Bull Kelp Monitoring in Island County, 2020
Island County Marine Resources Committee




Clockwise, from upper left:
Pacific sand lance school plus a Pacific herring at Ebey's Landing (V. Brisley). Kelp crab at Ebey's Landing (L. Rhodes). Kelp surveyors at Possession Point (R Beier). Harbor seal cruising through kelp at Lowell Point (J. Roman).

Report submitted in partial fulfillment of WA Department of Ecology grant SEANWS-2019-IsCoPH-00005, Task 2.4 (Monitoring: Kelp)
Project period: October 2019– September 2020
Report date: December 31, 2020
Project lead: Linda Rhodes

Project participants
Kayak surveys: Gayle Austin, Ron Beier, Barbara Bennett, Vernon Brisley, Nancy Hotter, Bill Meyer, Linda Rhodes, Jenny Roman
Temperature logger surveys: David Davis, Barbara Hardman
Aerial imaging: Gregg Ridder, Vernon Brisley

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Island County Marine Resources Committee
Northwest Straits Initiative
Puget Sound Partnership
United States Environmental Protection Agency

Key Observations for 2020

- Kelp beds were equivalent or slightly smaller than beds in 2019.
- At all sites, surface temperatures were lower than in 2019, especially in late summer.
- At Possession Point, midwater and bottom temperatures in early summer were slightly higher than in 2019.
- Many schools of juvenile Pacific herring & Pacific sand lance were observed at Ebey's Landing.
- Kelp crab were observed at all beds except Polnell Point, and Lowell Point had high crab abundance.
- There was much less trash in the Ebey's Landing bed than in previous years.
- Surveys at Lowell Point (Camano Island) were resumed after a 2-year hiatus.

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).

Focused *in situ* surveys of bull kelp beds in South Puget Sound have uncovered disturbing trends of progressive shrinkage of bed areas (Berry, 2017; Berry, 2019). In addition to loss of canopy area, maximum depth for beds decreased and condition of individual kelp appeared poor, with an abundance of epiphytes, endophytes, and kelp crab. Whether these disturbing patterns occur in other parts of Puget Sound is unknown, but does raise concerns about the status of bull kelp throughout the region.

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 2020.

II. Scope of Project and Objectives

This report describes the project period from fall 2019 through summer 2020. Boat-based surveys and aerial imaging occur from early to late summer, often through September.

Objectives for 2020 included:

1. Collect data from previously surveyed kelp beds by boat-based surveys to extend observations from 2015, 2016, 2017, 2018, and 2019.
2. Assess aerial imaging of the Island County coastline for detecting kelp beds.
3. Deploy temperature loggers for measuring temperatures at multiple depths.
4. Collect images of animals and plants within the kelp beds.

III. Project Progress in 2019 - 2020

Objective 1. Collect data from previously surveyed kelp beds by boat-based surveys.
The two beds that were surveyed in 2016 - 2019 were also surveyed in 2020: Ebey's Landing and Polnell Point (Figure 1). The Ebey's Landing bed is located in Admiralty Inlet and receives full marine influence from the Strait of Juan de Fuca. The Polnell Point bed is located at the head of Saratoga Passage between Whidbey and Camano Islands, and it receives strong freshwater influence from the Skagit River. A third bed, Possession Point, was surveyed in 2017 - 2019 and was surveyed in 2020. It is located at the confluence of Admiralty Inlet, Possession Sound, and the Central Basin of Puget Sound, and it receives both marine and riverine influences, as well as potential anthropogenic effects from the Central Basin. A fourth bed, Lowell Point, was surveyed in 2016-2017, but not surveyed in 2018-2019. Sound Water Steward volunteers from Camano Island were trained in-person on 06/29/20 and 08/22/20, and data sets were collected in August and September 2020. Lowell Point is located in Saratoga Passage, along the western shore of Camano Island immediately south of Camano Island State Park.

