

THIRD NORTHWEST ALGAL SYMPOSIUM

Oregon Institute of Marine Biology

Charleston, Oregon

Oct. 9 - 12, 1987



Cystoseira osmundacea

SCHEDULE

3rd Northwest Algal Symposium Oregon Institute of Marine Biology

Friday October 9	3:00 - 10:00	Arrival and Check-in
	5:30 - 6:00	Dinner
	6:00 - 6:30	Welcome
	6:30	Collecting Trip
	8:00	Social, poster set-up
Saturday October 10	8:00 - 8:30	Breakfast
	9:00 - 10:20	1st Session
	10:20 - 10:40	C/T Break
	10:40 - Noon	2nd Session
	Noon	Lunch
	1:40 - 3:20	3rd Session
	3:20 - 3:40	C/T Break
	3:40 - 5:20	4th Session
	5:30 - 6:30	Social
	6:30 - 8:00	Banquet
	8:00	Special Guest Speaker-Maxwell Doty
	9:00	Mixer
Sunday October 11	7:15 - 7:45	Light Breakfast
	8:00 - 9:00	5th Session
	9:00 - 9:20	C/T Break
	9:20 - 10:40	6th Session
	11:00	Brunch
	1:00 - 2:40	7th Session
	3:00 - 4:00	Seaweed Cooking Demonstration
	4:00	Social
	5:30	Dinner
	7:00 - 9:00	Symposium: Applied Phycology
	9:00	Business Meeting and Mixer
Monday October 12	8:00	Breakfast
	9:00	Check-out and Departure

PROGRAM

Friday October 9

- 3:00 - 10:00 Arrival and Check-in
- 5:30 - 6:00 Dinner
- 6:00 - 6:30 Welcome
- 6:30 Collecting Trip
- 8:00 Social and Poster set-up

Saturday October 10

- 8:00 - 8:30 Breakfast
- 9:00 - 10:20 1st Session. Ed Lippert, moderator.
- 9:00 - 9:20 SEASONAL DISTRIBUTION OF MUD FLAT DIATOMS IN TILLAMOOK BAY, OREGON. Janet Cruden and B.E. Lippert, Portland State University.
- 9:20 - 9:40 SUBSTRATUM TOPOGRAPHY AND SCALE: INFLUENCES ON ALGAL SETTLEMENT AND GRAZING PRESSURE. Ladd Johnson, University of Washington.
- 9:40 - 10:00 HERBIVORY ON ENCRUSTING ALGAE: STRATEGIES FOR SURVIVAL IN INTERTIDAL CRUSTS. Megan Dethier, University of Washington.
- 10:00 - 10:20 HERBIVORE INDUCED CHEMICAL AND MORPHOLOGICAL DEFENSES IN THE INTERTIDAL BROWN ALGA FUCUS DISTICHUS. Kathryn L. Van Alstyne, University of Washington.
- 10:20 - 10:40 C/T Break
- 10:40 - 12:00 2nd Session. Gayle Hansen, moderator.
- 10:40 - 11:00 THE EFFECT OF HERBIVORES ON THE RATE OF SUCCESSION. Terence M. Farrell, Oregon State University.
- 11:00 - 11:20 THE POPULATION ECOLOGY OF THE INTERTIDAL GREEN ALGA CODIUM SETICHELLII. Cynthia D. Trowbridge, Oregon State University.
- 11:20 - 11:40 BENTHIC PRIMARY PRODUCTION IN A SEMI-PROTECTED OUTER COAST ROCKY SHORE SYSTEM. Ronald Thom, Charles Simenstad, Karen Suzis and Jeffery Cordell, University of Washington.
- 11:40 - 12:00 LONG LINE CULTIVATION OF LAMINARIA SPECIES IN BRITISH COLUMBIA. Kitty Lloyd, B.C., Barkley Sound Kelp.
- 12:00 Lunch

Saturday October 19 (continued)

- 1:40 - 3:20 3rd Session. Richard Castenholz, moderator.
- 1:40 - 2:00 SUMMARY OF WORK ON CYANOBACTERIA OF TRUELOVE LOWLAND, SUMMER OF 1987. R. Lenihan, University of Washington.
- 2:00 - 2:20 AMMONIA EXCRETION IN THE ANABAENA ENDOSYMBIONT OF AZOLLA AND ISOENZYMIC CHARACTERIZATION OF BOTH PARTNERS. William J. Zimmerman and Thomas A. Lumpkin, Washington State University.
- 2:20 - 2:40 DOES THE TIMING OF HERBIVORE INTRODUCTION INFLUENCE AGLAL SUCCESSION IN LABORATORY STREAMS? Dean M. DeNicola, Oregon State University.
- 2:40 - 3:00 THE SEASONAL AND VERTICAL DISTRIBUTION OF PHYTOPLANKTON IN CRATER LAKE. Mary K. Debacon, Oregon State University.
- 3:00 - 3:20 ALGAL ASSEMBLAGES IN STREAMS FROM THE MT. ST. HELENS REGION, SIX YEARS FOLLOWING THE ERUPTION. Alan D. Steinman, Oregon State University.
- 3:20 - 3:40 C/T Break
- 3:40 - 5:20 4th Session. Bob Waaland, moderator.
- 3:40 - 4:00 THE ULTRASTRUCTURE OF CHLOROZEBRA SPP. (CHLOROPHYCEAE, CHLOROCOCCALES). John Ashley, Washington State University.
- 4:00 - 4:20 PREPARATION OF PORPHYRA PROTOPLASTS. J. Robert Waaland and Leal G. Dickson, University of Washington.
- 4:20 - 4:40 ORGANELLE ASSOCIATIONS IN ELONGATING CELLS OF POLYSIPHONIA. Brian Oates, University of British Columbia.
- 4:40 - 5:00 MOLECULAR GENETIC ANALYSIS OF POPULATIONS OF COSTARIA COSTATA (TURNER) SAUNDERS WITH A POLYMORPHIC SMALL SUBUNIT RIBOSOMAL DNA PROBE. Debashish Bhattacharya and Louis D. Druehl., Simon Fraser University.
- 5:00 - 5:20 RESTRICTION FRAGMENT LENGTH DIFFERENCE ANALYSIS OF ALARIA STANDS FROM VANCOUVER ISLAND. Lawrence W. Mroz and Louis D. Druehl, Simon Fraser University.
- 5:30 Social
- 6:30 - 8:00 Banquet
- 8:00 Special Guest Speaker: Maxwell Doty.
- 9:00 Mixer

