To the Chair, Vice-Chair, and Members of the House Committee on Agriculture and Natural Resources,

My wife Kari and I are the seaweed harvesters that requested HB3193. Carl Wilson is our state representative. The Oregon State Legislature unintentionally shut down our thriving seaweed business in Oregon in 2011 with the passage of SB600. Now we must go to California to harvest seaweeds for our business (Naturespirit Herbs LLC, established 1990).

Conflicting legislation regarding OPRD and DSL's territorial jurisdictions prevents either of these agencies from being able to issue a viable seaweed harvest permit. HB3193 fixes the problem of these conflicting territorial jurisdictions by assigning jurisdiction over seaweeds to ODFW. ODFW governs by the organism, not by territory. HB3193 would make the regulation of seaweed harvesting comparable to the regulation of clam or mussel harvesting in Oregon.

Oregon is the only west coast state in which the Department of Fish and Wildlife is *not* responsible for the management of the harvest of seaweeds. California, Alaska and British Columbia have had effective small-scale commercial hand harvesting permit systems in place for decades. We could learn much from their experience.

We are requesting your support for HB3193. HB3193 gives our family business a chance to grow and thrive, and gives Oregon the opportunity to develop a permit system for the small-scale commercial hand harvesting of edible and medicinal seaweeds, a unique and ecologically sustainable cottage industry.

Passage of HB3193 would be a win/win situation: a sustainable new cottage industry that does not compete with any other American industry. There is a steadily increasing demand for high quality domestic seaweeds, as gourmet foods and as therapeutic dietary supplements. Production of high quality edible and medicinal seaweed products is very labor-intensive, and provides a high level of employment and high level of value in relation to the small amount of seaweed resources harvested. Seaweeds are also broadly beneficial to people's health; the Japanese people's remarkable longevity and extremely low incidence of thyroid disease, breast cancer and prostate cancer may partly be due to the fact that they have the world's highest per capita seaweed consumption.

Therefore, passage of HB3193 would be beneficial to our family business, to coastal economies, to restaurants, to the local food movement, and to people's health.

Attached below is some additional information that you may find useful.

The first attachment is a copy of a letter I wrote to Curt Melcher, the director of ODFW in 2015. This letter explains the legal background and history of our seaweed harvest and our efforts to work with the state of Oregon to develop a seaweed harvest permit system.

The second attachment is a copy of Curt Melcher's informative reply to our letter.

The third attachment is a copy of the text of HB3193 with some suggested edits. Some of these edits are utilitarian and some are simply grammatical.

The fourth attachment is a description of our seaweed harvest methods.

The fifth attachment is a OIMB research study demonstrating the sustainability of our seaweed harvest methods.

The sixth attachment is a copy of our Naturespirit Herbs 2016 Retail Catalog, so you can better understand our family business and our seaweed products.

The last attachment is a copy of "Seaweeds and Human Health" which describes the health benefits of eating seaweeds.

Thank you for your attention to this matter.

Sincerely,
James and Kari

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RE: Seaweed Harvest in Oregon
January 5, 2015

Dear ODFW Director Curt Melcher,

Kari and I are writing to ask you to help document the legal issues currently preventing this state from being able to effectively manage a promising new cottage industry: the small-scale commercial hand harvesting of edible and medicinal seaweeds (also known as kelps or marine algae).

We began harvesting edible and medicinal seaweeds from the southern Oregon coast in 1990. We process and sell these seaweeds through our family mail order business, Naturespirit Herbs LLC, as dried "sea vegetables" as well as a variety of powdered and encapsulated products. Seaweeds provide over 80% of our family's income and provide much-needed employment in our rural community.

Over the years, Kari and I have been working with Oregon’s resource management agencies, marine biologists, legislators etc. in an effort to gain visibility, prove the sustainability of our harvest, and encourage the state of Oregon to develop a permit system for the small-scale commercial hand harvesting of edible and medicinal seaweeds. We have invested many hundreds of hours of our time in these efforts. However, we keep "falling through the cracks" in Oregon's resource management system.

In July of 2000 we received from OPRD a five-year experimental permit to hand harvest several species of seaweed from the ocean waters adjacent to Samuel Boardman State Park in southern Oregon. This permit was concurrent with a research study to determine sustainable levels of harvest of these seaweed species, using our harvest methods. The study was funded by a grant from Oregon Sea Grant and conducted by Lynda Shapiro at OIMB.

The results of the OIMB research study were very encouraging. All experimental harvest plots of all species studied had the same biomass as the control plots by the end of the following growing season, including the plots where 50% of the biomass had been harvested (we harvest a maximum of 25%; this preserves the integrity of the ecosystem).

However, Tim Wood, the director of OPRD at that time, informed us that he could not give us a non-research-related commercial seaweed harvest permit, because OPRD does not have the mandate to issue permits for the commercial use of natural resources.

In 2008, in response to concerns about the ecological sustainability of the large-scale mechanical harvest of Bull Kelp (using kelp boats with cutters that harvest thousands of tons per year, an industry that is very different from ours) the Department of State Lands adopted OAR *141-125-0110(13),* "*Notwithstanding the provisions of ORS 274.885, the Department will not allow or authorize the removal of kelp or other seaweed for commercial purposes*".

Nevertheless, ORS 274.895 allowed us to continue to harvest in Oregon. It was a 2,000 pound per person per year exemption crafted in 1967 to allow (without a lease) the small-scale harvest of kelp for making pickled kelp and candied kelp, which were popular regional specialty items sold in tourist shops along the Oregon coast at that time.

Then, in 2011, the Oregon State Legislature passed Senate Bill 600. Section 5 of this bill amended ORS 274.895 in a way that requires us to get a lease from DSL. This put our livelihood into a "catch-22" legal situation, because DSL's administrative rules state that they will not authorize the commercial harvest of kelp or other seaweeds.

Although Kari and I have invested hundreds of hours over the years in working with the state to gain visibility, prove the sustainability of our harvest, and encourage the state of Oregon to develop a permit system for the small-scale commercial hand harvesting of edible and medicinal seaweeds, our livelihood is now illegal in Oregon.

We must now go to California to harvest. However, we are still unable to find safe kayak access (or backpacking access) to ocean areas with sufficient quantities of several of the seaweed species we need to harvest for our business. Our primary concern here is safety, for ourselves and our harvesters. Another issue is driving distance; we must drive each day's harvest back to our home in southwestern Oregon for drying. This has imposed considerable economic hardship on our business and our family.

The legislature failed to consider this significant economic impact to a small business before passing SB600. Furthermore, there has not yet been any explanation or public discussion of the need for this "de facto" prohibition on small-scale commercial hand harvesting of seaweeds in Oregon.

Shutting down a thriving, ecologically sustainable family business as well as a promising new cottage industry is not good policy. It is also inconsistent with ORS 196.420(2):

> ***ORS 196.420 Policy****. It is the policy of the State of Oregon to:*
> *(2) Encourage ocean resources development which is environmentally sound and economically beneficial to adjacent local governments and to the state;*

In February of 2012, Kari and I met with Nancy Pustis and Chris Castelli at DSL to discuss possible ways to go forward with a seaweed harvest proposal. However, it soon became obvious that, even if DSL were to amend OAR *141-125-0110(13)* in a way that allows for the small scale commercial hand harvest of seaweeds in Oregon, the department could not issue a viable permit for our seaweed harvest until another major issue is addressed: conflicting legislation regarding DSL's and OPRD's overlapping jurisdictions in the intertidal zone.

Our interpretation of the statutes governing these two agencies is that the area of the ocean we harvest from is divided into four horizontal jurisdiction zones:

1. Subtidal zone (below Extreme Low Water): if DSL were to amend OAR *141-125-0110(13)*, DSL could authorize a lease to harvest seaweed in this zone (after consultation with the State Fish and Wildlife Commission). One or two of the ten seaweed species we harvest are found in this zone.

2. Lower intertidal zone (between Extreme Low Water and Mean Low Water): if DSL were to amend OAR *141-125-0110(13)*, DSL could authorize a lease to harvest seaweed in this zone (after consultation with the State Fish and Wildlife Commission). However, we would need to get a permit from OPRD as well, and OPRD's mandate does not allow them to issue such a permit. Five or six of the ten seaweed species we harvest are found in this zone.

3. Upper intertidal zone (between Mean Low Water and Mean High Water): DSL cannot authorize a lease to harvest seaweed in this zone. We would need to get a permit from OPRD to harvest seaweed in this zone, but OPRD's mandate does not allow them to issue such a permit. Three or four of the ten seaweed species we harvest are found in this zone.

4. Areas of offshore rocks and islands which are below Mean High Water: if DSL were to amend OAR *141-125-0110(13)*, DSL could authorize a lease to harvest seaweed in this zone (after consultation with the State Fish and Wildlife Commission). One or two of the ten seaweed species we harvest are found in this zone.

This unintentionally tangled jurisdictional situation clearly does not allow for practical, ecosystem based management of marine ecosystems. Also, because of the constantly fluctuating tides, it would be impossible to determine or enforce compliance with any kind of lease or permit system that is based on arbitrary horizontal territorial terms such as "Mean Low Water" and "Extreme Low Water".

In our opinion, the most practical way to resolve this situation would be for the Oregon State Legislature to assign jurisdiction over Oregon's marine algae to ODFW. Because ODFW manages organisms and not territories, the above-mentioned jurisdictional issues would be irrelevant if ODFW was responsible for the harvest of marine algae. This would make regulation of seaweed harvesting comparable to the regulation of clam or sea urchin harvesting.

It is our understanding that ODFW is currently responsible for the management of all marine organisms *except* for marine algae. It would seem that having jurisdiction over *all* marine organisms would be conducive to practical, ecosystem based marine management.

Oregon is the only west coast state in which the Department of Fish and Wildlife is *not* responsible for the management of the harvest of marine algae. Furthermore, California, Alaska and British Columbia have had effective small-scale commercial hand harvesting permit systems in place for many years.

State Representative Dennis Richardson and State Senator Betsy Johnson (the sponsor of Senate Bill 600) want to help resolve this situation. First, however, they need to document the issues at hand.

Therefore, we ask you to explain, in terms of rule and law, why ODFW cannot currently issue a permit for the commercial hand harvest of Oregon seaweeds.

We also ask you to explain, in terms of rule and law, what would need be done in order for ODFW to be able to manage the commercial hand harvest of Oregon seaweeds.

Thank you very much for your help.

Sincerely,
James Jungwith and Kari Rein

Oregon
John A. Kitzhaber, MD, Governor

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January 29, 2015

James Jungwirth
Kari Rein
Naturespirit Herbs LLC
PO Box 150
Williams, OR 97544

Dear Mr. Jungwirth and Ms. Rein:

Thank you for the letter explaining issues with commercial seaweed harvest in Oregon. I am writing to address the following two questions you posed at the conclusion of your letter:

ODFW, and its commission, the Oregon Fish and Wildlife Commission, do not currently have legal jurisdiction to govern the harvest of seaweed, or any other type of plant. ODFW's management jurisdiction pertains to wildlife as defined in its governing statutes, ORS Chapter 496 and ORS Chapter 506. These statutes specifically define the types of organisms that are within ODFW's management jurisdiction as follows:

ORS 496.004 (19): *"Wildlife" means fish, shellfish, amphibians and reptiles, feral swine as defined by State Department of Agriculture rule, wild birds as defined by commission rule and other wild mammals as defined by commission.*

ORS 506.011: "***Types of marine life defined.*** *As used in the commercial fishing laws, unless the context requires otherwise:*

(1) "Anadromous fish" includes but is not limited to salmon, as defined in ORS 506.016; roccus saxatilis, commonly known as striped bass; alosa sapidissima, commonly known as shad; acipenser medirostris and acipenser transmontanus, commonly known as sturgeon; and thaleichthys pacificus, commonly known as smelt.

(2) "Animals living intertidally on the bottom" includes but is not limited to starfish, sea urchins, sea cucumbers, snails, bivalves, worms, coelenterates and shore, hermit and other small crabs not included within subsection (1) or (7) of this section.

(3) "Black rockfish" means sebastes melanops, commonly known as black rockfish.

(4) "Blue rockfish" means sebastes mystinus, commonly known as blue rockfish.

(5) "Food fish" means any animal over which the State Fish and Wildlife Commission has jurisdiction pursuant to ORS 506.036.

(6) "Nearshore fish" means:

(a) Enophrys bison, commonly known as buffalo sculpin;

(b) Hemilepidotus hemilepidotus, commonly known as red Irish lord;

(c) Hemilepidotus spinosus, commonly known as brown Irish lord;

(d) Scorpaenichthys marmoratus, commonly known as cabezon;
(e) Hexagrammos decagrammus, commonly known as kelp greenling;
(f) Hexagrammos lagocephalus, commonly known as rock greenling;
(g) Hexagrammos stelleri, commonly known as whitespotted greenling;
(h) Oxylebius pictus, commonly known as painted greenling;
(i) Sebastes atrovirens, commonly known as kelp rockfish;
(j) Sebastes auriculatus, commonly known as brown rockfish;
(k) Sebastes carnatus, commonly known as gopher rockfish;
(L) Sebastes caurinus, commonly known as copper rockfish;
(m) Sebastes chrysomelas, commonly known as black and yellow rockfish;
(n) Sebastes dalli, commonly known as calico rockfish;
(o) Sebastes maliger, commonly known as quillback rockfish;
(p) Sebastes miniatus, commonly known as vermilion rockfish;
(q) Sebastes nebulosus, commonly known as china rockfish;
(r) Sebastes nigrocinctus, commonly known as tiger rockfish;
(s) Sebastes rastrelliger, commonly known as grass rockfish;
(t) Sebastes serranoides, commonly known as olive rockfish; or
(u) Sebastes serriceps, commonly known as treefish.
(7) "Shellfish" includes but is not limited to abalone, clams, crabs, crayfish or crawfish, mussels, oysters, piddocks, scallops and shrimp. "

These definitions do not include any sort of plant life, such as seaweeds; therefore, ODFW cannot act to regulate their harvest.

Granting ODFW the ability to manage seaweed harvest would require a statutory change in the Department's jurisdictional authority. Such a change would need to be enacted by the Oregon legislature. It is likely that changes would also need to be made to ODFW's commercial licensing statutes (ORS Chapter 508) to include commercial seaweed harvest. In addition to changing the jurisdiction and licensing statutes, the legislature could also choose to include specific provisions that define the methods or limitations concerning how the Department should implement the new jurisdictional authority. Since Oregon Department of Parks and Recreation and Oregon Department of State Lands currently have jurisdictional authority over seaweeds, it is likely that the legislature would also need to revise their respective statutes to address any issues with jurisdictional overlap that could be inadvertently created with a change in ODFW's authority.

Once ODFW gained the new authority from the legislature, it is likely that the Oregon Fish and Wildlife Commission would need to adopt administrative rules that define the details of how the department would manage commercial hand harvest of seaweeds. Management of commercial hand harvest of seaweeds by ODFW would also require establishing a new commercial permitting or licensing program and the funding and staffing to support the new program. This program would likely include substantial staff time to develop the permitting process, to handle any license or landing fees, to review and issue the seaweed harvest permits, to analyze logbook information submitted by the commercial harvesters, and to conduct periodic assessments of the status of the seaweed resources at a series of monitoring sites. These components of an ODFW commercial seaweed harvest program would incur financial costs to the agency. It is not clear if they could be supported by the small-scale of the commercial seaweed harvest industry or would require funding from another source.

I hope this addresses your questions. Please feel free to contact me or my staff if you require further information.

Sincerely,

Curtis E. Melcher

Curtis E. Melcher
Interim Director

Harvest Methods for Common Oregon Seaweeds

General guidelines for all species – Harvest each plant in a way that allows it to continue to grow and reproduce. Be careful not to damage or remove the holdfasts that attach the plants to the rocks. Harvest no more than 25% of plants in a stand. Keep all plants that have been harvested.

Bladderwrack *(Fucus gardneri)* – Cut 2-3" tips or cut plants no closer than 2" from holdfast.

Bullwhip Kelp *(Nereocystis luetkeana)* – Cut fronds no closer than 12" from bulb.

Grapestone *(Mastocarpus spp.)* – Carefully pluck or cut larger fronds by hand, leaving holdfasts with smaller fronds still attached.

Kombu *(Laminaria setchellii)* – Cut fronds no closer than 2" from base of frond.

Nori *(Porphyra spp.)* – Carefully pluck fronds by hand, leaving holdfasts and bases of fronds still attached.

Ocean Ribbons *(Lessoniopsis littoralis)* – Cut small clusters of fronds – take no more than 10% from any one plant.

Rainbow *(Mazzaella spp.)* – Carefully pluck or cut larger fronds by hand, leaving holdfasts with smaller fronds still attached.

Sea Cabbage/Sweet Kombu *(Hedophyllum sessile)* – Cut fronds no closer than 6" from holdfast.

Sea Fern *(Cystoseira osmundacea)* – Cut plants no closer than 12" from holdfast.

Sea Palm *(Postelsia palmaeformis)* – Cut fronds at least 2" from base, leaving 1-3" of grooved frond. Harvest before the end of July.

Wakame *(Alaria marginata)* – Cut fronds no closer than 4" from base of frond.

EXPERIMENTAL HARVESTS OF MACROALGAE ALONG THE OREGON COAST WITH AN ANALYSIS OF ASSOCIATED EPIPHYTIC DIATOM COMMUNITIES

by

JOHN J. YOUNG

A THESIS

Presented to the Department of Biology
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

December 2003

"Experimental Harvests of Macroalgae along the Oregon Coast with an Analysis of Associated Epiphytic Diatom Communities," a thesis prepared by John J. Young in partial fulfillment of the requirements for the Master of Science degree in the Deparment of Biology. This thesis has been approved and accepted by:

Dr. Lynda Shapiro, Chair of the Examining Committee

September 30, 2003

Date

Committee in Charge:

Dr. Lynda Shapiro, Chair
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Bryan Herczeg
Dr. Steve Murray

Accepted by:

Dean of the Graduate School

An Abstract of the Thesis of

John J. Young for the degree of Master of Science

in the Department of Biology to be taken December 2003

Title: EXPERIMENTAL HARVESTS OF MACROALGAE ALONG THE OREGON COAST WITH AN ANALYSIS OF ASSOCIATED EPIPHYTIC DIATOM COMMUNITIES

Approved: ______________________
Dr. Lynda Shapiro

Macroalgae (seaweeds) are the basis of a major global industry. Oregon, however, does not allow the commercial harvest of its seaweeds. This study looked at within- and between-year recoveries of five species of macroalgae following harvest. Three experiments compared seasonal harvests, removal methods, and removal amounts. Only *Alaria marginata* Postels *et* Ruprect regained pre-harvest lengths within one year. However, recovery was evident in all five species one year after treatments. These results suggest the possible sustainable harvest of Oregon's algal resources. Additionally, the diatom community epiphytic on *Mastocarpus papillatus* (C. Agardh) Kützing was chronicled between May and September 2002. Diversity peaked in May when abundance was lowest and reached a low in July when abundance was highest. *Cocconeis scuttelum* Ehrenberg was the most common epiphytic taxon. Characterizing the epiphytic community provides an additional metric for assessing macroalgal recovery.

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CHAPTER I

GENERAL INTRODUCTION

Marine algae are harvested commercially worldwide resulting in a multi-billion dollar industry annually (Zemke-White and Ohno 1999). Macrophyte harvesting along the west coast of the United States is included in these figures. Oregon, however, does not permit the commercial harvesting of its algal resources due to a lack of knowledge regarding seaweed recovery. Yet, with the potential for commercial harvest, it is necessary to examine the effects harvesting would have on Oregon's seaweed.

Studies that have experimentally tested the effects of harvesting on macrophyte populations provide the best basis for management plans (Nelson and Conroy 1989; Ang *et al* 1996; Griffen *et al* 1999; Lavery *et al* 1999). Chapter II of this thesis describes various harvest experiments to test the effects of (1) harvesting during different seasons, (2) different harvest amounts and (3) different removal methods on five perennial species of macroalgae. The data from these experiments are used in Chapter III to recommend a management strategy for the tested species. This work will be useful in drafting a management plan for the regulation of seaweed harvest in Oregon.

Chapter IV compares the epiphytic diatom community upon *Mastocarpus papillatus* (C. Agardh) Kützing, one of the species used in the harvest study, over a growing season. Epiphytic diatoms are used as environmental indicators because the silicified frustules are taxonomically distinct, easily preserved, and variations in community composition track environmental conditions (Christie and Smol 1993). This study provides baseline data on *M. papillatus* epiphytes that will aid in assessing recovery from disturbance events such as harvesting. The chapter also provides basic information on epiphyte diatom communities in the rocky intertidal.

CHAPTER II

EXPERIMENTAL HARVESTS OF FIVE SPECIES OF MACROALGAE ALONG THE OREGON COAST

Introduction

The harvest of seaweed is a major industry worldwide. Global harvesting of seaweed for use as food products is estimated to value over 3.6 billion US dollars annually (Zemke-White and Ohno 1999). Additionally, the annual estimated value of the production of phycocolloids (i.e., alginates, agar, and carrageenan) from seaweed is 2.6 billion US dollars (Zemke-White and Ohno 1999). These data do not include seaweed harvested for medicinal purposes because accurate figures are difficult to compile. Aquaculture is an important method of producing seaweed resources accounting for 52% of commercial production (Zemke-White and Ohno 1999). The remaining 48% is, therefore, collected from wild stocks. Due to the large scale of world seaweed harvest, studies have experimentally examined the impacts of harvesting activities on macrophyte populations (Nelson and Conroy 1989; Ang *et al* 1996; Griffen *et al* 1999; Lavery *et al* 1999). Based on these studies, management plans have been developed (Westermeier *et al* 1987; Westermeier *et al* 1999; Vásquez and Vega 2001).

The harvesting of marine algae for human use has been recorded before the 14th century in Portugal. This practice began by collecting beach cast seaweed for use as fertilizer. Today, the exploitation of its seaweed in Portugal continues with Portugal being the world's fifth largest agar producer (Santos and Duarte 1991). China, France, U.K., Korea, Japan, and Chile are responsible for 90% of the world's seaweed production.

Comparatively, the US is not a major contributor to world seaweed production (Zemke-White and Ohno 1999). Furthermore, with the exception of *Macrocystis* harvest, the west coast of the US has a negligible production of commercial seaweed (Merrill and Waaland 1998; Zemke-White and Ohno 1999). Most harvesting that does occur on the Pacific Coast of the US is by small cottage industries which take relatively small amounts of seaweed from the wild (Zemke-White and Ohno 1999). Yet, since 1984 the production of commercially important seaweeds has grown by 119% (Zemke-White and Ohno 1999). The increasing value of seaweed as a food and industrial resource makes large-scale harvesting in the Pacific States likely in the near future.

To remove marine algae from the Oregon intertidal zone requires a permit issued by the state. Historically, the issuing of these permits has been rare. Recently the state has, however, received an increase in requests for such permits. Permits are also required to harvest marine algae in the states of Washington, Alaska, and California. With the potential for a growing industry of seaweed harvest in Oregon, it is necessary to examine the effects harvesting will have on wild stocks of marine algae.

This study was designed to assess the effects of commercial harvesting on algal resources and to provide information useful in drafting a management plan for seaweed harvesting in Oregon. The study had two goals: to assess (1) the within and between year recovery of seaweeds harvested during different seasons and (2) the recovery in subsequent years following different removal methods and amounts. Within-year recovery was defined as reaching pre-harvest lengths or biomasses and second recovery was defined as reaching pre-harvest plot density.

The five species chosen for study were *Alaria marginata* Postels *et* Ruprecht, *Laminaria setchellii* Silva, *Fucus gardneri* Silva, *Mastocarpus papillatus* (C. Agardh) Kützing, and *Mazzaella splendens* (Setchel *et* Gardner) Fredericq *in* Hommersand, Fredericq *et* Freshwater. All five species are perennials and are harvested either for food or dietary supplements (Abbott and Hollenberg 1976; Zemke-White and Ohno 1999). They are found in the mid to low intertidal zone of rocky shores all along the Oregon coast. Species will be referred to by genus henceforth.

Materials and Methods

Three sites were chosen for experimentation. South Cove (43°18.13'N, 124°23.91'W) is part of Cape Arago State Park, Oregon, USA, Hooskanaden Creek (42°13.17'N, 124°22.73'W) and Lone Ranch Creek (42°05.98'N, 124°20.82'W) are located in Samuel H. Boardman State Park, Oregon, USA (Fig. 1). *Laminaria, Alaria,* and *Mazzaella* were harvested from Hooskanaden Creek. *Mastocarpus,* and *Fucus* were

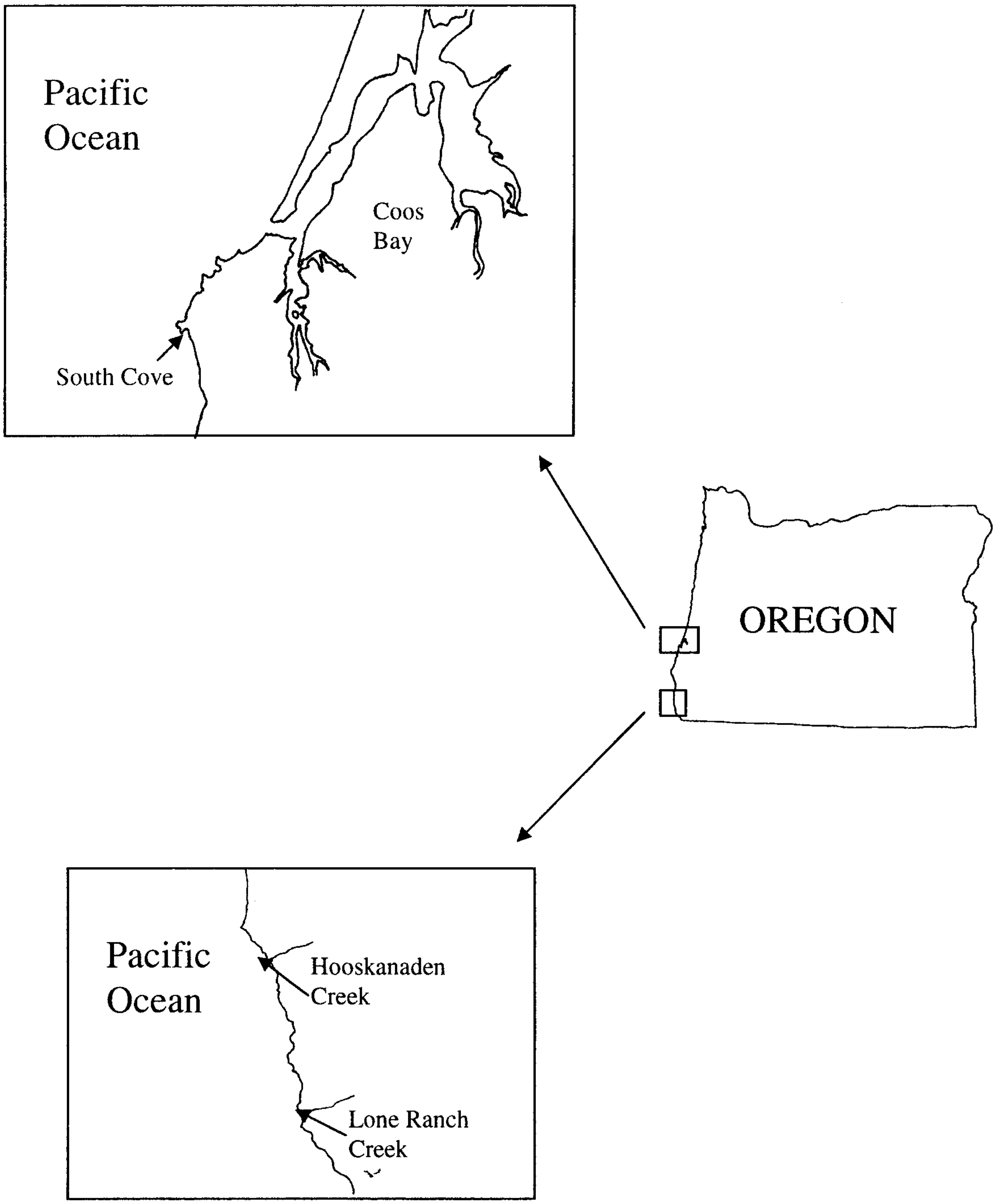


Figure 1: Selected Study Sites Along the Oregon Coast. *Alaria* and *Laminaria* were collected from South Cove and Hooskanaden Creek. *Fucus* and *Mastocarpus* were taken from Lone Ranch Creek. *Mazzaella* was collected from Hooskanaden Creek.

studied at Lone Ranch Creek. Experiments with *Laminaria* and *Alaria* were repeated at South Cove. All three sites are characterized by rocky substrata.