Objective 2: Assess 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, two major adjustments to the eelgrass protocol were made. First, flights are conducted in August or September, when beds achieve maximum area for the year. Second, a near infra-red (IR) camera was paired to the visible light (RGB) camera to allow discrimination of surface vs submerged kelp, and to improve accuracy of identification. Matched aerial images were collected on August 28, 2019, which were examined for mapping shoreline associated with kelp beds. Because aerial images are collected late in the fiscal year, the data from 2019 are included in this FY20 report.

Objective 3: Deploy temperature loggers for measuring temperatures at multiple depths.
In previous years, Onset programmable temperature loggers were tested at three bed locations for collection of surface, midwater, and demersal temperatures. A deployable system with three (3) loggers was developed, and the protocol was used by three separate field teams.

Figure 1. Approximate locations of kelp beds and names of beds surveyed in 2020.

Objective 4: Collect images of animals and plants within kelp beds.
In 2017, we first collected images of submerged aquatic vegetation (SAV) with a small-scale drop camera rig using a GoPro which was deployed from a kayak. Although knowledgeable WA Department of Natural Resources staff indicated the quality was sufficient for SAV identification, no trained or qualified individuals are available for reviewing. Subsequently, we discontinued drop-camera image collection and returned to using a pole-mounted camera for underwater imaging. When feasible, the pole-mounted camera is used on the same day after surveys, after survey work is completed.

III. Results

A. Collect data from previously surveyed kelp beds by boat-based surveys.

Ebey's Landing

This bed is located outside of the entrance to Admiralty Inlet, and it has been surveyed for six consecutive years (2015, 2016, 2017, 2018, 2019, 2020). Paired visible (red-green-blue or RGB) and near infra-red (NIR) images taken on August 28, 2019, show that much of the kelp that is visible at low tide is actually at the surface (Figure 2).

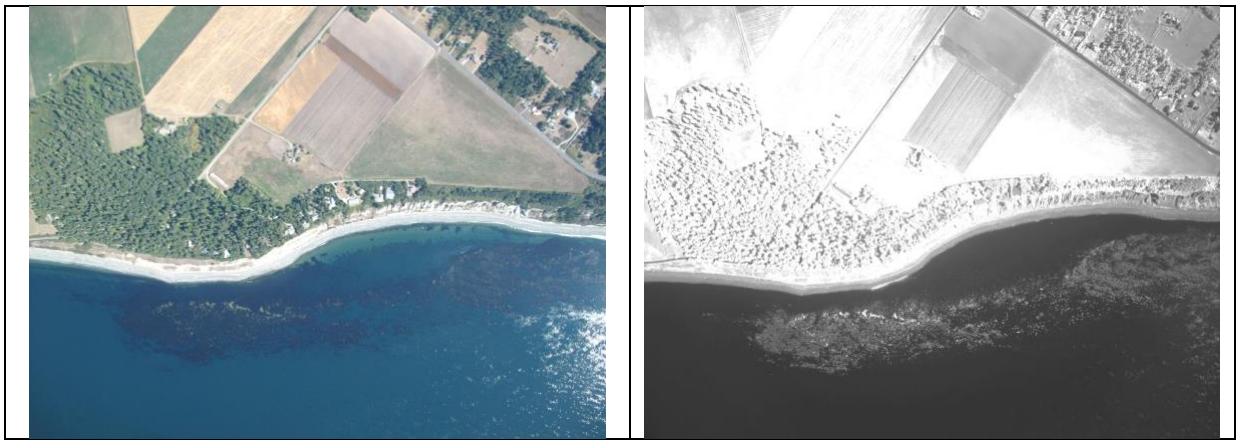


Figure 2. Ebey's Landing bull kelp bed on August 28, 2019, contrasting appearance in visible light (left) with near infra-red (right). Note that most of the kelp is visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley.