Sunday October 11

- 7:15 - 7:45 Light Breakfast
- 8:00 - 9:00 5th Session. David McIntire, moderator.
- 8:00 - 8:20 STRUCTURAL AND FUNCTIONAL DYNAMICS OF ALGAL ASSEMBLAGES IN LOTIC ECOSYSTEMS: INSIGHTS FROM MATHEMATICAL MODELS. C. David McIntire, Oregon State University.
- 8:20 - 8:40 VOLUME-FREQUENCY SPECTRA OF MARINE PHYTOPLANKTON IN A TEMPERATE NERITIC ENVIRONMENT. Louis A. Hobson, University of Victoria.
- 8:40 - 9:00 EFFECTS OF WATER MOTION AND NUTRIENT CONCENTRATION ON PORPHYRA ABBOTTAE GAMETOPHYTES IN CULTURE. G. Hannach and J.R. Waaland, University of Washington.
- 9:00 - 9:20 C/T Break
- 9:20 - 10:40 6th Session. John Rueter, moderator.
- 9:20 - 9:40 PROPERTIES OF WATER SOLUBLE EXTRACTS FROM TRICHODESMIUM AND THEIR GEOCHEMICAL SIGNIFICANCE. John Rueter, Nancy Walters and David Hutchins, Portland State University.
- 9:40 - 10:00 METABOLIC REGULATION OF AMMONIUM UPTAKE BY ULVA RIGIDA C. AG. (CHLOROPHYTA). Rodney M. Fujita, Patricia A. Wheeler, and Robert L. Edwards, Oregon State University.
- 10:00 - 10:20 EFFECTS OF THE DAILY LIGHT PERIOD ON DIURNAL GROWTH PATTERNS OF THE ALGA CAULERPA SERTULARIODES AND SEAGRASS HALOPHILA DECIPIENS. Susan Williams, Friday Harbor Laboratories, and William Dennison, N.Y., MSRC, SUNY.
- 10:20 - 10:40 ALGAL CALCIFICATION: MECHANISMS AND EFFECTS ON PHOTOSYNTHESIS. Ted McConnaughey, Seattle, WA.
- 11:00 Brunch
- 1:00 - 2:40 7th Session. Paul Gabrielson, moderator.
- 1:00 - 1:20 NEW COLLECTIONS OF INTERTIDAL AND SUBTIDAL SEaweEDS FROM THE ALEUTIAN ISLANDS, ALASKA. Kathy A. Miller, University of California, Berkeley.
- 1:20 - 1:40 GELIDIACEAE IN BRITISH COLUMBIA. Dawn E. Renfrew, University of British Columbia.
- 1:40 - 2:00 LIFE HISTORY INVESTIGATIONS OF THE RED ALGA RHODOPHYSEMA ELEGANS. (Crouan frat. ex., J. Agardh) P. Dixon from the North Atlantic. G.W. Saunders, C.A. Maggs and J. McLachlan, Simon Fraser University.
- 2:00 - 2:20 LIFE HISTORY STAGE RATIOS OF IRIDAEA CORDATA IN BRITISH COLUMBIA. Lesley G. Green, University of British Columbia.

Sunday October 11 (continued)

- 2:20 - 2:40 THE LIFE HISTORY AND SCALE MORPHOLOGY OF A NEW SPECIES OF
HALOSPHERA, PRASINOPHYCEAE, CHLOROPHYTA. Maurice Dube, Western
Washington University.
- 3:00 - 4:00 Seaweed Cooking Demonstration: Evelyn McConnaughey.
Tour of Cape Arago?
- 4:00 Social
- 5:30 Dinner
- 7:00 - 9:00 Symposium: APPLIED PHYCOLOGY.
- 7:00 - 7:40 Blaine Metting: COMMERCIAL EXPLOITATION OF MICROALGAE.
- 7:50 - 9:00 Tom Mumford: SEAWEED CULTURE IN THE PACIFIC NORTHWEST.
- 9:00 Business Meeting and Mixer.

Monday October 12

- 8:00 Breakfast
- 9:00 Check-out and Departure

P O S T E R S

PIGMENT, PROTEIN AND POLYSACCHARIDE COMPOSITION OF IRON-LIMITED MARINE
PHYTOPLANKTON.

David Hutchins, John Rueter, Nancy Walters and Valerie Kelly, Portland State
University.

THE MONTEREY BAY AQUARIUM KELP FOREST EXHIBIT: GROWING SEAWEEDES IN A 330,000
GALLON AQUARIUM.

Roger E. Phillips, James M. Watanabe and Peter B. Barnett, Monterey Bay Aquarium.

A HEAVY GROWTH OF PORPHYRA LANCEOLATA IN HUMBOLDT BAY, CALIFORNIA, IN 1987; AN
INVITATION TO EXPLOIT SOME OPPORTUNITIES FOR AQUACULTURE RESEARCH.

Robert A. Rasmussen, Humboldt State University.

P O S T E R

Pigment, protein and polysaccharide composition of iron-limited marine phytoplankton.

Dave Hutchins, John Rueter, Nancy Walters and Valerie Kelly, Department of Biology, Portland State University, P.O. Box 751, Portland, OR 97207

Cultures of three marine species were grown in chemically defined media to iron limitation. Pigment concentrations were estimated both by absorbance and fluorescence techniques. Chlorophyll and phycobilin content were less in iron-limited cultures. The cellular content of protein was analyzed on cell extracts and seemed to be conserved. The relative amount of polysaccharide compared to protein was used as an indicator of C storage and excess photosynthetic potential. These results are discussed in relationship to the role of iron in the bioenergetics of phytoplankton.

P O S T E R

A HEAVY GROWTH OF PORPHYRA LANCEOLATA IN HUMBOLDT BAY, CALIFORNIA, IN 1987: AN INVITATION TO EXPLOIT SOME OPPORTUNITIES FOR AQUACULTURE RESEARCH.

Robert A. Rasmussen, Department of Biological Sciences, Humboldt State University, Arcata, CA 95521.

