Washington Coastal Kelp Resources

Port Townsend to the Columbia River

Summer 2014

Final Report

March 31, 2015

by

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Principle Findings

The principle findings from the 2014 kelp resource inventory were as follows:

1) The total Washington state coastal kelp resource within the survey range of Port. Townsend to the Copalis River occupied canopy/planimeter areas of 850/2,901 ha, respectively, representing significant decreases of 34% in canopy area and 26% in planimeter area from that observed in 2013. Range-wide canopy densities (RDI) for *Nereocystis/Macrocystis* canopies were .29, a significant decrease from the .33 measured in the 2013 inventory.

2) *Nereocystis* canopy/planimeter range-wide surface extent measured 290/1,573 ha, representing significant decreases of 47% in canopy area and 33% in planimeter area from that observed in 2013. Canopy density decreased significantly from .23 to .18. Within the Straits of Juan de Fuca, significant decreases in canopy area of 50% and planimeter area of 38% were noted. Significant decreases in *Nereocystis* canopy/planimeter area of 27%/19%, respectively, occurred along the "open coast" portion of the range. Canopy density within the Straits of Juan de Fuca significantly decreased from .28 to .22, and on the open coast significantly decreased from .12 to .11.

3) *Macrocystis* canopy/planimeter area range-wide extent measured 560/1,328 ha, representing significant decreases in canopy area of 25% and planimeter area of 16%, when compared with the 2013 inventory. Canopy density significantly decreased from .47 to .42. *Macrocystis* canopy/planimeter areas significantly decreased by 25%16%, respectively, within the Straits of Juan de Fuca, and along the open coast, canopy/planimeter areas decreased by 26%/15%, respectively, but were statistically insignificant. Canopy density within the Straits of Juan de Fuca significantly decreased from .45 to .40, and also on the open coast significantly decreased from .54 to .47.

4) The survey sub-range with the most consistent total kelp canopy/planimeter areas, was between Neah Bay (map 15) and Destruction island (map 25), an area containing large *Macrocystis* canopies. In 2014, no sub-ranges experienced an increase in kelp canopy extent, while the sub-range with the greatest decrease in surface extent was along the Straits of Juan de Fuca from Twin Rivers to Cape Flattery, which experienced significant decreases in both canopy forming species, but especially *Nereocystis.*

5) Canopy species composition in 2014 was determined to be approximately 34%/66% *(Nereocystis/Macrocystis*) within both mixed canopies and with regard to the total kelp resource. Similar species composition indices in the 2013 inventory were determined to be 37%/63% *(Nereocystis/Macrocystis)* in mixed canopy areas and 42%/58% within the total range-wide resource. Significant decreases in *Nereocystis* along the Straits of Juan de Fuca were responsible for the shift in species composition.

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WASHINGTON COASTAL KELP RESOURCES

Port Townsend
to the
Columbia River

Section 1

Final Report

August 2014

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Introduction

Along the Washington coast there is an abundant "kelp" resource assemblage present (brown seaweeds - Order Laminariales). It is represented by three families, 16 genera and 26 species, more than any other area worldwide (Druehl 1969). Of these, the dominant, near shore, surface canopy forming species include *Nereocystis luetkeana* (bull kelp) and *Macrocystis integrifolia* (giant kelp). These species are present along 313 kilometers (12%) of the coast of Puget Sound and the Strait of Juan de Fuca, and along the outer coast from Cape Flattery to Destruction Island (Thom and Hallum 1990).

Each surface canopy, supported by air-filled pneumatocysts, is composed of individual plants that are attached to the bottom subtidal habitat by root-like "holdfasts." The vertical stipes, stretching from the sea floor to the surface canopy, provide critical habitat for numerous species of commercial and sport fish, as well as invertebrates (summary: Strickland and Chasan 1989). Along the central California coast, 77 species of fish have been identified in kelp forests (Miller and Geibel 1973), and McLean (1962) identified 204 species of invertebrates in a predominately *Nereocystis luetkeana* kelp forest located south of Monterey. Prominent marine mammals, such as seals, sea lions and sea otters, are also associated with this important near-shore habitat (Morejohn 1977). Most recently, sea otters have become re-established within the kelp beds of the Washington outer coast (Bowlby *et al.* 1988).

In addition to its role as an essential marine habitat, coastal kelp canopies exhibit some of the highest primary productivities of any ecosystem on earth (Wheeler and Druehl 1986). This material is provided to the food chain in three ways: 1) directly, while the kelp plants are still attached, 2) indirectly, by providing detritus that is eaten after it has fallen to the bottom, and 3) by producing dissolved organic matter (DOM) that is food for many microorganisms (Mumford 1989). Kelp bed primary productivity within *Nereocystis/Macrocystis* beds has been estimated at 350-2,800 g carbon/m^2 (Wheeler 1990), placing them ahead of tropical rain forests, reefs and estuaries, warm temperate forests, and cultivated land with regard to their contribution to the overall food chain.

Nereocystis luetkeana occurs from Point Conception to the eastern Aleutian Islands (Druehl 1970), and is the dominant, surface canopy kelp north of Santa Cruz, California. Its hydrodynamic shape makes it especially well suited to high exposure, "open coast" environments (Foster and Schiel 1985). *Nereocystis* is predominately an annual (Abbot and Hollenberg 1976), although mature plants have been seen to persist for up to 18 months. Impressive growth rates of up to 10 cm per day have been observed in young plants, and the mature surface canopy reaches its maximum extent in July through October. Sporangial sori mature at the surface between May and December, drop from the blade, and sink to the sea floor before releasing their spores (Abbot and Hollenberg 1976).

Macrocystis integrifolia has a range similar to bull kelp (Druehl 1970), and may form thick canopies in shallow water that is protected from heavy wave action. *Macrocystis* is a perennial, at least the basal holdfast and attached sporangial thalli. It develops its maximum surface canopy between May and October, and is found on sloping protected rocky habitat from the intertidal to shallow subtidal (Abbot and Hollenberg 1976).

Mixed canopies, containing both *Nereocystis* and *Macrocystis,* are present along much of the Washington coast-line west of Low Point, and when these species co-occur, *Nereocystis* is most commonly found offshore and *Macrocystis* inshore (Rigg 1915).

The extent of the total kelp canopy occupied by each of these individual species is dynamic from year to year. Annual fluctuations in canopy species composition are thought to be the result of a complex combination of physical, chemical, and biological factors (Foster and Schiel 1985). Water motion (Rosenthal et al. 1974), water temperature/nutrients (Craig Barilotti pers. comm.), light intensity (Luning 1981), available habitat, and exposure (Foster and Schiel 1985) have all been associated with kelp canopy health and development. In addition, warm water temperature anomalies, especially those associated with the "El Nino Southern Oscillation" (ENSO), have been known to dramatically reduce the abundance, diversity and stability of the near-shore kelp forest community (Tegner and Dayton 1991). In the latter months of 1997 and early 1998, the west coast of North America was again influenced by a significant ENSO countercurrent. It lasted several months, and raised surface sea temperatures by as much as eight degrees Fahrenheit in southern California and five degrees off the Washington coast (NOAA 1998). Aerial imagery obtained in the summer of 1998 revealed that the substantial southern California near shore *Macrocystis pyrifera* kelp canopy resource had been largely eliminated south of Newport Beach, presumably by these elevated temperatures or by resultant invertebrate overgrazing. Little is known regarding the effects of the ENSO, or other sea temperature anomalies, on the *Nereocystis* kelp resource.

The relationships of these individual physical factors, and identification of those that may be "limiting" at any one time, have yet to be fully understood, and continue to be the subject of numerous ongoing research investigations. In addition, adjacent kelp forests that appear to be exposed to similar physical factors may frequently produce vastly different canopy species compositions, further revealing the complexity of this dynamic habitat.

Biological factors, including the impact of herbivorous grazers, are also a major element determining the extent and diversity of the near shore kelp resource (Foster and Schiel 1985). In that regard, the effects of an ever increasing sea otter population on the Washington state-wide kelp resource, and a better understanding of the role of the otter in structuring near shore ecology, are the subject of ongoing research interest (Kivitek 1989). In 1969-70, 59 sea otters were translocated from Alaska to the outer Olympic Coast of Washington State (Jameson *et al* 1982). This population increased dramatically to 100 animals in 1987 (Bowlby *et al* 1988), and to over 400 individuals in 1997 (Jameson, National Biological Survey, pers. comm.), and to over 1,000 in a recent annual census (Jameson and Jefferies 2013) Their predation on invertebrate kelp

grazers, mainly sea urchins (Jameson 1986), has been shown to dramatically reduce the density of these species, and to increase kelp canopy extent in areas of significant otter abundance (Kivitek 1989). This increase in the kelp resource has been observed to have dramatic effects on the diversity and abundance of associated species, and the resulting near shore community structure (Estes and Palmisano 1974). This otter/urchin/kelp interrelationship has resulted in the sea otters designation as a "keystone predator". Kvitek (1998) supported this designation by showing that sea otter predation along the Washington outer coast has significantly reduced the numbers of sea urchins and the grazing pressure that they exert. It was concluded that in the presence of an established otter population, sea urchin grazing was not the dominant force structuring the near-shore community. Additional research will be needed to document the long-term effects of this important marine mammal on the Washington coastal kelp forest ecosystem.

In addition to the natural effects of physical, chemical, and biological factors on the near-shore environment, occasional "man-caused" pollution events may have significant additional effects on species abundance and diversity (Foster and Schiel 1985). On July 22, 1991, the fish processing ship "Tenyo Maru" collided with the Japanese freighter "Tuo Hai" approximately 22 miles WNW of Cape Flattery (Rogne *et al* 1993). The Tenyo Maru was heavily damaged from the collision, and sank in over 500 feet of water. Within minutes, an estimated 100,000 gallons of #2 diesel fuel, and an unspecified quantity of IFO #180 was released into the marine environment. In addition, oil continued to be released at a rate of 500 gallons/per day during the subsequent weeks. The prevailing WNW winds and seas carried the fuel oil towards both Vancouver Island and the Cape Flattery area. During its time at sea the oil was weathered, and would eventually be observed as "tar balls" in both the kelp beds, and to a lesser extent on rocks and beaches from Neah Bay to Cape Alava. Ongoing clean-up operations continued for several months after the spill in an attempt to minimize damage to the marine environment. Questions were raised from this event regarding the long-term effects of petroleum pollution on these kelp canopy forming species, and the resultant vulnerability of the related marine community.

Macrocystis canopies have been observed to be largely unaffected by hydrocarbon pollution, presumably due to the temporary protection provided by plant produced mucus (Mitchell *et al.* 1970), and the physical location of the reproductive sporophylls near the basal holdfast. Pollution effects on *Nereocystis* canopies have only been recently investigated (Antrim *et al.* 1995). Surface stipe tissue bleaching and loss, as a result of hydrocarbon contact, was observed both by Antrim (1995), and during the field clean-up operation following the "Tenyo Maru" spill. However, it is still unclear whether or not subsequent seasonal *Nereocystis* recruitment is affected by these polluting elements.

In addition to hydrocarbon pollution, preliminary research from California State University, Long Beach indicated elevated levels of radioactive iodine and cesium in kelp along the California coast following the 2011 Japan earthquake and trans-oceanic tsunami. It was indicated that direct negative effects of this type of pollution on humans

were unlikely, but that the effects throughout the marine food chain were unknown and in need of further research.

The presence of particulates, in the form of dissolved marine sediments, also have the potential for directly influencing the growth and surface extent of coastal kelp canopies, by attenuating the light penetrating the water column (Luning 1981). Indirect effects include changing densities and diversities of the marine organisms that depend on the kelp for food and/or habitat (Estes and Palmisano 1974). Increased nearshore sedimentation is frequently observed as a natural process during times of high tidal current flux in areas of sand or "mudstone" bottom composition. Marine sediment plumes have also been observed in the vicinity of river mouths during periods of elevated rainfall, and may persist for days or weeks after the rainfall stops. Increased marine sedimentation may also be the by-product of other intentional nearshore reclamation projects such as harbor dredging and maintenance, highway construction, landslide mitigation, and watershed modification.

In September 2011, Washington State and the National Park Service began the ambitious project of restoring the Elwha river watershed for the benefit of anadromous fisheries (NOAA 2008). Removal of the Elwha dam began in September 2011 and finished in March 2012, and researchers are optimistic that salmon will return to the Elwha River after a 100 year hiatus. The by-product of this restoration has been the transport of millions of cubic yards of sediment into the marine environment from the Elwha River watershed, and resultant tidal current transport east and west along a portion of the Straits of Juan de Fuca. Field research is currently underway to document the effects of this increased sedimentation on the Washington State nearshore environment (Helen Berry, pers. comm.).

The dynamic and sometimes vulnerable nature of the coastal kelp resource, considering its importance as habitat and food for hundreds of related species, points out the need for systematic methods of accurately assessing its extent and vitality. Until 1989, the Washington coastal kelp resource had only been sporadically mapped and analyzed since an initial state-wide visual survey conducted in 1912-1915 (Rigg 1912, 1915 - see: Mumford 1989 for review of previous survey efforts). Earlier ground based estimates of kelp canopy extent have given way to modern aerial surveys, which provide a cost effective and accurate methodology for the mapping and quantification of near shore kelp resources (Jamison 1971).

A previous study (Thom and Hallum 1990), utilizing two data sets from Puget Sound taken 66 years apart (one visual and one aerial photographic), indicated that there may have been an increase in kelp forest extent within the Sound. It was concluded, though, that differences in survey methodology and the lack of available historical data sets have made quantitative comparisons of long-term kelp resource abundance difficult.

A substantial portion of this dynamic kelp resource habitat falls within the Olympic Coast National Marine Sanctuary (OCNMS), established July 16, 1994. The management area occupies 3300 square miles, and includes the coastal zone between

Neah Bay and the Copalis River (NOAA 1995). Within this sanctuary are three national wildlife refuges: 1) Flattery Rocks, 2) Quillayute Needles, and 3) Copalis. OCNMS administration has four major components and mandates: 1) sanctuary management, 2) public education, 3) environmental regulation, and 4) an ongoing research program. The Washington Department of Natural Resources (WDNR) manages two million acres of state-owned aquatic lands (Mumford 1992). Aquatic or submerged lands include tidally influenced lands such as tidelands and bedlands, as well as the beds and shores of navigable freshwater bodies. Within these areas are located: 1) all subtidal aquatic plant communities (kelp, seagrass, and seaweeds), 2) over 40% of intertidal plant communities (seaweeds and seagrasses), and 3) freshwater plants living on the beds and shorelands of 70% of the navigable rivers and lakes. Washington State's aquatic lands have been a significant public resource since the were granted from the federal government at statehood in 1889. These lands are managed for the benefit of all current and future citizens of the state. Certain public aquatic rights are maintained in trust for the people, including the public rights of fishing, navigation and commerce. These rights are public ownership interests that apply to all tidelands, shorelands, navigable waters and underlying bedlands.

An Aquatic Management Plan was adopted by the WDNR in 1987. It calls for aquatic plant management through preservation, habitat protection and restoration, harvest management and cultivation. In 1988, WDNR imposed a moratorium on the commercial harvest of all wild seaweeds, until such time as more specific management guidelines can be adopted. Experimental harvest of seaweeds is currently permitted, if information is generated that will further management objectives.

In response to this conservation and management mandate, Ecoscan Resource Data was first contracted in 1989 by WDNR to establish a kelp resource mapping and analysis program along the coastal zone between Port Townsend and the Columbia River. Similar annual inventories were repeated in 1990 through 1992 and 1994 through 2013 (Van Wagenen 1989-1992, 1994-2013a). Results from the first four inventories were summarized following the 1992 survey (Van Wagenen 1989-1992b), and again following the 1997 survey (Van Wagenen 1989-1997c).

The primary objective of this inventory, as initiated in 1989, was the establishment and maintenance of an annual, state-wide, coastal kelp resource mapping and monitoring program that would accurately reflect the seasonal maximum resource extent, by species. The methodology utilized was designed to not only allow a systematic, accurate analysis of multi-year data from current and future inventories, but to also allow meaningful comparisons with historic surveys as well.

In 2010, the kelp resources of the Smith/Minor Islands Aquatic Reserve (southern extent of the San Juan Islands) were added to the mapping and analysis effort and a separate data base established to allow an increased kelp inventory effort throughout the San Juan Islands and Puget Sound in subsequent years. Beginning in 2012, and in succeeding years, kelp resources within the Cypress Island and Cherry Point Aquatic Reserves were also inventoried in addition to Smith/Minor Islands.

Data acquisition was accomplished utilizing cost-effective and versatile aerial digital color photography. Once obtained, each image was contrast enhanced to closely duplicate the appearance and resource rendition capability of aerial color-infrared film, which was discontinued by Eastman Kodak in 2006. Data processing included the mapping of the imaged kelp canopies onto a consistent baseline map series, followed by a computer measurement of kelp canopy extent. Data analysis for short term trends in kelp canopy extent was accomplished by statistically comparing indices from the current inventory with those of the previous year. Finally, measurements of resource abundance were tabulated and graphically presented in several formats to serve the needs of: a) field researchers conducting small-scale investigations within individual kelp beds, b) administrative resource managers considering long-term trends over large areas, and c) agency computer Geographic Information System (GIS) professionals, utilizing kelp canopy spatial extent as another "layer" in a larger environmental data model.

Methods and Results

The methodology utilized in this kelp resource inventory was divided into four phases:

1) Kelp canopy aerial photography and species composition estimations,
2) Qualitative kelp canopy mapping and species determination,
3) Quantitative kelp canopy/planimeter area and density analysis, and
4) Geographic Information System (GIS) electronic data-layer creation/file transfer.

The methods utilized in this current survey, with the exception of necessary changes in photographic equipment, as noted, were similar to those used in previous inventories (1989-1992, 1994-2013), to ensure data compatibility and comparability with these and other earlier studies.

Although the defined scope of this study was limited to the measurement of current resource abundance, specific comparisons were made with the last previous systematic analysis (2013), to document short-term changes in kelp canopy extent.