Bed area increased consistently from June through August, with a progressive expansion of the bed margin (Figure 3A). The area was similar to that in 2019, and still larger than areas measured in previous years (Figure 3B). In August 2019, the bed merged with the adjacent beds that extend southeastward to Fort Casey and Keystone (noticeable in the NIR image in Figure 2). This was the first time the merger was observed since surveys began in 2015. In 2020, bed merger was observed again in August, suggesting this may be a persistent expansion. Although survey data were collected into the adjacent bed, a southeast limit based on previous surveys (2015-2018) was established for bed area calculations, and was applied to both 2019 and 2020 surveys for bed comparisons shown in Figure 3

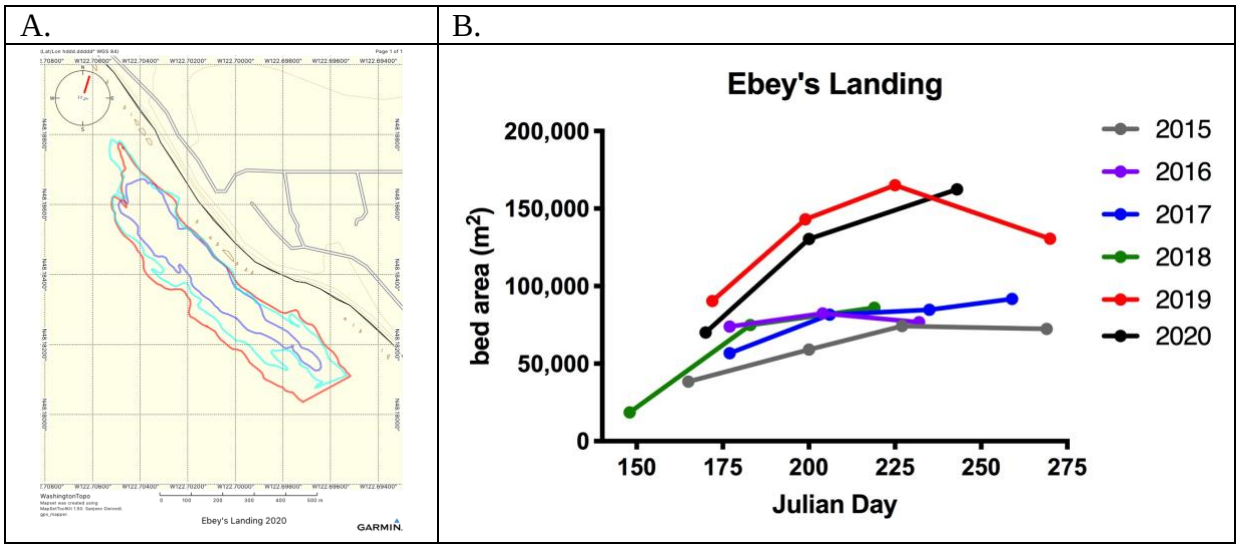


Figure 3. Ebey's Landing kelp bed survey areas. (A) Monthly perimeters of the surveyed bed at a zero-foot tidal height in 2020. (B) Comparison of bed areas from 2015 - 2020 across the survey dates.

Surface temperatures at the Ebey's Landing bed tend to be relatively low and consistent across the months, probably due to the strong marine influence from the Strait of Juan de Fuca (Figure 4A). In prior years, surface temperatures tend to peak at one month, but in 2020 it was consistently low, and there was no evidence of a persistent marine heat wave in the bed. Salinity was consistent across the survey season as in prior years (Figure 4B). Interestingly, surface salinities in 2019 and 2020 were slightly lower than those observed in previous years.