Christopher Toole, University of California Marine Extension Office, Foot of Commercial, Eureka, CA 95501.

An exceptionally heavy growth of *Porphyra lanceolata* on oyster rope cultures during the 1987 summer highlights the potential of Humboldt Bay for aquaculture research and application. Researchers are invited to consider the site for future experiments.

P O S T E R

THE MONTEREY BAY AQUARIUM KELP FOREST EXHIBIT. GROWING SEAWEEDS IN A 330,000 GALLON AQUARIUM.

Roger E. Phillips, James M. Watanabe and Peter B. Barnett. Monterey Bay Aquarium, 886 Cannery Row, Monterey, CA. 93940.

The Kelp Forest Exhibit at the Monterey Bay Aquarium was designed to display a living kelp forest community. A successful educational exhibit, it provides visitors with a SCUBA diver's view of a local kelp forest. It has also offered researchers at the Aquarium a unique opportunity to study aspects of the development and maintenance of a giant kelp forest community.

The exhibit was first filled with seawater in August 1984. Adult plants of giant kelp (Macrocystis pyrifera), and several other kelps, were transplanted into the exhibit directly from natural populations in the field. Fertile thalli of a variety of understory algae were used to seed the rockwork initially. Spores of other algal species as well as invertebrate larvae are continually being introduced with raw (unfiltered) seawater.

Growth rates of adult plants of giant kelp on exhibit ranged from 10 to 15 cm day⁻¹ (3 m frond) between March 1985 and August 1987. During this same time period, plants at a comparable depth in a natural kelp forest near the Aquarium grew 9 to 19 cm day⁻¹. Giant kelp is reproducing successfully in the exhibit, and many juvenile sporophytes have been allowed to grow into large canopy-forming adults.

Colonization of the artificial rockwork occurred rapidly. Over a period of 7 months mean per cent free space declined to less than 10%. Over 70 species of algae have been identified from the Kelp Forest Exhibit, and most of these have also reproduced successfully. Aspects of the development and succession of the understory community will be described.

SEASONAL DISTRIBUTION OF MUD FLAT DIATOMS IN TILLAMOOK BAY, OREGON.

Janet Cruden and B. E. Lippert, Department of Biology, Portland State University, P.O. Box 751, Portland, Oregon 97207.

Collections at eight sites in Tillamook Bay, Oregon were made as nearly as possible at low tide between October 1974 and June 1978. Six other sites were also sampled sporadically during this period. This report concerns collections made from mud, rock and plant scrapings at one site in the southwest corner of the bay. The material was examined while fresh, cleaned, and a total of 38 slides were made. Thirty-three genera and 165 species have been identified. A large number of taxa in Navicula and Nitzschia remain unidentified. Navicula and Nitzschia, while being highest in number of species present were low in individuals of each species counted per slide. Dominant species (> 30% per slide) throughout the study were: Berkleya rutilans, Cocconeis scutellum var. parva, Synedra fasciculata var. truncata, Nitzschia sp. (#13), Gomphonema sp. (#5). Differences from year to year in seasonal distribution of the dominant species does not seem to be correlated with salinity. There does not appear to be a direct relationship between recorded rainfall and salinity.

SUBSTRATUM TOPOGRAPHY AND SCALE: INFLUENCES ON ALGAL SETTLEMENT AND
GRAZING PRESSURE.

Ladd Johnson, Department of Zoology, University of Washington,
Seattle, WA 98195.

Substratum topography can be manipulated by molding and casting various natural and abstract surfaces to produce artificial substrata of varying topographic complexity. The settlement of the red intertidal alga Halosaccion americanum is enhanced on more complex substrata. The overwhelming tendency of Halosaccion to settle on ridgetops and high points leaves it exceedingly vulnerable to molluscan grazers at small scales. However, at larger scales (1 cm and up), high points experience less grazing pressure and may provide a refuge for Halosaccion.

In contrast, another red alga, Endocladia muricata, settles more in crevices and may thus avoid grazers during early, vulnerable stages. Moreover, it may require grazers to remove superior competitors such as Halosaccion.

HERBIVORY ON ENCRUSTING ALGAE: STRATEGIES FOR SURVIVAL IN
INTERTIDAL CRUSTS

Megan N. Dethier (Friday Harbor Labs, University of Washington,
Friday Harbor, WA. 98250) and Robert S. Steneck (The Darling
Center, University of Maine, Walpole, ME. 04573)

Intertidal algal crusts show distinct patterns in distribution and abundance that relate to their responses to desiccation stress and to their palatability to grazers. Food-choice experiments in the lab demonstrate that a variety of intertidal grazers (limpets and chitons) will consume crusts, and that they show distinct preferences among species. The various herbivores tested do not necessarily prefer the same crusts. The crusts, in turn, vary widely in their ability to recover following disturbance; some regrow quickly from tiny bits of tissue, others do not. Wound-healing was examined in another set of experiments, where crusts were artificially wounded to different depths. Rates of healing generally correlate with observations of crust recovery following severe grazing. In nature, crusts such as "Petrocelis" that are readily eaten but heal quickly and are desiccation tolerant are broadly abundant, whereas Ralfsia pacifica cannot wound-heal effectively but is distasteful, so it is common in areas of many grazers. Hildenbrandia survives in the intertidal zone despite its extremely slow growth in part because it is tough and quite effective at vertical regeneration.

HERBIVORE INDUCED CHEMICAL AND MORPHOLOGICAL DEFENSES IN THE INTERTIDAL
BROWN ALGA FUCUS DISTICHUS

Kathryn L. Van Alstyne, Department of Zoology NJ-15, University of
Washington, Seattle, WA 98195

Tissue loss to herbivory in Fucus distichus can be substantial; grazers often remove as much as 50 % of the plant's photosynthetic surface area. Fucus appears to have several mechanisms for deterring herbivorous gastropods (Littorina sitkana and Littorina scutulata). It produces a tough thick thallus, a strong mirrib and large quantities of polyphenolic compounds. When Fucus is damaged, concentrations of polyphenolic compounds are increased by approximately 20 %, resulting in a 50 % decrease in loss to herbivores. When the plant's mirrib is damaged, it produces adventive embryos which are avoided by herbivores relative to apically growing tissues. Adventive embryos are protected from grazers because they have high concentrations of polyphenolic compounds and because they grow in tight clumps which hinders grazing by Littorina sitkana.

