

24th NORTHWEST ALGAL SYMPOSIUM PROGRAM

Cornet Bay Environmental Learning Center, Deception Pass State Park,
Whidbey Island, Washington

Friday Afternoon, April 16

- 15:00- on **Registration** and Housing Assignments at Recreation Center (see map)
18:00 **Dinner** (Dining Hall, see map)

Friday Evening, April 16

- 19:00 **Informal Social** (on the beach or in the Dining Hall depending on weather) **Poster Set up** (Mess Hall) (Plan to remove Posters by 11:00 Sunday April 18)

Saturday Morning, April 17

- 08:00 **Breakfast** (Mess Hall)
08:00 **Registration** resumes in Recreation Center

24th NORTHWEST ALGAL SYMPOSIUM PROGRAM

Cornet Bay Environmental Learning Center, Deception Pass State Park,
Whidbey Island, Washington

Saturday Morning, April 17

- 08:00 **Breakfast** (Dining Hall)
08:00 **Registration** resumes in Recreation Center
- 09:00- 12:00 **Contributed Papers** (Recreational Center)
- 09:00 Welcoming Remarks
- 09:15 TREATMENT OF DIFFERENT WASTEWATER SOURCES BY ALGAE FOR WATER REUSE IN IRRIGATION
Carole Abourached, Ganti Murthy, Dept. of Biological & Ecological Engineering., Oregon State University, Corvallis, OR
- 09:30 STAGE PHOTOBIOREACTOR CULTIVATION PROCESS FOR ENHANCING LIPID PRODUCTION FROM DIATOM CELLS BY CONTROLLED SILICON LIMITATION
Jennifer Adkins and Gregory L. Rorrer, Oregon State University, Corvallis, OR

- 09:45 **MODELING ALGAE GROWTH IN A NOVEL DESIGN OPEN POND**
Kyle Sander and Ganti S. Murthy, Department of Biological & Ecological Engineering, Oregon State University, Corvallis, OR
- 10:00 **PHYTOPLANKTON COMMUNITY STRUCTURE AND ITS RELATION TO HYDROGRAPHIC CONDITIONS IN THE NORTH YELLOW SEA IN AUTUMN, 2007**
Xiuning Du and Guangxing Liu, College of Environmental Science and Engineering, Ocean University of China, Qingdao, China
- 10:15 **C/T Break** (Recreational Center)
- 10:45 **REFINDING *PHYLLOSPADIX SERRULATUS* ON THE SOUTHERN COAST OF OREGON**
 June Mohler, Portland, OR
- 11:00 **THE SEAWEEDS AND SEAGRASSES OF THREE ROCKY INTERTIDAL BEACHES ON THE CENTRAL COAST OF OREGON**
 Gayle I. Hansen, Oregon State University at PCEB/WED, U. S. Environmental Protection Agency, 2111 SE Marine Science Drive, Newport, OR
- 11:15 **CRYPTIC POPULATION DIVERSITY IN THE RAPHIDOPHYTE ALGA, *HETEROSIGMA AKASHIWO***
Megan Black, Chloe Deodato, Michael Jacobs, Anastasia Berg, William Hardin, and Rose Ann Cattolico, Department of Biology, University of Washington, Seattle, WA
- 11:30 ***ULVA* – A TALE OF TWO ISLANDS**
 Charles J. O’Kelly, Friday Harbor Laboratories, University of Washington, Friday Harbor, WA
- 11:45 **ADDITIONAL CRYPTIC DIVERSITY SUGGESTS A PACIFIC ORIGIN OF THE RED ALGAL FAMILY PALMARIACEAE**
 Sandra C. Lindstrom, Department of Botany, University of British Columbia, Vancouver, BC, Canada
- 12:00 **Lunch** (Dining Hall)

Saturday Afternoon, April 17

13:00-16:15 **Contributed Papers** (Recreational Center)