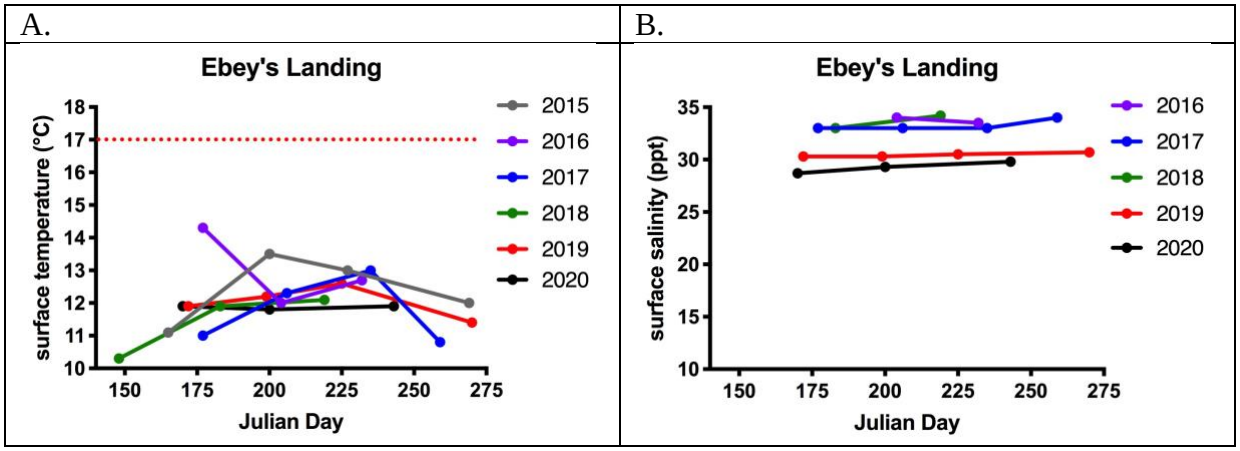


Figure 4. Ebey's Landing kelp bed mean surface temperatures and salinities. (A) Mean surface temperatures for the six years of surveys. The red dotted line at 17°C indicates a potential threshold temperature for detrimental effects on bull kelp physiology. (B) Mean surface salinities for the last five years of surveys.

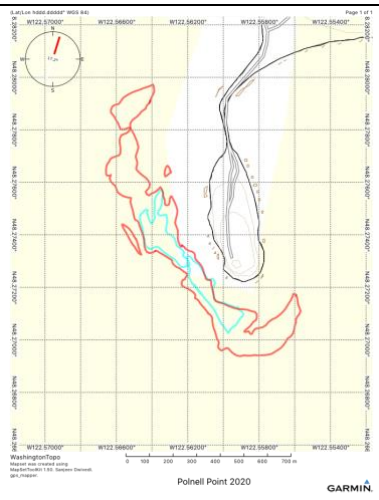
Polnell Point

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 within the influence of this large freshwater influx. Comparison of visible light and near infrared images of this bed shows that by August 28, 2019, most of the bed is strongly expressed at the surface (Figure 5).

Figure 5. Polnell Point bull kelp bed on August 28, 2019, showing the large area of the bed. Photos by Gregg Ridder and Vernon Brisley.

Because prior years of surveys showed that this bed has little or no surface expression in June and early July, surveys were conducted only in late July and August. This bed tends to show first along the southwest margin of the point, expanding south and north (Figure 6A). The majority of the bed at Polnell Point emerges at the surface late in the season, relative to Ebey's Landing, sometimes with rapid expansion late in the summer (Figure 6B). In 2020, bed area was comparable to 2016 and 2019 at the end of August (Figure 6B).

A.



B.

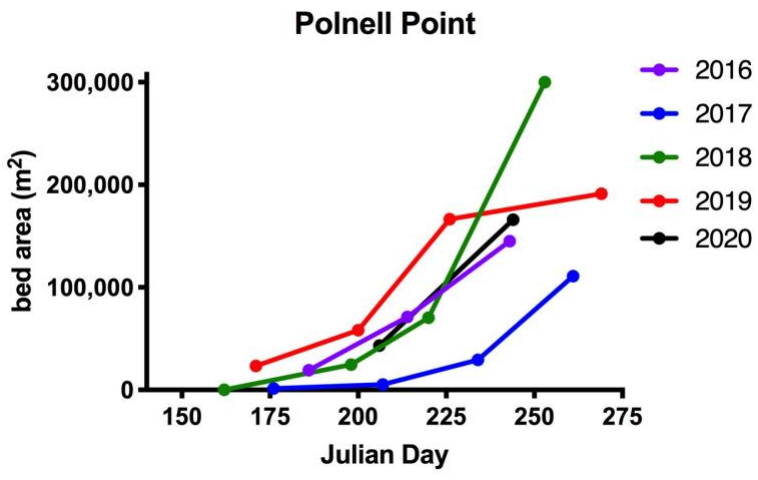


Figure 6. Polnell Point kelp bed survey areas. (A) Monthly perimeters of the surveyed bed at a zero-foot tidal height in 2020. (B) Comparison of bed areas from 2016 - 2020 across the survey dates.