THE EFFECT OF HERBIVORES ON THE RATE OF SUCCESSION.

Terence M. Farrell, Department of Zoology, Oregon State University, Corvallis, OR 97331

Herbivores have been shown to increase, decrease, or have no effect on the rate of succession in natural communities. I present a simple, predictive model of how herbivores affect the rate of succession as a function of the successional status of the species consumed and the effect of early colonists on the establishment of later successional species. The magnitude of the herbivores' affect on succession is predicted to depend on the intensity of consumption.

This model was tested in a high intertidal community. Barnacles, early colonists of disturbed areas, facilitated the establishment of several species of macroalgae (Pelvetiopsis limitata, Fucus distichus, and Endocladia muricata). The herbivores (limpets) had a greater influence on the establishment of algae than on the establishment of barnacles. As predicted by my model, herbivores decreased the rate of succession in this community.

THE POPULATION ECOLOGY OF THE INTERTIDAL GREEN ALGA
CODIUM SETCHELLII.

Cynthia D. Trowbridge, Department of Zoology, Hatfield
Marine Science Center, Oregon State University, Newport, OR
97365.

The green alga Codium setchellii is a scarce species, with small populations restricted to shaded rocky surfaces in low intertidal areas strongly influenced by sand transport. Reasons for the alga's low abundance at sandy sites include episodic recruitment, high juvenile mortality, adult growth constraints, seasonal herbivore attack, and unpredictable sand burial events. C. setchellii is not limited to sandy sites by physiological constraints, but rather is restricted to them for ecological reasons. In transplant experiments the alga was almost entirely eliminated from non-sandy sites by the diverse assemblage of generalist herbivores. C. setchellii establishment in non-sandy habitats is low because of the (1) herbivory, (2) low availability of space on rock surfaces, and (3) potentially small propagule pool. Once individual C. setchellii thalli are established at sandy or non-sandy sites, the alga's excellent competitive ability, flexible growth dynamics, high fecundity, and long lifespan enhance its persistence, preventing local extinction.

BENTHIC PRIMARY PRODUCTION IN A SEMI-PROTECTED OUTER COAST ROCKY SHORE SYSTEM.

Ronald Thom, Charles Simenstad, Karen Kuzis and Jeffery Cordell,
Fisheries Research Institute, WH-10, University of Washington, Seattle,
WA 98195.

We investigated the effect of habitat factors and season on the structure and productivity of benthic macrofloral assemblages in Neah Bay; a semi-protected embayment near the outer coast of Washington State. Habitats included a high intertidal green algal dominated assemblage, a mid-intertidal assemblage dominated by rockweed (i.e., Fucus), a low intertidal assemblage consisting of several massive brown algae, a subtidal kelp assemblage with a seasonally variable understory, a boulder seawall with little algal cover, and a cobble field dominated by rockweed. Depth, herbivore density, disturbance by logs and sediment movement were most easily related to among habitat differences in community structure. The mix of species within each habitat changed substantially over seasons within all habitats. However, total assemblage standing stock changed little with season. Productivity was greatest in the most stable habitats (i.e. rocky bench). Although productivity varied with season along with the standing stock of the macrophytes, winter productivity was relatively high. Data on fish and macroinvertebrates illustrated a close coupling between macrophyte assemblages and faunal assemblages.

LONG LINE CULTIVATION OF Laminaria SPECIES IN BRITISH COLUMBIA

Kitty Lloyd, Barkley Sound Kelp, P.O. Box 25, Bamfield, B.C. V0R 1B0

The cultivation of Laminaria and other seaweed species has its origins in Japan and China, where seaweeds have long been important for food and medicine. Use of long lines for grow-out of Laminaria "seedlings" was first started in China during the 1950's, and is now widespread there and in Japan, Korea and the U.S.S.R..

A 5 year research project to investigate the suitability of indigenous B.C. kelps for long line cultivation was initiated at the Bamfield Marine Station in 1978. This work focused on species selection, seedling production methods, farm site selection criteria, and seasonal timing of planting and harvesting. The two species found to be most suitable for cultivation were Laminaria groenlandica and L. saccharina.

At present, the author operates a small-scale (2 ha) commercial kelp farm near Bamfield, and in scaling up from experimental size, some unforeseen problems have been encountered (e.g. predation by snails). Experimentation with farm design, processing and drying methods, and product packaging and marketing continues.

SUMMARY OF WORK ON CYANOBACTERIA OF TRUELOVE LOWLAND, SUMMER OF 1987.

R. Lennihan, Department of Botany, University of Washington, Seattle, Washington, 98195.

A three-year project is being carried out on Truelove Lowland, Devon Island, NWT, Canada, to determine the role of cyanobacteria in carbon accumulation and nitrogen fixation in plant communities of the High Arctic.

Samples of macroscopic sheets of Nostoc commune were grown in the field under a variety of different temperature and water regimes. Growth rates varied from a 12% increase in wet weight per week, for samples grown in ice water under several inches of ice and snow (1° to 3°C water temp., 100 to 200 $\mu\text{Mol}/\text{m}^2/\text{s}$ of light), up to 75% increase in wet weight per week for warmer-water conditions in sedge meadows (10° to 19°C water temp., 400 to 1200 $\mu\text{Mol}/\text{m}^2/\text{s}$ of light). Sheet Nostoc, under favorable conditions, can increase in wet weight by a factor of 2.2 to 2.4 over the growing season.

Several other experiments were conducted to look at the growth responses of N. commune. Treatments with phosphorous and molybdenum showed no effects. Reduction of ambient light levels by a factor of 4 or 5 had no adverse effects on growth rates. Effects of de-hydration and re-hydration similarly had no adverse effects.

An experiment was conducted to determine the amount of "leakiness" (release of nitrogen compounds into solution) of growing N. commune. Results have not yet been analyzed.

Soil cores from four different community types were microscopically examined at three different times during the summer, to assay the different bluegreen algal genera and species, and their relative abundances. A minimum of 15 different genera were identified, with over forty different "species" being recognized and described, though not yet positively identified.

