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PERIOD COVERED: October 2016-September 2017

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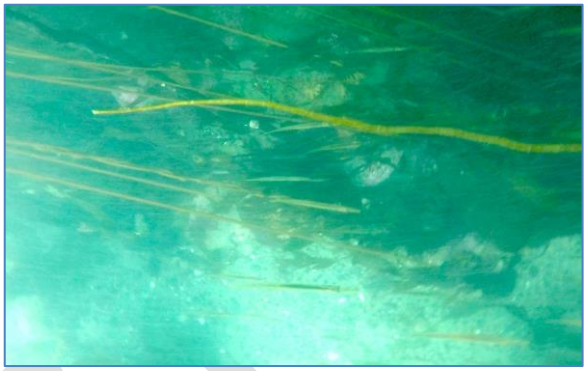
Bull Kelp Monitoring in Island County, 2017
Island County Marine Resources Committee

Clockwise, from upper left:
Bull kelp bed around Ben Ure Island (D. Paros). Tubesnouts (*Aulorhynchus* sp.) moving through the Ebey's Landing kelp bed (L. Rhodes). Floating kelp at the Lowell Point bed inspected by Russ Holmes (P. Holmes). Submerged aquatic vegetation with bryozoan colonies (white spots; *Membranipora* sp.) at the bottom of the Possession Point kelp bed (L. Rhodes)

Report submitted in partial fulfillment of WA Department of Ecology grant SEANWS-2016-IsCoPH-00005, Task 2.2 (Monitoring: Kelp).

Project period: October 2016 – September 2017
Report date: September 29, 2017
Project lead: Linda Rhodes
Project participants
Kayak surveys: Vernon Brisley, Barbara Brock, Paulette Brunner, Pat Holmes, Russ Holmes, Debra Paros, Linda Rhodes
Aerial imaging: Gregg Ridder, Vernon Brisley

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I. Introduction

Kelp forests represent significant habitat for a wide variety of invertebrate and vertebrate animals, and may also influence other submerged aquatic vegetation (Mann 2000; Graham et al 2007). In addition to providing structural habitat, primary productivities of kelp forests match or exceed those of tropical rain forests, marine reefs and estuaries, and warm temperate forests (Mann 1972a; Mann 1972b). In Washington State, two species of kelp are dominant: giant kelp (*Macrocystis integrifolia*) and bull kelp (*Nereocystis leutkeana*). While both species occur along Washington's outer coast and coastal Strait of Juan de Fuca, bull kelp is the species found along shorelines of the inner Salish Sea (Mumford 2007).

Following a state-wide moratorium of commercial harvest of wild kelp and seaweeds in 1988, Washington State Department of Natural Resources (WDNR) initiated annual aerial surveys of coastal aquatic vegetation from Port Townsend Bay to the Columbia River. These surveys have continued for nearly every year, and in 2010, surveys were extended to include the resources of the Smith and Minor Island Aquatic Reserve (SMIAR), which is contained entirely within Island County. In the latest analysis of coastal kelp from 2013 to 2014 (excluding SMIAR), decline in planimeter area of bull kelp around Port Townsend was ~14%, and range-wide decline in planimeter area of both kelps was 38% (Van Wagenen 2015).

The earliest comprehensive evaluation of kelp resources was conducted in 1911, where over half of the total tonnage of bull kelp in the American portion of the Salish Sea was estimated to be located within the jurisdiction of modern Island County (Rigg 1915). Uncertainty about the distribution of bull kelp in areas not monitored by WDNR overlaid by anticipated changes in marine conditions attributable to climate are motivations to conduct an inventory and assessment of this resource in Island County. The Island County Marine Resources Committee (MRC) considered this to be an important activity to conduct under its sponsorship. Efforts were initiated in 2015 to select kelp beds and test a kayak-based survey protocol. These efforts were expanded in 2016, and have continued through 2017.

II. Scope of Project and Objectives

This report reports on the project period from fall 2016 through late summer 2017. Boat-based surveys and aerial imaging occur from early to late summer, often through September. Due to the close co-incidence of the end of the field season and the report deadline, not all of the 2017 data can be included in this report.

Objectives for 2017 included:

1. Collect data from previously surveyed kelp beds by boat-based surveys to extend observations from 2016.
2. Conduct aerial imaging of the Island County coastline for detecting kelp beds.
3. Test temperature loggers to collect demersal temperature data.
4. Attempt to collect images of submerged aquatic vegetation for identification.
5. Explore augmented kelp bed reporting using a web-based survey.

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III. Project Progress in 2017

Objective 1. Collect data from previously surveyed kelp beds by boat-based surveys.
The five beds that were surveyed in 2016 were also surveyed in 2017: Ebey's Landing, Ben Ure Island (Cornet Bay State Park), Hoypus Point, Polnell Point, and Lowell Point (Camano Island State Park). A sixth bed was explored and surveyed in August: Possession Point (Figure 1). Survey data are reported in the Results section.

Figure 1. Approximate locations of kelp beds and names of beds surveyed in 2017.

Objective 2: Conduct aerial imaging of the Island County coastline for detecting kelp beds.
Much of the flight protocol had already been developed by Gregg Ridder for the MRC's eelgrass surveys. For kelp imaging, three major adjustments were made. First, flights were conducted in August, which had been shown to be the month of large bed areas and optimal low tides. Second, a paired near infra-red (IR) camera was added to the visible light (RGB)

camera to allow discrimination of surface vs submerged kelp, and to improve accuracy of identification. Third, both orthogonal and oblique images were obtained.

Objective 3: Test temperature loggers to collect demersal temperature data.
Onset programmable temperature loggers were obtained to test their utility as a way of collecting demersal temperature to match the surface temperature collected in the boat-based surveys. Although the loggers did not arrive until the end of July, preliminary testing was conducted during the August & September surveys at selected sites.

Objective 4: Attempt to collect images of submerged aquatic vegetation for identification.
During the bull kelp workshop held by the NW Straits Commission in April 2017, Tom Mumford indicated that collecting images of submerged aquatic vegetation could be used for identification and would be valuable information for kelp biologists. One MRC team had previously used a GoPro camera for imaging pelagic organisms in the beds. Vernon Brisley constructed a small scale apparatus for deploying a GoPro as a drop-camera from the kayak, and it was used to collect video and photographs at several of the surveyed beds.

Objective 5: Explore augmented kelp bed reporting using a web-based survey.
Resources for both the boat-based survey and for aerial imaging require considerable investment and dedication by volunteers. Anecdotal reporting from land or sea observations by anyone with smart phone GPS software and internet access could provide confirmatory information at different times of the year, and perhaps even uncover poorly known beds. A web-based reporting interface with simple instructions was constructed, and announced through several volunteer group newsletters.

III. Data Results

Due to the deadline for this report (September 30, 2017), some 2017 mapping information can not included. All tracking and waypoints files (.gpx) are available from IC MRC's Dropbox (links provided below). Excel spreadsheets summarizing results are in Appendix A.

Ebey's Landing

This bed is located outside of entrance to Admiralty Inlet, and it has been surveyed for three consecutive years (2015, 2016, 2017). Composite visible (red-green-blue or RGB) and near infra-red (NIR) images taken on August 20, 2017, show that much of the kelp that is visible at low tide is actually at the surface (Figure 2).