Preliminary studies at the southern sites (i.e., Hooskanaden Creek and Lone Ranch Creek) were done by randomly placing a 0.5M x 0.5M quadrat along transects parallel to shore and estimating species abundance via percent cover. Transects were placed at tidal levels supporting the zonal distribution of each individual species. Algal cover at Hooskanaden Creek averaged over 90%. *Alaria* and *Laminaria* were the dominant species in these measurements. *Mazzaella* was abundant at higher tidal elevations at Hooskanaden Creek. Lone Ranch Creek was estimated to have about 50% algal cover with *Fucus* and *Mastocarpus* being the most abundant.

Permanent transects and marked plots were placed through or in areas densely covered by the target species because such areas are chosen for harvesting. Bolts and bolt anchors drilled into the rock marked the endpoints of permanent transects. Some transects passed through areas covered with two target species. Areas along these transects were selected as harvest plots if they were densely covered (approximately 100%) with one target species. A numbered tag anchored to the rock with a screw and screw anchor marked the center of each plot. Quadrats were centered on the tag and an attached compass assured one edge of the quadrat was parallel to the transect. This allowed exact return to marked areas. Plots of *Laminaria* and *Alaria* were 0.5m x 0.5M and plots of *Fucus*, *Mastocarpus,* and *Mazzaella* were 0.2M x 0.2M.

Season of Harvest Experiments

Experimental harvests were conducted in May and June to compare the effects of harvesting during the spring and summer seasons, respectively. Three experimental plots were randomly assigned for each seasonal harvest. The first experiment occurred during the spring tide series between 25 and 30 May 2002. Harvests were performed on target species at all sites with the exception of *Mazzaella* and *Alaria* at South Cove. Large swells and high tides prevented these harvests. A summer harvest was performed on all species at all sites between 24 and 29 June 2002.

Experimental plots of *Alaria* and *Laminaria* had all harvestable quality plants (>50cm) marked through the stipes with numbered spaghetti tags (Floy Tag & Mfg., Inc. Seattle, Wa). Tagged plants were cut 6-10 cm above the meristems, and lengths recorded. Cutting above the meristems was chosen for *Laminaria* and *Alaria* because both show intercalary growth (Abbott and Hollenberg 1976). Furthermore, sporophylls of *Alaria* were spared. *Fucus, Mastocarpus,* and *Mazzaella* all possess apical meristems (Abbott and Hollenberg 1976), therefore, plants were cut 2-5 cm above the holdfast. All harvestable plants in experimental plots were tagged, cut and measured. Harvested plants were remeasured monthly during spring tides until August of 2002. Control plots (n=4 or more) were randomly assigned for each species at each site. Two of the control plots were tagged, measured, but left uncut. The other control plots were left untouched for subsequent year comparison. All tagged plants were then measured monthly through August 2002 during spring tides. All algae in experimental and tagged control plots were collected during the first spring tide in August 2002. Within-season controls were then used as experimental August harvest plots in subsequent years. Collection was done according to the methods described above.

Selective/Method of Harvest Experiment

Plots of the same sizes were randomly selected along the same transects used in the season of harvest experiments. Selected plots were randomly assigned a treatment of either 25% frond removal, 25% entire alga removal, 50% frond removal, 50% entire alga removal, or control. All treatments were replicated three times. In plots chosen for frond removal, the algae were cut in the same manner as in the season of harvest experiments. Plots chosen for entire alga removal had the designated number of algae removed from the substrate by prying off their holdfasts. Controls were left undisturbed and used for reference in all experiments during subsequent years.

Plots of *Alaria* and *Laminaria* had all holdfasts counted in the quadrat prior to any removal. Then all harvestable quality plants (>50cm) were counted. Either 50% or 25% of plants >50cm were removed according to the treatment assigned. In plots where an even number could not be taken, we rounded up to the next whole number. Plots of *Fucus*, *Mastocarpus*, and *Mazzaella* were not counted prior to removal. These plots were usually 100% full of the target species. A quadrat equally divided into four sections was used and algae were removed from one or two squares depending on the assigned treatment. Algae were always removed from the same squares to ensure consistency.

Experiments were performed on *Alaria* and *Laminaria* in both Hooskanaden Creek and South Cove over the first spring tide series in July 2002. The experiments were performed on *Mazzaella*, *Fucus*, and *Mastocarpus papillatus* during the second sping tide series in July 2002.

Experimental and control plots from both experiments were monitored during spring tides beginning in April 2003 through August of 2003. Recruitment in plots of *Alaria*, *Laminaria*, and *Fucus* was measured by counting the total number of holdfasts in the quadrat and the number of germlings. *Alaria* plants were scored as germlings if no sporophylls were present (typically < 50cm). *Laminaria* < 50cm were considered germlings and *Fucus* plants < 1cm in length were scored as germlings (Speidel *et al.* 2001). Percent cover was visually estimated with a subdivided quadrat for *Mazzaella* and *Mastocarpus*.

Collected algae were rinsed in freshwater to remove all epifauna previous to recording wet weight. The rinse water was passed through 150μm mesh and collected epifauna was preserved and cataloged. Algal samples were placed in a drying oven set at 60°C for 14 days prior to measuring dry weight. Aliquot samples from dried material of approximately 0.5g were placed in a muffle furnace set at 500°C for 14hrs to measure ash free dry weight (AFDW) and organic dry weight of the samples. Biomass was estimated by measuring the mass lost from the aliquot after heating and back calculating to determine organic dry weight of the plot. This figure was then multiplied by a constant derived from plot size to estimate organic cry weight per square meter.

Non-parametric Man-Whitney U-tests were used to compare final lengths of May and June harvested plants to control lengths. Within site biomasses and second year density data from the season of harvest experiments were compared with one-way

ANOVAs. When control replication was adequate (> 4), data from the selective harvest/method of removal experiments were analyzed using a factorial ANOVA design with method of removal (frond or entire alga) and amount of removal (25%, 50%, or control) as factors. One-way ANOVAs were used when a factorial design wasn't possible because control plot loss. A *post-hoc* Bonferroni test was performed on all significant results. All data were square root transformed if Cochran's C-test for homoscedasticity was significant. Furthermore, if transformations still failed Cochran's C-test, a non-parametric Kruskal-Wallis test was used. Statistical analyses were performed using the software package STATISTICA 6.0 (Statsoft).

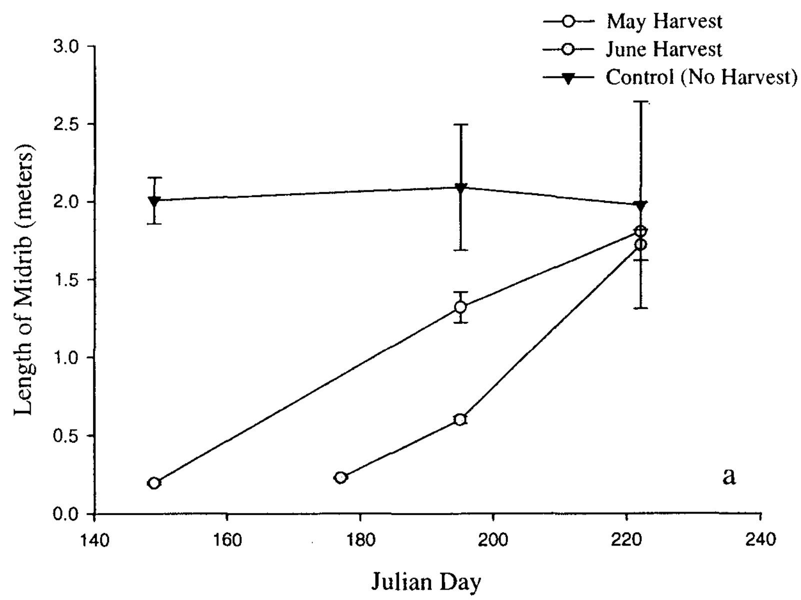
Results

Season of Harvest Experiments

Alaria marginata

The lengths of plants harvested in May from Hooskanaden Creek were not significantly different from the lengths of control plants when the experiment ended in August (Fig. 2a; p=0.620; Appendix A: Table 2). The same result was obtained when June harvested plants were compared to controls (p=0.522; Appendix A: Table 2). However, a June harvest only, performed at South Cove (Fig. 2b) showed a significant difference between lengths at the end of August (p<.001; Appendix A: Table 2).

The ANOVA indicated that there were no significant differences between the final biomasses of experimental and control plots (Fig. 3a; p=0.591; Appendix A: Table



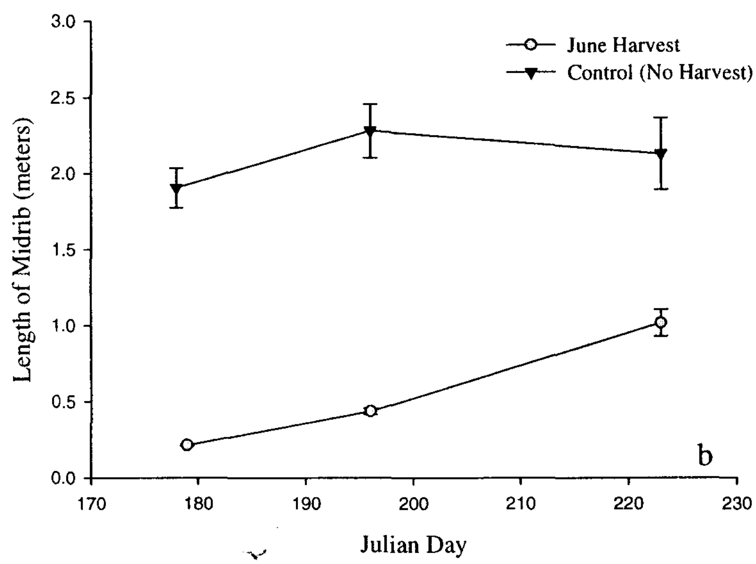


Figure 2: Season of Harvest Experiments for *Alaria*. Data points show the mean midrib lengths of *Alaria* from (a) Hooskanaden Creek and (b) South Cove. Error bars show one standard error from the mean.

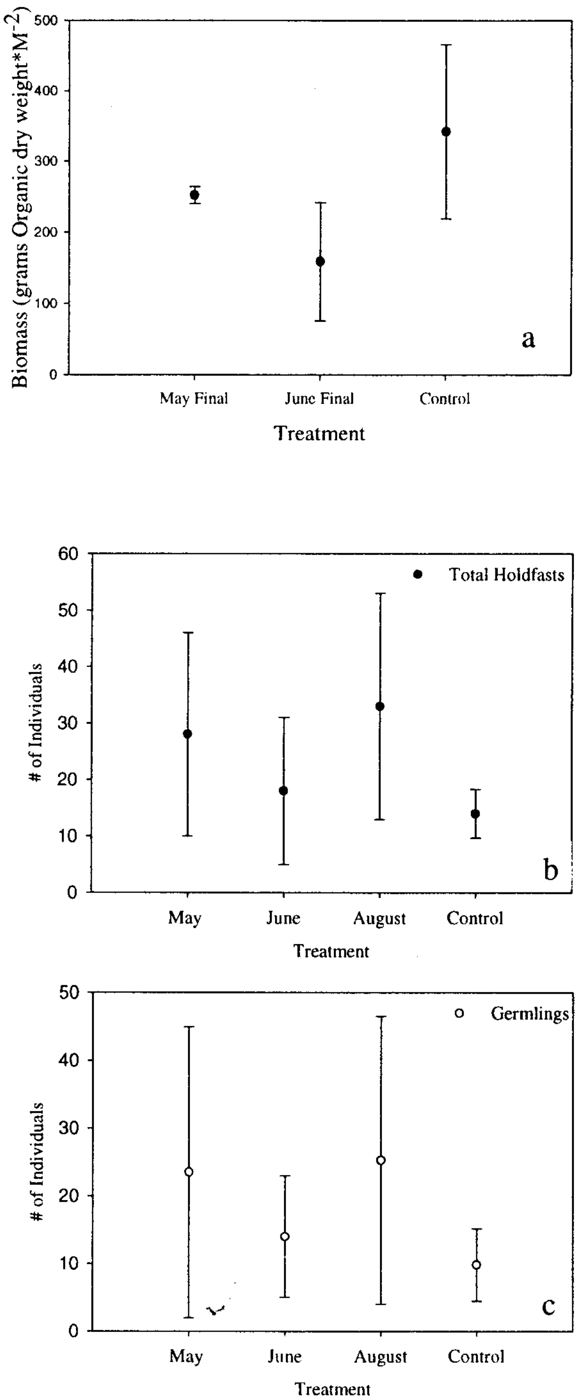


Figure 3: Recovery of *Alaria* from Hooskanaden Creek after the Season of Harvest Experiments. Within-year recovery (a) is represented by plot biomass. Second year recovery is shown by total(b) and germling(c) holdfast density. Error bars show one standard error from the mean.

3). Total and germling holdfast counts per plot in 2003 also showed no significant differences between all treatments (Figs. 3b and 3c; p=0.731 and p=0.847, respectively; Appendix A: Table 4). South Cove produced similar results (Fig. 4a and Figs. 4b and 4c).

Laminaria setchellii

The effects of both May and June harvests at Hooskanaden Creek were detected in August. There were significant differences in overall lengths between May harvested plants (p=0.001) and June harvested plants (p=0.005) and the controls (Fig. 5a; Appendix A: Table 2). The results of the same experiments performed at South Cove also produced significant differences (p= 0.008 and p<0.0001) between the two harvests and the controls (Fig. 5b; Appendix A: Table 2).

The biomasses of all plots harvested in August were square root transformed to satisfy the assumption of homoscedasticy required for an ANOVA (Fig. 6a; Appendix A: Table 3).There is a significant difference between the August biomass of experimental and control plots (p=0.001). *Post hoc* tests revealed significant differences between control and May (p=0.006) and June (p=0.001) biomasses. Total and germling holdfast counts per plot in 2003 were not significantly different (p=0.642; p=0.595) between all treatments (Figs. 6b and 6c; Appendix A: Table 4).

In the ANOVA comparing final biomasses of plots from South Cove, treatment effects were not significant (Fig. 7a; p=0.076; Appendix A: Table 3). Furthermore, there

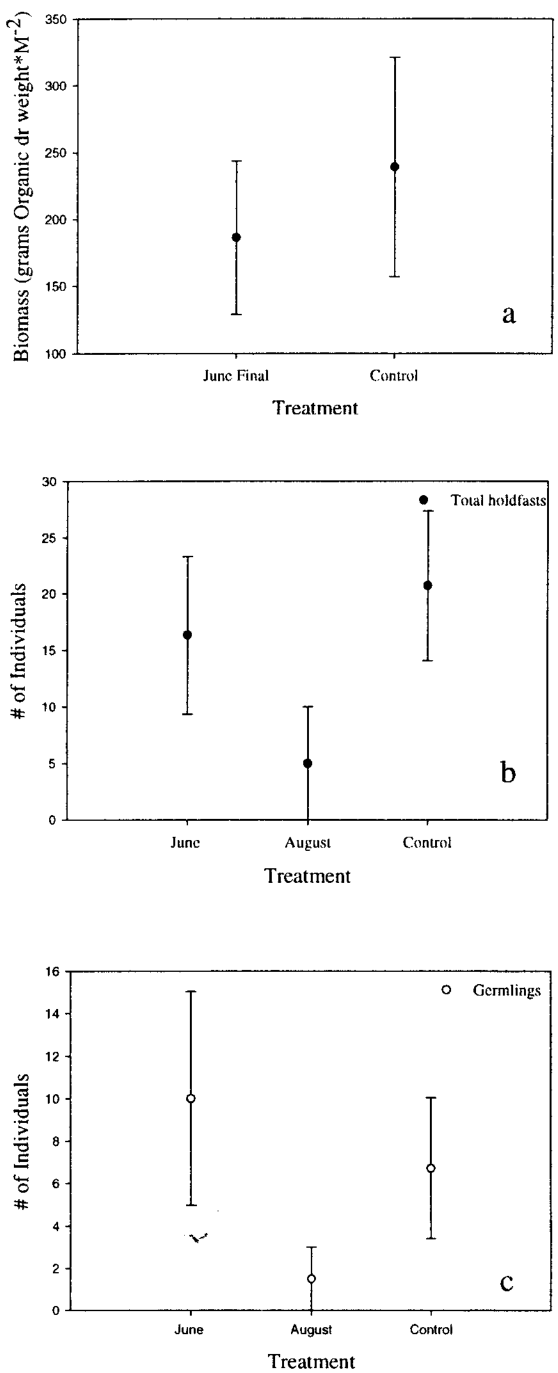
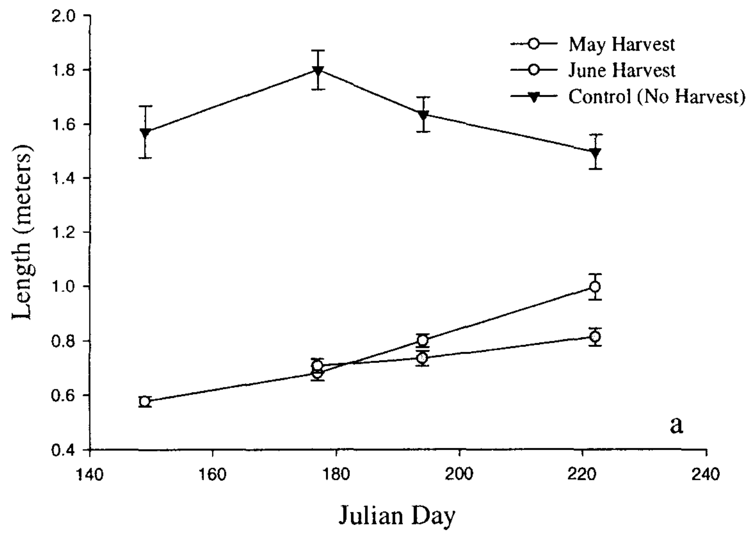


Figure 4: Recovery of *Alaria* from South Cove after the Season of Harvest Experiments. Within-year recovery (a) is represented by plot biomass. Second year recovery is shown by total(b) and germling(c) holdfast density. Error bars show one standard error from the mean.



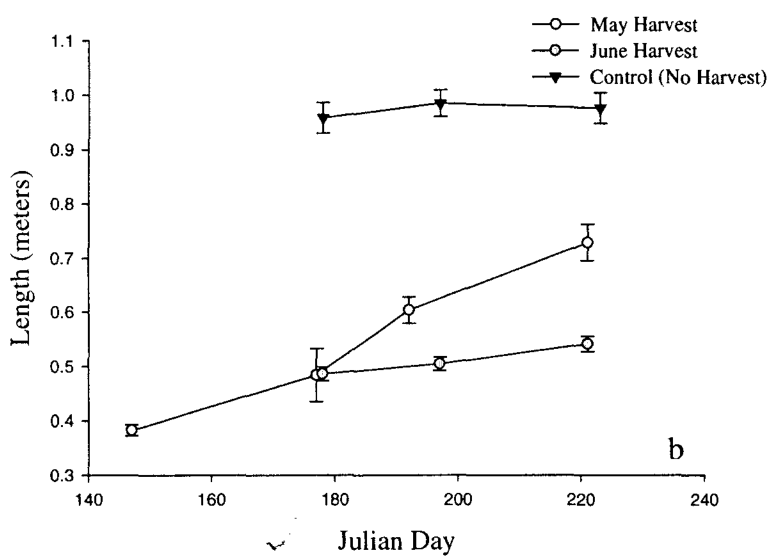


Figure 5: Season of Harvest Experiments for *Laminaria*. Data points show the mean lengths of *Laminaria* from (a) Hooskanaden Creek and (b) South Cove. Error bars show one standard error from the mean.

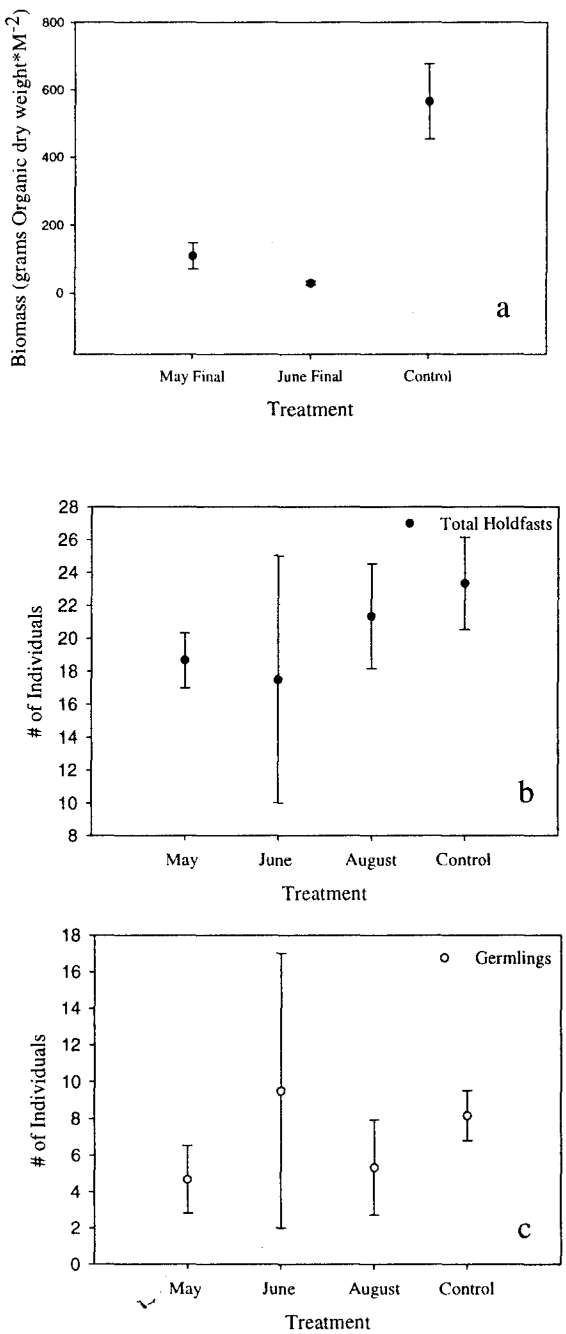


Figure 6: Recovery of *Laminaria* from Hooskanaden Creek after the Season of Harvest Experiments. Within-year recovery (a) is represented by plot biomass. Second year recovery is shown by total(b) and germling(c) holdfast density. Error bars show one standard error from the mean.

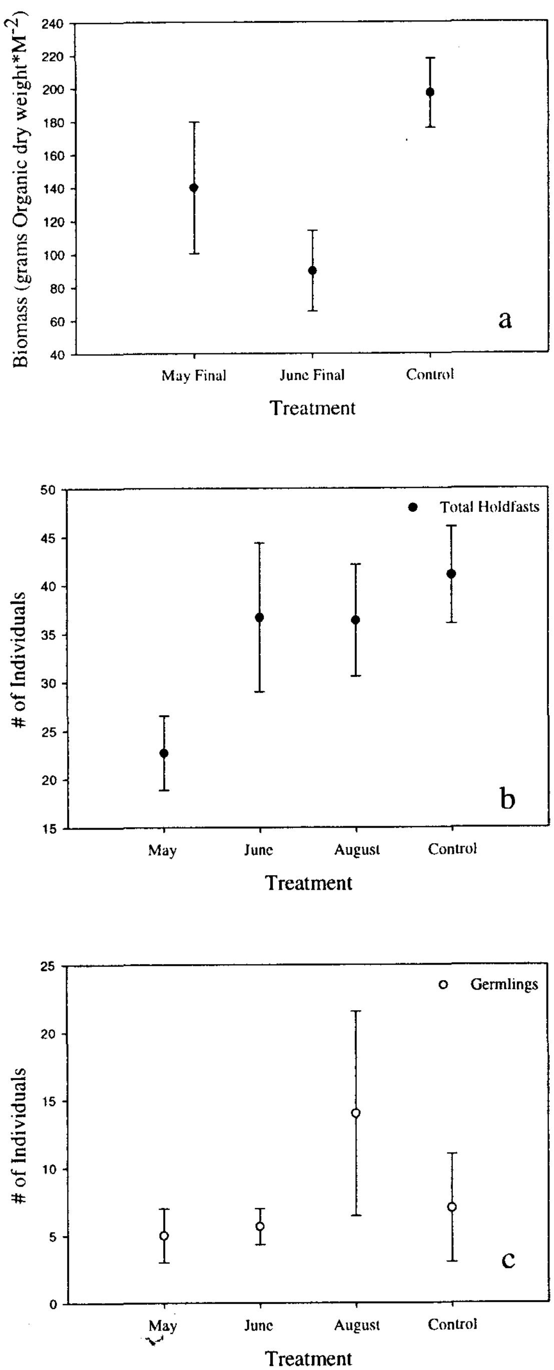


Figure 7: Recovery of *Laminaria* from South Cove after the Season of Harvest Experiments. Within-year recovery (a) is represented by plot biomass. Second year recovery is shown by total(b) and germling(c) holdfast density. Error bars show one standard error from the mean.

were no significant differences in total and germling holdfasts between experimental and control treatments (Figs. 7b and 7c; Appendix A; Table 4).

Fucus gardneri

In all of the tested seasons, *Fucus* did not grow appreciably following harvest (Fig. 8). Plants cut in May and June both had lengths significantly shorter than control lengths by August (p=0.002 and p=0.002, respectively; Appendix A: Table 2). The biomass data followed a similar pattern with significant differences in total organic dry weight (Fig. 9a; p=0.01; Appendix A: Table 3). The *post hoc* test revealed a significant difference between the June harvested and control plots (p=0.02), but no significant differences were found between the May harvest and control lengths. There were no significant differences in total and germling holdfast counts by harvest season in the 2003 season (Fig. 9b and 9c; p=0.743 and, p=0.829, respectively; Appendix A: Table 4).

Mastocarpus papillatus

Following harvest, *Mastocarpus* grew little or not at all (Fig. 10a). The plants harvested in both May and June were significantly smaller than the control plants (p=0.004 and, p=0.014, respectively; Appendix A: Table 2). The comparisons of the August biomasses from both experimental plots were not significantly different from that of the control plots (Fig. 10b; p=0.805; Appendix A: Table 3). No significant differences

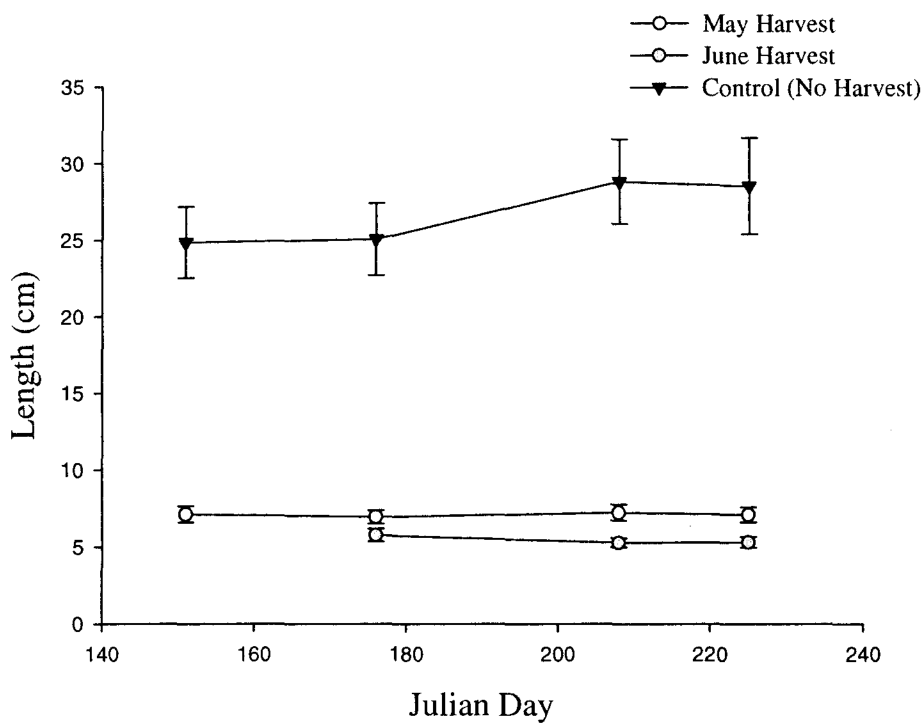


Figure 8: Season of Harvest Experiments for *Fucus*. Data points show the mean lengths of *Fucus* from Lone Ranch Creek. Error bars show one standard error from the mean.