1) Kelp Canopy Aerial Photography and Species Composition Estimations

A) Kelp Canopy Aerial Photography

The methodology related to obtaining high-quality imagery of the fully developed 2014 Washington coastal kelp resource was divided into two sections: 1) survey timing, imaging, and logistic considerations, and 2) photography of the 2014 kelp resource.

1) Survey Timing, Imaging, and Logistic Considerations

The seasonal timing, photographic scale, and flight parameters of this aerial survey were established, as in previous surveys, to systematically obtain imagery that best represented the maximum extent of the current kelp resource. Acceptable "survey windows" were chosen for the aerial over-flights in response to several biological (seasonal timing of maximum canopy development), physical (tidal level, weather and sea state) and logistic factors (length of survey range).

Seasonal timing of maximum kelp canopy development was the major biological factor involved in scheduling this resource survey, and established the criteria around which all other logistic decisions were made. It has been generally accepted, in Washington state, that the maximum extent of canopy forming kelp species occurs in August through October, with maturity of the *Nereocystis* canopy determining the beginning of this "biological window", and late summer storms determining the end (Thomas Mumford, Ron Jameson pers. comm.).

Within this three month period, several acceptable "tidal windows" were selected (utilizing NOAA tide tables for Destruction Island, Neah Bay, Twin Rivers and Port Townsend), that would allow the aerial imagery to be obtained at tidal levels of less than +1.0' MLLW. Once the tidal windows were established, the actual survey was conducted during the first window that had acceptable associated environmental conditions. These conditions included adequate ceiling and visibility (>8,000' MSL and five miles), surface winds less than ten knots, sea/swell less than five feet, and a sun angle of greater than 30 degrees from vertical. In Washington state, changeable weather (especially coastal fog, high winds and sea state) can be a major limiting factor on survey timing, and can frequently reduce the number of acceptable survey days in a given season to less than five. During the previous surveys, the vast majority of the aerial imagery was obtained within these optimum biological, tidal, and environmental windows, thereby allowing meaningful multi-year comparisons of seasonal kelp resource areal extent.

The aircraft altitude (7,500' MSL) and photographic scale (1"=2,500') used for these surveys was selected to provide a good balance between resource resolution and rendition on the imagery, the selected base-mapping scale (1:12,000), and the overall length of the survey area (110 miles). At this altitude and photographic scale, the entire survey range containing kelp (Port Townsend to Destruction Island) can be accurately recorded during a single low-tidal period. Considering the changeable nature of Washington coastal weather; this methodology has allowed the maximum utilization of the few optimum survey dates.

The film utilized on all surveys up through 2008 was 70 mm Kodak color infrared - type 1443, the accepted standard for use in documenting the areal extent of marine surface vegetation. Its ability to increase the contrast between kelp and the surrounding water, without sacrificing resolution, made it ideal for resource surveys of this type. 1n 2006, Eastman Kodak announced the discontinuation of 70mm Color Infrared Type 1443 Film, and no subsequent suitable film replacement has become available. Imagery obtained of the complete Washington kelp resource on September 14, 2008 utilized the last color 70mm color infrared film known to exist in North America, and, as a scientific recording medium, is sorely missed.

In response to the need to continue this important resource inventory in subsequent years, and to have results that are statistically comparable, digital color imagery, with contrast enhanced to simulate the appearance color infrared film, was utilized. A Nikon D200 digital (35mm D-SLR) camera was used to acquire the imagery. It was equipped with a 50mm Sigma (f 1.4) lens, and was approximately equivalent in focal

length to the 75mm medium format lens (.7x focal length multiplication factor) used on all surveys through 2008. The camera was mounted in the aircraft in a vertical orientation within the same aerial survey port that has been utilized since 1989, with the "long" axis of the image perpendicular to the coastline, thereby allowing maximum offshore coverage. The camera was connected via a USB (Universal Serial Bus) connection to a "tablet style" laptop computer. The camera was controlled by Nikon Camera Control Pro 2 software (v. 2.8.1), and allowed complete remote control over the camera exposure and image acquisition. The software and camera were set to create and store two, individual format, identical images for each exposure, and all files were stored directly on the computer hard disk after acquisition. The file types included high-resolution 12-bit "RAW NEF" (Nikon Exchange Format) files (15.4 MB), and "fine resolution" (2592 x 3872 pixel) "JPG" files (3.6 MB). The NEF files were later contrast enhanced to simulate the appearance of color-infrared film, and the JPG files were used for "backup" and as standard color imagery included with the survey. The camera viewfinder was equipped with a small "Sky Eye" CCD camera, which, when combined with a 6" portable LCD monitor, provided an accurate depiction of the camera visual field before triggering the exposure using a Nikon MC-36 remote. As in all previous film-camera inventories through 2008; continuous, sequential, vertical digital photographs (20%-30% overlap) were taken from 7,500' MSL throughout the survey range.

To ensure an accurate transition in methodology from the film to digital era, a complete set of digital imagery of the entire survey range from the Copalis River to Port Townsend was obtained under optimum environmental and tidal conditions on September 15, 2008. This was compared to color-infrared film imagery of the 2008 resource obtained the previous day, September 14th, 2008,. The imagery from the two virtually identical surveys was utilized to standardize the methodology for continuation of the mapping and analysis of the Washington coastal kelp resource in years 2009 and beyond.

2) Photography of the 2014 Kelp Resource

When the biological, tidal, imaging, and logistic factors were considered together, possible "optimum survey windows" were established for the 2014 kelp resource inventory: 1) August 9-14, 2) August 23-28, and 3) September 9-11. The lack of acceptable tidal levels (less than 1.0' (+) MLLW) through the survey range after September 11th limited the "optimum windows" for the 2014 inventory to these three.

Aerial photography of the 2014 Washington State coastal kelp resource was accomplished, under excellent associated environmental conditions, on two separate survey dates, August 10th, and August 11th , 2014. Continuous, sequential imagery was obtained from the Copalis River mouth to Port Townsend, including Protection Island, on August 10th, 2014. Due to persistent patchy fog from Destruction Island to Neah Bay, imagery throughout this range was obtained, but not utilized in the subsequent analysis. On August 11th, the remaining imagery from Destruction Island to Neah Bay, including Tatoosh Island, was obtained under optimum associated conditions.

Specific flight data for the 2014 aerial imagery acquisition were included in figures 1.1 & 1.2, and tidal levels (NOAA), including the "time of low tide," under which the imagery was recorded were included in figures 1.3 for five survey locations from Destruction Island to Port Townsend.

As in previous surveys, approximately 20% shoreline was included on each image to facilitate accurate projection onto the base-line maps. Larger canopies, that were not fully recorded on the initial "in-shore" photographic transect, were referenced on parallel "off-shore" flight lines. Each new transect was "side-lapped" by 30%-40% with those in-shore, to facilitate the accurate mapping of these off-shore canopies. All imagery on both survey dates was collected within target biological, physical and logistic survey "windows".

The imagery from both survey dates was "contrast enhanced," as previously discussed and appeared virtually identical in color appearance and resolution to that of color-infrared film. The primary imagery from both survey dates was of excellent quality, and judged suitable for the complete, subsequent mapping of the resource. The backup imagery containing patchy fog, obtained on August 10th between Destruction Island and Neah Bay, was not used in the mapping process. The "contrast enhanced" color, in addition the normal color imagery was sequentially indexed by map page and image number. Contact sheets/map page of all "contrast enhanced" imagery were presented as: "Washington Coastal Kelp Resources - Summer 2014 - Aerial Survey Imagery" - "Port Townsend to the Copalis River." The actual color and color enhanced imagery are included on the 2014 Washington Coastal Kelp Resource DVD's in each final report binder.

B) Kelp Canopy Aerial Species Composition Estimations

In order to facilitate the accurate determination of canopy species composition during the mapping process, low-altitude observation ("air-truth") flights were conducted from 2,000' MSL on August 11, 2014. A total of four flight hours were spent making independent qualitative observations of individual kelp canopy species composition, and results were recorded on maps from the 2013 inventory.

Visual observations of species composition were spatially divided into three "species classes", which included: 1) 100% *Nereocystis luetkeana*, 2) 100% *Macrocystis integrifolia*, and 3) "mixed canopies", containing both species. The composition of each mixed canopy area was also estimated (% *Nereocystis* / % *Macrocystis*), based on the relative sea surface area occupied by each species. Results of these mixed canopy estimations were tallied in multiples of 10 percent (80% *"Nereo"* / 20% *"Macro"*, etc.), to allow faster, more consistent data acquisition from the aerial platform. These "air-truth" observations were utilized in conjunction with the imagery to determine the areal extent of each species, as described under "Kelp Canopy Species Determination and Planimeter Area Mapping." Associated environmental data and observations from the visual over-flights were presented in figure 2.1.

2) Qualitative Kelp Canopy Mapping and Species Determination

Kelp bed mapping was accomplished in three phases: A) base-line map preparation, B) kelp bed canopy area mapping and indexing, and, C) kelp canopy species determination and planimeter area mapping.

A) Base-line Map Preparation

The base-line maps for this coastal kelp survey were originally designed for the 1989 inventory, and subsequently used again in all subsequent efforts. This base-map series presents an accurate and continuous depiction of the Washington state coastal zone from Port Townsend to the Columbia River, and allowed the systematic mapping of the range-wide resource. Forty-one contiguous base-line maps (24"x36", scale 1:12,000) were made of the Washington coastal zone between Port Townsend and the Columbia River, using USGS 7 1/2' quadrangle maps (scale 1:24,000) as a reference. These maps offered extensive shoreline detail, high accuracy, and continuous coverage for the entire survey range. Each of the "quad" maps was enlarged to a scale of 1:12,000 on a calibrated photocopier (Sharp "8400"). The contiguous "shoreline" portions of each of the enlarged maps were then assembled together, and became the land reference on each of the base maps. All standard detail from these USGS maps was preserved, including prominent shoreline features, offshore rocks, rivers, beaches, rocky intertidal habitat, towns, harbors, and topographic relief.

A range-wide index was included, showing the location of each individual map plate (figure 3.1). An additional map index, covering the survey range containing kelp (Port Townsend to Destruction Island), is presented in figure 4.1. The maps were indexed by map number (table 1), and map name (table 2), and numbered kelp beds present on each map page were also included. To aid in orientation and facilitate the "field use" of the maps, prominent geographic features were listed alphabetically in tabular form (table 3), with cross-references to the map name and number where they were found.

Four control points (A-D), oriented to the Universal Transverse Mercator (UTM) coordinate system - Zone 10, were chosen for each map that contained kelp, and were listed in table 4. This coordinate system was chosen since a UTM 1000 meter "grid" was already on the majority of the USGS 7.5' "quad maps". After enlargement this grid was preserved, and allowed the accurate establishment of these references. The points were arranged (A-D) using east to west orientation on maps W1-W16, and, north to south orientation on maps W17-W25. Maps W26-W41 did not contain control points, since kelp canopies have not been observed within this range, and subsequent digitizing was not required.

B) Kelp Bed Canopy Area Mapping and Indexing

All primary digital kelp "contrast enhanced" images from the August 10th – 11th surveys were projected onto the base-line maps utilizing a Dell 2300MP projector, and, after aligning common shoreline features from each media, individual kelp plants and kelp canopies (see glossary) were hand transferred. The transfer process specifically

involved: 1) the visual analysis of the extent of kelp represented on each slide by reference to color and surface appearance, 2) the identification of the "usable" portion of the image that was largely distortion-free (center three-fourths), 3) positioning this "usable" portion of the projected image in its proper location on the base-map, with regard to both shore-line features and kelp from other overlapping imagery, and 4) the black shading of all visible kelp, both developed canopies and individual plants. These black-shaded areas represented the areal extent of the actual kelp plants composing the surface canopy, and areas within the perimeter of the canopy that did not contain kelp were left un-shaded. When fully rendered from the survey imagery, each mapped canopy closely resembled the appearance of the actual surface canopy when viewed from above.

As previously discussed, the projected digital "contrast enhanced" images of the coastal kelp resource appeared virtually identical to the more traditional color-infrared film with regards to resource color rendition, saturation, perimeter distortion, and spatial resolution. As a result, the previous resource canopy/planimeter area/relative density (RDI) analysis methodology was considered appropriate for both current resource measurements and comparisons with both previous and future inventories.

Kelp bed index numbers (see glossary) were assigned, as in the previous surveys, allowing a more specific and detailed subsequent area analysis. These mapped canopies represented the qualitative kelp canopy area (see glossary) occupied within the survey range, and are presented in Section 4 - "Kelp Bed Canopy Area Maps: 1-41" (24"x36", 11"x17", and 8.5"x11").

C) Kelp Canopy Species Determination and Planimeter Area Mapping

Kelp canopy species composition was determined by combining both visual observations from the low-altitude over-flight and photographic data from the aerial imagery. The aerial observations of canopy species composition corresponded well with that determined quantitatively from the imagery, and allowed the accurate distinction of each of the three species classes (100% *Nereocystis*, 100% *Macrocystis*, and "mixed" canopy areas). On the imagery, *Nereocystis* and *Macrocystis* areas were separated visually by both canopy color and surface appearance. *Macrocystis* appeared reddish-brown, and had a consistent surface canopy presence on the imagery, with few color and density irregularities. *Nereocystis* appeared reddish-orange, and was much more irregular in appearance, with numerous "dense" and "sparse" areas within close proximity. The dense areas formed bright red-orange patches, and were clearly identifiable both in "100 % *Nereocystis*" and mixed canopy areas. The areal extent of each species class was spatially indicated on the canopy area maps (section 4), by encircling each class location with a perimeter polygon.

Once the mixed canopy areas were identified, with the help of the aerial observations, the imagery was projected for analysis onto a random dot grid. Within each mixed canopy polygon, all dots were tallied as to whether they fell in a *Nereocystis* or *Macrocystis* area. These data were compared with total number of dots within the mixed canopy area as a whole to obtain percent canopy species composition. Results

were rounded to the nearest 10% multiple for each species, as in the aerial estimations. These quantitative results compared very closely to the visual estimations obtained from the low-altitude over-flights, and were used in the subsequent area analysis to determine *Macrocystis* and *Nereocystis* areal extent in these "mixed" canopy areas. The aerial visual observations were not used in the quantitative analysis of species composition, unless a positive identification of the species where the random dots were located was not obtainable from the imagery. In these cases, which occurred less than ten percent of the time, aerial observations of species composition were used.

Planimeter area maps were created by establishing a computer derived perimeter polygon around the kelp within each species class, corresponding to the qualitative planimeter area occupied by each (see glossary).

These qualitative planimeter area and canopy species composition data are presented in Section 5 - "Kelp Canopy Planimeter Area/Species Composition Maps: 1 - 25. On the 8.5"x11" and 11"x17" maps the three species classes were noted as: 1) 100% *Nereocystis* - "N", 2) 100% *Macrocystis* - "M", and 3) mixed canopy areas - "B" (both species).

3) Quantitative Kelp Canopy/Planimeter Areas and Relative Density Analysis

The quantitative analysis of range-wide kelp resource abundance was divided into two sections: a) analysis of the 2014 Washington coastal kelp resource, and b) comparisons of the 2014 resource surface extent with that present in 2013. Within each section, data was tabulated and plotted at three levels to better depict both the "small and large scale" dynamics of kelp canopy abundance. These levels included analysis by kelp bed number (level 1), map number (level 2), and survey range (level 3). Large scale trends in resource abundance, by survey range, were presented in the "Data Summary" section.

A) Analysis of the 2014 Washington Coastal Kelp Resource

Quantitative kelp canopy and planimeter areas (see glossary) were accurately determined from the maps using computer image processing techniques. Each map page was digitized at 100 dots/inch (dpi) using a "Microtek" 9600XL flat-bed image scanner. Area values were determined by screen "pixel counting", utilizing "Global Lab Image" (V3.1) image processing software (Data Translation). Kelp canopy areas and planimeter areas were tabulated by kelp bed number, and divided into each of the assigned species classes. Mixed canopy/planimeter area data, for each species, were determined by multiplying the total mixed canopy "pixel count" by the calculated percent composition of each.

Level 1 - Analysis of the 2014 kelp resource extent, by kelp bed number

Quantitative kelp bed canopy area data, by kelp bed number and species class, were presented in table 5. An area summary of each kelp canopy, by species, was also included, in addition to an estimate of mixed canopy and total canopy percent species

composition. These canopy area and species composition data, by kelp bed number and species class, were plotted in figures 5.1 (5.1.1 - 5.1.4).

Quantitative kelp bed planimeter area data were presented in similar form to the kelp canopy area data in table 6, and plotted in figures 6.1 (6.1.1 - 6.1.4).

Kelp canopy/planimeter area data were summarized in table 7, in addition to the calculation of a Relative Density Index value (RDI - see glossary) for each species, and for the total kelp canopy. Kelp canopy area, planimeter area, and RDI data were plotted in figures 7.1 (7.1.1 - 7.1.4).

Level 2 - Analysis of the 2014 kelp resource extent, by map page number

Measurements of kelp canopy/planimeter area and RDI were also tabulated by map page and species (table 8), to better understand the overall distribution and density of the Washington coastal kelp resource. Kelp canopy area and species composition, by map page, were plotted in figure 8.1, and similar indices utilizing planimeter area measurements were plotted in figure 8.2. A final summary of canopy/planimeter area and RDI were plotted, by map page, in figure 8.3.1.

Kelp canopy range-wide species distribution, expressed as "percent of individual species" and "percent of the total kelp resource area" contained on each map page, was presented in table 9. For example, on map page 16 (Cape Flattery area): 8.5% of the total *Nereocystis*, 6.1% of the total *Macrocystis*, and 7.2% of the total kelp resource canopy area are found. These data were plotted, both for individual species and for the entire resource, in figure 9.1, (canopy area), and figure 9.2 (planimeter area).

Level 3 - Analysis of the 2014 kelp resource extent, by survey range

In addition to measurements tabulated by kelp bed number and map page, summaries of areal extent indices were provided for three large survey ranges, and four additional "special areas of research interest". This allowed a better understanding of the overall distribution and dynamics of the current kelp resource, in addition to comparisons with other previous inventories. These larger ranges included: 1) the "Straits of Juan de Fuca" - Port Townsend to Cape Flattery (canopies 1.1-16.2), 2) the "open coast" - Cape Flattery to the Columbia River (canopies 16.3-41.1) , and 3) the "total kelp resource" - Port Townsend to the Columbia River (canopies 1.1-41.1).