Because this bed is close to the south fork of the Skagit River, higher temperatures and lower salinities in surface waters were expected, and had been observed in prior years. However, surface temperatures in 2020 were the lowest observed among the years at comparable timepoints (Figure 7A). Although surface salinities can fluctuate widely, depending on water movements, it was stable at ~ 23-24 ppt in 2020 (Figure 7B).

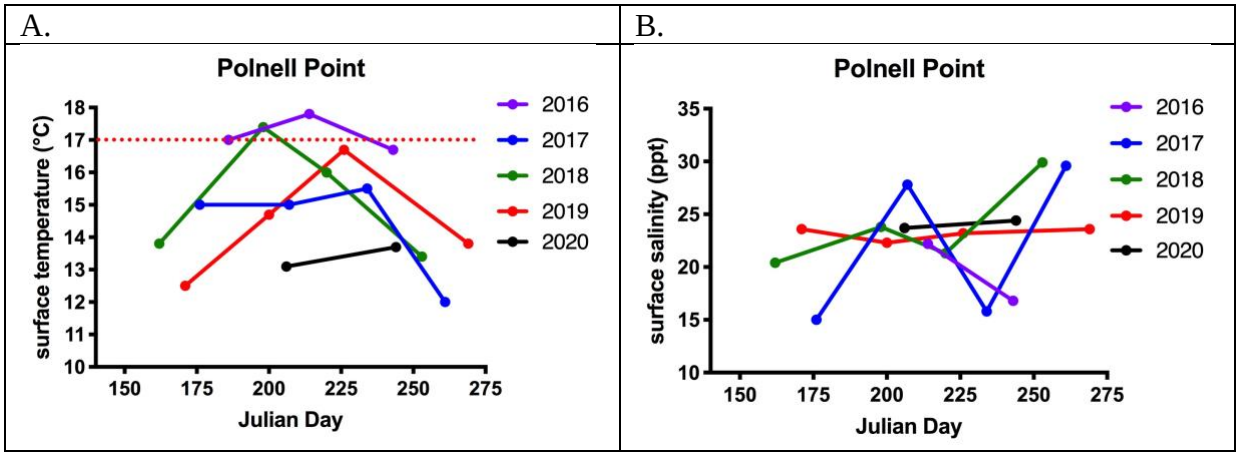


Figure 7. Polnell Point kelp bed mean surface temperatures and salinities. (A) Mean surface temperatures for the five years of surveys. The red dotted line at 17°C indicates a potential threshold temperature for detrimental effects on bull kelp physiology. (B) Mean surface salinities for the five years of surveys.

Possession Point

This bed is located south of Possession Point and at the convergence of Admiralty Inlet, Central Puget Sound, and Possession Sound. As a result, it is likely to receive fluctuating influences of marine waters and river inputs. Possession Point is an extremely popular fishing location and diving area, which may be due in part to its kelp bed. Although aerial assessment has identified kelp beds on either side of the Cultus Bay outflow, the surveyed bed is located to the east of the outflow and bounded by a stationary aid to navigation (Figure 8).

