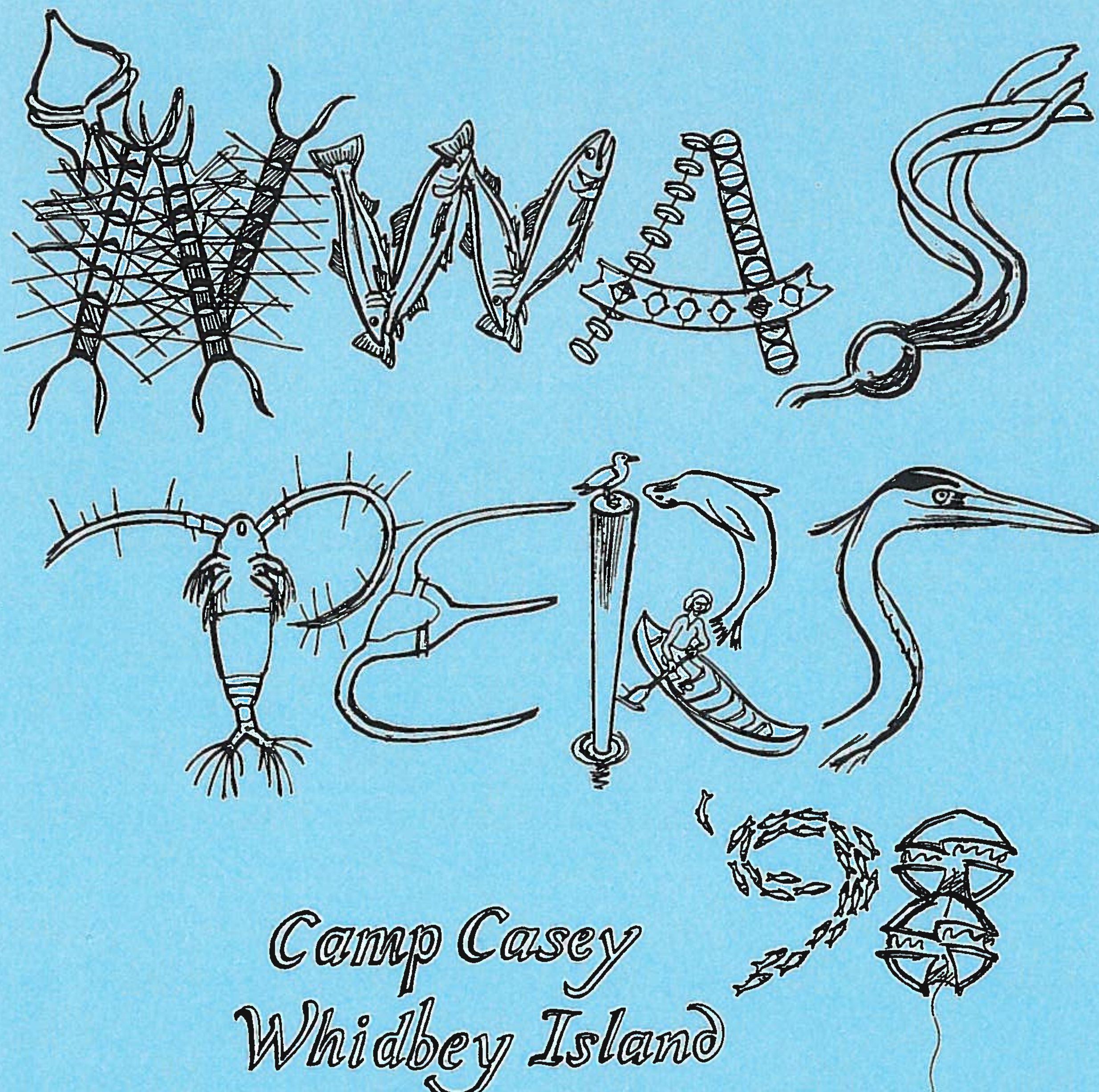


Camp Casey
Whidbey Island

Northwest Algal Symposium and Pacific Estuarine Research Society Joint Meeting

May 29-31, 1998

Shannon Point Marine Center

Padilla Bay
National Estuarine Research Reserve

12th NWAS

1998
Pacific Estuarine Research Society and Northwest Algal Symposium Joint Meeting

May 29-31, 1998
Casey Conference Center
Whidbey Island, Washington

Conference co-organizers:

Gisèle Muller-Parker, Suzanne Strom, and Douglas Bulthuis

Host Institutions:

Shannon Point Marine Center
(Western Washington University)

and

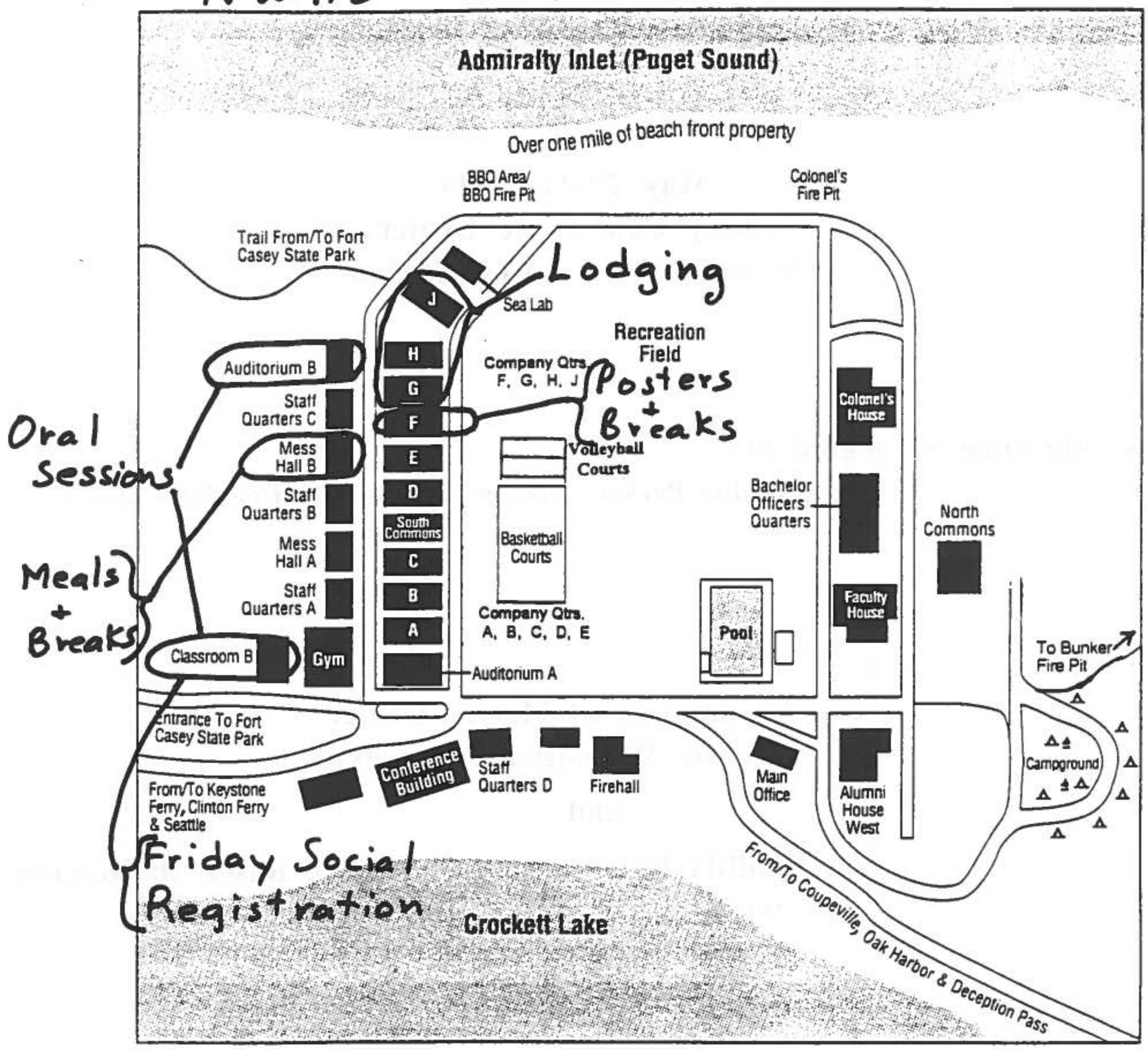
Padilla Bay National Estuarine Research Reserve
(Washington State Department of Ecology)

Acknowledgments:

Special thanks to the host institutions, Shannon Point Marine Center (Western Washington University) and Padilla Bay National Estuarine Research Reserve (Washington Department of Ecology) for support throughout the preparation of this meeting; to staff and volunteers at the host institutions and especially to Mary Ann Merrill and Ruth Schmit of Shannon Point Marine Center for handling registration, housing and speaker requests; to Hydrolab for financial support; to Jan Newton for organizing student awards; and to Dean Jacobson for designing the meeting logo for the T-shirts and program cover.

Casey Conference Center
Campus Map

NWAS and PERS 1998



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Program Overview

Friday, May 29

4:00-6:00 Registration (Classroom B), Poster set-up (Lower floor, Building F)

6:00-7:00 Dinner (Mess Hall B)

7:00-9:00 Registration & Social (Classroom B), Poster set-up (Lower floor, Building F)

Saturday, May 30

7:30 Breakfast (Mess Hall B)

8:30 Introduction and Welcome (Auditorium B)

9:00 - 10:20 Concurrent Sessions:
Saturday AM Session #1: Human Impacts on Coastal Ecosystems (Auditorium B)
Saturday AM Session #2: Algal Ecology (Classroom B)

10:20 - 11:00 Break and Poster Session (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

11:00 - 12:20 Concurrent Sessions:
Saturday AM Session #1 (continued): Human Impacts on Coastal Ecosystems (Auditorium B)
Saturday AM Session #2 (continued): Algal Ecology (Classroom B)

12:30 - 1:30 Lunch (Mess Hall B)

1:40 - 3:00 Concurrent Sessions:
Saturday PM Session #3: Exotic Species (Auditorium B)
Saturday PM Session #4: Oceanography of West Coast Estuaries (Classroom B)

3:00 - 3:40 Break and Poster Session (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

3:40 - 5:00: Concurrent Sessions:
Saturday PM Session #3 (continued): Exotic Species (Auditorium B)
Saturday PM Session #4 (continued): Oceanography of West Coast Estuaries (Classroom B)

6:00: Bar open at Officer's Club, Whidbey Naval Air Station, Oak Harbor
7:00: Banquet Dinner at Officer's Club, Whidbey Naval Air Station, Oak Harbor

Sunday, May 31

7:30: Breakfast (Mess Hall B)

8:30 - 9:30: PERS and NWAS Business Meetings (Classroom B)

9:30 - 11:00: Concurrent Sessions:
Sunday AM Session #5: Estuarine Restoration (Auditorium B)
Sunday AM Session #6: Systematics, Growth, and Physiology of Algae (Classroom B)

11:00 - 11:20: Break and Poster Session (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

11:20 - 12:40: Concurrent Sessions:
Sunday AM Session #5 (continued): Estuarine Restoration (Auditorium B)
Sunday AM Session #6 (continued): Systematics, Growth, and Physiology of Algae (Classroom B)

12:40: Lunch and Student Awards (Mess Hall B)
Poster removal

Northwest Algal Symposium
and
Pacific Estuarine Research Society
Joint Meeting

Program

Friday, May 29

4:00-6:00 Registration (Classroom B), Poster set-up (Lower floor, Building F)

6:00-7:00 **Dinner** (Mess Hall B)

7:00-9:00 Registration & Social (Classroom B),
Poster set-up (Lower floor, Building F)

Saturday, May 30

7:30 **Breakfast** (Mess Hall B)

8:30 **Introduction and welcome** (Auditorium B)

Concurrent Sessions #1 and #2: 9:00-12:20

Saturday am Session #1: Human Impacts on Coastal Ecosystems (Auditorium B)
Session Chair: Gary Williams

9:00 *Separating urban and industrial effects on water quality in the Ba Estuary, Fiji*
Edward Anderson*, **Nanise Cakausese** and **Laura Fagan**, Institute of Applied Sciences, University of the South Pacific, Suva, Fiji.

9:20 *Ribosomal DNA tracking for the determination of possible* Escherichia coli *origins in the Lake Union waterway and Shilshole Bay, Washington*
Deanna Akre* and **Jessica Wilcox**, Oceanography, University of Washington, Seattle, WA.

9:40 *Genetic markers from anaerobic bacteria used to discriminate human and cattle fecal contamination without culturing indicator organisms*
A.E. Bernhard* and **K.G. Field**, Oregon State University, Corvallis, OR.

10:00 *Using integrated pest management to control burrowing shrimp in commercial oyster beds: are we ready?*
T.H. DeWitt*, US EPA NHEERL Western Ecology Division, Newport, OR; **K.F. Wellman**, Battelle Seattle Research Center, Seattle, WA; **T. Wildman**, Independent Pest Management Consulting, Prosser, WA; **D.A. Armstrong**, School of Fisheries, University of Washington, Seattle, WA.

10:20-11:00	**Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)
11:00	*Using other people's data to analyze failure and recovery of Columbia River salmonid fisheries* **J. Palmisano***, Biological Consultants, Beaverton, OR
11:20	*Intertidal spawning beaches of the surf smelt and sand lance in Puget Sound* **Daniel E. Penttila***, Washington Department of Fish and Wildlife, LaConner, WA.
11:40	*Development of intertidal biophysical shore-zone model for a portion of the southern Strait of Georgia, British Columbia* **Mary Morris***, Archipelago Marine Research, Victoria, B.C., Canada; and **Mark Zacharias**, Land Use Coordination Office, Victoria, B.C., Canada.
12:00	*PRISM (Puget Sound Regional Assessment Model)* **Andrea E. Copping***, Washington Sea Grant Program, University of Washington, Seattle, WA.

Related Posters

Evaluating trends using fecal coliform data from shellfish bearing estuaries
Timothy A. Determan*, Office of Shellfish Programs, Washington State Department of Health, Olympia, WA.