Several special areas of research interest were also selected. The total kelp from Port Townsend to Disque (canopies 1.1-9.3) and from Twin Rivers to Cape Flattery (canopies 10.1-16.2) was tabulated, to allow comparisons with selected historic surveys that included this measurement. In addition, resource extent within the OCNMS (Neah Bay to the Copalis River - canopies 15.3-31.1) was tabulated to monitor changes in abundance within this region. Finally, the range from Neah Bay to Cape Alava (canopies 15.3-19.2), in addition to the area outside this range (canopies 1.1-15.2 and 20.1-41.1) was included, in reference to the area affected by the 1991 "Tenyo Maru" oil spill.

Kelp canopy/planimeter area and RDI data for each of these survey ranges was presented in table 10. As in table 9, calculations for "percent of individual species" and "percent of the total kelp resource" were included. These data were plotted, by survey range, in figure 10.1 and "special ranges of interest" in figure 10.2.

B) Comparisons of the 2013 and 2014 Washington Coastal Kelp Resource

Changes in kelp resource areal extent observed since the last systematic survey (2013) were included for comparative purposes, at all three analysis levels. Care must be taken in interpreting these observed changes, since only two data sets were involved spanning one year. At best, these data represent short-term changes only and don't necessarily reflect long-term trends in kelp resource extent and distribution.

Level 1 - 2013 and 2014 kelp resource extent comparisons, by kelp bed number

Canopy area measurements from the 2013 and 2014 surveys, in addition to resource percent change by kelp bed number and species, were included in table 11. Planimeter area measurements of these indices were presented in table 12. These data were plotted in figures 11 and 12 (11.1.1-11.1.4 and 12.1.1-12.1.4), respectively.

Level 2 - 2013 and 2014 kelp resource comparisons, by map page number

Canopy/planimeter area/RDI and percent change in these indices for each of the surveys, by map page, was included in Table 13, and plotted in figures 13.1 and 13.2.

Level 3 – 2013 and 2014 kelp resource extent comparisons, by survey range

Canopy/planimeter area/RDI data from the 2013 and 2014 surveys, in addition to resource percent change by survey range, were included in table 14, and plotted in figures 14.1 and 14.2.

In order to evaluate the significance of observed changes in resource extent between the two surveys, a t-test ("paired two sample for means") was applied to the data sets from tables 11 and 12. This test evaluates whether a samples' means are distinct, and does not assume equal population variance (Sokal and Rohlf, 1981). This test was judged appropriate, since there was a natural pairing of measurements making up each distinct and summarized value for canopy/planimeter area and RDI. Each data pair were analyzed at the 95% confidence level ($p = .05$), and the results of the tests were summarized in table 14, and plotted figures 14 (14.1.1 and 14.2.1).

4) Geographic Information System (GIS) Data-layer Creation and file transfer

Vector Data-layer Creation (1990 – present)

Kelp canopy elements from each of the original "Kelp Bed Planimeter Area Maps" were digitized (all counter-clockwise) on a 24"x36" Calcomp 23360 tablet digitizer into an ERDAS Annotation file ("*.OVR") and later converted to an "IMG" file (see glossary) for distribution. All map files were rectified to the UTM Coordinate System - Zone 10, utilizing the Clark 1866 Spheroid and Datum . Five GIS "class values/colors" (see glossary) were established for each map file, representing: 1) "Map Corners" (symbol-white) - GIS value "1", 2) Control Points (symbol-purple) - GIS value "2", 3) 100% *Nereocystis* canopies (polygon-red) - GIS value "3", 3) 100% *Macrocystis* canopies (polygon-blue) - GIS value "4", and 5) "Mixed" canopies (polygon-green) - GIS value "5." The control points in each map file were arranged (A-D) from east to west on maps W-1 to W-16, and north to south on maps W-17 to W-25, as previously discussed. All digitized elements were grouped and colored by class value, and files were named according to the convention: 1) project title - "Washington Coastal Kelp Resources" (WCKR), 2) survey year (05), 3) map number (01-25) and 4) vector layer ("v") - example "WCKR1010v.IMG."

Raster Data-Layer Creation (2001 – present)

Each of the 11"x17" "Kelp Bed Canopy Area Maps" was scanned at 200 dpi on a Microtek 9600 XL 11"x17" flatbed scanner and converted to an 8 bit "RGB" (red, green, blue) "TIFF" (tagged image format) file. Elements of interest within the scanned digital map files (map corners, control points and *Nereocystis/Macrocystis*/Mixed kelp beds) were hand colored within Adobe "Photoshop CS3" according to the coloring protocol established during vector data layer creation. Each map was then imported into ERDAS as a colored "TIFF" file and converted to an "IMG" file. A supervised classification (parallelepiped) was conducted using a signature file containing colors as assigned to map elements of interest within Photoshop CS. Elements from each class were grouped and colored as previously discussed and all map files were geo-referenced to the UTM Coordinate System - Zone 10 (4m pixel size), utilizing the Clark 1866 Spheroid and Datum. Control points (table 4) used in the geo-referencing process were displayed on each map as previously discussed. Each raster map GIS file ("img" format) was named (table 1) according to the vector data-layer convention except with an "r" following the map number to designate a "raster layer." In addition, original scanned and colored resource maps ("tif" format) were also included (table 1) for reference. Map data files were included on two enclosed data DVD's within the final report binders, and entitled "Geographic Information System Files"

All spreadsheet data from tables 1-14 were provided in "Excel 95/97" ("XLS" - Microsoft Inc.) file format. Each data file was also included on the enclosed DVD under the file names described in section 6.

Data Summary

This data summary focused mainly on a "large scale" assessment of the 2014 kelp resource, and changes observed since the 2013 inventory. As a result of this data tabulation method, though, additional "small scale" changes in kelp resource extent may become apparent, as further research is conducted. Investigators are encouraged to use these data in that regard. The major findings from this study were presented as: 1) summary of 2014 kelp resource areal extent, by survey range, and 2) summary comparisons of the 2013-2014 coastal kelp resource.

1) Summary of the 2014 Kelp Resource Extent, by Survey Range

Kelp canopy and planimeter area data from the 2014 survey were summarized within the following ranges, and sub-ranges (table 10): a) Strait of Juan de Fuca (Port Townsend to Cape Flattery), b) open coast (Cape Flattery to the Columbia River), c) range-wide (Port Townsend to the Columbia River), d) Port Townsend to Disque and Twin Rivers to Cape Flattery, e) the Olympic Coast National Marine Sanctuary (Neah Bay to Copalis), and f) Neah Bay to Cape Alava in comparison with the remainder of the survey range. In addition, range-wide kelp canopy species composition was summarized.

A) Straits of Juan de Fuca (Port Townsend to Cape Flattery - canopies 1.1-16.2)

The total kelp canopy/planimeter area in the Straits of Juan de Fuca was 629 ha and 2,035 ha, representing approximately 72% (canopy and planimeter percentages averaged) of the total kelp resource. The overall canopy density (RDI) was .31.

Nereocystis occupied areas of 232/1,053 ha (RDI=.22), representing approximately 74% of the total *Nereocystis* and 31% of the total kelp resource.

Macrocystis, within this range, occupied 397/982 ha (RDI=.40), representing approximately 72% of the total *Macrocystis* and 40% of the total kelp resource.

B) Open Coast (Cape Flattery to Destruction Island - canopies 16.3-41.1)

The total kelp canopy/planimeter area within the open coast range was 221/867 ha (RDI=.26), representing approximately 28% of the total kelp resource (canopy and planimeter percentages averaged).

Nereocystis occupied areas of 58/520 ha (RDI=.11), representing approximately 26% of the total *Nereocystis* and 13% of the total kelp resource.

Macrocystis occupied a surface extent of 163/347 ha (RDI=.47), representing approximately 28% of the total *Macrocystis* and 16% of the total kelp resource.

As in previous surveys, no kelp was observed on the open coast south of Destruction Island.

C) Total Range-wide Kelp Resource (Port Townsend to the Columbia River)

The total kelp canopy/planimeter area, on a range-wide basis, was 850/2,901 ha and the overall canopy density (RDI) was .29.

The total *Nereocystis* area was 290/1,573 ha (RDI=.18), representing approximately 34%/54% (canopy/planimeter percentages) of the total kelp resource extent.

Macrocystis occupied areas of 560/1,328 ha (RDI=.42), and represented 66%/46% (canopy/planimeter area percentages) of the total resource.

D) Port Townsend to Disque (1.1-9.3) and Twin Rivers to Cape Flattery (10.1-16.2)

The total kelp canopy/planimeter area from Port Townsend to Disque was 194/724 ha (RDI=.27), representing approximately 24% of the total kelp resource.

Similar indices within the range of Twin Rivers to Cape Flattery measured 435/1,311 ha (RDI=.33), and represented approximately 48% of the total resource.

E) Olympic Coast National Marine Sanctuary (canopies 15.3 - 31.1)

Kelp beds within the Olympic Coast NMS represented approximately 36% of the total kelp resource, with total canopy/planimeter areas of 301/1,104 ha (RDI=.27).

Nereocystis canopy extent was 82/632 ha (RDI=.13), representing approximately 34% of the total *Nereocystis* and 16% of the total kelp resource.

Macrocystis occupied areas of 219/471 ha (RDI=.46), representing 38% of the total *Macrocystis* and 21% of the total kelp resource.

F) Neah Bay to Cape Alava in comparison with the remainder of the range

The total kelp within the Neah Bay to Cape Alava range occupied canopy/planimeter areas of 260/870 ha (RDI=.30), representing 30% of the range-wide kelp canopy extent.

Nereocystis occupied 67/474 ha (RDI=.14), representing 27% of the *Nereocystis* and 12% of the total kelp resource.

Macrocystis occupied 193/396 ha (RDI=.49), and represented 32% of the *Macrocystis* and 18% of the total kelp resource.

Outside of this range, kelp bed canopy/planimeter extent totaled 590/2,031 ha (RDI=.29), representing 70% of the total resource extent.

Nereocystis occupied 223/1,099 ha (RDI=.20), corresponding to 74% of the *Nereocystis* and 32% of the total resource.

Macrocystis occupied 367/932 ha (RDI=.39), representing 68% of the *Macrocystis* and 38% of the total kelp resource.

Kelp Canopy Species Composition

Kelp canopy range-wide species composition, corresponding to canopy area values (table 5), was 34%/66% *(Nereocystis/Macrocystis)* within mixed canopies, and also 34%/66% within the total canopy area.

In regard to planimeter area values (table 6), canopy composition within mixed canopy areas was 35%/65% *(Nereocystis/Macrocystis),* and 54%/46% within the range-wide surface canopy.

2) Summary Comparisons of the 2013-2014 Coastal Kelp Resource

Statistical comparisons (table 14) of current resource surface extent were made with that measured within comparable survey ranges in 2013, as well as numerical comparisons of canopy species composition. All significant changes were evaluated at the 95% confidence level (p=.05).

A) Straits of Juan de Fuca (Port Townsend to Cape Flattery)

The total kelp canopy area in the Straits of Juan de Fuca decreased significantly from 999 ha to 629 ha (2013-2014), which represented an 37% decrease. The total kelp planimeter area significantly decreased (29%) from 2,867 ha to 2,035 ha. The relative density index significantly decreased from .35 to .31.

Nereocystis canopies experienced a significant decrease in canopy area from 468 ha to 232 ha, representing a loss of 50%. The planimeter area significantly decreased from 1,691 ha to 1,053 ha within this range, representing a loss of 38%. The relative density index significantly decreased from .28 to .22.

Macrocystis canopy areas within the "Straits" significantly decreased from 531 ha to 397 ha, representing a loss of 25%. The *Macrocystis* planimeter area also significantly decreased from 1,175 ha to 982 ha, representing a loss of 16%. Canopy density within this range significantly decreased from .45 to .40.

B) Open Coast (Cape Flattery to Destruction Island)

The total kelp canopy area along the open coast significantly decreased from 298 ha to 221 ha (2013-2014), which represented an 26% decrease. The total kelp planimeter area also significantly decreased by 17% from 1,047 to 887 ha. Kelp canopy density also decreased significantly from .29 to .26.

Nereocystis canopy areas significantly decreased 27% from 79 to 58 ha, when compared with data from 2013. Planimeter areas also significantly decreased by 19% from 640 to 520 ha. Canopy densities decreased significantly from .12 to .11.

Macrocystis canopy areas, within the open coast range, decreased by 26% from 219 to 163 ha, while the planimeter areas decreased by 15% from 407 to 347 ha. Both changes were statistically insignificant. Canopy density significantly decreased from .54 to .47.

C) Total Kelp Resource Range-wide (Port Townsend to the Columbia River)

The total kelp resource canopy area decreased significantly by 34% from 1,297 to 850 ha, when compared with the 2013 inventory. The total kelp resource planimeter area significantly decreased by 26% from 3,916 to 2,901 ha. Kelp canopy density decreased significantly from .33 to .29.

Range-wide *Nereocystis* canopy areas significantly decreased by 47% from 547 ha to 290 ha, and planimeter areas significantly decreased by 33% from 2,331 ha to 1,573 ha. Relative densities significantly decreased from .23 to .18.

Range-wide *Macrocystis* canopy areas significantly decreased by 25% from 750 to 560 ha and planimeter areas also significantly decreased by 16% from 1,582 ha to 1,328 ha. Relative densities significantly decreased from .47 to .42.

D) Port Townsend to Disque (1.1-9.3) and Twin Rivers to Cape Flattery (10.1-16.2)

Within the coastal range from Port Townsend to Disque (maps W-1 to W-9), the total kelp canopy area decreased by 29% from 275 ha to 194 ha, and the planimeter area also significantly decreased by 24% from 955 ha to 724 ha. Canopy densities significantly decreased from .29 to .27.

Within the Twin Rivers to Cape Flattery range (maps W-10 to W-15), the total kelp canopy area experienced a significant decrease of 40% in canopy area from 724 ha to 435 ha, and the kelp planimeter area also experienced a significant decrease of 31% from 1,911 ha to 1,311 ha. Canopy densities significantly decreased from .38 to .33.

E) The Olympic Coast National Marine Sanctuary (Neah Bay to Copalis)

Within the Olympic Coast NMS, total kelp canopy area significantly decreased by 28% from 416 ha to 301 ha and the planimeter area significantly decreased 19% from 1,359 ha to 1,104 ha. Canopy densities significantly decreased from .31 to .27.

Nereocystis canopy area significantly decreased by 36% from 128 ha to 82 ha. The planimeter area also significantly decreased by 22% from 807 ha to 632 ha. Canopy density within the range decreased significantly from .16 to 13.

Macrocystis canopy area, within this range, decreased by 24% from 288 ha to 218 ha and planimeter area decreased by 15% from 552 ha to 471 ha. Canopy density significantly decreased from .52 to .46.

F) Neah Bay to Cape Alava

Within the range of Neah Bay to Cape Alava, a significant decrease of 29% in total kelp canopy area occurred from 368 ha to 260 ha, and planimeter area also decreased significantly by 21% from 1,104 to 870 ha. Canopy density significantly decreased from .33 to .30.

Nereocystis canopy area significantly decreased by 39% from 109 ha to 67 ha, while planimeter area also significantly decreased by 26% from 638 to 474 ha. Canopy density significantly decreased from .17 to .14.

Macrocystis canopy area decreased 25% from 259 ha to 193 ha, and the planimeter area decreased 15% from 466 ha to 396 ha. Canopy density decreased from .56 to .49.

G) Port Townsend to Neah Bay and Cape Alava to Destruction Island (outside of the Neah Bay to Cape Alava range)

Outside of this range, the total kelp canopy area significantly decreased by 36% from 929 ha to 590 ha. The planimeter area also significantly decreased by 28% from 2,809 ha to 2,031 ha. Overall canopy density significantly decreased from .33 to .29.

Nereocystis canopy area significantly decreased by 49% from 438 ha to 233 ha and planimeter area also significantly decreased by 35% from 1,693 ha to 1,099 ha. Canopy densities significantly decreased from .26 to .20.

Macrocystis canopy area significantly decreased by 25% from 491 ha to 367 ha, and the planimeter area also significantly decreased 16% from 1,116 ha to 932 ha. Canopy densities significantly decreased from .44 to .39.

Kelp Canopy Species Composition (2013-2014)

Kelp canopy range-wide species composition in 2014, corresponding to canopy area values (table 5) was 34% *Nereocystis*/66% *Macrocystis* in mixed canopy areas, and 34%/66%, respectively, considering the total resource.

In regards to planimeter area indices (table 6), these 2014 values were 35%/65% *(Nereocystis/Macrocystis)* in mixed areas and 54%/46%, respectively, in reference to the total resource.

Kelp canopy range-wide species composition for the 2013 resource, corresponding to canopy area values (table 5) were 37%/63% *(Nereocystis/Macrocystis)* within mixed canopies, and 42%/58%, respectively, considering the total resource.

In regard to planimeter area values (table 6) for 2013, canopy composition within mixed canopy areas was 38%/62% *(Nereocystis/Macrocystis)* and 60%/40% within the total kelp resource.

Principle Findings

The principle findings from the 2014 kelp resource inventory were as follows:

1) The total Washington state coastal kelp resource within the survey range of Port. Townsend to the Copalis River occupied canopy/planimeter areas of 850/2,901 ha, respectively, representing significant decreases of 34% in canopy area and 26% in planimeter area from that observed in 2013. Range-wide canopy densities (RDI) for *Nereocystis/Macrocystis* canopies were .29, a significant decrease from the .33 measured in the 2013 inventory.

2) *Nereocystis* canopy/planimeter range-wide surface extent measured 290/1,573 ha, representing significant decreases of 47% in canopy area and 33% in planimeter area from that observed in 2013. Canopy density decreased significantly from .23 to .18. Within the Straits of Juan de Fuca, significant decreases in canopy area of 50% and planimeter area of 38% were noted. Significant decreases in *Nereocystis* canopy/planimeter area of 27%/19%, respectively, occurred along the "open coast" portion of the range. Canopy density within the Straits of Juan de Fuca significantly decreased from .28 to .22, and on the open coast significantly decreased from .12 to .11.