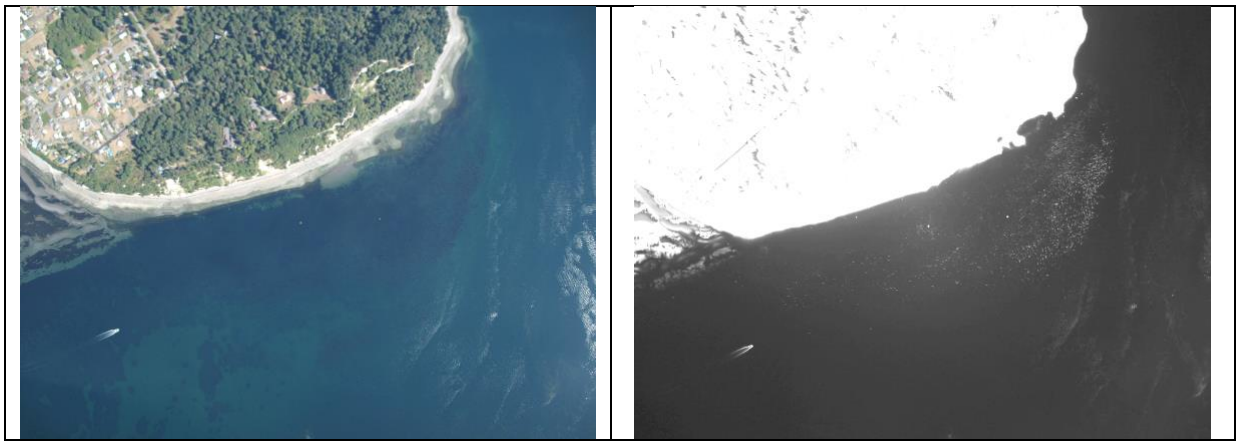


Figure 8. Possession Point bull kelp bed on August 28, 2019, contrasting appearance in visible light (left) with near infra-red (right). Note that nearly all of the kelp is visible at the surface in the near infra-red image. Photos by Gregg Ridder and Vernon Brisley.

Possession Point has been surveyed since 2017, when a single survey in August was conducted. In 2020, bed growth began closer to shore and then expanded in all directions through the summer (Figure 9A). The bed size in 2020 was more similar to its size in 2018, and did not reach the area measured in 2019 (Figure 9B).

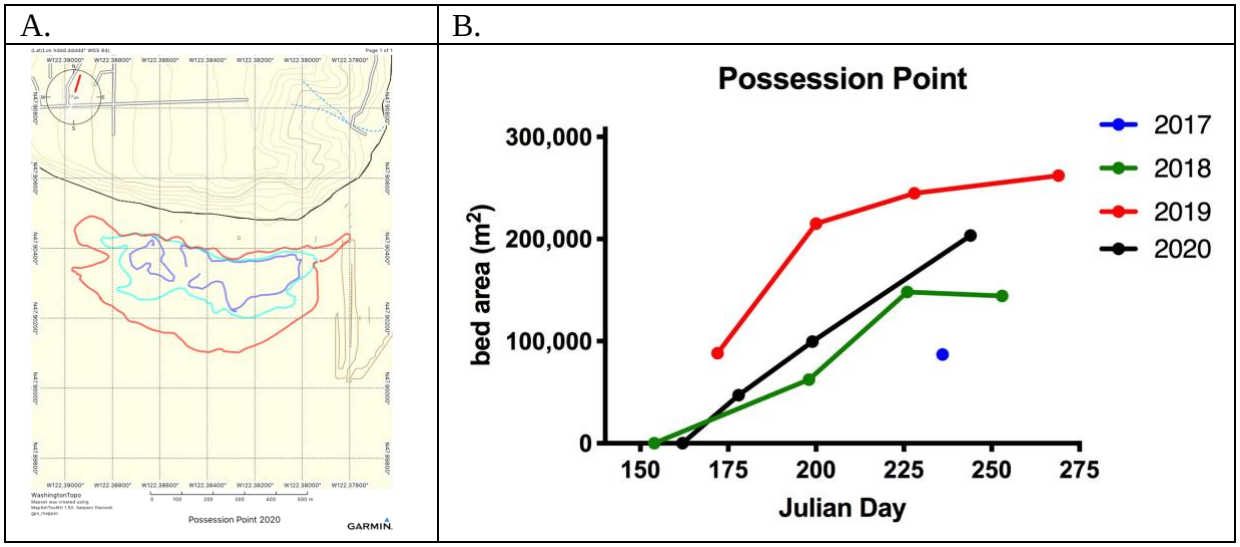


Figure 9. Possession Point kelp bed survey areas. (A) Monthly perimeters of the surveyed bed at a zero-foot tidal height in 2019. (B) Comparison of bed areas from 2017 - 2019 across the survey dates.

Surface temperatures at the Possession Point bed were higher than at the Ebey's Landing bed (compare Figure 10 with Figure 4). Unlike prior years, the highest surface temperature occurred early, rather than later, in the season (Figure 10A). Conversely, the lowest salinity also occurred in June (Figure 10B). This pattern is consistent with Possession Point receiving freshwater from river sources (e.g., Snohomish River) that are warmer in summer months.