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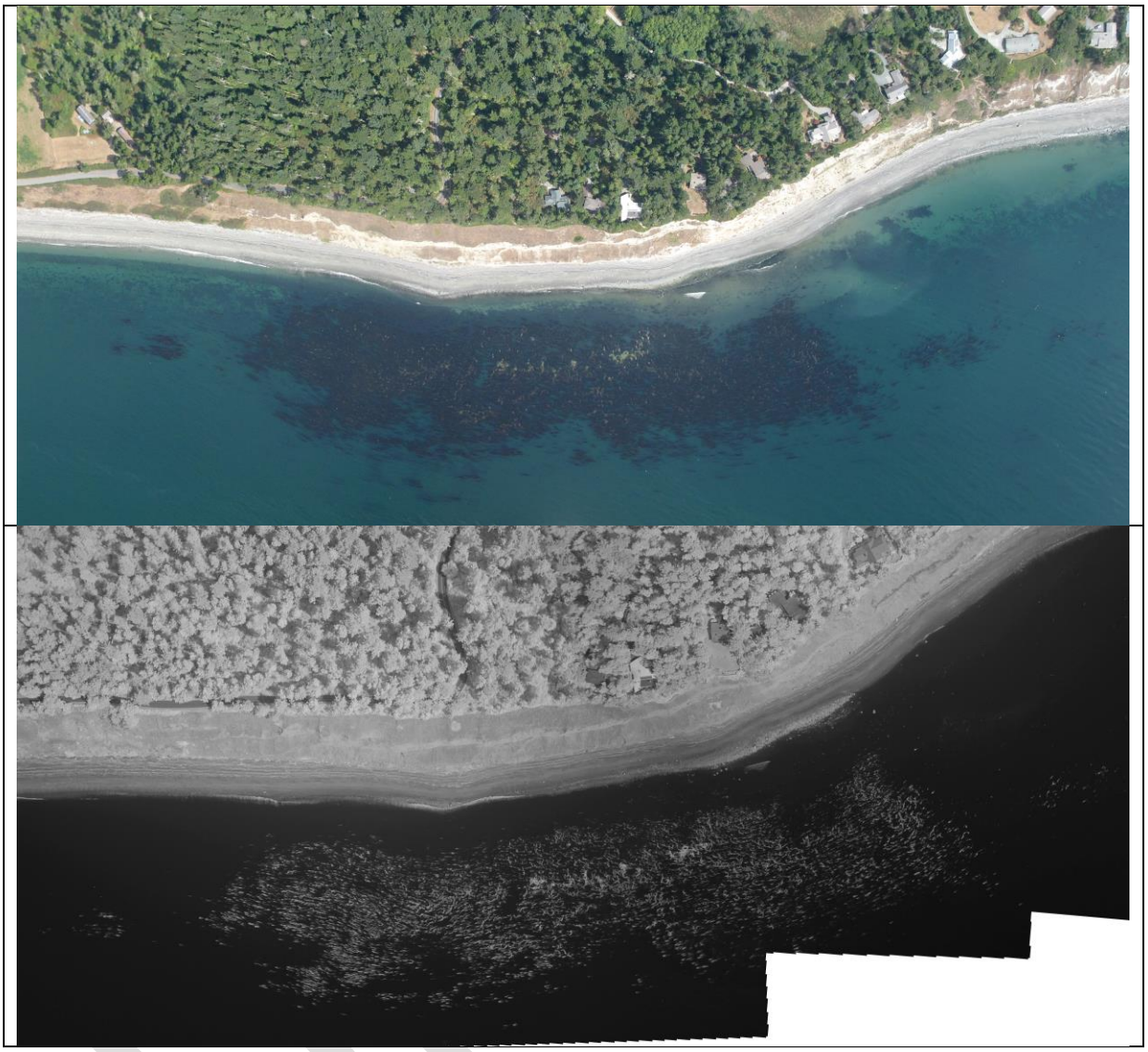


Figure 2. Ebey's Landing bull kelp bed on August 20, 2017, contrasting appearance in visible light (upper) with near infra-red (lower). Note that most of the kelp is visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley; composite by Gregg Ridder.

Although there was a consistent increase in bed area from June through September (Appendix A), there were slight changes in the distribution. From June through August, the bed margin progressively expanded (Figure 3). In September, the northern margin expanded significantly, and small auxiliary beds appeared along the northern and western margins of the bed. However, the southwestern margin appeared to recede from the August margin (Figure 3).

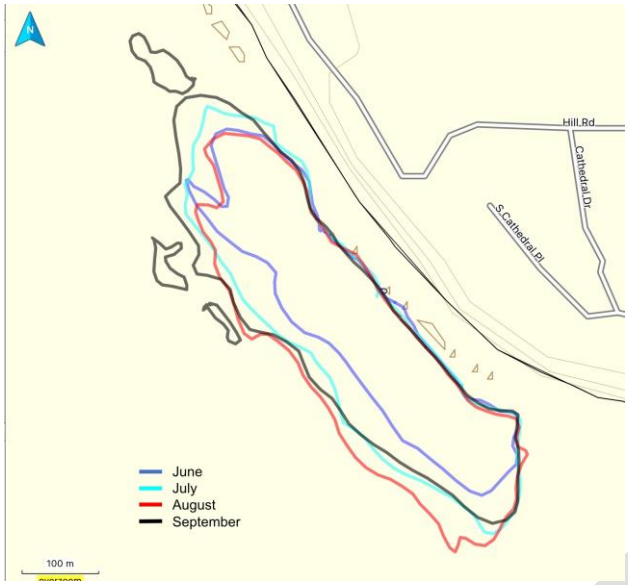


Figure 3. Monthly perimeters of the Ebey's Landing kelp bed and bed areas at a zero-foot tidal height in 2017.

Comparison of the 2017 bed areas with those from 2015 and 2016 revealed a similar temporal pattern of increase earlier in the summer through July. After July, bed area was constant or decreased slightly in 2015 and 2016, but in 2017 it increased slightly (Figure 4). In general, surface temperatures remain below 14°C, and salinity was consistently above 32 ppt (Appendix A), consistent with a strong marine influence. The year-to-year variations in area and temporal patterns may be related to differences in temperature, which were noticeably different across the three years (Figure 4). There is no simple correlation between area and temperature (Spearmans r, $p > 0.40$). However, our observations are single point measurements collected with low resolution (and probably low accuracy) devices at the surface. Temperature effects would be continuous and would include pelagic and demersal temperature fluxes.