King County's aquatic science resources on the internet
Cathy Laetz*, King County Department of Natural Resources, Water & Land Resources Division, Seattle, WA.

Accumulation of tributylin (TBT) in fish and shellfish from the Duwamish estuary and non-urban reference areas in Puget Sound, Washington
John A. Strand, **Kim A. Stark**, and **Cathy A. Laetz**, King County Department of Natural Resources, Seattle, WA; **Sandra M. O'Neill**, and **James E. West**, Washington Department of Fish and Wildlife, Olympia, WA; **Scott J. Mickelson***, **Diane McElhany**, **Tom D. Georgianna**, and **Kevin Li**, King County Environmental Laboratory, Seattle, WA.

Saturday am Session #2: Algal Ecology (Classroom B)
Session Chair: Kathryn Van Alstyne

9:00	*Herbivore food preferences for juvenile and adult seaweed* **Kathryn L. Van Alstyne***, **Hilmar Stecher, III.**, Shannon Point Marine Center, Western Washington University, Anacortes, WA; **Janette Ehlig** and **Shauna Whitman**, Department of Zoology, Oregon State University, Corvallis, OR
9:20	*Just how do limpets respond to algal cover?* **Adrian Sun***, University of Washington, Seattle WA.

9:40 *The return of* Diadema *to the Jamaican backreef, and the retreat of macroalgae: early signs of recovery?*
C. J. Slocum*, Stockton College, Pomona, NJ; **M. Itzkowitz**, Lehigh University, Bethlehem, PA; and **M. Haley**, University of the West Indies, Discovery Bay, Jamaica.

10:00 *Effects of short-term light reduction during different seasons on survival of intertidal and subtidal eelgrass,* Zostera marina, *in Padilla Bay, Washington.*
Douglas A. Bulthuis*, Padilla Bay National Estuarine Research Reserve, Washington Department of Ecology, Mount Vernon, WA

10:20-11:00 **Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

11:00 *Monitoring rocky intertidal communities in the Gulf of the Farallones*
J. Roletto[1], **N. Cosentino***[2], **D. Osorio**[1], and **E. Ueber**[1]. [1] Gulf of the Farallones National Marine Sanctuary, Ft. Mason, San Francisco, CA. [2] Cosentino Consulting, Petaluma, CA.

11:20 *Seven-year signal of intertidal disturbance following the Exxon Valdez oil spill*
William Driskell*, Seattle, WA; **Jennifer Ruesink**, Dept. of Zoology, University of British Columbia, Vancouver, B.C.; **Sandra Lindstrom**, Surrey, B.C. Canada; and **Jon Houghton**, Pentec Environmental, Inc., Edmonds, WA.

11:40 *A mixotrophic species of* Alexandrium *feeds on* Mesodinium sp.*: ultrastructural observations*
Dean Jacobson*, **Dean Rocco** and **Andrea Olah**, Dept. of Biology, Whitworth College, Spokane, WA

12:00 *Green tide algae of the Padilla Bay Estuary, Washington*
Hillary Hayden* and **J. Robert Waaland**, Dept. of Botany, University of Washington, Seattle, WA

Related Posters

Northeast Pacific algal biogeography: patterns along intertidal and latitudinal gradients
Christopher D. G. Harley*, Dept. of Zoology, University of Washington, Seattle, WA.

Activated defense mechanisms: acrylic acid as an activated defense compound in algae
Corinne E. Hicken*, Shannon Point Marine Center, Western Washington University, Anacortes, WA

Dinoflagellate predation is not affected by diatom morphotype
Susanne Menden-Deuer* and **Evelyn J. Lessard**, School of Oceanography, University of Washington, Seattle, WA

Diatoms of a rainforest spring
Kristina Rhode*, Center for Great Lakes and Aquatic Sciences, The University of Michigan, Ann Arbor, MI

12:30 **Lunch**

Concurrent Sessions #3 and #4: 1:30-5:00

Saturday pm Session # 3: Exotic Species (Auditorium B)
Session Organizer: Jeffery Cordell

1:40 *Cryptogenic marine algal species in Port Valdez, Alaska: how did they get there?*
Gayle I. Hansen* and **John W. Chapman**, Oregon State University and the Hatfield Marine Science Center, Newport, Oregon

2:00 *Invertebrates from ballast water collected at British Columbia ports*
C.D. Levings*, **G.E. Piercey**, and **M. Galbraith**, Fisheries and Oceans Canada, Science Branch, North Vancouver, BC

2:20 *1996 flood effects on native and exotic amphipod populations in Yaquina Bay*
Bruce Boese*, **John Chapman**, and **Janet Lamberson**, U.S. EPA and Oregon State University, Hatfield Marine Science Center, Newport, Oregon

2:40 *The effect of the exotic aquatic plant* Eichhornia crassipes *(water hyacinth) on the fish/invertebrate food web in the Sacramento/San Joaquin Delta, California*
Jason Toft*, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA

3:00-3:40 **Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

3:40 *Biological invasions on exposed shores: abiotic or biotic resistance?*
Marjorie Wonham*, Department of Zoology, University of Washington, Seattle, WA

4:00 *Predicting the expansion of smooth cordgrass,* Spartina alterniflora *(Loisel), in Willapa Bay, Washington, using spatial analysis, matrix models, and GIS*
Blake Feist* and **Charles Simenstad**, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA

4:20 *Willapa Bay, Washington: a rival for San Francisco Bay in impact of exotic species?*
Jeffery Cordell, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA; and **Victoria Luiting***, Raedeke Associates, Inc., Seattle, WA

4:40 *Characterizing diverse pathways for the introduction of nonindigenous species (NIS)*
Annette Olson* and **Elizabeth Linen**, School of Marine Affairs, University of Washington, Seattle, WA

Related Posters

Demersal fish and benthic invertebrates in the tidal freshwater Columbia River
Paul A. Fishman*, and **Steven R. Johnson**, Fishman Environmental Services, Portland, OR

Invasive Japanese foraminifer Trochammina hadai *discovered in northern Puget Sound*
Mary McGann*, U.S. Geological Survey, Menlo Park, CA; **Doris Sloan**, Dept. of Geology and Geophysics, University of California, Berkeley, CA; and **Roberto J. Llanso**, Washington State Department of Ecology, Olympia, WA

Saturday pm Session #4: Oceanography of West Coast Estuaries (Classroom B)
Session Chair: Carol Falkenhayn

1:40 *Wind effects on circulation in Puget Sound*
Glenn A. Cannon*, Puget Sound Environmental Consultants, Seattle, WA, and School of Oceanography, University of Washington, Seattle, WA

2:00 *Characterizing a deep water intrusion at the landward Admiralty sill*
Tor Bjorklund*, University of Washington, Seattle, WA

2:20 *An anomalous source of nitrogen in a southeast Alaskan fjord? Implications for possible management options.*
Don Heinle*, and **David Wilson**, CH2M HILL, Bellevue, WA

2:40 *What controls the termination of phytoplankton blooms?*
Jan Newton*[1,2], and **T. Aaron Morello**[2,3], [1]Washington State Department of Ecology, Olympia WA, [2]Northeastern University, [3]University of Washington.

3:00-3:40 **Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

3:40 *Biological and physical oceanographic processes in Willapa Bay, Washington: early results*
Carol Falkenhayn*[1,2], **Casey Clishe**[2], **Chris Moore**[2], and **Jan Newton**[2], [1]Washington Sea Grant Program, University of Washington, [2]Washington State Department of Ecology, Olympia, WA

4:00 *Identification of a 1000 yBP tsunami deposit in Puget Sound, Washington: diatom analysis of the Snohomish River Delta*
Lisa R. Hodges*, School of Oceanography, University of Washington, Seattle, WA

4:20 *Potential field modeling of the south Whidbey Island fault, northern Puget Sound: deep structure of a transpressional fault*
Julie A. Bowles*, School of Oceanography, University of Washington, Seattle, WA

4:40 *Plankton net avoidance revisited: effect of rigging composition (metallic/nonmetallic) and vibrations on net avoidance by* Euphausia pacifica
William Couch*, School of Oceanography, University of Washington, Seattle, Washington

6:00: Bar open at Officer's Club, Whidbey Naval Air Station, Oak Harbor

7:00: Banquet Dinner at Officer's Club, Whidbey Naval Air Station, Oak Harbor

Sunday May 31

7:30 **Breakfast** (Mess Hall B)

8:30-9:30 **PERS and NWAS Business Meetings** (Classroom B)

Concurrent Sessions #5 and #6: 9:00-12:40

Sunday am Session #5: Estuarine Restoration (Auditorium B)
Session Organizer: Charles Simenstad

9:40 *Habitat restoration planning in Bellingham Bay - Bellingham Bay demonstration pilot project*
Tracey McKenzie*, **T. Schadt**, **M. Stoner**, **R. Freidman-Thomas**, and **L. Pebles**, Pacific International Engineering, Edmonds, WA

10:00 *Functional assessment of restored, created, and replaced fish habitat in the Fraser River Estuary*
Colin Levings*, Fisheries and Oceans, Science Branch, Pacific Environmental Science Centre, North Vancouver, BC

10:20 *Application of adaptive management to ecological restoration projects in Puget Sound*
Ronald Thom*, **Amy Borde**, **Liam Antrim**, **William Gardiner**, and **David Shreffler**, Battelle Marine Sciences Laboratory, Sequim, Washington

10:40 *Comparison of two Puget Sound estuarine habitat assessment models - do we know enough to evaluate project impacts?*
Jon P. Houghton*, Pentec Environmental, Inc., Edmonds, WA

11:00-11:20 **Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

11:20 — *Using fallout insects to monitor ecological status and trends in restored wetland habitats in the Duwamish River waterway*
Heather Higgins*, and **Jeffery Cordell**, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA

11:40 — *Early geomorphic and ecological development of a created slough in the Chehalis River Estuary*
Charles Simenstad*, **Jeffery Cordell**, **W. Greg Hood**, Wetland Ecosystem Team, School of Fisheries, Seattle, WA; **Ronald Thom**, Battelle Pacific Northwest Laboratories, Marine Science Laboratory, Sequim, WA; and **Jessica Miller**, Portland, OR

12:00 — *Ecosystem allometry: landscape form and ecosystem process*
W. Gregory Hood*, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA

12:20 — *Restoring salt marshes in Oregon estuaries: if we rebuild them, will salmon come?*
Daniel Bottom*, **Trevan Cornwell**, **Barry Thom**, Oregon Department of Fish and Wildlife, Corvallis, OR; **Stan Van de Wetering**, Confederated Tribes of the Siletz Indians, Siletz, OR; and **Cate O'Keefe**, Hampshire College, School of Natural Science, Amherst, MA

Related Posters

Preliminary post construction results of an eelgrass (Zostera marina) *mitigation project*
Michael A. Kyte*, URS Greiner, Inc., Seattle, WA

Predicting the evolution of ecological functions of reflooded wetlands in the Sacramento-San Joaquin Delta, California
Charles Simenstad*, **Jeffery Cordell**, and **Jason Toft**, Wetland Ecosystem Team, School of Fisheries, University of Washington, Seattle, WA

Sunday am Session #6: Systematics, Growth, and Physiology of Algae (Classroom B)

Session Chair: David Garbary

9:40 — *The comparative cytology of* Katablepharis ovalis *and* K. phoenokistron *(Katablepharidaceae) Skuja*
Brec Clay*, and **Paul Kugrens**, Department of Biology, Colorado State University, Fort Collins, Colorado

10:00 — *Characterization and description of a new species of* Characiosiphon *from Colorado*
P. Kugrens, **B. Clay** and **R. Aguiar***, Department of Biology, Colorado State University, Fort Collins, Colorado

10:20 — Tetreutreptia pomquetensis *(Euglenophyta), a psychrophilic species: growth and fatty acid composition*
J.L. McLachlan*, Department of Biology, Dalhousie University, Halifax, NS; **J.M. Curtis** and **K. Boutilier**, National Research Council, Halifax, NS; **M. Keusgen**, Institut für Pharmazeutische Biologie, Univerität Bonn, Bonn, Germany; and **M.R. Seguel**, Department of Biology, Acadia University, Wolfville, NS

10:40 — *The phylogeny and biography of the Solieriaceae (Rhodophyta) based on rbcL sequence analysis and morphological evidence*
Max Hommersand*, and **Suzanne Fredericq**, Department of Biology, University of North Carolina, Chapel Hill, NC; Department of Biology, University of Southwestern Louisiana, Lafayette, LA

11:00-11:20 — **Break and Poster Session** (Lower Floor Building F: Posters & refreshments; Mess Hall B: Refreshments only)

11:20 — *Kelp endosymbiosis in red algae*
D. Garbary*, **K.Y. Kim**, **T. Klinger** and **D. Duggins**, Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia

11:40 — *Growth of* Laminaria saccharina *gametophyte suspensions in tubular and planar photobioreactors*
Ronald K. Mullikin* and **Gregory L. Rorrer**, Department of Chemical Engineering, Oregon State University, Corvallis, Oregon

12:00 — *Bubble column cultivation of* Agardhiella subulata, *regenerated microplantlets*
Gregory Rorrer and **Yao-ming Huang***, Department of Chemical Engineering, Oregon State University, Corvallis, Oregon

Related Posters

Isolation of a new bioactive metabolite from a cultured Indonesian Phormidium sp.
Anna Boulanger, **Mary Ann Roberts*** and **William H. Gerwick**, College of Pharmacy, Oregon State University, Corvallis, Oregon

Cosmopolitan cyanobacteria
P.C. Caron*, Department of Biology, University of Victoria, Victoria, British Columbia

Photoinduction of UV-absorbing mycosporine-like amino acids in marine phytoplankton
Gabriela Hannach and **Anne C. Sigleo***, U.S. Environmental Protection Agency, Newport, Oregon

An investigation of Northwest freshwater cyanobacteria strain diversity
C.R. Williams*, **B. Peters**, and **J. Robert Waaland**, Department of Botany, University of Washington, Seattle, WA

12:30 — **Lunch and Student Awards** (Mess Hall B)
Poster removal

Akre*, Deanna & Jessica Wilcox. Oceanography, University of Washington, 4717 18th Ave. NE, Seattle, WA 98105; 16626 Juanita Dr. NE #20D, Bothell, WWA 98011.

