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ECOSYSTEM OVERVIEW:

PACIFIC NORTH COAST INTEGRATED MANAGEMENT AREA (PNCIMA)

APPENDIX E: MARINE PLANTS

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1.0 INTRODUCTION

This chapter deals with large marine plants, specifically the benthically attached algaes (seaweeds) and sea grasses. Our knowledge of marine plants on the British Columbia (BC) coast is dominated by two species of kelp (*Nereocystis luetkeana* and *Macrocystis integrifolia*) and eelgrass (esp. *Zostera marina*). This is partially because these species are so common, but more importantly, these species form essential habitat for a huge number of other organisms including birds, invertebrates, and both juvenile and adult fish as well as providing much of the substrate for herring spawn. As habitat, these species form a critical component of ecosystem function in the nearshore. Kelp surveys have been done for a number of areas along BC's coast, but are rarely repeated, so temporal change is not well understood. There is evidence that *Macrocystis* increases in abundance relative to *Nereocystis* when sea surface temperatures increase, as they have been over the last 30 to 50 years. The effect of this global-warming-related change on the ecosystem is not known. Eelgrass beds are extremely sensitive to environmental change. So much so that in many cases of eelgrass decline, it is not possible to determine which environmental change was the ultimate cause. In terms of biodiversity, there are hundreds of known species of marine plants in the Pacific North Coast Integrated Management Area (PNCIMA, Figure E.0) (Johannessen *et al.* 2005; Sloan and Bartier 2000). Current data is insufficient to determine if this biodiversity is changing with time.

1.1 Marine Plants Defined

Benthic marine plants comprise four major groups: brown, green, and red algae, and seed plants. As the algal names suggest, these groups are recognized by their accessory photosynthetic pigments, which usually give them their distinctive color, and by other biochemical features and distinctive morphologies (Graham and Wilcox 2000). The brown, green and red benthic marine plants are known collectively as seaweeds, and they grow attached to rock or other organisms in the intertidal or shallow subtidal coastal environment. The seed plants include the seagrasses, which are adapted to marine life, and some salt-tolerant high intertidal plants, which are not discussed here. Diatoms, chrysophytes, tribophytes, and blue-green algae (Cyanophyta, or Cyanobacteria) also occur benthically in marine habitats, but they are not as conspicuous as the other groups and are not dealt with in this appendix.

Seaweeds, as their name implies, are adapted to living in the marine environment. Because of their simple morphologies (often one or a few cells thick, and all but a few species of kelp without conducting tissue), they obtain their inorganic nutrients for photosynthesis and other metabolic activities directly from seawater. Thus, most of their productivity occurs when plants are submerged. Species vary in their need for and ability to take up different inorganic nutrients. Seaweed ecology and physiology are treated in detail in Lobban & Harrison (1994).

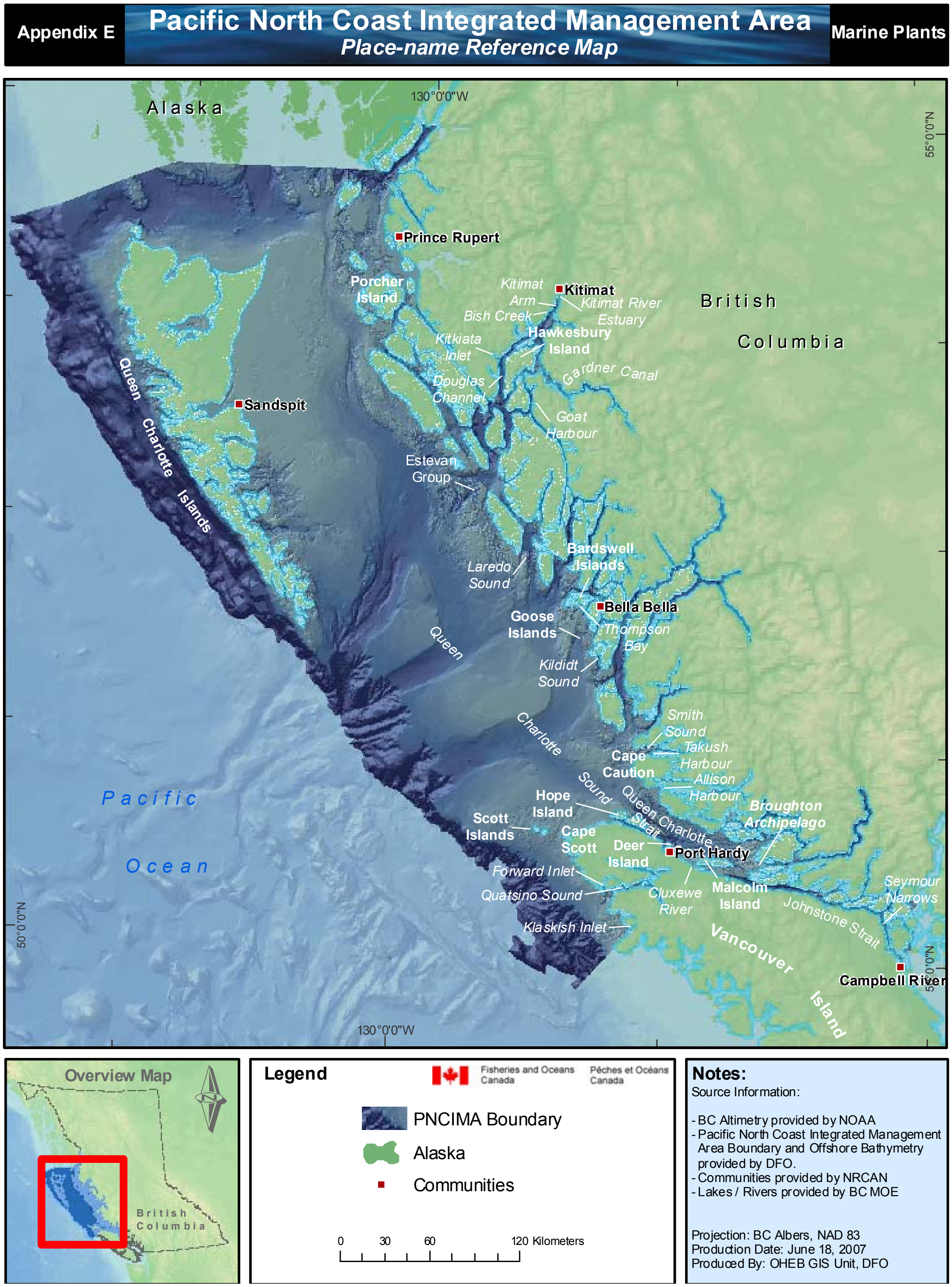

Figure E.0 PNCIMA region showing locations and features of BC waters.

Seaweeds also vary in their tolerance to temperature, salinity, light intensity, desiccation, and water motion, which results in individualized horizontal (geographic) and vertical (shorezone) distributions. Species diversity usually increases from high to low in the intertidal zone and then decreases again as water depth increases. Because they need light for photosynthesis, seaweeds occur from the splash zone to depths of rarely more than 30 m near the coast. However, in offshore areas such as Bowie Seamount, species can be found at depths of at least 35 m (Scagel 1970). These depths are still relatively shallow compared to the record depth of 268 m on a tropical seamount (Lobban and Harrison 1994).

Seaweeds also vary in their morphologies and chemical compositions, making them differentially attractive (or in a few cases, repellent) to herbivores. Sea urchins are a major grazer of seaweeds in temperate waters (Foreman 1977; Coon 1983), but mesograzers such as chitons and limpets can also have significant effects (Lobban and Harrison 1994). Effects of grazers can vary dramatically between regions even when community composition is very similar (Dethier and Duggins 1988).

