habitats in Netarts Bay was the cockle, which was 3X more abundant in the subtidal than the intertidal. However, the Shellfish Preserve may serve as an important intertidal spawning stock population for butter, cockle, and littleneck clams.

FOUR DECADES OF SUBTIDAL CLAMS IN TILLAMOOK BAY, OR USA

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Tillamook Bay hosts Oregon's largest commercial bay clam fishery and is also a major recreational clamming area. The Shellfish and Estuarine Habitat Assessment of Coastal Oregon (SEACOR) project completed a comprehensive randomized subtidal survey here in 2012 with a focus on 4 target bay clam species: gaper (*Tresus capax*), butter (*Saxidomus gigantea*), cockle (*Clinocardium nuttallii*), and native littleneck (*Leukoma staminea*) clams to complement our intertidal survey of 2010-2011. We compared our data to previous subtidal surveys from 1974-76, 1984, 1985 and 1996 in Hobsonville Channel, a large channel with extensive historical data, and the Main Channel, where much of the commercial fishery effort is focused. These data were used to identify patterns in bay clam distribution and abundance over four decades and identify habitat associations for the target species. While some significant density decreases were seen in various years, the 2012 biomass estimates for *T. capax*, *C. nuttallii*, and *S. gigantea* were comparable to the previous ODFW subtidal surveys indicating a multi-decadal persistence of these populations. However, the recent study shows a significant decrease in *L. staminea*

biomass and density in the targeted channels. High bay clam species densities and biomass were significantly associated with sand/gravel/cobble substrates across the decades with a few exceptions. The Oregon Department of Fish and Wildlife will be able to use these results along with future surveys to aid in the management of both these important clam resources and associated habitat.

PRE-SPAWN PACIFIC HERRING DISTRIBUTION AND POPULATION ESTIMATES IN YAQUINA BAY

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In 2014, the Oregon Department of Fish and Wildlife (ODFW) Marine Resources Program initiated a pilot program to develop an acoustic survey to determine a pre-spawn population estimate for Pacific herring in Yaquina Bay on the central Oregon coast. This survey aims to develop a timely population estimate to set a quota for the commercial roe herring fishery, typically executed immediately prior to annual spawning events in February and March, and to describe herring distribution within the bay prior to those events. A BioSonics DT-X echosounder was used to collect the acoustic fish densities from an ODFW vessel. A total of six acoustic surveys were conducted from late January through mid-February. Each survey consisted of 17 transects daily, which were randomly selected from a total of 68 transects. Preliminary results are presented. Distribution of herring within the bay changed dramatically throughout the sampling period, potentially in response to large freshwater inputs in early February. Daily population estimates will be compared to those developed from annual spawn surveys conducted, concurrent to the acoustic surveys, by the ODFW.

FINE-SCALE POPULATION STRUCTURE AMONG CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) OF THE SILETZ RIVER IN OREGON: A PRELUDE FOR INCORPORATION OF RIVERSCAPE GENETICS.

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The Siletz River system of the Central Oregon Coast, stretches 67 river miles into the coast range and supports a recreational fishery managed by Oregon Department of Fish and Wildlife and a subsistence fishery of the Confederated Tribes of Siletz Indians. Chinook salmon are commercially, recreationally and culturally valuable, but during the last century populations have experienced severe declines and many extant subpopulations currently persist at low abundances. Loss of genetic diversity within a population has important ecological ramifications; it influences the fitness of individuals, and impacts the adaptability of a species to changing environments. The loss of genetic diversity affects the ability of subpopulations to successfully recolonize habitats following a local extinction or extirpation. Landscape genetics examines how gene flow and population structure are affected by environmental influences; analytical tools have been developed to address these types of interdisciplinary questions. 1017 Chinook were genotyped at 15 neutral microsatellite loci and 2 clock genes. The total number of alleles and allelic richness was similar among samples, there were no departures from Hardy-

Weinberg expectations, and heterozygosity ranged between 0.81 and 0.95. Four temporally and spatially distinct subpopulations were detected. We present evidence for two primary ecological forces that contribute toward population structure: the physical barrier at the waterfalls and temporal behavioral factors among subpopulations. While we have not yet compared and contrasted all environmental factors identified during this study, our long-term aim is to apply riverscape genetics approaches to determine which factors provide influence contributing to structure within the system.

HABITAT-SPECIFIC NUTRIENT REMOVAL AND RELEASE IN OREGON SALT MARSHES

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Wetlands can be sources, sinks and transformers of nutrients, although it is their role in nutrient removal that is valued as a water purification ecosystem service. In order to quantify that service for any wetland, it is important to understand the drivers of nutrient removal within the system of interest and its variability among systems of the same type. We compared short-term exchanges of inorganic N and P between surface water and salt marsh habitats (high marsh, low marsh, and tidal channel) measured during summer 2012 at 20 salt marshes distributed among 8 Oregon estuaries. Nutrient fluxes were estimated using open-topped chambers deployed at low tide into which nutrient-amended artificial seawater was added. Patterns of nutrient exchange among habitats were consistent across all spatial scales for nitrite+nitrate (N+N) and phosphate (PO_4), though there was substantial variability among marshes. In general, channel habitat had the greatest uptake of N+N and PO_4, high marsh had the greatest efflux of both nutrients, while low marsh took up N+N and released PO_4 but at lower rates. Nutrient efflux in high marsh habitat was correlated with abundance of *Grindelia integrifola*, a native forb. We speculate that this may be due to salt excretion by these plants. We will also compare these fluxes to below-ground nutrient transformation and fluxes, the latter based on preliminary estimates of denitrification rate and sub-surface movement of tidal waters.

QUANTIFYING THE IMPACTS OF OYSTER AQUACULTURE ON SEAGRASS (ZOSTERA MARINA) AT THE LANDSCAPE SCALE IN WILLAPA BAY, WASHINGTON

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Seagrasses are foundation species, providing valuable ecosystem services including nursery habitat in estuaries worldwide. As such they are protected by no-net-loss provisions in federal and state regulations resulting in a protective approach by managers that avoids impacts from development activity - including shellfish aquaculture. Recent research suggests that oyster aquaculture has direct impacts to the native seagrass in US Pacific NW estuaries (eelgrass,

Zostera marina) over small spatial and short temporal scales. We quantified the impacts of aquaculture on *Z. marina* at a larger estuarine landscape scale in Willapa Bay, Washington which produces approximately 17% of US oysters. First we created a model of *Z. marina* density outside of aquaculture using distance to mouth, distance to channel, salinity, elevation, and cumulative wave stress as predictors. We then used these factors to predict *Z. marina* presence in oyster aquaculture areas. We found the amount of *Z. marina* observed on oyster aquaculture beds was less than the amount predicted but compared to the total amount of *Z. marina* in Willapa Bay, the impact of oyster aquaculture represented less than 1.0% of the total predicted values in any year. Bed type did not contribute to explaining observed variation, but mechanically harvested beds had significantly lower *Z. marina* than hand and mixed harvest beds. The majority of beds (all harvest types) had 65-145% of the model predicted *Z. marina* and exhibited relatively low variability between years.

CHANNEL MORPHOLOGY CHANGE FOLLOWING RESTORATION AT THE NI-LES'TUN UNIT OF THE BANDON MARSH NATIONAL WILDLIFE REFUGE: INITIAL RESULTS AND TOOL DEVELOPMENT

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The Ni-les'tun Unit of the Bandon Marsh NWR, totaling 169 hectares (418 acres) in the Coquille River Estuary, is the largest completed tidal wetland restoration project in Oregon. The site was originally tidal marsh and forested tidal wetland (tidal swamp) and high in the tide frame. Beginning in the late 1800s, the site was cut off from tidal inundation through a mix of diking, ditching, and tide gates to convert the wetland to agricultural uses. Between 2010 and 2011 over 2.5 km (1.5 miles) of artificial levees and three tide gates were removed, 20.9 km (13 miles) of agricultural ditches were filled or disked, and 8.5 km (5.3 miles) of new tidal channels were excavated. These actions have initiated the recovery of 169 hectares of ecologically significant tidal wetland habitats that have been prioritized at national, regional, and state scales. During the two years after restoration, channel morphology changed significantly from as-built constructed conditions. Channels are deepening and widening, especially low in the channel network where tidal forcing is greatest. Deposition of fine sediment is spatially heterogeneous throughout the network, and fine sediment appears to be moving down the channel network. In addition, channel responses appear to be significantly related to the use of a tidal marsh plane vertical datum instead of a geodetic datum or tidal datum for channel construction. Our key findings and the tools we developed to assess channel morphology response provide important "lessons learned" to inform other restoration projects.