13:00	ABIOTIC REGULATION OF SEXUAL VS. VEGETATIVE REPRODUCTION IN THE CLONAL KELP, <i>LAMINARIA SINCLAIRII</i> (LAMINARIALES, PHAEOPHYCEAE) <u>Kyle W. Demes</u> , Dept. of Botany, University of British Columbia, Vancouver, BC, Canada and Michael H. Graham, Moss Landing Marine Lab, Moss Landing, CA
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13:15	RECOVERY DYNAMICS IN ROCKY INTERTIDAL COMMUNITIES: PATTERNS, MECHANISMS AND SIMULATIONS Letitia L. Conway-Cranos, School of Marine Affairs and School of Aquatic and Fisheries Science, University of Washington, Seattle, WA
13:30	DO NATIVE MACRO-INVERTEBRATES CONSUME NATIVE OVER NON-NATIVE SEAWEEDS? <u>Sean C. Vogt</u> , Jayson R. Smith, and Steven N. Murray, Dept. of Biological Science, California State University, Fullerton, CA
13:45	HOW TO DISTINGUISH SPECIES OF <i>CALLIARTHRON</i> (CORALLINALES, RHODOPHYTA) WITH CALIPERS AND A CALCULATOR <u>Patrick T. Martone</u> , Botany Department, University of British Columbia, Vancouver BC, Kathy Ann Miller, University Herbarium, University of California, Berkeley, CA, and Paul W. Gabrielson, UNC Herbarium, University of North Carolina, Chapel Hill, NC
14:00	SEASONAL PATTERNS AND STRATEGIES IN THE REPRODUCTION OF CORALLINE ALGAE Kevin A. Miklasz, Hopkins Marine Station, Stanford University, Pacific Grove, CA
14:15	VIDEO ANALYSIS OF ULVOID ALGAL AND <i>ZOSTERA</i> POPULATIONS IN GREATER PUGET SOUND <u>Tim Nelson</u> , Jennifer Olson, Lydia Imhoff, Alyssa Bowen, and Myles Melton. Department of Biology, Seattle Pacific University, Seattle, WA
14:30	NEW INITIATIVES FOR OCEAN ACIDIFICATION RESEARCH Terrie Klinger, School of Marine Affairs, University of Washington, Seattle, WA
14:45	C/T Break (Recreational Center)
15:15	NWAS Business Meeting (Recreational Center)
16:00	Poster Session (Recreational Center) Authors to be available for discussion until 17:00
Poster 1	RELEASE OF DOPAMINE BY <i>ULVARIA OBSCURA</i> : EFFECTS OF WEATHER <u>Katie Anderson</u> , Amanda Winans, and Kathy Van Alstyne. Shannon Point Marine Center, Western Washington University, Anacortes, WA
Poster 2	THE DEVELOPMENT OF A SOLID-PHASE MICRO-EXTRACTION METHOD FOR MEASURING DMS RELEASE BY ULVOID ALGAE <u>Monique Savedo</u> , Kathryn Van Alstyne, and Mary Ellen Salyan. Shannon Point Marine Center, Western Washington University, Anacortes, WA
Poster	THE EFFECTS OF ENVIRONMENTAL AND CHEMICAL STRESSORS ON

3	OXIDANT RELEASE BY ULVOID ALGAE AND THE IMPACTS OF HYDROGEN PEROXIDE ON LARVAL <i>MYTILUS TROSSULUS</i> SURVIVAL AND DEVELOPMENT Dan H. van Hees, Department of Biology, Western Washington University, Bellingham, WA
Poster 4	COMPARISON OF CELL CYCLES OF ISOLATED AND IN-HOST SYMBIONTS OF THE ANEMONE <i>ANTHOPLLEURA ELEGANTISSIMA</i> <u>Zullaylee Ramos</u> , Jay Dimond and Brian Bingham, Shannon Point Marine Center, Western Washington University, Anacortes, WA
Poster 5	GROWTH OF DIATOM BIOFILMS FOR APPLICATIONS IN PHOTOCATALYSIS AND SOLAR ENERGY PRODUCTION Jeremy Campbell, Chemical Engineering, Oregon State University, Corvallis, OR

Saturday Evening, April 17

17:30-18:30 **Pre-Banquet Social and Auction** (Dining Hall, Cornet Bay ELC)

19:30 **Banquet** (Dining Hall, Cornet Bay ELC)

Banquet Speaker: Kathy Ann Miller, University Herbarium, University of California, Berkeley
MY LIFE IN RED, GREEN AND BROWN: WHAT SEAWEEDS HAVE TAUGHT ME

Sunday Morning, April 18

08:00 **Breakfast** (Dining Hall)

09:00 – 10:45 **ALGAL BIOFUELS AND BIOMASS PRODUCTION SYMPOSIUM/DISCUSSION** (Recreational Center)

11:00 **C/T Break** (Recreational Center)

Participants:

Mike Lakeman – Renewable Energy Specialist, Boeing Commercial Airplanes
Charley O’Kelly – Friday Harbor Labs, University of Washington
Guri Roesjadi – PNNL Sequim, Washington
Greg Rorrer – Oregon State University and National Science Foundation
Robin Kodner – Director of Research, Bodega Algae, Boston, Massachusetts

11:00 **Take down posters** if you have not already done so.

Pick up box lunch, clean cabins, check out before leaving

11:30 **Field Trip:** (see details and map elsewhere in program)
Low Tide
Partridge Point, Whidbey Island (1:04 PM -1.35ft)

ABSTRACTS (talks)

TREATMENT OF DIFFERENT WASTEWATER SOURCES BY ALGAE FOR WATER REUSE IN IRRIGATION

Carole Abourached, Ganti Murthy, Dept. of Biological & Ecological Engineering, Oregon State University, Corvallis, OR

Wastewater is rich in chemicals that can cause eutrophication and affect plant growth when discharged without adequate treatment. Although physical and chemical methods can be used to remove nutrients from wastewater, most of the nutrients cannot be recovered in a usable form. Use of bioremediation techniques such as algal growth can be an alternative solution. Microalgal wastewater treatment presents a low cost and effective method for wastewater purification because of the high uptake of inorganic nutrients (nitrate and phosphate) by algae. The resulting algae can be used as animal feed, organic fertilizer or as feedstock for biofuel production.