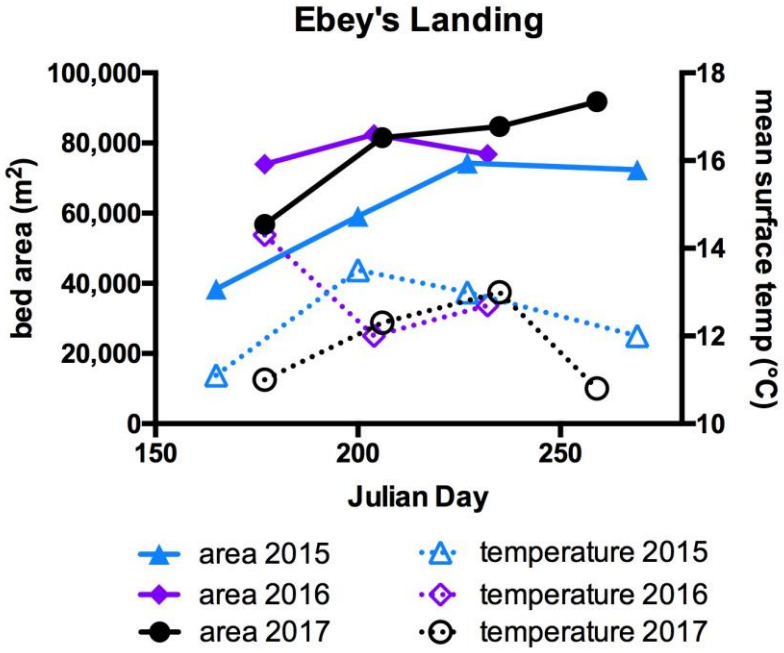


Figure 4. Plots of areas and temperatures at Ebey's Landing kelp bed in 2015, 2016, and 2017.

Ben Ure Island (Cornet Bay State Park)

This bed is located in Deception Pass and close to the restoration at Cornet Bay State Park, where extensive biological monitoring is conducted. The kelp bed is located very close to the rocky shoreline of Ben Ure Island (Figure 5).

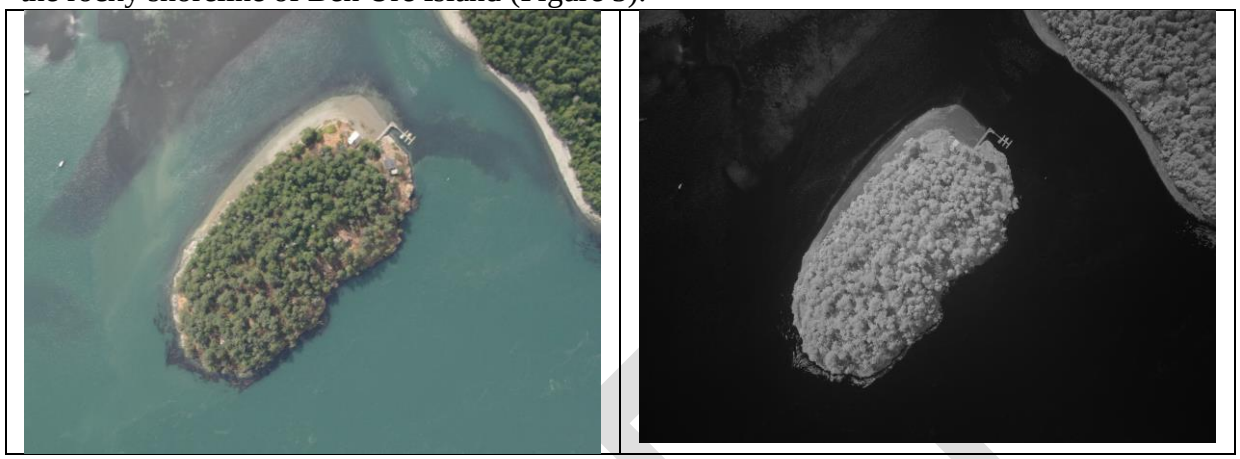
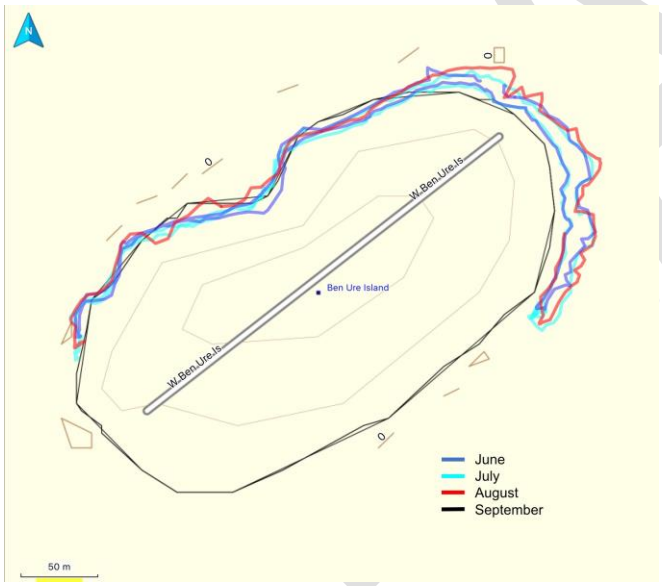


Figure 5. Aerial photograph of the Ben Ure Island kelp bed on August 20, 2017. Bull kelp is visible as a narrow band along the lower margin of the island in both the RGB (left) and NIR (right) images. Photos by Gregg Ridder and Vernon Brisley.



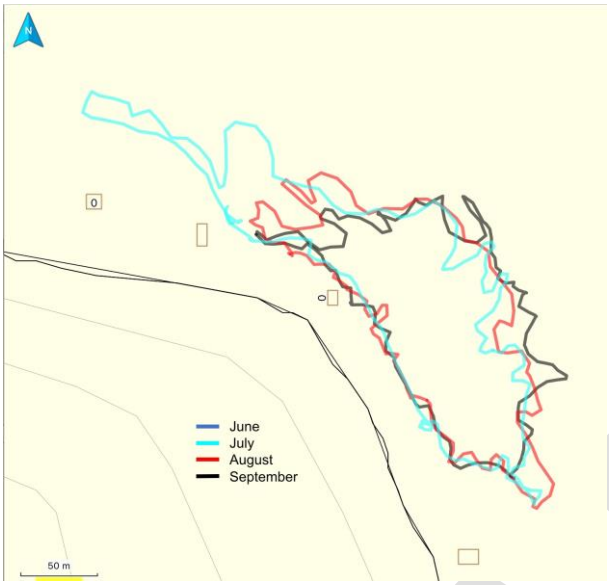
Obtaining a reliable inner perimeter is difficult, particularly because GIS products such as topological maps and LIDAR imaging do not generate an accurate shoreline that can be used as an inner margin. This means that area determination is not feasible. However, one meaningful evaluation is a comparison of the outer GPS tracks. Results from 2016 showed that the kelp bed margin did not change detectably from June through August (Figure 5). Temperatures also remained below 14°C, probably due to marine influence during flood tides.

Figure 5. Monthly perimeters of Ben Ure Island kelp bed and bed areas at a zero-foot tidal height in 2016.

Hoypus Point

This bed is located at the eastern end of Deception Pass, midway between Cornet Bay and Ala Spit. Hoypus Point is likely to receive strong pulses of marine water during flood tides and river water during ebb tides due to its location. A significant aspect of this bed is that

juvenile Chinook salmon from the Skagit River system often congregate around Hoypus Point during ocean migration. The bed could serve as refuge for forage fish or other prey for emigrating salmon.



The bed has a modest area (~14,000 m^2). Curiously, the bed size in 2016 was largest in July, then decreased in size (Appendix A). This was due to a northwestern section of the bed that was not detected later in the summer (Figure 6). Aerial imaging suggests that sediment transported from Deception Pass and from Skagit Bay converges at the bed (Figure 7, left image), forming an underwater spit possibly dividing the bed. The matched near infra-red image shows that only kelp on the east side is visible at the surface (Figure 7, right image). It is possible that active sediment movement later in the summer may have influenced bed area.