USING FERRIES FOR MARINE WATER QUALITY MONITORING IN THE SALISH SEA

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To better understand and predict water quality throughout Puget Sound, the Washington State Department of Ecology (Ecology) has sought partnerships for collecting monitoring data. In 2009, Ecology began working with Clipper Navigations, Inc. and installed oceanographic sensors on the Victoria Clipper IV ferry vessel. The twice-daily runs between Seattle and Victoria, B.C. provide data on phytoplankton concentration and temperature to better understand spatial gradients, variability, and dynamics of water masses, river plumes, and algal blooms. These data can also be used for daily calibration of satellite images, thus enabling Ecology to stitch together the long-term data from our marine flight program with satellite data.

In 2013, Ecology partnered with the Applied Physics Laboratory at the University of Washington to install instruments on Washington State Ferries (WSF) that will provide surface-to-bottom measurements of current velocities across Admiralty Reach from Port Townsend to Keystone. This is where water exchange occurs between the Strait of Juan de Fuca and Puget Sound. Direct observations of exchange velocities have been shown to correlate well with the surface signals from the Clipper measurements (Deppe et al, 2013), and thus Clipper data can be combined with the WSF data to give a comprehensive description of the exchange through Admiralty Reach.

These combined data sets are necessary to manage water quality (e.g., nutrient enrichment, low dissolved oxygen conditions, the transport of toxic chemicals, harmful algal blooms, and ocean acidification), improve our 303(d) listing decisions, and improve the performance of numerical models in Puget Sound.

THE REDOUBTABLE ECOLOGICAL PERIODIC TABLE

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Ecological periodic tables are repositories of reliable information on quantitative, predictably recurring (periodic) habitat–community patterns and their uncertainty, scaling and transferability. Their reliability derives from their grounding in sound ecological principles and theory and the scientific and statistical rigor with which they are constructed. Community state variables and their measurement uncertainty are entered into table elements representing categorical habitat types which are color-coded and systematically arranged to reflect the habitats' similarity in community composition and structure. Blocks (rows and columns of table elements) distinguish periodic habitat–community patterns that differ in space or time. Information is scale invariant for the space-time domain represented by each block and is not transferable to the space-time domains of any other blocks.

BIOGEOGRAPHIC DISTRIBUTIONS, ABUNDANCES, AND VULNERABILITIES TO CLIMATE CHANGE OF BRACHYURAN AND LITHODID CRABS FROM THE GULF OF CALIFORNIA TO THE BEAUFORT SEA

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As part of an EPA/USGS project to predict the relative vulnerability of near-coastal species to climate change we analyzed the biogeographic and abundance patterns of the brachyuran or 'True' crabs (n=368) and lithodid or 'King' crabs (n=20) that are found in the twelve MEOW ("Marine Ecosystems of the World") ecoregions between the Gulf of California (GOC) and Beaufort Sea at depths <200 m. To assess the vulnerability of each species we used species trait data queried from the "Coastal Biogeographic Risk Analysis Tool" (CBRAT), a web-based ecoinformatics tool. Species richness per ecoregion increases steadily from the Beaufort (n=3) to Southern California (n=138) and more than doubles between the Magdalena and the GOC ecoregions (138 and 298 species respectively). The Oregonian Ecoregion has 51 species. We calculated relative abundance values by analyzing extensive data sets augmented by expert opinion; allowing us to assign 78% of crab species to at least a Rare, Moderate or Abundant classification. The degree of relative climate vulnerably generally follows a south to north pattern with more species rated 'highly vulnerable' in the southern warm temperate ecoregions and 'None Known/Low' in the northern Arctic ecoregions. Out of the 388 total crab species 170 were assigned a 'high' ranking for climate vulnerability in one or more ecoregions. Traits such as commensalism, intertidal habitat, and endemicity were the three most determinant factors contributing to a high vulnerability rating. The pinnotherid crabs are the family at greatest risk largely because of their symbiotic strategy and generally rare abundances.

MAPPING OREGON'S OCEAN AND ESTUARINE SHORELINES USING SHOREZONE MAPPING PROTOCOLS

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The Oregon Department of Fish and Wildlife and Oregon Department of Land Conservation and Development initiated a mapping project for Oregon's ocean and estuary shorelines beginning in 2011. The project employs the standard ShoreZone mapping protocols that have been used in other areas of the US and Canada. ShoreZone is a coastal habitat mapping and classification system which includes collection of new high-resolution aerial imagery specifically for the interpretation and delineation of geomorphic and biological features of the intertidal zone and shoreline environment. The overall goal of ShoreZone mapping is to provide an accurate, robust, and accessible representation of coastal and estuarine shoreline morphology and a basic framework for the biophysical characterization of the coast. Coastal Ocean Resources, Inc., completed the ShoreZone aerial survey in 2011, and has completed image interpretation and data development for about 80% of the surveyed shorelines. They are currently working to complete the remaining 20%. The data products allow for both site-specific and landscape-scale analysis of shoreline habitats, and provide a tool for science, land-use planning and management, oil spill response, and other natural resource management applications. Results of the mapping effort will be presented and discussed, emphasizing areas where the new ShoreZone data complement past habitat surveys in Oregon.

EVALUATING THE POSSIBLE FEEDBACKS BETWEEN BIVALVE AGGREGATIONS AND ALKALINITY CYCLING UNDER ACIDIFICATION CONDITIONS

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Some bivalves display gregarious settlement that results in dense aggregations concentrating calcium carbonate as shells and organic matter through biodeposits. The ecological importance of these aggregations has been recognized as example of ecosystem engineering; however, the geochemical significance and ecological feedbacks are poorly understood. We propose a biogeochemical framework that focuses on two reversible processes and their feedbacks: calcification/dissolution of shells, and production/respiration of organic matter.

Most research to date has measured shell calcification, dissolution and biodeposit generation rates in single individuals, thus preventing the exploration of feedbacks among these processes in combination. Moreover, little is known about the habitat responses to ocean acidification despite the experimental evidence that calcification and dissolution are affected and a likely impact on biodeposit production.

In a series of flume experiments we will evaluate the geochemical feedbacks occurring at small spatial scales in oyster reefs and clam beds under normal and acidification scenarios. In particular, we will test our working hypothesis: respiration of organic matter in bivalve aggregations enhances metabolic dissolution of shells and regenerates alkalinity within the habitat and surrounding waters. We will assemble different types of shell aggregations altering shell:organic matter, dead shell:living bivalves ratios and the carbonate chemistry of the overlying water. We expect to find an increase in the alkalinity flux resulting from the dissolution of shells with increasing levels of reactive organic matter. This release of alkalinity could in turn buffer microenvironments and generate refugia for larval settlement and juvenile recruitment.

ESTUARINE REARING AND GROWTH OF JUVENILE CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) AS INFERRED FROM OTOLITH MICROSTRUCTURE

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Estuaries provide rearing and migratory habitat for juvenile Chinook salmon (*Oncorhynchus tshawytscha*). There is a remarkable amount of variation in juvenile habitat use and timing that can be difficult to quantify. This variation has been attributed to habitat complexity, for which estuaries may provide a critical matrix of habitats connecting watersheds to the sea. Habitat complexity has been shown to promote population diversity and support resilience in salmon populations; an acute management concern as we prepare for the effects of climate change on natural resources. In this study we will use otolith microstructure to identify and categorize the life history variation in juvenile Chinook caught in the Columbia River estuary over a two year period (2010-2012). Otoliths are fish ear stones through which structural and chemical analysis

can illuminate the age, growth and major migratory movements of individuals over their life-time. However ~75% of the Columbia River estuary is freshwater tidal and to date there is no known chemical signature for estuarine entrance. Our aim is to demonstrate a method for identifying estuarine rearing in a predominantly freshwater tidal system.

EMBATTLED BIVALVES: BIOGEOGRAPHIC DISTRIBUTIONS AND ABUNDANCES FROM THE BEAUFORT SEA TO THE GULF OF CALIFORNIA.

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As part of an EPA/USGS project to predict the relative vulnerability of near-coastal species to climate change, we have synthesized in a web-based tool, the Coastal Biogeographic Risk Analysis Tool (CBRAT), the biogeographic distributions and abundances of bivalves, found in depths <200 m, by twelve MEOW (Marine Ecoregions of the World) ecoregions, ranging from the Beaufort Sea to the Gulf of California (GOC). A total of 883 species have been reported over this domain, with the GOC having the greatest species richness (629) and the Beaufort the lowest (67). There are 29 endemic bivalves with the GOC having the majority (19) and Southern California the next highest concentration (5). Of the 72 families present, Veneridae is the most speciose with 85 species, while 11 families are only represented by a single species, of which 3 are considered nonindigenous. As a key trait to predicting climate vulnerability, we are presently assigning relative abundances to each species in each Ecoregion. The most progress has been made in the area between Southern California and Canada, where over 95% of the species have an assigned abundance. After further abundances are assigned, in combination with their other traits, the climate vulnerability of each species will be assessed. For instance, *Nuttallia obscurata*, a nonindigenous species with an increasing population, has a lower vulnerability than *Neaeromya compressa*, a commensal with relatively rare populations everywhere.