RIBOSOMAL DNA TRACKING FOR THE DETERMINATION OF POSSIBLE *ESCHERICHIA COLI* ORIGINS IN THE LAKE UNION WATERWAY AND SHILSHOLE BAY, WASHINGTON

Shilshole Bay and the Lake Union waterway are subject to problems with high fecal coliform concentrations. It is important to monitor fecal coliform input into the waterways in order to reduce the potential for public health hazards associated with these bacteria. In order to implement appropriate management decisions, the exact source of fecal coliform pollution must be identified. The use of ribosomal DNA tracking can identify the specific hosts of *Escherichia coli*, a component of fecal coliform, which contributes to pollution. Sampling took place under the Montlake Bridge, under the Fremont Bridge (both Lake Union waterway), in Shilshole Bay just west of the Ballard Locks and near the Shilshole Marina (Stations 1,2,3, and 4, respectively). Colonies of *E. coli* were obtained using the membrane filter procedure and selective culturing. The DNA gene sequences will be compared to a database collated and maintained by Dr. Mansour Samadpour of the University of Washington, Department of Environmental Health.

Anderson*, Edward, Nanise Cakausese and Laura Fagan. Institute of Applied Sciences, University of the South Pacific, Suva, Fiji

SEPARATING URBAN AND INDUSTRIAL EFFECTS ON WATER QUALITY IN THE BA ESTUARY, FIJI

Of five major rivers on Viti Levu, the main island of Fiji, the Ba River is most seriously affected by contaminants. The river passes Ba Town (population 11,000) and a sugar mill (production 135,000 tonnes*yr^{-1}) in the upper estuary to exit through the mangrove-lined lower estuary. Average flow is 10 $m^3 \cdot s^{-1}$ (dry season) and 60 $m^3 \cdot s^{-1}$ (wet season). The estuary is shallow and well-mixed. During the 1994 sugar cane crushing (dry season), dissolved oxygen (DO) fell to near zero along at least 7.5 km of the upper Ba estuary, with high BOD and temperature elevation of about 1.5°C. These effects were relieved promptly on cessation of crushing. Effluent from the sugar mill caused most of the oxygen sag. Fish were probably excluded from the low DO zone, but kai (freshwater mussels, *Batissa violacea*) persisted as a significant fishery. Fecal coliform bacteria (FC) were elevated (highest station average 17,800 colonies·100 mL^{-1}) during both crushing and non-crushing. Ba Town was the main source of FC contamination. Effluent treatment systems, installed in 1994, are expected to improve water quality. The Ba system offers an excellent model for teaching and research.

Bernhard*, A.E. and K.G. Field. Oregon State University, Corvallis, OR 97331.
GENETIC MARKERS FROM ANAEROBIC BACTERIA USED TO DISCRIMINATE HUMAN AND CATTLE FECAL CONTAMINATION WITHOUT CULTURING INDICATOR ORGANISMS

We developed and tested the use of rRNA markers for fecal anaerobes to identify and quantify sources of fecal pollution in coastal waters. Current culture-based methods using fecal coliforms to monitor fecal pollution in water do not provide reliable means to distinguish between human and animal sources, nor do they quantify the relative contributions of these sources. Our approach was to identify host-specific DNA patterns for anaerobic fecal bacteria and to analyze water samples directly for genetic markers, thereby avoiding the need to isolate and grow the indicator organisms. Using DNA extracted from 14 human and 13 cattle fecal samples, 16S rRNA gene fragments from *Bifidobacterium* and *Bacteroides* were amplified using genus- and group-specific primers. We analyzed the PCR-amplified marker genes for host-specific patterns using RFLP, LH-PCR (Length Heterogeneity PCR), and T-RFLP (Terminal Restriction Fragment Length Polymorphism). LH-PCR and T-RFLP are based on GeneScan (ABI), which separates different-length fragments amplified from the sample and estimates their relative proportions. Results revealed host-specific patterns, suggesting diagnostic species composition differences in the *Bifidobacterium* and *Bacteroides* populations of human and cattle fecal samples. These genetic markers from fecal anaerobes have also been detected in sewage effluent, estuarine, and river waters. Our data suggest that host-specific patterns of DNA amplified from anaerobic fecal bacteria may provide a reliable means to identify the source(s) of fecal pollution in water samples.

Bjorklund*, Tor, University of Washington 416 NE Mapleleaf Pl. #3, Seattle, WA 98115.
CHARACTERIZING A DEEP WATER INTRUSION AT THE LANDWARD ADMIRALTY SILL

The goal of this project is to characterize a deep water intrusion into the Main Basin of Puget Sound by mapping the fine scale structure of the water column over a complete tidal cycle. The data were collected by towing a CTD package from the *R/V Thompson* and continuously raising and lowering the unit (Tow-Yo), while underway, resulting in a saw-toothed "mapping" of the water column. Characterization of a deep water intrusion in this manner will provide new information into many important aspects of fjord circulation. Water body formation, and residence times in Puget Sound. It is my intention to determine *how* deep water rolls over the Admiralty sill and what implications the fine scale structure may have on the greater Puget Sound system. It is my understanding that this project is the first Tow-Yo study ever done to study the interactions between the landward Admiralty sill and the Main Basin.

Boese*, Bruce, John Chapman, Janet Lamberson. U.S. EPA and Ore. State Univ., Hatfield Mar. Sci. Center, Newport, OR 97365-5260.

1996 FLOOD EFFECTS ON NATIVE AND EXOTIC AMPHIPOD POPULATIONS IN YAQUINA BAY

Before the 30 year flood of February 1996 the exotic Corophium amphipods (*C. acherusicum* and *C. insidiosum*) and *Grandidierella japonica* had limited distributions and abundances in Yaquina Bay. In contrast, three native Corophium species (*C. brevis*, *C. salmonis* and *C. spinicorne*) were widely distributed in larger numbers within the bay. Laboratory tests suggested that this pattern was the result of tolerance differences to temperature and salinity. Based on this simple interpretation, the low salinities associated with the Feb. 1996 flood should have been deleterious to exotic populations, while having little effect on natives. However, the results of the 1996 benthic survey were nearly the opposite of what was predicted. While native species tended to increase, two of the three exotic species (*G. japonica* and *C. acherusicum*) exhibited spectacular increases in distribution and order-of-magnitude increases in abundance. These results suggest that severe winter floods may benefit summer populations of amphipods as a group and that winter salinity stress is a poor predictor of population success in comparatively short-lived species.

Bottom*[1], Daniel, Trevan Cornwell[1], Barry Thom[1], Stan Van de Wetering[2], and Cate O'Keefe[3]; [1]Oregon Department of Fish and Wildlife, 28655 Highway 34, Corvallis, OR 97333; [2]Confederated Tribes of the Siletz Indians; 201 SE Swan Avenue; Siletz, OR 97380; [3] Hampshire College, School of Natural Science, Amherst, MA 01002.

RESTORING SALT MARSHES IN OREGON ESTUARIES: IF WE REBUILD THEM, WILL SALMON COME?

In 1978, 1987, and 1996, the Siuslaw National Forest breached dikes in three salt marshes in Salmon River estuary, establishing an unprecedented series of marsh restoration "experiments" in successive stages of recovery. The Oregon Department of Fish and Wildlife began a research project in 1997 to evaluate use by estuarine fishes of marshes of different recovery ages. Initial results reveal consistent use by juvenile coho and chinook salmon from April through June, including some subyearling coho migrants. In addition to the age of recovering channels, differences in relative use by juvenile salmon may depend on marsh location in the estuary and channel size and morphology. Initial fish diet analyses indicate that prey of chinook in the restoring marshes include more amphipods and insect larvae, while fish in the undiked reference marshes consume more individuals and a greater diversity of insects. These preliminary results particularly suggest that estuarine marshes may be more important to juvenile coho salmon than is recognized by conventional generalizations about their freshwater life histories. But, the effectiveness of salt marsh restoration for salmon recovery will ultimately depend on decisions "upstream" that influence both the development of estuarine habitats and salmon life histories.

Boulanger, Anna, Mary Ann Roberts* and William H. Gerwick. College of Pharmacy, Oregon State University, Corvallis, Oregon 97331
ISOLATION OF A NEW BIOACTIVE METABOLITE FROM A CULTURED INDONESIAN PHORMIDIUM SP.

Marine cyanobacteria have been shown to be valuable resources of structurally-diverse natural products. As part of our research to survey and elucidate these novel structures, we have collected, grown and isolated from an Indonesian marine cyanobacterium *Phormidium sp*., a novel and highly bioactive metabolite. This new natural product, phormidolide, consists of a 16-membered macrolide ring with a polyhydroxyl chain. Phormidolide is an exceptionally potent brine shrimp toxin (*Artemia salina*), but is not active in fish (*Carassius auratus*), and molluscicidal (*Biomphalaria glabrata*) assays. Culture parameters, extraction, analysis, biosynthesis, and characterization of phormidolide will be discussed.

Bowles*, Julie A. School of Oceanography, University of Washington, Seattle, WA 98115
POTENTIAL FIELD MODELING OF THE SOUTH WHIDBEY ISLAND FAULT, NORTHERN PUGET SOUND: DEEP STRUCTURE OF A TRANSPRESSIONAL FAULT

The South Whidbey Island Fault is thought to be a major structural feature of the Puget Lowland. It is currently imaged as a steeply-dipping fault to roughly 5km depth. The deeper structure of the fault is unknown, and better knowledge of the fault at depth will be useful in estimating seismic hazards for this highly-populated area. The objective of this study is obtain high-resolution gravity and magnetics data for a portion of the South Whidbey Island Fault, and through forward and inverse modeling to examine the deep structure of the fault. A gravity survey running from Edmonds to west of Marysville is complemented by magnetics data taken with a towed magnetometer from the R/V Thompson during a student cruise, April 6-12, 1998. Two 38km-long magnetics track lines run roughly perpendicular across the strike of the fault trace. This is supplemented by 10 separate 11km lines covering the surface traces of the fault zone. Together, these lines should provide a good 2-D and limited 3-D representation of the magnetic anomaly around the fault. Models of the steep gravity and magnetic gradients should provide estimates of depth, dip angle and throw of the fault, all of which can be useful in determining future possible movement on the fault and the geographic area which may be affected by such movement.

Bulthuis*, Douglas A. Padilla Bay National Estuarine Research Reserve. 10441 Bay View-Edison Road, Mount Vernon, WA 98273-9668

EFFECTS OF SHORT-TERM LIGHT REDUCTION DURING DIFFERENT SEASONS ON SURVIVAL OF INTERTIDAL AND SUBTIDAL EELGRASS, ZOSTERA MARINA, IN PADILLA BAY, WASHINGTON, U.S.A.

The purpose of this study was to investigate the seasonal effects of short-term (2 months) light reduction on survival of the eelgrass, *Zostera marina*. Light was reduced to 10% of ambient photosynthetically active radiation for periods of 8-12 weeks in 1.25 by 1.25 m plots in field experiments conducted in intertidal and subtidal populations of *Z. marina* in Padilla Bay, Washington, U.S.A. Two months of light reduction resulted in reduced density of *Z. marina* during spring and summer at both the intertidal and subtidal sites. No significant decreases compared to controls were observed in autumn and winter during the two months of light reduction, but delayed effects on density were observed in some plots during subsequent seasons of growth. Very little recovery was observed in any of the plots during the 6-18 months following treatment. This study indicates that light reduction may have a greater effect on survival of *Z. marina* during spring and summer than it does in autumn or winter; that light reduction during autumn and winter may have delayed effects on density; that intertidal *Z. marina* may be more sensitive to light reduction than subtidal *Z. marina*; and that recovery from even short-term light reduction may take more than one year.

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WIND EFFECTS ON CIRCULATION IN PUGET SOUND

Understanding circulation and mixing within the Puget Sound estuarine system is important in assessing the fate of natural and man-induced contaminants. The water ultimately either transports contaminants out of the system or redistributes them within it. Direct measurements of circulation across a section north of West Point (10-15 years ago) focused on determining the physical processes causing space and time variations of the flow in the northern part of the main basin. Results showed that winds caused the dominant variability of the estuarine circulation. High correlations between winds and currents were found near the surface and at mid-depths of about 100 m. Analysis (EOF) shows that over 60% of the energy is highly correlated with wind speed even without having near-surface current observations. When the near-surface stratification is strong, wind effects are limited to the upper 30 m with counter flows occurring in the lower layer. When stratification is weak, direct effects can be detected down to about 100 m. These observations are related to other parts of the Puget Sound system, and suggestions are made for some additional research.

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COSMOPOLITAN CYANOBACTERIA

In a fourth year field and laboratory oriented phycology course, at the University of Victoria, instructed by Wm.P. Lucey, students were asked to respond to a final exam question on the distribution and adaptations of cyanobacteria that have contributed to their success. Students were encouraged to adopt a response which best conveyed their understanding of the issues with no strictures on format other than length. This original epic poem on cyanobacteria is the result of this encouragement, and was composed in response to the final exam question.

Clay, Brec* & Paul Kugrens. Department of Biology, Colorado State University, Fort Collins, Colorado 80523, USA
THE COMPARATIVE CYTOLOGY OF KATABLEPHARIS OVALIS AND K. PHOENOKISTRON (KATABLEPHARIDACEAE) SKUJA.