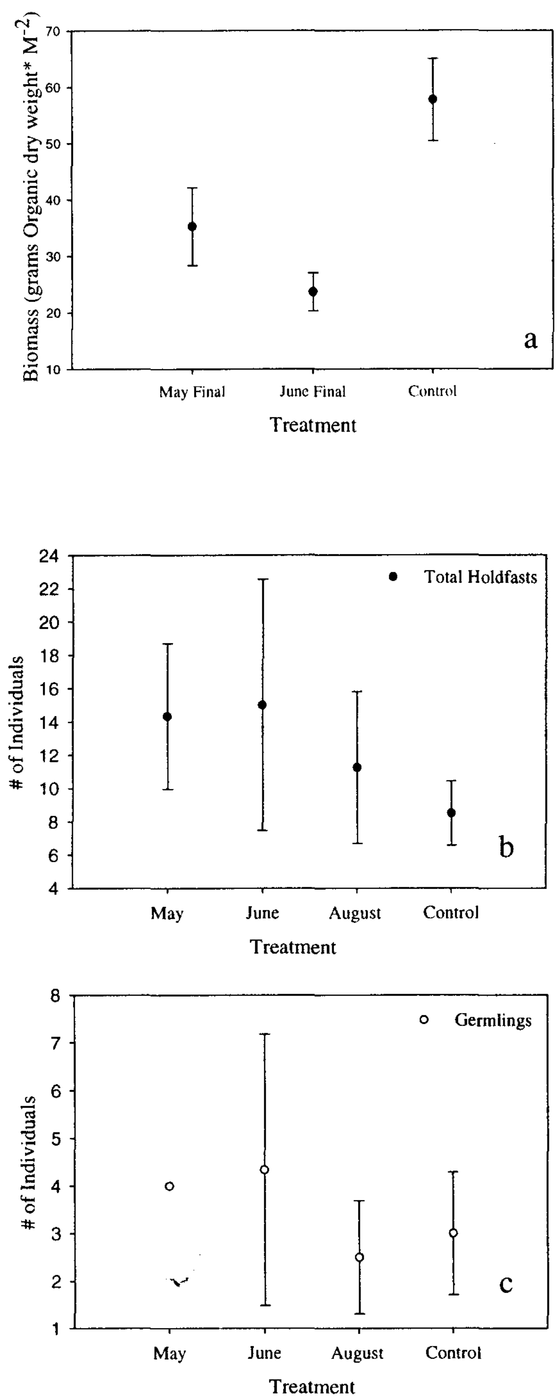


Figure 9: Recovery of *Fucus* from Lone Ranch Creek after the Season of Harvest Experiments. Within-year recovery (a) is represented by plot biomass. Second year recovery is shown by total(b) and germling(c) holdfast density. Error bars show one standard error from the mean.

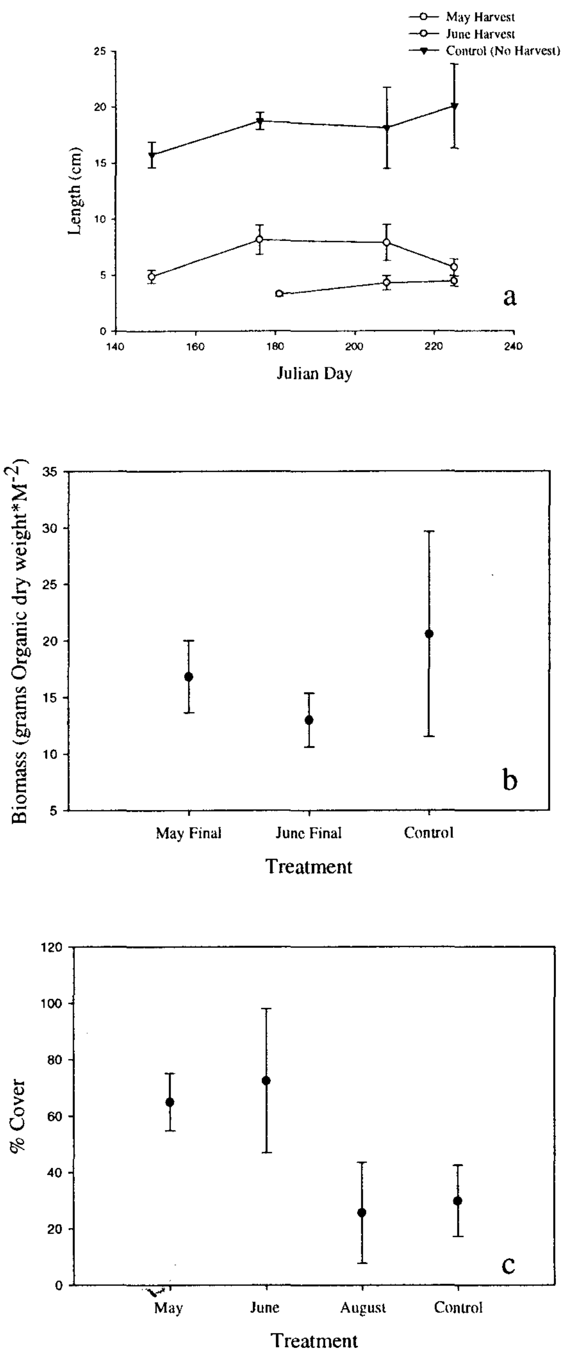


Figure 10: Season of Harvest Experiments with *Mastocarpus* at Lone Ranch Creek. Within-year recovery is shown by (a) lengths and (b) biomass. Second year recovery (c) is shown with percent cover. Error bars show one standard error from the mean.

(p=0.177) were found between the percent cover of the experimental plots and the control plots (Fig. 10c; Appendix A: Table 4) in 2003.

Mazzaella splendens

Mazzaella failed to increase in length following the single June harvest (Fig. 11a). Harvested thalli lengths in August were significantly smaller than control thalli lengths (p=0.0008; Appendix A: Table 2). The August biomass of the June harvested plots were not significantly different from the biomass of the control plots (Fig. 11b, p=0.369; Appendix A: Table 3). There were no significant differences between the percent cover of harvested and control plots (Fig. 11c; p=0.07; Appendix A: Table 4) in 2003; however, there was a trend of lower percent cover in plots harvested in June.

Selective/Method of Harvest Experiment

Alaria marginata

There were no significant differences in total *Alaria* holdfasts whether removal amount or method was considered (Fig. 12a; p=0.766 and p=0.433, respectively; Appendix A: Table 5). The interaction between the two factors (removal amount and method) also proved to be not significant (p=0.06). However, removal of fifty percent of the frond produced the largest mean plot density, nearly twice that of the controls.

The pattern was the same for the density of germlings except there was a significant interaction between removal amount and method of removal (Fig. 12b;

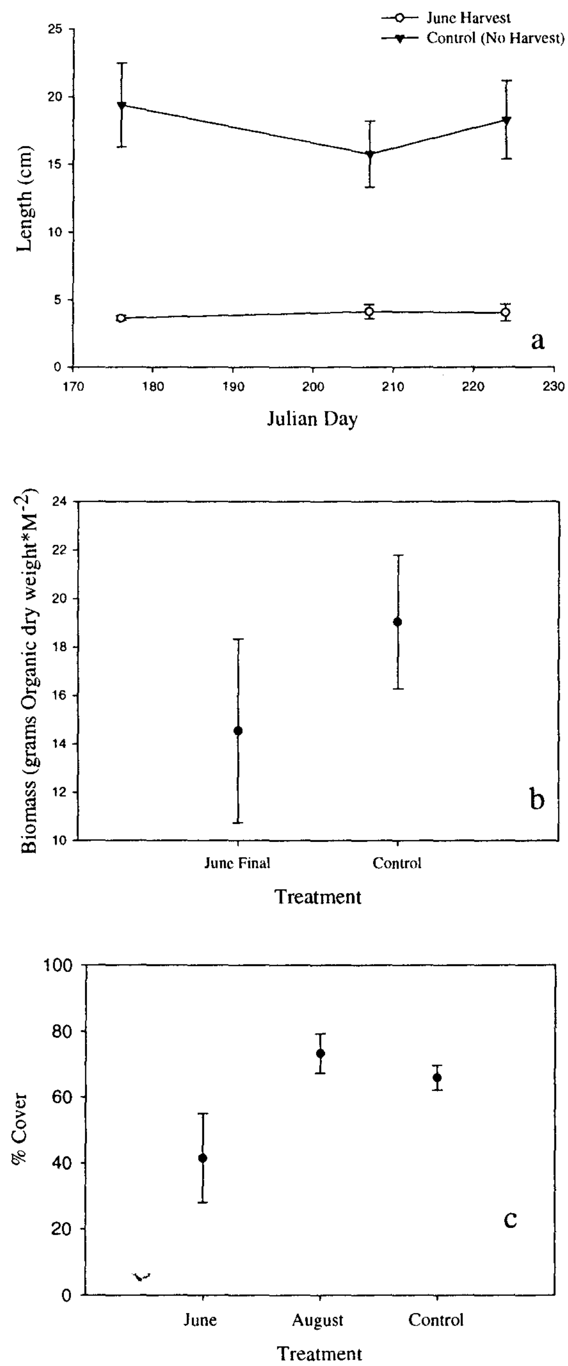


Figure 11: Season of Harvest Experiments with *Mazzaella* at Hooskanaden Creek. Within-year recovery is shown by (a) lengths and (b) biomass. Second year recovery (c) is shown with percent cover. Error bars show one standard error from the mean.

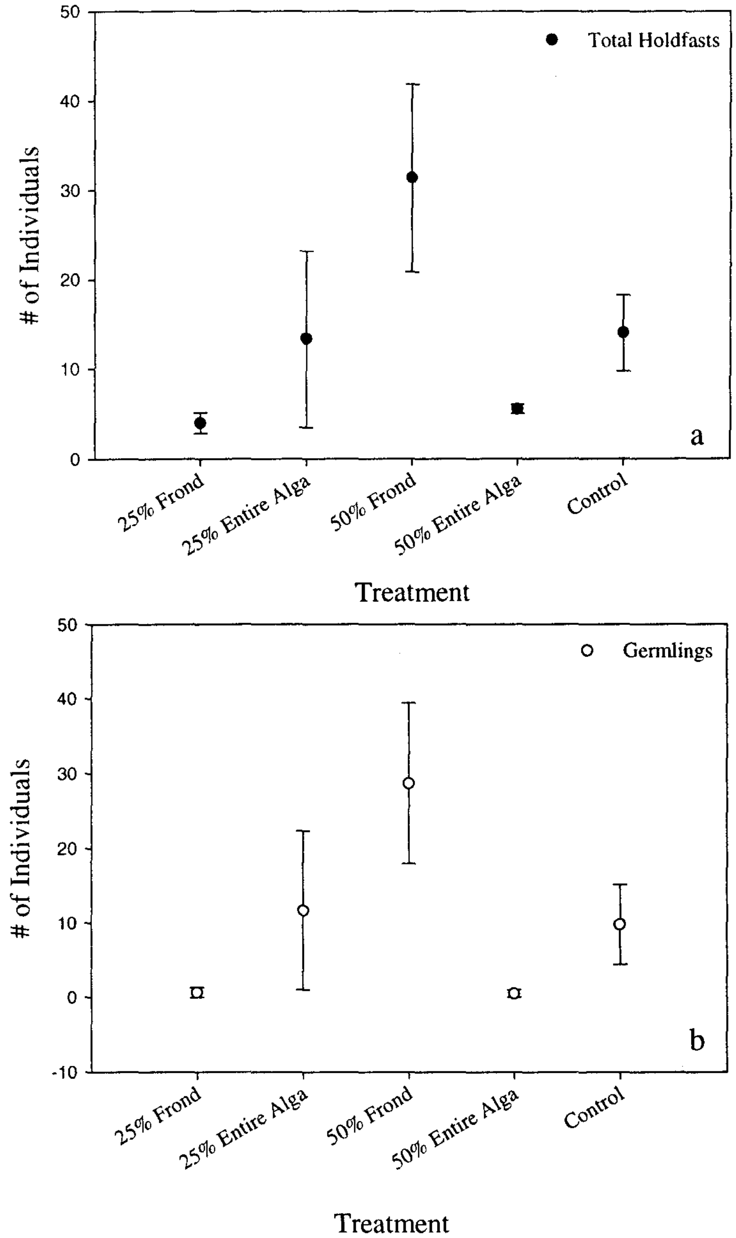


Figure 12: Recovery of *Alaria* from Hooskanaden Creek after the Selective/ Method of Harvest Experiments. Data points show the mean (a) total and (b) germling holdfast density. Error bars show one standard error from the mean.

p=0.03; Appendix A: Table 5). Again removal of fifty percent of the fronds in the plot yielded the greatest number of recruits. Removing 25% of the algae yielded second year density close to that of the controls. The treatments of 25% frond and 50% entire alga removal had the lowest plot densities. South Cove differed in that there were no significant differences between all effects, however, the trends were similar (Figs. 13a and 13b; Appendix A: Table 5).

Laminaria setchellii

A Kruskal-Wallis test revealed that removal of 25% of *Laminaria* present in plots produced significantly lower holdfast densities one year after the treatment (Fig. 14a; p=0.020; Appendix A: Table 6). Control plots, however, had the highest mean density of all treatments. Removing 50% of the fronds produced the second highest mean density.

There were no significant differences in germling density across treatments (Fig. 14b; Appendix A: Table 5). The one-way ANOVA comparing total and germling holdfast density differences at South Cove were not significant (Figs. 15a and 15b; Appendix A: Table 7). The removal of 50% of the fronds produced a larger mean total holdfast density than in the control plots, however, the variance was large.

Fucus gardneri

No significant treatment effects were found on total holdfast density (Fig. 16a) or germling density (Fig 16b). Statistical tables are shown in Appendix A: Table 5.

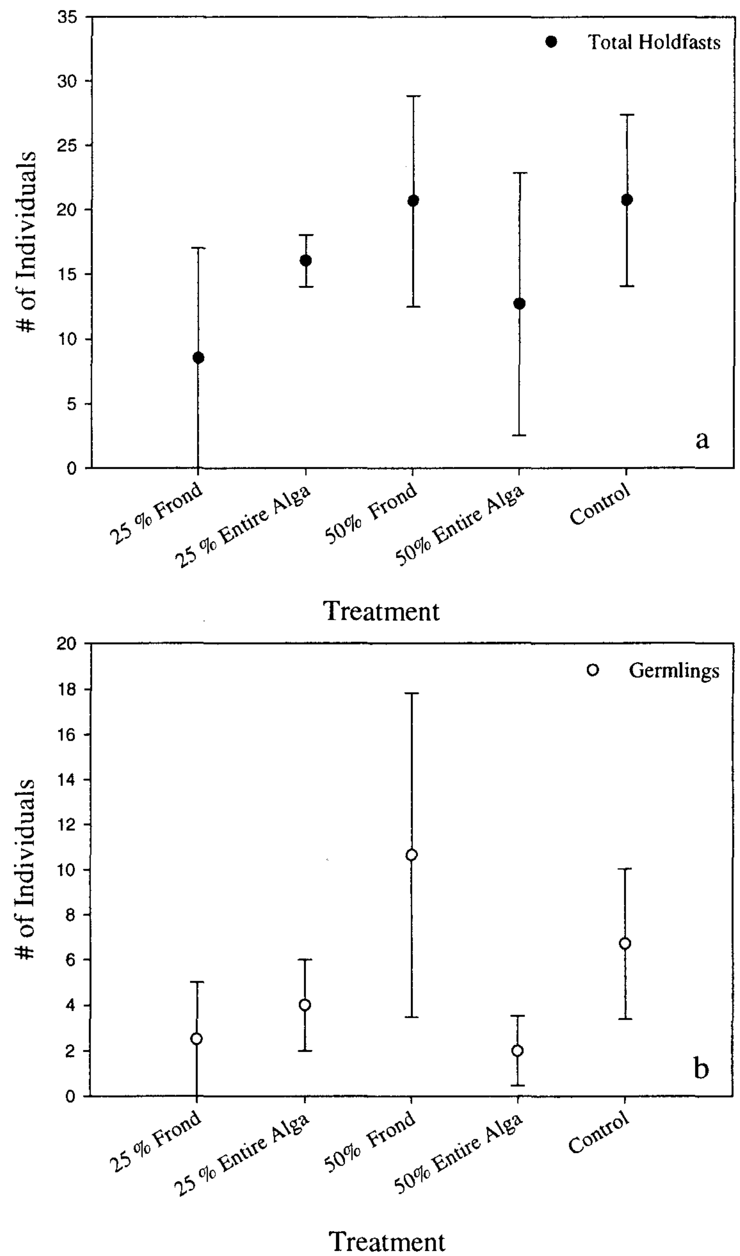


Figure 13: Recovery of *Alaria* from South Cove after the Selective/ Method of Harvest Experiments. Data points show the mean (a) total and (b) germling holdfast density. Error bars show one standard error from the mean.

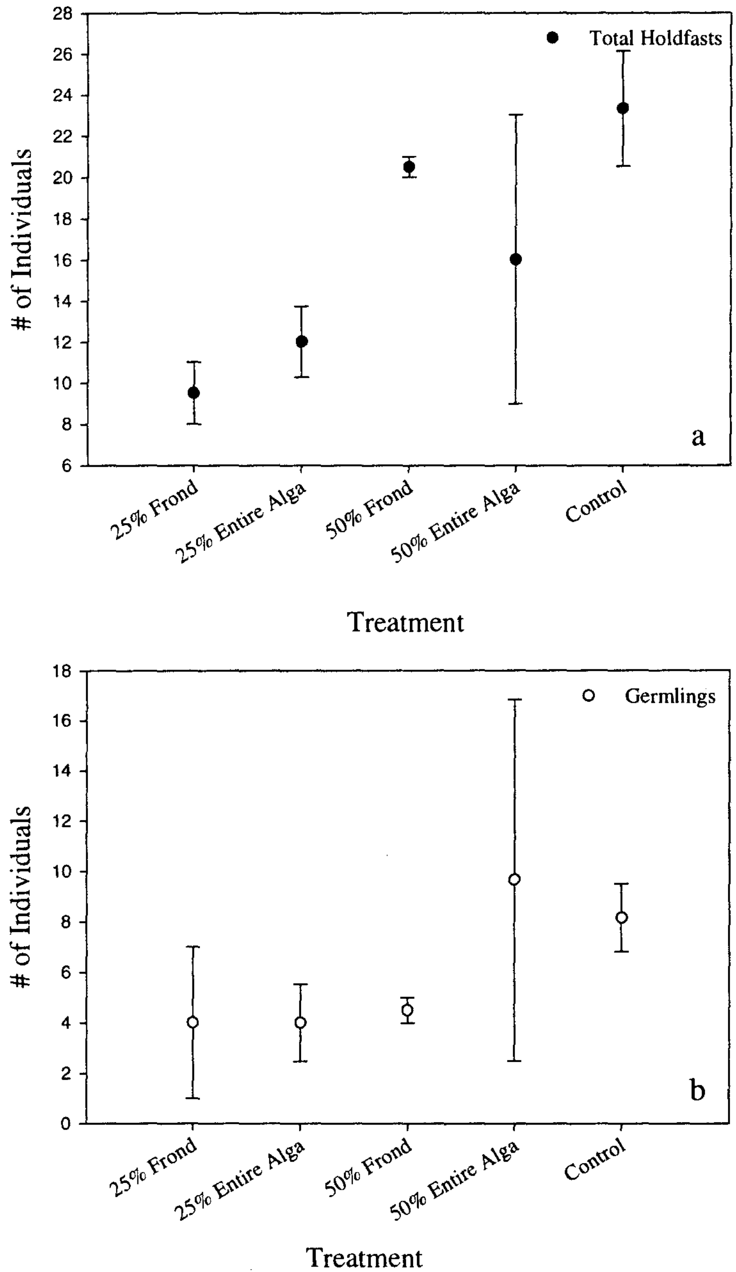


Figure 14: Recovery of *Laminaria* from Hooskanaden Creek after the Selective/ Method of Harvest Experiments. Data points show the mean (a) total and (b) germling holdfast density. Error bars show one standard error from the mean.

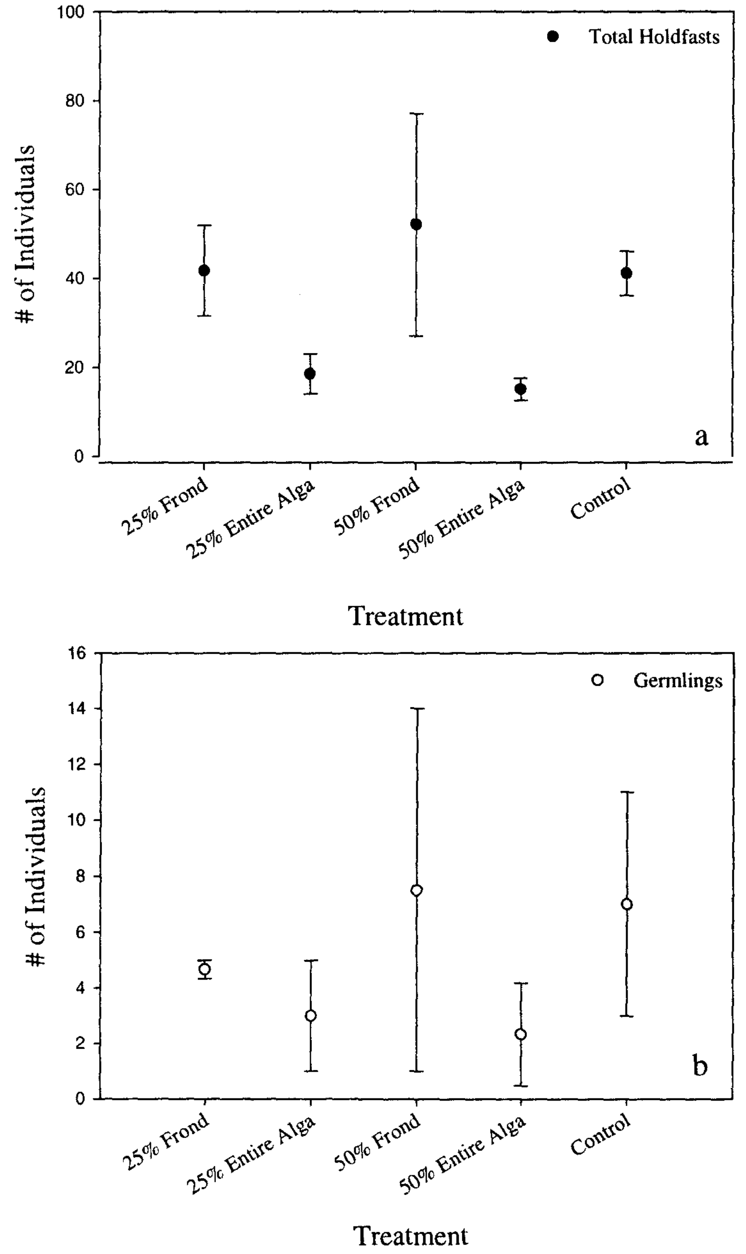


Figure 15: Recovery of *Laminaria* from South Cove after the Selective/ Method of Harvest Experiments. Data points show the mean (a) total and (b) germling holdfast density. Error bars show one standard error from the mean.

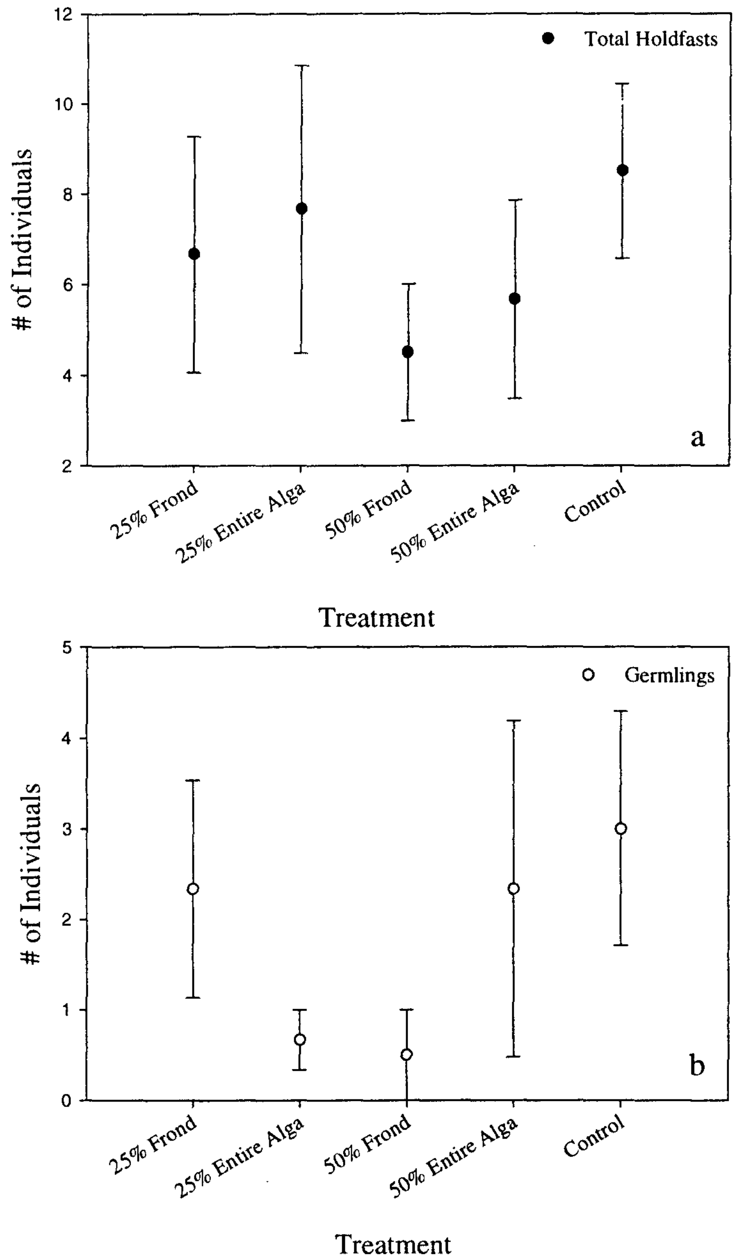


Figure 16: Recovery of *Fucus* from Lone Ranch Creek after the Selective/ Method of Harvest Experiments. Data points show the mean (a) total and (b) germling holdfast density. Error bars show one standard error from the mean.

Densities were lower in treatments of 25% entire alga and 50% frond removal but not significantly so.

Mastocarpus papillatus

None of the harvests had significant effects on percent cover of plots (Fig 17; Appendix A: Table 7). There was a trend of 25% removal having the highest second year cover, followed by 50% removal. Interestingly, the control treatment had the lowest second year cover.