GROWTH AND LONGEVITY IN THE RED ROCK CRAB, *CANCER PRODUCTUS*.

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Red rock crabs, *Cancer productus*, are an important component of Pacific Northwest nearshore ecology and its crab fisheries. While an understanding of life history parameters are critical to fisheries management, few studies have been conducted on red rock crab. We studied growth and longevity of the red rock crab at two sites representing a heavily fished saline estuary population (Coos Bay, OR) and an unfished population (Friday Harbor, WA).

Growth in crustaceans is incremental and age classes are unmixed, making these investigations difficult. We used an array of techniques including size distribution analysis, growth within confinements, and mark recapture in describing growth and longevity of C. productus. Preliminary data shows 20-30% growth per molt increment and variability of intermolt period and timing related to size and sex. Longevity appears longer than previously described. In addition, there are clear differences in population structure between the two sites, perhaps related to fishery effects.
We are continuing the mark recapture studies at both sites as we are most confident with these empirical growth and longevity measurements from wild populations.

BROAD-SCALE ENVIRONMENTAL PREDICTORS OF THE INTERTIDAL ZONATION OF *Z. MARINA* AND *Z. JAPONICA* IN THE PUGET SOUND

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Physical and biotic factors can influence the distribution of species at multiple scales, and are thus important when predicting invasive species impacts. I examined the influence of physical context and congener presence on variability the vertical zonation of an invasive seagrass, *Z. japonica* and its native congener *Z. marina*. Nearshore intertidal topography, hydrodynamic exposure, and tidal range were examined as abiotic predictors of the deep extents of *Z. japonica* and *Z. marina*, the shallow extent of *Z. marina* and the elevation overlap of the two species, both at within site and among site spatial scales. *Z. marina* extended to higher elevations at transects that were less rough, more gently-sloped, less wave exposed, and in the presence of *Z. japonica*. Site-scale rugosity was the best predictor of site scale shallow extent of *Z. marina*. *Z. japonica* deep extent was explained by *Z. marina* shallow extent at both spatial scales, and also by rugosity when examining site-averaged patterns. Overlap of the two species along a transect was poorly predicted by physical context, but site-averaged range overlap was greater where depth profiles were more linear. Bottom profile complexity was the most consistently important predictor studied, confirming the importance of the geomorphic template on the zonation of these species. Furthermore, these findings suggest a greater sensitivity of *Z. marina* shallow extent to physical factors, and a greater sensitivity of *Z. japonica* deep extent to biotic factors.

EXTRACTIVE SURVEYS OF THE SUBTIDAL SEAWEEDS AND SEAGRASSES IN THREE OREGON MARINE RESERVES

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To protect its marine flora and fauna, the state of Oregon recently established 5 subtidal areas along its outer coast as no-take marine reserves, off-limits to all harvest except as necessary for monitoring and research. Baseline studies of sub-canopy seaweed and seagrass species richness and biomass have been completed at 3 of these reserves (Redfish Rocks, Otter Rock, and Cascade Head). A depth-stratified (5-15 m) random sampling method was used to investigate each “reserve area” which consisted of the reserve and a nearby comparison area.

30-36 (0.25 m2) quadrats were placed within each reserve area and extracted by divers. The quadrat material was then examined for macrophytic species richness and biomass. Together, the reserve areas yielded >137 species: 31% were common to all 3 areas, but 50% were found in only 1 area. Red algae comprised 79% of the species, but the highest biomass occurred among the brown algae: Laminaria longipes dominated Redfish Rocks and Cascade Head and Desmarestia herbacea dominated Otter Rock. Otter Rock had the greatest overall diversity with an average of 32.3 macrophytic species/quadrat. It also had the greatest species uniformity with 21% of the species occurring in >50% of the quadrats. Redfish Rocks was the most depauperate and patchy averaging 9.5 species/quadrat with only 8% that extended into >50% of the quadrats. The most prevalent species was the red alga Callophyllis flabellulata, which occurred in 92% of the sampled quadrats. Bray-Curtis-MDS plots will be used to illustrate the overall and within-area quadrat similarities.

SOME COMMON SUBTIDAL SEAWEEDS FOUND IN OREGON'S MARINE RESERVES

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Extractive surveys of three Oregon Marine Reserves have revealed >140 species of seaweed (macroalgae) in the benthos, at depths of 5-15 meters. Of these algal species, 80% were red, 12% were brown, and 8% were green. The brown algae, which include the large kelps, contained 65% of the biomass. Approximately 30 new distribution records to Oregon were found, including 6 species that are possibly new to science. Illustrations of 22 of the common species are provided, including 5 new records to the state.

SOME MARINE ALGAE FOUND ON JAPANESE TSUNAMI DEBRIS

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The Great Tohoku Earthquake and Tsunami of March 2011 generated nearly 1.5 million tons of floating debris (JTMD). After one to three years of drifting with currents across the Pacific, debris has reached the NE Pacific coast carrying Japanese marine species that may colonize our shores. Of the >50 algal species found on debris, 32 are not yet known to occur in Oregon. Illustrations of 20 of the species are provided, including 11 that are not yet known in Oregon.

DIFFERENCES IN LARVAL AVAILABILITY AND SETTLEMENT ACROSS INVERTEBRATE TAXA TO THE PUBLIC PIER IN YAQUINA BAY, OR

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The daily delivery and settlement of invertebrate larvae in Yaquina Bay, OR were investigated in relation to the influence of local oceanography and nearshore physical processes along the central Oregon coast. Sampling was conducted daily for 41 consecutive days (24 June 2013-3 August 2013) from the Newport Public Pier and timed to coincide with the end of the incoming high tide. Sampling consisted of plankton tows, two types of settling substrata (PVC plates and Tuffies), and water samples for chlorophyll-a and nutrients. Settling substrata were examined daily in the laboratory to quantify mussel, barnacle, and crab larval availability and settlement. Over the sampling period, six distinct physical events were identified including two major upwelling events lasting 10 and 13 days, respectively. Our results suggest that availability and settlement of barnacle larvae were coupled and positively correlated with upwelling events. In contrast, larval mussels settled later, larval availability was not coupled with larval settlement and neither was correlated with upwelling events. The highest species richness for larval decapods occurred during Spring tides, possibly in relation to the influx of coastal water during these periods of high water exchange. Comparison of larval availability and settlement across a diverse range of taxa suggests that different larval behaviors likely contribute to the variability in observed patterns.

THE ASSIGNMENT OF FEEDING GUILD CLASSIFICATIONS AND FUNCTIONAL ROLES TO ESTUARINE BENTHIC MACROINVERTEBRATES

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The assignment of feeding guild classifications and functional roles to estuarine benthic macroinvertebrates is a new effort being conducted by Ecology's Marine Sediment Monitoring Program (MSMP) in conjunction with the Puget Sound Ecosystem Monitoring Program. Functional information has been applied to elucidate food web dynamics and carbon pathway sources and sinks in past studies of Puget Sound, Strait of Georgia, and other estuaries worldwide. The guild classification system developed by Macdonald et al. (2012), which incorporates a suite of functional feeding characteristics: feeding mode, food type and source, motility and life habit, has been adopted by the MSMP and applied to the benthic taxa from samples collected between 1997 and 2012 in eight Puget Sound regions and six urban bays. Distribution maps have been generated from the abundance data. Spatial patterns and temporal changes in benthic feeding guild distribution are noted, and applicable extent of the modeling system is discussed.

TRANSGRESSIVE MIGRATION OPPORTUNITIES FOR TIDAL WETLAND DEVELOPMENT UNDER THE INFLUENCE OF FUTURE CLIMATE CHANGE IN PUGET SOUND

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The future distribution and resilience of tidal wetlands in Puget Sound will be influenced by a variety of processes, including climate change impacts such as accelerated sea level rise,

changes in river hydrology, and alterations in sediment delivery to the coastal zone. Under the influence of climate change, there is spatial and temporal variability in tidal wetlands submergence, adaptive capacity to remain in current distributions, and transgressive migration into newly inundated upland. The overall aim of this research is to conduct a spatially-explicit assessment of opportunities for transgressive migration and adaptive capacity of tidal wetlands to future climate change to plan for strategic conservation and restoration of tidal wetlands in Puget Sound. We use the Puget Sound Nearshore Ecosystem Restoration Project's (PSNERP) geodatabase as the baseline for existing tidal wetland distributions. We then parameterize the Sea Level Affecting Marshes Model (SLAMM) for variable conditions affecting local sea level change across Puget Sound to assess opportunities for tidal wetlands to transgressively migrate under future climate change as a function of the spatial variability in controlling processes such as eustatic sea level rise, vertical land movement, and hydrological alterations. A portfolio approach will capture potential changes in tidal wetland distributions at multiple time steps into the future and under a range of climate scenarios. The products of these projections are designed to highlight areas in Puget Sound where there are opportunities for tidal wetlands to transgressively migrate and persist, which can inform strategic conservation and restoration of current and future tidal wetlands.