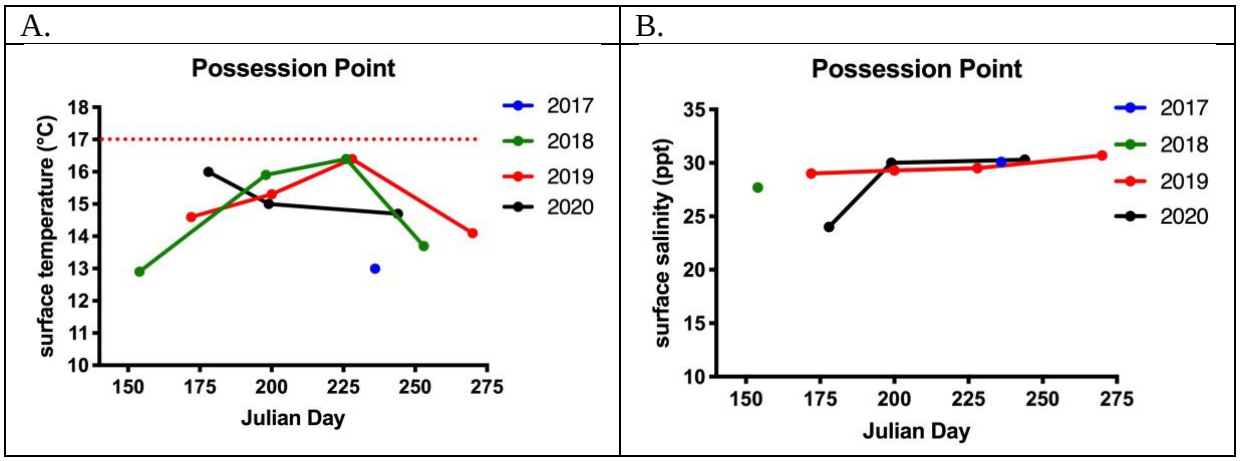


Figure 10. Possession Point kelp bed mean surface temperatures and salinities. (A) Mean surface temperatures for the past four years of surveys. The red dotted line at 17°C indicates a potential threshold temperature for detrimental effects on bull kelp physiology. (B) Mean surface salinities for the past four years of surveys.

Lowell Point

This bed is located in Saratoga Passage, along the western shoreline of Camano Island and immediately south of Camano Island State Park. As a result of its location, this bed receives freshwater from the Skagit, Skykomish, and Snohomish Rivers. Due to the proximity of the State Park, crabbing and fishing are common activities near the bed, and there is frequent small boat traffic near the bed in Saratoga Passage. The bed is comma-shaped, following the shallower underwater shelf around the point (Figure 11 and Figure 12A)