The colorless flagellate *Katablepharis* Skuja is comprised of six species based on light microscopic studies. Two of these, *K. ovalis* and *K. phoenokistron*, are compared at the light microscopic and ultrastructural levels. For *K. phoenokistron*, this represents the first ultrastructural study. Although the two species share most cellular characteristics, including a complex feeding apparatus, alveolar-like sacs associated with subpellicular microtubules, ejectisomes, and a cell covering of fused scales, they differ in some respects. At the light microscopic level, cells of *K. ovalis* are ovate to sub-ovate with both flagella directed anteriorly when swimming. Cells of *K. phoenokistron* are cylindrical and have one anteriorly directed flagellum and one trailing flagellum when swimming. At the ultrastructural level, the feeding apparatus in *K. ovalis* has two cytopharyngeal rings whereas *K. phoenokistron* possesses nine to ten rings. The question of which of these species is primitive or advanced is addressed by comparing them to other protist groups that have similar structural features. In addition to intrageneric comparisons, larger scale phylogenetic relationships for Katablepharis were explored. Based on ultrastructural studies, a possible *Katablepharis*/alveolate relationship is presented. Specifically, *katablepharids* may be related to apicomplexans based on the similarity of the rings and associated microtubules in the feeding apparatus and the apical complex.

Copping*, Andrea E. Washington Sea Grant Program, University of Washington. 3716 Brooklyn Ave NE, Seattle WA 98105
PRISM

PRISM (Puget Sound Regional Assessment Model) is a University of Washington initiative focusing on environmental issues of concern to the people of the state of Washington and the region. Faculty, staff and students are working to create PRISM as an integrated assessment model bringing together information collected from many sources, using up-to-date computer, data acquisition, and visualization technologies. By combining information on the natural and the built world, PRISM will allow investigators to construct new scenarios about the interaction between humans and natural resources in the Puget Sound basin, leading to alternate futures for growth and resource consumption in the region. The integrating theme of PRISM is the movement of water: through the atmosphere, into rivers and streams and throughout Puget Sound. PRISM information is accessible through an integrated distributed database - Virtual Puget Sound- that relies heavily on modeling and visualization interfaces. To date, PRISM has focused on constructing the physical template of the Puget Sound basin, including the bathymetry, shoreline, digital elevations, vegetation, and links to atmospheric transport. PRISM investigators are now turning their attention to questions associated with salmon survival and the Endangered Species Act. This presentation will include a demonstration of Virtual Puget Sound capabilities.

Cordell, Jeffery[1], and Victoria Luiting*[2]. [1]Wetland Ecosystem Team, School of Fisheries, Box 357980, University of Washington, Seattle, WA 98195-7980; [2]Raedeke Associates, Inc., 5711 NE 63rd Street, Seattle, WA 98115.
WILLAPA BAY, WASHINGTON: A RIVAL FOR SAN FRANCISCO BAY IN IMPACT OF EXOTIC SPECIES?

San Francisco Bay, with over 230 species of introduced plants and animals and increasing rates of invasions, has been described as the "most invaded estuary on the west coast of the United States." However, other estuaries and embayments to the north and south of San Francisco Bay that have not been as intensively studied may have similar magnitudes of invasion. As an outgrowth of a study of the biological effects of the invasive cordgrass *Spartina alterniflora* in Willapa Bay, southwestern Washington, we compared exotic species from one habitat (fine-grained intertidal sediments) with exotic species from similar habitats in San Francisco Bay. A high percentage of exotic species found in San Francisco Bay also occurred in Willapa Bay. In addition, data from Willapa Bay benthic core samples show that at the Class level (e.g., Gastropoda, Bivalvia, Polychaeta, etc.) each category examined was dominated by one or several exotic species. Although we are only beginning to study the effects of exotic species in west coast estuaries, there is evidence that these include changes in the physical structure of habitats (e.g., increases in accretion rate, promotion of emergent vegetation), potential displacement of native species through competitive interactions, and alteration of estuarine food webs.

Couch, William*. University of Washington, School of Oceanography.
PLANKTON NET AVOIDANCE REVISITED: EFFECT OF RIGGING COMPOSITION (METALLIC/NONMETALLIC) AND VIBRATIONS ON NET AVOIDANCE BY *EUPHAUSIA PACIFICA*

Hypothesis: Noise and vibration from plankton net rigging, hauling cable and vessel equipment are major contributing factors to net avoidance by certain macro-zooplankton. Accurately sampling plankton is important. Using metallic cable and a mechanical winch to haul plankton nets is standard practice throughout oceanography. Information regarding the fidelity of sampling with this equipment will be of a benefit to all involved in collecting plankton in the field. Certain macro-zooplankton are able to avoid capture in a net. It is thought that they see the net or hauling cable, consider it a threat and swim away as if avoiding a predator. Other mechanisms that could also broadcast a warning to motile plankton include daylight, cable vibration, bioluminescence, a pressure wave, rigging noise and a chemical signal. Samples taken with different cables and net configurations from the *R/V Barnes* in Dabob Bay, WA are currently being analyzed for significant differences that could be the result of using these distinctly different materials and equipment.

Determan*, Timothy A. Washington State Department of Health, Office of Shellfish Programs. P.O. Box 7824, Olympia, WA 98504-7824.
EVALUATING TRENDS USING FECAL COLIFORM DATA FROM SHELLFISH-BEARING ESTUARIES

Since the 1980s, harvest of shellfish from several Puget Sound estuaries has been curtailed due to fecal contamination from point and nonpoint sources in upland watersheds. Significant public and private wealth has been spent on source control programs. Citizens, elected officials, and remedial action workers need a measure of program effectiveness. But detection of spatial and temporal change is difficult due to factors inherent with fecal coliform data in estuarine waters (skewness, high variance, etc.). A procedure mandated by the National Shellfish Sanitation Program to classify shellfish growing areas was adapted to measure trends. Results from several estuaries are presented.

DeWitt*, T.H.[1], K.F. Wellman[2], T. Wildman[3], D.A. Armstrong[4]. [1]US EPA NHEERL Western Ecology Division, Newport, OR; [2]Battelle Seattle Research Center, Seattle, WA; [3]Independent Pest Management Consulting, Prosser, WA; [4]School of Fisheries, Univ. Washington, Seattle.
USING INTEGRATED PEST MANAGEMENT TO CONTROL BURROWING SHRIMP IN COMMERCIAL OYSTER BEDS: ARE WE READY?

Endemic thalassinid shrimp (*Neotrypea californiensis, Upogebia pugettensis*) are considered to be pests to the commercial production of oysters (*Crassostrea gigas*) because their burrowing buries and kills oysters. Oyster growers in Willapa Bay and Grays Harbor, WA, have used the pesticide, carbaryl, since the 1960's to kill shrimp on their owned or leased tideflats. Presently, 800 acres of tideflats annually are sprayed with carbaryl in these two estuaries. Recently, oyster growers and regulatory agencies decided that integrated pest management (IPM) might be an appropriate approach for controlling the shrimp. IPM integrates understanding and monitoring of pest population growth, susceptibility of pest life stages to various control methods, and a model of the pest density:crop damage relationship. IPM has never been used to control pests in an estuarine aquaculture environment. Our team evaluated whether existing information could be used to develop an IPM plan for burrowing shrimp. We found that critical information is lacking on rigorous methods to monitor shrimp population growth, on the population ecology of both shrimp species (which should be managed as two species, not one), on the efficacy of non-pesticide methods to control shrimp, and on the quantitative relationship between shrimp density and reduction of oyster yield. We believe that IPM for burrowing shrimp has merit conceptually, but that a lack of specific knowledge and tools precludes its application now.

William Driskell*[1], Jennifer Ruesink[2], Sandra Lindstrom[3], and Jon Houghton[4]. [1]6536 20th Avenue N.E., Seattle, WA 98115, [2] Dept. of Zoology, University of British Columbia, 6270 University Boulevard, Vancouver, B.C. V6T 1Z4, [3] 13965 64th Avenue, Surrey, B.C. V3W 1Y7, [4]Pentec Environmental, Inc. 120 Third Ave. So. Edmonds, WA 98020.
SEVEN-YEAR SIGNAL OF INTERTIDAL DISTURBANCE FOLLOWING THE EXXON VALDEZ OIL SPILL

On March 24, 1989, the *Exxon Valdez* spilled more than 10 million gallons of oil, which eventually contacted over 500 km of shoreline in Prince William Sound, Alaska. Most of this area was subsequently cleaned using hot seawater delivered at high pressure, manual scrubbing, or fertilization with nitrate/phosphate nutrients to stimulate oil-eating bacteria. According to some short-term, postspill studies, intertidal areas in the sound recovered rapidly despite the impacts of the stranded oil and the ensuing cleanup. We present evidence to the contrary, showing that 7 years after the spill, a dominant, mid-intertidal species, the rockweed *Fucus gardneri*, continued to exhibit dynamics characteristic of a major perturbation. On many of the rocky shores treated with high-pressure hot water, the years since the spill have been marked by extreme and synchronous increases and declines in *Fucus* cover, apparently due to the large-scale eradication of *Fucus* caused by rigorous shoreline treatment activities and subsequent recruitment of a uniform aged population onto the newly available bare rock. The strength of these patterns through 1996 suggests that the effects of the spill may still be distinguishable in the intertidal assemblage for several more years.

Falkenhayn*, Carol[1], [2], Casey Clishe[2], Chris Moore[2], & Jan Newton[2]. [1]University of Washington, Washington Sea Grant Program, [2]Washington State Department of Ecology. P.O. Box 47710, Olympia, WA 98504-7710.
BIOLOGICAL AND PHYSICAL OCEANOGRAPHIC PROCESSES IN WILLAPA BAY, WASHINGTON: EARLY RESULTS

This EPA-funded project is an intensive monitoring study of Willapa Bay, a large estuary in southwest Washington. The objective of this study is to thoroughly assess the physical variation in the marine water column environment and how this variation affects the biological community. We are focusing on what controls the pelagic primary production and how that varies spatially and temporally. Willapa Bay is a highly dynamic environment with numerous physical factors operating within the system at any given time, such as tidal mixing, watershed input, oceanic input, wind mixing, and climate effects. To assess these physical factors, we have deployed moored sensors that record data at 15-minute intervals at four stations in the bay. Variables measured are temperature, salinity, fluorescence (calibrated to chlorophyll a) and light transmission of the surface waters. We also conduct monthly transects by boat, where we collect depth profiles at 1 nm. horizontal resolution along the axis of the bay. To study the pelagic primary production, we conduct monthly rimary productivity experiments at several locations in the bay. We will be presenting initial results from this study.

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PREDICTING THE EXPANSION OF SMOOTH CORDGRASS, SPARTINA ALTERNIFLORA (LOISEL), IN WILLAPA BAY, WASHINGTON, USING SPATIAL ANALYSIS, MATRIX MODELS, AND GIS

The smooth cordgrass, *Spartina alterniflora*, Loisel, was accidentally introduced into Willapa Bay, Washington, ca. 1890, and has since expanded into a significant portion (approximately 1,000 ha) of the unvegetated littoral flats. The overall objective of this research is to identify factors controlling the observed heterogeneity of *S. alterniflora* extents and to determine which areas of Willapa Bay are most susceptible to future range expansion. We addressed this objective by comparing 1992 extents of *S. alterniflora* throughout Willapa Bay with various spatial datasets such as bathymetry, sediment texture, seed dispersal, oyster culture activity, and predicted wave energy using Geographic Information System (GIS) software. A habitat suitability matrix was generated from these comparisons that will be fed into a spatially explicit matrix model, currently in development. *Spartina alterniflora* appears to be confined to upper intertidal elevations and does not proliferate uniformly within these areas in space or in time. Sediment type, oyster culture activities, wave energy, climatic trends, and seed dispersal patterns all appear to contribute to the observed spatial and temporal heterogeneity of *S. alterniflora* extents. Based on our findings to date, it is not reasonable to assume that *S. alterniflora* will invade the entire intertidal area of Willapa Bay. However, predicting range expansion is confounded by hydrogeomorphology, habitat and climatic heterogeneity, and by inter- and intraspecific feedback processes.

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DEMERSAL FISH AND BENTHIC INVERTEBRATES IN THE TIDAL FRESHWATER COLUMBIA RIVER

Two study areas (Rkm 84 and Rkm 167) were sampled twice each in 1995-96 to characterize habitat, benthic invertebrates and fish, with the focus on juvenile white sturgeon (*Acipenser transmontanus*) as part of the Columbia River Channel Deepening Project studies. The up-river study area (Hayden Island) appears to support greater numbers of juvenile sturgeon; this might be related to prey abundance, flow dynamics or other factors. By chance, the sampling also provided data from before and after the major flood event of February, 1996. In addition to providing data needed for dredged material management decisions, the study results underscore issues such as biodiversity and exotic species in this very perturbed system.

Garbary*[1], D, KY Kim[2], T Klinger[2] & D Duggins[2]. [1]Dept. of Biology St. Francis Xavier University, Antigonish, Nova Scotia, Canada [2]Friday Harbor Labs, Univ. of Washington, Friday Harbor, WA 98250
KELP ENDOSYMBIOSIS IN RED ALGAE

Large *in situ* populations of kelp gametophytes were observed during the fall and winter in the San Juan Islands (Washington). These gametophytes were endosymbiotic in the cell walls of red algae, and dozens to hundreds of gametophytes were present in single host thalli. Over fifteen hosts were identified with the most common being filamentous species of *Pleonosporium*, *Callithamnion* and *Scagelia*, although polysiphonous (*Polysiphonia*, *Pterosiphonia* and *Herposiphonia*), and membranous (*Polyneura*) hosts also were found. Host plants were collected from three sites with differing kelp communities: 1) in a bed of *Agarum fimbriatum*, 2) in a bed of *Nereocystis luetkeana* and 3) on a floating dock with *Alaria marginata*, *Costaria costata* and *Laminaria groenlandica*. When gametophytes became reproductive the gametangia were formed at or above the host surface. Embryonic and juvenile sporophytes were observed on the host surface, and these were associated with the endophytic gametophytes. We suggest that endophytism is of adaptive significance with respect to nutrient absorption, avoidance of siltation and herbivory, and as a dispersal mechanism.

Hannach, Gabriela & Anne C. Sigleo*. U.S. Environmental Protection Agency, 2111 SE Marine Science Drive, Newport, Oregon 97365.