Seaweeds reproduce by spores or gametes, and most species have an alternation of either isomorphic or heteromorphic generations (Lobban and Harrison 1994; Graham and Wilcox 2000).

BC has a particularly diverse assemblage of seaweeds (Scagel *et al.* 1993). Scagel (1957) summarized the state of knowledge on marine algae and included keys to genera, followed by a floristic treatment of the benthic marine green algae (Scagel 1966). No comprehensive flora of the benthic marine plants of BC has been published. Lüning (1990) described the most important features of zonation of intertidal and subtidal vegetation common to the coast from BC to central California.

1.2 Marine Plant Species List

The herbarium of the University of British Columbia (UBC) houses over 5700 specimens (402 different taxa) collected by Scagel and his associates in the central coast region of BC over the past 50 years. The number of species is similar to the 376 whose distributions overlap the region according to Scagel *et al*. (1993). However, comparison of these two lists reveals that 66 taxa that should occur within the region, based on records north and south of the central coast, have not yet been collected there. Many of these are microscopic and have probably been overlooked in samples collected thus far. However, some species are conspicuous and should have been observed. Herbarium specimens could have been misidentified, species could have been overlooked or seasonally absent during sampling, or taxonomy may have changed as a result of molecular techniques. A combination of the two lists provides a list of 419 taxa, which, together with Sloan and Bartier's (2000) list of marine plants from the Queen Charlotte Islands, form an approximate listing of the plant diversity for the PNCIMA region (for a comprehensive list see the Biophysical Overview report (Johannessen *et al.* 2005).

Despite falling entirely within van den Hoek's (1984) northeast Pacific cold temperate zone and Valentine's (1966) Oregonian Province, the PNCIMA region shows characteristics of a transitional zone. It is here that the northern limits of some species are reached (Table E.0)(Norris and Abbot 1972; Scagel *et al.* 1993; Lindstrom and Gabrielson 1989; Wynne *et al.* 1973; Phillips 1979). The UBC database reveals northern records for other species that could be easily misidentified, so specimens should be verified before these northern records can be confirmed. For other species, the central coast represents their southern limits (Hawkes *et al.* 1978; Scagel *et al.* 1993; Wynne 1985).

Table E.0 Marine plant species at their range limits in PNCIMA (source: Norris and Abbot 1972; Scagel *et al.* 1993; Lindstrom and Gabrielson 1989; Wynne *et al.* 1973; Phillips 1979; UBC database; Hawkes *et al.* 1978; Wynne 1985).

Species at their northern limit	**UBC northern records**
Cumagloia andersonii	*Fauchea fryeana*
Dictyoneuropsis reticulata	*Gelidium coulteri*
Gloiosiphonia verticillata	*Grateloupia doryphora*
Hollenbergia nigricans	*Halymenia gardneri*
Laminaria sinclairii	*Halymenia schizymenioides*
Phyllospadix torreyi	*Hersposiphonia grandis*
Pleonosporium squarrulosum	*Holmesia californica*
Polyneuropsis stolonifera	*Hymenena setchellii*
Postelsia palmaeformis	*Isabbottia ovalifolia*
Pterothamnion reversum	*Membranoptera multiramosa*
	Myriogramme pulchra
	Prionitis cornea
Species at their southern limit	
Codium ritteri	
Eudesme virescens	
Hommersandia maximicarpa	
Laminaria yezoensis	
Tayloriella divaricata	

2.0 KELP

Kelp is the common name for seaweeds belonging to the brown algal order Laminariales. They include the largest known marine algae, the floating kelp *Nereocystis* (bull kelp) and *Macrocystis* (giant kelp), which are reported to reach 30 m or more in length. The Northeast Pacific in general and the BC coast in particular are rich in both species number and species abundances: 27 species of kelp are reported for this region. Druehl (1970) plotted the geographic distribution of kelp species along the northeast Pacific coast.

A few species occur in the mid intertidal (*Alaria* spp., *Hedophylum sessile*, *Postelsia palmaeformis*), but most are restricted to the low intertidal or subtidal. The floating kelp species occurring in this area, *Nereocystis luetkeana* and *Macrocystis integrifolia*, can form large offshore or narrow, fringing beds along coastal BC. *Macrocystis pyrifera* is common in Sitka Sound, Alaska, and from central California to Baja California (O'Clair and Lindstrom 2000) . Its apparent absence in the intervening area is puzzling. The possibility of *M. pyrifera* occurring in central BC should be considered.

Temperate kelp beds are among the most productive ecosystems in the world (Mann 1982). In general, kelp productivity ranges from 400-1900 g C m^{-2} yr^{-1} (Westlake 1963). In St. Margaret's Bay, Nova Scotia, macrophyte beds were found to contribute about 75% of the total primary production (Mann 1982). Kelp beds are important spawning and nursery areas for fish and invertebrates, and kelp contribute a significant amount of fixed carbon to the nearshore ecosystem (Duggins *et al.* 1989). Herring, salmon, surf smelt, sand lance, abalone, and sea urchins are among the important species to utilize kelp beds (Shaffer 2004).

Leaman (1976; 1980) compared his summer 1975 survey of kelp fishes in relatively small Barkley Sound *Nereocystis* beds with a two-day investigation of a 15 ha mixed kelp bed of *Macrocystis* and *Nereocystis* and a smaller *Nereocystis* bed off Deer Island in Beaver Harbour, near Port Hardy. He observed an absence of neritic fishes in the Deer Island beds in contrast to their abundance in Barkley Sound; benthic fishes were of similar diversity among all beds, although species composition varied. Leaman noted differences in the relative depth distributions and densities of the floating kelps between Barkley Sound and Beaver Harbour, and differences in understory species.

The BC Research Council inventoried *Nereocystis* and *Macrocystis* beds along the BC coast during the summer of 1946 (BCRC 1947a; 1947b). They estimated a harvestable biomass of 50,815 and 8,570 tons, respectively, for the central zone, extending from Cape Scott and Seymour Narrows on Vancouver Island to Cape Caution, and 15,370 tons and 5,660 tons, respectively, for beds in their Northern Zone but in areas that fall within the central coast region of this report.