3) *Macrocystis* canopy/planimeter area range-wide extent measured 560/1,328 ha, representing significant decreases in canopy area of 25% and planimeter area of 16%, when compared with the 2013 inventory. Canopy density significantly decreased from .47 to .42. *Macrocystis* canopy/planimeter areas significantly decreased by 25%16%, respectively, within the Straits of Juan de Fuca, and along the open coast, canopy/planimeter areas decreased by 26%/15%, respectively, but were statistically insignificant. Canopy density within the Straits of Juan de Fuca significantly decreased from .45 to .40, and also on the open coast significantly decreased from .54 to .47.

4) The survey sub-range with the most consistent total kelp canopy/planimeter areas, was between Neah Bay (map 15) and Destruction island (map 25), an area containing large *Macrocystis* canopies. In 2014, no sub-ranges experienced an increase in kelp canopy extent, while the sub-range with the greatest decrease in surface extent was along the Straits of Juan de Fuca from Twin Rivers to Cape Flattery, which experienced significant decreases in both canopy forming species, but especially *Nereocystis*.

5) Canopy species composition in 2014 was determined to be approximately 34%/66% *(Nereocystis/Macrocystis)* within both mixed canopies and with regard to the total kelp resource. Similar species composition indices in the 2013 inventory were determined to be 37%/63% *(Nereocystis/Macrocystis)* in mixed canopy areas and 42%/58% within the total range-wide resource. Significant decreases in *Nereocystis* along the Straits of Juan de Fuca were responsible for the shift in species composition.

Discussion

This scope of this inventory was established to provide a current, accurate measurement of the Washington state coastal kelp resource to promote a better understanding of the seasonal dynamics of this important habitat. In this regard, discussion will be limited to comparative methodology and sources of error that may affect the accuracy of this current inventory, and its subsequent utility for multi-year comparative purposes.

The data acquisition and analysis methodology utilized in this survey was established for the 1989 inventory, and, with limited exception, has remained consistent in all subsequent survey efforts. The only change in flight data acquisition parameters have involved reducing the survey altitude from 9,500' MSL in 1989 to 7,500' MSL in subsequent years, which improved resource rendition on the imagery. All other mapping, analysis, and data presentation methodologies have remained consistent.

As previously indicated, all primary imagery obtained on August 10th and 11th, 2014, and subsequently used for all kelp mapping and analysis, was collected within target biological, physical and logistic survey "windows". The associated wind and sea state were optimum and the imagery was collected within sixty minutes of the "time of low tide" at each station, thereby insuring negligible tidal current effects on the surface canopy. The resultant imagery was judged of excellent quality and appropriate for the complete and accurate mapping of the current resource in addition to its utility for multi-year comparative purposes.

Conclusion

The annual Washington Coastal Kelp Resource inventory was established in 1989 to be a tool in the hands of researchers and agency management professionals leading toward a better understanding of the near-shore marine environment as a whole. The ultimate and ongoing goals of this program, as stated, are the management of these resources for the benefit of all current and future citizens of Washington state. This mandate is being accomplished through: 1) sanctuary management, 2) public education, 3) environmental regulation, 4) habitat protection and restoration, 5) commercial utilization management, and 6) an ongoing research program.

The goals of this 2014 resource inventory were again achieved in the continuation of the systematic, measurement and analysis of the Washington coastal kelp resource from Port Townsend to the Columbia River. This survey provided important data regarding the status of current kelp canopy abundance, by species, in addition to comparisons with the 2013 inventory. These data were tabulated at several levels to aid individual research investigators, agency resource managers, and GIS professionals in an effort to better understand the factors that influence the seasonal dynamics, and related species diversity, of this magnificent resource.

Glossary

Kelp Bed Canopy - An aggregation of surface kelp plants in close proximity to each other which produced a consistent infrared return on the imagery, such that individual plants were indistinguishable when projected at mapping scale (1:12,000)

Kelp Bed Index Numbers - Reference labels assigned to each distinct kelp bed, by map page. The total kelp resource on each map where kelp was present (W-1 to W-25) was divided into several discreet geographic areas, each with similar exposure to incoming seas and swells. These areas were numbered in the format: "Map Page. Kelp Bed Index Number" (ex. 10.3), with the number before the decimal corresponding to the map page that the canopy was found on, and the number after the decimal referencing the discreet geographic area on that page that the canopy occupied.

A few simple conventions were followed in establishing this indexing system: 1) break points between canopy numbers were referenced by fixed shoreline points wherever possible (see kelp bed # 8.1), 2) discreet "offshore" canopies were separated from "onshore" canopies (see kelp bed # 8.4), and, 3) map boundaries formed break points between kelp beds only if the bed was not bisected by the boundary. In that case, a single kelp bed index number was maintained between the pages, and was numbered with the map page where the greatest component of the kelp canopy was found (see 7.3). The extent of the qualitative canopy area (see definition) itself also formed natural "breaks" between kelp beds (see map W-10). Frequently, these natural breaks are due to lack of suitable sub-tidal habitat or invertebrate overgrazing. Kelp beds separated by these natural breaks that were similar in exposure, species composition and density, were grouped together by a common index number. Kelp beds with substantially different values for these indices were given discreet index numbers. This indexing system was established for the 1990 survey and has remained constant in subsequent replicate kelp canopy mapping efforts.

Kelp Bed Qualitative Canopy Area - The geographic (spatial) extent of individual surface kelp plants and canopies, as fully rendered from the original imagery. Each visible individual kelp plant and canopy was hand transferred to the "canopy area" maps, and represented by black-shading wherever present. Areas within the perimeter of the canopy that did not contain kelp were left un-shaded. This index depicted the actual appearance of the surface kelp canopy, as viewed on the original imagery.

Kelp Bed Quantitative Canopy Area - The numeric extent (hectares) of individual surface kelp plants and canopies. Each qualitative canopy area map was scanned into the image processing system at full scale (1:12,000), and subsequent screen "pixel counts" conducted. All "black-shaded" pixels that represented actual kelp at the surface were counted, individual pixel area determined, and a quantitative kelp canopy area established. This index represented numerically the actual extent of the surface kelp canopy, as mapped from the original imagery.

Kelp Bed Qualitative Planimeter Area - The geographic (spatial) extent of the surface kelp canopy contained within its own perimeter, assuming continuous kelp coverage within. Since the surface kelp resource was composed of individual plants and established canopies; this measurement systematically defined the perimeter and subsequent enclosed area of this plant assemblage, by species class. This value depicted kelp canopy areal extent in slightly different terms than "canopy area", as previously defined, and served three purposes in this analysis: 1) it allowed comparisons of current and historic estimates of kelp resource abundance, which utilized similar "perimeter" estimation methods, 2) it allowed an understanding of the sea surface area that was actually occupied or influenced by the kelp canopy, and 3) it allowed a measurement of kelp canopy density (see "relative density index").

Qualitative planimeter area, by kelp bed number and species, was established by computer enhancement of each scanned "canopy area" map. This methodology systematically established perimeter polygons around each "species class", and included all kelp plants inside the polygons that were within 50 meters of each other, giving each plant a 25 meter "radius of association" (2 mm at the 1:12,000 mapping scale). Within the analysis software ("Global Lab Image"-V3.1-Data Translation), individual kelp plants and canopies within each species class were "dilated" (expanded) with a "5x5" pixel "structuring element", thereby adding a 25 meter radius of kelp to each existing kelp pixel. Individual kelp plants within 50 meters of each other became part of the same perimeter, while plants greater than 50 meters apart retained discrete perimeters. Within established canopies, this transform had the effect of defining the canopy perimeter 25 meters beyond that visually apparent on the "canopy area" maps, as well as filling in the all of the "holes" in kelp coverage within the canopy. This computer synthesized value is spatially similar to that obtained by using a hand planimeter to determine kelp canopy areal extent, and hence the name. Many environmental surveys have used planimeter areas to describe resource abundance, since prior to computers, this was all that was available. In addition, by the nature of the process, area statistics from other hand digitized kelp resource maps (for data entry into a geographic information system; see definition), will closely approximate the quantitative planimeter area (see definition), thereby allowing comparisons. This index is always larger than the kelp "canopy area", which is a depiction and measurement of the sea surface area actually occupied by visible kelp plants. These computer established perimeters were transferred to the kelp "canopy area" maps, by species class, and presented as Section 5 - Kelp Bed Species Composition/Planimeter Area Maps: 1-25.

In addition to allowing comparisons with both historic (planimeter derived), and computer (digitizer derived) data, planimeter area measurements more accurately depict the influence, or sea surface area occupied, by kelp canopy species that have more irregular distributions (dense canopies in some areas and sparse areas containing individual plants in others). *Nereocystis* canopies are frequently observed with this growth pattern, and their prominence underrepresented by a strict "canopy area" analysis only.

Kelp Bed Quantitative Planimeter Area - The numeric extent (hectares) of the qualitative planimeter area. Each quantitative planimeter area, by canopy number and species was scanned into the image processing program, and a screen "pixel count" conducted. All pixels within the individual perimeters were counted, individual pixel area determined, and a quantitative canopy planimeter area established.

Kelp Bed Relative Density Index (RDI) - The percentage of the planimeter area that actually contained surface kelp plants. This index was calculated by dividing the canopy area by the planimeter area and approximated the probability of encountering kelp at a random point within the canopy perimeter. This value approaches "1" for very dense canopies and "0" for very sparse canopies. The measurement is independent of canopy size, and a good indicator of changes in density over time. In considering the relationship between canopy area and planimeter area, several examples underscore this basic relationship, and subsequent multi-year trends.

Canopy Area (ha)	Planimeter Area (ha)	Density (RDI)	Interpretation
10	20	.5	10 ha of kelp are contained within 20 ha of the sea surface that it occupies (prob. of encountering kelp within perimeter = .5)
5	20	.25	5 ha of kelp are contained within 20 ha of the sea surface that it occupies (prob. of encountering kelp within perimeter = .25)
Can. Chg.	**Plan. Chg.**	**Den. Ch**	**Interpretation - Multi-Year Trends**
10 to 10	20 to 20	.5 to .5	Kelp resource area (canopy area), spatial extent (plan. area), and density (RDI) **stable** over time
10 to 15	20 to 20	.5 to .75	**Increased** resource area within **similar** spatial extent at **inc. dens.**
10 to 20	20 to 40	.5 to .5	**Inc.** resource area and spatial extent at **similar** densities
10 to 20	20 to 30	.5 to .66	**Inc.** resource area and spatial extent at **increasing** densities
10 to 15	20 to 40	.5 to .38	**Inc.** resource area and spatial extent at **decreasing** densities
10 to 5	20 to 20	.5 to .25	**Dec.** resource area within **similar** spatial extent at **dec. density**
10 to 5	20 to 10	.5 to .5	**Dec.** resource area and spatial extent at **similar** densities
10 to 5	20 to 15	.5 to .33	**Dec.** resource area and spatial extent at **decreasing** densities
10 to 5	20 to 30	.5 to .38	**Dec.** resource area within **inc.** spatial extent at **dec.** densities

ERDAS (Earth Resource Data Analysis System) - A "raster" based image processing and geographic information system (see below)

- **Class Value** - A group of screen "picture cells" (pixels) or points within a closed polygon that share a common condition or attribute. In this study, three species class values were established: 100% Nereocystis , 100% Macrocystis , and mixed canopies.

- **Geographic Information System (GIS)** - A computer software platform designed to facilitate the assembly and analysis of diverse data sets pertaining to specific geographic areas using spatial locations of the data as the basis for the information system

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WASHINGTON COASTAL KELP RESOURCES

Port Townsend
to the
Columbia River

Section 2

Tables: 1 - 14

August 2014

List of Tables
(Section 2)

Table 1

Washington Coastal Kelp Resources - Summer 2014

Kelp Resource Map Index

- By Map Number

MAP NUMBER	MAP NAME	KELP BED INDEX NUMBERS
W-01	Port Townsend	1.1, 1.2
W-02	Diamond Point	2.1, 2.2, 2.3, 2.4, 2.5
W-03	Gray's Marsh	3.1, 3.2
W-04	Dungeness	4.1, 4.2, 4.3
W-05	Green Point	5.1, 5.2
W-06	Port Angeles	5.2, 6.1, 6.2, 7.1
W-07	Angeles Point	7.1, 7.2, 7.3
W-08	Crescent Bay	7.3, 8.1, 8.2, 8.3, 8.4
W-09	Low Point	9.1, 9.2, 9.3, 10.1
W-10	Twin	10.1, 10.2, 10.3, 10.4, 10.5, 10.6
W-11	Pillar Point	10.6, 11.1, 11.2, 11.3
W-12	Pearson Creek	12.1
W-13	Sekiu	12.1, 13.1, 13.2, 14.1
W-14	Sekiu River	14.1, 15.1
W-15	Neah Bay	15.1, 15.2, 15.3, 15.4
W-16	Cape Flattery	15.4, 16.1, 16.2, 16.3, 16.4
W-17	Makah Bay	17.1, 17.2, 17.3
W-18	Point of the Arches	18.1, 18.2
W-19	Cape Alava	19.1, 19.2
W-20	Carroll Island	20.1, 20.2
W-21	La Push	21.1, 21.2
W-22	Strawberry Bay	22.1, 22.2
W-23	Hoh Head	23.2, 23.2, 24.1
W-24	Abbey Island	24.1, 24.2
W-25	Destruction Island	25.1, 25.2
W-26	Kalaloch	26.1
W-27	Tunnel Island	27.1
W-28	Little Hogsback	28.1
W-29	Taholah	29.1
W-30	Moclips	30.1
W-31	Copalis Beach	31.1
W-32	Ocean City	32.1
W-33	Point Brown	33.1
W-34	Westport	34.1
W-35	Grayland	35.1
W-36	Willapa Bay	36.1
W-37	Leadbetter Point	37.1
W-38	Ocean Park	38.1
W-39	Loomis Lake	39.1
W-40	Long Beach	40.1
W-41	Columbia River	41.1

Table 2

Washington Coastal Kelp Resources - Summer 2014

Kelp Resource Map Index

- By Map Name

MAP NAME	MAP NUMBER	KELP BED INDEX NUMBERS
Abbey Island	W-24	24.1, 24.2
Angeles Point	W-07	7.1, 7.2, 7.3
Cape Alava	W-19	19.1, 19.2
Cape Flattery	W-16	15.4, 16.1, 16.2, 16.3, 16.4
Carroll Island	W-20	20.1, 20.2
Columbia River	W-41	41.1
Copalis Beach	W-31	31.1
Crescent Bay	W-08	7.3, 8.1, 8.2, 8.3, 8.4
Destruction Island	W-25	25.1, 25.2
Diamond Point	W-02	2.1, 2.2, 2.3, 2.4, 2.5
Dungeness	W-04	4.1, 4.2, 4.3
Gray's Marsh	W-03	3.1, 3.2
Grayland	W-35	35.1
Green Point	W-05	5.1, 5.2
Hoh Head	W-23	23.2, 23.2, 24.1
Kalaloch	W-26	26.1
La Push	W-21	21.1, 21.2
Leadbetter Point	W-37	37.1
Little Hogsback	W-28	28.1
Long Beach	W-40	40.1
Loomis Lake	W-39	39.1
Low Point	W-09	9.1, 9.2, 9.3, 10.1
Makah Bay	W-17	17.1, 17.2, 17.3
Moclips	W-30	30.1
Neah Bay	W-15	15.1, 15.2, 15.3, 15.4
Ocean City	W-32	32.1
Ocean Park	W-38	38.1
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Point Brown	W-33	33.1
Point of the Arches	W-18	18.1, 18.2
Port Angeles	W-06	5.2, 6.1, 6.2, 7.1
Port Townsend	W-01	1.1, 1.2
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Sekiu River	W-14	14.1, 15.1
Strawberry Bay	W-22	22.1, 22.2
Taholah	W-29	29.1
Tunnel Island	W-27	27.1
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Westport	W-34	34.1
Willapa Bay	W-36	36.1

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
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Admiralty Inlet	Port Townsend	W-1
Agate Bay	Crescent Bay	W-8
Agency Creek	Neah Bay	W-15
Agnew Town	Green Point	W-5
Ahlstroms Prairie	Capa Alava	W-19
Alexander Island	Hoh Head	W-23
Allens Bay	Carroll Island	W-20
Allens Slough	Carroll Island	W-20
Anderson Point	Makah Bay	W-17
Angeles Point	Angeles Point	W-7
Archawat Creek	Cape Flattery	W-16
Archawat Peak	Cape Flattery	W-16
Ashenbrenner Picnic Area	Kalaloch	W-26
Baada Point	Neah Bay	W-15
Bagley Creek	Port Angeles	W-6
Bahobohosh Point	Makah Bay	W-17
Bahokus Peak	Cape Flattery	W-16
Baker Creek	Moclips	W-30
Beach Creek	Cape Flattery	W-16
Bear Creek	Cape Flattery	W-16
Beaver Creek	Moclips	W-30
Black Lake	Long Beach	W-40
Bodelteh Islands	Capa Alava	W-19
Boone Creek	Copalis Beach	W-31
Boulder Beach	Hoh Head	W-23
Breaker Lake	Long Beach	W-40
Breakers	Long Beach	W-40
Briscoe Lake	Long Beach	W-40
Browns Point	Destruction Island	W-25
Buckmans Lake	Port Townsend	W-1
Butler Cove	Pillar Point	W-11
Butler Creek	Pillar Point	W-11
Cake Rock	La Push	W-21
Camp Tapawingo	Grays Marsh	W-3
Capa Alava	Capa Alava	W-19
Cape Disappointment	Columbia River	W-41
Cape Disappointment Lighthouse	Columbia River	W-41
Cape Elizabeth	Little Hogsback	W-28
Cape Flattery	Cape Flattery	W-16
Cape George	Diamond Point	W-2
Cape Johnson	La Push	W-21
Carroll Islnad	Carroll Island	W-20
Cedar Creek	Carroll Island	W-20