EFFECTS OF OCEAN ACIDIFICATION ON THE EMBRYONIC DEVELOPMENT OF *METACARCINUS MAGISTER*

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Ocean acidification is a phenomenon taking place in response to the introduction of excess carbon dioxide into oceans from the atmosphere. Shell-forming organisms such as crustaceans are expected to be affected by inhibition of the calcification process in acidified water. Crustaceans make up 30% of the fisheries revenue in the United States and, according to the 2011 'Status of the Fisheries Report', for the past 10 years Dungeness crab (*Metacarcinus magister*) has ranked first in value compared to all other commercial fisheries. Besides shell production inhibition, hypercapnia may affect early development of crabs. To examine this, an experiment was conducted in a simulated ocean acidification environment on the embryos of four *Metacarcinus magister* crab ovigers. Embryos were held in carbon dioxide enriched seawater at three levels: an ambient concentration of 400 ppm, the moderate of 750 ppm, and the level projected by the IPCC for the year 2100, 1000 ppm. Physical development was monitored daily using a microscope and we recorded the number of days embryos spent in each of three stages. Mortality was observed in about one-fourth of the embryos, but did not significantly vary between treatments. Development was not significantly delayed; there was successful hatching in all three treatments and no significant variation in hatching between mothers or treatments.

TRAIT-BASED FRAMEWORK TO PREDICTING RELATIVE VULNERABILITY TO CLIMATE CHANGE IN NEAR-COASTAL SPECIES AND HABITAT

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Like Icarus, near-coastal species are "flying too close" to the sun, and are being impacted by climate-induced changes in air and ocean temperature, precipitation, salinity, ocean pH, sea level rise, and nonindigenous species. Sound management requires knowledge of what species and habitats are at the greatest risk and which climate changes are the major stressors. To address this issue, we are developing a trait-based framework to predict the relative vulnerability of near-coastal species based on available information: biogeographic distributions, habitat attributes (e.g., depth ranges), physiological limits, regional abundances, population trends, and niche specialization. The biotic data are synthesized and the vulnerabilities calculated in a web-based system, the Coastal Biogeographic Risk Analysis Tool (CBRAT). Vulnerability is assessed at the "Marine Ecosystems of the World" (MEOW) ecoregion scale, covering the species that occur in the 12 ecoregions spanning the Gulf of California to the Beaufort Sea. The framework has been applied to all the rockfish (*Sebastes* spp.) and brachyuran and lithodid crabs that occur at <200 m (total 462 species). One-hundred sixty (43.5%) brachyuran crabs, 10 (50%) lithodid crabs, and 39 (52.7%) rockfish were assigned high climate vulnerability in one or more MEOW ecoregions. Traits associated with high vulnerabilities differed among taxa. Among crabs, high vulnerabilities most frequently resulted because species are obligate symbionts (59 species), have exclusively intertidal distributions (57 species), or are endemic (48 species). In comparison, high vulnerabilities in rockfish most frequently resulted from the interaction of climate change and population declines due to overfishing (21 species).

A COMPARISON OF BULK ESTUARINE TURNOVER TIMESCALES TO PARTICLE TRACKING TIMESCALES USING A MODEL OF THE YAQUINA BAY ESTUARY

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The ability to determine a bulk estuarine residence timescale that is well-defined under realistic conditions is in high demand for estuarine research and management. We compare how residence timescales vary with tidal and river forcing from idealized forcing scenarios using a three-dimensional circulation model of the Yaquina Bay estuary in order to understand the limitations and benefits of different timescale methods for future application. Using model results, we compare bulk formula approaches–the tidal prism method, freshwater fraction method, and the new estuarine timescale calculation method based on the Total Exchange Flow (TEF)–to directly calculated timescales from particle tracking in order to assess the utility of the bulk formula timescales. All of the residence times calculated had similar magnitudes during high river discharge, but varied significantly at low discharge and had different dependences on tidal amplitude. Even in the application of a single estuary-averaged residence timescale, we did not find that any of the bulk residence timescales described the estuary over a realistic range of tidal and river discharge forcing. During high discharge, the Yaquina Bay residence time is on the order of 2-5 tidal cycles based on the particle tracking analysis, but during low discharge the residence time varies across methods and spatial considerations appear to be more important. The TEF method does not appear to be applicable to the Yaquina Bay; this method under predicts residence time and its dependence on river discharge and its utility in other estuaries is also unclear.

CHARACTERIZATION OF ECOSYSTEM STRUCTURE AND FUNCTION RECOVERY WITHIN THE NOAA MOC-P MITIGATION BASIN, NEWPORT, OREGON

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Seagrass ecosystems are considered some of the most productive coastal habitats in the world. Within estuaries of the Pacific Northwest, *Zostera marina* (eelgrass) is recognized to be an ecosystem engineering species that provides important ecosystem functions and services. In 2010, construction of the National Oceanic and Atmospheric Administration (NOAA) Marine Operations Center – Pacific (MOC-P) began in Yaquina Bay, Newport, OR. Construction of MOC-P included a 396-m pier; coupled with this construction were unavoidable ecological impacts to eelgrass ecosystems. The Port of Newport (PON) developed a compensatory mitigation plan, including the creation of a transplanted eelgrass bed, to offset losses caused by pier construction. To characterize ecosystem structure and function recovery within the NOAA MOC-P mitigation basin, we conducted an ecosystem-based approach to monitoring, rather than the single-target approach employed by PON. Ecological indicators and environmental variables were monitored over the course of 12 months at the re-planted mitigation bed and two nearby reference sites. Each eelgrass ecosystem monitored during this study was observed to be unique in structure, predominately driven by differences in physical setting. Most ecological indicators at the mitigation bed were comparable to those exhibited by an existing bed within the reference sites. After 12 months of monitoring, large-scale eelgrass cover increased at the mitigation site, which was the only significant change not observed at the reference sites. The re-planted eelgrass bed within the mitigation basin was observed to be an expanding bed that was adequately performing the functions associated with eelgrass ecosystems in the Pacific Northwest.

ASSESSMENT COPPER (ANTIFOULING) PAINT TOLERANCE IN SESSILE MARINE ORGANISMS − TRANSLATING LOCAL OBSERVATIONS TO GLOBAL AND EVOLUTIONARY PERSPECTIVE

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Copper in the form of cuprous oxides is the active agent used in most antifouling paints, designed to stop the growth of organisms on hulls and other submerged surfaces. While fouling rates on copper-painted surfaces are limited, leached copper may favor the spread of certain copper tolerant populations. This presentation compares and contrasts studies of copper tolerance in marine organisms, focusing on settlement panel dosing experiments conducted in marinas throughout California. The aim is to synthesize information from different geographic areas to better define how introduction history and local patterns of evolution influence copper tolerance.

ASSESSING BIOGENIC HABITAT IN OREGON'S NEARSHORE OCEAN USING ROV VIDEO

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The component of seafloor habitat consisting of structure-forming invertebrates and algae is often referred to as biogenic habitat. Examples include algae beds, sand dollar beds, seagrass beds, coral beds, sponge reefs, and other concentrations of structure-forming invertebrates growing on rocky substrates. These areas are important in that they provide shelter for fish, especially juveniles, and habitat structure for many other marine organisms. While we are gaining increased understanding of the physical components of seafloor habitat as a result of recent high-resolution seafloor maps for several nearshore rocky reefs, and while federal agencies are developing information on deeper-water biogenic habitat, we currently have little information on nearshore, shallow-water biogenic habitat and there are no quantitative assessments occurring to date. Biogenic habitat is quickly becoming the focus of conservation efforts due to its importance to fish and its vulnerability to impacts. The Marine Habitat Project at ODFW has initiated an investigation of methodological approaches for assessing biogenic habitat using Remotely Operated Vehicle (ROV) video transects, with an initial focus on assessing utilization by rockfish and associated demersal fish and invertebrates. The first phase of this project has used our existing video and invertebrate and habitat data derived from past ROV surveys to examine the range of invertebrate species encountered, patterns of their distribution, and statistical properties of the data. These data will be summarized, and associations of fish and invertebrates with distinct structural components of biogenic habitat will be presented and discussed.