Figure 6. Monthly perimeters of Hoypus Point kelp bed and area at a zero-foot tidal height in 2016.

Figure 7. Aerial photograph of the Hoypus Point kelp bed. Left image shows an apparent underwater spit, possibly dividing the kelp bed. Right image is a near infra-red photo, slowing that kelp blades are visible at the surface on only one side of the underwater. Photos by Gregg Ridder and Vernon Brisley.

<u>Polnell Point</u>

This bed is located at the eastern end of Crescent Harbor, and approximately 13 km from the south fork of the Skagit River. The bed is clearly within the influence of the large freshwater influx, as salinities ranged between 16 - 24 ppt in 2016 and between 15 - 30 ppt in 2017. Comparison of RGB and NIR images of this bed, show that although much of the bed is still submerged on August 20, 2017, as little of the kelp appeared in the NIR image (Figure 8).

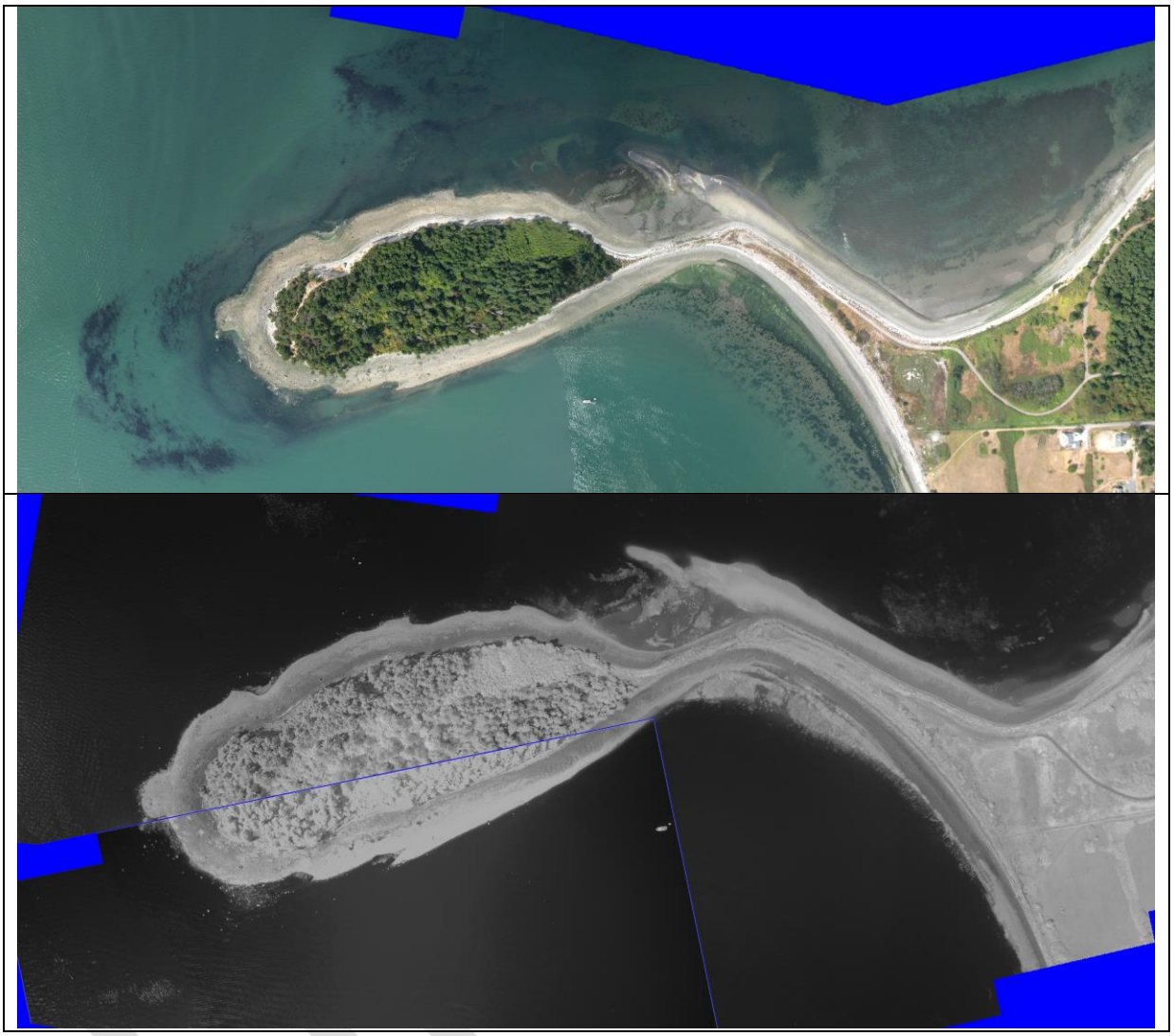


Figure 8. Polnell Point bull kelp bed on August 20, 2017, contrasting appearance in visible light (upper) with near infra-red (lower). Note that most of the kelp is not visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley; composite by Gregg Ridder.

The dynamics of bed area for Polnell Point and Lowell Point (see below) are strikingly different from the beds under strong marine influence. These Saratoga Passage beds can be non-existent in early summer, then display a dramatic increase in area with a short period of time (Figure 9). The Polnell Point bed exhibited the largest increase in area in both 2016 (~760%) and 2017 (7540%) of all the beds. In 2017, kelp appeared in smaller beds that emerged as much larger beds (Figure 10). Surface temperatures at Polnell Point exceeded 17°C in 2016, but were much lower in 2017 (Figure 9).

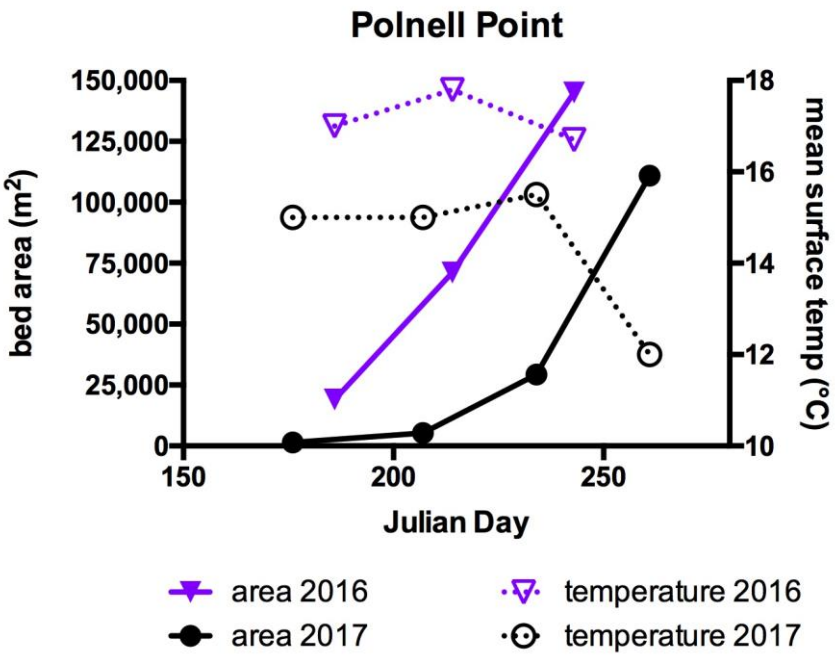


Figure 9. Plots of areas and temperatures at Polnell Point kelp bed in 2016 and 2017.