Two Freshwater (*Chlamydomonas reinhardtii* and *Scenedesmus dimorphus*) and two marine microalgal strains (*Dunaliella tertiolecta* and *Nannochloris* sp.) are compared in their efficiency in treating different wastewater sources (synthetic wastewater, municipal wastewater and landfill leachate). Algal growth is evaluated by determining dry algal biomass and total chlorophyll content. The effect of algae growth on water quality is examined by measuring parameters such as pH, COD, nitrate and phosphate concentrations.

TWO-STAGE PHOTOBIOREACTOR CULTIVATION PROCESS FOR ENHANCING LIPID PRODUCTION FROM DIATOM CELLS BY CONTROLLED SILICON LIMITATION

Jennifer Adkins and Gregory L. Rorrer, Oregon State University, Corvallis, OR

Diatoms are a class of single-celled algae which make silica cell walls and require dissolved silicon as a substrate for cell division. Manipulation of soluble silicon delivery to the culture offers a route to control cell cycle and lipid production. A two-stage, semi-continuous photobioreactor cultivation process was developed to induce the production of lipid-rich algal biomass from the centric diatom *Cyclotella*. In the first stage of the process, algal cells were grown up to high density until all of the dissolved silicon in the feed medium was consumed. The cells were in the silicon-starved state when the cell density was constant for 24 hours and the dissolved silicon concentration was near-zero and ceased to change. During silicon starvation, the total lipid content increased from 7 wt% in the dry algal biomass to over 40 wt%. Then, about one-half of the total culture volume was harvested, and fresh medium containing dissolved silicon was perfused into the reactor over 48, 72 and 96 hrs. The silicon was rapidly consumed by the silicon-starved cells under a surge uptake mechanism. The silicon concentration was maintained at the near-zero concentrations present at the end of the first stage, so that silicon starvation was maintained within the diatom cells. Consequently, high lipid content in the algal biomass was maintained at 30 wt% as the culture grew back to the target cell density. This study illustrates

how bioreactor cultivation strategies can be used to enhance lipid production by algal cultures for the purpose of algal biodiesel.

CRYPTIC POPULATION DIVERSITY IN THE RAPHIIDOPHYTE ALGA, *HETEROSIGMA AKASHIWO*

Megan Black, Chloe Deodato, Michael Jacobs, Anastasia Berg, William Hardin, and Rose Ann Cattolico, Department of Biology, University of Washington, Seattle, WA

The five most divergent mitochondrial genes coding for the proteins cytochrome C oxidase subunit 1, NADH dehydrogenase subunits 2,4,5, & 7 of the electron transport chain were sequenced for 48 *Heterosigma akashiwo* cultures. The extent of the diversity seen among isolates of this harmful algal bloom forming raphidophyte was much greater than reported previously when either ribosomal DNA or rubisco sequences were examined. Of the 7527 nucleotides examined, 175 base changes (2.3%) were used to generate barcodes for each strain. Twenty DNA haplotypes were identified for the five genes. When DNA sequences were translated into proteins, thirteen haplotypes were produced. Some amino acid substitutions caused an altered hydrophobicity or charge in the protein sequence, possibly causing an impact on protein function. Evolutionary history of each gene is not consistent. Data shows that not only were there different rates of evolution among *H. akashiwo* genes, but single gene phylogenies were incongruent.

Examination of only the NAD5 protein phylogeny suggests that although extensive sequence variation exists among strains, the branch lengths were minimal when compared to four *Saccharina* species. Interestingly, the distance between *H. akashiwo* and its sister genus, *Chattonella*, for mitochondrial genes is often greater than the genetic distance observed in other stramenopile taxa. The use of mitochondrial proteins as bar codes in this study will be useful when examining regional population genetic questions. For example, in the Salish Sea, one protein haplotype has been observed most frequently. However, *H. akashiwo* from five different haplotypes were documented to also co-occur.

RECOVERY DYNAMICS IN ROCKY INTERTIDAL COMMUNITIES: PATTERNS, MECHANISMS AND SIMULATIONS

Letitia L. Conway-Cranos, School of Marine Affairs and School of Aquatic and Fisheries Science, University of Washington, Seattle, WA

Understanding the way natural communities change over time remains one of the great challenges to the field of ecology. Knowledge of the mechanisms by which communities respond to perturbations is a fundamental aspect of understanding community dynamics. Recovery rates and trajectories can profoundly influence the way disturbance determines community structure and as such it is important to understand the factors that contribute to variation in them. Life history characteristics (e.g., lifespan and dispersal potential) of disturbed taxa, size of initial disturbance, rates of input to the population (recruitment) and species interactions throughout the course of succession may all have important effects on rates of community recovery, yet the relative contributions of these factors have not been well characterized. Here I combine field data of post-disturbance community development with Markov simulations to broaden our understanding of

the mechanisms driving observed differences in successional rates and trajectories. I have calculated community recovery rates following an experimental disturbance across a major biogeographic break on the California coast in four intertidal assemblages (zones) that are each dominated by a taxon with a unique combination of life history traits: The California mussel *Mytilus californianus*, the acorn barnacle *Chthamalus fissus/dalli*, the rockweed *Silvetia compressa* and the red turf seaweed *Endocladia muricata*. I present here an examination of the relative importance of recruitment, mobile consumers and facilitative interactions in driving successional rates and trajectories using the rocky intertidal ecosystem on the west coast of North America as a model system.