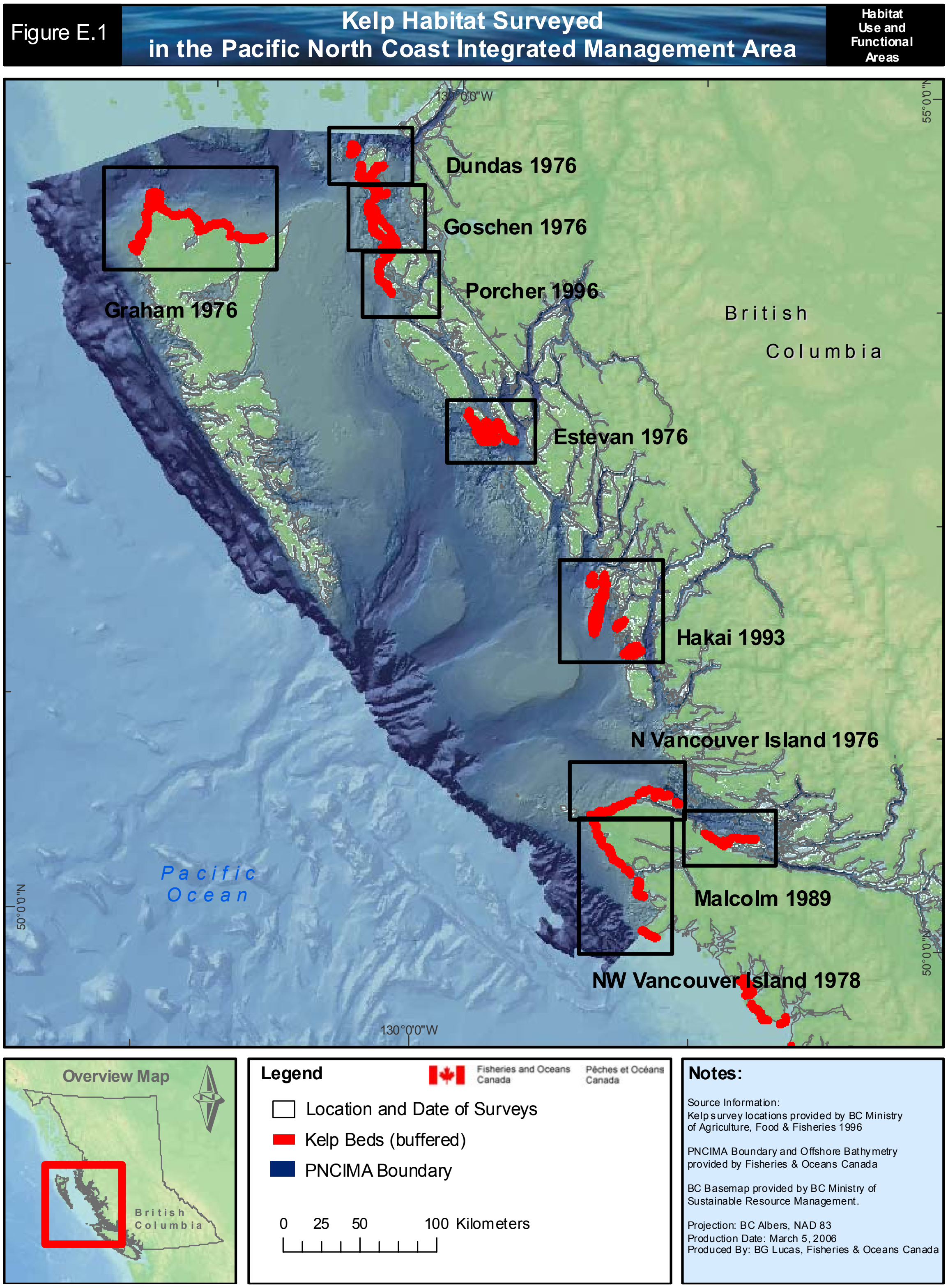

Figure E.1 Locations of surveyed kelp beds in PNCIMA, buffered to enhance visibility (data from BC Ministry of Agriculture, Fisheries and Food 1996).

More recently, floating kelp have been the subject of a number of inventories of standing stocks using the Kelp Inventory Method (KIM-1) developed by Foreman (1975) or a modification thereof (summarized by Sutherland 1990; Field 1996). Inventory areas are shown in Figure E.1, and results are summarized in Table E.1. Basically, KIM-1 combines bed area, density and species composition from infrared aerial photography with field-determined bed density and mean plant weight to provide species-specific biomass estimates for each km-wide section of coastline. The majority of PNCIMA coastline has not been surveyed, therefore the absence of kelp beds on the figure does not indicate the absence of kelp. The kelp beds of the PNCIMA region represent about 80% of the total surveyed biomass for the coast of BC.

Table E.1 Estimated annual yield of BC kelp (*Nereocystis* and *Macrocystis*) biomass in surveyed areas. Locations in bold are within PNCIMA (data provided by the BC Ministry of Agriculture, Fisheries and Food).

Inventory Area	Most Recent Year of Survey	Coastline Length (km)	Bed Area (ha)	Total Standing Crop (wet tonnes)	Annual Yield (wet tonnes)	Annual Yield Excluding Protected Areas
Port Hardy-Malcolm Island	1989	40	761	37 934	7 587	7 587
North Vancouver Island	1976	68	885	38 077	7 604	6 287
Northwest Vancouver Island	1978	72	840	48 615	9 723	5 918
Nootka Sound	1995	85	850	73 836	14 767	8 611
Strait of Juan de Fuca	1988	118	511	50 148	10 030	6 732
Estevan Group	1976	82	1 470	77 615	15 524	8 298
Dundas Group	1976	61	1 527	74 350	14 870	4 854
Melville Group	1981	16	127	2 997	599	0
Porcher Group	1996	122	1 741	113 575	22 715	3 056
Shakes	1981	14	0	1 968	394	394
North Graham Island	1976	162	2 375	77 410	15 482	9 303
Hakai Pass/Bardswell Group	1993	126	1 550	55 224	11 045	2 602
TOTAL		966	12 707	651 749	130 340	63 642

Modified from Lindstrom (1998).

Most beds have been surveyed only once during the 20-year period 1974-93. The exception is the Malcolm Island area in Queen Charlotte Strait, which was assessed in 1974, 1978, 1980, 1983 and 1989. Comparisons among the years reveal that the total bed area grew slightly during this period, and *Macrocystis* abundance increased whereas *Nereocystis* area declined (Sutherland 1990). Foreman (1984) had earlier noted this change in the Malcolm Island bed, namely that the high *Nereocystis* densities from 1974 to 1978 were unusual and appeared to be correlated with record low mean annual seawater temperatures and salinities during that period. A comparison of beds in the Estevan Group area between surveys in 1946 and 1976 (using different methods) revealed significant differences in the size of beds between the two periods (some increasing, others disappearing; (Field *et al.* 1977)). A comparison of beds at the north end of Vancouver Island between 1967 and 1976 (again, using different methods) revealed a large increase in *Nereocystis* area and biomass and a similar significant decrease in *Macrocystis* area and biomass (Coon *et al.* 1981), whereas beds of the northwest coast of Vancouver Island were comparable between 1967 and 1978 (Coon *et al.* 1982). These shifts in species composition, with increases in relative abundance of *Nereocystis* from 1967 to 1978 and of *Macrocystis* from 1974 to 1993, coincide with a documented regime shift in the North Pacific (Mantua *et al.* 1997; Anderson and Piatt 1999).

As previously noted, urchins are a major grazer of kelp, particularly *Nereocystis*. An abundance of urchins can decimate kelp beds, creating barren ground. Such a devastation has been documented by Foreman (1977) in the Strait of Georgia and by Coon (1983) at Porcher Island, where biomass declined from 36,000 to 195 wet tonnes between September 1976 and September 1981 due to urchin grazing. Sea otters, a major predator of urchins, are often associated with healthy kelp beds (Estes 1996).

Coon & Roland (1980) examined harvesting impacts on *Macrocystis integrifolia*, and Coon (1983; 1990) reviewed provincial management strategies and inventory methods. Mumford (1987; 1992) published a bibliography on *Nereocystis luetkeana*. Kelp beds in the vicinity of salmon farms in the Broughton Archipelago, Johnstone Strait, and northwest Vancouver Island have been mapped by the Living Oceans Society (LOS 2003).

Druehl, his students and associates have published extensively on BC kelp (see Scagel *et al.* 1993 for references). Druehl and Kemp (1982) studied changes in blade morphology and growth characteristics of *Macrocystis integrifolia*, which included specimens from Malcolm Island. Foreman (1976; 1984) reported on the ecology and population dynamics of *Nereocystis luetkeana*, including specimens from Malcolm Island.