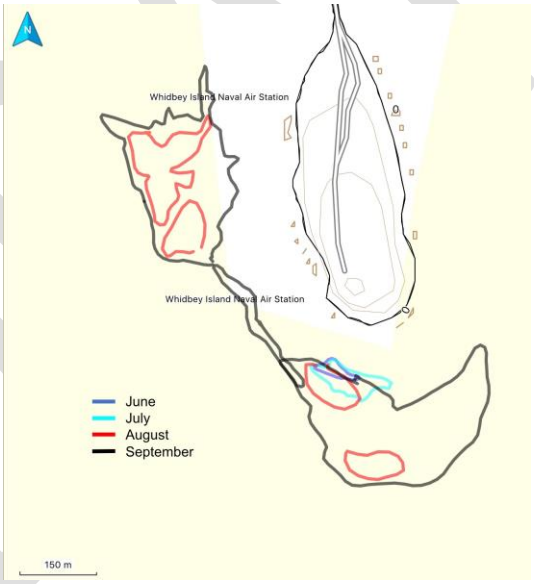


Figure 10. Monthly perimeters of Polnell Point kelp bed and area at a zero-foot tidal height in 2017.

Lowell Point (Camano Island State Park)

This bed is located along the western shore of Camano Island in Saratoga Passage, where the shoreline leads into Elger Bay. A prospective restoration project at the park would connect a salt marsh within the park boundary to the shoreline. Currently, there is beach monitoring for forage fish eggs at the state park beach. In June, there was no visible kelp at the surface, although subsurface kelp was reported. By August, most of the kelp was located at the surface (Figure 11).

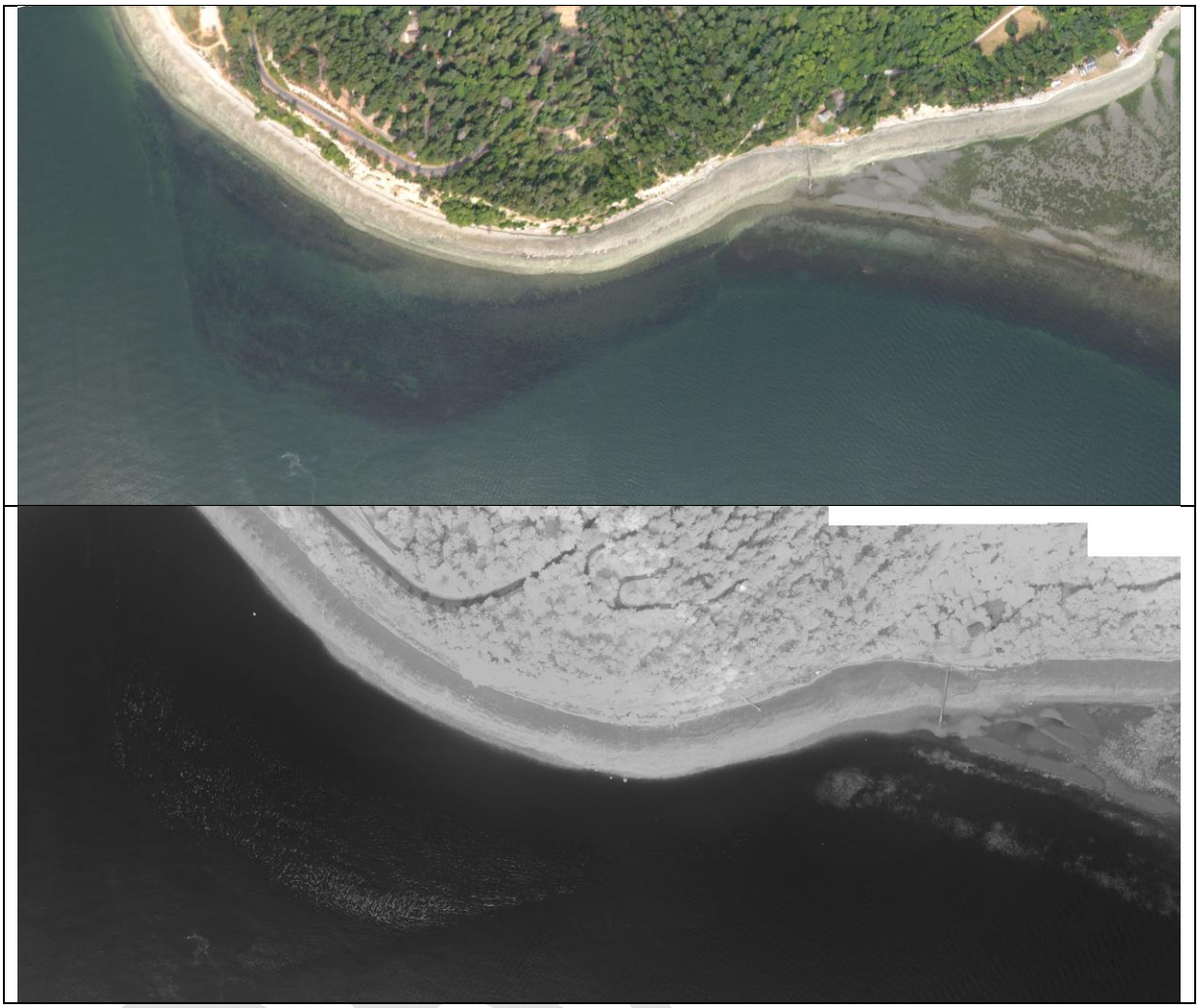
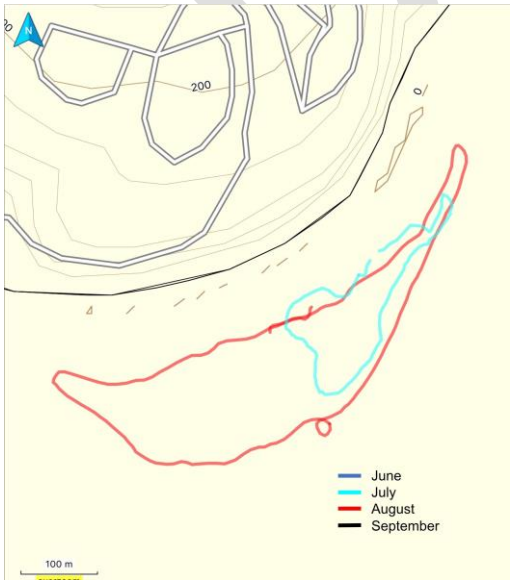


Figure 11. Lowell Point bull kelp bed on August 20, 2017, contrasting appearance in visible light (upper) with near infra-red (lower). Note that most, but not all, of the kelp is visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley.



The bed emerged dramatically in July and August (Figures 12 and 13). Similar to Polnell Point, Lowell Point experienced high temperatures in 2016 and lower temperature in 2017 (Figure 13).

Figure 12. Monthly perimeters of Lowell Point kelp bed and area at a zero-foot tidal height in 2017.