Mazzaella splendens

There were significant treatment effects in the percent cover of *Mazzaella* plots one year after harvesting (Fig, 18; p=0.005; Appendix A: Table 7). Removing 50% of the algae present at the holdfast produced the lowest percent cover in 2003. *Post hoc* tests found significant differences between the 50% entire alga removal and all other treatments. The treatments of 25% and 50% frond removal both had mean percent covers not significantly different from control plots. Plots with 25% removal of the entire alga were not assessed in 2003 because of plot marker tag loss.

Discussion

For all species examined, the season of harvest had no effect on net growth. At the end of summer, the May-harvested treatments produced the same results as the June

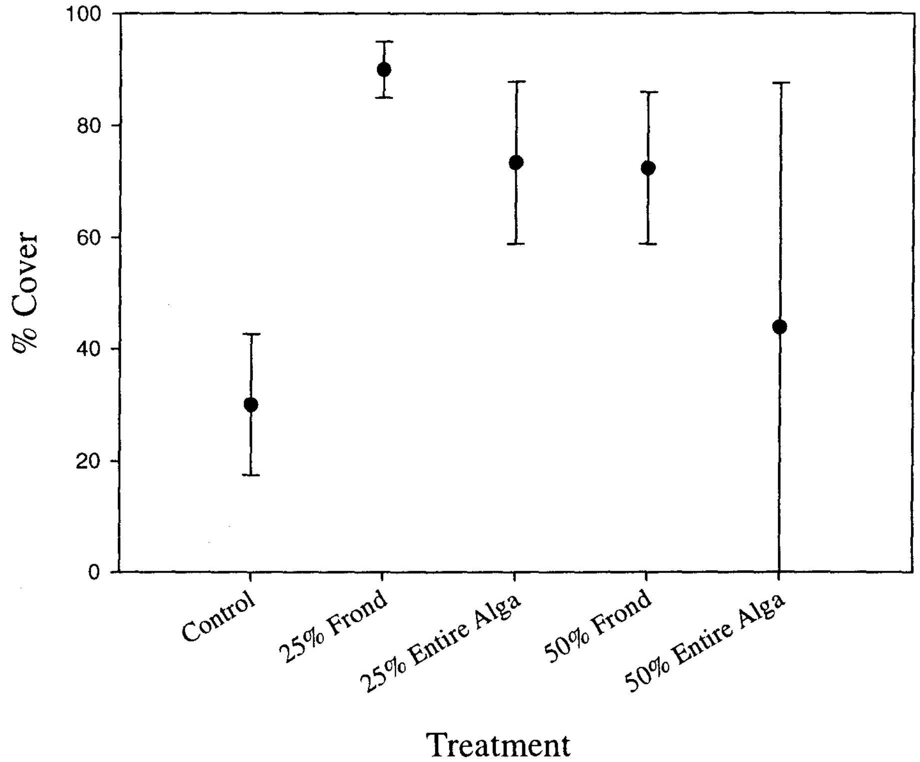


Figure 17: Recovery of *Mastocarpus* from Lone Ranch Creek after the Selective/ Method of Harvest Experiments. Data points show the mean percent plot cover. Error bars show one standard error from the mean.

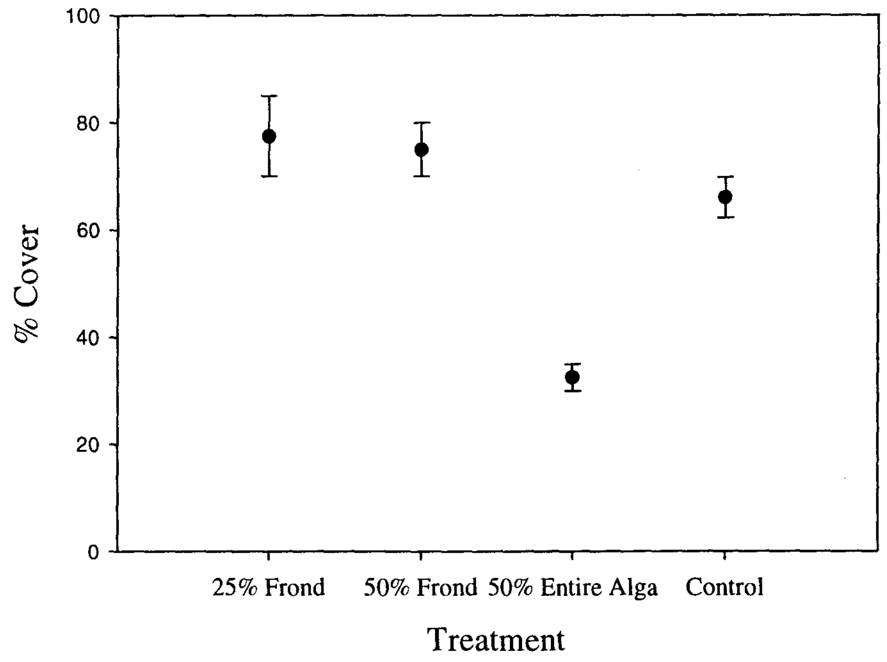


Figure 18: Recovery of *Mazzaella* from Hooskanaden Creek after the Selective/ Method of Harvest Experiments. Data points show the mean percent plot cover. Error bars show one standard error from the mean.

harvests. These comparisons lead to the conclusion that, in terms of net growth, harvesting in May or June had no effect on recovery within the same year that these species were harvested.

Alaria marginata

Alaria exhibits a typical laminarian life-history with an alteration of generations. Under short day conditions the macroscopic sporophyte stage releases zoospores which settle and grow into microscopic male or female gametophytes. The gametophytes are fertile and produce sporophytes throughout the summer (Lee 1999). Vegetative growth in the sporophyte occurs through an intercalary meristem between the stipe and the frond (Buggeln 1974; tom Dieck 1991). The sporophyte frond is collected by harvesters.

Harvesting *Alaria* as early as May and as late as August was unlikely to have significant effects on reproduction and recruitment. This is supported by the lack of significant differences between total and germling holdfast densities between treatment and control plots one year after treatments. Pfister (1992) found removal of the vegetative frond throughout the growing season significantly decreased the reproductive investment of *Alaria nana* yet, reproductive investment was not different between controls and plants with portions of the frond removed. My harvest times would allow for regeneration of fronds before the zoospores are shed in the fall. Additionally, I found the net growth of *Alaria* to increase following a harvest. The lengths of both May and June harvested plants, by August, were not significantly different from control lengths. The lack of apparent growth of the controls is likely due to breakage of the frond rather than reaching a terminal length. Larger (e.g. uncut) blades were probably more vulnerable to breakage. The experimentally shortened plants are less subject to breakage from wave action and rock abrasion which can cause catastrophic wounds in larger plants (DeWreede *et al* 1992). Furthermore, the congener *Alaria esculenta* (L.) has been demonstrated to grow throughout the year (Buggelin 1974) with growth pulses between April and Late June (Buggelin 1977). Herbivory is not likely to contribute significantly to the shortening of the control plants because the high concentration of phenolics in growing *Alaria marginata* (Steinberg 1984; Duggins and Eckman 1997) probably results in little grazing. The results comparing the biomass of experimental and control plots suggest recovery within the growing season and a possibility for two harvest yields per year.

The slower net growth of plants at South Cove is likely due to less nutrient input. Upwelling along the Oregon coast is known to intensify south of Cape Blanco (Strub *et al* 1987). This would increase the nutrient levels at Hooskanaden Creek above those of South Cove. Microclimate variations can have significant impacts on local vegetation (Begon *et al* 1996).

Removal of 50% of fronds from plots in the selective/method of harvest experiments produced the highest recruitments, although the differences were not statistically significant. Removing just the frond spares the sporophylls allowing production of spores and increased reproduction. Furthermore, thinning adult fronds from the plots increased the light penetration to juveniles allowing heightened growth. The lower recruitment observed in plots where 50% of the algae present were removed at the holdfast supports this argument. This treatment removed the sporophylls and therefore lowered spore potential. Dispersal distance in marine algae is thought to be relatively low (see Dayton 1973; Reed *et al* 1988) so these treatments are likely to have localized effects.

Laminaria setchellii

The life history of *Laminaria* is similar to that of *Alaria* except sporangia form on the sporophyte frond. Vegetative growth is via an intercalary meristem (tom Dieck 1991; Lee 1999). Again, the frond is collected by harvesters.

Net growth was slow in individuals following both May and June harvests. The significant differences in plot biomass between harvested plots and controls indicate that *Laminaria* was unable to recover during the same year it was harvested. This could be attributed to the timing of frond removal. Kain (1963) and Lüning (1969) found the growth of *Laminaria hyperborea* to be punctuated by two phases: the fastest growth occurring between January and June and a slow growth period between July and December. In this study, both spring and summer harvests occurred during the end of the period of fast growth, which could explain the minimal net growth observed in all treatments. Harvesting *Laminaria* earlier in the year during the period of rapid growth might ameliorate the effects seen in our May and June harvests.

Lüning (1969), however, showed that second year *L. hyperborea* sporophytes assimilate reserve materials from the previous year's frond. Late summer harvests of *Laminaria* could reduce growth in subsequent seasons due to the removal of the frond containing this reserve material. Also, the lack of frond lengthening in our treatments could affect reproductive potential because the sori form on the frond. Days with 8 or less hours of light induce the formation of sori in *L. saccharina* (Lüning 1988). Earlier harvests may allow for greater frond lengthening and a possible increase in reproductive potential. Lüning *et al* (2000) found that frond removal can, however, prevent the formation of sporangia which could negate any benefits of earlier harvests.

Despite these possibilities for lowered reproductive potential, recovery in the subsequent year was evident by the lack of significant differences in total and germling holdfast densities between May harvest, June harvest, and control plots. This supports the conclusion that the tested times of harvest had no effect on the recovery of *Laminaria.*

Removing 25% of *Laminaria* present from plots resulted in the lowest total holdfast density in the subsequent year. There was, however, no effect on germling density. Species of *Laminaria* are able to produce large numbers of spores per plant (Kain 1975; Chapman 1984). This allows a population to persist through disturbance events such as harvesting (Chapman 1984) and ice scour (Heine 1989). The removal of more plants from plots may open more space for early settling germlings, allowing them to reach adult size in the following year. Chapman (1984) found high reproductive pulses for two species of Nova Scotia *Laminaria* in all months except July. Additionally, removal of fewer plants from the plots may be hindering the growth of juvenile sporophytes through shading. Juvenile sporophytes of *L. saccharina* off Long Island survived summer conditions only if they settled the previous autumn (Lee and Brinkhuis 1988). Late year thinning may facilitate an autumnal settlement event by freeing space for new recruits. However, in this study germling densities were not significantly different between treatments.

Fucus gardneri

Fucus displays a different life-history than the previous two brown algal species. Gametes are produced by antheridia and oogonia that develop in conceptacles on the receptacles of the adult thallus. Therefore, no gametophyte stage exists separate from the parent frond. Conceptacles form under short day (8:16 hr LD) conditions (Lee 1999) and gametes are dropped near parent fronds to fertilize (Pearson and Brawley 1996). The zygote grows into the adult thallus with apical growth (Lee 1999). The adult thallus is harvested.

Following cutting *Fucus* failed to grow for the rest of the season. Cutting removes the apical meristems preventing further net growth of the alga. Adventitious growth was not observed. Harvesting removes the receptacles preventing conceptacle formation and therefore reproduction. Leaving the holdfasts of harvested plants still attached to the rock possibly limited the desiccation, thermal, and wave force stress on germlings (Speidel 2001). This allowed for recovery to occur in plots harvested during May. This is evident by the lack of significant differences between the biomasses of control plots and those harvested in May. Recovery, however, is relatively slow because the biomass of June harvest plots were significantly different from control plots. All plots were indistinguishable in total and germling holdfast density one year following treatment. *Fucus distichus* has been demonstrated to be reproductive throughout the year and recruits through new settlement only (Ang 1991). Harvesting of large plants may have freed space for more germlings to settle. High densities of *F. distichus* germlings have been demonstrated reduce mortality (Ang and DeWreede 1992).

The lack of significant differences in total and germling holdfasts between the control and selective/method of harvest experimental plots were maybe due to the remaining adults protecting germlings from stressors. Speidel (2001) showed that removal of up to 80% of *Fucus* adults from plots recovered within one year, however, removal of 100% resulted in a significantly longer recovery period. A similar pattern was seen in *Fucus* populations disturbed by oil spills (van Tamelen *et al* 1997). *Fucus* recovery is relatively rapid if a few adults survive the disturbance event (Speidel 2001). The four experimental treatments in my study all left some adults still attached to the rock which could have facilitated the recruitment of the germlings. It is important to note, however, that reproduction can only occur in uncut plants. Harvesting at commercial scales would reduce the reproductive potential of the population resulting in lower recruitment and density. Kim and DeWreede (1996) compared *Fucus distichus* recovery between three patch sizes where all algae were removed and found the intermediate size of 10x10cm produced the highest percent cover after 20 months. Our plot sizes for *Fucus* were 20x20cm, suggesting a smaller harvest area may result in faster recovery.

<u>*Mastocarpus papillatus*</u>

The complex life-history of *Mastocarpus* begins with macroscopic male and female gametophytes (Lee 1999). The male releases spermatia to fuse with the carpogonium to produce the second stage carposporophyte, which grows upon the female gametophyte. The carposporophyte releases carpospores that germinate into the tetrasporophyte stage. The tetrasporophyte of *Mastocarpus* forms a dark crust referred to as the "petrocelis" stage. This stage releases tetraspores that geminate into male and female gametophytes (Lee 1999). Alternatively, *Mastocarpus* can reproduce through an apogamous life-history where carpospores geminate into the erect form (Polanshek and West 1977). Vegetative growth is though apical cell divisions of filamentous axes (Lee 1999). Only the gametophyte stage is harvested.

Due to the removal of the apical meristems little net growth was observed in harvested *Mastocarpus*. Removal of gametophyte fronds would lead to lowered reproductive output because fewer spermatia would be formed. Also, the carposporophyte generation is removed along with female gametophytes. The negative effects on reproduction due to harvesting, however, may be mitigated by the tetrasporophyte stage. Harvesting would have no direct impact on tetraspore production which could replenish gametophyte stocks. Sussmann and DeWreede (2001) found annual variations in abundance of the tetrasporophyte stage with peaks in the summer and early autumn. This suggests a high tetraspore potential for *Mastocarpus* shortly after our harvests would have cleared space for new recruits. This conclusion is supported by the apparent recovery of *Mastocarpus* after both harvests. Lack of significant differences in the biomasses of control versus experimental plots suggest recovery within the harvest year. Furthermore, the mean percent covers of all treatments were not significantly different one year after experimentation, suggesting recovery after one year's time.

Through natural breakage *Mastocarpus* may experience disturbances similar to harvesting. Large fronds of the congener *Mastocarpus stellatus* are subject to removal by drag forces during periods of high wave energy (Pratt and Johnson 2002). *Masocarpus papillatus* does not increase the diameter of its stipe in proportion with frond size and, therefore, larger thalli are more vulnerable to breakage (Carrington 1990). By manually shortening the fronds, harvesting may lessen the consequences of drag forces during winter storms allowing the basal disc to survive into subsequent years.

The experiments comparing different removal amounts and methods also produced no significant differences in second year percent cover. This suggests recovery within one year of these harvests. Space may have been opened for new recruits by experimentally thinning plots allowing for the observed recovery.

Mazzaella splendens

The life-history of *Mazzaella* is similar to that of *Mastocarpus* described above. *Mazzaella* growth is also the same as described above. The two algae differ, however, in that the gametophyte and tetrasporophyte stages in *Mazzaella* are isomorphic and that an apogamous life-history is not known (Lee 1999). Both the gametophyte and tetrasporophyte stages of *Mazzaella* are collected by harvesters.

The lack of within-season net growth observed in harvested *Mazzaella* is attributed to the removal of the meristems. These harvests likely removed both gametophytes (with associated carposporophytes) and tetrasporophytes. This has the potential to lower the population's reproductive potential significantly. However, the differences in biomass of June harvested and control plots were not significant suggesting recovery within the harvest season.

Mazzaella thalli typically senesce at the end of the autumn down to the basal disc which is responsible for holding space for the subsequent year's holdfast and initiating growth of the next year's blade (Hansen 1977). Our harvests were unlikely to have effects lasting through the winter because the holdfast was spared. This is supported by the lack of significant differences in the percent cover of experimental and controls plots one year after treatment. Scrosati (1999) reported on harvest recovery of the congener *M. parksii* (as *M. cornucopiae*) and showed complete recovery in early spring harvested plants when the holdfasts were spared and suggested a high sustainable yield when only thalli were cut. Harvesting at commercial scales may, however, lower the recovery ability of *Mazzaella* since the absence of neighboring plants following extended harvests would limit recruitment in cleared areas. Harvested individuals cannot contribute significantly to reproduction therefore, recruitment must be from neighboring plants.

Removal of *Mazzaella* at the holdfast resulted in significantly lower percent cover the following year. Loss of the perennial basal disc caused the alga to loose its space on the rock and allowed the invasion of other organisms (Hansen 1977). Both frond removal treatments were not significantly different from controls because the basal discs were spared.

Limitations and Conclusions

These experiments did not assess the effects of harvesting on the associated community. Pieces of macroalgae that break off of growing fronds enter the food web as detritus. Duggins and Eckman (1997) showed *Alaria* and *Laminaria* to be an important food source for invertebrates once the secondary metabolites had been leeched from the frond. Harvesting would reduce this food source.

The findings in these experiments represent the first two years of a three year study. The results to date suggest these species can support sustainable harvesting. These data suggest that leaving the holdfast allows for the fastest recovery in most cases and recovery is evident after one year. The biomass of all experimental and control plots will be compared at the end of three years to fully assess recovery. Associated fauna will be collected during this time and compared between treatments. These results will provide data useful in drafting plans for the management of Oregon's algal resource.

BRIDGE I

The previous chapter examined the effects of different harvest times, amounts, and methods. All species reached initial density after most treatments one year following harvesting. Harvest time and amount had little effect on recovery. Sparing the holdfast allowed for faster recovery in most cases. These data suggested that the marine algae of Oregon can support a commercial industry. Chapter III uses the results from the harvest experiments to recommend a management strategy that would protect Oregon seaweed from overexploitation. I suggested harvest times, methods, and removal amounts to reduce harvest impacts on the recovery of the five species examined.

CHAPTER III

PROPOSED MANAGEMENT RECOMMENDATIONS FOR THE HARVEST OF FIVE MACROALGAL SPECIES ALONG THE OREGON COAST

Here I present suggestions recommendations for the harvest management of the five species discussed in the previous chapter. These suggestions are based on the data collected during the first two years of a three year study. Data collected from the third year may result in changed the following management strategiesrecommendations. In addition, these recommendations may be inappropriate during years with anomalous climate conditions. For example, the warm phase El Niño Southern Oscillations may reduce nutrient input leading to longer recovery periods for harvested algae. I will begin with general recommendations for the management of algal harvesting along the Oregon coast and then suggest species-specific management strategies (Table 1).

The macroalgae of Oregon can potentially support a commercial harvest. Strict management, however, will be required to prevent overexploitation. Prior to issuing of harvest permits, Oregon Parks and Recreation Department (OPRD) should survey the coast and delineate areas suitable for harvest. These areas should support an abundance of macroalgae. If they occur in state park boundaries, other criteria (e.g. preserving a natural environment for park visitors) may be relevant but are not considered here. Algal spore dispersal distance are often relatively small (see Daton 1973; Reed *et al* 1988). T therefore, I recommend harvests to occur along straight transect lines parallel or perpendicular to shore through dense beds of target species. Based on the size of my experimental plots, I recommend these transects should be 50cm wide and 50 meters long with 100 meters between each harvest transect. Harvesting along transects would allow spore dispersal into the harvested areas from neighboring plants.

To finance the cost of enforcement, OPRD might consider selling permits. Applications for harvest should specify which species are to be harvested and where. The permittee would be required to report wet weights of all harvested species, take pictures of harvested areas before and after removal, and estimate percent of standing crop harvested. These data would help the state further manage the harvest of marine algae.

Alaria marginata

Alaria grows rapidly following harvesting. Data from harvest experiments suggest that two crops of *Alaria* can be produced during one growing season. The timing of the first harvest should be between April and May to allow plants to recover before a second harvest in August. My data suggests that *Alaria* can fully recover from two harvests within one year. *Alaria* should be harvested by cutting the frond at least six inches (≈ 12cm) above the stipe. This allows for the meristems and the sporophylls to be spared which facilitates recovery. The highest recruitment and plot densities were seen in plots where the holdfasts and sporophylls were not removed. My experiments removed 68.6 kg (≈ 151 lbs) of *Alaria* wet weight from a study site and full recovery was seen within one year. James Jungwirth of Nature Spirit Herbs and Sea Vegetables, the sole current permitee, harvests 400 lbs of *Alaria* under an experimental commercial harvest permit with no apparent impact in subsequent years. My plot sizes and harvest amounts, however, are too small to suggest that any amount greater than what I took will have no detectable impact.

Laminaria setchellii

Net growth of *Laminaria* was slow following harvesting. *Laminaria* should be harvested only between March and May to allow for the intra-annual recovery of the harvested individuals. Harvest experiments showed that the method of removal had no measurable effect of removal method on recovery. The scale of my experiments, however, may have been too small to detect significant effects of holdfast removal. It is thereforeTo be cautious, I am recommendinged that fronds should be cut at least 6 inches (≈ 12cm) from the stipe. I removed 46.5 kg (≈102 lbs) of *Laminaria* wet weight from a site and full recovery was evident within one year. Jungwirth is allowed 400 lbs under his permit. My experiments found significantly higher plot density following recovery when larger amounts were50% of *Laminaria* were harvested in plots than when lesser amounts were harvested. This result suggests that larger amounts could be taken without affecting recovery. , hData are not available, however, to recommend an upper limit of harvest amount.

Fucus gardneri

Fucus failed to grow following harvesting since cutting removed the apical meristems, preventing further growth of harvested individuals. Furthermore, harvesting removed the reproductive structures of *Fucus*. Recovery, therefore, was dependent on neighboring individuals. RIn this study, removal method had no measured affect on *Fucus*, . hoHowever, previous work has shown that recovery was significantly longer when all holdfasts were removed from a plot (Sspeidel 2002). Therefore, *Fucus* should be harvested by cutting the frond at least six inches (≈12cm) above the holdfast. My experiments found no significant differences in biomass between May harvest and controls plots, but did find significant differences between June harvest and control plots. Therefore, I recommend *Fucus* be harvested only between April and May to facilitate intra-annual recovery. I removed 7.3 kg (≈16 lbs) wet weight of *Fucus* from a site without measured effects. Jungwirth is allowed 800 lbs of *Fucus* annually. *Fucus* is vulnerable to overexploitation because recovery is dependant on neighboring individuals repopulating harvested areas. I therefore, cannot safely recommend harvest amounts greater than those which I removed.

Mastocarpus papillatus

Harvesting of *Mastocarpus* removes the apical meristems preventing further growth within the harvest year. However, I observed full recovery one year after harvests. Biomass comparisons between May harvest, June harvest, and control plots produced no significant differences. Therefore, I recommend *Mastocarpus* be harvested between May and August. Removal method had no measurable affect on *Mastocarpus* suggesting recovery can occur either by regrowth from spared holdfasts or settlement of new recruits. *Mastocarpus* can be harvested by cutting the frond or pulling off the holdfast. I removed 2.2 kg (≈4.8 lbs) wet weight of *Mastocarpus* from a site with no detectable effect. I found no significant differences in recovery between removal amounts suggesting greater amounts could be harvested without effect. , hHowever, more data are needed to set an upper harvest limit.

Mazzaella splendens

Harvesting removes the apical meristems of *Mazzaella* preventing further growth within the harvest year. Additionally, harvesting removes all life-history stages of *Mazzaella*. I found no significant differences in biomass between June harvest and control plots. This suggests *Mazzaella* can be harvested between June and August and recover intra- and inter-annually. The removal of *Mazzaella* holdfasts resulted in significantly lower percent cover one year after harvest. Therefore, I recommend *Mazzaella* should be cut at least 4 inches (≈8cm) above the holdfast. *Mazzaella* should not be harvested in such a way that the holdfast is removed. I was unable to test the effects of different harvest amounts for *Mazzaella* and therefore, cannot make recommendations as to harvest limits.

Table 1. Recommended Management Strategies for the Harvest of Five Macroalgal Species of Oregon.

Species	Harvest time	Harvest method	Harvest amount per transect
Alaria marginata	April to May August	Cut 6 inches above stipe	150 pounds/year
Laminaria setchellii	March to May	Cut 6 inches above stipe	100 pounds/year
Fucus garneri	April to May	Cut 6 inches above holdfast	15 pounds/year
Mastocarpus papillatus	May to August	Cut frond or pull holdfast	5 pounds/year
Mazzaella splendens	June to August	Cut/tear 4 inches above holdfast	No Data

BRIDGDE II

The previous two chapters dealt with effects of seaweed harvest and possible management strategies,. Chapter II examininged the effects of seaweed harvest on the harvested species only. Potential impacts on the associated community were not assessed and . Accordingly, the management recommendations presented in Chapter III do not consider those possible impacts. Examination of associated communities is needed before any potentialfull effects from harvesting can be elucidated.

Chapter IV provides a first step in understanding the community dynamics of marine macrophytes. The following chapter gives a detailed analysis of the epiphytic diatom community upon *Mastocarpus papillatus* (C. Agardh) Kützing. Additionally, I examine temporal changes in this community structure over a growing season and examine the role of grazing by *Littorina keenae* in changing epiphytic community structure. These data will allow comparison of epiphytic communities to be used as an additional metric to assess recovery of *M. papillatus* after harvesting. The information is also valuable in itself. Epiphytic communities in estuaries have been well studied, but similar communities in the rocky intertidal are virtually unknown.

CHAPTER IV

ANALYSIS OF THE EPIPHYTIC DIATOM COMMUNITY UPON THE MACROALGA *Mastocarpus papillatus* (C. Agardh) Kützing

Introduction

Micro-organisms have often been used as metrics to assess various environmental factors. Fecal coliforms are common indicators of sewage contamination and bacterial diversity has been used to test restoration success (Milbrandt 2003). Epiphytic diatoms are used as biomonitors of water quality (Kelly *et al* 1998) and have been used to assess habitat fidelity (Winter and Duthie 2000), disturbance (Luttenton and Rada 1986), and paleolimnological conditions (Christie and Smol 1993). Diatoms are good bio-indicators because the silicified frustules are taxonomically distinct and easily preserved and variations in community composition track environmental conditions (Christie and Smol 1993). Epiphytes are ideal indicators of nutrient loading because they quickly respond via changes in their community structure. Experiments have shown that the epiphytic assemblage of *Zostera marina* L. changed following nutrient addition both in the laboratory (Coleman and Burkholder 1994) and *in situ* (Coleman and Burkholder 1995), making these epiphytes good indicators of eutrophication.

Epiphytic diatoms are also important components of estuarine communities because of their significant role in the food web. The primary production of algal epiphytes has been estimated at times to be greater than that of the substrate providing seagrasses (Morgan and Kitting 1984; Kitting *et* al 1984; Mazzella and Alberte 1986). Epiphytic diatoms also have high nutritional value and likely lack the phenolic compounds found in seagrasses that inhibit herbivory (Zimmerman *et al* 1979; Harrison 1982). Studies have shown epifaunal grazers derive more nutrition from algal epiphytes than seagrasses (Kitting *et al* 1984; Harrison 1982; Howard 1982). These properties make epiphytes important determinates in epifaunal abundances and assemblages (Hall and Bell 1988; Nelson 1997).

Like estuaries, the rocky intertidal is a dynamic and productive system, yet epiphytic communities have been less well studied. Macroalgae are the dominate vegetation of the intertidal zone, and they provide substrate for epiphytic colonizers.