PHOTOINDUCTION OF UV-ABSORBING MYCOSPORINE-LIKE AMINO ACIDS IN MARINE PHYTOPLANKTON

Production of UV-absorbing compounds may improve the ability of some algal populations to acclimate to variations in the radiation environment. High fluence visible light (HL, 400-700 nm), UV-A (320-400 nm), and UV-B (280-320 nm) radiation were tested for their ability to stimulate production of mycosporine-like amino acids (MAAs) in cultures of *Dunaliella tertiolecta*, *Thalassiosira weissflogii*, *Pyramimonas parkeae*, *Pavlova gyrans*, *Isochrysis sp*., and *Amphidinium carterae*. Methanol extracted MAAs were separated by HPLC. Only the prymnesiophyte *P. gyrans* exhibited pronounced UV absorption due to MAAs. Of three MAAs detected in this species, only one with peak absorption in the UV-A - tentatively shinorine or porphyra-334 - was photoinducible. Large (up to 145-fold) increases in the concentration of this MAA were obtained with HL and with UV-A+UV-B radiation. In all other species only one MAA was detected, a compound with peak absorption in the UV-B - tentatively mycosporine-glycine - and limited inducibility. In these species HL had minimal or no effect on MAA production. UV-A radiation effectively increased the chl a-specific MAA content in *Isochrysis sp*. (77%), *T. weissflogii* (73%), and *P. parkeae* (43%), and UV-B supplementation increased it by a further 141% in *Isochrysis sp*. and 95% in *P. parkeae*. We conclude that although MAAs may be commonly present in phytoplankton cells, an ability to produce significant amounts of these compounds through photoinduction is limited to certain species or taxa.

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CRYPTOGENIC MARINE ALGAL SPECIES IN PORT VALDEZ, ALASKA: HOW DID THEY GET THERE?

Of 101 marine macrophytic species occurring in Port Valdez, Alaska, 46 are widespread in boreal areas (occurring in the North Pacific, Arctic and the North Atlantic) and 21 have distributions that extend to the southern hemisphere. These widespread species are considered "cryptogenic" since they have hidden origins, and they are thought to have a high probability of being anthropogenically introduced to or misidentified in at least some parts of their range. A number of these taxa have excellent natural dispersal capabilities. At least 22 can survive unattached, and 25 are ephemeral and frequently reproduce and/or fragment. However, nearly all also occur as fouling organisms on the hulls of ships, and recent studies have shown that the propagules of many can survive the now shorter entrainment times required for transport in ballast water across the North Pacific. It is likely that the broad ranges of these species have been created by both natural and anthropogenic means. Future ecological and taxonomic studies that employ field, molecular and morphological techniques should help to resolve the cryptogenic nature of these species and determine their native vs. introduced status in the areas they inhabit.

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NORTHEAST PACIFIC ALGAL BIOGEOGRAPHY: PATTERNS ALONG INTERTIDAL AND LATITUDINAL GRADIENTS

Prior studies on algal biogeography have focused on identifying biogeographic boundaries and centers of diversity. Here, I add to previous work by 1) examining how algae are distributed along a depth gradient, as well as the more typical latitudinal gradient, 2) examining how algal attributes (e.g. size) vary in a biogeographic context, and 3) investigating the taxonomic scale at which biogeographic patterns manifest themselves. Preliminary results indicate that green algal diversity peaks at 40-50 degrees N, in the low intertidal. Brown algal diversity is highest at 40 degrees N, also in the low intertidal. Red algal diversity peaks at the southern limit of this study (35 degrees N) in the subtidal. In general, algal size (between species) decreases with increasing height in the intertidal, but does not vary with latitude, species range, or species abundance. Intertidal ranges are not meaningfully correlated with latitudinal ranges. Species with larger intertidal ranges tend to be more locally abundant. In Rhodophyta, species with larger latitudinal ranges, and those higher in the intertidal, tend to be more locally abundant. Species found in multiple ocean basins have larger ranges on Northeast Pacific shores, but they are no more abundant locally. The above patterns may result from differences within or between genera, families, and orders.

Hayden*, Hillary S. & J. Robert Waaland. University of Washington, Seattle, WA.
GREEN TIDE ALGAE OF THE PADILLA BAY ESTUARY, WASHINGTON

Chlorophytic macroalgae were collected in August and September 1996 and April through August 1997 at six sites in the Padilla Bay Estuary of Washington State and identified to species using morphological and molecular characters. Based on morphological identification, fourteen chlorophytic macroalgal species were found, including representatives of *Acrosiphonia*, *Blidingia*, *Enteromorpha*, *Rhizoclonium*, *Ulva*, *Ulvaria* and *Urospora*. A different assemblage of species was found among and within sites during each collection while the number of species at all sites peaked in May and June 1997. Preliminary molecular analysis using restriction digests of the 5.8s coding region and flanking internal transcribed spacers of nuclear rDNA was carried out on individuals of *Enteromorpha prolifera*, *Enteromorpha linza* and *Ulva fenestrata*. Morphological and molecular data are consistent for *E. prolifera* individuals, but are inconsistent for *E. linza* and *U. fenestrata* individuals. Digestion patterns suggest that gene flow may be occurring among these species and raise questions about the current taxonomy and systematics of Ulvaceae. These questions will be explored in a cladistic analysis using DNA sequence data from introns in chloroplast trnL and nuclear RNA Polymerase II genes.

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AN ANOMOLOUS SOURCE OF NITROGEN IN A SOUTHEAST ALASKAN FJORD? IMPLICATIONS FOR POSSIBLE MANAGEMENT OPTIONS

Prior studies by scientists from the University of Alaska and the National Marine Fisheries Service have established that primary production in Southeast Alaskan interior coastal waters is limited by light during the winter with consequent enrichment of surface waters by nitrogen and phosphorus advected from deep waters. In the spring, stratification increases, light increases, primary production ensues, nutrients are depleted in the surface layers, and primary production becomes nutrient limited. Data collected during a study for a proposed discharge to Stevens Passage south of Juneau indicated the presence of anomolous amounts of nitrogen in surface waters. The nitrogen did not appear to be derived from deep waters, but did appear to extend the "spring bloom" over a limited area. The source of the nitrogen is not known, but can be speculated on, and further suggests the possibility of a means of enhancing production in selected areas.

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ACTIVATED DEFENSE MECHANISMS: ACRYLIC ACID AS AN ACTIVATED DEFENSE COMPOUND IN ALGAE

Acrylic acid is produced by both phytoplankton and macroalgae when methylsulfoniopropionate (DMSP) is cleaved, with dimethyl sulfide (DMS) as a byproduct. It has been suggested that DMSP may act as an activated defense precursor molecule, and acrylic acid may deter grazing by herbivores. This study explored whether grazing by two herbivores, the green sea urchin *Strongylocentrotus droebachiensis* and the isopod *Idotea wosnesenskii*, would be deterred by acrylic acid. The results showed that *S. droebachiensis* grazing was deterred by acrylic acid at concentrations of 0.1% to 2.0% wet weight, while *I. wosnesenskii* was not.

Higgins*, Heather and Jeffery Cordell. Wetland Ecosystem Team, School of Fisheries, Box 357980, University of Washington, Seattle, WA 98195-7980.
USING FALLOUT INSECTS TO MONITOR ECOLOGICAL STATUS AND TRENDS IN RESTORED WETLAND HABITATS IN THE DUWAMISH RIVER WATERWAY

The Duwamish Waterway in Seattle, Washington, is a highly industrialized estuary that has lost over 90 percent of its preexisting wetlands. However, recent efforts by a partnership of local, state, and federal agencies and the University of Washington have begun to restore and monitor small patches of created and reference wetland habitats in this estuary. Restoration has consisted of removal of existing over-water structures and creation of side channels, small basins, and shallow intertidal flats, with subsequent planting of emergent and riparian vegetation in and around these areas. Among several methods chosen for monitoring the biological status and trends at these restoration sites was insect fallout traps that consist of open plastic storage bins with antifreeze or other preservative, placed in habitats of interest. We present data which show that this method is a convenient and effective way to measure (1) input of adult insects that comprise mportant prey for juvenile salmon; (2) differences in discrete biological strata in wetlands; and (3) functional trajectories in the development of created wetland habitats.

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IDENTIFICATION OF A 1000 yBP TSUNAMI DEPOSIT IN PUGET SOUND, WASHINGTON: DIATOM ANALYSIS OF THE SNOHOMISH RIVER DELTA

The Pacific Northwest is a seismically active region. Strong evidence, such as uplifted marine platforms at the Seattle Fault, suggests the occurrence of large-scale seismic events within the upper crust of the Puget Sound approximately 1000 years ago. An earthquake at the Seattle Fault that produced these platforms very likely generated a tsunami that could deposit marine sedimentary material in various coastal areas of Puget Sound. Tsunamigenic deposits have been discovered and studied at Lynch Cove, Cultus Bay, and West Point: radiocarbon dates of these deposits correlate to the age of rapid uplift of the platforms of about 1000 years ago [Atwater and Moore, 1992]. Recently, another possible tsunami deposit has been discovered at the Snohomish River delta, 60 km north of the Seattle Fault [Bourgeois and Johnson, 1997]. Several mechanisms have been suggested for the deposition of the anomalous sand layer: erosion and redeposition of estuarine sand by a locally-generated tsunami, earthquake-induced liquefaction of a sand bed beneath the delta, and a severe flooding event of the Snohomish River [Bourgeois and Johnson, 1997]. To answer this question, microfossil diatom analysis has been performed on the deposit and its surrounding strata. The anomalous presence of estuarine diatom species within the deposit suggests an offshore origin for the sand. Therefore, the deposit was most likely laid down by a tsunami that occurred as a result of a large-scale seismic event along the Seattle Fault about 1000 years ago.

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THE PHYLOGENY AND BIOGRAPHY OF THE SOLIERIACEAE (RHODOPHYTA) BASED ON rbcL SEQUENCE ANALYSIS AND MORPHOLOGICAL EVIDENCE.

The family Solieriaceae presently contains about 20 genera that are widely distributed in warm-temperate and tropical waters throughout the world. Phylogenetic hypotheses based on rbcL sequences correlate well with results from recent studies of cell wall polysaccharides. Molecular and morphological evidence are consistent with an australasian origin for the family and a Tethyan distribution for its tropical representatives from west to east as far as the Pacific coast of North and South America. The austral cluster includes *Callophycus*, *Areschougia*, *Erythroclonium* and *Rhabdonia*. The remaining species are divisible into seven groups most of which have strong bootstrap support: (1) *Sarconema*, (2) an Indo-Pacific *Solieria robusta* group, (3) an Atlantic *Solieria group*, (4) a *Eucheuma* group, (5) a *Meristotheca/Meristiella* group, (6) an *Agardhiella* group, and (7) a *Sarcodiotheca* group that includes *Eucheuma uncinatum* from the Gulf of California. The recent separation of *Eucheuma* into sections including the genera *Kappaphycus* and *Betaphycus* based on cell wall composition will be discussed.

Hood*, W. Gregory. Wetland Ecosystem Team, School of Fisheries, Box 357980, University of Washington, Seattle, WA 98195-7980.
ECOSYSTEM ALLOMETRY: LANDSCAPE FORM AND ECOSYSTEM PROCESS.

I describe a model of ecosystem processes which is based on the allometry of landscape form and in ecosystem fluxes across landscape boundaries. An allometric model of landscape form serves as a structural model into which sub-models of specific boundary processes can be incorporated, allowing scaling of form and process. To illustrate this idea, I describe the allometry of various physical and biological parameters of estuarine sloughs of the Chehalis River (Washington, USA), including length, width, depth, surface area, surface current velocity, area of intertidal sedges along the sloughs, the residence time and abundance of insect flotsam within the sloughs, and the potential effect of slough size on fish feeding within the sloughs. An artificial slough, which was excavated to mitigate port improvements, illustrates the implications of ecosystem allometry for habitat restoration and preservation.

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COMPARISON OF TWO PUGET SOUND ESTUARINE HABITAT ASSESSMENT MODELS - DO WE KNOW ENOUGH TO EVALUATE PROJECT IMPACTS?

I compare two models developed to define the quality of estuarine habitats for supporting specific ecological functions; both have recently been used to successfully to define major project impacts and resultant mitigation needs. Both models are habitat based and assume an adequate knowledge exists about how important resource groups utilize local habitat. Neither model requires new field sampling, rather, they draw upon knowledge from past studies demonstrating species:habitat relationships. The Commencement Bay Model rates the quality of individual subareas of habitat (e.g., lower intertidal sand, subtidal mud) for providing selected ecological functions (e.g., feeding) as low, medium, or high. The total area of habitat of each quality for each resource group and function is summed under both existing and post-project conditions. The net change caused by the project is used to assess net impact and mitigation requirements. The SEWIP Model is a modification of the indicator value approach (IVA) model developed for freshwater wetlands. In the SEWIP Model, a series of questions is posed regarding the physical and chemical habitat aracteristics of the site. The response to each question has a pre-assigned score reflecting expectations about how the condition described will affect the overall function of the site. The sum of the response score becomes the "IVA score" that represents the capacity of the site to support specific ecological functions. Multiplied by site area, the "IVA acres" are used to calculate habitat losses due proposed changes at the site and to define mitigation needs.

Jacobson*, Dean, Dean Rocco & Andrea Olah. Whitworth College, Dept. of Biology, Spokane Washington 99251
A MIXOTROPHIC SPECIES OF ALEXANDRIUM FEEDS ON MESODINIUM SP. : ULTRASTRUCTURAL OBSERVATIONS

After observing food vacuole (f.v.)-like inclusions in *Alexandrium pseudogonyaulax* collected from Puget Sound, similar food inclusions were examined, using single-cell TEM analysis, from cells collected from N. Whidbey Island, Washington, and Coos Bay, southern Oregon. A variety of food items reveal geographic and temporal variations of diet. As much as 20% of the populations contained f.v., and the majority of these were clearly ciliate-derived. F.v. contents were sometimes diverse, containing both plastidic and non-plastidic ciliates (including *Strombidinopsis*) and small thecate dinoflagellates, or they could be dominated by *Mesodinium sp.* food vacuoles, identified by chloroplast structure. For example, a late summer Anacortes population was characterized by red-pigmented f.v. and characteristic yellow autofluorescence; Mesodinium f.v. also dominated the Coos Bay sample. One *Alexandrium* cell was captured in the actual process of ingesting a *Mesodinium* cell through the posterior-sulcal region, its epitheca intact.