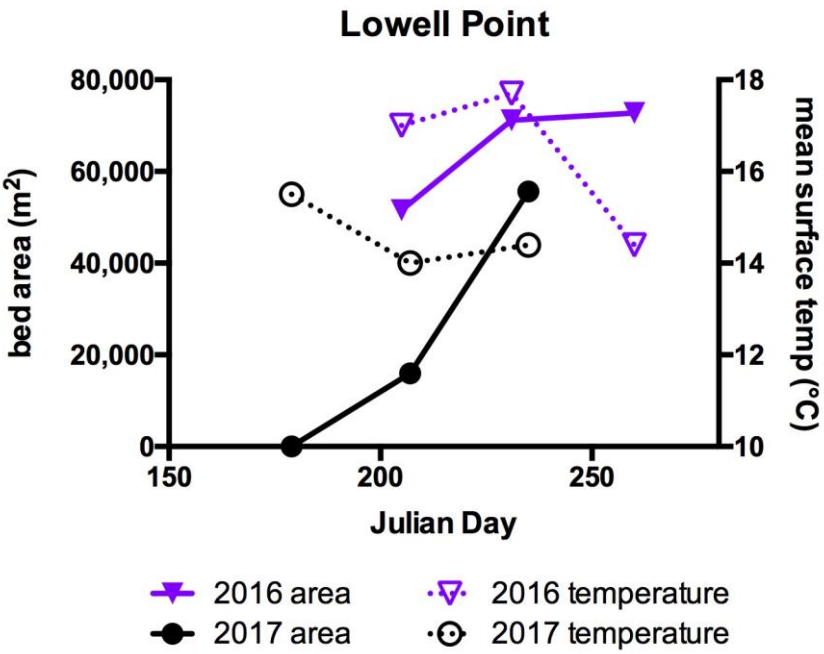


Figure 13. Plots of areas and temperatures at Lowell Point kelp bed in 2016 and 2017

Possession Point

This bed was reported by Gregg Ridder from his aerial imaging work. He observed bull kelp across the entrance to Scatchet Bay and a prominent bed extending around Possession Point (Figure 14).

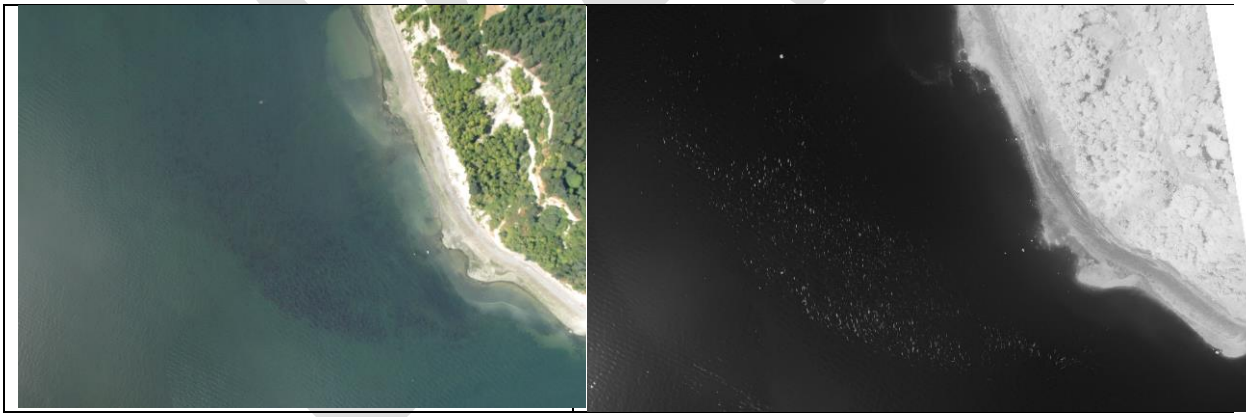


Figure 14. Possession Point bull kelp bed on August 20, 2017, contrasting appearance in visible light (left) with near infra-red (right). Note that nearly all of the kelp is visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley.

A single time point kayak survey was conducted in August, which was limited to the bed around Possession Point (Figure 15). This bed is probably affected by both marine and freshwater (from the Snohomish River), as the salinity displayed a narrow range around 30 ppt.

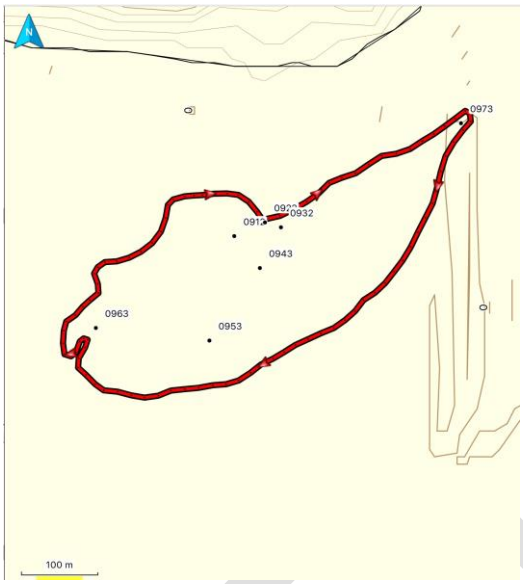


Figure 15. August 2017 perimeter of Possession Point kelp bed and area at a zero-foot tidal height in 2017.

Comparison of kelp beds.

Bed areas were at a maximum in the last monthly survey in either August or September (Figure 16). Interestingly, the Possession Point bed was nearly the same size as the Ebey's Landing bed. The greatest difference in bed growth occurred between the Saratoga Passage beds (Lowell Point, Polnell Point) and Ebey's Landing. The Saratoga Passage beds were very small or not visible at the surface in June, but emerged quickly over the 3-4 month survey period. In contrast, the Ebey's Landing bed was already prominently visible in June, and grew ~ 50% by September. While lower salinity might affect bed appearance and growth rate, temperature may also have a role. Mean surface temperatures were consistently higher for the Saratoga Passage beds (Figure 16). For the Ebey's Landing bed, surface temperatures climbed to a peak in August, matching the Possession Point surface temperature (Figure 16). In contrast, surface temperatures in the Saratoga Passage beds were elevated June through August. In September, temperatures were dramatically lower regardless of the bed (Figure 16).

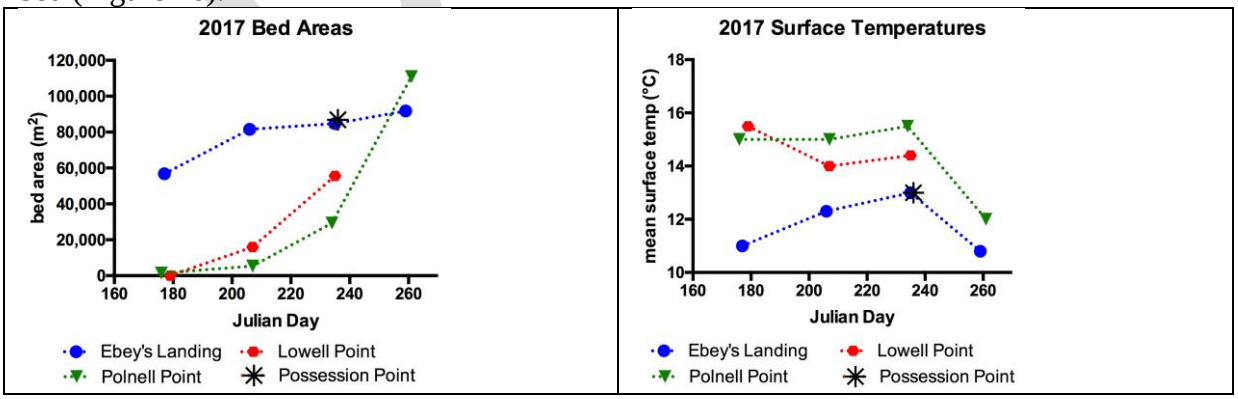


Figure 16. Monthly kelp bed areas (left) and corresponding mean surface temperatures (right) for 2017.