Despite their importance, algal epiphytes in rocky bottom systems have been the subject of few ecological investigations. Belegratis *et al* (1999) examined the epiphytic community of *Cystoseira* species and Christie *et al* (1998) assessed epiphyte recolonization following kelp harvest. However, both these studies focused on macro-epiphytes. Additionally, epifaunal abundance on marine macroalgae has been linked to epiphytic biomass (Hagerman 1966; Gunnill 1982; Johnson and Scheibling 1987). Yet, to date no studies have attempted to quantify and describe the microepiphytic community of intertidal macroalgae.

Given the use of epiphytic diatoms in assessing environmental factors (i.e., water quality, habitat fidelity, disturbance) and their importance in energy cycling (O'Quinn and Sullivan 1983), it is important to establish a community baseline in the rocky intertidal. This study identified and catalogued the epiphytic diatom community on the macroalga *Mastocarpus papillatus* (C. Agardh) Kützing throughout a growing season. These data may be useful in assessing recovery from disturbance events such as trampling, harvesting, or oil spills. Furthermore, this work provides a first crucial step in using these organisms as a nutrient indicator in open coastal areas.

Materials and Methods

Diatom communities were analyzed from dried samples of *Mastocarpus papillatus* (Rhodophyta) archived from a harvest study. Three monthly replicates were analyzed beginning in May 2002 and continuing through September 2002. All samples were collected from Lone Ranch Creek (42°05.98'N, 124°20.91'W, Fig. 19) in Samuel H. Boardman State Park, Oregon, USA from the same cove and tidal level. Collected *M. pappillatus* were briefly rinsed in freshwater to remove all macrofauna and then dried in an oven set at 60°C for 14 days.

Initial comparisons of epiphyte abundance between rinsed samples (dipped in freshwater) and unrinsed samples were made. Aliquots from these samples were counted using a hemocytometer. Comparisons were analyzed by a student's T-test. No significant difference was found in epiphytic abundance between rinsed and unrinsed

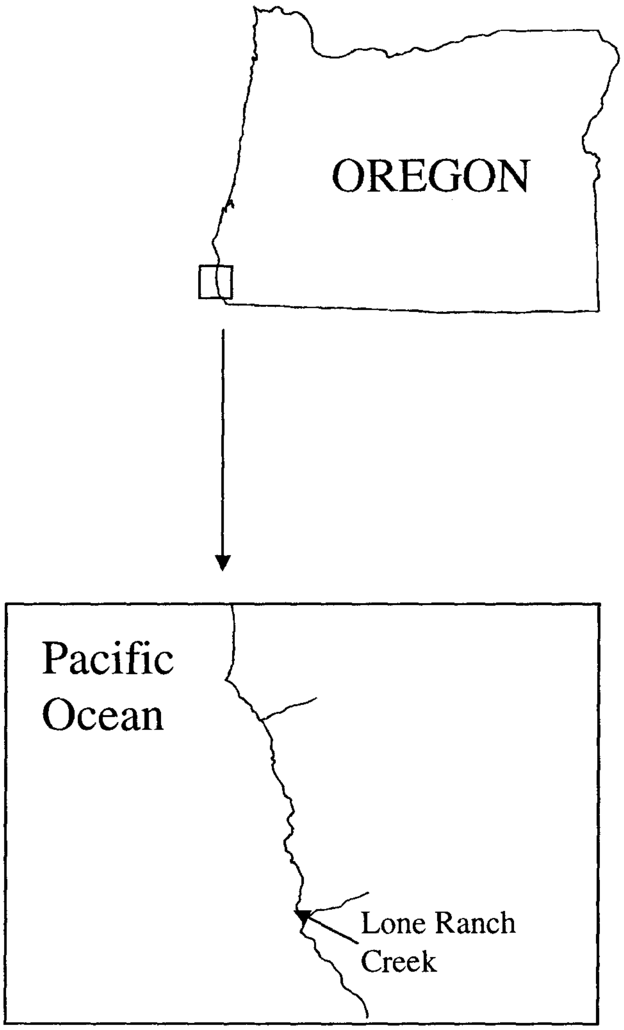


Figure 19: Location of Lone Ranch Creek. All samples of *Mastocarpus papillatus* were collected at this site.

samples ($t = 3.18$, $p < 0.468$). Rinsing *Mastocarpus* in freshwater had no effect on epiphytic abundance.

Dry weight of *Mastocarpus papillatus* was correlated with surface area so surface area estimations could be made from archived samples. Samples for analysis were collected on 6th July, 2003. I assumed that this correlation would not differ between months and years. Surface area was measured using the program OPTIMUS (Optimus Corporation) and correlated with known sample weights. Measured surface area was doubled to account for both sides of the frond. Surface area was natural log transformed and correlated with dry weight. There was a strong correlation between the natural log of surface area and the dry weight of *Mastocarpus* ($r^2=0.881$, $n=108$, $p< 0.0001$, Fig. 20). Algal dry weight is a good predictor of surface area.

The bumpy surface of *Mastocarpus* was not scraped to remove algae. Rather, three 0.5g replicate samples of *Mastocarpus* from each month were chemically digested by submergence in concentrated $KMnO_4$ for 14hrs. Equal portions of 18M HCl was added to the solution and gently warmed at 75°C in a sand bath for 4hrs. Samples were washed six times by centrifuging at 15,000 rpms for 20 minutes or until the solution pH was neutral and diluted with distilled water to 40mL. One milliliter aliquots from each replicate were analyzed. Ten slides with 100μL each per sample were mounted in NAPHRAX. Transects were counted across the cover slip of each slide. Fifty valves were identified and counted per slide so that each replicate was rarefied to 500 individuals. Diatoms were identified according to Hustedt (1962), Hendey (1964), Ricard (1987), Round (1990), and Hartley *et al* (1996). The area of transects and the

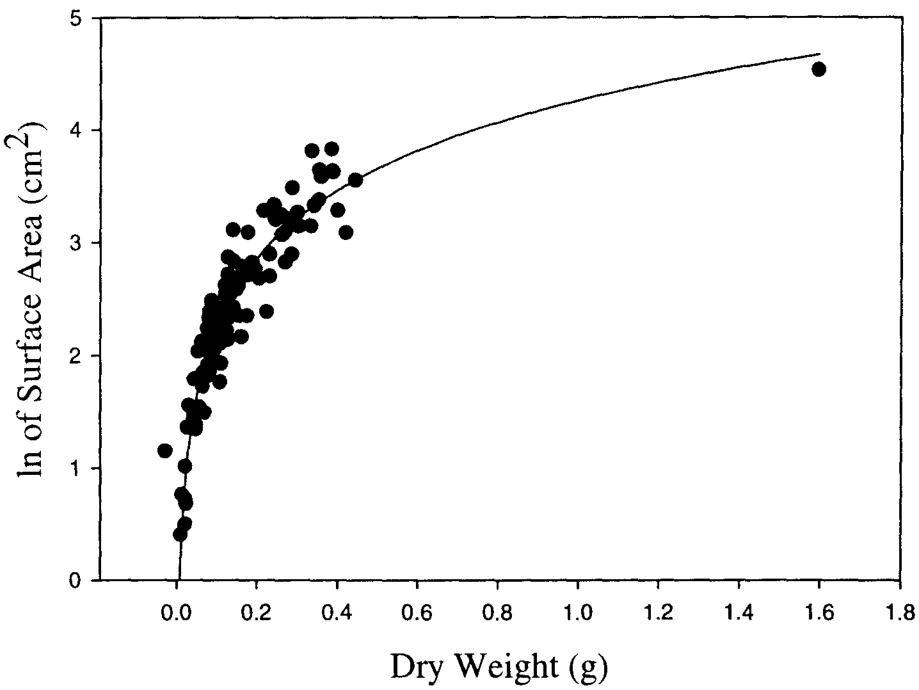


Figure 20: Correlation between the ln of Surface Area and the Dry Weight of *Mastocarpus papillatus* (r= 0.881, n=108, p<0.0001).

volume on each slide was used to calculate diatom abundance per mm^2 on the host alga. The total number of all araphid and centric species were divided by two and either the p or r-valve was counted for raphid species to avoid over estimation.

Changes in epiphytic abundance were analyzed with a one-way ANOVA with different months or days as treatments. A Bonferroni *post-hoc* test was performed on all significant results. A non-parametric Kruskal-Wallis test was used if the assumptions necessary for an ANOVA were violated.

Mastocarpus blades were sampled intensely between 15 July, and 18 July, 2003. Three replicates were collected each day for analysis. All samples were collected from the site described above and treated in the same manner. Analysis was the same as described above. This was done to ensure that any patterns seen over a monthly scale were not just an artifact of the day samples were collected.

Changes in epiphytic diversity were measured with the Shannon-Weiner index.

$$H = -\sum_{i=1}^{i} (Pi * \ln Pi)$$

where Pi represents the proportion of the i^{th} species in the sample. Differences in epiphytic diversity were measured using an ANOVA with month or day as the treatment factor. Changes in epiphytic communities were measured by creating a similarity index using the Bray-Curtis coefficient where y_{ij} represents the ith row (species) and jth column (species abundance) in the generated data matrix (Clarke and Warwick 2001). Non-

$$S_{jk} = 100\left\{1 - \frac{\sum_{i=1}^{p}\left|y_{ij} - y_{ik}\right|}{\sum_{i=1}^{p}\left(y_{ij} + y_{ik}\right)}\right\}$$

metric Multi Dimensional Scaling (MDS) plots and cluster diagrams were made from 4th root transformed similarity matrices. One-way ANOSIMs were used to test for differences in epiphytic communities across different months and different days. All univariate analyses were performed using the statistical software package Statistica 6.0 (Statsoft). Multivariate statistics analyzed with the statistic package PRIMER E (Clarke and Gorley 2001).

Littorina keenae removed from samples collected between 15 and 18 July 2003 were analyzed for ingested diatoms. Snails were placed in $MgCl_2$ and all soft body tissue was removed and chemically digested as described above. Littorine gut contents were qualitatively sampled and mounted in NAPHRAX. Diatom valves were counted as described above and compared to the ambient epiphytic community using the same multivariate statistical methods.

Results

A total of 38 diatom taxa were identified from *Mastocarpus* fronds (Appendix B, Table 8). *Cocconeis scuttelum* was the most abundant species in all samples, however, its abundance increased over the growing season. The abundance of *C. scuttelum* (Fig. 21) was lowest in May with a mean of 232.6 (±27.8 S.E.) per rarified sample, and increased to its highest value of 380.3 (±14.3 S.E.) in July.

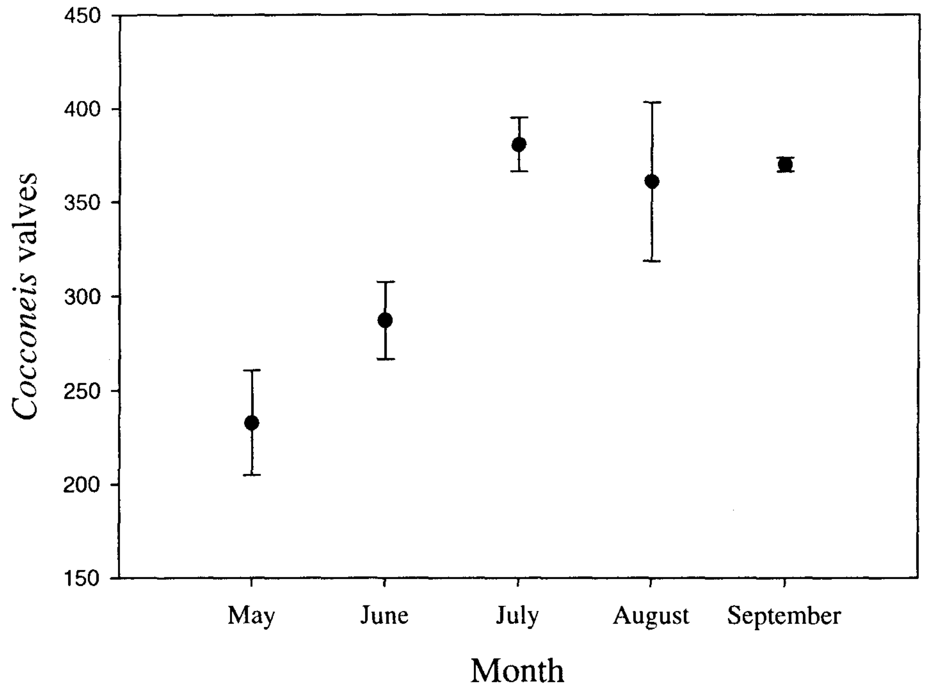


Figure 21: Mean Numbers of *Cocconeis scuttelum* Valves Counted per Sample. Error bars show one standard error from the mean.

Abundance differed significantly during the 2002 growing season (χ^2=12.32, p=0.015, Fig. 22a). Abundance was the lowest in May with 79.5 cells per mm^2 (± 20.3 S.E.) and peaked in July with 3361.2 cells per mm^2 (± 87.9 S.E.). Abundance declined slightly during August and September. Shannon-Weiner diversity (H') also differed significantly (F=9.889, p< 0.0017, Fig. 22b). Diversity peaked in May with a mean H'=1.907 ±0.14 S.E. and reached a low in July (H'=.9688 ±0.14 S.E.). Post-hoc analyses revealed significant differences between May diversity and July, August, and September diversity. The four day intensive sampling period yielded no significant differences in epiphytic abundance and diversity (F=0.433, p=0.735, Fig. 23a and F=1.35, p=0.325, Fig. 23b, respectively).

The MDS plot and cluster diagram showed that samples from both May and June grouped closely (Figs. 24a and 24b). July, August, and September samples yielded no distinct grouping in the MDS. The ANOSIM comparing epiphytic communities across months produced a global R of 0.370 (p=0.006), suggesting distinction between monthly communities. Pair-wise testing found a strong distinction between the epiphytes of May and July (R=0.889). This was further supported by the May and June replicates grouping closely and independently. The May community was also distinct from August (R=0.741). Other pair-wise tests failed to produce significant differences between communities sampled during a month. There was little distinction between communities sampled on consecutive days (R=0.275, p=0.019, Fig. 25a).

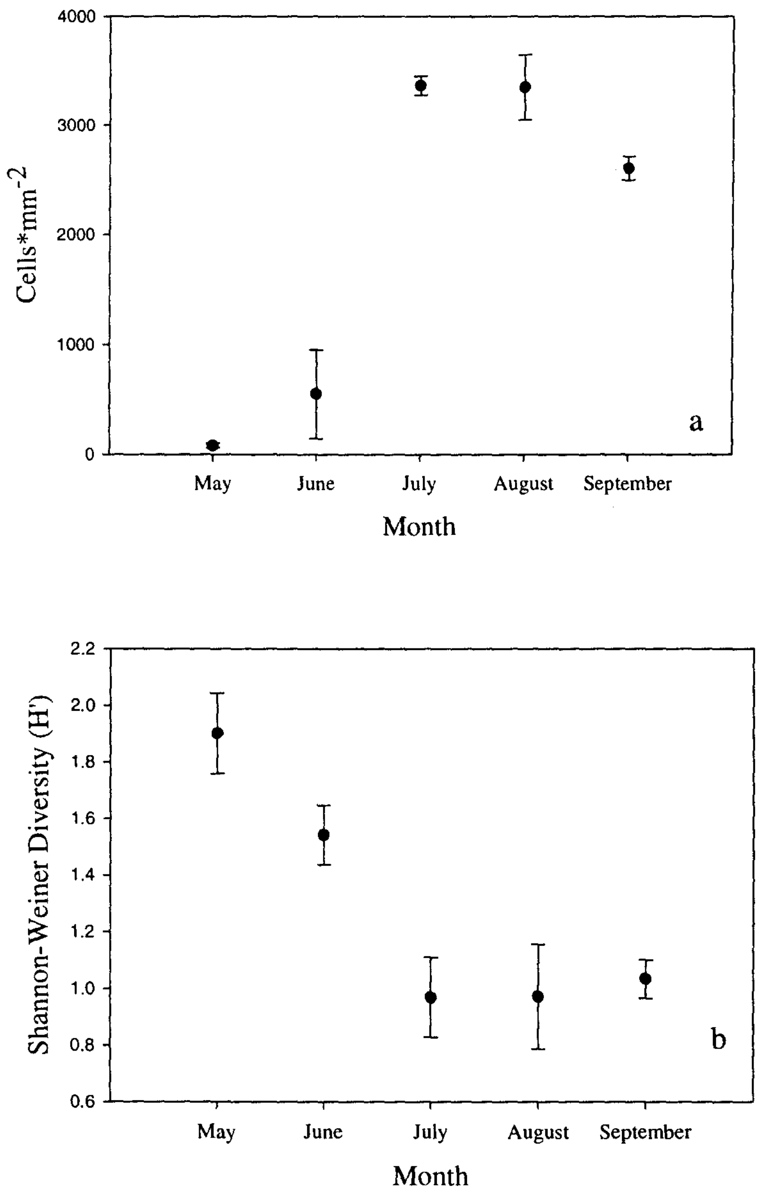


Figure 22: Epiphytic Diatom Patterns over the 2002 Growing Season. Mean epiphyte (a) abundance and (b) diversity is shown with data points. Error bars show one standard error from the mean.

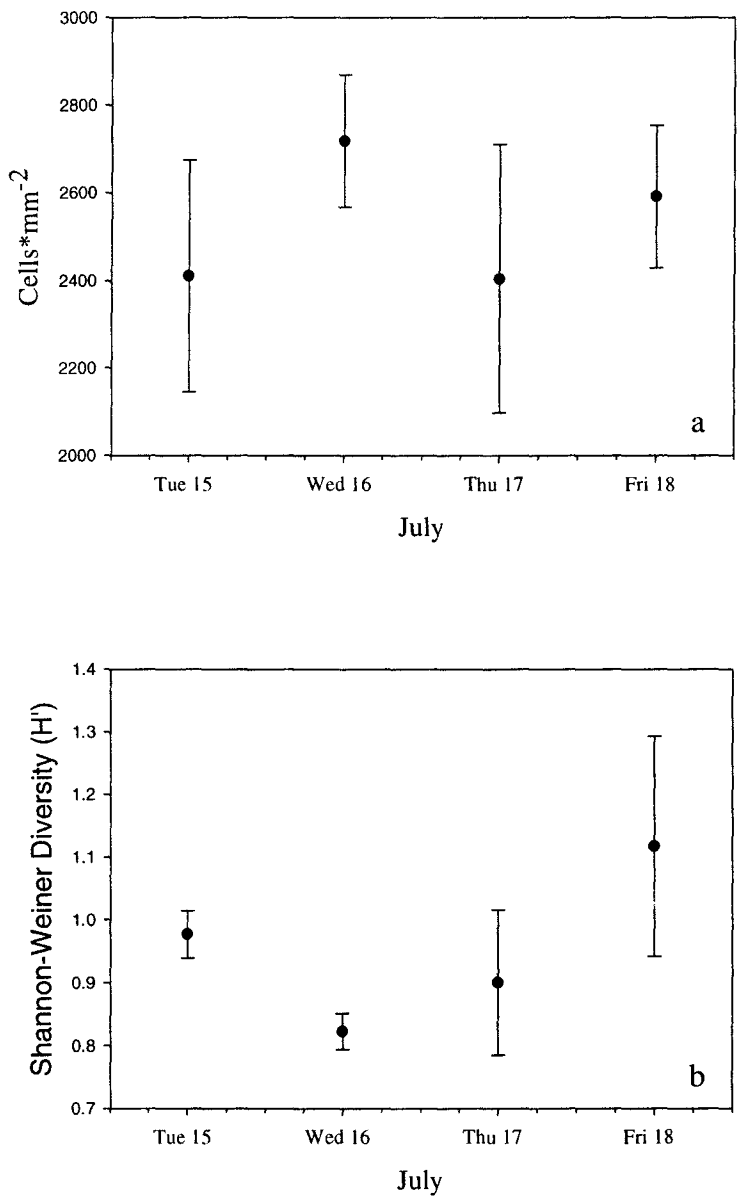
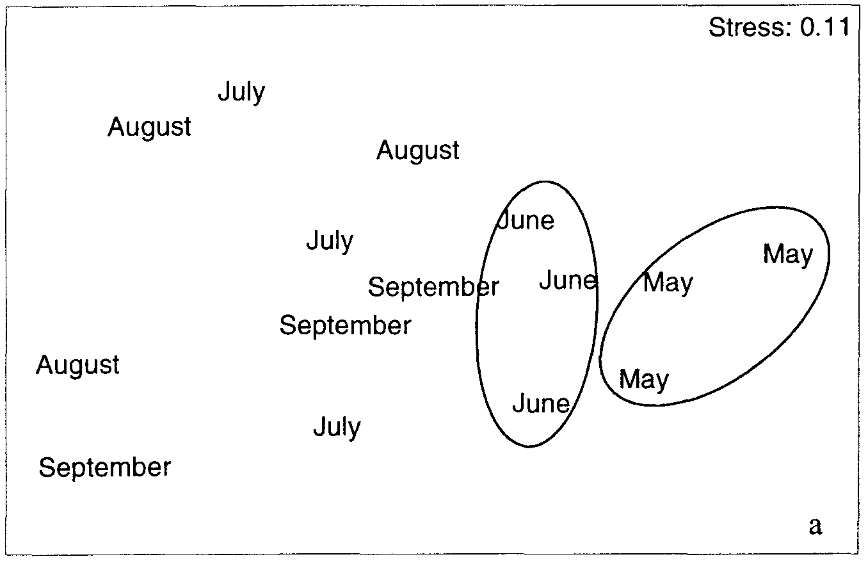


Figure 23: Epiphytic Diatom Patterns over Four Consecutive Days in 2003. Mean epiphyte (a) abundance and (b) diversity is shown with data points. Error bars show one standard error from the mean.



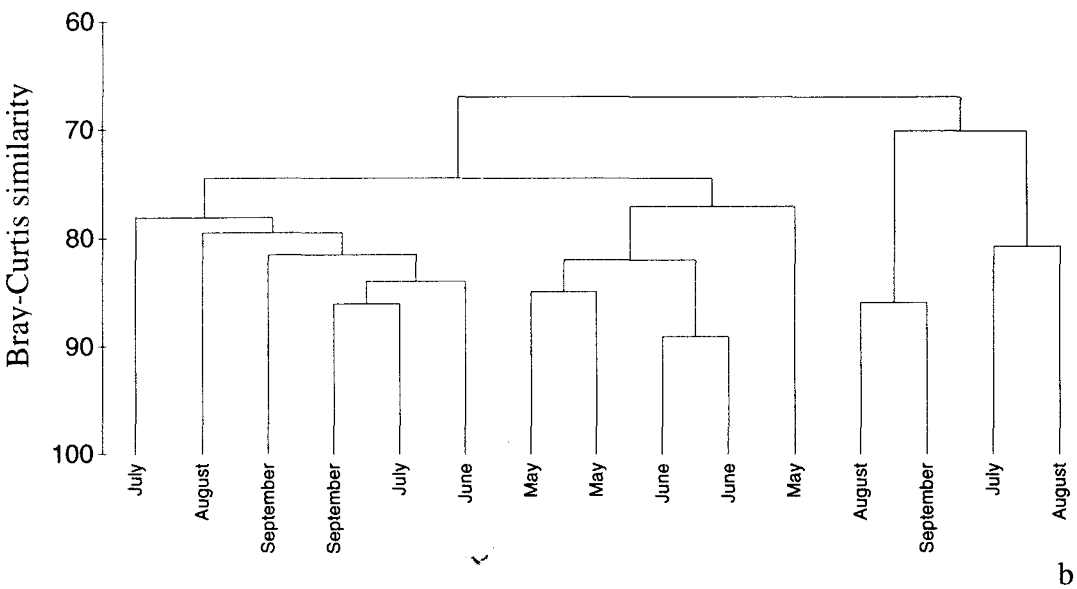


Figure 24: Epiphytic Community Patterns in 2002. Communities are shown with (a) MDS plot and (b) cluster diagram. Both figures are based on Bray-Curtis similarty matrices from 4th root transformed data.

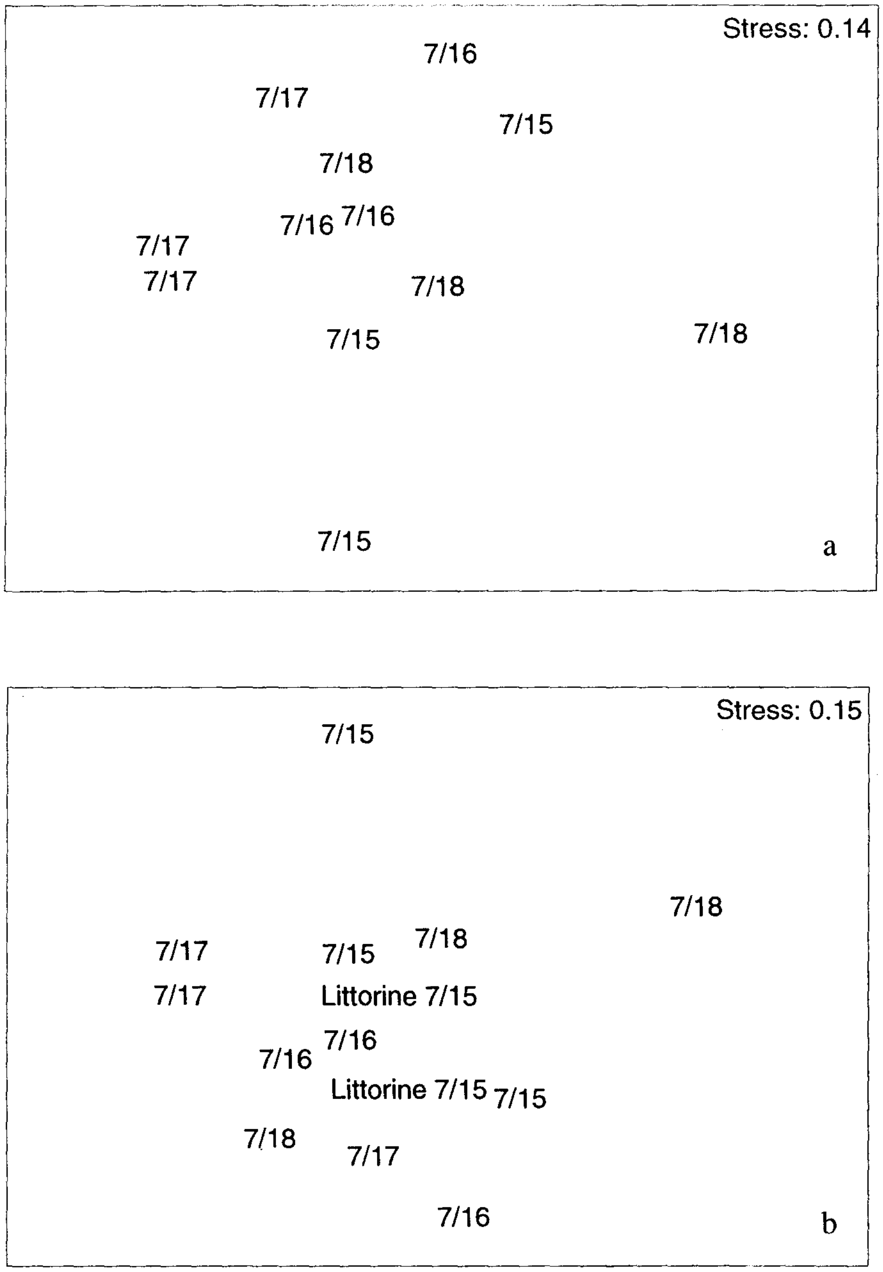


Figure 25: MDS Plots of the Epiphytic Communities from 2003. Communities are from (a) four consecutive days in 2003 and (b) with littorine gut diatom community superimposed.

The analysis of littorine gut diatoms showed no evidence of selective feeding. The gut diatom community grouped closely with the ambient epiphytic diatom community from the same sampling day (Fig. 25b).