ABIOTIC REGULATION OF SEXUAL VS. VEGETATIVE REPRODUCTION IN THE CLONAL KELP, *LAMINARIA SINCLAIRII* (LAMINARIALES, PHAEOPHYCEAE)

Kyle W. Demes, Dept. of Botany, University of British Columbia, Vancouver, BC, Canada and Michael H. Graham, Moss Landing Marine Laboratories, Moss Landing, CA, USA

Clonal kelp taxa may reproduce both sexually and vegetatively resulting in a potential trade-off in the allocation of acquired carbon and nitrogen resources. Such trade-offs may dictate a different response of clonal kelps to varying environmental conditions relative to a clonal kelp taxa. Laboratory temperature and nutrient manipulation experiments demonstrated that investment in sexual and vegetative reproduction in *Laminaria sinclairii* (Harvey ex Hooker f. et Harvey) Farlow, C.L. Anderson et D.C. Eaton was regulated by different abiotic factors. Blade growth and sorus production (investment in sexual reproduction) were significantly higher at 12°C compared to 17°C, regardless of nutrient concentration. Net carbon storage and depletion in rhizomes were observed in the low and high temperature treatments, respectively. Rhizome elongation (investment in vegetative reproduction), on the other hand, was significantly higher in 12 μM NO₃⁻ than in 2 μM NO₃⁻, irrespective of temperature. This increase in rhizome growth was concurrent with elevated rhizome percent tissue nitrogen levels also observed in treatments with higher nutrients. These results suggest that physiologically, *Laminaria sinclairii* is similar to a clonal kelp and that its rhizome functions similar to the stipes of other kelps with respect to carbon and nitrogen storage.

PHYTOPLANKTON COMMUNITY STRUCTURE AND ITS RELATION TO HYDROGRAPHIC CONDITIONS IN THE NORTH YELLOW SEA IN AUTUMN, 2007

Xiuning Du and Guangxing Liu, College of Environmental Science and Engineering, Ocean University of China, Qingdao, China.

The investigation was carried out in the North Yellow Sea (NYS), in autumn (from 14 to 25 October 2007). Phytoplankton species composition, abundance, distribution, and the relationships between phytoplankton and hydrographic conditions were analyzed. Temperate neritic species and cosmopolitan species dominated phytoplankton community in autumn. Compared with historic records, dinoflagellates species richness and abundance showed an increasing trend; total phytoplankton abundance was lower than that of 1960s but higher than that of 1990s. Species composition varied greatly during the past half century. More warm water species and oceanic species appeared in October 2007 with growing species richness and abundance

compared with Chinese General Oceanographic Survey (CGOS) in 1958-1960. Three biogeographic assemblages were identified: the coastal oligohaline assemblage of south Liaoning (ASL), the coastal oligohaline assemblage of north Shandong (ANS) and the central low temperature and high salinity assemblage of the northern Yellow Sea (ACY). When the autumn 2007 phytoplankton community was compared with the results from winter 2006/2007 in the same investigation waters, we found obvious seasonal variations in each of the above assemblages. The coastal oligohaline assemblage of south Liaoning changed most significantly. Stepwise linear regression analysis between phytoplankton abundance and hydrographic factors identified that bottom temperature in autumn and salinity in winter predominantly influenced on the phytoplankton community, and thus, we identified the 18°C isotherm and 31.8psu isohaline as the potential dividing line of high and low density areas, respectively. This study highlights variations in species composition, community structure, important species most suitable temperature and salinity analysis as well as interactions with water types.

THE SEAWEEDS AND SEAGRASSES OF 3 ROCKY INTERTIDAL BEACHES ON THE CENTRAL COAST OF OREGON

Gayle I. Hansen, Oregon State University at PCEB/WED, U. S. Environmental Protection Agency, 2111 SE Marine Science Drive, Newport, Oregon 97365-5260

Compared to neighboring states, Oregon is thought to have a fairly low biodiversity (species richness) of seaweeds and seagrasses with a known overall state count of about 420 vouchered species. Moreover, recent ecological surveys of biodiversity along the Oregon coast have reported a maximum count per intertidal site of only 40 identified species (66 OTU) for the PISCO-SWAT surveys (2008) and 36 identified species (49 OTU) for the Goddard-ODFW survey (1997). In order to further investigate these low numbers, a traditional taxonomic survey was conducted of the seaweeds and seagrasses at 3 rocky intertidal sites on the central coast of Oregon: Seal Rock, Otter Crest, and Boiler Bay. These well-known research areas are close to OSU's Hatfield Marine Science Center and have been studied by scientists and students for many years. For my survey, both historical and present-day collections were used, and all species occurrences were vouchered with herbarium specimens. More than 2,000 sheets of specimens were examined for the study. The 3 sites were all found to be species rich with a combined total count of 360 species. Individual beach counts ranged from 170 to 200 identified species. This is 4 to 5 times greater than the maximum site species counts reported by PISCO and ODFW. Species lists from the 3 beaches will be compared to each other and to the earlier surveys, and comments will be made on species size, habit, and tolerance to sand scour and wave action. New and unusual records to Oregon will be illustrated.