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Anecdotal observations in beds

Although the original (2015) NWSC protocol did not include observations of animals within the kelp during surveys, IC MRC volunteers have been making observations in all three years (Appendix B). Harbor seal tended to be observed where there was rocky shoreline or intertical rocks large enough to serve as haul-outs. Observed birds were primarily great blue heron, pigeon guillemots, a variety of seagulls (including migratory Heermans gulls), common loons, and bald eagles. One Western grebe was spotted at the margin of the Ebey's Landing bed in September.

Overall, schools of forage fish (primarily herring) appeared to be lower in abundance than in 2016. In the Ebey's Landing bed, dense schools were observed only in June 2017, whereas schools were observed June through August in 2016. However, forage fish schools were numerous and large at the Possession Point bed in August (Figure 17). Also, larger (~12") jumping fish, possibly salmon, were also frequent in the Possession Point bed. In August in the Ebey's Landing bed, aggregations of tubesnouts (*Aulorhynchus*. sp.) were observed in stronger currents throughout the bed as well as "loafing" among kelp blades (Figure 18). Shiner perch, especially ones < 2" in length, continued to be reported in beds throughout the summer.

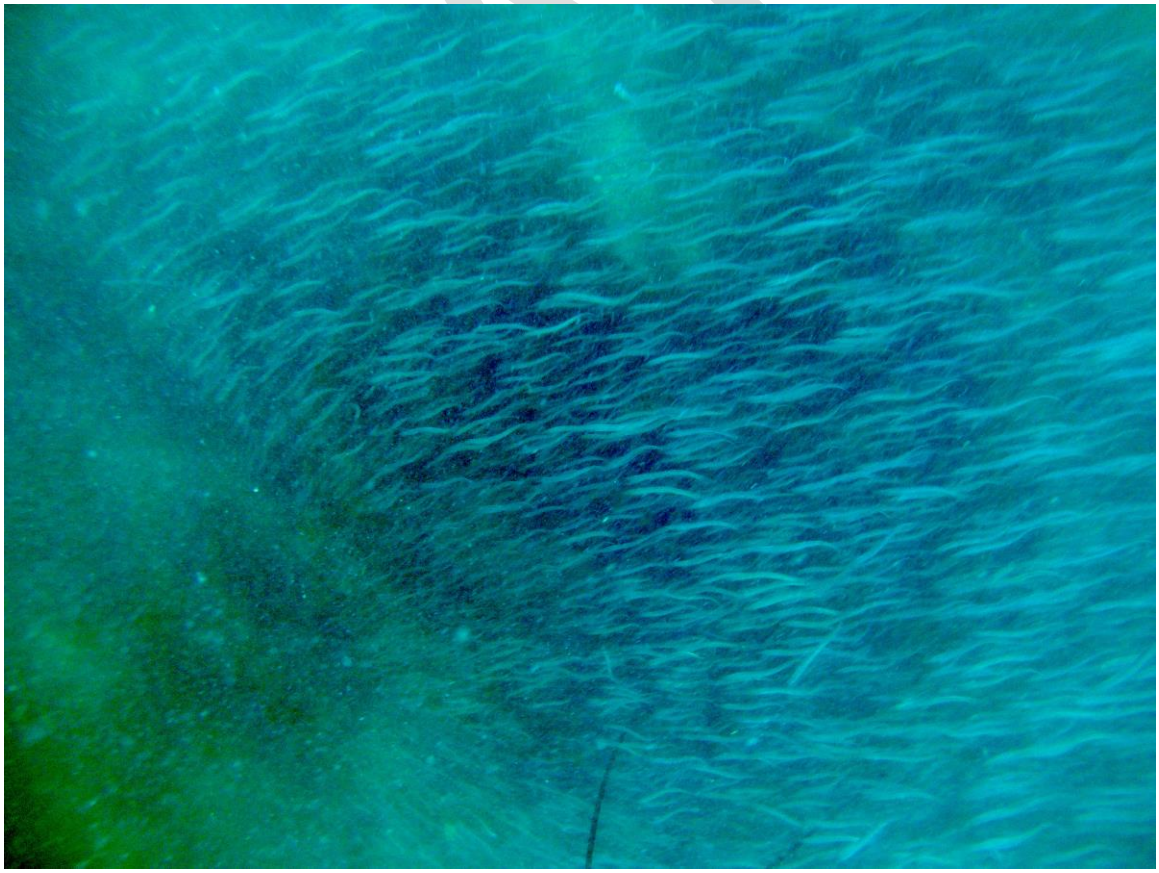

Figure 17. Dense forage fish school (probably herring) in Possession Point bed in August 2017. (Photo by L. Rhodes)

Figure 18. Aggregations of tubesnouts (*Aulorhynchus*. sp.) positioned in faster current in the kelp bed (left) or "loafing" in still waters among kelp blade (right). . (Photo by L. Rhodes)

Both *Aurelia* sp. and *Phacellophora* sp. jellyfish were reported in the beds in 2017, although there is a suggestion of overall lower abundance relative to 2016. Bryozoan colonies (*Membranipora* sp.) were found across the beds, including macroalgae other than bull kelp. Unlike all the other beds, Possession Point was outstanding severely affected by kelp crab (*Pugettia producta*), where ~20% of individual kelp were populated by ≥ 1 crab in the August survey (Figure 19). Many bull kelp individuals were gnawed away, and in some cases, one or more blades were missing.

Figure 19. Multiple kelp crab attached to a single bull kelp at Possession Point in August. (Photo by L. Rhodes)

Aerial Imaging

Aerial imaging from a small airplane was conducted primarily on August 19-20, 2017. The Island County shoreline was simultaneously photographed using a visible light (RGB) camera and a near infra-red (NIR) camera. Two types of photographs were collected:

oblique images and orthogonal (straight down) photographs. A total of > 5,000 images were collected and georeferenced to the airplanes GPS data. These data will be evaluated by inspection for the presence of kelp by comparing the RGB and NIR images. The ultimate objective will be to construct a map of the locations of kelp beds throughout Island County's nearshore waters. We anticipate this activity to occur during the fall and winter of 2017-2018.

Informative composites of beds surveyed by boat were constructed by Gregg Ridder. These composites have already been displayed earlier in this report.