Discussion

The epiphytic community of *Mastocarpus* changed over the growing season between May and September. The changes in *Mastocarpus* epiphytes were directional in the early portion of the season with distinct May and June communities. However, distinct monthly communities broke down beginning in July. That is, the community distinctions broke down when abundance increased and diversity decreased. The decrease in diversity was attributed to the dominance of *Cocconeis scuttelum*, which comprised nearly eighty percent of valves identified in the July, August, and September samples. This dominance would, in turn, increase the index of similarity between samples and obscure distinctions between monthly communities.

Seasonal succession has been demonstrated in planktonic diatom communities (Sancetta 1989; McQuoid and Hobson 1995; Hobson and McQuoid 1997; Tilstone *et al* 2000; Rousseau *et al* 2002). A host of biotic and abiotic factors have been attributed to drive these successional processes such as silica availability (Rousseau *et al* 2002), diatom resting stages (McQuoid and Hobson 1995), and nutrient availability (Kamykowski and Zentara 1985). These patterns have been observed in many places around the globe and can be relatively predictable. Changes in attached diatom communities have received less attention. Amspoker and McIntire (1978) reported on the distribution of intertidal diatoms in the Yaquina estuary, Oregon and found sediment size and salinity to be determinates in species composition, explaining community differences between sites. Salinity and sediment size are not responsible for the epiphytic patterns observed upon *Mastocarpus* at Lone Ranch Creek. There is minimal freshwater input so salinity is unlikely to change and the substrate was constant between samples. Epiphytic diatoms communities in the Yaquina estuary were also found to be strongly determined by desiccation as well as biotic factors such as host-epiphyte interactions (McIntire and Overton 1971). Desiccation stress should vary little between sampling dates because between the spring and fall equinox all extreme tides occur during the daylight and all samples were taken from the same tidal height. Interactions with *Mastocarpus* could possibly be an important factor structuring the epiphytic community. However, since the fronds displayed little net growth between May and September, possible interactions should not vary between sampling dates. Any possible interactions are likely minor because the quality (size, thickness, stipe strength) of *Mastocarpus* remained unchanged between May when the epiphyte load is low and September when there was high epiphytic abundance. A seasonal pattern is likely to exist in this system because the basal disc of *Mastocarpus* is perennial, but the frond is annual and, therefore, only available for colonization during the growing season.

With abiotic factors such as salinity, dessication, and substrate unlikely to be strong determinates in shaping these communities, the question remains: what forces the observed changes? Grazers have been demonstrated to be important in altering the trajectories of algal succession in freshwater streams (Steinman *et al* 1989); benthic algal biomass decreased in streams subjected to herbivory. Furthermore, herbivory was responsible for slowing the natural succession of these communities. Similar results have been reported in intertidal diatoms from the Oregon coast where littorines and limpets reduced benthic diatom biomass significantly during the summer but not in the winter (Castenholz 1961). Experimental enclosures showed that littorines were able to clear diatom films and keep areas nearly denuded of benthic microalgae (Castenholz 1961). Diatoms are known to be a principle constituent of littorine diets (Castenholz 1961; Davies and Beckwith 1999; Worm and Sommer 2000). Thus, herbivory may be a strong determinate in the observed patterns of *Mastocarpus* epiphytes. My gut content results confirmed that *Littorina keenae* does feed on benthic diatoms. The results suggested, however, that they feed indiscriminately as evidenced by the lack of distinction between the epiphytic and gut diatom communities from the same day. The patterns observed by Steinman *et al* (1989) and Castenholz (1961) differed from mine in that the abundance of the *Mastocarpus* epiphytic community increased in the presence of herbivory. Herbivore density was not measured during the sampling days so community changes cannot be attributed solely to herbivore density. Exclusion experiments where littorines and other herbivores are kept from *Mastocarpus* fronds would accurately test the hypothesis that metazoan herbivory is shaping this epiphytic community. This would not eliminate the possibility that micrograzers are exerting pressure and driving community change.

Admiraal (1977) found grazing by ciliates were responsible for the change in species composition of benthic diatoms in a Wadden Sea mudflat.

Steinman *et al* (1989) found that a species of *Cocconeis* became the most abundant benthic species following increased herbivore density. The genus *Cocconeis* is a common epiphytic species with a global distribution (Hendey 1964). De Stefano *et al* (2000) found *Cocconeis* to be the dominate epiphytic genus upon *Posidonia oceanica* (L.) Delile in the Mediterranean Sea. *Cocconeis* was also the dominate genus in North Brittany mudflats during the winter, but was less dominate during the summer (Riaux-Gobin 1991). Conversely, in this study *C. scuttelum* was common in all monthly samples of *Mastocarpus*, but reached its highest abundance in July. Therefore, it is reasonable to assume that *C. scuttelum* is a successful competitor in this system. It may be more efficient in occupying space, acquiring nutrients and light, and surviving adverse conditions. Hudon and Bourget (1983) reported on the low light tolerance of the genus *Cocconeis*, and *C. placentula* is typically considered to be a shade specific species (Tuji 2000). Dense periphyton mats have been shown to induce physiological stress on individuals deeper in the mat through nutrient attenuation (Meulemans and Roos 1985; Hudon *et al* 1987).

Stevenson *et al* (1991) hypothesized that succession in a Kentucky stream was driven by late succession species reducing available nutrients to a level where early succession species can no longer survive, and then out competing them. This may be the most likely explanation for the increase in abundance of *C. scuttelum* upon *Mastocarpus* between May and August. Nutrients are usually high in May when *C. scuttelum* is present but in lower numbers. *C. scuttelum* may reduce the nutrient pool to levels where other species can no longer persist during periods between local upwelling events. The Oregon coast experiences intermittent periods between strong north winds and calm conditions (Huyer 1976). The north winds drive upwelling, which increases the nutrient pool (Mann and Lazier 1996). These nutrients are typically depleted by phytoplankton during the downwelling that occurs between upwelling events. This intermittent nutrient input may allow *C. scuttelum* to gain a competitive advantage and dominate in the periphyton. This hypothesis, however, remains untested. Microcosm experiments with mixed species and various nutrient regimes could be performed to assess this possibility.

The forces shaping the community dynamics of *Mastocarpus* epiphytes and for the mid summer increase in *C. scuttelum* remains unclear. However, the pattern of increasing biomass and decreasing diversity is not unique to this system. Diversity often decreases with increasing latitude and altitude. Communities at intermediate latitudes are dominated by fewer species well suited to prevailing conditions. Succession generally follows a path from a low diversity of early colonizers to a stable community with high relative diversity. However, climatic variations may lead to a climax community with lower diversity (Begon *et al* 1996).

CHAPTER V

CONCLUDING SUMMARY

There were two objectives of this thesis: (1) to explore possible impacts of commercial seaweed harvest in Oregon and to recommend strategies to manage the resource, and (2) describe the epiphytic diatom community of *Mastocarpus papillatus*. Data from these experiments were needed to prevent the overexploitation of Oregon's wild algae stocks. This work provides a first step in developing a sustainable commercial seaweed harvest industry in Oregon.

The goals of the experiments from Chapter II were to compare algal recovery following harvesting during different seasons, harvesting different amounts, and different harvest methods. The data suggested that all five species should be harvested in the spring. Only *Alaria marginata* supported a second late seasonal harvest. My experiments found no measurable effect of different harvest amounts, and, with the exception of *M. papillatus*, recovery increased when the holdfast was not removed. The results from these experiments suggested that Oregon's seaweed can support a sustainable commercial harvest if managed correctly as outlined in Chapter III.

The experiments from in Chapter IV catalogued the epiphytic diatom community upon *M. papillatus* and chronicled community changes over a growing season. A distinct pattern was seen starting with relatively high epiphytic epiphyte diversity and low abundance early in the season shifting to relatively low diversity and high abundance in the mid to late summer. Similar patterns were not seen when communities were compared over four consecutive days. These patterns are were attributed to the mid season dominance of the diatom species *Cocconeis scuttelum.* Comparisons of gut contents from the dominant epiphyte grazer *Littorina keenae* to ambient epiphyte communities eliminated herbivory as one possible process controlling the dominance of *C. scuttelum. C. scuttelum* may out out-compete other epiphytes leading to its dominance in this system.

APPENDIX A

STATISTICAL TABLES FROM CHAPTER II

Table 2. Man-Whitney U Tests Comparing Mean Lengths of Harvested and Unharvested Algae in August 2002.

Alaria setchellii

Hooskanaden Creek

	n	U	p
May Harvest vs. Control	5	34.0000	0.6203
June Harvest vs. Control	5	26.0000	0.5217

South Cove

	n	U	p
June Harvest vs. Control	10	24.0000	0.000364

Laminaria setchellii

Hooskanaden Creek

	n	U	p
May Harvest vs. Control	4	0.00	0.0017
June Harvest vs. Control	4	0.00	0.0055

South Cove

	n	U	p
May Harvest vs. Control	7	25.00	0.0080
June Harvest vs. Control	22	1.00	0.0000

Table 2. *continued.*

Fucus gardneri

	n	U	p
May Harvest vs. Control	4	0.00	0.0021
June Harvest vs. Control	4	0.00	0.0018

Mastocarpus papillatus

	n	U	p
May Harvest vs. Control	5	0.00	0.0045
June Harvest vs. Control	4	0.00	0.0014

Mazzaella splendens

	n	U	p
June Harvest vs. Control	5	2.00	0.0001

Table 3. ANOVA Source Tables Comparing Biomass of Season of Harvest Plots in 2002.

Alaria marginata

Hooskanaden Creek

Source	d.f.	MS	F	p
Harvest Month	2	23076.1	0.58527	0.5910
Error	5	39428.0		

South Cove

Source	d.f.	MS	F	p
Harvest Month	1	4760	0.23717	0.646857
Error	5	20071.6		

Laminaria setchellii

Hooskanaden Creek

Source	d.f.	MS	F	p
Harvest Month	2	1263.2	23.069	0.0008
Error	7	54.757		

South Cove

Source	d.f.	MS	F	p
Harvest Month	2	9943.9	3.81364	0.076
Error	7	2607.5		

Table 3. *continued.*

Fucus gardneri

Source	d.f	MS	F	p
Harvest Month	2	663196	7.4247	0.0186
Error	7	89323		

Mastocarpus papillatus

Source	d.f.	MS	F	p
Harvest Month	2	39.817	0.22539	0.8047
Error	6	176.656		

Mazzaella splendens

Source	d.f.	MS	F	p
Harvest Month	1	34.706	0.97537	0.3687
Error	5	35.582		

Table 4. ANOVA Source Tables for Total and Germling Holdfast Density of Season of Harvest Plots in 2003.

Alaria marginata

Hooskanaden Creek

Total Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	301.026	0.438671	0.7309
Error	9	686.222		

Germling Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	210.906	0.267269	0.8474
Error	9	789.117		

South Cove

Total Holdfasts

Source	d.f	MS	F	p
Harvest Month	2	192.952	0.786457	0.4844
Error	9	245.344		

Germling Holdfasts

Source	d.f.	MS	F	p
Harvest Month	2	43.369	0.629623	0.5547
Error	9	68.881		

Table 4. *continued.*

Laminaria setchellii

Hooskanaden Creek

Total Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	24.587	0.5783	0.6424
Error	10	42.517		

Germling Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	15.1111	0.66084	0.5947
Error	10	22.8667		

South Cove

Total Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	172.91	1.7440	0.2449
Error	7	99.14		

Germling Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	51.1111	0.87548	0.4980
Error	7	58.3810		

Table 4. *continued.*

Fucus gardneri

Total Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	31.504	0.41870	0.7435
Error	10	75.242		

Germling Holdfasts

Source	d.f.	MS	F	p
Harvest Month	3	2.5159	0.29368	0.8291
Error	10	8.5667		

Mastocarpus papillatus

Source	d.f.	MS	F	p
Harvest Month	3	1498.58	2.19404	0.1766
Error	7	683.02		

Mazzaella splendens

Source	d.f.	MS	F	p
Harvest Month	2	635.35	4.7616	0.06955
Error	5	133.43		

Table 5. Factorial ANOVA Source Tables for Total and Germling Holdfast Density of Selective/Method of Harvest Plots in 2003.

Alaria marginata

Hooskanaden Creek

Total Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	13.762	0.09355	0.7660
Removal Amount	2	133.962	0.91068	0.4332
Method*Amount	2	534.115	3.63097	0.0652
Error	10	147.100		

Germling Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	0.21066	0.05191	0.8243
Removal Amount	2	2.90917	0.71694	0.5117
Method*Amount	2	20.4228	5.03299	0.0307
Error	10	4.05779		

South Cove

Total Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	26.694	0.10040	0.7573
Removal Amount	2	78.935	0.29689	0.7489
Method*Amount	2	123.432	0.46426	0.6404
Error	11	265.871		

Table 5. *continued.*

Germling Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	0.1111	0.001732	0.9676
Removal Amount	2	13.7225	0.213856	0.8107
Method*Amount	2	107.5191	1.675622	0.2316
Error	11	64.1667		

Laminaria setchellii

Hooskanaden Creek

Germling Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	12.9643	0.32752	0.5798
Removal Amount	2	24.1295	0.60959	0.5626
Method*Amount	2	10.3449	0.26134	0.7751
Error	10	39.5833		

Fucus gardneri

Total Holdfasts

Source	d.f.	MS	F	p
Removal Method	1	1.3444	0.07401	0.7917
Removal Amount	2	13.2365	0.72861	0.5090
Method*Amount	2	9.4032	0.51760	0.6127
Error	9	3.83333		

Table 5. *continued.*

Germling Holdfasts

Source	d.f	MS	F	p
Removal Method	1	5.87778	1.53333	0.2469
Removal Amount	2	3.45721	0.90188	0.4395
Method*Amount	2	9.60135	2.50470	0.1365
Error	9	3.83333		

Table 6. Kruskal-Wallis Test Results from Selective/Method of Harvest Plots of *Laminaria setchellii* at Hooskanaden Creek. Results are for total holdfast density only.

Source	d.f.	χ^2	p
Removal Method	1	0.2539683	0.6143
Removal Amount	2	7.8666667	0.0196

Table 7. ANOVA Source Tables for Plot Density of Selective/Method of Harvest Plots in 2003.

Laminaria setchellii

South Cove

Total Holdfasts

Source	d.f.	MS	F	p
Treatment	4	616.77	2.15960	0.1760
Error	7	285.60		

Germling Holdfasts

Source	d.f.	MS	F	p
Treatment	4	12.2083	0.586	0.6834
Error	7	20.8333		

Mastocarpus papillatus

Source	d.f.	MS	F	p
Treatment	4	1694.09	2.08647	0.1652
Error	9	811.94		

Mazzaella splendens

Source	d.f.	MS	F	p
Treatment	3	865.30	16.5766	0.0050
Error	5	52.20		

APPENDIX B

SUMMARY OF EPIPHYTIC DIATOM SPECIES ABUNDANCE OVER THE 2002 GROWING SEASON

Table 8. Summary of the Mean Relative Abundance of *Mastocarpus* Diatom Epiphytes Collected and Counted During the 2002 growing season. Estimations of relative abundance are indicated as follows: X = absent (0%), R = rare (<1%), C = common (1-10%), F = frequent (10-50%), and D = dominant (>50%).

	Sample Month				
Taxon	May	June	July	August	September
Achnanthes brevipes Agardh	X	X	X	X	R
Achnanthes groenlandica Cleve	R	R	R	X	R
Achnanthes spp.1	X	R	R	R	R
Amphora exigua Gregory	R	X	X	X	X
Berkeleya rutilans (Trentepohl ex Roth) Grunow	X	R	X	X	X
Berkeley spp.1	X	X	X	X	R
Cocconeis californica Grunow	F	F	F	F	F
Cocconeis clandestine A. Schmidt	R	C	R	R	R
Cocconeis costada Gregory	C	C	R	R	R
Cocconeis scuttelum Ehrenberg	F	D	D	D	D

Table 8. *continued.*

Taxon	Sample Month: May	June	July	August	September
Cocconeis speciosa Gregory	C	R	X	R	R
Cuneolus skvortzowii (Nikolaev) Medlin	R	R	R	R	R
Fragilaria striatula Lyngbye	X	R	R	R	X
Gomphoseptatum aesuarii (Cleve) Medlin	C	R	C	C	C
Licmophora spp. 1	R	R	X	X	R
Navicula directa (Wm. Smith) Ralfs in Pritchard	C	R	X	R	X
Navicula distans (Wm. Smith) Schmidt	C	C	R	R	R
Navicula spp. 1	X	X	X	R	X
Navicula spp. 2	R	R	R	R	R
Navicula spp. 3	X	R	R	R	R
Navicula spp. 4	X	R	X	X	X

Table 8. *continued.*

Taxon	Sample Month May	June	July	August	September
Navicula spp. 5	R	R	R	R	R
Navicula spp. 6	R	R	R	X	R
Navicula spp. 7	X	X	R	X	X
Nitzschia frustulum (Kutzing) Grunow in Cleve *et* Grunow	R	R	R	R	R
Opephora marina (Gregory) Petit	C	C	R	C	C
Opephora pacifica (Grunow) Petit	C	C	C	C	R
Parlibellus delognei (Van Huerck) Medlin	R	R	R	X	R
Pseudogomphonema kamtschaticum (Grunow) Medlin	C	C	R	R	R
Skeletonema costata (Greville) Cleve	R	X	X	X	X
Thalassionema nitzschioides (Grunow) Grunow ex Hustedt	C	C	C	R	R

Table 8. *continued.*

	Sample Month				
Taxon	May	June	July	August	September
Thalassiosira spp. 1	R	R	X	X	X
Thalassiosira spp. 2	R	X	X	X	X
Unknown 1	R	X	R	X	R
Unknown 2	R	X	X	X	X
Unknown 3	X	X	R	R	X

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HB 3193

2017 Regular Session

DRAFT

SUMMARY

Relating to small-scale hand ~~harvests~~ harvesting of seaweed.

Repeals Department of State Lands leasing requirements for kelp harvesting.

Requires State Department of Fish and Wildlife to adopt a permit program by rule for small-scale commercial hand ~~harvests~~ harvesting of seaweed from ocean shores and tidal submerged lands. Requires department to consult with Department of State Lands and State Parks and Recreation Department before adopting rules.

Allows State Department of Fish and Wildlife to enter into memorandum of agreement with Department of State Lands and State Parks and Recreation Department to assign sole responsibility for permitting to State Department of Fish and Wildlife when harvesting of seaweed would occur on ocean shores or over tidal submerged lands.

Requires State Department of Fish and Wildlife to deposit moneys received from permit fees into Seaweed Harvest Permit Program Account. Continuously appropriates moneys in account to department for purposes of administering permit program.

A BILL FOR AN ACT

Relating to small-scale commercial hand ~~harvests~~ harvesting of seaweed; creating new provisions; amending ORS 274.990 and 506.011; and repealing ORS 274.885, 274.890 and 274.895.

Be It Enacted by the People of the State of Oregon:

SECTION 1. ORS 274.885, 274.890 and 274.895 are repealed.

SECTION 2. ORS 274.990 is amended to read:

274.990. Violation of ORS 274.745 [*or 274.895*], or any rule promulgated under [*such sections*] **that section**, is a misdemeanor.

SECTION 3. ORS 506.011 is amended to read:

506.011. As used in the commercial fishing laws, unless the context requires otherwise:

(1) "Anadromous fish" includes but is not limited to salmon, as defined in ORS 506.016; roccus saxatilis, commonly known as striped bass; alosa sapidissima, commonly known as shad; acipenser medirostris and acipenser transmontanus, commonly known as sturgeon; and thaleichthys pacificus, commonly known as smelt.

(2) "Animals living intertidally on the bottom" includes but is not limited to starfish, sea urchins, sea cucumbers, snails, bivalves, worms, coelenterates and shore, hermit and other small crabs not included within subsection (1) or (7) of this section.

(3) "Black rockfish" means sebastes melanops, commonly known as black rockfish.

(4) "Blue rockfish" means sebastes mystinus, commonly known as blue rockfish.

(5) "Food fish" means any animal over which the State Fish and Wildlife Commission has jurisdiction pursuant to ORS 506.036.

(6) “Nearshore fish” means:

(a) Enophrys bison, commonly known as buffalo sculpin;

(b) Hemilepidotus hemilepidotus, commonly known as red Irish lord;

(c) Hemilepidotus spinosus, commonly known as brown Irish lord;

(d) Scorpaenichthys marmoratus, commonly known as cabezon;

(e) Hexagrammos decagrammus, commonly known as kelp greenling;

(f) Hexagrammos lagocephalus, commonly known as rock greenling;

(g) Hexagrammos stelleri, commonly known as whitespotted greenling;

(h) Oxylebius pictus, commonly known as painted greenling;

(i) Sebastes atrovirens, commonly known as kelp rockfish;

(j) Sebastes auriculatus, commonly known as brown rockfish;

(k) Sebastes carnatus, commonly known as gopher rockfish;

(L) Sebastes caurinus, commonly known as copper rockfish;

(m) Sebastes chrysomelas, commonly known as black and yellow rockfish;

(n) Sebastes dalli, commonly known as calico rockfish;

(o) Sebastes maliger, commonly known as quillback rockfish;

(p) Sebastes miniatus, commonly known as vermilion rockfish;

(q) Sebastes nebulosus, commonly known as china rockfish;

(r) Sebastes nigrocinctus, commonly known as tiger rockfish;

(s) Sebastes rastrelliger, commonly known as grass rockfish;

(t) Sebastes serranoides, commonly known as olive rockfish; or

(u) Sebastes serriceps, commonly known as treefish.

(7) "Ocean shore" has the meaning given that term in ORS 390.605.

(8) "Seaweed" means one or more species of multicellular marine algae belonging to the kingdom Protista that inhabit the ocean shore and tidal submerged lands.

[*(7)*] **(9)** "Shellfish" includes but is not limited to abalone, clams, crabs, crayfish or crawfish, mussels, oysters, piddocks, scallops and shrimp.

(10) "Tidal submerged lands" has the meaning given that term in ORS 274.705.

SECTION 4. Sections 5 to 7 of this 2017 Act are added to and made a part of the commercial fishing laws.

SECTION 5. (1) As used in this section:

(a) "Small-scale commercial hand ~~harvest~~ harvesting of seaweed" means the gathering or collecting of seaweed by cutting or plucking the fronds of the seaweed by hand for ~~the purpose of selling the seaweed for human consumption~~ commercial purposes.

(b) "Small-scale commercial hand ~~harvest~~ harvesting of seaweed" does not mean mechanical harvesting using a boat with cutters or other large-scale mechanized ~~cutting~~ harvest ~~process~~ methods to collect or remove seaweed from the ocean shore or tidal submerged lands.

(2) A person may not harvest or remove seaweed from the ocean shore or tidal submerged lands owned by the State of Oregon for ~~a~~ commercial ~~purpose~~ purposes unless the person has first obtained a permit from the State Department of Fish and Wildlife.

(3) The State Department of Fish and Wildlife, after consultation with the Department of State Lands and the State Parks and Recre-

ation Department, shall adopt by rule a program for granting permits for small-scale commercial hand ~~harvests~~ harvesting of seaweed ~~for the purposes of human consumption~~.

(4) Rules adopted under this section:

(a) Shall provide for a single permitting process for small-scale commercial hand ~~harvests~~ harvesting of seaweed from the ocean shore and tidal submerged lands that includes, but is not limited to:

(A) Conditions of approval for permits issued under this section;

(B) A schedule of reasonable fees for permits issued under this section;

(C) A process for an annual review of the activities authorized by the permit program; and

(D) Any ~~provision~~ provisions necessary to ensure small-scale commercial ~~harvests~~ hand harvesting of seaweed ~~are~~ is conducted in a responsible and sustainable manner. ~~that allows seaweed to continue to grow and reproduce.~~

(b) May include an exemption from the permit requirements for a person to harvest seaweed, in an amount to be determined by the State Department of Fish and Wildlife, for personal use.

(5) All moneys received by the State Department of Fish and Wildlife from permit fees imposed under this section shall be paid into the Seaweed Harvest Permit Program Account established under section 7 of this 2017 Act to administer and implement the provisions of this section.

SECTION 6. The State Department of Fish and Wildlife may enter into a memorandum of agreement with the Department of State Lands and the State Parks and Recreation Department with respect to the permit program for small-scale commercial hand ~~harvest~~ harvesting of seaweed provided for under section 5 of this 2017 Act.

The memorandum of agreement may assign sole responsibility for permitting to the State Department of Fish and Wildlife when the harvesting of seaweed would occur on ocean shores subject to the jurisdiction of the State Parks and Recreation Department or over tidal submerged lands subject to the jurisdiction of the Department of State Lands.

<u>SECTION 7.</u> (1) There is established a Seaweed Harvest Permit Program Account in the State Treasury, separate and distinct from the General Fund. Interest on moneys in the account shall be credited to the account.

(2) The account shall consist of moneys deposited into the account by the State Department of Fish and Wildlife from moneys received from the collection of permit fees provided under section 5 of this 2017 Act. The moneys in the account are continuously appropriated to the department for administering the permit program established under section 5 of this 2017 Act.

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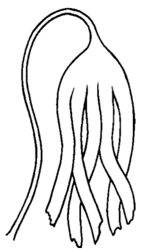

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Naturespirit Herbs is our family business, started in 1990 and located in the Siskiyou Mountains of southwestern Oregon. We are harvesters of edible and medicinal wild seaweeds, herbs, and fungi. We are also health care practitioners that understand the therapeutic uses of our products. We offer a complete line of wild sea vegetables, seaweed powders, seaweed capsules, wildcrafted herbs, herbal extracts and herbal extract formulas. We harvest everything in a respectful, ecologically sound way, and strive to provide the highest possible quality.

James Jungwirth and Kari Rein
Co-founders of Naturespirit Herbs

Seaweeds and Health

Seaweeds, also known as marine algae or sea vegetables, are a concentrated source of bioavailable minerals, electrolytes and trace elements. Because of their extremely high iodine content, seaweeds have been used for centuries in Europe and Asia to support healthy thyroid function. Seaweeds also contain large amounts of therapeutic polysaccharides (algin, fucoidan, laminarin, carrageenans, agar, porphyran etc.), vitamins, carotenoids, polyphenols, chlorophylls and antioxidants.

Modern research suggests that eating seaweeds regularly can promote healthy thyroid and immune system function, facilitate the removal of heavy metals, radioactive elements, PCB's and dioxins from our bodies, inhibit cancers and metastases, prevent strokes, and reduce chronic inflammation, high blood pressure, high blood sugar, high cholesterol levels and atherosclerosis. In fact, the Japanese people’s remarkable longevity and extremely low incidence of thyroid disease, cardiovascular disease and many cancers may partly be due to the fact that they have the world’s highest per capita seaweed consumption.

How much is good to eat? Three to six grams of dried seaweed per day is a good average amount for nutritional or therapeutic purposes. That’s about 2.5 to 5 pounds of seaweed per person per year. Additional seaweed, health and thyroid information can be found at our website.

About our Sea Vegetables and Seaweed Powders

Our sea vegetables and seaweed powders are nutrient-dense wild foods, harvested from the wild and rugged Northern California coast. The ideal growing conditions here support some of the most luxuriously abundant seaweed beds in the world.

We are ecologically responsible harvesters. Each plant is trimmed by hand, in a way that allows it to continue to grow and reproduce. A maximum of 25% of any one species is harvested from an area per year. We return to the same beautiful seaweed "gardens" year after year, and have never observed negative impacts from our harvesting.

After harvesting, we rapidly air-dry our seaweeds at low temperatures, which preserves maximum flavor, nutrition and bioactivity. This is the key to excellent quality; you will not find higher quality seaweed products anywhere, at any price. We package them in clear food grade poly bags with colorful labels that include cooking instructions and recipes.

Sea vegetables will retain their quality for 2-3 years if kept dry and away from light and heat. Although we strive to produce perfectly clean sea vegetables, please inspect for small crustaceans or shellfish before eating. Seaweed powders may also contain trace amounts of crustaceans or shellfish.