NEW INITIATIVES FOR OCEAN ACIDIFICATION RESEARCH

Terrie Klinger, School of Marine Affairs, University of Washington

The persistence of contemporary marine ecosystems and the goods and services humans derive from them are threatened by changes in the chemistry and heat content of the ocean. Carbon dioxide (CO₂) derived from human activities is the principal driver of these changes, causing ocean warming and changes in carbonate chemistry and pH (commonly referred to as ocean acidification). Coastal regions of the northeastern Pacific are particularly vulnerable to ocean

acidification due to the combined influences of ocean circulation, oxidation of organic matter, upwelling, river inputs, and industrial emissions of sulfuric and nitric oxides. Biological and ecological responses to ocean acidification remain largely unknown. Recent findings will be reviewed, and new research initiatives will be described. A new facility for the study of ocean acidification and warming is being built at Friday Harbor Laboratories. This facility will include a chemical analytical laboratory, indoor and outdoor experimental chambers, and in-water mesocosms, and will be available for use by visiting researchers and students.

ADDITIONAL CRYPTIC DIVERSITY SUGGESTS A PACIFIC ORIGIN OF THE RED ALGAL FAMILY PALMARIACEAE

Sandra C. Lindstrom, Department of Botany, University of British Columbia, Vancouver, BC, Canada

The red algal family Palmariaceae is a unique member of the Rhodophyta, having a distinctive life history and unusual cell wall biochemistry. In the mid 1980s, members of the family occurring in British Columbia and northern Washington received systematic treatment by Hawkes, who described two new species from northern B. C., *Palmaria callophylloides* and *P. hecatensis*. Ongoing collecting efforts in Alaska, an area already known for its strong representation of this family, provide records of at least four undescribed taxa. These four species include at least two *Halosaccion*-like taxa and two *Palmaria*-like taxa. Two of these species are known only from the Aleutian Islands, one from the northern and western Gulf of Alaska, and the fourth is known so far only from Cook Inlet in the northern Gulf of Alaska. One of the *Halosaccion*-like taxa is clearly basal in molecular phylogenetic analyses to other members of the family, including North Atlantic *Palmaria palmata*. Moreover, in phylogenetic analyses of sequence data, specimens identified as *Palmaria callophylloides* and *Devaleraea ramentacea* occur intermixed in separate biogeographic groups. The phylogeny of the family and some nomenclatural problems will be discussed in light of molecular data from nuclear and organellar sequences.

HOW TO DISTINGUISH SPECIES OF *CALLIARTHRON* (CORALLINALES, RHODOPHYTA) WITH CALIPERS AND A CALCULATOR

Patrick T. Martone, Botany Department, University of British Columbia, Vancouver BC, Kathy Ann Miller, University Herbarium, University of California, Berkeley, CA, Paul W. Gabrielson, UNC Herbarium, University of North Carolina, Chapel Hill, NC

Coralline algae are notoriously difficult to identify to species. Because many taxa exhibit morphological plasticity, it is difficult to discern where one species ends and another begins. This problem dates back to original collections of “type” material: some phycologists designated distinct morphotypes as distinct species while others recognized several morphotypes as one morphologically variable species. To examine species boundaries in coralline algae, we have been extracting DNA from 70-year-old type specimens and comparing *rbcL* sequences. We have also sequenced *rbcL* for recent collections of corallines, enabling us to recognize the range of morphological variability and to identify characters that are useful for differentiating coralline species in the field. Here we present results for the articulated coralline genus *Calliarthron*

Manza. Sequence comparison suggests that there are only two genetically distinct *Calliarthron* species: *C. tuberculosum* and *C. cheilosporioides*. We conclude that *C. regenerans* and *C. setchelliae* are synonyms of *C. tuberculosum*, and we propose the transfer of *C. yessoense* and *C. latissimum* to the Japanese genus *Alatocladia*; thus, the genus *Calliarthron* occurs only in the eastern Pacific Ocean. Morphometric analyses identify several characters that differ significantly between the two *Calliarthron* species and suggest that measures of intergenicular thickness and wingspan are sufficient to distinguish the species in the field.