3.0 SEAGRASSES

Seagrasses are flowering plants that live in the marine environment. *Zostera marina*, commonly called eelgrass, forms extensive meadows in soft sediments, such as sand and mud, in the lower intertidal and shallow subtidal. Eelgrass beds are most common in protected waters, such as heads of inlets, but they also occur in soft sediments along other shores. The beds provide essential habitat for waterfowl, crab, herring and juvenile salmon (BC MSRM 2002). They also stabilize sediments and contribute to nutrient cycling in both direct and indirect ways (Phillips and Menez 1988; Dunster 2003). The importance of eelgrass beds to the life cycles of economically important fish and shellfish has led Washington State to adopt a "no net loss" policy for eelgrass. In BC, Environment Canada and The Bullitt Foundation funded a discussion paper, Eelgrass Conservation for the BC Coast (Wright 2002), which concentrated on eelgrass beds in the Strait of Georgia, threats to their survival, the importance of mapping and monitoring, and difficulties with restoration and protection.

Although a single species of *Zostera*, *Z. marina*, is native to the Pacific coast of North America, Backman (1991) recognized five ecotypes, based on differences that were maintained in common garden experiments. Three of the ecotypes occur in Washington State, *Z. marina* var. *phillipsii* and *Z. marina* var. *marina* (as var. *typica*) in Puget Sound and *Z. marina* var. *latifolia* on the outer coast. *Zostera marina* var. *marina* occurs primarily in the intertidal whereas var. *phillipsii* and var. *latifolia* are primarily subtidal. The leaves of var. *latifolia* are significantly wider than those of other varieties. Backman did not examine any specimens from BC.

The introduced species, *Zostera japonica*, found in the Strait of Georgia at a higher elevation than *Z. marina*, has not yet been reported in PNCIMA.

Before 2000, most eelgrass mapping in BC was carried out by governmental agencies as part of regional resource planning, management, or resource-based activities (see Sec. 5.2 Vegetation of Herring Spawning Grounds). Since 2000, interest in the health of eelgrass beds has intensified, and the BC Seagrass Conservation Working Group network, an NGO, is spearheading fine-scale eelgrass mapping, monitoring and conservation for all of coastal BC. An eelgrass bed mapping atlas is available online (CMN 2006). Additional maps that may be of interest to eelgrass mappers are cited in Dunster (2003). Dunster also lists the Living Oceans Society as the contact agency for coarse-scale eelgrass mapping in the North Coast Fjords ecosection.

In 2002, the Northwest Stewardship Society undertook an initial survey of potential eelgrass sites in Douglas Channel from Bish Creek north to the Kitimat River estuary, using an underwater camera. Also in 2002, the Heiltsuk Fisheries Program Eelgrass Project began a reconnaissance of an eelgrass lagoon that is currently being mined for marine clay (Dunster 2003). Both groups are working with the SeaChange Marine Conservation Society. Coastal & Ocean Resources Inc. has mapped eelgrass beds in the

Douglas Canal area near Kitimat, including Kitimat Arm, Kitkiata Inlet, Hawkesbury Island, Goat Harbour, and Gardner Channel (two sites) using their towed underwater Seabed Imaging and Mapping System (SIMS); data are owned by the University of Victoria (Dunster 2003). Living Oceans Society's maps of eelgrass beds in the vicinity of salmon farms in the Broughton Archipelago (southeastern Queen Charlotte Strait), Johnstone Strait, and northwest Vancouver Island (including Quatsino Sound) are available online (LOS 2003).

Three species of surfgrasses are recorded for the BC's central mainland coast: *Phyllospadix scouleri*, *P. serrulatus*, and *P. torreyi* (Pojar and MacKinnon *eds*. 1994; Gabrielson *et al.* 2000). In contrast to eelgrass, surfgrass flourishes on low intertidal to shallow subtidal bedrock on exposed coasts. Phillips (1979) provided ecological information on the species of *Phyllospadix* occurring from Oregon to Vancouver Island, including elevation of occurrence and flowering phenology.

4.0 COMMERCIAL HARVESTING

The Ministry of Agriculture, Food and Fisheries is responsible for the management of commercial marine plant harvests in BC. A harvest licence is required, which stipulates the species, quota, method of harvest, and area of harvest. The royalty levied on harvested wet tonnage varies from $10 per tonne for kelp to $100 per tonne for *Porphyra*, *Enteromorpha* (now *Ulva*), *Rhodymenia* [sic—presumably *Palmaria*], and *Monostroma*. Most other algae are charged $50 per tonne. Data on province-wide harvests from 1992-2001 is shown in Figure E.2.

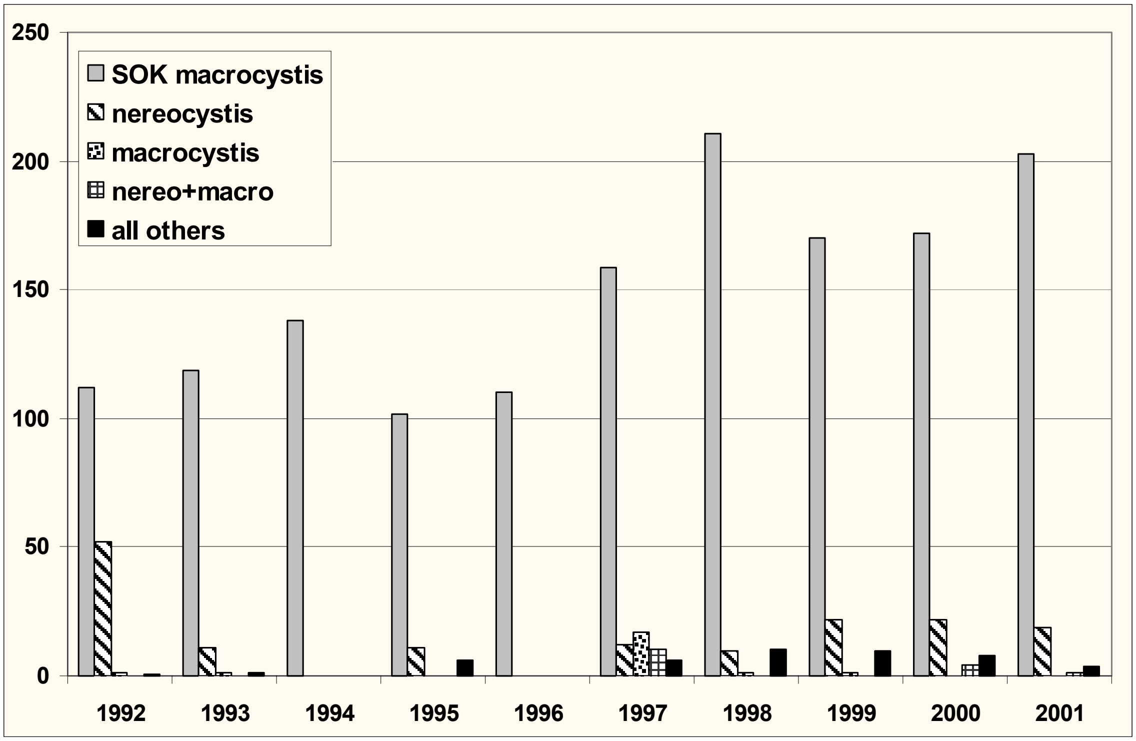

Figure E.2 Seaweed harvests in BC, 1992-2001. SOK = herring spawn on kelp (data from BC Ministry of Agriculture, Fisheries and Food).