Sea Vegetables and Seaweed Powders

	1 oz.	1/2 lb.	Bulk
Kelp Fronds *(Nereocystis luetkeana)*	**$7.60**	**$39.00**	**$74.00/lb.**

These delicate, crispy Bull Kelp fronds are ready to eat as a salty snack. They can also be crumbled and sprinkled on salads, cooked vegetables, rice, popcorn etc. Of all the seaweeds, Kelp Fronds have the highest content of minerals and electrolytes (especially potassium and magnesium). They are also a very good source of iodine and therapeutic polysaccharides (algin, fucoidan and laminarin). Kelp Fronds will quickly "ground" the energy of a child that has eaten too much sugar! Bull Kelp is a Brown seaweed.

Nori *(Porphyra spp.)* **$7.40** **$37.00** **$70.00/lb.**

Nori has a deep, rich seafood taste, and makes a delicious snack as is or toasted until crisp. Toasted and crumbled Nori adds lots of flavor to breads, soups and sauces, and makes a savory sprinkle on salads, cooked vegetables, rice or popcorn. This is whole leaf Nori; it has not been processed into sheets for making sushi. Nori is a Red seaweed, and is a great source of protein, carotenes, vitamins, and porphyran, a therapeutic polysaccharide.

Sea Palm *(Postelsia palmaeformis)* **$6.80** **$32.00** **$60.00/lb.**

Sea Palm fronds are slender, crispy, and ready to eat as a jerky-like snack. Kids love to nibble on Sea Palm, and it "grounds" their energy if they have had too much sugar. Cooked Sea Palm is remarkably noodle-like in texture, and is excellent in pasta dishes, stir-fries and salads. It cooks tender in about 30 minutes. Sea Palm is a Brown seaweed, and is a good source of minerals and therapeutic polysaccharides (algin, fucoidan and laminarin).

Wakame *(Alaria marginata)* **$6.60** **$31.00** **$58.00/lb.**

Wakame has a very mild flavor, and is our favorite sea vegetable for cooking with rice or vegetable dishes. It is also very good when simmered until tender (about 30 minutes... save the broth!) and used in pasta dishes, salads and marinades. Wakame is a Brown seaweed, and is a great source of calcium, potassium and therapeutic polysaccharides (algin, fucoidan and laminarin).

Kombu *(Laminaria setchellii)* **$6.40** **$29.00** **$54.00/lb.**

(See Kombu Powder below for nutritional and thyroid information.) Kombu is a hearty sea vegetable that adds lots of flavor and body to soups, broths and bean dishes. It takes 60 to 90 minutes to cook tender. Kombu is a Brown seaweed. Not recommended for people with overactive thyroid conditions.

Sea Vegetable Powder *(A mix of Kombu and Wakame)* **$6.60** **$31.00** **$58.00/lb.**

Once you try this you'll never go back to commercial kelp powders! Our Sea Vegetable Powder has a clean, fresh taste. Ready to use as a flavorful, salty seasoning on cooked vegetables, rice or popcorn, as an ingredient in breads and smoothies, for thickening soups and sauces, or simply mixed into a cup of water or juice. Sea Vegetable Powder is a good source of iodine, calcium, potassium and therapeutic polysaccharides (algin, fucoidan and laminarin). One level teaspoonful weighs about three grams.

Six Mix Seaweed Powder *(Six different seaweed species)* **$8.20** **$43.00** **$82.00/lb.**

This is the same mix we use in our Sea Vegetable Blend Capsules (see page 3). It contains four Brown seaweed species and two Red seaweed species, providing a broad-spectrum nutritional and therapeutic supplement. Six Mix Seaweed Powder has a mild flavor, and may be sprinkled on food, added to smoothies or simply mixed into a cup of water or juice. Contains Kombu *(Laminaria setchellii)*, Wakame *(Alaria marginata)*, Kelp Fronds *(Nereocystis luetkeana)*, Sea Fern *(Cystoseira osmundacea)*, Gigartina *(Gigartina papillata)* and Iridea *(Iridea cordata)*. One level teaspoonful weighs about three grams.

Bladderwrack Powder *(Fucus gardneri)* **N/A** **$31.00** **$58.00/lb.**

Bladderwrack is a Brown seaweed that has been used for centuries in Europe to support healthy thyroid function (also see Bladderwrack Capsules on page 3 and Thyroid Support Formula on page 6). It is a very good source of iodine and therapeutic polysaccharides (algin, fucoidan and laminarin). Bladderwrack powder has a strong flavor, and may be sprinkled on food, added to smoothies, or simply mixed into a cup of water or juice. Best if kept in a freezer for long term storage. Not recommended for pregnant women or people with overactive thyroid conditions. One level teaspoonful weighs about three grams.

Kombu Powder *(Laminaria setchellii)* **N/A** **$29.00** **$54.00/lb.**

Kombu is a Brown seaweed that is exceptionally high in iodine and therapeutic polysaccharides (algin, fucoidan and laminarin). It has been used for millennia in China and many other Asian countries to support healthy thyroid function (also see Kombu Capsules on page 3 and Thyroid Support Formula on page 6). Our Kombu Powder has a mild flavor, and may be sprinkled on food, added to smoothies or simply mixed into a cup of water or juice. Not recommended for people with overactive thyroid conditions. One level teaspoonful weighs about three grams.

Gigartina Powder *(Gigartina papillata)* **N/A** **$49.00** **$94.00/lb.**

Gigartina is a Red seaweed that contains large amounts of carrageenans (antiviral and herpes-suppressing polysaccharides). Gigartina is also known for its tonic effect on the lungs, digestive tract and immune system (also see Red Marine Algae Capsules on page 3). Our Gigartina Powder has a pleasant flavor, and may be sprinkled on food, added to smoothies or simply mixed into a cup of water or juice. One level teaspoonful weighs about three grams.

About our Seaweed Capsules

Our vegetarian capsules contain pure food grade quality seaweeds; no fillers or additives are used. Each bottle contains 60 grams of dried seaweed (compare this with other brands).

We hand harvest our seaweeds from the wild and rugged Northern California coast, and rapidly air-dry them at low temperatures, which preserves maximum flavor, nutrition and bioactivity. This is the key to excellent quality; you will not find higher quality encapsulated seaweeds anywhere, at any price. We invite you to compare the clean fresh taste of the seaweeds in our capsules with other companies' products!

Seaweeds are a natural product of the ocean, and may contain trace amounts of crustaceans or shellfish.

Seaweed Capsules
(10% discount on orders of 5 bottles or more)

Sea Vegetable Blend *(Six different seaweed species)*
(600 mg. per capsule, 100 capsules per bottle) $26.00 per bottle
Our Sea Vegetable Blend capsules contain a mix of four Brown seaweed species and two Red seaweed species, providing a broad spectrum of nutritional and therapeutic benefits. Contains Kombu *(Laminaria setchellii)*, Wakame *(Alaria marginata)*, Kelp Fronds *(Nereocystis luetkeana)*, Sea Fern *(Cystoseira osmundacea)*, Gigartina *(Gigartina papillata)* and Iridea *(Iridea cordata)*. **Suggested use:** one to three capsules three times daily, with meals.

Bladderwrack *(Fucus gardneri)*
(600 mg. per capsule, 100 capsules per bottle) $23.00 per bottle
Bladderwrack is a Brown seaweed that has been used for centuries in Europe to support healthy thyroid function (also see Thyroid Support Formula on page 6). Avoiding chronic stress, all wheat and soy products, excess sugar and carbs, chlorinated water, and fluoride toothpaste may also help. Bladderwrack is a very good source of iodine and therapeutic polysaccharides (algin, fucoidan and laminarin). Not recommended for pregnant women or people with overactive thyroid conditions. If the recommended dosage causes gas or loose stools, start with less. If possible, keep unopened bottles in a freezer to preserve maximum potency. **Suggested use:** one to three capsules three times daily, with meals.

Kombu *(Laminaria setchellii)*
(600 mg. per capsule, 100 capsules per bottle) $23.00 per bottle
Kombu is a Brown seaweed that is exceptionally high in iodine and therapeutic polysaccharides (algin, fucoidan and laminarin). It has been used for millennia in China and many other Asian countries to support healthy thyroid function (also see Thyroid Support Formula on page 6). Avoiding chronic stress, all wheat and soy products, excess sugar and carbs, chlorinated water, and fluoride toothpaste may also help. Not recommended for people with overactive thyroid conditions. **Suggested use:** one to three capsules three times daily, with meals.

Red Marine Algae *(Gigartina papillata)*
(600 mg. per capsule, 100 capsules per bottle) $26.00 per bottle
Gigartina is a Red marine algae (seaweed) that contains large amounts of carrageenans (antiviral and herpes-suppressing polysaccharides). Gigartina is also known for its tonic effect on the lungs, digestive tract and immune system. **Suggested use:** one to three capsules three times daily, with meals.

About our Herbs and Herbal Extracts

Bulk Wildcrafted Herbs

See our Wildcrafted Herbs Pricelist at our website (or ask us to mail you a copy). We harvest a wide variety of medicinal wild plants and fungi. Each herb is harvested during its optimal stage of development, in a way that causes minimal impact on future plant populations. However, we do not usually keep herbs in stock; we harvest them for people that order them. That way you always get fresh herbs, and valuable herbs never end up getting old in storage and going to waste.

Herbal Extracts and Formulas

Most of our herbal extracts and formulas are made with herbs that we have ethically harvested from healthy wild environments. Some are organically grown. A few high quality imported herbs (organic, unsprayed, non-irradiated etc.) are also used. Fresh herbs are chopped, macerated in one to two parts of certified organic 95% grain alcohol, then pressed and filtered. This produces a (1:1), (1:1.5) or (1:2) ratio of herb to alcohol. Dried herbs are powdered and macerated in four or five parts of a mix of organic grain alcohol and water (different herbs require different alcohol percentages for optimum extraction).

Herbal Extract Price Codes

Price Code	4 oz.	8 oz.	16 oz.	32 oz.
A	**$34.00**	**64.60**	**122.40**	**231.20**
B	**$38.00**	**72.20**	**136.80**	**258.40**
C	**$42.00**	**79.80**	**151.20**	**285.60**
D	**$50.00**	**95.00**	**180.00**	**340.00**

Herb Source and Use Codes

WC = Wildcrafted

OG = Organically Grown

US = Unsprayed

◊ = Not recommended for use during pregnancy

Δ = For external use only

⊕ = For health care professionals only

Single Herb Extracts

(This is a partial list of what we have in stock - the full list can be found at our website)

HERBAL EXTRACT	*PRICE CODE*
Anemone ⊕ ◊ *(Anemone occidentalis)* Fr Herb (1:1.5) WC	D
Balsam Poplar *(Populus balsamifera)* Dr Buds (1:5) WC	C
Balsamroot *(Balsamorhiza sagittata)* Fr Root (1:1.5) WC	B
Baneberry ◊ *(Actea rubra)* Fresh Root (1:1.5) WC	B
Bayberry *(Myrica californica)* Dried Root Bark (1:5) WC	C
Betony *(Pedicularis densiflora)* Fresh Herb (1:1) WC	B
Bladderwrack ◊ *(Fucus gardneri)* Fr Whl Plant (1:1) WC	B
Bleeding Heart ◊ *(Dicentra formosa)* Fresh Root (1:1) WC	C
Bugleweed *(Lycopus virginicus)* Fresh Herb (1:1.5) OG	A
Calamus ◊ *(Acorus calamus)* Fresh Root (1:1.5) OG	B
California Poppy ◊ *(Eschscholzia californica)* Fresh Whole Plant (1:1.5) WC	B
Cedar, Western Red ◊ *(Thuja plicata)* Fr Leaf (1:2) WC	A
Cilantro *(Coriandrum sativum)* Fresh Herb (1:1) OG	A
Coral Root ◊ *(Corallorhiza maculata)* Fresh Root (1:1.5) WC	D
Dandelion *(Taraxacum officinale)* Fresh Root (1:1) WC	A
Devil's Club ◊ *(Oplopanax horridum)* Fr Rt Brk (1:1.2) WC	C
Echinacea *(Echinacea purpurea)* Fr Rt, Flower & Seed (1:1.5) OG	B
Elderberry *(Sambucus caerulea)* Fresh Berry (1.4:1) WC	C
Feverfew *(Tanacetum parthenium)* Fresh Herb (1:1.5) OG	A
Figwort *(Scrophularia californica)* Fresh Herb (1:1) WC	B
Gigartina *(Gigartina papillata)* Fr Whole Plant (1:1) WC	C
Hawthorn *(Crataegus douglasii)* Fr Flwrng Tips (1:2) WC	C
Horsetail *(Equisetum telemateia)* Fresh Herb (1:1) WC	A
Indian Pipe ◊ *(Monotropa uniflora)* Fr Whl Plant (1:2) WC	D
Indian Warrior – see Betony	
Japanese Knotweed *(Polygonum cuspidatum)* Fresh Root (1:1.5) WC	B
Lomatium ◊ *(Lomatium dissectum)* Fresh Root (1:1.5) WC	C
Motherwort ◊ *(Leonurus cardiaca)* Fresh Herb (1:1.5) OG	A
Nettle Root *(Urtica dioica)* Fresh Root (1:1.5) WC	B
Nettle Seed *(Urtica dioica)* Fresh Seed (1:1) WC	C
Oat Seed *(Avena sativa)* Fresh Milky Seed (1:1.5) OG	A
Oregon Grape *(Mahonia aquifolium)* Fr Root (1:1.5) WC	B
Red Root *(Ceanothus cuneatus)* Dried Root (1:4) WC	C
Silk Tassel ◊ *(Garrya fremontii)* Dr Leafy Tips (1:4) WC	B
Skullcap *(Scutellaria lateriflora)* Fresh Herb (1:1) OG	A
Spikenard Berry *(Aralia californica)* Fr Berry (2:1) WC	D
Spikenard Root *(Aralia californica)* Fresh Root (1:1) WC	B
St. John's Wort *(Hypericum perforatum)* Fr Flowering Tips (1:1.5) WC	B
Stone Root *(Collinsonia canadensis)* Fresh Root (1:1) OG	B
Sweet Root *(Osmorhiza occidentalis)* Fresh Root (1:2) WC	C
Trillium *(Trillium ovatum)* Fresh Whole Plant (1:1.5) WC	D
Usnea ◊ *(Usnea spp.)* Dried Lichen (1:5) WC	B
Valerian, Sitka *(Valeriana sitchensis)* Fr Root (1:1.5) WC	C
Wild Indigo ◊ *(Baptisia australis)* Fresh Root (1:1) OG	A
Wild Lettuce *(Lactuca serriola)* Fresh Herb (1:1) WC	B
Yarrow *(Achillea millefolium)* Fresh Flower (1:1.5) WC	A
Yellow Pond Lily *(Nuphar polysepalum)* Fr Rt (1:1.5) WC	B
Yerba Mansa *(Anemopsis californica)* Fresh Root (1:1) OG	B
Yerba Santa *(Eriodictyon californicum)* Fr Lf (1:1.5) WC	A
Yew ◊ *(Taxus brevifolia)* Fresh Leafy Tips (1:1.5) WC	C

Herbal Extract Formulas

All herbal extract formulas are price code "C"

(See price codes and herb source/use codes on page 4)

Adaptogen Blend ◊ Adaptogenic herbs are the ultimate tonics: metabolic regulators that promote health and well-being and help keep the brain and body from going into stress mode. Best with long term use (also see Adrena-Tone Formula). *Ingredients:* Extracts of Eleuthero, American Ginseng, Devils Club, Rhodiola, Ashwagandha, Schisandra, Gotu Kola, Reishi, Holy Basil, Spikenard Root and Spikenard Berry. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Adrena-Tone ◊ Supports healthy adrenal gland function when experiencing prolonged stress and nervous exhaustion or adrenal fatigue. Best with long term use, some kind of relaxation practice, more sleep, B-vitamins, increased dietary fats, oils and proteins, and reduced sugars and starches (also see Liver Deficiency Tonic and Thyroid Support Formula). *Ingredients:* Extracts of Eleuthero, Licorice, Ashwagandha, Rhodiola, Schisandra, Skullcap, Oat Seed, Anemone, American Ginseng and Lobelia. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Brain Tonic ◊ This formula contains herbs for stimulating circulation, increasing oxygen supply to the brain and improving mental clarity, especially for older folks with poor memory function and general debility. Best with long term use and daily aerobic exercise. *Ingredients:* Extracts of Ginkgo, Gotu Kola, Rhodiola, Schisandra, Calamus, American Ginseng, Ashwagandha, Prickly Ash, Cereus, Bayberry, Rosemary and Oregano. *Suggested use:* 30 to 60 drops (1-2 squirts) in a little water up to 4X daily.

Breathe Deep ◊ A combination of decongestant, broncho-dilating, antispasmodic and anti-inflammatory herbs. Used to promote easier breathing for people with chronic lung conditions. *Ingredients:* Extracts of Khella, Lobelia, Yerba Santa, Horehound, Passionflower Root, Cereus, Iknish, Elecampane, Hawthorn, Ginkgo, Feverfew and Myrrh. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Cand-Aid ◊ Used internally to prevent or reduce an overgrowth of candida or other yeasts. For best results use long term, avoid sugars and starches, eat more fats, oils and proteins, and use lots of yogurt, sauerkraut or probiotics (also see Lymph-Immune Tonic). *Ingredients:* Extracts of Pao D'arco, Spilanthes, Usnea, Myrrh, Oregano, Quassia, Sweet Root, Chaparro, Echinacea and Red Cedar. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Colon Tonic ◊ A gentle formula for improving colon tone, stimulating peristalsis and relieving chronic constipation. Best with daily aerobic exercise and increased intake of water and dietary fiber (vegetables, fruits, seaweeds, flax, psyllium etc.) *Ingredients:* Extracts of Cascara Sagrada, Turkey Rhubarb, Licorice, Yellow Dock, Cayenne, Prickly Ash, Blue Flag, Goldenseal, Ginger, Lobelia and Bayberry. NOTICE: This product contains Cascara Sagrada and Turkey Rhubarb. Read and follow directions carefully. Do not use if you have or develop diarrhea, loose stools, or abdominal pain because Cascara Sagrada and Turkey Rhubarb may worsen these conditions and be harmful to your health. Consult your physician if you have frequent diarrhea or if you are pregnant, nursing, taking medication, or have a medical condition. *Suggested use:* 2-6 squirts (1/4 to 1 tsp.) in a little water up to 2X daily (mornings and evenings).

Cramp Calm ◊ A blend of herbs traditionally used to relieve painful menstrual, stomach, intestinal, gall bladder or urinary tract cramps (also see Pain Formula). *Ingredients:* Extracts of Wild Yam, Cramp Bark, Baneberry, Silk Tassel, California Poppy, Western Peony, Lobelia, Skullcap, Passionflower Root and Ginger. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Digestive Bitters – Bitters are customarily taken before eating to stimulate the appetite and digestive juices and to prevent indigestion, gas, bloating etc. Best with long term use. *Ingredients:* Extracts of Gentian, Angelica, Cardamom, Ginger, Calamus, Prickly Ash, Bayberry, Schisandra and Centaury. *Suggested use:* 15 to 30 drops in a little water 15 minutes before eating.

Female Tonic ◊ This is a reproductive tonic for women with long or irregular menstrual cycles, PMS distress and crampy, slow-onset menses. Best with long term use and regular consumption of Brown seaweeds (also see Liver Deficiency Tonic). *Ingredients:* Extracts of Dong Quai, Chaste Tree, Blue Cohosh, Cotton Root, American Ginseng, Ocotillo, Anemone, Baneberry and Oregon Grape. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Flu Season ◊ Made with herbs known for their antiviral, expectorant, immunostimulant and diaphoretic qualities. Our family and friends rely on this one during cold and flu season! *Ingredients:* Extracts of Lomatium, Iknish, Spikenard, Balsamroot, Ginger, Echinacea, Myrrh, Red Root, Oregano, Cayenne and Yerba Santa. *Suggested use:* 2 to 6 squirts (1/4 to 1 tsp.) in a little water up to 4X daily.

All herbal extract formulas are price code "C"
(See price codes and herb source/use codes on page 4)

Heart Calm ◊ Promotes healthy and regular heart function. Best with long term use (also see Adrena-Tone and Thyroid Calm Formulas). Not recommended for use by people with bradycardia (slow heartbeat). *Ingredients:* Extracts of Hawthorn, Motherwort, Cereus, Passionflower, Lily-of-the-Valley, Bugleweed, Skullcap, Oat Seed and Eleuthero. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Herbal Cough Syrup – This tasty and concentrated syrup is locally renowned. It is made with expectorant, demulcent and antispasmodic herbs that help move phlegm and promote easier breathing. *Ingredients:* Spikenard, Balsamroot, Elecampane, Wild Cherry, Iknish, Balsam Poplar, Lobelia, Yerba Santa and Yerba Mansa in a honey/alcohol base. *Suggested use:* 2 to 4 squirts or 1/4 to 1/2 teaspoon as needed.

Herbal Liniment Δ Our liniment can be applied to bruises, sprains, aching muscles and arthritic joints (also see Muscle Calm and Pain Formulas). *Ingredients:* Extracts of Arnica, Cayenne, Hyssop, Yarrow, Balsam Poplar, Wormwood, Tobacco, Bleeding Heart, Melilot, Yerba Mansa and Horse Chestnut. *Suggested use:* Apply to affected areas as needed. CAUTION: Contains Cayenne! Use with care and wash hands with soap after applying. For topical use on unbroken skin only.

Hypertens-Ease ◊ A formula for supporting healthy blood pressure levels. It is composed of cardio-tonic, diuretic, vasodilating and blood-thinning herbs. Best with long term use, regular aerobic exercise, increased consumption of Brown seaweeds, vegetables, fats, oils and proteins, and decreased consumption of sugars and starches. Not recommended for use by people with low blood pressure. *Ingredients:* Extracts of Hawthorn, Passionflower, Eleuthero, Bladderwrack, Dandelion, Red Root, Feverfew, Prickly Ash, Cayenne and Puncture Vine. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Kids Comfort – A combination of gentle, time-tested herbs for babies and small children, used for fevers, coughs, belly-aches, gas, colic, constipation, teething, agitation and sleeplessness. *Ingredients:* Extracts of Catnip, Fennel, Peppermint, Chamomile, Lemon Balm and Licorice. *Suggested use:* 15 to 30 drops in a little water as needed.

Liver Deficiency Tonic ◊ A constitutional tonic for people with deficient liver function, with dry skin, allergies, unstable blood sugar, difficult digestion of fats, oils and proteins, and a tendency toward adrenaline stress and constipation. Best with long term use, increased consumption of vegetables, fats, oils and proteins, and decreased consumption of sugars and starches (also see Adrena-Tone and Digestive Bitters). *Ingredients:* Extracts of Oregon Grape, Yellow Dock, Milk Thistle, Prickly Ash, Blue Flag, Buckbean, Red Root, Ocotillo, Schisandra and Devil's Club. *Suggested use:* 30 to 60 drops (1-2 squirts) in a little water up to 4X daily.

Lymph-Immune Tonic ◊ A blend of herbs for stimulating the immune system. Chronic immune deficiency may caused by underactive thyroid function (see Thyroid Support Formula), chronic stress (see Adrena-Tone Formula), colon flora dysbiosis (use probiotics), excessive dietary sugars and starches, or protein deficiency. Best with long term use. *Ingredients:* Extracts of Echinacea, Red Root, Astragalus, Myrrh, Stillingia, Reishi, Ocotillo, Baptisia, Devil's Club, Lomatium and Blue Flag. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Meno-Peace ◊ These herbs have a long history of use in relieving the discomforts of menopause. *Ingredients:* Extracts of Dong Quai, Motherwort, Bugleweed, Licorice, Oat Seed, Anemone, Baneberry, Cereus, Blue Cohosh and Devil's Club. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Mental Alertness ◊ This formula contains herbs known for their ability to improve mental alertness, focus and clarity, without being too stimulating. We keep it handy for when we feel tired but don't want to use caffeine. (If you want caffeine, see Wake Up Formula.) *Ingredients:* Extracts of Calamus, Schisandra, Gotu Kola, Rhodiola, American Ginseng, Rosemary, Peppermint and Nettle Seed. *Suggested use:* 30 to 60 drops (2-4 squirts) in a little water up to 4X daily.

Mouth and Gum Tonic – A stimulating antiseptic mouthwash (or gargle). Tingly and refreshing! *Ingredients:* Extracts of Cinnamon, Cloves, Peppermint, Myrrh, Prickly Ash, Bloodroot, Bayberry, Spilanthes, Bistort and Stevia. *Suggested use:* 10 to 20 drops in a little water (and maybe a pinch of sea salt and baking soda) as a mouthwash or gargle, or just put a few drops on your toothbrush!

Muscle Calm – This muscle relaxant formula is used internally for painful muscle spasms and stiffness, from hard work, strains or injuries (also see Herbal Liniment and Pain Formula). It may also be used as a relaxing adjunct to massage and bodywork. *Ingredients:* Extracts of Betony, Skullcap, Western Peony, St. John's Wort, Aspen, Baneberry, Bleeding Heart and Yerba Mansa. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

All herbal extract formulas are price code "C"
(See price codes and herb source/use codes on page 4)

Pain Formula ◊ Contains herbs traditionally used for relieving pain (also see Muscle Calm Formula). *Ingredients:* Extracts of California Poppy, Skullcap, Bleeding Heart, Aspen, St. John's Wort, Melilot, Hedge Nettle, Motherwort and Baneberry. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily, or topically as needed.

Pollen Season – Formulated for people that suffer from hay fever and sinus allergies (best with long term use). It may also be used as a simple decongestant for other wheezy/watery/drippy lung or nose conditions. *Ingredients:* Extracts of Yerba Santa, Yerba Mansa, Ambrosia, Bayberry, Feverfew, Horehound, Inside-Out Flower, Red Root, Horseradish and Oregon Grape. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Pros-Tone – Used to maintain prostate health, relieve chronic prostate conditions and soothe any related urinary tract symptoms. Best with long term use, regular aerobic exercise and regular consumption of Brown seaweeds (also see Venous Tonic Formula). *Ingredients:* Extracts of Saw Palmetto, Red Cedar, Nettle Root, Dong Quai, American Ginseng, Cotton Root, Stone Root, Pygeum, Eryngo and Baneberry. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Relaxation – A combination of sedative herbs to promote relaxation and a good night's sleep. *Ingredients:* Extracts of Valerian, Skullcap, Passionflower, Catnip, Anemone, Oat Seed, Wild Lettuce, St. John's Wort, Bugleweed, California Poppy and Ashwagandha. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Thyroid Calm ◊ These are herbs for calming thyroid function when it is excessive. Best with long term use (also see Adrena-Tone and Heart Calm Formulas). *Ingredients:* Extracts of Bugleweed, Motherwort, Cereus, Oat Seed, Reishi, Skullcap, Devil's Club and American Ginseng. *Suggested use:* 60 to 120 drops (2-4 squirts) in a little water up to 4X daily.

Thyroid Support ◊ Formulated to enhance the effectiveness of our Bladderwrack and Kombu capsules (see page 3) in supporting healthy thyroid function (also see Adrena-Tone Formula). Avoiding chronic stress, all wheat and soy products, excess sugars and starches, chlorinated water, and fluoride toothpaste may also help. Best with long term use. *Ingredients:* Extracts of Ashwagandha, Gotu Kola, Guggulu, Rhodiola, Blue Flag, Anemone, Prickly Ash, Reishi, Nettle Seed, Eleuthero and American Ginseng. *Suggested use:* 60 to 90 drops (2-3 squirts) in a little water up to 4X daily.