SEASONAL PATTERNS AND STRATEGIES IN THE REPRODUCTION OF CORALLINE ALGAE

Kevin A. Miklasz, Hopkins Marine Station, Stanford University, Pacific Grove, CA

Coralline algae produce spores inside of cavities called conceptacles. Conceptacles allow the reproductive output of corallines to be characterized into discrete units, making corallines ideal for quantitative studies of algal reproduction. Within a conceptacle, though, the reproductive patterns are not what one would expect: one either finds a few small spores (in the species which have small conceptacles) or many large spores (in the species which have large conceptacles). This is the exact opposite one would expect to find in other groups- the usual tradeoff is a few large offspring or many small offspring. The issue may be that we are looking within a conceptacle, and that differing conceptacle densities between species can explain the bizarre patterns found. In particular, if the species with small conceptacles produces those conceptacles in much greater density than those with large conceptacles, then we can recover the traditional paradigm. In this ongoing study, I am quantifying the reproductive output of four coralline algae species (two crustose and two articulated) with different conceptacle sizes. Since reproduction is often seasonally variable in algae, reproductive output is being monitored for one year starting last August. Therefore this study is also the first to look at the reproductive seasonality of these four coralline species. Preliminary results indicate that a modified form of the traditional paradigm can be recovered when conceptacle density is considered.

MY LIFE IN RED, GREEN AND BROWN: WHAT SEAWEEDS HAVE TAUGHT ME

Kathy Ann Miller, Herbarium, University of California, Berkeley, CA

I began college as a Medieval History and Literature major, and finished 8 years later (a long strange trip) as a Botany major. I received my Ph.D. at UC Berkeley and worked as a post-doc in the University Herbarium there. I was a professor at the University of Puget Sound for ten years, then left after receiving tenure for life at a marine lab (four years at USC's lab on Santa Catalina Island), and now have been in Berkeley for the last five years, working with Paul Silva and curating the collection at the University Herbarium -- I've come full circle. I have enjoyed many fabulous far flung field adventures, but I always return to the seaweed flora of California, my true love.

REFINDING *PHYLLOSPADIX SERRULATUS* ON THE SOUTHERN COAST OF OREGON

June Mohler, Portland, OR

There are three species of *Phyllospadix* (Potamogetonaceae) known to be found in Oregon. *Phyllospadix serrulatus* Ruprecht ex Ascherson is found from the islands of the Gulf of Alaska to Oregon, *P. scouleri* Hooker is found from Sitka, Alaska to the Tropic of Cancer, Baja California Mexico, and *P. torreyi* Watson is found from Vancouver Island, Canada to the Tropic of Cancer, Baja (Phillips and Meñez, 1988). Since Phillips (1979) and with the exception of Turner and Lucas (1984), little more has been written about *P. serrulatus* in Oregon. Observations in 2009 and 2010 confirmed Phillips' reports and extended the range of *P. serrulatus* further south to Cape Blanco. Additional observations indicate that *P. serrulatus* may be much more common in Oregon than previously assumed. It is currently present or even the dominant surfgrass cover, in rocky intertidal areas where it may have been mistaken for *P. scouleri*. In the absence of flowers or seeds, rhizome and leaf features were used to determine species. *P. serrulatus* is unique of the three in having only two roots per node, prominent fin cells, and distinctly truncate leaf tips.

VIDEO ANALYSIS OF ULVOID ALGAL AND *ZOSTERA* POPULATIONS IN GREATER PUGET SOUND

Tim Nelson, Jennifer Olson, Lydia Imhoff, Alyssa Bowen, and Myles Melton. Department of Biology, Seattle Pacific University, Seattle, WA, USA.

Ulvoid algal blooms have been increasing world-wide and are known to cause loss of eelgrass meadows and deleterious human health effects. The history and spatial distribution of these blooms is not well-known in Washington State, although the State has taken action on occasion to remove problematic blooms in response to citizen complaints. Using underwater video compiled by the Washington State Department of Natural Resources Submerged Vegetation Monitoring Program, we determined ulvoid algal cover at 209 different sites over a 4 year period (2004-2007). The highest ulvoid cover and the greatest impact on eelgrass occurred in Central Puget Sound. Anecdotes to the effect that 2006 was a particularly "green" year were confirmed for Central Puget Sound, but not all regions responded similarly or equally from one year to the next. Analysis of depth distributions suggest that ulvoid algae and seagrasses occur at similar depths, with site to site differences affecting whether ulvoids accumulate higher, lower, or at the same tidal elevation as eelgrass. Averaged across all regions and sites, however, ulvoid algal median distribution is slightly higher than that of *Zostera*.

ULVA – A TALE OF TWO ISLANDS

Charles J. O'Kelly, Friday Harbor Laboratories, University of Washington, Friday Harbor, WA

In the current published seaweed floras for the Hawaiian Islands, twelve species of *Ulva* (including "*Enteromorpha*") are accepted, all of which are based on European, North American, and Middle Eastern types. On the basis of nuclear-encoded ITS1 region and/or chloroplast-encoded *rbcL* gene sequences from 94 specimens collected from five of the eight main islands, only one of the species named in the floras (*Ulva fasciata* Delile => *U. lactuca* L.) is actually present. Of the 15 operational taxonomic units (OTUs) identified, only one corresponded to a species with a European type – a single specimen of *U. procera* (Ahlner) Hayden et al. Also present, and newly reported for Hawaii, was the Japanese species *U. ohnoi* Hiraoka & Shimada. The remaining 12 OTUs correspond to unnamed *Ulva* species, with eight of the molecular

identities being new to science.