5.0 MARINE PLANT COMMUNITIES

PNCIMA has a wide variety of marine plant flora. Many studies of marine plants in the area are dated or for a very limited geographical area, making it difficult to assess current status and long term variability for kelp and sea grasses. Older studies have also used different methods, making temporal analysis difficult. Studies monitoring seasonal variability are also lacking. A summary of studies conducted in the PNCIMA area illustrates the diversity and importance of plant communities in marine ecosystems.

5.1 General Studies

Scagel (1961) reported on the oceanography, notably temperature and salinity, meteorology, and geological formations and history in Queen Charlotte Strait in the 1950s and related the geographic distribution of seaweeds there to these factors. He provided a list of common benthic organisms along the Strait as well as data on their horizontal distribution, from Hope Island to the eastern end of the Strait, their vertical distribution at Hope Island, and a comparison of vertical distributions of some intertidal species at Hope Island, Deer Island, and Cluxewe (as Klucksiwi) River. The results reveal that more than half of these common species drop out between Hope Island and the innermost sites and that vertical distributions are somewhat to distinctly lower as one moves inside the strait, where salinity is lower.

Adkins (1977) reported on the state of knowledge of marine resources in the Queen Charlotte Sound region, drawing heavily on Scagel's 1961 species list for her one-page marine plant summary.

Petro-Canada (1983) reviewed studies of marine plants in the Queen Charlotte Islands and adjacent areas.

The North Island Straits Coastal Plan (BC MSRM 2002) discusses the importance of eelgrass and kelp beds in the area, the potential interest in kelp aquaculture off Malcolm Island, and in which of the 66 coastal units marine plant aquaculture is appropriate, conditionally acceptable, or inappropriate.

5.2 Vegetation of Herring Spawning Grounds

Three areas of the BC's central mainland were photographed aerially in 1979 (see Bennett 2003) with both Ektachrome and color infrared film in order to map shoreline vegetation in the Thompson Bay area (Haegele and Hamey 1980c), in Laredo Sound (Haegele and Hamey 1980b), and in Kildidt Sound (Haegele and Hamey 1980a). Vegetation to a maximum depth of 10 m was mapped at a scale of 1:6000, based on texture and color. Five categories of marine plants were recognized: seagrasses, rockweed, red algae, brown algae (including kelp and *Sargassum muticum*), and green algae. Published vegetation maps are at scale of 1:21,000 or 1:23,000. No ground-truthing was carried out at these locations, but at other sites there was a close correspondence between air photos and diver identifications.

A diving survey was carried out on the west coast Vancouver Island in Quatsino Sound, Forward Inlet and Klaskish Inlet (Haegele and Hamey 1987).

Bennett (2003) described Haegele's eelgrass data collection methods and the form and structure of his data to make them more readily available to other applications, including GIS mapping and analysis.

5.3 Shore-zone Bio-bands

The shoreline of BC has been mapped to identify its biophysical attributes, namely landform, substrate, slope, exposure, and major biota (BC MSRM 2005; Howes *et al.* 1997; 1999; Searing and Frith 1995). The shore biota is described as "bio-bands", assemblages of intertidal species visible from the air and named for dominant species or assemblages. Morris & Thuringer (2001) summarized bio-band definitions for the west coast of Vancouver Island and definitions of biophysical characteristics associated with various habitats.

Shore-zone data have been used by the Coast Information Team (CIT 2003) to identify 59 shoreline categories (17 representative types of coastal classes times 5 wave-energy classes less 4 man-made or unidentified categories) that are potential ecosystem targets for protection in central and northern coastal BC. Among the bio-band assemblages, CIT focused on saltmarsh vegetation, eelgrass beds and kelp beds as the major nearshore habitats because of their high biological productivity and sensitivity to human impacts and because "these categories are recognized ecologically, are protected by policy, and are the best surrogates at this scale to represent a range of habitats" (CIT 2003). They acknowledged, however, that these habitats are not necessarily the most diverse and therefore selected a Habitat 3 category (representing the highest diversity of intertidal biota) as an additional target. This habitat occurs on semi-exposed, lower intertidal bedrock. Indicator bio-bands are mussels-barnacles, chocolate brown algae, surfgrass, urchins, and *Nereocystis*; indicator species include diverse red algae, *Hedophyllum sessile, Egregia menziesii, Eisenia arborea, Laminaria setchellii,* and *Phyllospadix* spp. Application of a MARXAN analysis indicated that more than 30% of the linear saltmarsh, eelgrass, and kelp bed shoreline could be preserved by protecting less than 20% of the total shoreline (CIT 2003). Offshore analyses rated the following important algal areas high for conservation: Goose Islands, Bardswell Islands and vicinity, the Scott Islands, the entrance to Queen Charlotte Strait, and the Broughton Archipelago.

5.4 Intertidal Communities

A study by CERF (Coastal Ecosystems Research Foundation) (CERF 2004; Lamb *et al.* 1999), extending for about 30 km from Allison Harbour in Queen Charlotte Strait to Takush Harbour in Smith Sound, classified 32 intertidal sites into four habitat types based on intertidal sessile species. Exposed sandy beaches were mostly devoid of sessile algae and invertebrates. Exposed rocky shores, the most frequently surveyed habitat type (37.5%), were indicated by *Codium fragile*, *Corallina gracilis* [probably *Corallina vancouveriensis*], *Egregia menziesii*, *Hymenena setchellii*, *Microcladia borealis*, *Mazzaella splendens*, *Phyllospadix* spp., and *Porphyra* spp. Many of these exposed rocky sites had offshore *Nereocystis* and *Macrocystis* kelp beds, and one of the sites had the northernmost record of *Postelsia palmaeformis*. *Cladophora* sp. was the indicator species for sheltered mud beach habitat, and *Bryopsis* sp., *Neorhodomela* sp. (as *Rhodomela* sp.), *Petrocelis* sp. (the alternate phase of *Mastocarpus*), and some of the species diagnostic of exposed rocky shores characterized semi-exposed rocky habitats (moderately sheltered rock and sand, representing 34% of sites sampled). Other organisms, such as *Fucus*, *Balanus*, *Semibalanus*, *Ulva*, *Littorina* and limpets, occurred at all rocky site types and were thus not useful at sorting sites into categories; however, they were indicative of tidal zones. Thirteen of the 32 sites were revisited in 2002; results from this survey have yet to be analyzed.

5.5 Subtidal Communities

The CERF study recognized up to seven subtidal habitat types, each dominated by a different set of species (Lamb *et al.* 1999). Exposure and current were thought to determine the community present in each habitat type. The habitats identified were: (1) a protected bay, mostly in a *Nereocystis* kelp bed, *Membranipora* and *Tonicella lineata* dominant; (2) areas exposed to heavy wave action, often with sandy substrate, *Ulva* and *Zostera* dominant; (3) rocky bottom leading into sand or mud, encrusting coralline algae and *Luidia foliolata* dominant; (4) rocky substrate, *Strongylocentrotus* (and articulated coralline algae) dominant; (5) exposed sites, substrate not specified but presumably bedrock based on the dominant species, *Henricia leviuscula* and *Phyllospadix*; (6) "generally exposed coastal sites", encrusting coralline algae and *Acmea mitra* dominant; and (7) "rocky substrate", *Allopora porphyra* and *Coryphopterus nicholsi* dominant.