AMMONIA EXCRETION IN THE ANABAENA ENDOSYMBIONT OF AZOLLA
AND ISOENZYMIC CHARACTERIZATION OF BOTH PARTNERS

William J. Zimmerman and Thomas A. Lumpkin, Department of Agronomy and Soils, Washington State University, Pullman, WA 99164-6420.

Excretion of ammonia by Anabaena azollae (Arad) from Azolla filiculoides, induced by L-methionine D,L-sulfoximine, occurred more rapidly in cultures utilizing N_2 ($0.86 \mu\text{mol NH}_4^+ \text{ h}^{-1} \text{ mg}^{-1}$ protein) as compared to sources of combined nitrogen ($<0.70 \mu\text{mol NH}_4^+ \text{ h}^{-1} \text{ mg}^{-1}$ protein). The rate of ammonia release was consistent for at least 24 hours, and even with $>2.0 \text{ mM}$ exogenous NH_4^+ present in the medium when little or no internal:external ammonia gradient should exist for these cyanobacterial cells. This strain and two others designated as A. azollae from Azolla caroliniana and Azolla pinnata (Newton and Gates isolates, respectively) were very similar in morphology and heterocyst frequency but differed in their electrophoregrams of seven enzyme systems. They were more related to each other, however, than to Anabaena PCC 7120. Enzymic characterization was also completed on selected varieties of all species of Azolla to confirm the validity and necessity for biochemical taxonomy of this plastic genus. Known isoenzymes were identified whenever possible.

DOES THE TIMING OF HERBIVORE INTRODUCTION INFLUENCE ALGAL SUCCESSION
IN LABORATORY STREAMS?

Dean M. DeNicola, Department of Botany, Oregon State University,
Corvallis, OR 97333

To examine the effects of grazing on algal succession, herbivores were introduced into laboratory stream channels at different stages of algal community development. In separate streams, the snail Juga silicula (500 animals m^{-2}) and the caddisfly Dicosmoecus gilvipes (50 animals m^{-2}) were introduced on days 1, 9, 16 and 28 of algal development; the mayfly Baetis sp. (500 animals m^{-2}) was introduced on days 1 and 16. Two streams served as ungrazed controls. In the ungrazed streams Scenedesmus obliquus was the most abundant early colonizer; it declined in abundance slightly after day 16 resulting in an increase in the relative abundance of diatoms, primarily Nitzschia oregona. By day 40, filaments of Stigeoclonium tenue were common. Snail and caddisfly introductions altered this pattern by accelerating the decline of S. obliquus relative to the increase in the abundance of diatoms, and delaying the appearance of Stigeoclonium filaments. Grazing also was associated with low densities of the relatively large sized N. oregona, and an increase in the relative abundance of the more adnate Navicula minima and Achnanthes lanceolata. These changes in succession were delayed and less pronounced as the postponment of grazer introduction lengthened. At the experimental densities, Dicosmoecus was more effective in altering the successional pattern than Juga. Introduction of Baetis sp on day 1 had a similar impact as early Juga and Dicosmoecus introductions, but no alternation in community structure was observed after its introduction on day 16. The timing of herbivory in natural streams may be important in maintaining patches of algae in different successional stages.

THE SEASONAL AND VERTICAL DISTRIBUTION OF PHYTOPLANKTON IN CRATER LAKE

Mary K. Debacon, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97330.

Phytoplankton samples were collected in conjunction with a 10-year limnological and monitoring program established by the National Park Service. For each of the samples analyzed over a two-year period (6/23/85 to 4/14/87), species composition, cell counts, cell densities, and biovolume estimations were determined. Cluster analysis, as well as DCA, showed four major cluster groups which seemed to indicate seasonal trends in phytoplankton assemblages. Stephanodiscus hantzschii dominated one of these clusters, being homogeneously distributed throughout the upper 250 meters of the water column in March 1985 and April 1987 but limited in range below 100 meters in the remaining samples. Nitzschia gracilis accounted for 90 to 97% of the community composition of a cluster corresponding to the upper 20 meters of the July and August samples for both trend years; this layer represents the epilimnion of the lake during thermal stratification. Mean species diversity in the water column, measured by Shannon's and Simpson's indices, showed that lowest species diversity was found in the upper 10 meters during this time period. Maximum mean biovolume values (range 52,185 $\mu\text{m}^3/\text{L}$ to 110,070 $\mu\text{m}^3/\text{L}$) occurred in July and August when N. gracilis was the dominant organism in the upper 20 meters. Correlation analysis between mean biovolume and mean chlorophyll a concentration in the upper 250 meters of the water column showed a positive relationship from January to June. Negative correlations were found between these two variables in July and August. It is postulated that a lower mean chlorophyll content per unit cell volume for N. gracilis relative to the other taxa found in the lake may account for this discrepancy.

ALGAL ASSEMBLAGES IN STREAMS FROM THE MT. ST. HELENS REGION, SIX YEARS FOLLOWING THE ERUPTION.

Alan D. Steinman. Department of Botany, Oregon State University, Corvallis, OR 97331.

A survey of twenty-one streams was conducted in the Mt. St. Helens, Washington region during July and August, 1986. Classification analysis revealed that the 21 streams could be organized into seven distinct clusters. The majority of streams were dominated by diatoms (Achnanthes minutissima, Fragilaria vaucheriae, Cymbella minuta, and Navicula spp.). Several clusters were identified based on dominance by cyanophytes (Nostoc paludosum or Phormidium tenue) or chlorophytes (Oedogonium spp., Microspora spp., or Zygnematales). Thermal streams inside the cone were dominated by thick mats of Mastigocladus laminosum. Although diatoms still dominate the flora of the region (as was the case soon after the blast), the appearance of taxa from other algal classes suggests that successional processes are at work in these streams.

THE ULTRASTRUCTURE OF CHLOROZEBRA SPP. (CHLOROPHYCEAE, CHLOROCOCCALES)

John Ashley, Department of Botany, Washington State University,
Pullman, WA 99164-4230.