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Cedar Creek	Copalis Beach	W-31
Cedar Creek	Abbey Island	W-24
Chilean Mem. Monument	La Push	W-21
Clallam Bay	Sekiu	W-13
Clallam Bay City	Sekiu	W-13
Clallam County Airport	Angeles Point	W-7
Clallam River	Sekiu	W-13
Clam Lake	Loomis Lake	W-39
Classet Creek	Cape Flattery	W-16
Coast Guard Res.	Port Townsend	W-1
Coast Guard Res.	Sekiu	W-13
Coast Guard Res.	Port Angeles	W-6
Coast Guard Sta.	Neah Bay	W-15
Coast Guard Sta.	La Push	W-21
Cohassett Town	Westport	W-34
Cohassett lake	Westport	W-34
Colby Creek	Makah Bay	W-17
Columbia River	Columbia River	W-41
Connor Creek	Ocean City	W-32
Copalis Beach Town	Copalis Beach	W-31
Copalis Head	Copalis Beach	W-31
Copalis Nat. Wildlife Refuge	Moclips	W-30
Copalis Nat. Wildlife Refuge	Little Hogsback	W-28
Copalis River	Copalis Beach	W-31
Copalis Rock	Copalis Beach	W-31
Coville Creek	Crescent Bay	W-8
Cranberry Bog	Ocean Park	W-38
Cranberry Bog	Ocean City	W-32
Cranberry Bog	Grayland	W-35
Cranberry Creek	Ocean City	W-32
Cranberry Lake	Loomis Lake	W-39
Cranberry Marsh	Long Beach	W-40
Crane Town	Green Point	W-5
Crescent Bay	Crescent Bay	W-8
Crying Lady Rock	Strawberry Bay	W-22
Dahdayla Island	La Push	W-21
Dear Lake	Long Beach	W-40
Destruction Island	Destruction Island	W-25
Destruction Island Viewpoint	Destruction Island	W-25
Diamond Point	Diamond Point	W-2
Diamond Pt. Airport	Diamond Point	W-2
Diamond Rock	Abbey Island	W-24
Discovery Bay	Diamond Point	W-2
Dry Creek	Angeles Point	W-7

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Dtokoah Point	Neah Bay	W-15
Duck Creek	Little Hogsback	W-28
Duck Lake	Point Brown	W-33
Dungeness Bay	Dungeness	W-4
Dungeness City	Dungeness	W-4
Dungeness Nat. Wildlife Refuge	Dungeness	W-4
Dungeness River	Dungeness	W-4
Eagle Point	Sekiu	W-13
East Twin River	Twin	W-10
Ediz Hook	Port Angeles	W-6
Educket Creek	Neah Bay	W-15
Elephant Rock	Tunnel Island	W-27
Elk Creek	Copalis Beach	W-31
Ellen Creek	La Push	W-21
Elwha River	Angeles Point	W-7
Elwha Station	Angeles Point	W-7
Fairview Hall Town	Green Point	W-5
Falls Creek	Sekiu	W-13
Falls Creek	Hoh Head	W-23
Falls Town	Strawberry Bay	W-22
Father and Son Rock	Point of the Arches	W-18
Field Creek	Low Point	W-9
Finn Hall City	Green Point	W-5
First Beach	Strawberry Bay	W-22
Flat Rock	Little Hogsback	W-28
Flattery Creek	Cape Flattery	W-16
Foot Rock	Carroll Island	W-20
Fords Dry Lake	Long Beach	W-40
Fort Canby	Columbia River	W-41
Fort Canby State Park	Columbia River	W-41
Fort Canby State Park	Columbia River	W-41
Fort Worden Military Res.	Port Townsend	W-1
Forty Rock	Hoh Head	W-23
Fresh Lake	Loomis Lake	W-39
Freshwater Bay	Angeles Point	W-7
Fuca Pillar	Cape Flattery	W-16
Garfield Gas Mound	Little Hogsback	W-28
Gettysburg Ranch	Low Point	W-9
Giants Graveyard	Strawberry Bay	W-22
Gibson Farm	Pillar Point	W-11
Gibson Spit	Grays Marsh	W-3
Gile Lake	Long Beach	W-40
Goodman Creek	Hoh Head	W-23
Goodman Creek Trail	Hoh Head	W-23

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Grass Island	Westport	W-34
Grayland Beach State Park	Grayland	W-35
Grayland Town	Grayland	W-35
Grays Harbor	Westport	W-34
Grays Marsh	Grays Marsh	W-3
Green Point	Green Point	W-5
Grenville Arch	Taholah	W-29
Grenville Bay	Taholah	W-29
Gunsight Rock	La Push	W-21
Heather Town	Grayland	W-35
Highland Heights	Moclips	W-30
Hobuck Beach	Makah Bay	W-17
Hobuck Creek	Makah Bay	W-17
Hobuck Lake	Makah Bay	W-17
Hogsback Rock	Tunnel Island	W-27
Hoh Head	Hoh Head	W-23
Hoh Indian Res.	Abbey Island	W-24
Hoh River	Abbey Island	W-24
Hoko River	Sekiu	W-13
Hole in the Wall	La Push	W-21
Hole in the Wall	Cape Flattery	W-16
Holman Town	Long Beach	W-40
Ilwaco City	Long Beach	W-40
Indian Creek	Pillar Point	W-11
Iron Springs	Copalis Beach	W-31
Island Lake	Loomis Lake	W-39
Jackson Creek	Hoh Head	W-23
Jagged Island	Carroll Island	W-20
James Islnad	La Push	W-21
James Lake	La Push	W-21
Jamestown	Grays Marsh	W-3
Jansen Creek	Sekiu River	W-14
Jefferson Oil Seep	Abbey Island	W-24
Jim Creek	Pillar Point	W-11
Joe Creek	Moclips	W-30
Johnson Creek	La Push	W-21
Kakesosta Rock	Strawberry Bay	W-22
Kalaloch Campground	Kalaloch	W-26
Kalaloch Creek	Kalaloch	W-26
Kalaloch Rocks	Kalaloch	W-26
Kalaloch Town	Kalaloch	W-26
Kallapa Creek	Makah Bay	W-17
Kanen Point	Diamond Point	W-2
Kayostla Beach	Carroll Island	W-20

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Kessiso Rocks	Cape Flattery	W-16
Klachopis Point	Neah Bay	W-15
Klapot Point	Grays Marsh	W-3
Klipsan Beach Town	Loomis Lake	W-39
Koitlah Point	Cape Flattery	W-16
Kulakala Point	Grays Marsh	W-3
Kydaka Point	Sekiu	W-13
Kydikabbit Point	Cape Flattery	W-16
La Push City	La Push	W-21
Landing Strip	Ocean City	W-32
Landing Strip (aban.)	Sekiu River	W-14
Lang Lake	Ocean City	W-32
Leadbetter Point State Park	Leadbetter Point	W-37
Lees Creek	Port Angeles	W-6
Lighthouse	Destruction Island	W-25
Litschke Lake	Loomis Lake	W-39
Little Hogsback	Little Hogsback	W-28
Little James Islnad	La Push	W-21
Long Beach City	Long Beach	W-40
Long Lake	Grayland	W-35
Loomis Lake	Loomis Lake	W-39
Loomis Lake State Park	Loomis Lake	W-39
Loomis Ranch	Loomis Lake	W-39
Lost Lake	Loomis Lake	W-39
Low Point	Low Point	W-9
Lower Elwha Indian Res.	Angeles Point	W-7
Lower Elwha Town	Angeles Point	W-7
Lyre Creek	Low Point	W-9
Makah Air Force Sta.	Makah Bay	W-17
Makah Air Force Sta.	Cape Flattery	W-16
Makah Bay	Makah Bay	W-17
Makah Bay Indian Res.	Cape Flattery	W-16
Makah Indian Res.	Makah Bay	W-17
Makah Nat. Salmon Hatchery	Makah Bay	W-17
Mallard Lake	Loomis Lake	W-39
Mannys Prairie	Point of the Arches	W-18
McKenzie Head	Columbia River	W-41
Meadowbrook Creek	Dungeness	W-4
Middle Creek	Cape Flattery	W-16
Middle Point	Sekiu	W-13
Middle Point	Port Townsend	W-1
Middle Rock	Abbey Island	W-24
Midway (site)	Cape Flattery	W-16
Moclips River	Moclips	W-30

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Moclips Town	Moclips	W-30
Moores Corner Town	Long Beach	W-40
Morehead Boys Camp	Ocean Park	W-38
Morse Creek	Port Angeles	W-6
Mosquito Creek	Hoh Head	W-23
Murdock Creek	Low Point	W-9
Mushroom Rock	Cape Flattery	W-16
Nahcotta Town	Ocean Park	W-38
Natural Arch	Strawberry Bay	W-22
Natural Arch	Hoh Head	W-23
Neah Bay	Neah Bay	W-15
Neah Bay City	Cape Flattery	W-16
Neah Bay City	Neah Bay	W-15
Nelson Creek	Copalis Beach	W-31
Nelson Creek	Low Point	W-9
New Dungeness Lighthouse Res.	Dungeness	W-4
North Beach Penn.	Ocean Park	W-38
North Beach Penn.	Leadbetter Point	W-37
North Fork	Tunnel Island	W-27
North Head	Columbia River	W-41
North Head Lighthouse	Columbia River	W-41
North Rock	Abbey Island	W-24
Norwegian Memorial	Carroll Island	W-20
Observatory Point	Crescent Bay	W-8
Ocean City	Ocean City	W-32
Ocean City State Park	Ocean City	W-32
Ocean Creek	Cape Flattery	W-16
Ocean Grove	Copalis Beach	W-31
Ocean Park Airport	Loomis Lake	W-39
Ocean Park City	Ocean Park	W-38
Ocean Shores Airport	Point Brown	W-33
Ocean Shores City	Point Brown	W-33
Oceanside Town	Loomis Lake	W-39
Oil City (site)	Abbey Island	W-24
Old Town	Dungeness	W-4
Olsen Creek	Sekiu River	W-14
Olympic Nat. Park	Destruction Island	W-25
Olympic Nat. Park	La Push	W-21
Olympic Nat. Park	Makah Bay	W-17
Olympic Nat. Park	Carroll Island	W-20
Olympic Nat. Park	Hoh Head	W-23
Olympic Nat. Park	Strawberry Bay	W-22
Olympic Nat. Park	Point of the Arches	W-18
Olympic Nat. Park Hdq.	Port Angeles	W-6

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Oneal Lake	Columbia River	W-41
Oyhut Nat. Wildlife Area	Point Brown	W-33
Oyhut Town	Ocean City	W-32
Ozette Indian Res.	Capa Alava	W-19
Ozette Island	Capa Alava	W-19
Pacific Beach State Park	Moclips	W-30
Pacific Beach Town	Moclips	W-30
Pacific Park	Long Beach	W-40
Paradise Cove	Grays Marsh	W-3
Pauls Lake	Loomis Lake	W-39
Pearsons Creek	Pearsons Creek	W-12
Petroleum Creek	Point of the Arches	W-18
Pilingoo	Moclips	W-30
Pillar Point	Pillar Point	W-11
Pillar Pt. State Rec. Area	Pillar Point	W-11
Point Brown	Point Brown	W-33
Point Chehalis	Westport	W-34
Point Grenville	Taholah	W-29
Point Wilson	Port Townsend	W-1
Point of the Arches	Point of the Arches	W-18
Port Angeles	Angeles Point	W-7
Port Angeles City	Port Angeles	W-6
Port Angeles Harbor	Port Angeles	W-6
Port Williams	Grays Marsh	W-3
Portage Head	Makah Bay	W-17
Pratt Cliff	Little Hogsback	W-28
Protection Island	Diamond Point	W-2
Pysht River	Pillar Point	W-11
Pysht Town	Pillar Point	W-11
Quateata Point	Strawberry Bay	W-22
Queets City	Kalaloch	W-26
Quileute Indian Res.	Strawberry Bay	W-22
Quileute Indian River	Strawberry Bay	W-22
Quillayute Needles	Strawberry Bay	W-22
Quillayute River	La Push	W-21
Quinault River	Taholah	W-29
Raft River	Tunnel Island	W-27
Rainy Creek	Tunnel Island	W-27
Rasmussen Creek	Neah Bay	W-15
Reed Creek	Pillar Point	W-11
Reed Creek	Pearsons Creek	W-12
Rialto Beach	La Push	W-21
Riiho Park	Loomis Lake	W-39
Roberts Farm	Grayland	W-35

Table 3

Washington Coastal Kelp Resources - Summer 2014

Geographic Features Index

- By Location

LOCATION	MAP NAME	MAP NUMBER
Stackpole Slough	Leadbetter Point	W-37
Starbuck Mine	Carroll Island	W-20
Steamboat Creek	Destruction Island	W-25
Strangers Lake	Port Townsend	W-1
Strawberry Bay	Strawberry Bay	W-22
Strawberry Point	Strawberry Bay	W-22
Strawberry Rock	Makah Bay	W-17
Striped Peak	Crescent Bay	W-8
Striped Peak Lookout Twr.	Crescent Bay	W-8
Sunset Beach	Moclips	W-30
Susie Creek	Low Point	W-9
Taholah City	Taholah	W-29
Tape Lake	Loomis Lake	W-39
Tatoosh Island	Cape Flattery	W-16
Tatoosh Lighthouse	Cape Flattery	W-16
Taylor Point	Strawberry Bay	W-22
Teahwhit Head	Strawberry Bay	W-22
The Lagoon	Grays Marsh	W-3
The Lagoon	Port Angeles	W-6
The Middle Ground	Grays Marsh	W-3
The Pot Holes	Grays Marsh	W-3
Third Beach	Strawberry Bay	W-22
Thompson Spit	Diamond Point	W-2
Thunder Field	La Push	W-21
Tibbals Lake	Port Townsend	W-1
Tinker Lake	Long Beach	W-40
Titaeoclos Falls	Cape Flattery	W-16
Toleak Point	Hoh Head	W-23
Tounge Point	Crescent Bay	W-8
Travis Spit	Grays Marsh	W-3
Tskawahyah Island	Capa Alava	W-19
Tunnel Island	Tunnel Island	W-27
Twin City	Twin	W-10
Two Man Rock	Carroll Island	W-20
Violett Point	Diamond Point	W-2
Waatch Creek	Cape Flattery	W-16
Waatch Point	Makah Bay	W-17
Waatch River	Makah Bay	W-17
Waddah Is. Coast Guard Res.	Neah Bay	W-15
Waddah Island	Neah Bay	W-15
Washington Harbor	Grays Marsh	W-3
Washington Islands Wild. Area	Abbey Island	W-24
Wedding Rocks	Capa Alava	W-19
West Twin River	Twin	W-10

Table 4

Washington Coastal Kelp Resources - Summer 2014

Map Control Points - UTM, Zone 10

- By Map Number

MAP NUMBER	CONTROL POINT A	CONTROL POINT B	CONTROL POINT C	CONTROL POINT D
	North (m)/East (m)	North (m)/East (m)	North (m)/East (m)	North (m)/East (m)
W-01	5,331,000/516,009	5,331,004/513,564	5,330,126/511,753	5,328,563/510,396
W-02	5,328,083/509,177	5,326,000/506,000	5,326,403/502,804	5,326,000/500,980
W-03	5,325,000/499,000	5,326,000/496,000	5,328,000/495,000	5,330,000/493,000
W-04	5,332,000/492,000	5,333,000/490,000	5,334,000/488,000	5,331,000/486,000
W-05	5,329,996/484,022	5,329,000/481,000	5,329,000/478,000	5,328,532/476,059
W-06	5,329,081/473,780	5,329,000/470,000	5,329,000/467,000	5,329,957/465,655
W-07	5,330,737/464,106	5,331,000/460,000	5,332,634/459,033	5,331,000/456,000
W-08	5,331,543/453,828	5,333,700/451,008	5,334,403/448,399	5,333,923/445,211
W-09	5,333,493/443,616	5,333,000/441,000	5,333,000/437,000	5,333,759/434,835
W-10	5,333,995/433,627	5,334,000/431,000	5,333,893/427,091	5,335,000/425,000
W-11	5,335,000/423,000	5,336,000/421,000	5,338,000/419,000	5,340,000/417,000
W-12	5,340,000/415,000	5,342,000/413,000	5,343,000/411,000	5,344,000/408,000
W-13	5,344,000/406,000	5,345,000/404,000	5,346,000/401,000	5,347,000/399,000
W-14	5,348,000/396,000	5,350,000/394,000	5,351,000/392,000	5,352,000/390,000
W-15	5,354,000/388,000	5,355,000/386,000	5,357,000/384,000	5,357,000/382,000
W-16	5,358,000/379,000	5,360,000/378,000	5,360,000/373,000	5,358,000/374,000
W-17	5,356,000/375,000	5,355,000/378,000	5,351,000/377,000	5,348,000/377,000
W-18	5,345,000/376,000	5,343,000/375,000	5,340,000/375,000	5,338,000/375,000
W-19	5,336,000/372,000	5,336,000/373,000	5,334,000/373,000	5,331,000/374,000
W-20	5,326,000/375,000	5,324,000/375,000	5,321,000/375,000	5,319,000/376,000
W-21	5,316,000/376,000	5,314,000/376,000	5,311,000/378,000	5,309,000/379,000
W-22	5,306,000/380,000	5,304,000/380,000	5,303,000/383,000	5,301,000/385,000
W-23	5,299,000/387,000	5,297,000/389,000	5,294,000/390,000	5,292,000/390,000
W-24	5,291,000/392,000	5,289,000/393,000	5,286,000/394,000	5,284,000/395,000
W-25	5,282,000/388,000	5,282,000/389,000	5,280,000/388,000	5,280,000/389,000

Control Points "A-D" Orientation:
- Maps: 1 - 16 - East to West
- Maps: 17 - 41 - North to South

Table 5
Washington Coastal Kelp Resources - Summer 2014
Kelp Canopy Areas (ha)/Species Composition
By Kelp Bed Number