5.6 Estuaries

Estuaries are highly productive habitats where terrestrial, freshwater and marine ecosystems meet. Although they account for less than 3% of the BC shoreline, they are used by 80% of all coastal wildlife (PECP 2005). 442 large estuaries were identified in BC from existing mapping products (PECP 2004). MacKenzie *et al*. (2000) surveyed twenty eight central and north coast estuaries. Their objectives were to acquire site-specific information about estuarine ecosystems based on plant community types, to describe the range of estuary types, including biological and geomorphogical information, to create a site classification, and to identify estuaries with particularly high habitat value or rare ecosystems. The report also included a proposed ecosystem classification framework for estuarine wetlands, as part of a broader Wetland and Riparian classification (MacKenzie and Banner 1999). Fourteen estuarine ecosystem associations were recognized. A mapping system has been developed for BC estuaries by Howes *et al.* (1999), including definitions of algal and eelgrass-dominated bio-bands.

5.7 Genetic Diversity

In addition to the genetically-diverse assortment of species in PNCIMA, there is also intraspecific diversity, such as that reported for *Zostera marina* in Washington State (Backman 1991). Lindstrom *et al.* (1997) found distinct genotypes in the red alga *Palmaria mollis* from northwestern and northeastern areas of Vancouver Island. Specimens from northwestern Vancouver Island were more similar to other outer coast sites (outer Queen Charlotte Islands and Sitka, Alaska), whereas those from northeastern Vancouver Island were more closely related to inner coastal sites (Strait of Georgia and Ketchikan, Alaska). Ongoing research by Lindstrom (unpublished) has revealed distinctive genotypes for other intertidal algae in the northern Vancouver Island area.

6.0 SPECIES AT RISK

The BC Ministry of Sustainable Resource Management (BCMSRM) North Island Straits Coastal Plan (BC MSRM 2002) points out the occurrence of red- and blue-listed species of algae in the various shoreline units and warns against tenures and activities that would disturb these species (Table E.2). The draft Quatsino Sound Coastal Plan (BC MSRM and DFO 2004) also records red-listed and blue-listed species. Other red-listed species are reported to occur within the region. However, as previously mentioned, the identity of several of these species requires verification.

Table E.2 Provincial Red and Blue listed algal species occurring or reported to occur in PNCIMA (source: BC MRSM 2002; BC MSRM and DFO 2004).

Species	**Status**	**Location**	**Coastal Plan**
Tayloriella divaricata	Red	Broken Islands unit	North Island Straits
Leptonematella fasciculata	Red	Call Inlet unit	North Island Straits
Hollenbergia nigricans	Red	Deserters and Walker Group	North Island Straits
Dictyoneuropsis reticulata	Red	Hope Island area	North Island Straits
Laminaria sinclairii	Red	Hope Island area	North Island Straits
Myriogramme pulchra	Red	Hope Island area	North Island Straits
Desmarestia tortuosa	Red/Blue	Upper Holberg unit	Quatsino Sound
Laminaria sinclairii	Red	San Josef-Cape Parkins unit	Quatsino Sound
Percursaria dawsonii	Blue	San Josef-Cape Parkins and Quatsino Approaches-Brooks Bay units.	Quatsino Sound
Bonnemaisonia geniculata	Red	PNCIMA	Unknown
Codium ritteri	Red	PNCIMA	Unknown
Eugomontia sacculata	Red	PNCIMA	Unknown
Phycodrys riggii	Red	PNCIMA	Unknown
Stictyosiphon tortilis	Red	PNCIMA	Unknown
Tayloriella abyssalis	Red	PNCIMA	Unknown

7.0 INFORMATION GAPS

- It is not yet known which, if any, species could provide the best indicators of environmental health. Likewise, the long term impact of global warming has not been assessed.
- Productivity of kelp beds and eelgrass beds needs to be determined.
- A comprehensive list of marine plant species occurring in BC has not yet been developed.
- Species that have been found on either side of the region, but not within it, may be discovered with additional surveys.
- The identity of UBC herbarium specimens from the region should be re-examined and their taxonomy updated, if indicated.
- Long-term monitoring stations would help fill knowledge gaps for the region, and allow comparisons of community dynamics in PNCIMA to those of other areas of the northeast Pacific.
- Marine plant beds and estuaries in PNCIMA have not been fully mapped.

8.0 ACKNOWLEDGEMENTS

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9.0 GLOSSARY

Heteromorphic generations – Appearing distinct or different.

Isomorphic – Appearing identical, in this case between generations.

Mesograzers – Use individual seaweeds as both habitat and food.

Morphology – Physical form.

Neritic – Fish residing in waters over the continental shelf that is less than 200 meters deep.

Phenology – The study of the seasonal timing of life cycle events (changes in plants and animals).

10.0 REFERENCE LIST

Adkins, B.D. 1977. Biological and Oceanographic Analysis of the Queen Charlotte Sound Marine Natural Region. Contract no. 76-147 to Parks Canada, National Parks Branch, Parks System Planning Division. 103p.

Anderson, P.J. and Piatt, J.F. 1999. Community Reorganization in the Gulf of Alaska Following Ocean Climate Regime Shift. Marine Ecology Progress Series 189: 117-123p.

Backman, T.W.H. 1991. Genotype and Phenotype Variability of *Zostera marina* on the West Coast of North America. Canadian Journal of Botany 69: 1361-1371p.

BC Ministry of Agriculture, Fisheries and Food. 1996. Kelp Beds. Downloadable Data from Fisheries and Oceans Canada GIS Unit Spatial Data Holdings, Vancouver, BC.

BC Ministry of Sustainable Resource Management. 2002. North Island Straits Coastal Plan. December 2002. BC Coast & Marine Planning Branch. 236p. http://ilmbwww.gov.bc.ca/ilmb/lup/coastal/north_island/nis/index.htm.

BC Ministry of Sustainable Resource Management. 2005. Physical and Biophysical Shorezone Mapping. (accessed August 2006). http://srmapps.gov.bc.ca/metastar/home.do.

BC Ministry of Sustainable Resource Management and Fisheries and Oceans Canada. 2004. Quatsino Sound Coastal Plan. BC Coast & Marine Planning Branch. 197p. http://ilmbwww.gov.bc.ca/ilmb/lup/coastal/north_island/quatsino/index.htm.

Bennett, K. 2003. Haegele Eelgrass Metadata Report: Source Metadata and Digital Data Specifications. Report to Department of Fisheries & Oceans, Canadian Wildlife Service, and Ducks Unlimited. 33p. http://www.shim.bc.ca/atlases/Eelgrass/Eelgrassmetafn.pdf.

British Columbia Research Council. 1947a. Marine Plants of Economic Importance in British Columbia Coastal Waters. Part I. Technical Bulletin. 4. British Columbia Research Council. Vancouver, BC. 13p.

British Columbia Research Council. 1947b. Marine Plants of Economic Importance in British Columbia Coastal Waters. Part II. Technical Bulletin. 10. British Columbia Research Council. Vancouver, BC. 35p.

Coast Information Team. 2003. An Ecosystem Spatial Analysis for Haida Gwaii, Central Coast, and North Coast British Columbia. (accessed August 2006). 184p. http://www.livingoceans.org/documents/ESA%20report%2022Sept03%20distn%20draft.pdf.

Coastal Ecosystems Research Foundation. 2004. Ongoing Research. CERF (Coastal Ecosystems Research Foundation). http://cerf.bc.ca/. (accessed 2004).

Community Mapping Network. 2006. Sensitive Habitat Inventory and Mapping Eelgrass Bed Mapping Atlas. Community Mapping Network. http://www.shim.bc.ca. (accessed 2006).