The genus Chlorozebra was observed from the soils of two locations in central and eastern Washington. This is the first description of this alga in North America. This genus had been previously observed in soils from the Himalayas (Reisigl 1969) and the Austrian Alps (Vinatzer 1975). The alga has a unique striated chloroplast, which feature gives it its 'zebra-like' appearance. The striated chloroplast was common in mid-aged cells, but was obscured by starch in stationary phase cells. The alga has a single centrally located pyrenoid. Older cells become multinucleated with age. Various ultrastructure features are examined. Numerous storage products were observed and various cytochemical stains were used to identify these products. The species isolated from Washington soils appears to be a new species not previously described.

PREPARATION OF PORPHYRA PROTOPLASTS.

J. Robert Waaland and Leal G. Dickson, Department of Botany,
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We have investigated production of protoplasts from blades of several species of the marine red alga Porphyra. We have used a two step enzymatic digestion procedure in which blades are treated first with a proteolytic enzyme then with abalone gut and/or cellulase enzyme. Successful protoplast production depends on multiple factors including which species is used, how the blade is handled prior to the enzymatic treatment and the details of the enzymatic treatment itself. Of the species tested, we have obtained the highest yield (70-80% of cells) of protoplasts from P. nereocystis. We have also successfully produced protoplasts from P. perforata (especially a green mutant strain), P. miniata, and P. gardneri. We have obtained regeneration of callus from P. miniata and filaments, callus and blades from P. nereocystis.

ORGANELLE ASSOCIATIONS IN ELONGATING CELLS OF POLYSIPHONIA

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Elongating cells of Polysiphonia contain unusual organelle associations that are restricted to these cells. Tight organelle associations that include mitochondria, chloroplasts, dictyosomes and smooth endoplasmic reticula are found. Mitochondria appear to play a central role in these cells and undergo a dramatic morphological change to enhance their capabilities. Prior to elongation mitochondria in apical cells possess an ovoid shape, but as cells lengthen so do the mitochondria. Ultimately, the organelle becomes so stretched that mitochondrial envelopes from opposing sides become appressed, while the ends do not, resulting in a "dumbbell-like" shape. This morphology greatly increases the surface area, thus increasing the rate of nutrient and energy exchange between this organelle and the chloroplasts, dictyosomes and smooth endoplasmic reticula. In cells undergoing elongation mitochondria appear to wrap themselves around chloroplasts with the envelopes of the two organelles very close. Dictyosomes are also found closely associated with mitochondria, but on the side opposite that of the chloroplast. Smooth endoplasmic reticula are found between dictyosomes and mitochondria and in some instances appear to surround the mitochondrion. The functions of these intimate associations are unknown, however, since they are found only in elongating cells it would appear that they are actively involved in that process. Cells of other algal species reveal organelle associations, but they are not as tight, nor do morphological changes occur to enhance exchange between the organelles.

MOLECULAR GENETIC ANALYSIS OF POPULATIONS OF COSTARIA COSTATA
(TURNER) SAUNDERS WITH A POLYMORPHIC SMALL SUBUNIT RIBOSOMAL DNA
PROBE.

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The kelp, Costaria costata (Turner) Saunders, may exhibit great phenotypic plasticity in the field. Morphological data cannot, however, be utilized to identify breeding groups (populations) due to the clinal nature of the phenotypic variance. Molecular genetic markers allow the evolutionary analysis of populations since population-specific "tags" may be developed which are independent of the phenotype of the species. In this study we have characterized a population marker for C. costata which encodes the small subunit of the highly polymorphic nuclear ribosomal DNA (rDNA) locus. The small nuclear rDNA gene has been subcloned, sequenced and used to establish breeding limits and to interpret gene flow in local stands of C. costata using hybridization analysis.

RESTRICTION FRAGMENT LENGTH DIFFERENCE ANALYSIS OF
ALARIA STANDS FROM VANCOUVER ISLAND.

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The kelp genus Alaria Greville (Laminariales, Phaeophyta) is taxonomically confusing. The taxonomic relationship between A. marginata and A. tenuifolia from sites around Vancouver Island has been described as a rassenkreisse (a circular cline), on the basis of morphology. Since kelp exhibit phenotypic plasticity in response to environmental variation, morphology may be an unsuitable indicator of taxonomic relatedness. The goal of this study is to test for the existence of a rassenkreisse using molecular biological methods. Restriction fragment length differences (RFLDs) between A. marginata and A. tenuifolia have been found, using the small subunit ribosomal DNA from Costaria costata as a probe. This sequence will be used to search for RFLD's between other stands of these species.

STRUCTURAL AND FUNCTIONAL DYNAMICS OF ALGAL ASSEMBLAGES IN LOTIC ECOSYSTEMS: INSIGHTS FROM MATHEMATICAL MODELS

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While the culture approach has provided an enormous amount of information about the biochemistry, cytology, reproduction, and life cycles of the algae, it has generated relatively few insights into the functional and structural attributes of algal assemblages in natural ecosystems. Unfortunately, the process of isolation and maintenance of individual algal taxa in culture is always accomplished at the expense of the integrity of the variables that couple an alga with the rest of the ecosystem. Mathematical modelling provides an alternative, relatively unexplored approach to the investigation of the production dynamics of algal assemblages in complex ecological systems. The approach works best as an iterative tool - to generate hypotheses, to synthesize the results of field and laboratory studies, to evaluate a data base, and to set priorities for future research. Used in this way, model structure and parameters are continuously updated as new information becomes available through research. The following predictions for algal assemblages in small, shaded streams are presented as examples of hypotheses generated by mathematical modelling: (1) the biomass of algae turns over about 65 times per year; (2) algal primary production is about $70 \text{ g m}^{-2} \text{ yr}^{-1}$; (3) as much as 70% of algal primary production channels through the process of grazing; (4) an increase in algal production in response to increases in light energy or nutrients can have a significant impact on grazer production and biomass without a conspicuous change in algal biomass; and (5) under conditions of low light energy ($< 100 \text{ uE m}^{-2} \text{ s}^{-1}$) and high grazing pressure, algal assemblages consist of adnate diatoms; while at higher light intensities and low grazing, up to one-half of the algal biovolume can be represented by filamentous and colonial chlorophytes.