MAP KELP BED NUMBER	KELP BED CANOPY AREAS (ha)					CANOPY AREA SUMMARY (ha)			CANOPY AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed *% Nereo*	Canopy *% Macro*	Total *% Nereo*	Canopy *% Macro*
		Nereo	*Macro*	Total								
1.1	18.3	0.0	0.0	0.0	0.0	18.3	0.0	**18.3**	0	0	**100**	**0**
1.2	13.9	0.0	0.0	0.0	0.0	13.9	0.0	**13.9**	0	0	**100**	**0**
2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.3	0.1	0.0	0.0	0.0	0.0	0.1	0.0	**0.1**	0	0	**100**	**0**
2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
3.2	3.0	0.0	0.0	0.0	0.0	3.0	0.0	**3.0**	0	0	**100**	**0**
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
4.2	1.4	0.0	0.0	0.0	0.0	1.4	0.0	**1.4**	0	0	**100**	**0**
4.3	2.8	0.0	0.0	0.0	0.0	2.8	0.0	**2.8**	0	0	**100**	**0**
5.1	4.8	0.0	0.0	0.0	0.0	4.8	0.0	**4.8**	0	0	**100**	**0**
5.2	2.3	0.0	0.0	0.0	0.0	2.3	0.0	**2.3**	0	0	**100**	**0**
6.1	7.9	0.0	0.0	0.0	0.0	7.9	0.0	**7.9**	0	0	**100**	**0**
6.2	0.6	0.0	0.0	0.0	0.0	0.6	0.0	**0.6**	0	0	**100**	**0**
7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
7.3	14.8	0.0	0.0	0.0	0.9	14.8	0.9	**15.7**	0	0	**94**	**6**
8.1	15.4	0.0	0.0	0.0	0.0	15.4	0.0	**15.4**	0	0	**100**	**0**
8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
8.3	1.8	0.0	0.0	0.0	0.0	1.8	0.0	**1.8**	0	0	**100**	**0**
8.4	1.9	0.0	0.0	0.0	0.0	1.9	0.0	**1.9**	0	0	**100**	**0**
9.1	12.7	0.0	0.0	0.0	31.5	12.7	31.5	**44.3**	0	0	**29**	**71**
9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
9.3	11.0	5.5	12.9	18.5	30.5	16.5	43.5	**60.0**	30	70	**28**	**72**
10.1	4.9	0.0	0.0	0.0	35.7	4.9	35.7	**40.6**	0	0	**12**	**88**
10.2	0.0	6.4	6.4	12.8	3.3	6.4	9.7	**16.0**	50	50	**40**	**60**
10.3	1.3	0.0	0.0	0.0	16.3	1.3	16.3	**17.5**	0	0	**7**	**93**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrosystis sp.*

Table 5
Washington Coastal Kelp Resources - Summer 2014
Kelp Canopy Areas (ha)/Species Composition
By Kelp Bed Number

MAP KELP BED NUMBER	KELP BED CANOPY AREAS (ha)					CANOPY AREA SUMMARY (ha)			CANOPY AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed % *Nereo*	Canopy % *Macro*	Total % *Nereo*	Canopy % *Macro*
		Nereo	*Macro*	Total								
10.4	0.3	0.0	0.0	0.0	12.3	0.3	12.3	**12.6**	0	0	**2**	**98**
10.5	0.5	10.1	23.6	33.7	1.7	10.6	25.3	**35.9**	30	70	**30**	**70**
10.6	0.2	1.4	3.2	4.5	4.9	1.5	8.0	**9.5**	30	70	**16**	**84**
11.1	6.2	1.5	3.6	5.1	28.0	7.8	31.6	**39.4**	30	70	**20**	**80**
11.2	15.4	0.0	0.0	0.0	25.7	15.4	25.7	**41.1**	0	0	**38**	**62**
11.3	1.2	0.0	0.0	0.0	2.5	1.2	2.5	**3.7**	0	0	**32**	**68**
12.1	0.0	14.4	21.6	35.9	0.0	14.4	21.6	**35.9**	40	60	**40**	**60**
13.1	5.1	0.0	0.0	0.0	1.3	5.1	1.3	**6.4**	0	0	**80**	**20**
13.2	0.0	2.8	6.4	9.2	2.4	2.8	8.8	**11.6**	30	70	**24**	**76**
14.1	10.7	0.0	0.0	0.0	37.6	10.7	37.6	**48.3**	0	0	**22**	**78**
15.1	1.5	1.0	2.4	3.5	2.4	2.6	4.8	**7.4**	30	70	**35**	**65**
15.2	3.4	1.5	3.6	5.1	20.7	5.0	24.3	**29.3**	30	70	**17**	**83**
15.3	0.0	1.5	6.0	7.5	0.3	1.5	6.3	**7.8**	20	80	**19**	**81**
15.4	4.0	0.0	0.0	0.0	11.1	4.0	11.1	**15.1**	0	0	**27**	**73**
16.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
16.2	18.6	0.0	0.0	0.0	38.3	18.6	38.3	**56.9**	0	0	**33**	**67**
16.3	2.6	0.0	0.0	0.0	0.0	2.6	0.0	**2.6**	0	0	**100**	**0**
16.4	2.5	0.0	0.0	0.0	0.5	2.5	0.5	**3.0**	0	0	**84**	**16**
17.1	3.0	0.0	0.0	0.0	5.3	3.0	5.3	**8.3**	0	0	**37**	**63**
17.2	5.4	0.0	0.0	0.0	7.4	5.4	7.4	**12.8**	0	0	**42**	**58**
17.3	4.3	0.0	0.0	0.0	0.0	4.3	0.0	**4.3**	0	0	**100**	**0**
18.1	1.5	0.0	0.0	0.0	1.3	1.5	1.3	**2.7**	0	0	**54**	**46**
18.2	0.3	0.0	0.0	0.0	4.2	0.3	4.2	**4.5**	0	0	**7**	**93**
19.1	14.6	0.0	0.0	0.0	94.6	14.6	94.6	**109.2**	0	0	**13**	**87**
19.2	8.5	0.0	0.0	0.0	24.4	8.5	24.4	**32.8**	0	0	**26**	**74**
20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
20.2	1.2	0.0	0.0	0.0	0.0	1.2	0.0	**1.2**	0	0	**100**	**0**
21.1	2.8	0.0	0.0	0.0	3.3	2.8	3.3	**6.2**	0	0	**46**	**54**
21.2	1.6	0.0	0.0	0.0	7.3	1.6	7.3	**8.8**	0	0	**18**	**82**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrosystis sp.*

Table 5
Washington Coastal Kelp Resources - Summer 2014
Kelp Canopy Areas (ha)/Species Composition
By Kelp Bed Number

MAP KELP BED NUMBER	KELP BED CANOPY AREAS (ha)					CANOPY AREA SUMMARY (ha)			CANOPY AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed *% Nereo*	Canopy *% Macro*	Total *% Nereo*	Canopy *% Macro*
		Nereo	*Macro*	Total								
22.1	2.1	0.0	0.0	0.0	0.0	2.1	0.0	**2.1**	0	0	**100**	**0**
22.2	4.9	0.0	0.0	0.0	5.9	4.9	5.9	**10.8**	0	0	**46**	**54**
23.1	2.5	0.0	0.0	0.0	0.0	2.5	0.0	**2.5**	0	0	**100**	**0**
23.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
24.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
24.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
25.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
25.2	0.1	0.0	0.0	0.0	8.9	0.1	8.9	**9.0**	0	0	**1**	**99**
26.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
28.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
29.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
30.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
31.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
32.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
33.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
34.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
35.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
36.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
37.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
38.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
39.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
40.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
41.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
TOTALS	**244.0**	**46.1**	**89.6**	**135.7**	**470.3**	**290.2**	**559.9**	**850.1**	**34**	**66**	**34**	**66**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrosystis sp.*

Table 6

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Planimeter Areas (ha)/Species Composition

- By Kelp Bed Number

MAP.KELP BED NUMBER	KELP BED PLANIMETER AREAS (ha)					PLANIMETER AREA SUMMARY (ha)			PLANMETER AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed *% Nereo*	Canopy *% Macro*	Total *% Nereo*	Canopy *% Macro*
		Nereo	Macro	Total								
1.1	57.4	0.0	0.0	0.0	0.0	57.4	0.0	**57.4**	0	0	**100**	**0**
1.2	26.0	0.0	0.0	0.0	0.0	26.0	0.0	**26.0**	0	0	**100**	**0**
2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.3	1.6	0.0	0.0	0.0	0.0	1.6	0.0	**1.6**	0	0	**100**	**0**
2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
3.2	22.1	0.0	0.0	0.0	0.0	22.1	0.0	**22.1**	0	0	**100**	**0**
4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
4.2	17.5	0.0	0.0	0.0	0.0	17.5	0.0	**17.5**	0	0	**100**	**0**
4.3	36.2	0.0	0.0	0.0	0.0	36.2	0.0	**36.2**	0	0	**100**	**0**
5.1	46.5	0.0	0.0	0.0	0.0	46.5	0.0	**46.5**	0	0	**100**	**0**
5.2	27.1	0.0	0.0	0.0	0.0	27.1	0.0	**27.1**	0	0	**100**	**0**
6.1	42.9	0.0	0.0	0.0	0.0	42.9	0.0	**42.9**	0	0	**100**	**0**
6.2	7.9	0.0	0.0	0.0	0.0	7.9	0.0	**7.9**	0	0	**100**	**0**
7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
7.3	50.5	0.0	0.0	0.0	3.9	50.5	3.9	**54.4**	0	0	**93**	**7**
8.1	60.4	0.0	0.0	0.0	0.0	60.4	0.0	**60.4**	0	0	**100**	**0**
8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
8.3	8.9	0.0	0.0	0.0	0.0	8.9	0.0	**8.9**	0	0	**100**	**0**
8.4	6.3	0.0	0.0	0.0	0.0	6.3	0.0	**6.3**	0	0	**100**	**0**
9.1	60.1	0.0	0.0	0.0	72.8	60.1	72.8	**132.9**	0	0	**45**	**55**
9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
9.3	67.0	12.1	28.2	40.3	68.3	79.0	96.4	**175.5**	30	70	**45**	**55**
10.1	28.0	0.0	0.0	0.0	82.2	28.0	82.2	**110.2**	0	0	**25**	**75**
10.2	0.0	33.1	33.1	66.2	12.5	33.1	45.6	**78.7**	50	50	**42**	**58**
10.3	9.6	0.0	0.0	0.0	34.9	9.6	34.9	**44.5**	0	0	**21**	**79**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrocystis sp.*

Table 6

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Planimeter Areas (ha)/Species Composition

- By Kelp Bed Number

MAP.KELP BED NUMBER	KELP BED PLANIMETER AREAS (ha)					PLANIMETER AREA SUMMARY (ha)			PLANMETER AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed *% Nereo*	Canopy *% Macro*	Total *% Nereo*	Canopy *% Macro*
		Nereo	Macro	Total								
10.4	4.7	0.0	0.0	0.0	22.0	4.7	22.0	**26.7**	0	0	**18**	**82**
10.5	5.1	29.2	68.0	97.2	6.2	34.3	74.2	**108.5**	30	70	**32**	**68**
10.6	3.3	8.7	20.4	29.1	18.2	12.0	38.5	**50.6**	30	70	**24**	**76**
11.1	43.6	4.4	10.3	14.8	60.1	48.0	70.4	**118.5**	30	70	**41**	**59**
11.2	46.9	0.0	0.0	0.0	52.0	46.9	52.0	**98.9**	0	0	**47**	**53**
11.3	6.3	0.0	0.0	0.0	8.8	6.3	8.8	**15.1**	0	0	**42**	**58**
12.1	0.0	43.8	65.7	109.5	0.0	43.8	65.7	**109.5**	40	60	**40**	**60**
13.1	24.6	0.0	0.0	0.0	5.8	24.6	5.8	**30.3**	0	0	**81**	**19**
13.2	0.0	8.4	19.5	27.9	8.2	8.4	27.7	**36.1**	30	70	**23**	**77**
14.1	49.4	0.0	0.0	0.0	79.3	49.4	79.3	**128.6**	0	0	**38**	**62**
15.1	12.8	2.7	6.3	9.1	5.5	15.5	11.8	**27.3**	30	70	**57**	**43**
15.2	21.4	4.0	9.3	13.3	55.6	25.4	64.9	**90.2**	30	70	**28**	**72**
15.3	0.0	5.3	21.0	26.3	1.7	5.3	22.7	**28.0**	20	80	**19**	**81**
15.4	22.1	0.0	0.0	0.0	28.2	22.1	28.2	**50.3**	0	0	**44**	**56**
16.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
16.2	85.1	0.0	0.0	0.0	73.6	85.1	73.6	**158.8**	0	0	**54**	**46**
16.3	17.8	0.0	0.0	0.0	0.0	17.8	0.0	**17.8**	0	0	**100**	**0**
16.4	22.6	0.0	0.0	0.0	3.5	22.6	3.5	**26.1**	0	0	**87**	**13**
17.1	36.8	0.0	0.0	0.0	20.7	36.8	20.7	**57.5**	0	0	**64**	**36**
17.2	43.7	0.0	0.0	0.0	24.4	43.7	24.4	**68.1**	0	0	**64**	**36**
17.3	41.6	0.0	0.0	0.0	0.0	41.6	0.0	**41.6**	0	0	**100**	**0**
18.1	20.9	0.0	0.0	0.0	3.7	20.9	3.7	**24.6**	0	0	**85**	**15**
18.2	5.0	0.0	0.0	0.0	14.5	5.0	14.5	**19.5**	0	0	**26**	**74**
19.1	113.0	0.0	0.0	0.0	156.6	113.0	156.6	**269.6**	0	0	**42**	**58**
19.2	60.4	0.0	0.0	0.0	48.1	60.4	48.1	**108.4**	0	0	**56**	**44**
20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
20.2	11.5	0.0	0.0	0.0	0.0	11.5	0.0	**11.5**	0	0	**100**	**0**
21.1	37.7	0.0	0.0	0.0	11.1	37.7	11.1	**48.8**	0	0	**77**	**23**
21.2	18.8	0.0	0.0	0.0	16.6	18.8	16.6	**35.5**	0	0	**53**	**47**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrocystis sp.*

Table 6

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Planimeter Areas (ha)/Species Composition

- By Kelp Bed Number

MAP.KELP BED NUMBER	KELP BED PLANIMETER AREAS (ha)					PLANIMETER AREA SUMMARY (ha)			PLANMETER AREA COMPOSITION			
	Nereo Canopy	Mixed Canopy			*Macro* Canopy	Total *Nereo*	Total *Macro*	Total Canopy	Mixed *% Nereo*	Canopy *% Macro*	Total *% Nereo*	Canopy *% Macro*
		Nereo	Macro	Total								
22.1	11.2	0.0	0.0	0.0	0.0	11.2	0.0	**11.2**	0	0	**100**	**0**
22.2	48.4	0.0	0.0	0.0	12.7	48.4	12.7	**61.1**	0	0	**79**	**21**
23.1	28.3	0.0	0.0	0.0	0.0	28.3	0.0	**28.3**	0	0	**100**	**0**
23.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
24.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
24.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
25.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
25.2	2.1	0.0	0.0	0.0	34.9	2.1	34.9	**37.0**	0	0	**6**	**94**
26.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
28.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
29.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
30.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
31.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
32.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
33.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
34.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
35.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
36.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
37.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
38.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
39.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
40.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
41.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0	0	**0**	**0**
TOTALS	**1,421.1**	**151.6**	**282.0**	**433.6**	**1,046.4**	**1,572.7**	**1,328.4**	**2,901.1**	**35**	**65**	**54**	**46**

"Nereo" = *Nereocystis sp.*
"Macro" = *Macrocystis sp.*

Table 7

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Areas (ha.)/RDI

- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP CANOPY SUMMARY		
	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI
1.1	18.3	57.4	0.32	0.0	0.0	0.00	18.3	57.4	0.32
1.2	13.9	26.0	0.54	0.0	0.0	0.00	13.9	26.0	0.53
2.1	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
2.2	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
2.3	0.1	1.6	0.08	0.0	0.0	0.00	0.1	1.6	0.08
2.4	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
2.5	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
3.1	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
3.2	3.0	22.1	0.14	0.0	0.0	0.00	3.0	22.1	0.14
4.1	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
4.2	1.4	17.5	0.08	0.0	0.0	0.00	1.4	17.5	0.08
4.3	2.8	36.2	0.08	0.0	0.0	0.00	2.8	36.2	0.08
5.1	4.8	46.5	0.10	0.0	0.0	0.00	4.8	46.5	0.10
5.2	2.3	27.1	0.08	0.0	0.0	0.00	2.3	27.1	0.08
6.1	7.9	42.9	0.19	0.0	0.0	0.00	7.9	42.9	0.19
6.2	0.6	7.9	0.08	0.0	0.0	0.00	0.6	7.9	0.08
7.1	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
7.2	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
7.3	14.8	50.5	0.29	0.9	3.9	0.23	15.7	54.4	0.29
8.1	15.4	60.4	0.25	0.0	0.0	0.00	15.4	60.4	0.25
8.2	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
8.3	1.8	8.9	0.20	0.0	0.0	0.00	1.8	8.9	0.20
8.4	1.9	6.3	0.30	0.0	0.0	0.00	1.9	6.3	0.30
9.1	12.7	60.1	0.21	31.5	72.8	0.43	44.3	132.9	0.33
9.2	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
9.3	16.5	79.0	0.21	43.5	96.4	0.45	60.0	175.5	0.34
10.1	4.9	28.0	0.17	35.7	82.2	0.43	40.6	110.2	0.37
10.2	6.4	33.1	0.19	9.7	45.6	0.21	16.0	78.7	0.20
10.3	1.3	9.6	0.13	16.3	34.9	0.47	17.5	44.5	0.39