Temperature Loggers

Surface temperatures measured by pool thermometers in the boat-based surveys indicated that temperatures were approaching possible thermal limits for bull kelp. However, the accuracy of these thermometers is unknown. Although surface temperatures are measured, the critical temperature to measure may be actually be near the bottom or in the midwater. Operating a temperature logger with its associated cable, such as a YSI unit, may not be feasible for many kayaks, so a lightweight alternative was explored. HOBO data loggers are small, lightweight units that can be attached to the depth measurement device, therefore not adding much weight or complexity to the equipment. Unfortunately, the loggers arrived in late July. Nonetheless, we conducted several trials deploying the HOBO loggers in August and September. Although the loggers adapt to changes in air temperature relatively quickly, transitions in water appear to be slower. We plan to perform controlled experiments with the loggers to determine the optimal "soak" time for obtaining accurate pelagic and benthic measurements in the fall of 2017.

Images of Submerged Aquatic Vegetation

At the April 2017 workshop, Tom Mumford had suggested that collecting images of submerged aquatic vegetation (SAV) in the kelp beds could be used for identification and characterization of beds. One of the volunteers, Vernon Brisley, developed a small weighted case to hold a GoPro camera in a "face-down" position for image collection. This camera rig was deployed at the Ebey's Landing and Possession Point beds as a feasibility trial. Over three hours of video with associated still images were collected and made available. Betty Bookheim (WA Department of Natural Resources) was able to identify SAV in some of the photographs and videos, indicating that deployment methods could be optimized for the best quality images.

Augmented Kelp Bed Reporting via a Web-based Form

One way to expand the base of information about the location of bull kelp is to make reporting available on the internet. An introductory page with links to instructions and a reporting form was developed (https://islandcountybullkelp.wordpress.com). The link was advertised on the bull kelp project page hosted by the Island County MRC. The link was also advertised in the Sound Water Stewards June newsletter and in the Shore Stewards Summer newsletter. As of September 28, there have been < 10 entries.

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V. Discussion

Bull kelp bed observations

The potential for bull kelp forests to serve as critical habitat for both finfish and marine invertebrates has highlighted the gap in knowledge about the distribution and sizes of kelp beds in the Salish Sea. The marine waters around Island County contain some of the largest known kelp beds in or adjacent to Puget Sound, and some of these beds were recognized at the beginning of the last century when George Rigg conducted boat-based surveys of kelp beds along all of Washington State's coast in 1911 and 1912. Using an estimate of ~ 30 pounds per kelp plant and density estimates ranging from 0.75 to 1.25 plants per ft^2, Rigg calculated that approximately 100,000 tons of bull kelp resided around Smiths Island, which is contained within the current Smith and Minor Island Aquatic Reserve (Rigg 1915). The Smiths Island beds represented over 75% of the harvestable bull kelp identified in Puget Sound and the San Juan Islands at that time. Currently, the beds of the Smith and Minor Island Aquatic Reserve are surveyed annually by WA DNR by aerial photography.

However, little is known about Island County kelp beds outside of the Aquatic Reserve. We developed a series of tasks to begin to address this deficiency. First, prominent beds amenable to *in situ* assessment by boat were identified from aerial imaging. We took advantage of imaging conducted by Gregg Ridder for another MRC project, the annual eelgrass survey. Using his 2015 aerial photographs, Ridder identified larger kelp beds as candidates. Additional criteria for candidate beds were proximity to on-going monitoring (e.g., forage fish surveys, beach seining); proximity to past or prospective restoration projects; and availability of prior kelp survey data. Six of the seven candidate sites were surveyed in 2017, based on volunteer interest and ability.

Aerial imaging was shown to be highly feasible for collecting information on the locations of beds. Flight times are relatively modest (< 2 hours), although there are high demands on the pilot to follow the shoreline. A high volume of overlapping images provides multiple perspectives for each section of shoreline, improving the likelihood of detecting bull kelp. Qualitative examination of the images indicates this method has good promise for mapping locations. The work (yet to come) will be in inspection of each paired (RGB and NIR) of images, criteria for identification, and actual mapping. If a pipeline can be developed for consistent identification, the application of aerial imaging would be a major boost in mapping where these important habitats are located each year.

Based on the kinetics of bed area over the month, it appears that beds with strong marine influence (Ben Ure Island, Ebey's Landing) are present at the surface early in the year (i.e., before May). In contrast, beds with strong river influence undergo large fluxes in size from spring through summer. Confounding variables between the two environments (e.g., temperature, salinity, nutrient loads) make it difficult to attribute their effects. Sites such as Hoypus Point and Possession Point may represent intermediates in a marine-river spectrum.

Surface temperatures in 2016 was higher than in 2017, particularly for the Saratoga Passage beds (Polnell Point, Lowell Point). This observation should be corroborated with

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independent measurements as the accuracy of the pool thermometers is unknown. Unfortunately, the only continuous measurements currently collected in Island County waters are in Penn Cove and in Port Susan. However, the measurements could serve a surrogates for relative changes in temperature. The protocol could be improved by collecting temperatures with a certified logger and by collecting temperatures at both the surface and at depth. We will be pursuing the use of HOBO loggers to attempt to address temperature data collection feasible for citizen science in kayaks.

The use of a web-based survey form was disappointing, but should not be abandoned. Better advertising and expanded awareness of bull kelp may improve the response. Outreach to kayak or boating organizations may be worthwhile, especially to engage visitors to Island County.

In summary, 2017 was a productive year, building on the observations of 2015 and 2016. The status of the beds in Saratoga Passage is uncertain, as their growth dynamic and the appearance of the kelp is distinctly different from stable, persistent beds near Admiralty Inlet and in Deception Pass. The substantial burden of kelp crab on the Possession Point bed is disturbing, although there is no previous information this bed. Maintaining the boat-based surveillance would be improve our knowledge of the resilience of these important nearshore habitats.

References

Graham, M.H., J.A. Vasquez, A.H. Bushmann. 2007. Global ecologyof the giant kelp Macrocystis: from ecotypes to ecosystems. Ocean. Mar. Biol Ann. Rev. 45:39-88.

Mann, K.H. 1972a. Ecological energetics of the seaweed zone in a marine bay on the Atlantic coast of Canada: I. Zonation and biomass of seaweeds. Mar. Biol. 12:1-10.

Mann, K.H. 1972b. Ecological energetics of the seaweedzone in a marine bay on the Atlantic coast of Canada: II. Productivity of the seaweeds. Mar. Biol. 14:199-209.

Mann, K.H. 2000. Ecology of Coastal Waters: With Implications for Management, 2nd edition. Wiley-Blackwell, 432 pp.

Mumford, T.F. 2007. Kelp and eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Seattle District, U.S. Army Corps of Engineers, Seattle, WA. Last accessed September 5, 2016. URL: http://www.pugetsoundnearshore.org/technical_papers/kelp.pdf

Pacific Gas and Electric.. 1987. Thermal Effects Monitoring Program. 1986 Annual Report. Diablo Canyon Power Plant. Pacific Gas and Electric Company, San Francisco, CA. DCL-87-087. Prepared by TERA Corp., Berkeley, CA. May 1987

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Rigg, G.B. 1915. The kelp beds of Puget Sound. IN: Potash from Kelp. F.K. Cameron, ed. U.S. Department of Agriculture report no. 100. April 10, 1915.

Van Wagenen, R.F. 2015. Washington Coastal Kelp Resources: Port Townsend to the Columbia River, Summer 2014. Contract report to Washington Department of Natural Resources, Nearshore Habitat Program. Last accessed September 5, 2016. URL: http://file.dnr.wa.gov/publications/aqr_nrsh_vanwagenen_2015_kelp_tables.pdf

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