Coon, L.M. 1983. Marine Plants in British Columbia: Management and Development Strategies and Constraints. Presented at the Canadian Regional Science Association. UBC Paper. 2. British Columbia Marine Resources Branch. 32p.

Coon, L.M. 1990. An Overview of Kelp Inventory Methods used in British Columbia and Results. Presented to the Marine Plant Working Group, BC Ministry of Agriculture, Food & Fisheries, Aquaculture & Commercial Fisheries Branch.

Coon, L.M. and Roland, W.G. 1980. Harvesting Impacts on *Macrocystis integrifolia*: A Preliminary Study. Fisheries Development Report. 12. Marine Resources Branch, Ministry of the Environment, Province of British Columbia. 46p.

Coon, L.M., Roland, W.G., Field, E.J., Clark, E.A.C., and Clayton, W.E.L. 1981. Kelp Inventory 1976: Part 5 - North Coast Vancouver Island, Hope, Nigei and Balaklava Islands. Fisheries Development Report. 20. BC Ministry of Environment - Marine Resources Branch. Province of British Columbia. 19p.

Coon, L.M., Roland, W.G., Sutherland, I.R., and Hall, R.A. 1982. Kelp Inventory, 1978: Northwest Coast of Vancouver Island. Fisheries Management Report. 28. BC Ministry of the Environment - Marine Resources Branch. 16p.

Dethier, M. and Duggins, D.O. 1988. Variation in Strong Interactions in the Intertidal Zone along a Geographical Gradient: A Washington-Alaska Comparison. Marine Ecology Progress Series 50: 97-105p.

Druehl, L.D. 1970. The Pattern of Laminariales Distribution in the Northeast Pacific. Phycologia 9: 237-247p.

Druehl, L.D. and Kemp, L. 1982. Morphological and Growth Responses of Geographically Isolated *Macrocystis integrifolia* Populations when Grown in a Common Environment. Canadian Journal of Botany 60: 1409-1413p.

Duggins, D.O., Simenstad, C.A., and Estes, J.A. 1989. Magnification of Secondary Production by Kelp Detritus in Coastal Marine Ecosystems. Science 245: 170-173p.

Dunster, K. 2003. Eelgrass Mapping Review: Eelgrass Mapping Initiatives in Coastal British Columbia. Prepared for Canadian Wildlife Service. Delta, BC. (accessed August 2006). http://www.shim.bc.ca/eelgrass/Eelgrass_Mapping_Inventory_Final_v1.pdf.

Estes, J.A. 1996. The Influence of Large, Mobile Predators in Aquatic Food Webs: Examples from Sea Otters and Kelp Forests. *In* Aquatic Predators and their Prey. Edited by Greenstreet, S.P.R. and Tasker, M.L. 65-72p.

Field, E.J. 1996. Kelp Inventory, 1993: Areas of the British Columbia Central Coast from Hakai Passage to the Bardswell Group. Fisheries Development Report. 37. BC Ministry of Agriculture, Food, & Fisheries - BC Aquaculture and Commercial Fisheries Branch. Province of British Columbia. 23p.

Field, E.J., Coon, L.M., Clayton, W.E.L., and Clark, E.A.C. 1977. Kelp Inventory 1976: Part 1 - The Estevan Group and Campania Island. Fisheries Management Report. 9. BC Ministry of Environment - Marine Resources Branch. Province of British Columbia. 18p.

Foreman, R.E. 1975. A Method for Inventory of Floating Kelps and its Application to Selected Areas of Kelp Licence Area 12. BERP Reports. 75-1. Submitted to Federal Fisheries and Marine Service and Provincial Marine Resources Branch. 81p.

Foreman, R.E. 1976. Ecology and Population Dynamics of *Nereocystis luetkeana*. BERP Report. 76-2. Submitted to Marine Resources Branch, BC Department of Recreation & Conservation. 89p.

Foreman, R.E. 1977. Benthic Community Modification and Recovery Following Intensive Grazing by *Strongylocentrotus droebachiensis*. Helgoländer Meeresuntersuchungen 30: 468-484p.

Foreman, R.E. 1984. Studies on *Nereocystis* Growth in British Columbia, Canada. Hydrobiologia 116/117: 325-331p.

Gabrielson, P.W., Widdowson, T.B., Lindstrom, S.C., Hawkes, M.W., and Scagel, R.F. 2000. Keys to the Benthic Marine Algae and Seagrasses of British Columbia, Southeast Alaska, Washington and Oregon. Phycological Contribution. 5. Department of Botany, University of British Columbia. Vancouver, BC. 189p.

Graham, L.E. and Wilcox, L.W. 2000. Algae. Prentice Hall. New Jersey, USA. 640p.

Haegele, C.W. and Hamey, M.J. 1980a. Shoreline Vegetation on Herring Spawning Grounds in Kildidt Sound, British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 1592. Fisheries and Oceans Canada. 25p.

Haegele, C.W. and Hamey, M.J. 1980b. Shoreline Vegetation on Herring Spawning Grounds in Laredo Sound, British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 1580. Fisheries and Oceans Canada. 23p.

Haegele, C.W. and Hamey, M.J. 1980c. Shoreline Vegetation on Herring Spawning Grounds in Thompson Bay, British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 1579. Fisheries and Oceans Canada. 21p.

Haegele, C.W. and Hamey, M.J. 1987. Shoreline Vegetation Maps on Herring Spawing Grounds in the Upper West Coast of Vancouver Island. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 1921. Fisheries and Oceans Canada. 43p.

Hawkes, M.W., Tanner, C.E., and Lebednik, P.A. 1978. The Benthic Marine Algae of Northern British Columbia. Syesis 11: 81-115p.

Howes, D.E., Harper, J.R., and Owens, E. 1997. Physical Shore-Zone Mapping System for British Columbia. Resource Inventory Committee, Province of British Columbia. (accessed August 2006). http://ilmbwww.gov.bc.ca/risc/pubs/coastal/pysshore/index.htm.

Howes, D.E., Morris, M., and Zacharias, M.A. 1999. British Columbia Estuary Mapping System. Resources Inventory Committee, Province of British Columbia. (accessed August 2006). http://ilmbwww.gov.bc.ca/risc/pubs/coastal/estuary/index.htm.

Johannessen, D.I., Verrin, S.M., Winchell, P., Truman, K., Birch, R., and Lindstrom, S. 2005. Biophysical Overview Report for the Pacific North Coast Integrated Management Area Parts A, B, and C: Draft for Expert Review. Fisheries and Oceans Canada, Pacific Region, Science Branch.

Lamb, E., Dolmat, Y., Holloway, J., Shankel, C., and Megill, W. 1999. Findings of the 1999 CERF Survey of Coastal Biodiversity on the Central Coast of British Columbia. CERF Central Coast Report. Report submitted to Fisheries and Oceans Canada, Oceans Directorate. Vancouver, BC. http://cerf.bc.ca.

Leaman, B.M. 1976. The Ecology of Fishes in British Columbia Kelp Beds I. Barkley Sound Nereocystis Beds. Marine Resources Branch, British Columbia Department of Recreation and Conservation; Institute of Animal Resource Ecology, University of British Columbia.

Leaman, B.M. 1980. The Ecology of Fishes in British Columbia Kelp Beds I. Barkley Sound Nereocystis Beds. Fisheries Development Report. 22. BC Ministry of Environment- Marine Resources Branch. Province of British Columbia.

Lindstrom, S.C. 1998. The seaweed resources of British Columbia. *In* Seaweed Resources of the World. Edited by Critchley, A.T and Ohno, M. Japan International Cooperation Agency. Yokosuka. 266-272p.