STRESSED SEBATES: A TRAIT-BASED EVALUATION OF CLIMATE RISKS TO ROCKFISHES OF THE NORTHEASTERN PACIFIC USING THE COASTAL BIOGEOGRAPHIC RISK ANALYSIS TOOL (CBRAT)

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The EPA and USGS have developed a framework to evaluate the relative vulnerability of near-coastal species to impacts of climate change. This framework is implemented in a web-based tool, the Coastal Biogeographic Risk Analysis Tool (CBRAT). We evaluated the vulnerability of the 74 rockfish (*Sebastes* spp.) that are currently known to occur in 12 MEOW (Marine Ecoregions of the World) northeastern Pacific ecoregions from the Beaufort Sea down through the Gulf of California. Using traits such as relative abundance at an ecoregion scale, population declines, growth, productivity, and habitat preferences, we assigned a high vulnerability score to 39 of the 74 species of Northeast Pacific *Sebastes* in one or more ecoregions. 16 of the 30 (53%) rockfish species occurring within the Puget Sound ecoregion were given a high vulnerability, and 20 of the 52 (38%) rockfish species were given a high vulnerability in the Oregon, Washington Outer Coast ecoregion. Current population decline (largely from over fishing) coupled with projected additional stresses from climate change is the single most

important trait, accounting for 38% of the high vulnerability classifications. The second most important trait, accounting for 31% of the high vulnerability classifications, was rarity in the southernmost ecoregion of a species' range, which presumably reflects a vulnerability to climate warming. Greater detail regarding the process of assigning vulnerability scores, as well as an analysis of vulnerability by ecoregion will be presented.

MAPPING SUBMERGED AQUATIC VEGETATION USING SINGLE-BEAM SONAR: APPLICATION FOR NATURAL RESOURCE MANAGEMENT IN WASHINGTON STATE

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Submerged aquatic vegetation (SAV) provides important ecological functions for many marine organisms including fish, invertebrates, and birds. As a major marine land manager for the state of Washington, the Department of Natural Resources (DNR) is charged with providing economic and recreational opportunities for the state's residents, while protecting environmental resources for future generations. In order to manage protected marine vegetation, the DNR Aquatic Assessment Monitoring Team (AAMT) is developing remote sensing techniques using a single-beam sonar system for monitoring SAV and physical site characteristics. Acoustic methods are advantageous because they are capable of high-resolution tidal and sub-tidal habitat mapping. Also, due of the speed and ease of data collection, single-beam sonar allows for investigations at multiple spatial and temporal scales. Current study sites are located in nearshore habitats throughout the Puget Sound, Grays Harbor, and Willapa Bay. Geo-referenced data are collected and processed to determine vegetative distributions and habitat characteristics at each site. We will map the occurrence of SAV to determine patch characteristics and associate changes in distributions with physical site properties and water quality parameters. These results can inform management decisions for the placement of buffer zones around protected marine vegetation, and provide information on the magnitude and source of vegetative patch dynamics.

CAN OREGON MARSHES KEEP UP WITH THE RISING TIDE? A STUDY OF SHORT AND LONG TERM MARSH ACCRETION

T Chris Mochon Collura[1], Cheryl Brown[1], Theodore DeWitt[1], Chris Janousek[2]

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More frequent inundation of Oregon coastal marshlands associated with rising sea level threatens these important and diverse habitats. Study plot accretion rates determined by the marker horizon method and longer term peak Cs^{137} detection in eight marsh systems from Coquille to Tillamook were found to vary depending on a number of factors including plot elevation and plant species present. From 2009 to 2013, marker horizon plots in the low marsh generally accreted more, with a maximum observed accretion rate of 2.3 cm y^{-1} at one *Carex lyngbyei* dominated plot directly adjacent to the lower Siletz River. Inundated less frequently, high marsh plots had lower annual accretion rates which were often times below the current rate of sea level rise for the region. These results agree with long term accretion rates determined

from Cs^{137} deep (~0.5 m) cores. Our results suggest that low marsh habitat in Oregon estuaries may be able to keep pace with the current rate of sea level rise. Accretion rates from this study will also be compared to others in the region.

CONSEQUENCES OF SALINITY ON GROWTH AND TISSUE CHEMISTRY IN EELGRASS (*ZOSTERA MARINA)*

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Historically, wasting disease caused by the protist *Labyrinthula zosterae* has negatively impacted eelgrass (*Zostera marina*) in the North Atlantic. When eelgrass is stressed, it may become more susceptible to the disease. Previous studies have suggested that conditions of lower salinity are more optimal for eelgrass, and results in lower levels of wasting disease. *Labyrinthula zosterae* is present in eelgrass meadows of Washington State, USA. In this study, we tested whether salinity is a stressor by measuring eelgrass growth rates. Eelgrass from Ship Harbor, WA was grown in a laboratory tank experiment for three weeks in salinities ranging from 5 to 35 ppt. Eelgrass growth rates were measured by leaf elongation. No differences in growth were found amongst the salinity treatments. This result suggests that eelgrass was not stressed by salinity. However, salinity may influence eelgrass' production of phenolic compounds, which could defend against wasting disease, but further investigation is necessary.

SEAWALLS AND SEATTLE: EFFECTS OF SEAWALL ARMORING ON SUBTIDAL FISH AND CRAB ASSEMBLAGES IN ELLIOTT BAY

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Shoreline armoring is prevalent worldwide, yet its ecological effects are poorly understood. In this study, we monitored shallow subtidal fish and crab communities in three sites modified by seawall armoring and three reference beaches with minimal anthropogenic structure within the urbanized estuary of Elliott Bay, WA for eighteen months. Overall fish densities were greater at reference beaches, although these habitats were deeper, and overall crab densities were greater at seawall sites. Species presence was correlated with species habitat preferences. In particular, species that were associated sandy habitats were more abundant at reference beaches and virtually absent at seawall sites. Species assemblages at seawall sites and reference beaches were significantly different during both high and low annual periods of fish abundance. One of the reference beaches in this study was a recent habitat enhancement site and was inhabited by fish not seen elsewhere, including black rockfish, quillback rockfish, and larval fish. All three beaches monitored in this study were restoration sites that were previously armored, suggesting that restoring some of the benthic structure to modified sites may promote habitat use. These results contribute to a growing literature that suggests that shoreline armoring can impair the value of nearshore habitats to fish and crabs, although some species in our system may benefit from habitat modification, and that the fish communities of many modified nearshore habitats may be different than those occurring historically.

SEDIMENT TOTAL ORGANIC CARBON: IS THIS A USEFUL INDICATOR OF SEDIMENT CONDITION FOR PACIFIC NORTHWEST ESTUARIES?

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Total organic carbon (TOC) content of sediments has been used as an indicator of benthic community condition during multiple cycles of the EPA National Coastal Assessment (NCA). Because percent TOC is generally positively correlated with sediment percent fines, previous analyses have shown that an uncorrected TOC index will substantially overestimate potentially impacted sites. Within the Pacific Northwest region, individual estuaries differ significantly in the regression slopes that relate TOC to grain size, and estuary classification has so far failed to provide insight into the drivers of this variation. Within an individual estuary, the spatial variation in depositional versus erosional conditions may drive the relationship. Given the multiple sources of variation, we conclude that TOC is currently not a useful indicator of marine benthic condition in estuarine condition assessments.

CHANGES IN PUGET SOUND BENTHIC MACROINVERTEBRATE ASSEMBLAGES AS CHARACTERIZED WITH FUNCTIONAL FEEDING GUILDS

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Recent reports from the Washington State Department of Ecology (Ecology) Marine Sediment Monitoring Program (MSMP) have documented declines in benthic macroinvertebrate assemblage condition throughout several geographical regions and urban bays of Puget Sound, based on comparisons of data from baseline (1997-2003) and resample (2004-2012) surveys. Community condition was characterized with a suite of structural abundance and diversity indices and an overarching Benthic Index. Previous relational analyses conducted on baseline data collected from 1997-1999 showed correspondence between community structure, station depth, sediment particle size, and percent total organic carbon; however, no clear relationship was seen between community structure and levels of toxic contaminants in the sediments. To better understand the mechanisms driving community composition and its changes over time, all benthos data collected from 1997-2012 have been reexamined to characterize benthic assemblages on a functional, rather than structural, level. Feeding guild and functional role classifications developed by Macdonald et al. (2012) have been assigned to the benthic taxa identified in our samples. Relationships between these functional measures of benthic assemblages and synoptically collected physical and chemical sediment measurements will be discussed. Other environmental measures not currently measured by the MSMP, but which may affect benthos community composition, will also be discussed, including water column parameters, phytoplankton shifts, nutrient conditions, and chemicals of concern.

DOES JAPANESE EELGRASS (*ZOSTERA JAPONICA*) AFFECT RECRUITMENT AND GROWTH OF MANILA CLAMS, AND THE GROWTH AND CONDITION OF PACIFIC OYSTERS?