Table 7

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Areas (ha.)/RDI

- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP CANOPY SUMMARY		
	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI
10.4	0.3	4.7	0.06	12.3	22.0	0.56	**12.6**	**26.7**	**0.47**
10.5	10.6	34.3	0.31	25.3	74.2	0.34	**35.9**	**108.5**	**0.33**
10.6	1.5	12.0	0.13	8.0	38.5	0.21	**9.5**	**50.6**	**0.19**
11.1	7.8	48.0	0.16	31.6	70.4	0.45	**39.4**	**118.5**	**0.33**
11.2	15.4	46.9	0.33	25.7	52.0	0.49	**41.1**	**98.9**	**0.42**
11.3	1.2	6.3	0.18	2.5	8.8	0.28	**3.7**	**15.1**	**0.24**
12.1	14.4	43.8	0.33	21.6	65.7	0.33	**35.9**	**109.5**	**0.33**
13.1	5.1	24.6	0.21	1.3	5.8	0.22	**6.4**	**30.3**	**0.21**
13.2	2.8	8.4	0.33	8.8	27.7	0.32	**11.6**	**36.1**	**0.32**
14.1	10.7	49.4	0.22	37.6	79.3	0.47	**48.3**	**128.6**	**0.38**
15.1	2.6	15.5	0.17	4.8	11.8	0.41	**7.4**	**27.3**	**0.27**
15.2	5.0	25.4	0.20	24.3	64.9	0.37	**29.3**	**90.2**	**0.32**
15.3	1.5	5.3	0.28	6.3	22.7	0.28	**7.8**	**28.0**	**0.28**
15.4	4.0	22.1	0.18	11.1	28.2	0.39	**15.1**	**50.3**	**0.30**
16.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
16.2	18.6	85.1	0.22	38.3	73.6	0.52	**56.9**	**158.8**	**0.36**
16.3	2.6	17.8	0.14	0.0	0.0	0.00	**2.6**	**17.8**	**0.14**
16.4	2.5	22.6	0.11	0.5	3.5	0.14	**3.0**	**26.1**	**0.12**
17.1	3.0	36.8	0.08	5.3	20.7	0.25	**8.3**	**57.5**	**0.14**
17.2	5.4	43.7	0.12	7.4	24.4	0.31	**12.8**	**68.1**	**0.19**
17.3	4.3	41.6	0.10	0.0	0.0	0.00	**4.3**	**41.6**	**0.10**
18.1	1.5	20.9	0.07	1.3	3.7	0.35	**2.7**	**24.6**	**0.11**
18.2	0.3	5.0	0.06	4.2	14.5	0.29	**4.5**	**19.6**	**0.23**
19.1	14.6	113.0	0.13	94.6	156.6	0.60	**109.2**	**269.6**	**0.41**
19.2	8.5	60.4	0.14	24.4	48.1	0.51	**32.8**	**108.4**	**0.30**
20.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
20.2	1.2	11.5	0.11	0.0	0.0	0.00	**1.2**	**11.5**	**0.11**
21.1	2.8	37.7	0.08	3.3	11.1	0.30	**6.2**	**48.8**	**0.13**

Table 7

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Areas (ha.)/RDI

- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP CANOPY SUMMARY		
	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI	Canopy Area (ha.)	Planimeter Area (ha.)	RDI
21.2	1.6	18.8	0.08	7.3	16.6	0.44	**8.8**	**35.5**	**0.25**
22.1	2.1	11.2	0.19	0.0	0.0	0.00	**2.1**	**11.2**	**0.19**
22.2	4.9	48.4	0.10	5.9	12.7	0.46	**10.8**	**61.1**	**0.18**
23.1	2.5	28.3	0.09	0.0	0.0	0.00	**2.5**	**28.3**	**0.09**
23.2	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
24.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
24.2	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
25.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
25.2	0.1	2.1	0.05	8.9	34.9	0.26	**9.0**	**37.0**	**0.24**
26.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
27.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
28.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
29.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
30.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
31.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
32.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
33.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
34.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
35.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
36.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
37.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
38.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
39.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
40.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
41.1	0.0	0.0	0.00	0.0	0.0	0.00	**0.0**	**0.0**	**0.00**
TOTALS	**290.2**	**1,572.7**	**0.18**	**559.9**	**1,328.4**	**0.42**	**850.1**	**2,901.4**	**0.29**

Table 8

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Areas (ha.)

- By Map Number and Species

MAP NUMBER	MAP NAME	CANOPY AREA (ha.)			PLANIMETER AREA (ha.)			RDI
		Nereocystis	*Macrocystis*	Total	*Nereocystis*	*Macrocystis*	Total	Total
1	Port Townsend	32.2	0.0	**32.2**	83.4	0.0	**83.4**	0.39
2	Diamond Point	0.1	0.0	**0.1**	1.6	0.0	**1.6**	0.08
3	Gray's Marsh	3.0	0.0	**3.0**	22.1	0.0	**22.1**	0.14
4	Dungeness	4.2	0.0	**4.2**	53.7	0.0	**53.7**	0.08
5	Green Point	7.1	0.0	**7.1**	73.6	0.0	**73.6**	0.10
6	Port Angeles	8.6	0.0	**8.6**	50.8	0.0	**50.8**	0.17
7	Angeles Point	14.8	0.9	**15.7**	50.5	3.9	**54.4**	0.29
8	Crescent Bay	19.0	0.0	**19.0**	75.7	0.0	**75.7**	0.25
9	Low Point	29.3	75.0	**104.3**	139.2	169.2	**308.4**	0.34
10	Twin	25.0	107.2	**132.2**	121.6	297.5	**419.2**	0.32
11	Pillar Point	24.4	59.7	**84.1**	101.3	131.2	**232.5**	0.36
12	Pearson Creek	14.4	21.6	**35.9**	43.8	65.7	**109.5**	0.33
13	Sekiu	7.9	10.1	**18.0**	32.9	33.5	**66.4**	0.27
14	Sekiu River	10.7	37.6	**48.3**	49.4	79.3	**128.7**	0.38
15	Neah Bay	13.1	46.4	**59.5**	68.3	127.6	**195.9**	0.30
16	Cape Flattery	23.7	38.8	**62.5**	125.6	77.1	**202.7**	0.31
17	Makah Bay	12.7	12.7	**25.4**	122.1	45.1	**167.2**	0.15
18	Point of the Arche	1.8	5.4	**7.2**	25.9	18.2	**44.2**	0.16
19	Cape Alava	23.1	119.0	**142.1**	173.4	204.6	**378.0**	0.38
20	Carroll Island	1.2	0.0	**1.2**	11.5	0.0	**11.5**	0.11
21	La Push	4.4	10.6	**15.0**	56.6	27.7	**84.3**	0.18
22	Strawberry Bay	7.0	5.9	**12.9**	59.6	12.7	**72.4**	0.18
23	Hoh Head	2.5	0.0	**2.5**	28.3	0.0	**28.3**	0.09
24	Abbey Island	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
25	Destruction Island	0.1	8.9	**9.0**	2.1	35.0	**37.0**	0.24
26	Kalaloch	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
27	Tunnel Island	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
28	Little Hogsback	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
29	Taholah	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
30	Moclips	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
31	Copalis beach	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
32	Ocean City	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
33	Point Brown	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
34	Westport	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
35	Grayland	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
36	Willapa Bay	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
37	Leadbetter Point	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
38	Ocean Park	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
39	Loomis Lake	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
40	Long Beach	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
41	Columbia River	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.00
TOTALS		**290.2**	**559.9**	**850.1**	**1,573.2**	**1,328.8**	**2,901.5**	**0.29**

Table 9

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Areas

Percent of Individual Species/Total Kelp Resource Area

- By Map Number and Species

MAP NUMBER	MAP NAME	CANOPY AREA (percent)			PLANIMETER AREA (percent)		
		Nereocystis	*Macrocystis*	Total	*Nereocystis*	*Macrocystis*	Total
1	Port Townsend	11.1	0.0	**3.8**	5.3	0.0	**2.9**
2	Diamond Point	0.0	0.0	**0.0**	0.1	0.0	**0.1**
3	Gray's Marsh	1.0	0.0	**0.4**	1.4	0.0	**0.8**
4	Dungeness	1.4	0.0	**0.5**	3.4	0.0	**1.9**
5	Green Point	2.5	0.0	**0.8**	4.7	0.0	**2.5**
6	Port Angeles	3.0	0.0	**1.0**	3.2	0.0	**1.8**
7	Angeles Point	5.1	0.2	**1.8**	3.2	0.3	**1.9**
8	Crescent Bay	6.6	0.0	**2.2**	4.8	0.0	**2.6**
9	Low Point	10.1	13.4	**12.3**	8.9	12.7	**10.6**
10	Twin	8.6	19.2	**15.6**	7.7	22.4	**14.5**
11	Pillar Point	8.4	10.7	**9.9**	6.4	9.9	**8.0**
12	Pearson Creek	5.0	3.8	**4.2**	2.8	5.0	**3.8**
13	Sekiu	2.7	1.8	**2.1**	2.1	2.5	**2.3**
14	Sekiu River	3.7	6.7	**5.7**	3.1	6.0	**4.4**
15	Neah Bay	4.5	8.3	**7.0**	4.4	9.6	**6.8**
16	Cape Flattery	8.2	6.9	**7.4**	8.0	5.8	**7.0**
17	Makah Bay	4.4	2.3	**3.0**	7.8	3.4	**5.8**
18	Point of the Arches	0.6	1.0	**0.8**	1.7	1.4	**1.5**
19	Cape Alava	8.0	21.3	**16.7**	11.0	15.4	**13.0**
20	Carroll Island	0.4	0.0	**0.1**	0.7	0.0	**0.4**
21	La Push	1.5	1.9	**1.8**	3.6	2.1	**2.9**
22	Strawberry Bay	2.4	1.1	**1.5**	3.8	1.0	**2.5**
23	Hoh Head	0.9	0.0	**0.3**	1.8	0.0	**1.0**
24	Abbey Island	0.0	0.0	**0.0**	0.0	0.0	**0.0**
25	Destruction Island	0.0	1.6	**1.1**	0.1	2.6	**1.3**
26	Kalaloch	0.0	0.0	**0.0**	0.0	0.0	**0.0**
27	Tunnel Island	0.0	0.0	**0.0**	0.0	0.0	**0.0**
28	Little Hogsback	0.0	0.0	**0.0**	0.0	0.0	**0.0**
29	Taholah	0.0	0.0	**0.0**	0.0	0.0	**0.0**
30	Moclips	0.0	0.0	**0.0**	0.0	0.0	**0.0**
31	Copalis beach	0.0	0.0	**0.0**	0.0	0.0	**0.0**
32	Ocean City	0.0	0.0	**0.0**	0.0	0.0	**0.0**
33	Point Brown	0.0	0.0	**0.0**	0.0	0.0	**0.0**
34	Westport	0.0	0.0	**0.0**	0.0	0.0	**0.0**
35	Grayland	0.0	0.0	**0.0**	0.0	0.0	**0.0**
36	Willapa Bay	0.0	0.0	**0.0**	0.0	0.0	**0.0**
37	Leadbetter Point	0.0	0.0	**0.0**	0.0	0.0	**0.0**
38	Ocean Park	0.0	0.0	**0.0**	0.0	0.0	**0.0**
39	Loomis Lake	0.0	0.0	**0.0**	0.0	0.0	**0.0**
40	Long Beach	0.0	0.0	**0.0**	0.0	0.0	**0.0**
41	Columbia River	0.0	0.0	**0.0**	0.0	0.0	**0.0**
TOTALS		**100.0**	**100.0**	**100.0**	**100.4**	**100.4**	**100.4**

Table 10

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Area Summary (ha.)

Percent of Individual Species/Total Kelp Resource

- By Survey Range

SURVEY RANGE SUMMARY	KELP CANOPY AREAS			KELP PLAN. AREAS			RDI
	2014 Can. Area (ha)	Percent of Ind. Spec.	Percent of Tot. Res.	2014 Plan. Area (ha)	Percent of Ind. Spec.	Percent of Tot. Res.	2014
1) Strait of Juan De Fuca (Port Townsend to Cape Flattery)							
Total Nereocystis-"Straits" (Canopies 1.1-16.2)	232.2	80.0	27.3	1,053.0	67.0	36.3	0.22
Total Macrocystis-"Straits" (Canopies 1.1-16.2)	396.8	70.9	46.7	981.6	73.9	33.8	0.40
TOTAL KELP-"STRAITS" (Canopies 1.1-16.2)	**629.0**		**74.0**	**2,034.6**		**70.1**	**0.31**
2) Open Coast (Cape Flattery to the Columbia River)							
Total Nereocystis-"Open Coast" (Canopies 16.3-41.1)	58.0	20.0	6.8	519.8	33.0	17.9	0.11
Total Macrocystis-"Open Coast" (Canopies 16.3-41.1)	163.1	29.1	19.2	346.8	26.1	12.0	0.47
TOTAL KELP-"OPEN COAST" (Canopies 16.3-41.1)	**221.0**		**26.0**	**866.6**		**29.9**	**0.26**
3) Total Kelp - Range-wide							
Total Nereocystis-"Range-wide" (Canopies 1.1-41.1)	290.2		34.1	1,572.8		54.2	0.18
Total Macrocystis-"Range-wide" (Canopies 1.1-41.1)	559.9		65.9	1,328.4		45.8	0.42
TOTAL KELP RESOURCE-"Range-wide" (Canopies 1.1-41.1)	**850.1**		**100.0**	**2,901.1**		**100.0**	**0.29**

SPECIAL AREAS OF INTEREST	2014 Can. Area (ha)	Percent of Ind. Spec.	Percent of Tot. Res.	2014 Plan. Area (ha)	Percent of Ind. Spec.	Percent of Tot. Res.	2014
1) Total Kelp in "Straits" - By Sub-Range							
Total Kelp-Port Townsend to Disque (Canopies 1.1-9.3)	194.2		22.8	723.7		24.9	0.27
Total Kelp-Twin Rivers to Cape Flattery (Canopies 10.1-16.2)	434.9		51.2	1,310.8		45.2	0.33
2) Olympic Coast National Marine Sanctuary							
Total Nereocystis-Neah Bay to the Copalis River (Canopies 15.3-31.1)	82.1	28.3	9.7	632.3	40.2	21.8	0.13
Total Macrocystis-Neah Bay to the Copalis River (Canopies 15.3-31.1)	218.7	39.1	25.7	471.3	35.5	16.2	0.46
TOTAL KELP - OLYMPIC COAST NMS (Canopies 15.3-31.1)	**300.8**		**35.4**	**1,103.6**		**38.0**	**0.27**
3) Neah Bay to Cape Alava							
Total Nereocystis-Neah Bay to Cape Alava (Canopies 15.3-19.2)	66.8	23.0	7.9	474.3	30.2	16.3	0.14
Total Macrocystis-Neah Bay to Cape Alava (Canopies 15.3-19.2)	193.3	34.5	22.7	396.0	29.8	13.6	0.49
TOTAL KELP-NEAH BAY TO CAPE ALAVA (Canopy 15.3-19.2)	**260.1**		**30.6**	**870.3**		**30.0**	**0.30**
4) Port Townsend to Neah Bay and Cape Alava to Destruction Is.							
Total Nereocystis-Outside Above Range (1.1-15.2 and 20.1-41.1)	223.3	77.0	26.3	1,098.5	69.8	37.9	0.20
Total Macrocystis-Outside Above Range (1.1-15.2 and 20.1-41.1)	366.6	65.5	43.1	932.4	70.2	32.1	0.39
TOTAL KELP-OUTSIDE RANGE Neah Bay to Cape Alava (1.1-15.2 and 20.1-41.	**590.0**		**69.4**	**2,030.9**		**70.0**	**0.29**

Table 11

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy Area Change (2013-2014)

- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP BED CANOPY AREA CHANGE 2013-14		
	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)
1.1	21.0	-13	18.3	0.0	0	0.0	**21.0**	-13	**18.3**
1.2	16.8	-17	13.9	0.0	0	0.0	**16.8**	-17	**13.9**
2.1	0.2	-100	0.0	0.0	0	0.0	**0.2**	-100	**0.0**
2.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
2.3	0.1	24	0.1	0.0	0	0.0	**0.1**	24	**0.1**
2.4	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
2.5	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
3.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
3.2	3.8	-21	3.0	0.0	0	0.0	**3.8**	-21	**3.0**
4.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
4.2	1.4	-1	1.4	0.0	0	0.0	**1.4**	-1	**1.4**
4.3	5.0	-44	2.8	0.0	0	0.0	**5.0**	-44	**2.8**
5.1	8.2	-41	4.8	0.0	0	0.0	**8.2**	-41	**4.8**
5.2	13.3	-83	2.3	0.0	0	0.0	**13.3**	-83	**2.3**
6.1	10.3	-23	7.9	0.0	0	0.0	**10.3**	-23	**7.9**
6.2	0.8	-18	0.6	0.0	0	0.0	**0.8**	-18	**0.6**
7.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
7.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
7.3	16.8	-12	14.8	0.0	1,000	0.9	**16.8**	-7	**15.7**
8.1	18.0	-15	15.4	0.0	0	0.0	**18.0**	-15	**15.4**
8.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
8.3	2.3	-22	1.8	0.0	0	0.0	**2.3**	-22	**1.8**
8.4	2.8	-32	1.9	0.0	0	0.0	**2.8**	-32	**1.9**
9.1	19.8	-36	12.7	32.3	-2	31.5	**52.1**	-15	**44.3**
9.2	0.0	-100	0.0	0.0	0	0.0	**0.0**	-100	**0.0**
9.3	51.7	-68	16.5	50.0	-13	43.5	**101.7**	-41	**60.0**
10.1	14.6	-67	4.9	46.1	-23	35.7	**60.7**	-33	**40.6**
10.2	11.0	-42	6.4	17.0	-43	9.7	**27.9**	-43	**16.0**
10.3	1.7	-26	1.3	21.5	-24	16.3	**23.2**	-24	**17.5**

Pct. Chg. of "1000" = Infinite Increase In Area

Table 11

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy Area Change (2013-2014)

- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP BED CANOPY AREA CHANGE 2013-14		
	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)
10.4	1.3	-77	0.3	18.3	-33	12.3	**19.7**	-36	**12.6**
10.5	15.1	-30	10.6	38.7	-35	25.3	**53.8**	-33	**35.9**
10.6	4.3	-64	1.5	12.8	-38	8.0	**17.1**	-44	**9.5**
11.1	21.1	-63	7.8	49.5	-36	31.6	**70.6**	-44	**39.4**
11.2	37.4	-59	15.4	32.3	-20	25.7	**69.7**	-41	**41.1**
11.3	1.7	-34	1.2	3.4	-27	2.5	**5.2**	-29	**3.7**
12.1	20.9	-31	14.4	27.7	-22	21.6	**48.6**	-26	**35.9**
13.1	10.6	-52	5.1	1.9	-33	1.3	**12.5**	-49	**6.4**
13.2	5.5	-50	2.8	9.3	-5	8.8	**14.8**	-22	**11.6**
14.1	55.7	-81	10.7	57.5	-35	37.6	**113.2**	-57	**48.3**
15.1	10.3	-75	2.6	5.3	-10	4.8	**15.6**	-53	**7.4**
15.2	15.3	-68	5.0	38.9	-37	24.3	**54.2**	-46	**29.3**
15.3	2.6	-43	1.5	10.3	-39	6.3	**12.9**	-40	**7.8**
15.4	9.9	-59	4.0	14.1	-22	11.1	**24.0**	-37	**15.1**
16.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
16.2	36.2	-49	18.6	44.1	-13	38.3	**80.4**	-29	**56.9**
16.3	3.0	-14	2.6	0.0	0	0.0	**3.0**	-14	**2.6**
16.4	6.1	-58	2.5	0.9	-42	0.5	**6.9**	-56	**3.0**
17.1	5.0	-39	3.0	11.2	-53	5.3	**16.2**	-49	**8.3**
17.2	8.2	-35	5.4	9.5	-22	7.4	**17.7**	-28	**12.8**
17.3	8.9	-51	4.3	0.0	0	0.0	**8.9**	-51	**4.3**
18.1	2.8	-47	1.5	1.8	-28	1.3	**4.5**	-39	**2.7**
18.2	1.1	-72	0.3	4.4	-6	4.2	**5.5**	-19	**4.5**
19.1	17.0	-14	14.6	129.2	-27	94.6	**146.2**	-25	**109.2**
19.2	8.3	2	8.5	33.5	-27	24.4	**41.9**	-22	**32.8**
20.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
20.2	1.9	-34	1.2	0.0	0	0.0	**1.9**	-34	**1.2**
21.1	4.0	-29	2.8	4.7	-29	3.3	**8.7**	-29	**6.2**
21.2	2.5	-37	1.6	7.4	-1	7.3	**9.8**	-10	**8.8**

Pct. Chg. of "1000" = Infinite Increase In Area

Table 11
Washington Coastal Kelp Resources - Summer 2014
Kelp Bed Canopy Area Change (2013-2014)
- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP BED CANOPY AREA CHANGE 2013-14		
	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)	2013 Can. Area (ha)	2013-14 Pct. Chg	2014 Can. Area (ha)
22.1	1.9	8	2.1	0.2	-100	0.0	**2.1**	-1	**2.1**
22.2	5.1	-4	4.9	7.8	-25	5.9	**12.9**	-16	**10.8**
23.1	3.3	-25	2.5	0.5	-100	0.0	**3.9**	-35	**2.5**
23.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
24.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
24.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
25.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
25.2	0.2	-47	0.1	8.1	11	8.9	**8.3**	9	**9.0**
26.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
27.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
28.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
29.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
30.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
31.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
32.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
33.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
34.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
35.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
36.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
37.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
38.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
39.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
40.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
41.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
TOTALS	**546.9**	**-47**	**290.2**	**750.2**	**-25**	**559.9**	**1,297.1**	**-34**	**850.1**

Pct. Chg. of "1000" = Infinite Increase In Area

Table 12
Washington Coastal Kelp Resources - Summer 2014
Kelp Bed Planimeter Area Change (2013 - 2014)
- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP BED PLANIMETER AREA CHANGE 2013-14		
	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)
1.1	66.9	-14	57.4	0.0	0	0.0	**66.9**	-14	**57.4**
1.2	30.2	-14	26.0	0.0	0	0.0	**30.2**	-14	**26.0**
2.1	1.7	-100	0.0	0.0	0	0.0	**1.7**	-100	**0.0**
2.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
2.3	1.6	2	1.6	0.0	0	0.0	**1.6**	2	**1.6**
2.4	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
2.5	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
3.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
3.2	22.1	0	22.1	0.0	0	0.0	**22.1**	0	**22.1**
4.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
4.2	16.1	9	17.5	0.0	0	0.0	**16.1**	9	**17.5**
4.3	49.0	-26	36.2	0.0	0	0.0	**49.0**	-26	**36.2**
5.1	86.2	-46	46.5	0.0	0	0.0	**86.2**	-46	**46.5**
5.2	83.5	-68	27.1	0.0	0	0.0	**83.5**	-68	**27.1**
6.1	54.6	-21	42.9	0.0	0	0.0	**54.6**	-21	**42.9**
6.2	9.4	-16	7.9	0.0	0	0.0	**9.4**	-16	**7.9**
7.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
7.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
7.3	49.1	3	50.5	0.0	1,000	3.9	**49.1**	11	**54.4**
8.1	66.2	-9	60.4	0.0	0	0.0	**66.2**	-9	**60.4**
8.2	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
8.3	10.0	-10	8.9	0.0	0	0.0	**10.0**	-10	**8.9**
8.4	9.1	-31	6.3	0.0	0	0.0	**9.1**	-31	**6.3**
9.1	70.5	-15	60.1	74.4	-2	72.8	**144.8**	-8	**132.9**
9.2	0.4	-100	0.0	0.0	0	0.0	**0.4**	-100	**0.0**
9.3	153.1	-48	79.0	101.3	-5	96.4	**254.4**	-31	**175.5**
10.1	55.7	-50	28.0	97.1	-15	82.2	**152.9**	-28	**110.2**
10.2	40.5	-18	33.1	58.7	-22	45.6	**99.1**	-21	**78.7**
10.3	10.9	-12	9.6	46.1	-24	34.9	**56.9**	-22	**44.5**

Pct. Chg. of "1000" = Infinite Increase in Area

Table 12
Washington Coastal Kelp Resources - Summer 2014
Kelp Bed Planimeter Area Change (2013 - 2014)
- By Kelp Bed Number

MAP.KELP BED NUMBER	*NEREOCYSTIS CANOPY*			*MACROCYSTIS CANOPY*			KELP BED PLANIMETER AREA CHANGE 2013-14		
	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)	2013 Plan. Area (ha)	2013-14 Pct. Chg	2014 Plan. Area (ha)
10.4	10.2	-54	4.7	28.2	-22	22.0	**38.4**	-30	**26.7**
10.5	37.4	-9	34.3	89.2	-17	74.2	**126.6**	-14	**108.5**
10.6	22.0	-45	12.0	44.0	-12	38.5	**66.0**	-23	**50.6**
11.1	87.2	-45	48.0	93.9	-25	70.4	**181.0**	-35	**118.5**
11.2	71.8	-35	46.9	57.7	-10	52.0	**129.5**	-24	**98.9**
11.3	7.4	-14	6.3	10.2	-14	8.8	**17.6**	-14	**15.1**
12.1	63.5	-31	43.8	77.2	-15	65.7	**140.7**	-22	**109.5**
13.1	46.6	-47	24.6	7.7	-25	5.8	**54.3**	-44	**30.3**
13.2	18.8	-55	8.4	26.9	3	27.7	**45.7**	-21	**36.1**
14.1	170.4	-71	49.4	113.2	-30	79.3	**283.6**	-55	**128.6**
15.1	39.5	-61	15.5	8.8	33	11.8	**48.4**	-43	**27.3**
15.2	62.2	-59	25.4	96.5	-33	64.9	**158.6**	-43	**90.2**
15.3	9.7	-46	5.3	32.9	-31	22.7	**42.6**	-34	**28.0**
15.4	40.3	-45	22.1	30.9	-9	28.2	**71.2**	-29	**50.3**
16.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
16.2	117.6	-28	85.1	80.5	-9	73.6	**198.0**	-20	**158.8**
16.3	18.3	-2	17.8	0.0	0	0.0	**18.3**	-2	**17.8**
16.4	50.0	-55	22.6	3.0	15	3.5	**53.1**	-51	**26.1**
17.1	47.5	-23	36.8	32.0	-35	20.7	**79.4**	-28	**57.5**
17.2	49.7	-12	43.7	26.9	-10	24.4	**76.6**	-11	**68.1**
17.3	60.4	-31	41.6	0.0	0	0.0	**60.4**	-31	**41.6**
18.1	26.2	-20	20.9	4.1	-11	3.7	**30.4**	-19	**24.6**
18.2	15.2	-67	5.0	4.2	246	14.5	**19.4**	1	**19.5**
19.1	128.1	-12	113.0	191.4	-18	156.6	**319.4**	-16	**269.6**
19.2	75.3	-20	60.4	60.0	-20	48.1	**135.3**	-20	**108.4**
20.1	0.0	0	0.0	0.0	0	0.0	**0.0**	0	**0.0**
20.2	9.8	17	11.5	0.0	0	0.0	**9.8**	17	**11.5**
21.1	37.8	0	37.7	15.9	-30	11.1	**53.7**	-9	**48.8**
21.2	21.2	-11	18.8	18.9	-12	16.6	**40.1**	-12	**35.5**

Pct. Chg. of "1000" = Infinite Increase in Area

Table 13

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Area Change (2013-2014)

- By Map Numbers

MAP NUMBER	MAP NAME	2013 CANOPY AREA (ha.) Total	Pct. Chg. 2013-14 Total	2014 CANOPY AREA (ha.) Total	2013 PLAN. AREA (ha.) Total	Pct Chg. 2013-14 Total	2014 PLAN. AREA (ha.) Total	2013 RDI	2014 RDI
1	Port Townsend	37.9	-15	32.2	97.1	-14	83.4	0.39	0.39
2	Diamond Point	0.3	-51	0.1	3.3	-51	1.6	0.08	0.08
3	Gray's Marsh	3.8	-21	3.0	22.2	0	22.1	0.17	0.14
4	Dungeness	6.4	-35	4.2	65.1	-17	53.7	0.10	0.08
5	Green Point	21.5	-67	7.1	169.7	-57	73.6	0.13	0.10
6	Port Angeles	11.1	-22	8.6	64.0	-21	50.8	0.17	0.17
7	Angeles Point	16.8	-7	15.7	49.1	11	54.4	0.34	0.29
8	Crescent Bay	23.1	-17	19.0	85.3	-11	75.7	0.27	0.25
9	Low Point	153.9	-32	104.3	399.6	-23	308.4	0.39	0.34
10	Twin	202.5	-35	132.2	539.9	-22	419.2	0.38	0.32
11	Pillar Point	145.4	-42	84.1	328.1	-29	232.5	0.44	0.36
12	Pearson Creek	48.6	-26	35.9	140.7	-22	109.5	0.35	0.33
13	Sekiu	27.2	-34	18.0	100.0	-34	66.4	0.27	0.27
14	Sekiu River	113.2	-57	48.3	283.6	-55	128.7	0.40	0.38
15	Neah Bay	106.7	-44	59.5	320.8	-39	195.9	0.33	0.30
16	Cape Flattery	90.3	-31	62.5	269.4	-25	202.7	0.34	0.31
17	Makah Bay	42.8	-41	25.4	216.5	-23	167.2	0.20	0.15
18	Point of the Arches	10.0	-28	7.2	49.8	-11	44.2	0.20	0.16
19	Cape Alava	188.1	-24	142.1	454.7	-17	378.0	0.41	0.38
20	Carroll Island	1.9	-34	1.2	9.8	17	11.5	0.19	0.11
21	La Push	18.5	-19	15.0	93.8	-10	84.3	0.20	0.18
22	Strawberry Bay	15.0	-14	12.9	81.3	-11	72.4	0.19	0.18
23	Hoh Head	3.9	-35	2.5	34.5	-18	28.3	0.11	0.09
24	Abbey Island	0.0	0	0.0	0.0	0	0.0	0.00	0.00
25	Destruction Island	8.3	9	9.0	35.2	5	37.0	0.24	0.24
26	Kalaloch	0.0	0	0.0	0.0	0	0.0	0.00	0.00
27	Tunnel Island	0.0	0	0.0	0.0	0	0.0	0.00	0.00
28	Little Hogsback	0.0	0	0.0	0.0	0	0.0	0.00	0.00
29	Taholah	0.0	0	0.0	0.0	0	0.0	0.00	0.00
30	Moclips	0.0	0	0.0	0.0	0	0.0	0.00	0.00
31	Copalis Beach	0.0	0	0.0	0.0	0	0.0	0.00	0.00
32	Ocean City	0.0	0	0.0	0.0	0	0.0	0.00	0.00
33	Point Brown	0.0	0	0.0	0.0	0	0.0	0.00	0.00
34	Westport	0.0	0	0.0	0.0	0	0.0	0.00	0.00
35	Grayland	0.0	0	0.0	0.0	0	0.0	0.00	0.00
36	Willapa Bay	0.0	0	0.0	0.0	0	0.0	0.00	0.00
37	Leadbetter Point	0.0	0	0.0	0.0	0	0.0	0.00	0.00
38	Ocean Park	0.0	0	0.0	0.0	0	0.0	0.00	0.00
39	Loomis Lake	0.0	0	0.0	0.0	0	0.0	0.00	0.00
40	Long Beach	0.0	0	0.0	0.0	0	0.0	0.00	0.00
41	Columbia River	0.0	0	0.0	0.0	0	0.0	0.00	0.00
TOTALS		**1,297.1**	**-34**	**850.1**	**3,913.7**	**-26**	**2,901.5**	**0.33**	**0.29**

Pct. Chg. of "1000" = Infinite Increase in Area

Table 14

Washington Coastal Kelp Resources - Summer 2014

Kelp Bed Canopy/Planimeter Area Summary (ha.) Change (2013-2014)

- By Survey Range

SURVEY RANGE SUMMARY	KELP CANOPY AREAS			KELP PLAN. AREAS			REL. DENS.	INDEX
1) Strait of Juan De Fuca (Port Townsend to Cape Flattery)	2013	Pct. Chg. 2013-14	2014	2013	Pct. Chg. 2013-14	2014	2013	2014
Total Nereocystis-"Straits" (Canopies 1.1-16.2)	467.6	-50	232.2	1691.4	-38	1053.0	0.28	0.22
Total Macrocystis-"Straits" (Canopies 1.1-16.2)	531.1	-25	396.8	1175.1	-16	981.6	0.45	0.40
TOTAL KELP-"STRAITS" (Canopies 1.1-16.2)	**998.7**	**-37**	**629.0**	**2866.5**	**-29**	**2034.6**	**0.35**	**0.31**
2) Open Coast (Cape Flattery to the Columbia River)								
Total Nereocystis-"Open Coast" (Canopies 16.3-41.1)	79.3	-27	58.0	639.7	-19	519.8	0.12	0.11
Total Macrocystis-"Open Coast" (Canopies 16.3-41.1)	219.1	-26	163.1	407.1	-15	346.8	0.54	0.47
TOTAL KELP-"OPEN COAST" (Canopies 16.3-41.1)	**298.4**	**-26**	**221.0**	**1046.9**	**-17**	**866.6**	**0.29**	**0.26**
3) Total Kelp - Range-wide								
Total Nereocystis-"Range-wide" (Canopies 1.1-41.1)	546.9	-47	290.2	2331.1	-33	1572.8	0.23	0.18
Total Macrocystis-"Range-wide" (Canopies 1.1-41.1)	750.2	-25	559.9	1582.2	-16	1328.4	0.47	0.42
TOTAL KELP RESOURCE-"Range-wide" (Canopies 1.1-41.1)	**1297.1**	**-34**	**850.1**	**3913.3**	**-26**	**2901.1**	**0.33**	**0.29**

SPECIAL AREAS OF INTEREST	2013	Pct. Chg. 2013-14	2014	2013	Pct. Chg. 2013-14	2014	2013	2014
1) Total Kelp in "Straits" - By Sub-Range								
Total Kelp-Port Townsend to Disque (Canopies 1.1-9.3)	274.6	-29	194.2	955.4	-24	723.7	0.29	0.27
Total Kelp-Twin Rivers to Cape Flattery (Canopies 10.1-16.2)	724.0	-40	434.9	1911.1	-31	1310.8	0.38	0.33
2) Olympic Coast National Marine Sanctuary								
Total Nereocystis-Neah Bay to the Copalis River (Canopies 15.3-31.1)	128.0	-36	82.1	807.2	-22	632.3	0.16	0.13
Total Macrocystis-Neah Bay to the Copalis River (Canopies 15.3-31.1)	287.7	-24	218.7	551.5	-15	471.3	0.52	0.46
TOTAL KELP - OLYMPIC COAST NMS (Canopies 15.3-31.1)	**415.6**	**-28**	**300.8**	**1358.7**	**-19**	**1103.6**	**0.31**	**0.27**
3) Neah Bay to Cape Alava								
Total Nereocystis-Neah Bay to Cape Alava (Canopies 15.3-19.2)	109.0	-39	66.8	638.2	-26	474.3	0.17	0.14
Total Macrocystis-Neah Bay to Cape Alava (Canopies 15.3-19.2)	259.0	-25	193.3	466.0	-15	396.0	0.56	0.49
TOTAL KELP-NEAH BAY TO CAPE ALAVA (Canopy 15.3-19.2)	**368.1**	**-29**	**260.1**	**1104.2**	**-21**	**870.3**	**0.33**	**0.30**
4) Port Townsend to Neah Bay and Cape Alava to Destruction Is.								
Total Nereocystis-Outside Above Range (1.1-15.2 and 20.1-41.1)	437.8	-49	223.3	1693.0	-35	1098.5	0.26	0.20
Total Macrocystis-Outside Above Range (1.1-15.2 and 20.1-41.1)	491.2	-25	366.6	1116.2	-16	932.4	0.44	0.39
TOTAL KELP-OUTSIDE RANGE Neah Bay to Cape Alava (1.1-15.2 and 20.1-41.1)	**929.0**	**-36**	**590.0**	**2809.2**	**-28**	**2030.9**	**0.33**	**0.29**

-20 = Significant Decrease (95%CI) in Kelp Extent (2013-2014)

21 = Significant Increase (95%CI) in Kelp Extent (2013-2014)

3 = No Significant Chg. (95%CI) in Kelp Extent (2013-2014)