Lindstrom, S.C. and Gabrielson, P.W. 1989. Taxonomic and Distributional Notes on Northeast Pacific Antihamnieae (Ceramiales, Rhodophyta). Japan Journal of Phycology (Sorui) 37: 221-235p.

Lindstrom, S.C., Olsen, J.L., and Stam, W.T. 1997. Postglacial Recolonization and the Biogeography of *Palmaria mollis* (Rhodophyta) along the Northeast Pacific Coast. Canadian Journal of Botany 75: 1887-1896p.

Living Oceans Society. 2003. Salmon Farm Tenures in British Columbia. Living Oceans Society. http://livingoceans.org.

Lobban, C.S. and Harrison, P.J. 1994. Seaweed Ecology and Physiology. Cambridge University Press. New York, USA. 366p.

Lüning, K. 1990. Seaweeds: Their Environment, Biogeography, and Ecophysiology. Wiley & Sons, Inc. New York. 527p.

MacKenzie, W. and Banner, A. 1999. Classification and Description of Wetland and Related Ecosystems in British Columbia. Working Draft. Ministry of Forests Research Program, FRBC Project, Resource Inventory Committee, BC Wetlands Working Group. 88p.

MacKenzie, W., Remington, D., and Shaw, J. 2000. Estuaries of the North Coast of British Columbia: A Reconaissance Survey of Selected Sites, May 1, 2000. A Cooperative Project of the Ministry of Environment, Lands and Parks and the Ministry of Forests, Research Branch. Province of British Columbia. 98p. http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/wetlands/reports.html.

Mann, K.H. 1982. Ecology of Coastal Waters: A Systems Approach. University of California Press. Berkeley, CA. 322p.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., and Francis, R.C. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bulletin of the American Meteorological Society 78: 1069-1079p.

Morris, M. and Thuringer, P. 2001. Discussion Report: Interaction of Coastal Species with Intertidal Habitat Types. Report to the BC Land Use Coordination Office. Victoria, BC. 17p.

Mumford, T.F. 1987. Bibliography for *Nereocystis luetkeana* (Bull kelp). DNR Notes. 47. Washington State Department of Natural Resources. 15p.

Mumford, T.F. 1992. Bibliography for *Nereocystis luetkeana* (Bull kelp): Updated. Washington State Department of Natural Resources. 15p.

Norris, J.N. and Abbot, I.A. 1972. Some New Records of Marine Algae from *RN Proteus* Cruise to British Columbia. Syesis 5: 87-94p.

O'Clair, R.M. and Lindstrom, S.C. 2000. North Pacific Seaweeds. Plant Press. Auke Bay, Alaska. 160p.

Pacific Estuary Conservation Program. 2004. PECP Identified Estuaries of British Columbia Mapping Project. Community Mapping Network. 18p. http://www.shim.bc.ca/. (accessed 2006).

Pacific Estuary Conservation Program. 2005. National Round Table on the Environment and the Economy. (accessed August 2006). http://www.nrtee-trnee.ca/eng/programs/Current_Programs/Nature/Natural-Heritage/Documents/PECP-Case-Study-Complete_e.htm.

Petro-Canada. 1983. Offshore Queen Charlotte Islands Initial Environmental Evaluation. 1. Petro-Canada.

Phillips, R.C. 1979. Ecological Notes on *Phyllospadix* (Potamogetonaceae) in the Northeast Pacific. Aquatic Botany 6: 157-170p.

Phillips, R.C. and Menez, E.G. 1988. Seagrasses. Smithsonian Contributions to the Marine Sciences. 34. Smithsonian Institution Press. Washington, DC. 96p.

Pojar, J. and MacKinnon, A. (*eds.*). 1994. Plants of Coastal British Columbia. Lone Pine Publishing. Vancouver, BC. 527p.

Scagel, R.F. 1957. An Annotated List of the Marine Algae of British Columbia and Northern Washington (Including Keys to Genera). Bulletin National Museum of Canada 150; Biological Series (National Museum of Canada) 52. Ottawa, Ontario. 289p.

Scagel, R.F. 1961. The Distribution of Certain Benthonic Algae in Queen Charlotte Strait, British Columbia, in Relation to Some Environmental Factors. Pacific Science 15: 494-539p.

Scagel, R.F. 1966. Marine Algae of British Columbia and Northern Washington, Part 1: Chlorophyceae (Green Algae). Bulletin (National Museum of Canada); 207; Biological Series (Ottawa); 74. Department of the Secretary of State. Ottawa, Ontario.

Scagel, R.F. 1970. Benthic Algae of Bowie Seamount. Syesis 3: 15-16p.

Scagel, R.F., Gabrielson, D.G., Garbary, L., Golden, M.W., Hawkes, S.C., Lindstrom, J., Oliveira, C., and Widdowson, T.B. 1993. A Synopsis of the Benthic Marine Algae of British Columbia, Southeast Alaska, Washington and Oregon. University of British Columbia, Phycological Contribution. 3. University of British Columbia. Vancouver, BC. 532p.

Searing, G.F. and Frith, R.H. 1995. British Columbia Biological Shore-Zone Mapping System. BC Ministry of Resources Inventory Standards Committee. (accessed August 2006). http://ilmbwww.gov.bc.ca/risc/pubs/coastal/bioshore/index.htm.

Shaffer, A. 2004. Preferential Use of Nearshore Kelp Habitats by Juvenile Salmon and Forage Fish. Edited by Droscher, T.W. and Fraser, D.A. 2003 Georgia Basin Puget Sound Research Conference Proceedings. Puget Sound Water Quality. Olympia, Washington. 11p.

Sloan, N.A. and Bartier, P.M. 2000. Living Marine Legacy of Gwaii Haanas I: Marine Plant Baseline to 1999 and Plant-related Management Issues. Parks Canada Technical Report in Ecosystem Science. 27. Parks Canada-Heritage Canada. Halifax-Atlantic Canada. 104p.

Sutherland, I.R. 1990. Kelp Inventory 1989: The Vancouver Island and Malcolm Island Shores of Queen Charlotte Strait (Including a Summary of Historical Inventory Information for the Area). Fisheries Development Report. 36. BC Ministry of Agriculture and Fisheries - Aquaculture and Commercial Fisheries Branch. Province of British Columbia. 40p.

Valentine, J.W. 1966. Numerical Analysis of Marine Molluscan Ranges on the Extratropical Northeastern Pacific Shelf. Limnology and Oceanography 11: 198-211p.

van den Hoek, C. 1984. World-wide Latitudinal and Longitudinal Seaweed Distribution Patterns and their Possible Causes, as Illustrated by the Distribution of Rhodophytan Genera. Helgoländer Meeresuntersuchungen 38: 227-257p.

Westlake, D.F. 1963. Comparisons of Plant Productivity. Biological Reviews 38: 385-429p.

Wright, N. 2002. Eelgrass Conservation for the BC Coast: A Discussion Paper. Prepared for BC Coastal Eelgrass Stewardship Project. 16p. http://www.shim.bc.ca/atlases/atlas.html#eelgrass.

Wynne, M.J. 1985. Two New Species of *Tayloriella* (Rhodomelaceae, Rhodophyta) from the Northeastern North Pacific. Journal of Phycology 21: 107-114p.

Wynne, M.J., McBride, D.L., and West, J.A. 1973. *Polyneuropsis stolonifera* gen. et sp. nov. (Delesseriaceae, Rhodophyta) from the Pacific Coast of North America. Syesis 6: 243-253p.