Kugrens, P., B. Clay & R. Aguiar*. Department of Biology, Colorado State University, Fort Collins, Colorado 80523, USA
CHARACTERIZATION AND DESCRIPTION OF A NEW SPECIES OF CHARACIOSIPHON FROM COLORADO.

A large unicelled green alga, which resembled *Characium*, was isolated from a power plant's retaining pond. The cells ranged from 150 -230 µm in length and 80- 120 µm in diameter. The large vegetative cells are attached to the substrate by a small holdfast. The vegetative cells are multinucleate and contain numerous stellate chloroplasts, each with a central pyrenoid. When a vegetative cell reaches a maximum size, the cytoplasm cleaves to form numerous fusiform zoospores. Zoospores are biflagellate and measure 12 - 14 µm in length and 4-6 µm in diameter. Each zoospore contains a single parietal chloroplast with a prominent pyrenoid, which is located in the center of the chloroplast, and an anterior stigma. Zoospore release involves a dissolution of the vegetative wall. Released zoospores settle near the vegetative cell from which they were produced, attach to the substrate with their flagella, and after losing their flagella, form a small holdfast by which they attach to the substrate. Settled zoospores cluster together near the parent cell and only a few will grow into mature vegetative cells. New wall material is inserted between the holdfast and the apex after the wall breaks in this region. The initial wall material can be recognized as distinct fragments at either end of the vegetative cell. The young vegetative cell is fusiform and uninucleate, and it becomes more rounded as enlargement occurs. Others will become dormant and the chloroplast becomes orange in color. Sexual reproduction was not observed. The ultrastructural features of the various stages will be presented and discussed.

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PRELIMINARY POSTCONSTRUCTION RESULTS OF AN EELGRASS (*Zostera marina*) MITIGATION PROJECT

The City of Sequim extended its existing wastewater outfall into deeper offshore waters in 1997. An innovative eelgrass mitigation plan was designed and implemented for this project. Marine dredging equipment was used to relocate eelgrass from the construction corridor into prepared receiving areas. Use of a dredge bucket for relocation resulted in low hummocks of eelgrass and associated sediment. Following relocation, a large amount of the transferred eelgrass remained on the sediment surface and appeared undisturbed in receiving areas. The areal extent of the relocated eelgrass was 6,700 square feet. In addition to the receiving areas that did not contain eelgrass prior to relocation, the construction corridor within the boundaries of the existing eelgrass bed is expected to become eelgrass habitat. It is hoped that the patches of eelgrass within the receiving areas will grow into meadows, merge with existing beds, and recolonize the construction corridor.

Laetz*, Cathy. King County Department of Natural Resources, Water & Land Resources Division. 700 5th ave, suite 2200, Seattle, WA 98104.
KING COUNTY'S AQUATIC SCIENCE RESOURCES ON THE INTERNET

King County has a progressive, innovative, and interactive approach to communications on the Internet. King County's Internet policies allow web developers to be creative, to construct interactive pages, and to use the latest technologies available. All County departments, sections, and projects are encouraged to put useful information and content onto web pages. The Water and Land Resources Division has several pages that provide aquatic science information to the public in a creative, engaging, and interactive manner. Marine, estuarine, and freshwater projects all have sites on the Internet. The types of information provided on our web pages include reports, documents, newsletters, graphs, photographs, and public notices. User feedback indicates that our sites are useful, interesting, and providing the public with an alternative means of obtaining important information.

Levings*, Colin. Fisheries and Oceans, Science Branch, Pacific Environmental Science Centre, 2645 Dollarton Highway, North Vancouver, BC V7H 1V2.
FUNCTIONAL ASSESSMENT OF RESTORED, CREATED, AND REPLACED FISH HABITAT IN THE FRASER RIVER ESTUARY

Management techniques used in fish habitat management of the Fraser River estuary include the creation and restoration of vascular plants communities (especially brackish water marsh, eelgrass beds and salt marshes), lowering of terrestrial habitat, and development of artificial reefs. Under the auspices of the Fraser River Action Plan, functional evaluations of some of these projects were assessed for plant survival, and use by invertebrates and fish. Invertebrate fish food species (e.g., chironomids) were as abundant on created brackish and salt marshes compared to natural vegetation. However, height relative to tidal levels of the marsh platforms and their topography limited availability of the food for fish. One habitat created from dredge spoil 17 years ago and transplanted with brackish marsh is now dominated by salt marsh species. Subtidal artificial reefs were developed on concrete pipes, with the idea that they might replace productivity of water column habitat lost by filling, but judging from the species mix present on the reef this seems unlikely. Over the past two decades, considerable replacement or switching of habitat types has occurred in the Fraser River estuary, owing to both human interventions and natural variation in geomorphology. An understanding of the implications of these changes for ecosystem functions supporting fish is hampered by lack of long-term monitoring data as well as the virtual absence of information on the ecological linkages between the various landscape element s in the estuary.

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INVERTEBRATES FROM BALLAST WATER COLLECTED AT BRITISH COLUMBIA PORTS

Between December 1995 and January 1997 we conducted the first ballast water sampling program from ships in BC ports, with emphasis on Vancouver. The project focused on invertebrates and on vessels arriving from northeast Asian ports as well as some from the northeast Pacific. 500 L of water was pumped from the ships' standpipes and filtered through a 44 micron mesh net. Three of the 67 samples examined did not contain any organisms. In the others, organisms ranging from springtails to decapod zoea to medusae were obtained, with maximum abundance about 3442 animals m^{-3}. Cyclopoid and calanoid copepods were the most abundant taxa, accounting for approximately 35000 animals observed. 7475 adult calanoid copepods were examined to determine if non-indigenous species (in particular the Asian copepod *Pseudodiaptomus inopinus*) were present. None have been seen to date. Results of the study confirmed that ballast water has the potential to introduce non-indigenous species to BC from other parts of the North Pacific.

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INVASIVE JAPANESE FORAMINIFER TROCHAMMINA HADAI DISCOVERED IN NORTHERN PUGET SOUND

Sampling of northern Puget Sound from Blaine to Everett for the NOAA/Washington Cooperative Agreement Bioeffects Survey was conducted in June, 1997 by the Washington State Department of Ecology. As one goal of the study, sediment was obtained at 99 sites representing a variety of substrates and water depths (0.5-170.0 m) to test for the presence of a microscopic sand-sized animal which is common in Japanese estuaries. This foraminifer, *Trochammina hadai* Uchio, was first discovered on the West Coast in 1995 in San Francisco Bay. Since then, it has been discovered in many other ports along the West Coast, presumably introduced through the release of ballast water. In Puget Sound, the invasive foraminifer was found in sediments collected at numerous sites scattered throughout the study area, including Drayton Harbor, southern Straits of Georgia, Samish and Padilla bays, Outer Fidalgo Bay off March Point and Cap Sante, and Saratoga Passage off Whidbey Island. The species was particularly abundant in Birch and Inner Fidalgo bays, and at numerous locations in Bellingham Bay. It appears to prefer water depths of <12.0 m. As a primary consumer, it remains to be determined what effect the introduction of *T. hadai* has had on the trophic structure of Puget Sound and other West Coast estuaries.

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HABITAT RESTORATION PLANNING IN BELLINGHAM BAY - BELLINGHAM BAY DEMONSTRATION PILOT PROJECT

The Bellingham Bay Demonstration Pilot was initiated in 1996 with the charter of developing a cooperative partnership among regulatory agencies and local community to address contaminated sediment, habitat restoration, and source control problems in an urban embayment of Puget Sound. Some key process objectives of the Pilot are to build a comprehensive repository of environmental and land use information, to develop a more streamlined and predictable regulatory process, and to provide for the effective integration of environmental remediation, habitat restoration, and economic development. This presentation will focus on the habitat restoration element of the pilot, describe the process used to identify Baywide habitat vision, restoration goals and objectives, a range of habitat actions, and how these are integrated with sediment clean up and aquatic land uses. How priority habitat actions were integrated with short term remediation actions will be presented along with the framework for the long term restoration plan, including implantation. The presentation will also illustrate the partnering required between federal, tribal, state, and local entities to develop a comprehensive habitat restoration plan for Bellingham Bay.

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TETREUTREPTIA POMQUETENSIS (EUGLENOPHYTA), A PSYCHROPHILIC SPECIES: GROWTH AND FATTY ACID COMPOSITION

This quadriflagellated euglenoid is found in shallow-water embayments along the southeastern coast of the Gulf of St Lawrence during winter when the embayments are ice covered. Growth at normal psu occurred between temperatures of liquid water and 7°C, with a maximum of u = 0.35 d^{-1}, and the alga could not be maintained at 10°C. Growth was significantly reduced at 15 psu with little growth at 5 psu. Both [NH_4^+] and [NO_3^-] served as nitrogen sources, urea was not utilized and growth was unaffected until the N:P ratio fell below 20:1. Growth in artificial media was comparable to that in enriched seawater media. Cells grown at 5°C contained 22% FA (dwt) or ~1.65 ng $cell^{-1}$. The major FAs were: 18:4w3; 16:0; 16:4w3; 20:5w3 with the occurrence of the unusual 18:5w3 being a first report for euglenoids. The two most abundant SQDGs had FA pairings of [18:4/16:0] and [18:4/18:4] at 60% and 20% respectively, or 80% of the total SQDGs. The 18:4 pairings are a unique feature of *T. pomquetensis*, and [18:4/18:4] has not, to our knowledge, been reported previously. The PUFA spectrum recommends this alga as a potential food resource in cold-water aquaculture.

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DINOFLAGELLATE PREDATION IS NOT AFFECTED BY DIATOM MORPHOTYPE

This research examines the potential role of diatom morphotype (shape, size, appendices) as defense against dinoflagellate predation.Diatoms show a great variety in morphotype, partially due to siliceous and chitinous appendages. Traditionally, these extensions are believed to reduce sinking, maintaining the cell in the euphotic zone. Experimental evidence, however, fails to demonstrate this effect. Previous research suggests that chitinous threads reduce diatom mortality rate due to ciliate grazing. Here we investigate whether cell surface extentions affect diatom mortality due to dinoflagellate predation. Diatoms are able to attain high levels of biomass, frequently forming blooms despite predation by protozoan and metazoan grazers. Predator defense in diatoms is a potential mechanism to decrease loss rates, resulting in a net accumulation of biomass. Dinoflagellates have been identified as major consumers of diatom biomass. Furthermore dinoflagellates have the potential to grow as fast as their prey. Some thecate dinoflagellates - *Protoperidinium spp.* - feed by enveloping their prey in a pseudopod (pallium) excreted through a small orifice in the theca. Theoretically, the time needed to ingest a cell should depend on the cell surface area of the prey and should be less for cells without spines. In laboratory cultures, *Protoperidinium spp.* is able to feed on different centric diatoms. A single *Protoperidinium* species was observed to ingest diatom species ranging from 15 to 400 micron in length. Additionally the formation of dinoflagellate fecal pellets was documented. Overall diatom appendages did not alter dinoflagellate predation.

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DEVELOPMENT OF INTERTIDAL BIOPHYSICAL SHORE-ZONE MODEL FOR A PORTION OF THE SOUTHERN STRAIT OF GEORGIA, BRITISH COLUMBIA

The objective of this project was to develop descriptions of shore-zone biotopes from a combination of field observations of intertidal macrobiota and a hydrodynamic model for a portion of the southern Strait of Georgia. The biotopes were assigned to digitally-mapped shoreline units within the Georgia Basin and thus provide a summary of the intertidal biota for the area in the absence of detailed synoptic surveys. A number of intertidal shore sites were visited throughout the Strait of Georgia to document shoreline biota in the study area. The species assemblages observed were analysed using a multivariate cluster analysis program called TWINSPAN and the species grouping detected were related to the parameters of the physical model (temperature, salinity, wave exposure, current, and shoreline morphology) using a tree-based regression model. The regression tree predicted shoreline biotopes with an accuracy of 72%. The output rules from the tree models were used to classify the remainder of the 1434 km of coastline in the study area. Results indicate that this methodology may provide a useful tool for assessing coastal inventory and management priorities.

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GROWTH OF *LAMINARIA SACCHARINA* GAMETOPHYTE SUSPENSIONS IN TUBULAR AND PLANAR PHOTOBIOREACTORS

Liquid suspensions of *Laminaria saccharina* gametophytes were cultivated at 12°C in a 3-L tubular photobioreactor, a 5-L planar photobioreactor, and a 1-L stirred-tank photobioreactor and their growth characteristics compared. The tubular photobioreactor consisted of two parts: a 1.9 L coil of translucent silicone tubing (39 m length, 0.8 cm diameter) which was illuminated at 20-30 microeinsteins $m^{-2}sec^{-1}$ but not continuously aerated, and a 0.9 L aeration tank which was aerated at 1 L/min but not illuminated. The suspension culture was recycled between the aeration tank and the tubular section by a peristaltic pump at 123 ml/min. The 5-L planar photobioreactor vessel was constructed of Plexiglas with dimensions of 37 cm by 29 cm by 5 cm. The suspension culture in the planar vessel was illuminated at 20 microeinsteins $m^{-2}sec^{-1}$ and aerated at 1 L/min. The 1-L stirred-tank photobioreactor was illuminated at 20 microeinsteins $m^{-2}sec^{-1}$ and aerated at 1 L/min. Specific growth rates of 0.060 day^{-1} and final cell concentration of 2,100 mg DCW/L were achieved in the tubular photobioreactor after 50 days. Specific growth rates of 0.039 day^{-1} and final cell concentration of 2,000 mg DCW/L were achieved in the planar photobioreactor after 90 days. The growth rate in the stirred-tank photobioreactor was 0.037 day^{-1} and final cell concentrations of 1,000 mg DCW/L were achieved after 50 days. The efficient delivery of light to the suspension culture in the tubular and planar photobioreactors make these systems attractive for the large-scale production of photosynthetic biomass.