Traveler's Insurance ◊ Composed of antimicrobial and immunostimulant herbs, this formula may be used to protect the digestive tract from vacation-ruining horrors such as traveler's diarrhea, giardia, shigellosis, dysentery, parasites etc. (also see Cramp Calm Formula). *Ingredients:* Extracts of Chaparro, Oregon Grape, Chaparro, Oregon Grape, Lomatium, Oregano, Quassia, Garlic, Usnea, Eleuthero, Astragalus, Echinacea and Myrrh. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Urinary Tract Tonic – This formula can be used to soothe and support the urinary tract and to prevent infections or chronic irritation. Drinking more water, avoiding sugars and starches, eating more vegetables, fats, oils and proteins, and using probiotics, sauerkraut or yogurt may also help. *Ingredients:* Extracts of Corn Silk, Pipsissewa, Horsetail, Marshmallow, Nettle Seed, Bidens, Eryngo, Echinacea and Myrrh. *Suggested use:* 3 to 6 squirts or 1/2 to 1 tsp. in 8 ounces of water up to 4X daily.

Venous Tonic ◊ A blend of herbs that have long been used to support venous tone and to prevent varicose veins, hemorrhoids, and other aching, congested conditions of the uterus, cervix, prostate or legs. Best with long term use (also see Liver Deficiency Tonic). *Ingredients:* Extracts of Stone Root, Witch Hazel, Horse Chestnut, Prickly Ash, Ocotillo, Red Root, Baneberry and Gotu Kola. *Suggested use:* 30 to 90 drops (1-3 squirts) in a little water up to 4X daily.

Wake Up ◊ Made with three of nature's finest caffeine herbs; causes less restlessness than coffee. Extremely convenient! We keep a bottle in our car to use if we feel drowsy (also see Mental Alertness Formula). Contains caffeine; do not use if sensitive to caffeine. Not recommended for use by pregnant or nursing women or by children under 18 years old. *Ingredients:* Extracts of Guarana, Yerba Mate and Green Tea. *Suggested use:* 1 to 3 squirts in a little water up to 4X daily.

Retail Ordering Information

Naturespirit Herbs
PO Box 150
Williams OR 97544

www.naturespiritherbs.com
info@naturespiritherbs.com
Phone (541) 846-7995

Ordering by Phone – Our business hours are Monday through Friday, 8:00 am to 5:00 pm Pacific Time.

Ordering by email – We welcome email orders. However, for security reasons, please do not email your credit card info.

Payment and Terms – We accept payment by check, credit card, money order, PayPal or bank wire. All orders must be prepaid unless other arrangements have been made. When credit is established, payment is due upon receipt of goods. There is a 2% monthly late charge on overdue accounts and a $25.00 fee for bounced checks.

Shipping and Handling – Shipping and handling is $8.00 for all retail orders shipped by Parcel Post to destinations in the continental USA. If you want your order to be shipped by Priority Mail, UPS or FedEx, or if you live outside the continental USA, you pay actual shipping cost, with an $8.00 minimum.

Prices and Availability – Are subject to change without notice.

Returns – Please contact us for a return authorization before returning anything. Our policy is to refund unopened items if they are returned within 30 days of the invoice date.

Bulk Wildcrafted Herbs – Our Wildcrafted Herbs Pricelist is available at our website (or ask us to mail you a copy).

SEAWEEDS AND HUMAN HEALTH

Seaweeds are plant-like ocean organisms that are botanically classified as macrophytic marine algae. Marine algae have been divided into three main groups, based more on their pigments and coloration than their genetics: red marine algae (Rhodophyta), brown marine algae (Phaeophyta) and green marine algae (Chlorophyta). "Kelp" is a somewhat vague term that loosely refers to the larger brown seaweed species. Edible seaweeds are often called "sea vegetables."

In botanical terminology, seaweeds have holdfasts, stipes and blades (or fronds) instead of roots, stems and leaves. Their holdfasts function simply as anchors, and do not extract nutrients as do the roots of higher plants. Seaweeds absorb and concentrate nutrients directly from seawater. They do not make flowers or seeds, but reproduce by a mind-boggling (and perhaps even immoral) variety of complex reproductive schemes, most of which involve sperm, ova, and free-swimming “spores.”

Seaweeds come in an amazing variety of beautiful shapes, colors and sizes, and are found in all of the world’s oceans. They are most abundant in shallow rocky coastal areas, especially where they are exposed at low tide.

Coastal people around the world have been harvesting and eating sea vegetables since the beginning of time. In the United States and Europe, increasing numbers of people are learning that eating sea vegetables can provide a broad range of health benefits.

Seaweeds are usually preserved by drying. This is the easiest and best way of preserving their flavor, nutrition and bioactivity. Most dried sea vegetables maintain their quality very well for a year or two if kept away from moisture, light and heat (like crackers, their flavor slowly fades, but nutrition and bioactivity are not affected). They keep very well in airtight glass jars in a dark cupboard.

Sea vegetables are some of the most nutritionally and therapeutically valuable foods on earth. Their value to human health is largely due to their high mineral content and to the therapeutic sulfated polysaccharides they contain. Seaweeds are also an abundant source of all the known vitamins, chlorophylls, lignans, polyphenols and antioxidants.

Many chronic diseases will improve or resolve simply by adding seaweeds to the diet. Eating sea vegetables regularly can facilitate the excretion of heavy metals, radioactive elements, dioxins and PCBs from our bodies, promote a healthy immune system, prevent thyroid disease, obesity, cancers and metastases, cardiovascular disease, type 2 diabetes, nervous system disorders, osteoporosis, reduce chronic inflammation, inhibit viruses (including herpes and human papilloma virus), and help regulate menses. In fact, the Japanese people’s remarkable longevity and extremely low incidence of cardiovascular disease, thyroid disease, breast cancer and prostate cancer may largely be due to the fact that they have the world’s highest per capita seaweed consumption!

Although many people eat sea vegetables as "health foods," others consider them to be delicious gourmet foods, and eat them purely for gastronomic pleasure. They come in a wide variety of tastes and textures. Some sea vegetables may be eaten dried as salty snacks, like potato chips or jerky. Others are re-hydrated, cooked until tender, and eaten alone or in myriad recipes. Powdered seaweeds may be added to smoothies or sprinkled on foods as a salty condiment. Some people prefer the convenience of taking them in capsule form. There are several very good sea vegetable recipe books; these are listed in the bibliography.

How much is good to eat? Three to six grams per day or 1 to 1.5 ounces of dried seaweed per week is a good average dietary amount for nutritional or therapeutic purposes. (That's about 3 to 5 pounds per person per year.) Dr. Ryan Drum recommends eating both brown and red seaweeds in a 2 to 1 ratio for general health purposes. Small amounts taken with each meal every day would provide maximum benefit. Chew your seaweeds well. Powdered seaweeds are often easier to digest than whole seaweeds. If you experience gas or loose stools when you first start eating seaweed, try eating less and slowly increase the amount after a few weeks. The body and the digestive flora may take up to 3 months to learn to efficiently digest seaweeds.

Phycophobia: Many American and European people have varying degrees of cultural phycophobia (fear of seaweed) although this is slowly changing. Others do not want to eat seaweeds simply because they are reminded of the rotting piles of seaweed they have seen washed up on the beach; this is like not wanting to eat vegetables because you have seen a compost pile!

What about arsenic? In April of 2007, Amster et al. published an inflammatory article about arsenic in kelp (Case Report: Potential Arsenic Toxicosis Secondary to Herbal Kelp Supplement. Eric Amster, Asheesh Tiwary, and Marc B. Schenker *Environ Health Perspect*. 2007 April; 115(4): 606–608.). Although the article largely consists of an obvious jump to a preconceived conclusion, it has been widely bandied about in the medical community as "proof" that kelp and other seaweeds are unsafe for human consumption. This is simply not true. (Do you remember when Echinacea caused autoimmune disease?)

Seaweeds naturally contain an average of about 30 parts per million (ppm) by dry weight of arsenic. The USDA has no standards for allowable levels of arsenic in seaweeds. However, the European Pharmacopoeia (European Pharmacopoeia Commission 2007) allows up to 90 ppm of arsenic in kelp for use in medicinal products. Also, most of the arsenic in seaweeds occurs in the form of organically bound arsenic compounds, which are relatively nontoxic.

Most seafoods also contain moderate amounts of arsenic, and although they are usually consumed in much larger amounts than seaweeds, this is apparently not considered to be a health risk. If the arsenic in seaweed really was a health risk, the Japanese people, who have the world's highest per capita consumption of seaweed, would all have chronic arsenic poisoning. They do not. As mentioned earlier, the Japanese people are some of the healthiest and longest-lived people in the world.

Seaweeds and water pollution: Seaweeds are at the bottom of the food chain and are therefore not prone to bioaccumulation of pollutants. However, seaweeds can absorb considerable amounts of heavy metals or radioactive elements if they are growing near a local point source of these pollutants, such as a nuclear power plant, mine, smelter, chemical plant, paper mill, landfill, waste dump, chemical agricultural region etc. Heavy metals or radioactive elements can also be carried from these sources to the sea by rivers and streams.

Buying sea vegetables: Be cautious when buying imported sea vegetables. There is usually no way of knowing where or how these seaweeds were grown. Most of the seaweeds from Japan and other Asian countries are grown on aquaculture farms. Some are fertilized with chemical fertilizers; many are grown in polluted waters.

On the other hand, most of the seaweed harvesters in the USA and Canada are small scale, ecologically sustainable hand harvesters of clean wild seaweeds.

Most commercial kelp meals and powders come from eastern Canada, Norway or Iceland. These are often very inexpensive, but seem to be of universally poor quality in terms of smell and taste.

Harvesting your own seaweeds (see bibliography for more info): Harvest from cleanest waters you can find. Ask local people, environmental groups and government agencies (such as the EPA) about local pollution sources before harvesting. Most states allow the personal harvest of 10 pounds or so of fresh seaweed per day without a permit.

Go to your harvest area at low tide, and carefully cut seaweed from the rocks, leaving the holdfasts and the base of the blades or fronds for regrowth. Harvest no more than 25% of the plants in a stand. Rinse any snails or sand off in the sea as you harvest. Fresh seaweed is as perishable as fresh fish; keep it cool and moist until you are ready to start drying it.

Dry seaweeds outdoors in full sun or in a warm, dry, well-ventilated room. Dry them as quickly as possible and do not allow them to re-dampen once they begin to dry. Hang larger seaweeds on ropes using clothespins; spread smaller seaweeds on nylon screens. If necessary, finish the drying in a heated room. Seaweeds are not fully dry until they snap crisply when bent. Store dried seaweeds in a cool dark place in airtight jars or buckets (or double bag them in heavy-duty food grade polyethylene bags).

Minerals: Seaweeds are by far the most concentrated natural food source of minerals, electrolytes and trace elements (20 to 50% of dry weight) in a ratio that is remarkably similar to that of our own blood. This similarity may not a coincidence, since marine algae were presumably the first foods available to the first animal life on this planet.

Ever since the time our distant ancestors left the ocean and began to live on land, our bodies have had to work much harder to find, ingest, absorb and selectively retain or excrete minerals in order to maintain the "internal ocean" (blood plasma and interstitial fluid) that bathes and feeds our cells.

The ratio and concentration of minerals in our blood plasma and interstitial fluid is so vitally important that our bodies will steal minerals from our bones and other tissues to maintain it. Ongoing mineral deprivation of bone and other tissues can result in chronic disease (Paul Bergner does a wonderful job of documenting the connection between dietary mineral deficiencies and chronic disease in his book, "The Healing Power of Minerals").

Eating seaweeds regularly may be the best way to be sure that we are ingesting enough of all the minerals we need for optimum health. This is especially important today because modern chemical farming, depleted soils and processed foods have resulted in widespread mineral deficiency-caused disease.

Essential minerals and trace elements found in seaweeds include boron, calcium, chloride, chromium, cobalt, copper, fluoride, iodine, iron, lithium, magnesium, manganese, molybdenum, potassium, phosphorus, selenium, silicon, sodium, sulfur and zinc. The amounts of each mineral varies widely between species, season of harvest and area of harvest.

The electrolytes: potassium and sodium: Potassium and sodium are the two most important electrolyte minerals. Adequate potassium and sodium is necessary for proper functioning of our nervous system, muscles, heart, kidneys and pancreas, and for regulating blood pressure and blood sugar.

Most people are aware that too much sodium in the diet can cause hypertension (high blood pressure). However, the level of sodium in one's body is actually less of an issue than the sodium-to-potassium ratio. An excessive sodium-to-potassium ratio in the body causes it to retain water and increase blood volume, causing hypertension.

Most western diets provide too much sodium and not enough potassium. Excessive sodium intake washes potassium out of the body through the urine. Potassium deficiency can also be brought on by medications such as diuretics and cortisone.

Increasing dietary potassium can also help the body adapt to stress (our bodies respond to stress by retaining sodium and excreting potassium through the urine).

Seaweeds are some of nature's most concentrated sources of potassium and sodium, in a nearly ideal ratio. Their salty taste is mostly due to their high potassium content; potassium is much saltier to the taste than sodium. Dr. Ryan Drum has observed that a craving for salt is usually a misplaced craving for potassium, since the human tongue cannot distinguish between the two, and sodium deficiency is extremely rare. So if you crave salt, eat some seaweed!

Blood sugar regulation: Eating seaweed can help people regulate their blood sugar better. Potassium, chromium, magnesium and other minerals are essential to blood sugar regulation. Also, the polysaccharides in seaweeds slow the absorption of dietary sugars and help prevent blood sugar and insulin spikes.

Type 2 (adult onset) diabetes is largely the result of a diet that is high in empty calories (refined sugars, fats and starch) and low in the vitamins and minerals needed to burn them (eat your vegetables!). Their bodies have had no choice but to store these empty calories; eventually, all of their cells become so full they can't fit any more in response to insulin, hence the name "insulin resistant diabetes." Type 2 diabetes has also been linked with low thyroid function, chronic stress, high cholesterol, obesity etc.

Seaweeds also often benefit people with hypoglycemia (low or unstable blood sugar, often associated with high carbohydrate, low fat and low protein diets). If you give seaweed (especially Kelp Fronds) to kids that have had too much sugar or who are crashing from low blood sugar, it's amazing how fast it grounds their energy!

Nervous system disorders and muscle spasms: Most seaweeds have a distinct calming effect on the nervous system and muscles, and eating them regularly can often help or even resolve ADHD, nervousness, irritability, anxiety, depression, insomnia, fibromyalgia, muscle spasms, tics and restless legs syndrome. The high levels of potassium, sodium, calcium, magnesium, and other minerals in seaweeds are food for the nervous system and muscles, and are largely responsible for this calming effect. Many brown seaweeds also contain surprisingly high levels of melatonin, which may also play a part. Nervous system and muscle disorders are also often closely linked to blood sugar regulation and thyroid function.

Iodine: The thyroid gland needs iodine to produce thyroid hormones, which regulate our metabolism, circulation, energy level, sense of well-being, immune system, and growth of skin, hair and fingernails. Iodine is also essential to healthy breast, ovary, testes, prostate and salivary gland health and function.

Most Americans do not get enough dietary iodine. Chlorinated water, fluoridated water and toothpaste, aspirin and many prescription drugs increase the need for dietary iodine. Land plants are not a reliable source of iodine; most seaweeds contain hundreds of times as much as any land plant. The brown seaweeds, especially Kombu *(Laminaria spp.)* are especially high in iodine. Consumption of 3 to 6 grams of most dried seaweeds daily will provide adequate dietary iodine. Excess iodine is easily excreted through the urine.

Seaweeds and thyroid function: Bladderwrack *(Fucus spp.)* Kombu *(Laminaria spp.)* and Sargasso Weed *(Sargassum spp.),* which are all brown seaweeds, have a long history of use in different parts of the world to prevent and treat underactive thyroid (hypothyroid) conditions, obesity and goiter. This is because of their very high iodine content and because much of this iodine occurs in the form of thyroid hormone precursors (MIT and DIT) that are particularly easy for the thyroid gland to assemble into thyroid hormones.

In addition, actual thyroid hormones (T3 and T4) have been found in significant amounts in Kombu and Sargasso Weed (other brown seaweeds may contain T3 and T4 as well). These seaweeds could therefore be expected to provide actual thyroid activity in the body in addition to supplying iodine to the thyroid.

Why would seaweeds bother to produce animal thyroid hormones? That is a *good* question, but it may also be the *wrong* question, because marine algae probably made T3 and T4 long before animal life existed! Marine algae were among the first foods available in the history of life on earth. It is reasonable to assume that early animal life became physiologically dependent on the constant presence of algal T3 and T4 in their diet, and later learned to make their own.

Hypothyroid (underactive thyroid) conditions are rampant and continually increasing in the USA. Symptoms include intolerance to cold, fatigue, depression, forgetfulness, slow metabolism, high cholesterol, weight gain, water retention, constipation, dry skin and hair, brittle nails, immune deficiency, muscle cramps and heavy menses. (Chronic fatigue syndrome, fibromyalgia and type 2 diabetes are also often associated with low thyroid function.) Hypothyroidism occurs much more often in women than men.

Causes of hypothyroidism include exposure to radioactive iodine (I-131), heavy metals, dioxins, PCBs, PBDEs (flame retardants), resorcinol-based glues or MTBE gasoline additives; autoimmune thyroid disease (Hashimoto's thyroiditis etc.), long term adrenal exhaustion, long term veganism, excessive consumption of soy products and insufficient dietary intake of iodine, selenium or L-tyrosine. Underactive thyroid conditions can also be a non-pathological response to grief, depression, or menopause.

Many people are successfully using seaweeds to treat their hypothyroid conditions and avoiding the use of synthetic thyroid hormones (and the associated health risks). Some people are even able to slowly wean themselves from synthetic thyroid hormones with concurrent long-term use of seaweeds. Thyroid nodules also often resolve with long term use of brown seaweeds.

In my own experience, 3 to 6 grams daily of powdered Kombu *(Laminaria setchellii)* or Bladderwrack *(Fucus gardneri)* is a highly effective treatment for hypothyroid patients. Kombu seems to be somewhat more effective than Bladderwrack.

Gotu Kola *(Centella asiatica),* Ashwagandha *(Withania somnifera),* Eleuthero *(Eleutherococcus senticosus)* and various species of Reishi *(Ganoderma lucidum, G. oregonense* and *G. tsugae)* or Artist's Conk *(Ganoderma applanatum)* can also be very helpful for people with hypothyroidism.

People seeking more detailed holistic information on thyroid function and disease should read Dr. Ryan Drum's brilliant thyroid articles (see bibliography).

Iodine sensitivity and hyperthyroidism: Some people are extremely sensitive to the iodine in seaweed, and may show signs and symptoms of hyperthyroidism (excessive thyroid function): nervousness, insomnia, rapid heartbeat, heart palpitations, excessive sweating etc. These people should be cautious about the amount of seaweed in their diet. People with chronic hyperthyroidism probably should not eat seaweed (especially Kombu or Bladderwrack).

Osteoporosis: The high levels of minerals in sea vegetables make them some of the world's most alkalizing foods. Maintaining an alkaline body is essential to good health in general, and to preventing osteoporosis in particular. If our blood becomes too acidic, our bodies will take calcium from our bones to buffer our blood's pH. Over time, this can lead to decreased bone density, or osteoporosis. Eating sea vegetables regularly can reduce our need for calcium/magnesium supplements and help prevent osteoporosis.

Vitamins: Seaweeds are an excellent source of all the known vitamins, particularly the B vitamins. Vitamin content varies widely between species, season of harvest and area of harvest.

Therapeutic sulfated polysaccharides: Seaweeds contain large amounts (25 to 40% of dry weight) of therapeutic sulfated polysaccharides, including algin, fucoidan and laminarin, which are produced by brown seaweeds, and carrageenans, agar, and porphyran, which are produced various red seaweed species. These unique seaweed gels are the means by which seaweeds absorb and concentrate minerals from seawater. They also have many amazing beneficial health effects.

Water soluble fiber: All seaweed gels are relatively indigestible by humans, and act as high quality water-soluble fiber in our digestive tracts and as food for our colon flora. This may be why many seaweeds are considered to be soothing intestinal tonics in many Asian medical traditions.

Protection from heavy metals and radioactive elements: Algin, a polysaccharide found in all brown seaweed species, will bind with heavy metals and many radioactive elements in the food, water and digestive juices in our gastrointestinal tract. This prevents their absorption or reabsorption and allows them be eliminated through the feces. Fucoidan, laminarin, carrageenans and agar all have similar properties. This means that eating seaweeds (especially the brown seaweeds) regularly can effectively reduce our body loads of these toxic elements. The potential value of this to human health cannot be underestimated.

The average American today has hundreds of times more lead in his or her body than a century ago, primarily because of the use of tetraethyl lead in gasoline for 65 years (it was outlawed in the USA in 1989) and from commercial lead smelters, incinerators etc. Most Americans also have some degree of mercury toxicity from amalgam dental fillings, coal burning power plants, cement production and contaminated ocean fish. Both heavy metals can cause serious neurological disorders, autoimmune diseases, hypothyroidism, cancers and birth defects.

In 1957 the U.S. Atomic Energy Commission recommended taking five grams of powdered kelp, algin or sodium alginate daily for protection from the radioactive fallout from atmospheric nuclear testing. This is probably good health advice for today as well. Sr-90 is the most easily traced radioactive isotope produced by atomic bombs and nuclear reactors. When absorbed by the body, Sr-90 is deposited in the bones and teeth, continuously emitting radiation as it decays (it has a half-life of about 29 years) causing bone cancers and leukemias. Scientific studies measuring Strontium-90 in the deciduous teeth of children and the bones of adults indicated that although levels declined during the 1970's, they were as high in the 1980's and 1990's as they were during the late 1950's, when radioactive fallout from nuclear testing was at its peak.

It is a deplorably under-publicized fact that all nuclear power plants regularly release radioactive Iodine (I-131) into the atmosphere. The I-131 attaches to water droplets and dust particles and descends to the earth's surface, entering food (especially milk) and water supplies. When ingested, I-131 concentrates in the tissues that need the most iodine; the thyroid gland, ovaries or testes, salivary glands and, in women, the areola of the breast as well. As the I-131 decays (it has a half-life of 8 days), it irradiates and damages these tissues, causing loss of function, autoimmune diseases and cancers. Most cancers do not show up until *at least* 15 years after exposure. People that live near nuclear power plants have significantly higher rates of autoimmune diseases, cancers and birth defects

When meltdowns occur at nuclear power plants (such as Chernobyl or Three Mile Island) large amounts of I-131 and other radioactive elements are released into the atmosphere. According to the National Institute of Health, the I-131 fallout from the nuclear accident at Chernobyl caused large numbers of people worldwide (including the United States) to contract thyroid cancer.

If a person maintains a full body load of natural iodine (I-127), the radioactive iodine is not absorbed. Seaweeds, especially the brown seaweed species, are by far the most concentrated natural food source of iodine.

Protection from dioxins and PCBs: Dioxins and PCBs are particularly insidious environmental pollutants because they are extremely toxic, extremely stable, and extremely lipophilic, and because they concentrate in animal fats as they move up the food chain. Humans get most of their dioxins and PCBs from meat and dairy products. Once ingested, dioxins and PCBs are very readily absorbed and very slowly excreted, so they tend to stay in the liver, brain and body fat for decades.

We are all carrying significant body loads of these toxins. Dioxins and PCBs are and can cause cancer, immune system damage, autoimmune disease, hormone disruption, thyroid disease, endometriosis, infertility, miscarriage, birth defects, learning disabilities, lowered testosterone levels, reduced sperm counts, diabetes, lung problems and skin disorders.

A landmark research study conducted by Morita and Nakano (Morita K, Nakano T: Seaweed accelerates the excretion of dioxin stored in rats. J Agric Food Chem 2002, 50:910-917) clearly demonstrates that regular consumption of Wakame, Kombu and Hiziki by rats reduces absorption of dioxins and PCBs from food (and reduces the reabsorption of dioxins and PCB from the digestive juices secreted into the gastrointestinal tract) allowing them to be eliminated through the feces, effectively reducing body loads of these toxic chemicals. (Wakame, Kombu and Hiziki are brown seaweeds; I assume that it is the polysaccharides in the brown seaweeds that are binding with the dioxins and PCBs.)

Morita and Nakano's research strongly suggests that eating brown seaweeds regularly can effectively reduce body loads of dioxins and PCBs for humans as well.

Fucoidans: Fucoidans are a class of sulfated polysaccharides found in most brown seaweed species (5 to 20% by dry weight). Fucoidans have received a lot of attention from the research community because they have demonstrated so many broadly beneficial health effects. They have strong immune enhancing, immune-modulating, anti-inflammatory, antioxidant, anti-coagulant, cholesterol-lowering, anti-cancer, and anti-metastatic activity.

Immune enhancement and virus inhibition: Perhaps the most significant aspect of fucoidans is their ability to build up and strengthen the immune system. Fucoidans also possess strong inhibitory activity against a number of coated viruses, such as HSV-1, HSV-2, HPV, EBV, CMV and HIV. Their mechanism of action involves blocking virus entry into cells, rather than killing the virus directly.

Immune modulation: Fucoidans also provide an array of health benefits via their ability to modulate the immune system. Immune modulating substances have the ability to increase immune function when it is depressed, as in conditions like chronic fatigue syndrome, and to reduce it when it is over-stimulated, as in auto-immune diseases like lupus or rheumatoid arthritis, allergies, etc.

Healing from tissue trauma: Dr. Ryan Drum has noted that consumption of fucoidan-rich brown seaweed broths seem to prevent bruising, reduce inflammation and speed tissue healing after injuries or surgery. The researched antioxidant, anti-inflammatory and anticoagulant activity of fucoidans would strongly support his observation.

Cancers and metastases: Researchers have determined that fucoidan tends to combat cancer by reducing angiogenesis (blood vessel growth), inhibiting metastasis (spreading of cancer cells to other parts of the body), and promoting death of cancer cells (apoptosis).

Seaweeds and cardiovascular health: Eating seaweeds regularly, especially the brown seaweeds, improves the quality of the blood, which is the key to cardiovascular health. Seaweed provides abundant minerals for the blood, blood vessels, heart and kidneys. It provides blood thinning, anti-inflammatory and antioxidant polysaccharides, which keeps the blood thin and easier for the heart to push through the blood vessels, prevents clots from forming, prevents free radical damage to the blood vessels and keeps plaques from clogging the blood vessels that feed the body.

The fucoidans in brown seaweeds improve lipid metabolism in the liver, which decreases the total amount of serum cholesterol and improves the ratio of good (HDL) cholesterol to bad (LDL) cholesterol. Seaweed also helps keep thyroid hormones at optimal levels, which is also supports healthy cholesterol levels and the prevention of atherosclerosis.

Blood pressure: The hypotensive effect of many brown seaweeds, especially Kombu *(Laminaria spp.)* and Bladderwrack *(Fucus spp.)* has been well established in folk medicine and with modern research.

Irregular or painful menses: Regular consumption of brown seaweeds often helps regulate the menstrual cycle. This may be due to the estrogen-lowering fucoidans and lignans or to simple thyroid stimulation.

Carrageenans: Carrageenans are immune-enhancing, broad-spectrum anti-viral (including HSV-1, HSV-2 and HPV) sulfated polysaccharides found in many red seaweed species. Some species contain more than others. The various Pacific species of the genus *Gigartina* (also known as *Mastocarpus* or Grapestone) as well as the Atlantic species *Chondrus crispus* (Irish Moss) are particularly high in carrageenans (50 to 80% of dry weight). Carrageenans are also widely used in the food industry as thickening and stabilizing agents and in cosmetic and skin care products

There are a variety of products made from different red seaweed species being marketed today for topical and internal use for suppression of herpes simplex 1 and 2, mostly under the generic name of Red Marine Algae. I have no solid data on their efficacy in real life.

Organoleptic experiment with seaweed and HSV-1: I have been using 5 to 10 grams daily of a mix of six powdered brown and red seaweeds during the last two years. I would normally have expected to get five or six outbreaks of oral herpes (HSV-1) during this time. However, during the last two years I have had only one very mild outbreak, and that was after a period of slacking off in my use of these seaweeds for a few weeks.

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