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The Willapa Bay shellfish industry has purported that the thick infestations of Japanese eelgrass (*Zostera japonica*) over thousands of hectares is problematic for commercial clam beds. Using a series of replicated field trials where *Z. japonica* was removed using the herbicide imazamox, we examined how *Z. japonica* affects the recruitment, growth as a function of age class, and commercial harvesting efficiency of Manila clams, and growth and condition index of Pacific oysters. Recruitment density of Manila clams was not affected by *Z. japonica* removal or by site enhancement using crushed oyster shells (20 m^3/ha). Summer growth of two and three year-old clams was reduced by *Z. japonica* by 16% and 13% respectively, but there was no effect on older clams. The time to commercially harvest marketable clams on a bed was not affected by *Z. japonica*, but the number of marketable clams left unharvested increased by 8%. Control of *Z. japonica* on two commercial oyster beds resulted in a 14% increase in oyster condition index and total meat wt./oyster after one summer of growth at one site, but not on the other. Overall, *Z. japonica* does appear to be detrimental to commercial shellfish production in Willapa Bay, but the significance of that effect is site and age-class dependent.

RESPONSE OF A DEVELOPING SALISH SEA DIATOM BLOOM TO OCEAN ACIDIFICATION

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Increasing atmospheric carbon dioxide (CO_2) acidifies the ocean through a series of reactions involving CO_2 and water, and is known as ocean acidification. While most studies to date focused on how reduced pH affects calcifying marine organisms, comparatively little is known about how increasing pCO_2 affects the physiology and biochemistry of primary producers, especially the phytoplankton. Any pCO_2 effect to phytoplankton may alter marine food webs, and have widespread implications for the health and stability of marine ecosystems. In this study we explored how elevated pCO_2 affects the physiology, biochemistry and community composition of a developing diatom bloom. To test this, we diluted a natural community of Salish Sea plankton to 5% with pre-equilibrated filtered seawater at one of three pCO_2 concentrations (400, 750, and 1000 ppmv). The plankton communities were then allowed to incubate in atmospheres of equivalent CO2 concentration, allowing air-sea gas exchange to modulate CO2 chemistry, rather than more intrusive techniques. During the development of the bloom we sampled for chlorophyll a, nutrients (N, P, Si), particulate organic carbon and nitrogen, pCO_2, and community composition. While no changes were observed in chlorophyll a or community composition across pCO_2 treatments, we found a significant increase in organic carbon, but not organic nitrogen, in the community grown under elevated pCO_2 compared to lower pCO_2 treatments. A higher concentration of carbon in phytoplankton under elevated pCO_2 suggests that in a future, acidified ocean, the nutritional quality of phytoplankton will be compromised, thus affecting marine food web efficiency.

PREDICTING AND MEASURING CO_2 SEQUESTRATION WITHIN AN EELGRASS (*ZOSTERA MARINA*) MEADOW

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Eelgrass contributes directly to CO_2 sequestration when its tissues do not completely mineralize, and indirectly when organically laden sediment becomes trapped and buried within a meadow. The sequestration potential is widely acclaimed because of its high tissue production and sloughing rates, and slow decay rate. An accurate estimate of CO_2 sequestration must take into consideration that 1) Tissue production and loss varies temporally and spatially within a meadow, 2) Decaying tissue can be beached, buried or settled out in deep sea, and 3) The ability to trap sediments depends on the amount and form of the external supply, the structure of the meadow, as well as the hydrodynamics. Tissue production and loss under different environmental conditions can be modeled and/or measured. Sediment capture and burial can be measured and predicted under certain conditions. The quantity of beached material and material exported to deep sea cannot be predicted, but can, however, be measured. These methods are reviewed towards the objective of developing feasible sampling plans for obtaining the data needed to conservatively estimate the CO_2 sequestrated by an existing estuary containing eelgrass meadows or to predict the sequestration potential of an eelgrass restoration project. A case study will be provided.

EVALUATING THE FUTURE OF PADILLA BAY'S EELGRASS HABITAT IN THE FACE OF SEA LEVEL RISE: AN ECOGEOMORPHIC FIELD AND HYBRID MODELING APPROACH

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Estuaries worldwide are facing the possibility of conversion to open water if accretion cannot keep pace with increasing rates of eustatic sea level rise (ESLR) due to climate change. Recent research into sediment elevation dynamics in Padilla Bay, a National Estuarine Research Reserve in Puget Sound, WA, has revealed a mean bay-wide elevation deficit of -0.39 cm yr^{-1} since 2002. Using field data collected as part of this research (measurements of sediment accretion rates, suspended sediment concentrations, eelgrass stem density, and above- and belowground eelgrass biomass) we modified, initialized, and calibrated a mechanistic and non-linear Marsh Equilibrium Model (MEM) to predict the response of this eelgrass-dominated estuary to rising sea levels. We then coupled the MEM with a Relative Elevation Model (REM) to create a hybrid that combines each model's strengths in simulating above- and below-ground processes, respectively. The hybrid model predicts elevation change under various ESLR and suspended sediment scenarios. We used an 11-year elevation change dataset obtained from an extensive surface elevation table network in Padilla Bay for model validation. Here we present model structure and preliminary results suggesting sediment accretion rates to be primarily

determined by stem density instead of plant biomass or water depth, which differentiates this model from its predecessors.

ABUNDANT OR RARE? A HYBRID APPROACH FOR DETERMINING SPECIES RELATIVE ABUNDANCE AT AN ECOREGOIONAL SCALE

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Everyone knows what abundant and rare species are, but quantifying the concept proves elusive. As part of an EPA/USGS project to assess near-coastal species vulnerability to climate change affects, we designed a hybrid approach to determine species relative abundance at an ecoregional scale as defined by the Marine Ecoregions of the World (MEOW). Over the continuum from absent to very abundant, many different phrases have been used to describe abundance. To resolve this conundrum, we developed a hierarchical abundance schema, with three levels of detail. We then developed guidance for interpreting natural history text in terms of relative abundance within a habitat and across the entire ecoregion. Recognizing that not all data are created equal, we combined as many sources as possible including quantitative data, qualitative data, expert opinion, frequency of occurrence in online biodiversity databases, and known spatial distribution using a weighted approach to identify a species' abundance relative to other species in the same taxon/guild within the ecoregion. A key factor in assigning the relative abundance at the ecoregional scale is not only the species' abundance within a particular habitat but the area of the habitat; species very abundant in a limited habitat may be rare at the ecoregion scale. Details of this methodology, results of applying it to the 74 rockfish (*Sebastes* spp.) and 388 brachyuran and lithodid crabs in the 12 ecoregions from the Beaufort Sea to the Gulf of California, and the web based Coastal Biological Risk Analysis Tool (CBRAT) will be presented.

LARVAL SUPPLY, SETTLEMENT, AND POST-SETTLEMENT PROCESSES AS DETERMINANTS OF THE SPATIAL DISTRIBUTION OF OLYMPIA OYSTERS (*OSTREA LURIDA*) IN COOS BAY, OR

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The Olympia oyster (*Ostrea lurida*) is the target of several restoration efforts along the west coast of the United States, where it is native. Often, restoration efforts focus on laying down shell to encourage larval settlement. These efforts would be aided by a better understanding of the larval dispersal patterns, settlement behavior, and post-settlement mortality of oysters in the estuary of interest. In Coos Bay, Oregon, we investigated all three of these components of the oyster life cycle at multiple sites throughout the estuary. We used time-integrative sampling techniques-- larval tube traps and settlement plates-- to sample larvae and settlers every two

weeks during the summer and fall of 2012 and again in 2013. We also monitored the survival and growth of older oysters at these same sites during the first half of 2013. Not only did larval abundance, settlement, survival, and growth vary throughout the bay, the relationship between larvae and settlers also changed depending on location. Larvae of this species are apparently restricted to the upper portion of the bay; differential settlement success, early post-settlement survival, and growth patterns appear to structure the population within that range. We hope that our results will help inform projects intent on revitalizing this struggling native species.

IN HOSPITE HYDROGEN PEROXIDE PRODUCTION OF TWO SYMBIOTIC ALGAE HOSTED BY *ANTHOPLEURA ELEGANTISSIMA* UNDER TEMPERATURE AND IRRADIANCE STRESS

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Increasing ocean water temperature, associated with global climate change, can cause cnidarian bleaching, threatening anemones, corals, and other symbiotic cnidarians. Reactive oxygen species like H2O2, produced by symbiotic algae under irradiance and temperature stress, result in symbiosis breakdown. The intertidal sea anemone *Anthopleura elegantissima*, hosts two very different symbionts, *Symbiodinium muscatinei* (zooxanthellae) and *Elliptochloris marina* (zoochlorellae). To test for differences in H_2O_2 production by the two symbionts, *A. elegantissima* tentacles containing either zooxanthellae or zoochlorellae were exposed to irradiances of 0, 100, or 900 µmol quanta m^{-2} s^{-1} at 10°C and 20°C. Although similar studies have been done with isolated symbionts, it is known that extraction from the host anemone stresses the cells, potentially increasing H_2O_2 production. In our study, temperature had no significant effect on H_2O_2 production in either of the symbiotic states, but both zooxanthellate and zoochlorellate anemone increased peroxide production significantly in the highest light treatment. The effect, however, was more dramatic in anemones hosting zooxanthellae, suggesting, contrary to our expectations, that anemones hosting zooxanthellae have a greater H_2O_2 burden despite the superior ability of zooanthellae to photoacclimate to high temperature and irradiance. Further work is needed to reconcile this conclusion with the fact that *A. elegantissima* at high tidal elevations generally host zooxanthellae.