VOLUME-FREQUENCY SPECTRA OF MARINE PHYTOPLANKTON IN A TEMPERATE
NERITIC ENVIRONMENT

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A seasonal study was carried out to determine whether or not volume-frequency distributions of near-surface nano- and micro-plankton were approximated by a power function in temperate neritic waters. Measurements of buoyancy frequency, the nutrients, $\text{NO}_3\text{-N}$, $\text{Si(OH)}_4\text{-Si}$, and $\text{PO}_4\text{-P}$, phytoplankton photosynthetic pigments, and cell concentrations and volumes were made within and on either side of a frontal zone in the Strait of Georgia. Fit of volume-frequency spectra to a power function model was variable. The logarithmically transformed model accounted for a large percentage of the variance in spectra when nano-flagellates and dinoflagellates dominated phytoplankton crops in pre-diatom bloom and nutrient depleted waters. When diatoms dominated crops, the fit was better in summer than in spring months and often was positively correlated to temperature. The possible covariance of temperature and grazing on diatoms by large omnivorous zooplankters was considered.

Most of the values for the exponent of the power function varied around a corrected value of -0.92 . Values were corrected because regression coefficients and slopes of lines were significantly correlated, and this correlation was removed by dividing slopes by regression coefficients.

Results of this study support the use of a power function model to predict volume-frequency spectra of temperate neritic phytoplankton from the time of the demise of the spring diatom bloom until at least the early fall season.

EFFECTS OF WATER MOTION AND NUTRIENT CONCENTRATION ON PORPHYRA ABBOTTAE GAMETOPHYTES IN CULTURE.

G. Hannach and J.R. Waaland, Department of Botany, University of Washington, Seattle, WA 98195.

The combined effects of water motion and nutrient level on growth, morphology and light absorption of Porphyra abbottae gametophytes were studied under controlled laboratory conditions. Water motion and nutrients had a positive interactive effect on light-saturated growth. Whereas motion stimulated growth at all nutrient levels, addition of nutrients did not make up for poor stirring, suggesting that carbon supply may easily become limiting in quiet water. Water motion and nutrients affected blade pigmentation in opposite ways. Light absorption by chlorophyll and the phycobiliprotein pigments were both found to depend on growth conditions. Blades grown under well-stirred conditions were thinner and more elongated than those grown in slow water motion. Changes in thallus morphology may help explain the positive effect of water movement on algal growth in addition to its effect on carbon and nutrient supply rates.

Properties of water soluble extracts from *Trichodesmium* and their geochemical significance.

John Rueter, Nancy Walters and Dave Hutchins, Department of Biology, Portland State University, P.O. Box 751, Portland, OR 97207

Trichodesmium can account for a large portion of the population in oligotrophic systems. Its cycles of blooms and decreases have been previously documented as well as propensity to disintegrate. We studied the water soluble extract of dense net collections of predominantly *Trichodesmium*. This extract contains polysaccharide and protein, has absorption and fluorescence spectra indicating phycoerythrin and has iron binding capacity. The extract also increases the soluble iron in a solution of seawater and continental dust. The geochemical significances of this extract are 1) as a pathway for C and N to be transferred from dense *Trichodesmium* blooms to other bacterioplankton or phytoplankton and 2) that it may play a crucial role in the solubilization of the major iron source in the open ocean.

METABOLIC REGULATION OF AMMONIUM UPTAKE BY ULVA RIGIDA
C. AG. (CHLOROPHYTA).

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Quantification of the relationship between the rate of nitrogen (N) uptake and N concentration is essential for understanding the N relations of macroalgae. Most analyses interpret N uptake kinetics in terms of the Michaelis-Menten model, which assumes that initial uptake rates are measured (i.e., that substrate concentration remains constant) and that the rate-limiting step does not change over the incubation time. Non-linear time-courses of ammonium depletion by both phytoplankton and macroalgae and the accumulation of dissolved inorganic N, amino acid, and protein pools on time scales similar to those used for uptake rate determinations imply that the rates of the component processes of uptake (membrane transport, assimilation into amino acids, and incorporation into proteins) change over time. We tested this hypothesis by measuring the time course of N pool accumulation in N-limited Ulva rigida. We also determined the rates of each component process using the stable isotope tracer N-15 in each of the N pools after a pulse of N-15 labeled ammonium. The results indicate that the rate of membrane transport limits the rate of net ammonium uptake during the first 5 min. of uptake. The rate of assimilation into amino acids limits uptake between 5 and 30 min. after the start of uptake. After 30 min., the rate of incorporation into proteins limits uptake. Finally, the rate of assimilation becomes rate-limiting again after 8 h. The implications of multiphasic limitation of net N uptake rate for the interpretation of N uptake kinetics and the relationship of N uptake rate to growth rate are discussed.

EFFECT OF THE DAILY LIGHT PERIOD ON DIURNAL GROWTH PATTERNS OF THE ALGA CAULERPA SERTULARIODES & SEAGRASS HALOPHILA DECIPIENS.

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The role of the daily light period (Hsat) on diurnal patterns of growth in Caulerpa sertulariodes and Halophila decipiens was investigated at 2 depths (16m, 25m) in a tropical submarine canyon. Hsat was manipulated by placing shades and underwater lights over the plants. Growth was measured 4 times daily and chl a content was determined. Diurnal patterns differed between Caulerpa and Halophila; Caulerpa grew at a constant rate but Halophila grew only during the day. The diurnal growth pattern was under endogenous control (continuous light, continuous dark treatments). Integrated daily growth of both plants was not correlated with daily irradiance but showed a saturation response to Hsat. Hsat of <9 h limited the growth of the plants.

ALGAL CALCIFICATION: MECHANISMS AND EFFECTS ON PHOTOSYNTHESIS

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Calcification physiology and its relationship to photosynthesis are examined in algae and algae-invertebrate symbioses. It appears that CaCO_3 supersaturation is usually initiated when the enzyme Ca^{2+} ATPase pumps Ca^{2+} into membrane isolated extracytosolic compartments in exchange for 2H^+ . CO_2 diffuses into the alkaline solution, hydrates, and precipitates as CaCO_3 . The net reaction is: $\text{CO}_2 + \text{H}_2\text{O} + \text{Ca}^{2+} = \text{CaCO}_3 + 2\text{H}^+$. This model is supported by enzymatic studies and analyses of the stable carbon and oxygen isotope ratios of the precipitates.