Newton*, Jan[1,2] & T. Aaron Morello[2,3]. [1]Washington State Dept. of Ecology, P.O. Box 47710, Olympia WA 98504-7710, [2]Northeastern University, [3]University of Washington.
WHAT CONTROLS THE TERMINATION OF PHYTOPLANKTON BLOOMS?

Because biomass is the net balance of growth and loss processes, the termination of a phytoplankton bloom can arise from either relatively low resource-limited growth or relatively strong loss processes. In order to evaluate this balance, the phytoplankton specific growth rate was measured using the chlorophyll labeling method over the course of three bloom events in Dabob Bay, Washington. During each event, a station was occupied for ~30 consecutive days and labeling experiments were conducted at 3 to 5-day intervals. Loss processes (grazing rates, advection, cell sinking) were also measured. One spring bloom, one fall bloom, and one late-spring period with fairly stable phytoplankton biomass were observed. The highest growth rates ($1 d^{-1}$) were observed in fall, during a bloom of the diatom *Chaetoceros*. However, growth rates fell as the bloom progressed, likely in response to temperature and light decreases. In contrast, the spring bloom showed steady growth rates ($0.6 d^{-1}$) over the entire rise and fall of the phytoplankton biomass. Strong loss processes (grazing and sinking) are indicated. During the late-spring stable biomass period, growth rates were lowest ($0.3 d^{-1}$) and there was evidence of nutrient limitation. It is apparent from these data that in this temperate coastal embayment, termination of a phytoplankton bloom may be driven by changes in either loss or growth terms. The utility of the chlorophyll labeling technique for studying ecosystem dynamics is clearly demonstrated.

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CHARACTERIZING DIVERSE PATHWAYS FOR THE INTRODUCTION OF NONINDIGENOUS SPECIES (NIS)

Some pathways for unintentional introduction of NIS are relatively well understood, but risks associated with shipments of some live marine products are not well-regulated and little information is available to characterize risk. We developed and have applied a simple interdisciplinary framework to characterize the biological and social events necessary for unwanted invasions to occur via shipments of live seafood and scientific specimens. In a pilot study we used the framework to determine whether any of these products pose a risk of NIS introduction to the Puget Sound region. First, we found that regulations governing trade and importation were insufficient to safeguard against accidental introductions from some pathways. Next, through contacts with local users in the Puget Sound region, we determined that one pathway, the trade in live baitworms, appears to be "closed", while some live seafood (especially that packed in live seaweeds), as well as scientific specimens of marine algae were potentially "open" pathways. For pathways characterized as "open" we recommended educational measures to forestall unwanted NIS introductions while quantitative studies and policy development are undertaken. Those pathways tentatively identified as "closed" would have a lower priority for policy action or scientific research, but would still be targeted for education.

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USING OTHER PEOPLE'S DATA TO ANALYZE FAILURE AND RECOVERY OF COLUMBIA RIVER SALMONID FISHERIES

Since the initial in-river commercial harvests of the 1860s, wild anadromous stocks of Columbia River salmonids (*Oncorhynchus* spp.) have declined. Their life cycles are complex and require freshwater, estuarine, and ocean habitats. Extensive marine feeding migrations take them thousands of miles from natal streams and expose them to several natural and human factors that influence growth and survival. Several factors recently have changed the ecology of Columbia River salmonids. Some changes blocked or degraded habitats; others altered species richness, community structure, food webs, productivity, and biotic interactions, such as predation and competition. Collectively, these factors adversely affected wild salmonid growth, spawning success, body size, genetics, abundance, and survival. New data strongly suggests that favorable climatic and oceanic conditions may have masked the original adverse impacts of hydropower development to the river's salmonid stocks between the 1940s and 1970s. Now, unfavorable conditions of the atmosphere and sea may be preventing a recovery.

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INTERTIDAL SPAWNING BEACHES OF THE SURF SMELT AND SAND LANCE IN PUGET SOUND

Intertidal spawning habitats of the surf smelt, *Hypomesus*, and the sand lance, *Ammodytes*, are common and widespread in Puget Sound. From 1991 to the present, the Washington Department of Fish and Wildlife (WDFW) has sampled 8,300 beach substrate sites to inventory the spawning beaches of these species. These species generally use mixed sand/gravel substrates in the upper one-third of the intertidal zone for egg deposition/incubation. Details of their spawning ecology can be characterized. About 20% of the Puget Sound shoreline may be used by these species for spawning, with about 200 miles of surf smelt spawning beach and 130 miles of sand lance spawning beach documented at Present. A complete inventory of the spawning beaches of these important forage fishes will allow more rational management of their stocks and "critical" habitats. WDFW has "no net loss" management regulations for documented surf smelt and sand lance spawning sites.

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DIATOMS OF A RAINFOREST SPRING

This is a preliminary report of a survey of the diatom flora of the Taft Spring complex, located in the temperate rainforest of the Hoh River Valley, Olympic National Forest, Washington. A total of 16 epiphytic and epipelic samples were collected in May and August of 1997. To date, 83 diatom taxa have been identified. At least 2 undescribed taxa, and many undescribed regional varieties, occur within the spring. The diatom flora of this spring complex is much more diverse than the flora of the adjoining Hoh River.

J. Roletto[1], N. Cosentino[2]*, D. Osorio[1], and E. Ueber[1]. [1] Gulf of the Farallones National Marine Sanctuary, Ft. Mason, Bldg. 201, San Francisco, CA. [2] Cosentino Consulting, 2 Ash Ln. Petaluma, CA.
MONITORING ROCKY INTERTIDAL COMMUNITIES IN THE GULF OF THE FARALLONES.

Long term monitoring on rocky intertidal algae and invertebrates has been conducted since 1993 at the South Farallon Islands. Methods used include point-frames, shore search and photographic recording. The mean annual percent cover for algae and invertebrates at the South Farallon Islands ranged from 144-243%. No significant seasonal or annual (temporal) differences in mean percent cover were found. Site (location) differences were detected. We have found 171 taxa; 5 of which are rare and 7 have extended ranges. *Corallina*, *Mazzaella*, *Mytilus*, *Anthopleura*, *Ulva*, and *Mastocarpus* were the dominant genera found on the Islands.

Rorrer, Gregory & Yao-ming Huang*. Department of Chemical Engineering, Oregon State University. Corvallis, Oregon 97331
BUBBLE COLUMN CULTIVATION AGARDHIELLA SUBULATA, REGENERATED MICROPLANTLETS

Suspension cultures derived from red macroalgae are a potential source of valuable compounds. A microplantlet suspension culture of the red macroalga, *Agardhiella subulata*, was established through callus regeneration. The phototrophic culture was maintained in static flasks at 24°C and 30uE·m^{-2}s^{-1} light intensity. Cell density and photosynthetic oxygen evolution rate were measured in a 2-L bubble column reactor at 0.275 vvm aeration and 65 uE·m^{-2}s^{-1} light intensity with a 2.5% medium perfusion rate. The specific growth rate was 0.08 day^{-1} for the first 30 days and a final density of 985mg DCW/L was achieved after 33 days. The study shows that *Agardhiella* microplantlets can be cultivated in an aerated bubble column reactor.

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PREDICTING THE EVOLUTION OF ECOLOGICAL FUNCTIONS OF REFLOODED WETLANDS IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

Over 90% of the once-vast tidal-freshwater wetlands of the Sacramento-San Joaquin Delta have been leveed and removed from tidal and floodwater inundation. One primary goal of the CALFED Bay/Delta Program is to restore ecosystem health and improve water management, and restoration of a significant portion of these tidal wetlands by breaching is considered to be one primary objective toward recovery of ecosystem integrity. We are collaborating with coastal geomorphologists (LUMCON), hydrologists (Phil Williams and Assoc.) and fisheries biologists (Calif. Dept. Water Resources) to analyze historically breached-levee wetlands as a means to predict the feasibility, patterns and rates of restoration to natural ecological function. Such a study necessitates an interdisciplinary approach, involving measurements of hydrological, geomorphological, biogeochemical and ecological indicators. We are comparing such indicators of habitat quality to existing mitigation and restoration sites that were purposefully constructed by levee breaching or comparable restoration actions (e.g., dredge material disposal). Using the same indicators, we will compare the status of both these naturally and intentionally restored wetlands to wetland function at the few natural "reference" wetland sites remaining in the Delta.

Simenstad*[1], Charles, Jeffery Cordell[1], Ronald Thom[2], W. Greg Hood[1], and Jessica Miller[3]. [1]Wetland Ecosystem Team, School of Fisheries, Box 357980, Seattle, WA 98195-7980; [2]Battelle Pacific Northwest Laboratories, Marine Science Laboratory, 1529 West Sequim Bay Road, Sequim, WA 98382; [3]3404 NE 26th Avenue, Portland, OR 97212.
EARLY GEOMORPHIC AND ECOLOGICAL DEVELOPMENT OF A CREATED SLOUGH IN THE CHEHALIS RIVER ESTUARY

Since 1990, we have periodically assessed the status of a created slough in the Chehalis River estuary, WA. Using an adjacent natural slough (Ann's Slough) as a reference site, we are comparing both structure (geomorphology, vegetation, large woody debris) and ecological function (fish utilization and prey resources), and have conducted manipulative experiments to evaluate important rate processes (fish short-term residence times and growth rates). Although many initial, dramatic differences in slough geo morphology remain, natural accretion processes and development of transplanted *Carex lyngbyei* vegetation in the created slough indicate that it may be on a convergent path with Ann's Slough. Differences in fish communities, and particularly juvenile salmon densities, are now insignificant. However, relative composition and abundances of benthic invertebrates and (fall-out and emergent) insects, and belowground Carex biomass differ. Juvenile salmon growth, residence time and diet indicate that their use of the created slough is analogous to Ann's Slough, but that the created slough may not yet be providing a natural suite or availability of prey organisms. Among the lessons that may be taken from these early trajectories of ecological function in the created slough, are some insights into 'gardening' versus 'self-design' in coastal wetland restoration.

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THE RETURN OF DIADEMA TO THE JAMAICAN BACKREEF, AND THE RETREAT OF MACROALGAE: EARLY SIGNS OF RECOVERY?

The Caribbean marine community changed dramatically after the 1983 epidemic death of the sea urchin *Diadema antillarum*. The most rapid and apparent change was a marked increase in biomass and species composition of macroalgae. Densities of *Diadema* (a key grazer in Jamaica) have remained low, and macroalgal cover high; researchers have predicted serious damage to coral reefs as a result. We report the first major change in the macroalgal-dominated community. On some rock outcrops, clearings of macroalgae were visible around *Diadema*. We documented the number of urchins and damselfishes, and macroalgal species composition and percentage cover on each outcrop. We found a significant negative correlation between the number and density of *Diadema* urchins and percentage algal cover. No significant correlations were found between other grazers and algal cover. The algal communities on trimmed outcrops (with more *Diadema*) differed from weedy outcrops in terms of species composition and dominance. These results document a pattern suggesting the beginning of recovery for the backreef site. If the *Diadema* population continues to expand, these small clearings would be expected to increase in size and number, eventually changing the large-scale pattern of this habitat to more closely resemble pre-epidemic patterns.

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ACCUMULATION OF TRIBUTYLTIN (TBT) IN FISH AND SHELLFISH FROM THE DUWAMISH ESTUARY AND NON-URBAN REFERENCE AREAS IN PUGET SOUND, WASHINGTON

King County and the Washington Department of Fish and Wildlife measured the concentrations of TBT in shellfish, other invertebrates, and fish from the Duwamish estuary in 1997. These studies supported ecological and human health risk assessments of combined sewer overflows and other sources of chemical contaminants. TBT was detected in all species from the study area. TBT concentrations were highest in organisms from the Duwamish River and Elliott Bay and lowest in organisms from non-urban reference areas (Port Susan and Hood Canal). The highest concentration was found in shiner perch from the Duwamish River (161 ug/Kg wet weight). The median TBT concentration in edible filets (muscle) of the longer-lived quillback rockfish (39.3 ug/Kg wet weight) in Elliott Bay were substantially higher than the median TBT concentration in filets (muscle) of English sole (1.4 ug/Kg wet weight) from the same area. The concentrations of TBT in the soft parts of mussels from the Duwamish River ranged between 21.8 and 72.8 ug/Kg wet weight. Concentrations of TBT in intertidal amphipods (26.8 ug/Kg wet weight, median) from Kellogg Island were essentially the same as the concentrations (20.5 ug/Kg wet weight, median) measured in Kellogg Island sediments.

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JUST HOW DO LIMPETS RESPOND TO ALGAL COVER?

In the perilous world of the intertidal, the common rockweed, *Fucus gardneri*, must struggle against an assortment of potential competitors and grazers as it disperses across mussel beds and invades mussel gaps. Despite being threatened by limpets early on in life, *Fucus* also attracts them as an adult. My data suggest that this attraction enables limpets to remain in mussel gaps in the presence of bird predators at much higher levels than would otherwise occur. However, this poses a dilemma. How does *Fucus* persist in this seemingly dysfunctional relationship? To address one part of the question, I have conducted experiments on the degree to which limpets respond to increases in algal cover. Through the use of artificial cover, I can show that limpet numbers increase predictably as cover increases. This increase, however, levels off quickly, suggesting that *Fucus* might be able to persist in mussel gaps. In fact, the limpets attracted may actually end up helping *Fucus* through their consumption of more quickly growing algae.

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APPLICATION OF ADAPTIVE MANAGEMENT TO ECOLOGICAL RESTORATION PROJECTS IN PUGET SOUND

The purpose of our paper is to describe a method for applying the principles of adaptive management to ecological restoration projects in estuaries and coastal systems. It is well documented that the success of ecological restoration, especially at severely disturbed sites, is uncertain. Although it is known that restoration can be successful, this success is difficult to predict, because ecologists lack reliable, long-term information to make accurate, predictive models. Adaptive management principles acknowledge the uncertainty associated with predicting the level of success of ecological restoration projects and the inherent variability in the natural environment. We have been applying adaptive management principles to seagrass and salt marsh restoration projects in Puget Sound. The method involves three components: (1) a clear goal statement, (2) a conceptual model, and (3) a system-development matrix. Monitoring, which is critical to any adaptive management program, provides the feedback required to assess the progress of the developing system. The conceptual model identifies critical physical factors required for the system to develop toward its goal, and the matrix provides the framework for decision-making to achieve desired objectives.