ACOUSTIC TELEMETRY STUDIES OF DUNGENESS CRAB IN THE COLUMBIA RIVER ESTUARY

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The Columbia River estuary and the adjacent nearshore zone are important habitat for Dungeness crab (*Cancer magister*), and these areas support valuable commercial and recreational fisheries. The estuary sustains high density of juvenile crabs and is thought to function as a nursery, while larger crabs and especially females migrate to more saline nearshore habitat to mate and release brooded larvae. However, little is known about these crab migrations or indeed crab distribution and movements within the estuary. Additionally, dredge operations in the mouth of the Columbia and sediment deposition events in the

nearshore impact crab populations. For the past several years, we have been investigating crab population dynamics and movements in Baker Bay, a large lateral bay near the mouth of the Columbia River. Acoustic telemetry utilizing both mobile tracking and moored receivers is being used to follow the position of tagged crabs. Additionally, we are using acoustics and video sampling to investigate dredge deposition events on crabs in the nearshore zone. This presentation will report the results of recent studies of crab movements in the Columbia River estuary.

ARE HARVESTS OF COCKLES (*CLINOCARDIUM NUTTALLII*) FROM NETARTS BAY (OREGON) MANAGED IN A SUSTAINABLE MANNER? A REVIEW OF COMMERCIAL AND SPORT HARVESTS OVER 2008-2013

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Netarts Bay is a 2,300 ac (9.4 km^2) tidal basin located on the northern Oregon coast. Intertidal and subtidal zones of the bay are home to diverse communities of shellfish, including Dungeness crab, red rock crab, and several species of clams (gaper clams, butter clams, cockles, littleneck clams, purple varnish clams, Olympia oysters, and many others). Cockles (*Clinocardium nuttallii*) are a popular target for recreational and commercial clammers, and recent concerns have been raised about sustainability of the harvests. To ensure that commercial and sport harvests are managed at sustainable levels, the Oregon Department of Fish and Wildlife (ODFW) Shellfish Program carries out diverse activities including: (1) establishment of commercial regulations; (2) monitoring of commercial catch rates; (3) enactment of sport fishing regulations; (4) creel surveys to monitor sport clammers; and (5) bay-wide shellfish stock assessment surveys. A review of ODFW shellfisheries records indicates that cockles are currently being harvested by commercial and sport clammers from Netarts Bay in a sustainable manner. ODFW records show that the number of digger trips by sport clammers has not increased over the past five years, the number of active permitted commercial harvesters has declined, the Catch-Per-Unit-Effort for sport clammers has been relatively constant, the total number of cockles collected by sport diggers has remained reasonably stable, and the overall number of cockles removed by commercial harvesters has decreased over time. These findings will be re-evaluated in 2015 when data become available for the new ODFW SEACOR shellfish stock assessment in Netarts Bay.

CAN SEAGRASS PROVIDE REFUGIA FROM OCEAN ACIDIFICATION FOR ESTUARINE BIVALVES?

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Ocean acidification (OA), caused by the invasion of anthropogenic carbon dioxide from the atmosphere into oceanic waters, reduces pH and the saturation state (Ω) of calcium carbonate minerals. Reduced Ω has been shown to negatively affect growth and survival of some species of marine calcifiers. “Phytomitigation,” which relies on the uptake of carbon dioxide by marine primary producers via photosynthesis and subsequent removal of organic matter via sinking and

burial, is one proposed strategy to combat the OA threat. However, primary producers support heterotrophic communities, and themselves respire, and therefore are also associated with carbon dioxide production, driving immense diurnal swings in carbon-related parameters. The utility of phytomitigation is therefore unclear. Our study will examine the potential of seagrass habitats, in one Oregon estuary, to provide refugia from OA via phytomitigation. We will deploy instrument packages to record carbon dioxide, partial pressure, light, oxygen, temperature, conductivity and pressure at fore- and back-bay locations, as well as within and outside the beds of two species of seagrass: *Zostera marina* and *Zostera japonica*. The two species differ greatly in their morphology, and may have different effects on local carbon chemistry, on daily and seasonal time-scales. We will deploy newly set juveniles of the bivalve species, *Saxidomus giganteus* and *Crassostrea gigas*, to the same sites to determine whether integrated differences in local chemistry have effects on condition and growth. The resulting data will potentially inform decisions regarding the implementation of phytomitigation strategies, such as the co-culture or co-restoration of seagrass and bivalve species.

HYDROLOGY IN A PEATY HIGH MARSH: HYSTERETIC FLOW AND BIOGEOCHEMICAL IMPLICATIONS

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Terrestrial nutrient input to coastal waters is a critical water quality problem worldwide, and salt marshes may provide a valuable nutrient buffer (either by removal or by smoothing out pulse inputs) between terrestrial sources and sensitive estuarine habitats. One of the major challenges in characterizing whether salt marshes provide this ecosystem service is quantifying the role of subsurface nutrient processing. This in turn depends on tidal/rain infiltration, water movement through variably porous layers of the marsh, and biogeochemical processing within those layers. To address the hydrologic controls, we installed groundwater and piezometric wells in various portions of a well-studied, 2-hectare, meso-haline salt marsh in Yaquina River (Oregon) estuary. Analysis of sediment cores for texture, organic content and bulk density revealed 10-20cm of porous, compressible peat overlying approximately 1.5 m of relatively impermeable clay/silt in the high marsh, which comprised >80% of marsh area. Water infiltrated the surface peat layer very rapidly on overtopping tides and rain events, and pore space remained filled for hours to days depending on precipitation. The water holding capacity in the upper 15 cm along with dry period percolation data was used to estimate flow rate through the system under both dry and saturating precipitation conditions. The implications for solute introduction and transport, along with how this may affect nitrogen dynamics, will be discussed.

UNDERSTANDING THE ECOLOGY OF A NON-ENDEMIC EELGRASS IN PACIFIC NORTHWEST ESTUARIES

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Zostera japonica is a non-native eelgrass brought in from Japan that is increasing in range and density in Pacific Northwest (PNW) estuaries. Eelgrass habitat provides important ecosystem services for coastal communities, commercial fisheries, and water quality. Recent decisions in Washington State to treat *Z. japonica* as a noxious weed revealed an emergent need to establish baseline knowledge regarding its effects on the ecology of the PNW estuaries. The goals of this project were to quantify the ecological role that *Z. japonica* plays by (1) comparing use of estuarine habitat types including *Z. japonica*, native *Zostera marina* and clam aquaculture via paired deployment of cameras and small fish traps and (2) examine the effect of habitat type on recruitment and survival of juvenile Dungeness crab. Review of video footage yielded a total of 11 species that utilized these habitats in Willapa Bay, Washington. Comparison of CPUE across all habitat types revealed no difference in total CPUE of all species combined. Habitat was found to be a significant predictor of total catch per unit effort (CPUE) for the top four observed species (Dungeness crab, surf perch, staghorn sculpin, and three-spine stickleback), but there was not enough power to discern where this habitat effect occurred. Examination of crab recruitment across intertidal habitat types indicates that recruitment of Dungeness crab is enhanced in structured eelgrass habitat when compared to clam aquaculture beds.

EUTROPHICATION AND ACIDIFICATION IMPACTS ON SEAGRASS DO NOT EQUALLY TRANSLATE TO ITS CONSUMERS.

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Ecological redundancy may be critical for ecosystem maintenance. Still, there are many gaps in our understanding of interspecific differences within a functional group, particularly regarding whether members of a functional group respond equally to anthropogenic stressors. Herbivores are crucial in determining the abundance, composition, and structure of plant communities, and plants have evolved numerous defence strategies to decrease such impacts. We examined the independent and interactive effects of two anthropogenic stressors (ocean acidification and eutrophication) on a seagrass and its two common herbivores. Both disturbances modified seagrass resistance traits against herbivory by altering nutritional quality and chemical defense content, and altered the plant's tolerance strategies such as leaf production and carbon reserves, but there were contrasting responses of herbivores to such plant changes. Acidification, eutrophication and their interaction influenced herbivore feeding behaviour, yet while sea urchins preferred nutrient enriched seagrass (regardless of acidification), isopods were deterred by these tissues. Contrastingly, carbon enrichment deterred sea urchins and attracted isopods, while the carbon x nutrient enrichment was never preferred. Such differing herbivore responses to disturbance-induced changes in seagrass have important implications regarding our understanding of ecological redundancy and the management of seagrass ecosystems under anthropogenic stress. ecological redundancy and the management of seagrass ecosystems under anthropogenic stress.