The two protons generated during calcification subsequently react with 2HCO_3^- to produce 2CO_2 . If one CO_2 is used in calcification, the other is available for photosynthesis, resulting in 1:1 ratios of calcification to photosynthesis. Approximately 1:1 ratios of calcification are often observed. By facilitating the photosynthetic utilization of bicarbonate, calcification approximately doubles the potential rate of photosynthesis in hard water, alkaline environments such as the ocean.

NEW COLLECTIONS OF INTERTIDAL AND SUBTIDAL SEAWEEDS FROM
THE ALEUTIAN ISLANDS, ALASKA

Kathy Ann Miller, University Herbarium, Department of
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I was privileged to spend five weeks of June and July, 1987 in the Aleutian Islands, Alaska, as a participant in the NSF-sponsored Otter/Urchin Food Webs Research Group headed by C. Simenstad, D. Duggins (University of Washington) and J. Estes (USFW/University of California, Santa Cruz). As time allowed, I made intertidal and/or subtidal collections at (from west to east) Attu, Alaid, Nizki, Shemya, Kiska, Amchitka, Adak, Seguam, Yunaska, Chuginadak, and Umnak islands. This extremely preliminary report includes observations on subtidal algal ecology, notes on some distributional records, intimations of seaweeds new to science, and speculations on biogeographical patterns in the north Pacific. I welcome your collaboration in working up my collections of this overwhelmingly beautiful flora.

GELIDIACEAE IN BRITISH COLUMBIA.

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Four representatives of Gelidiaceae occur in British Columbia. Three are members of Gelidium, a genus characterized by a bilocular cystocarp with one ostiole per locule, sessile or intercalary carpogonia, the presence of unicellular, internal "rhizines" and empty spore germination. One species belongs to Pterocladia, differentiated from Gelidium by its unilocular cystocarp. Gelidium purpurascens is tall and robust, terete to compressed and highly branched. Tetrasporangial stichidia have a small sterile margin, and in cystocarps the continuity of stretched vegetative filaments with the pericarp is maintained. The B.C. plants correspond to G. purpurascens type material and differ from G. robustum, to which it was previously assigned. Gelidium coulteri is intertidal, brownish, more sparsely branched and often forms a turf. Female gametophytes are not known from B.C., but the B.C. plants correspond well with Californian G. coulteri where cystocarps are known, dictating placement in Gelidium. Pterocladia caloglossoides is small, creeping, mat-forming, flattened and sparsely branched. Tetrasporangia are in distinctive V's of progressive maturity. Although cystocarps are unknown in B.C. material, it fits descriptions of South American and Californian plants and can be placed in Pterocladia. A fourth gelidiaceous alga, Gelidium sp., appears to be an undescribed taxon. It is soft, lax, compressed to flattened, highly branched and is unique among Gelidium species in being monoecious.

LIFE HISTORY INVESTIGATIONS OF THE RED ALGA RHODOPHYSEMA ELEGANS.
(Crouan frat. ex., J. Agardh) P. Dixon from the North Atlantic.

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The life history was completed for Rhodophysema elegans. Two distinct populations were distinguished: 1) an asexual bisporangial population, and; 2) a sexual tetrasporangial population. The presence of intercalary stalk cells provided morphological evidence of vegetative sporangia in the bisporangial populations. Cytological evidence supported a direct life history with 35-37 chromosomes in vegetative cells and 34-36 chromosomes noted for bisporangial initials. In tetrasporangial isolated, the lack of intercalary stalk cells and the presence of spermatia and wedge- to vase- shaped carpogonia provided morphological evidence of a sexual life history. During cytological investigations, 17-18 chromosomes were noted in vegetative cells with 35-37 chromosomes for tetrasporangial initials. The evidence establishes a sexual life history for tetrasporangial isolates.

LIFE HISTORY STAGE RATIOS OF IRIDAEA CORDATA
IN BRITISH COLUMBIA

Lesley G. Green, Department of Botany, University of British Columbia, Vancouver, British Columbia, V6T 2B1, CANADA.

Populations of the red alga Iridaea cordata consist of isomorphic diploid and haploid plants, the ratio of which can be determined using the resorcinol test. Three populations in Vancouver, British Columbia were studied and found to have a summer predominance of 1N gametophytic plants (62-80% gametophytic). In contrast, the winter haploid plants made up only 35-37% of the population. These results contrast with and extend the conclusions drawn by other authors on other populations of Iridaea cordata. Some possible influences causing these ratios were also investigated, including growing spores in culture and testing for apparent apomeiosis using resorcinol. The maximum amount of apomeiosis thus observed was 6%. Resettlement on sites cleared at different seasons was also tested; more Iridaea grew on rocks cleared in winter than on those cleared in summer.

THE LIFE HISTORY AND SCALE MORPHOLOGY OF A NEW SPECIES
OF HALOSPHERA, PRASINOPHYCEAE, CHLOROPHYTA.

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The spherical, nonmotile, phycoma stage of this species of Halosphaera is common in winter in Puget Sound and the coastal waters of Washington. When the developing phycoma reach a size of 190-300 μ , the nucleus and protoplast divide forming 128-256 motile cells. The new species is intermediate between H. viridis and H. minor in the size of the phycoma and in the number of motile cells formed. Body scales of the motile stage differ in morphology and size from H. minor, and there is an additional crown type scale not reported in H. minor.

S Y M P O S I U M

COMMERCIAL EXPLOITATION OF MICROALGAE.

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A small number of commercial products are derived from microalgal biomass. To date, economically feasible products have been limited to those of a relatively high value and early predictions of large quantities of inexpensive microalgal feedstock materials have not been realized. Large-scale mass culture out-of-doors is restricted to species capable of outcompeting undesirable "weeds" at extreme alkalinity, salinity, and/or temperature. Very high value special chemicals are also produced and can be extracted from microalgae cultivated in closed, light-jacketed fermentors. Products from outdoor mass culture include a number of health food formulations from the cyanobacterium Spirulina, beta-carotene from the phytoflagellate Dunaliella, and biofertilizer and soil-conditioning agricultural inocula. Protein-rich biomass is a by-product from utilization of microalgal oxygen production for wastewater treatment as well. Phycobiliproteins and restriction endonucleases are examples of high priced microalgal extracts for small markets.

SEAWEED CULTURE IN THE PACIFIC NORTHWEST

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