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THE EFFECT OF THE EXOTIC PLANT EICHHORNIA CRASSIPES (WATER HYACINTH) ON THE FISH/INVERTEBRATE FOOD WEB IN THE SACRAMENTO/SAN JOAQUIN DELTA, CALIFORNIA

Eichhornia crassipes is a floating aquatic macrophyte that was introduced into the Sacramento/San Joaquin Delta region in the 1940's. *E. crassipes* is native to Brazil, and has a history of worldwide invasions. Its international prominence, detrimental economic impacts, and associated management challenges makes it an important research focus. A common native plant that functionally occupies the same habitat as *E. crassipes* in the Delta is *Hydrocotyle umbellata* (Pennywort). The relative effect on community dynamics of *E. crassipes* as compared to its suitable native counterpart *H. umbellata* is unknown. The current state of *E. crassipes* in the Delta will be examined, as well as an outline of research that will characterize the invertebrate and fish communities associated with both *E. crassipes* and *H. umbellata*. Temporal and spatial patterns of the distribution and abundance of *E. crassipes* and *H. umbellata* will also be conducted by utilizing Geographic Information System (GIS) analysis.

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HERBIVORE FOOD PREFERENCES FOR JUVENILE AND ADULT SEAWEEDS

Juvenile seaweeds appear more likely to be preferred by grazers over adult tissues because they are structurally less robust then adults. The consequences of grazing should also be more pronounced on juveniles because each bite taken by a grazer removes a greater proportion of the plant's biomass in a juvenile than an adult plant. We conducted laboratory feeding experiments with three common marine herbivores to determine whether grazers preferred juvenile over adult tissues of eight species of kelps and fucoid brown algae. Preferences of herbivores for juvenile versus adult tissues were both herbivore-dependent and plant species-dependent, suggesting that preferences were the result of a combination of morphological and chemical features of the plants. We also conducted analyses of nitrogen, lipid, ash, and phenolic concentrations of juvenile and adult seaweeds to determine whether there were chemical differences in the tissues that might influence herbivore food preferences.

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AN INVESTIGATION OF NORTHWEST FRESHWATER CYANOBACTERIA STRAIN DIVERSITY.

Recent work on freshwater cyanobacteria suggests that multiple strains of planktonic species are present in waterbodies and that they respond to spatial and temporal changes in environmental conditions. There is disagreement in the literature whether strains are cosmopolitan or particularly suited to local environments. We are investigating strain and species diversity in the genera *Anabaena* and *Microcystis*, with an emphasis on Pacific Northwest lakes. These two genera are particularly interesting because they contain common species with known toxic strains. Toxic strains may or may not be continuously present within a lake or in closely situated waterbodies. We are developing techniques for PCR amplification of the phycocyanin operon and intergenic spacer (PC-IGS) to investigate community structure and phylogenetic relationships within these genera. Preliminary work indicates that PC IGS sequences will be useful in delineating strains of *Anabaena*. Data on isolates of *Anabaena* from American Lake, Washington will be presented as well as information on *Microcystis* from culture collections. Work continues on development of strain specific PCR primers that will be used to screen cyanobacterial populations for specific strains.

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BIOLOGICAL INVASIONS ON EXPOSED SHORES: ABIOTIC OR BIOTIC RESISTANCE?

Invasive marine species in Puget Sound are concentrated in sheltered waters. Why are exposed rocky shores less invaded? Alternative hypotheses for predicting the success of potential invaders include: propagule pressure (i.e., opportunity), physical conditions, and biotic resistance (from competition, predation, or both). I am testing these hypotheses for exposed and sheltered shores with the non-native blue mussel, *Mytilus galloprovincialis*, a Mediterranean species imported to Washington and British Columbia for aquaculture. *M. galloprovincialis* is a successful invader in South Africa and Asia, where it has established on both exposed and sheltered shores. In Puget Sound, *M. galloprovincialis* has been documented from mid Puget Sound and from the outer coast: its capacity to disperse to sheltered and exposed shores is clear. I will present results for the second 2 invasion hypotheses: abiotic and biotic factors. *M. galloprovincialis* locally is likely to compete with native sibling species *M. trossulus*. I have tested both survivorship and susceptibility to predation of *M. galloprovincialis* and *M. trossulus* on exposed and sheltered shores on the outer coast. I then ask whether these results can be scaled up to a broader regional distribution, comparing exposed outer coast sites to a sheltered site in Puget Sound.

Casey Conference Center information

Casey Conference Center is owned and operated by Seattle Pacific University, a private Christian university. It is rented to nonprofit organizations, mainly schools and sports camps. In the 1890s, the newly built Fort Casey guarded the entrance to Bremerton's naval shipyard. You can walk to the adjacent Fort Casey State Park, which is located up the hill behind the barracks buildings. There are interesting gun emplacements, tunnels, bunkers, trails and a lighthouse to explore. The state park closes at dusk. Nearby places of interest include Coupeville, a village of Victorian homes and shops located 3 miles north of Casey Conference Center, and Port Townsend on the Olympic peninsula which can be accessed by a short walk and ferry ride. Casey Conference Center does not permit the following anywhere on the Casey Conference Center property: pets, alcohol, illegal substances, firearms and fireworks. Cigarette smoking is allowed only outside the buildings. You will be able to purchase alcoholic beverages at the Saturday night Banquet, which is in the Officer's Club on the Whidbey Naval Air Station in Oak Harbor. Do not collect any organisms from the beach.

Refer to the map for the layout of Casey Conference Center. Please park vehicles off to the sides of the roads (parallel parking). Do not park on the grass, double park, and block any roadway. Emergency vehicles must have adequate room to access all buildings.

Lodging is provided in the Company Quarters ("Barracks") H and J. These rustic two-story buildings were once used to house the enlisted men when the grounds were part of Fort Casey, a U.S. military installation. H and J are divided into individual bedrooms with two single beds per room. Please occupy the room we have assigned to you. There are no locks on the doors. You will be issued a linen set, which should be left in the room upon departure. Please close all windows when you leave.

Food service is provided by Marriott in Mess Hall B. We have selected the enhanced fare menu, which provides the greatest variety of food choices. This option also includes continuous beverage service in Mess Hall B, located across the road from the poster area in lower "F". You may help yourself to hot and cold drinks during open hours.

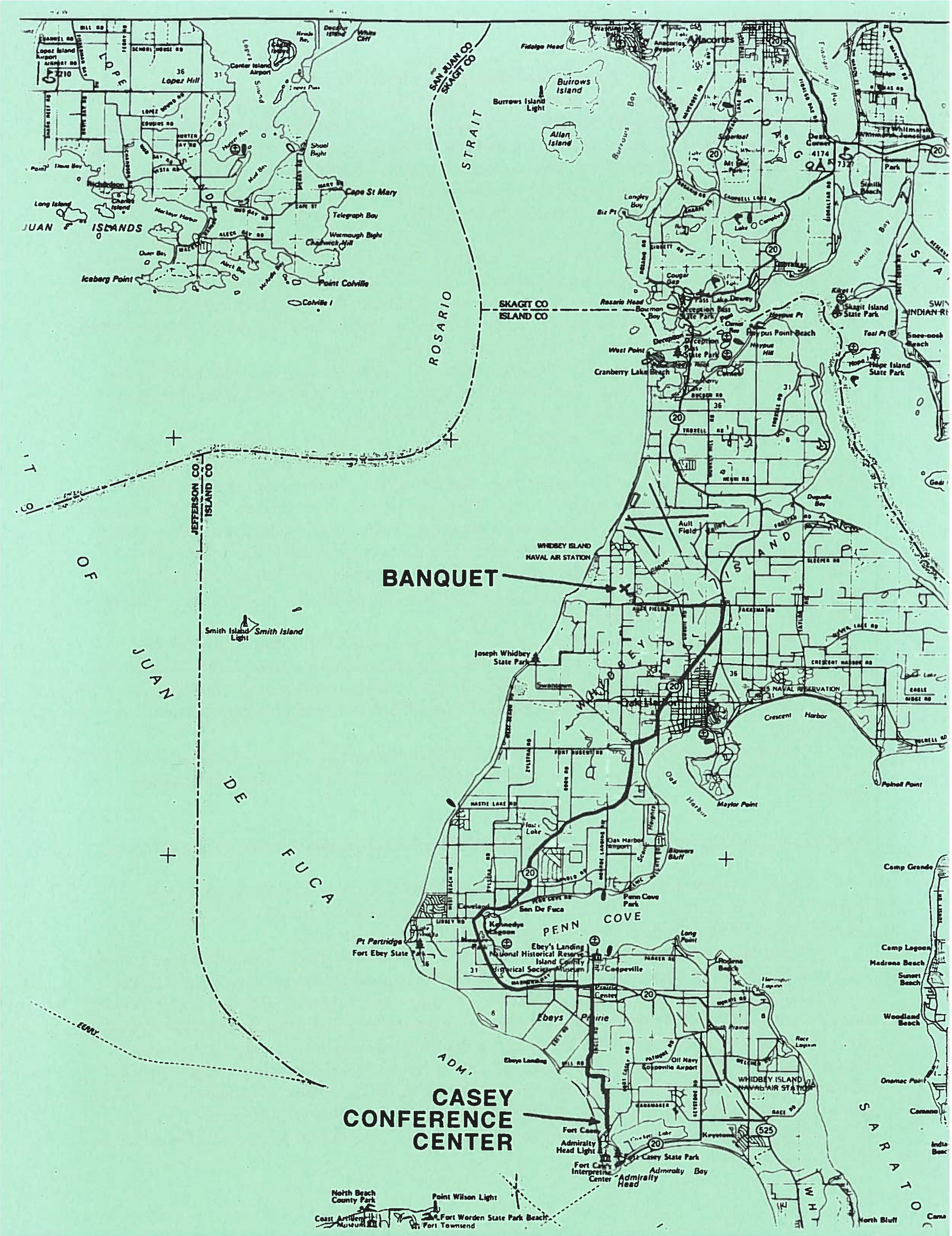
There are 3 **pay phones** by the mess halls (2 near Mess Hall A and 1 near Mess Hall B). Emergency messages can be sent to two 24-hour answering service phone numbers: 360-678-5050, or 206-775-0775 (toll-free from Seattle). The answering service will need to know the group name (Shannon Point Marine Center, or NWAS/PERS). NWAS/PERS will have a message board in Classroom B.

Emergency information: Whidbey General Hospital is located in Coupeville (phone: 678-5151) at 101 North Main St. You can get to the hospital in 10 minutes, or dial 911 for an ambulance if necessary.

Directions to the Saturday night banquet at the Officer's Club, Naval Air Station Whidbey Isl.

The bar is open at 6 PM, dinner will be served at 7 PM. Allow 35 minutes to get to the Officer's Club from Casey Conference Center. Please car pool. We also have several vans and will provide limited transportation in these (sign up for vans at registration desk).

Please refer to the map of Whidbey Island (it is 16.5 miles from Casey Conference Center to the Ault Field Road turnoff from Highway 20). Turn left (north) towards Coupeville (observe 25 MPH speed limit in town area!). At the traffic light, turn left (north) onto Highway 20 (towards Oak Harbor). In Oak Harbor, take a left at the light at Burger King (continuing on HWY 20) going straight through the commercial area of Oak Harbor. About 4 or 5 miles from the Burger King, take a left at AULT FIELD ROAD (traffic light and N.A.S. Whidbey sign). At the second traffic light on Ault Field Rd, take a right (across from the auto parts store) and enter the Main Gate of N.A.S. Whidbey. Stop at the gate and identify yourself as part of the NWAS/PERS group at the Officer's Club (wear your name tags). After the main gate, take a left at the four-way stop sign. The Officer's Club is on the corner at the end of that road.



BANQUET
CASEY
CONFERENCE
CENTER
WHIDBEY ISLAND
NAVAL AIR STATION
Ault Field
Oak Harbor
Crescent Harbor
PENN COVE
Penn Cove Park
San De Fuca
Coveland
Kennedys Lagoon
Ebey's Landing
National Historical Reserve
Island County
Historical Society Museum
Coupeville
Prairie Center
Ebeys Prairie
Ebeys Landing
Fort Casey
Admiralty Head Light
Fort Casey State Park
Fort Casey Interpretive Center
Admiralty Head
Admiralty Bay
Keystone
Pt Partridge
Fort Ebey State Park
Joseph Whidbey State Park
Swantown
Oak Harbor Airport
Blowers Bluff
Maylor Point
Polnell Point
Camp Grande
Camp Lagoon
Madrona Beach
Sunset Beach
Woodland Beach
Race Lagoon
Long Point
Outlying Coupeville Airport
North Beach County Park
Point Wilson Light
Coast Artillery Museum
Fort Worden State Park Beach
Port Townsend
North Bluff
Smith Island Light
Smith Island
JEFFERSON CO.
ISLAND CO
SKAGIT CO
ISLAND CO
SAN JUAN CO
SKAGIT CO
ROSARIO
STRAIT
OF
JUAN
DE
FUCA
FERRY
ADM'
Rosario Head
Bowman Bay
Deception Pass
Deception Pass State Park
Pass Lake
West Point
Cranberry Lake Beach
Hoypus Pt
Hoypus Point Beach
Kiket I
Skagit Island State Park
Hope Island State Park
Dugualla Bay
Burrows Island
Burrows Island Light
Allan Island
Burrows Bay
Fidalgo Head
Anacortes
Langley Bay
Lake Campbell
Cougar Gap
Whitmarsh Junction
Similk Beach
Similk Bay
Lopez Hill
Center Island Airport
Shoal Bight
Cape St Mary
Telegraph Bay
Watmough Bight
Chadwick Hill
Point Colville
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Richardson
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Swinomish Channel ent., Padilla Bay, Rosario Strait, etc, WASHINGTON   Latitude: 48° 28' N Longitude: 122° 31' W