In contrast, the 14 OTUs attested in the summer flora of San Juan Island, in Puget Sound, Washington, mostly correspond with species found commonly in the temperate Northern Hemisphere. Of these 14 OTUs, however, only one was consistently associated with “green tide” events – the species formerly known as *U. lactuca*.

Accurate identifications of *Ulva* species, using molecular markers, are necessary to track species introductions as well as to characterize and monitor “green tide” events. This study indicates the strong possibility of greater species diversity in *Ulva* than previously recognized. Tropical waters, in particular may have distinct, and undetermined, floras.

MODELING ALGAE GROWTH IN A NOVEL DESIGN OPEN POND

Kyle Sander and Ganti S. Murthy, Department of Biological & Ecological Engineering, Oregon State University, Corvallis, OR

Biofuels from algae are an attractive alternative to bioethanol and biodiesel from food crops. Algae have much higher productivities compared to terrestrial crops and do not require arable land for their production. Algae production in open ponds is one of the cost effective means for large scale production of algae for biofuels production. Optimal growth parameters in open ponds can be determined by developing mathematical models that can accurately predict the algal growth dynamics.

Algae growth was modeled using a four state model. This model was compiled using parameters from controlled experiments found in literature. This model attempts to capture the effects of CO₂ sparging, irradiance, photoinhibition, dissolved oxygen and nitrogen on algae biomass concentration in the pond.

The model was then validated using data from a novel design small scale (1200L, 0.51 m deep) open raceway pond. The bottom half of the pond is illuminated using light emitting diodes. Pond was continuously agitated using a paddlewheel to maintain algal cells in suspension. An automatic pH controller regulated CO₂ injection based on the pH levels. Temperature, ambient light intensity, CO₂ injection schedules were continuously monitored using a data acquisition system. Algal biomass concentration was monitored using spectrophotometer absorbance at 680 nm. Algae composition (ash, structural carbohydrates, crude lipids, carbon and nitrogen content) was determined using standard laboratory techniques.

DO NATIVE MACRO-INVERTEBRATES CONSUME NATIVE OVER NON-NATIVE SEaweEDS?

Sean C. Vogt, Jayson R. Smith, and Steven N. Murray, Dept. of Biological Science, California State University, Fullerton, CA, USA 92834-6850.

Non-indigenous species (NIS) of seaweeds have become established on rocky shores worldwide. However, the ecological effects of only 6.5% of seaweed introductions have been studied. In particular, little is known about the feeding responses of native consumers when they encounter new additions to the seaweed flora. Yet, native consumers can feed on non-native seaweeds at

rates that may determine their success in a recipient community. Based mostly on studies performed in terrestrial systems, cases have been made for both the selective consumption (Biotic Resistance Hypothesis) and avoidance (Enemy Release Hypothesis) of NIS by native consumers. To investigate feeding interactions in southern California coastal waters, we performed a series of two-choice laboratory experiments using native macro-invertebrates and native and introduced seaweeds. The feeding preferences of the sea hare *Aplysia californica*, the snail *Chlorostoma aureotincta*, the crab *Pachygrapsus crassipes*, and the urchin *Strongylocentrotus purpuratus* were determined for four morphologically and/or taxonomically similar pairs of native (*Chondracanthus canaliculatus*; *Sargassum agardhianum*; *Macrocystis pyrifera*) and non-native (*Caulacanthus ustulatus*; *Sargassum muticum* and *Sargassum horneri*; *Undaria pinnatifida*) seaweeds. *Chlorostoma aureotincta* and *S. purpuratus* chose to feed mostly on native seaweeds over NIS, while mixed results were obtained for *A. californica* and *P. crassipes*. Each macro-invertebrate consumed only small amounts of native and non-native *Sargassum* spp. Our results indicate that southern California macro-invertebrates have diverse feeding responses that override the origin of their seaweed food and that their impact on the success of a seaweed introduction must be evaluated on a case by case basis.