A SUMMARY OF RECREATIONAL CRAB CATCH AND EFFORT IN OREGON.

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The Shellfish Program of ODFW recently published an Informational Report, "The Oregon Recreational Dungeness Crab Fishery". That report includes estimates of recreational crabbing effort and catch throughout Oregon (the main estuaries, the lower Columbia river, and the nearshore ocean) from 2007 through 2011. The methods for producing estimates in each of those fisheries differ slightly. Overall estimates are probably low due to seasonal and spatial sampling gaps, though they still point out that the recreational fishery accounts for around 5% of the total take when compared to the commercial fishery. The report is available at https://nrimp.dfw.state.or.us/CRL/Reports/Info/2012-04.pdf and includes descriptions of the bays we surveyed and associated data for each. This poster summarizes the main points in the report, introduces some related topics, and provides an opportunity for the discussion of catch and effort estimation methods in this and other fisheries.

LAMPREY ARE THE NEW SALMON: RIVER AND PACIFIC LAMPREY IN THE COLUMBIA RIVER ESTUARY

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Recent coast-wide declines in Pacific Lamprey (*Entosphenus tridentatus*) populations have led to concerns about the long-term viability of the species, mirroring the downward trends and concerns for Pacific salmon in the 1990s. Unlike salmon, however, very little is known about the basic biology and ecology of native anadromous lamprey. To address this deficiency, we provide the first study of anadromous Pacific and River (*Lampetra ayresii*) Lamprey in the Columbia River estuary, using data from two fish community studies that bracket three decades (1980-81 and 2001-12). River and Pacific Lamprey showed distinct seasonal abundance patterns, with Pacific Lamprey juveniles and adults present in the estuary during winter and early spring while River Lamprey were present during summer months. During 2008-2012 we also documented lamprey wounds on eight fish species caught in the estuary. The most commonly wounded fishes were non-native American Shad (*Alosa sapidissima*), subyearling Chinook Salmon (*Oncorhynchus tshawytscha*), Shiner Perch (*Cymatogaster aggregata*), and Pacific Herring (*Clupea pallasii*). This basic information about lamprey in the Columbia River estuary adds to the growing body of regional research that should aid conservation efforts. Our results also highlight the fact that life history traits such as timing, size, and residency, as well as host selectivity, vary among lamprey populations.

BIOGEOGRAPHY OF ECOSYSTEM ENGINEERS: COMMUNITY RAMIFICATIONS

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The biogeographic patterns of large marine intertidal organisms on the coast of Europe have a historical record of over 100 years and due to upwelling zones individual species often have more than one northern or southern limit. This mosaic nature of the European coast allows one to test proposed mechanism and validate models at multiple locations. We will demonstrate this for two intertidal species, the foundation barnacle species *Semibalanus balanoides* on rocky shores and the ecosystem engineer *Diopatra* in sediments.

Long term trends of biogeographic change can reverse and distributions shift rapidly on short time scales as a function of extreme climatic events. The boreal barnacle *Semibalanus* illustrated this after the extreme winter of 2009-2010 when it expanded its range to the south by ~100 km, and filled in gaps in its distribution where it had not been seen in decades. In the Pacific Northwest another ecosystem engineering polychaete *Abarenicola pacifica* is illustrative of the reversal of patterns due to such oceanographic effects as the Pacific Decadal Oscillation.

MICROSATELLITE DESIGN AND APPLICATION IN *WATERSIPORA* (BRYOZOA), A COMPLEX OF INVASIVE SPECIES

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DNA microsatellites are a popular tool used in genetic analysis of populations. The number of microsatellite loci analyzed and the variability of each locus contribute to the utility of microsatellite analysis. The purpose of this study was to identify potential microsatellite loci in the invasive bryozoan *Watersipora* sp., a complex of cryptic species associated with hull fouling around the globe. The genomes of four *Watersipora* colonies were sequenced using Illumina paired-end sequencing. Potential microsatellite loci were identified in the four genomes using the program PAL-Finder. Primer 3 was used to identify forward and reverse primers for each locus. A set of ten microsatellites was tested for variability by performing PCR on samples of two cryptic species of *Watersipora* (*subtorquata* and new species). Samples were also compared using cytochrome c oxidase I (COI) mitochondrial gene sequences. Samples were collected from six locations along the California coast and in Australia, regions where the widespread range of invasions in this species complex has been observed. Initial genotyping data suggests COI DNA barcodes have reliably shown non-interbreeding species, and that there are regional intraspecific differences in genetic diversity in introduced populations.

STATUS OF THE EUROPEAN GREEN CRAB IN THE PACIFIC NORTHWEST.

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European green crabs (*Carcinus maenas*) were first introduced into San Francisco Bay during the 1980's and spread northward during the 1990's via larvae carried on in ocean currents. North-ward flowing currents were especially strong during the unusually warm and strong El Niño of 1997-1998, during which green crabs spread to Oregon, Washington and British

Columbia. Since this colonizing event, green crabs in Oregon and Washington, have persisted, but only produced new cohorts after warm winters (2003, 2005, 2006 and 2010). While green crabs are rare in Oregon and Washington, they are thriving in the inlets on the west coast of Vancouver Island. Recent range expansion into the Central Coast of British Columbia and Sooke causes concern that green crabs may soon expand their distribution into Alaska and the Salish Sea, either through larval transport or via shellfish culture. Once a satellite population of European green crabs is established in the inland sea, the invader would spread rapidly as favorable habitats are abundant and larvae would be retained. DFO has developed regulatory measures for aquaculture and shellfish growers that are designed to prevent the transfer of green crab to uninfected areas. Collaborative "monitoring" arrangements have been set up between DFO and the First Nations in Bella Bella and in Sooke, with the hope of reducing the reproductive capacity of these two satellite populations. Recent monitoring efforts by DFO did not detect any green crabs in the Salish Sea. Cooperative sampling programs by DFO, Alaska, and Washington agencies are planned for 2014 and 2015.

APPLICATION OF A EUTROPHIC CONDITION INDEX TO BENTHIC MACROALGAL ACCUMULATION IN PACIFIC NORTHWEST ESTUARIES

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Studies of benthic macroalgal accumulation in coastal estuaries of the Pacific Northwest, USA, were conducted over a 12-year period, including aerial mapping and ground surveys. The results were applied to an assessment framework for eutrophication developed by the European Union and recently used to evaluate macroalgal accumulation in the Southern California Bight. A detailed five-year, fixed-transect survey in Yaquina estuary, Oregon revealed large temporal and spatial variations in average accumulation and corresponding eutrophic condition index (ECI) values during the summer-fall period of highest percent cover and biomass. Two sites with similar average macroalgal accumulation and ECI values had very different levels of sediment pore water sulfides, known to be highly toxic to benthic organisms. Thus, other factors (e.g., water flow, sediment porosity, bioturbation) not included in the ECI may be important in determining the impact of high macroalgal accumulation on the benthic environment. However, application of this ECI to macroalgal results from probabilistic field surveys of 13 PNW coastal estuaries conducted between 2004 and 2009 generally yielded ratings between "good" and "high" indicating little or no eutrophication in these systems, in contrast to results reported for many of the southern California estuaries. Further, aerial monitoring of summer macroalgal extent in Yaquina estuary between 1997 and 2009 revealed no indication of a systematic increase in abundance of this benthic macrophyte.

SEASONAL AND SPATIAL PATTERNS OF LOW-DISSOLVED OXYGEN IN BELLINGHAM BAY

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Hypoxia is a common effect of eutrophication and, for the past sixty years, an increasing problem in coastal marine ecosystems. It is often the result of phytoplankton blooms, where sinking organic matter produces an increase in heterotrophic microbial activity and subsequent decreases in dissolved oxygen concentrations. Hypoxic incidents have been reported in Bellingham Bay (Bellingham, WA) by Lummi fishermen during summer months, but there is evidence that normoxic conditions return to bottom waters in the winter. In order to understand the seasonal and spatial extent of hypoxia, water samples have been collected in Bellingham Bay throughout 2013-2014 to examine changes in stratification, nutrient supply, oxygen concentrations and respiration. The purpose of our study was to identify if normoxic conditions return during winter months and explore the environmental conditions that cause this. We hypothesized that, when there is seasonal hypoxia, there is stronger stratification, more nutrient supply to the system, and elevated oxygen consumption in bottom waters. This study also looked at how additions in carbon and increases in temperature during winter potentially affect oxygen consumption. Stratification was found to be a predictor of hypoxia and was stronger in stations close to the Nooksack River. Stratification during summer months coincided with periods of upwelling, although stratification also appears to be influenced by spring tide events. Our study supports the idea that hypoxia occurs predominantly in summer months and is influenced by stratification, although there are other environmental factors at play.

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