ABSTRACTS (posters)

RELEASE OF DOPAMINE BY *ULVARIA OBSCURA*: EFFECTS OF WEATHER

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The bloom-forming green alga *Ulvaria obscura* is unique among macroalgae in that it is the only alga known to produce large quantities of dopamine, a nitrogen-containing compound with anti-herbivore and allelopathic properties. Dopamine can be released into the surrounding seawater by intertidal *U. obscura* when it is rehydrated upon immersion by an incoming tide. The release of dopamine only appears to occur by *U. obscura* that are physiologically stressed and algae that release dopamine do not appear to survive. We hypothesized that dopamine release is affected by desiccation, and that more dopamine would be released when algae are emersed on days when weather conditions (temperature, solar radiation, relative humidity, and wind speed) promote drying. To test this hypothesis, we conducted 6 experiments on the beach in front of the Shannon Point Marine Center in the summers of 2008 and 2009. In each experiment, bowls (N=5) containing 14 g of *U. obscura* were placed on the beach to desiccate for 75 min. The algae were then rehydrated by adding 1 L of filtered seawater. Dopamine concentrations in the seawater were sampled over 3 hours following the addition of the filtered seawater. They were also measured in the algal tissues at the start of the experiment and after the algae had been immersed for 3 hrs. The amount of dopamine released in each experiment was compared to an evapotranspiration index that was based on the Penman equation.

GROWTH OF DIATOM BIOFILMS FOR APPLICATIONS IN PHOTOCATALYSIS AND SOLAR ENERGY PRODUCTION

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Diatoms are marine algae that synthesize silica shells known as frustules, which exhibit microscale and nanoscale structural organization. It has been proposed that these intricate frustule features may enhance the capture and utilization of light in photoactive systems, such as photocatalytic reactions and photovoltaic energy production. Additionally, the large surface area and chemical stability of silica frustules makes them attractive as catalyst supports. By controlling seeding and growth conditions, we have developed a method for the preparation of uniform biofilms of the diatom *Pinnularia* sp. on glass surfaces without the use of surface modifications or extreme processing conditions. A simple, environmentally sustainable method for removal of cellular organics is also presented. Utilizing these methods, diatom frustules can be incorporated into reactors and devices in a reliable manner.

COMPARISON OF CELL CYCLES OF ISOLATED AND IN-HOST SYMBIONTS OF THE ANEMONE *ANTHOPLEURA ELEGANTISSIMA*

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The common intertidal anemone *Anthopleura elegantissima* hosts two distinct symbiotic algae: *Symbiodinium muscatinei* and *Elliptochloris marina*. Previous work showed that algae in pellets expelled from *A. elegantissima* have a higher mitotic index than those remaining inside the host. However, it is not known whether the anemones preferentially expel dividing cells or if the algae, released from host control, are simply able to grow faster. We isolated algae from *A. elegantissima* and used flow cytometry to measure cell cycles every six hours for two days following extraction from the host. At each sample time, we also extracted fresh algae from other *A. elegantissima*. By comparing cell cycles of freshly isolated algae to those of algae outside the host for several days, we can determine whether growth rates change when algae are removed from the host. By simultaneously measuring mitotic indices in the samples, we can also determine whether mitotic index is an accurate proxy for algal growth rate. Flow cytometry appears to be an effective way to measure cell cycles of the symbiotic algae of *A. elegantissima*.

THE DEVELOPMENT OF A SOLID-PHASE MICRO-EXTRACTION METHOD FOR MEASURING DMS RELEASE BY ULVOID ALGAE

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Ulvoid algae produce a strong sulfur odor due, in part, to the release of dimethyl sulfide (DMS). In order to develop a relatively easy method for measuring DMS in the field, we explored the use of solid phase micro-extraction (SPME) combined with gas chromatography (GC). Our study addressed the following questions: 1) What is the relationship between GC peak area and DMS concentration?, 2) Do check standards produce the correct peak size for known amounts of DMS?, 3) Do different SPME fibers absorb different amounts of DMS?, 4) Does the number of times a SPME fiber is used affect DMS absorption?, 5) Does temperature affect the absorption of DMS by the fiber?, and 6) What is the smallest amount of DMS that

can be measured with this method? To answer these questions, we added known amounts of DMS into 54 L glass carboys. Our results show that different SPME fibers absorb different amounts of DMS and that the amount of DMS absorbed by a SPME fiber does not change over 20 uses.

THE EFFECTS OF ENVIRONMENTAL AND CHEMICAL STRESSORS ON OXIDANT RELEASE BY ULVOID ALGAE AND THE IMPACTS OF HYDROGEN PEROXIDE ON LARVAL *MYTILUS TROSSULUS* SURVIVAL AND DEVELOPMENT

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Current global conditions are leading to increased numbers of harmful macroalgal blooms, which have detrimental effects on the ecosystems in which they occur. Macroalgae produce harmful chemicals such as ROS (reactive oxygen species) and dopamine. These chemicals may be produced in high quantities in response to environmental stress, such as temperature, desiccation, and hypoxia, and are subsequently introduced into the aquatic environment. In Washington State, little research has been done to quantify their production by macroalgae. These macroalgal toxins can have negative effects on some marine invertebrates including the mussel *Mytilus trossulus*, which can be very abundant near algal blooms. This research project aims to investigate the impacts of environmental and chemical stressors on oxidant production in two bloom forming macroalgae (*Ulva lactuca* and *Ulvaria obscura*) found in Washington State. I will also subject larval *M. trossulus* to hydrogen peroxide to determine if the chemical has an impact on larval survival and development.

Map to Point Partridge, westernmost point on Whidbey Island