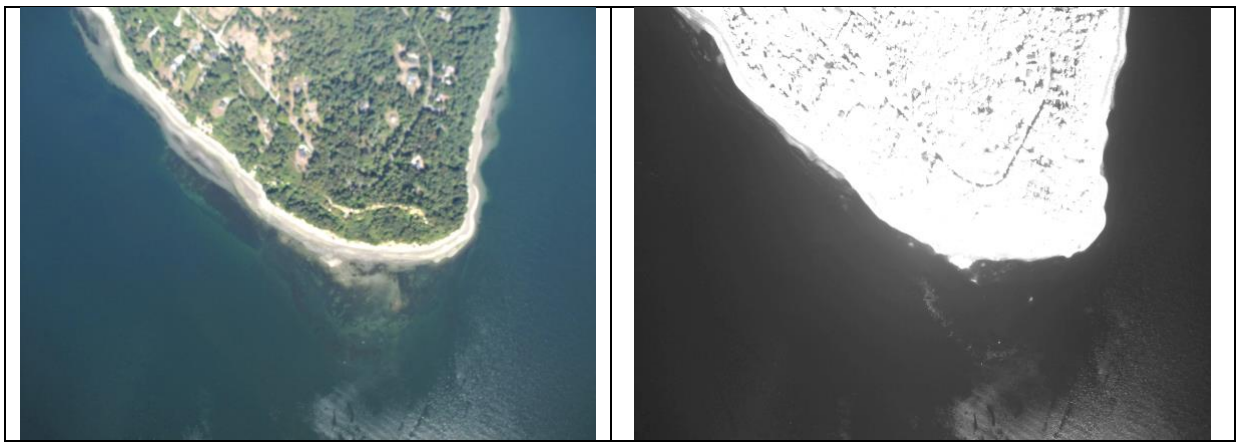


Figure 11. Lowell Point bull kelp bed on August 28, 2019, contrasting appearance in visible light (left) with near infra-red (right). Photos by Gregg Ridder and Vernon Brisley.

Lowell Point was surveyed in 2016 and 2017, but not in 2018 and 2019 due to a lack of volunteers. The bed was considerably smaller in 2020 than at comparable dates in 2016 and 2017 (Figure 12B). The monthly growth pattern was similar to that observed in 2017 and to those observed at Polnell Point and Possession Point: Surface expression occurs later in the summer (Figure 6B and Figure 9B). Bed area in 2020 was considerably lower than in

earlier years at comparable times (Figure 12). This is not likely related to surface temperatures because the 2020 temperatures were comparable or lower than those recorded in 2016 and 2017 (Appendix 1).

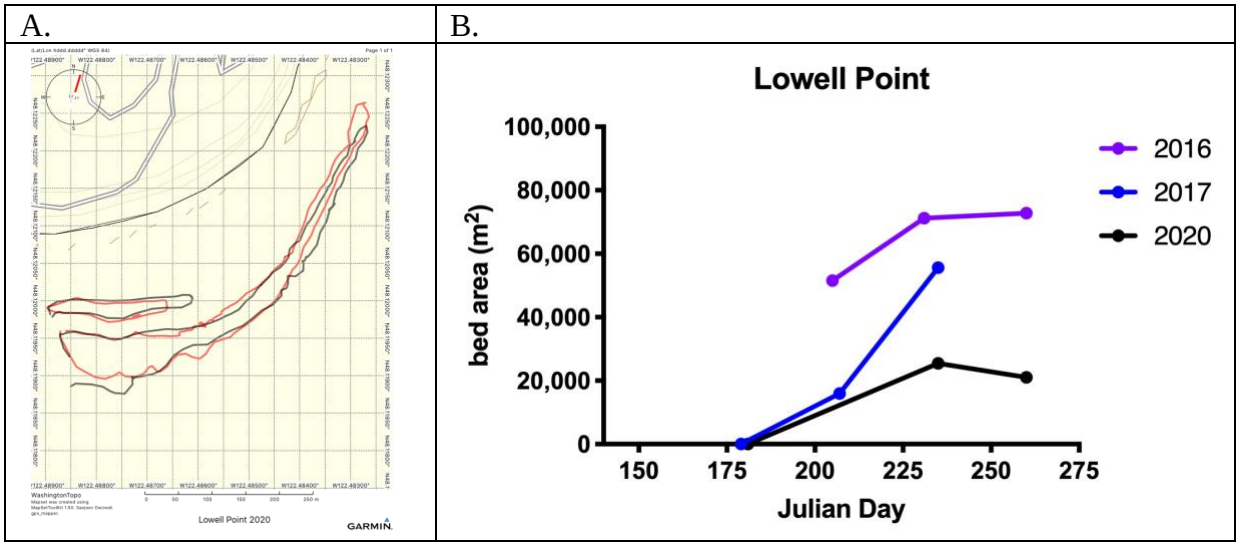


Figure 12. Lowell Point kelp bed survey areas. (A) Monthly perimeters of the surveyed bed at a zero-foot tidal height in 2020. (B) Comparison of bed areas from 2016, 2017, and 2020 across the survey dates.

Cross-Site Comparisons

A comparison of areas, temperatures, and salinities for 2020 across all of the surveyed sites reveals several observations. Although three beds (Ebey's Landing, Polnell Point, Possession Point) were similar in size by late summer, the dynamics of monthly bed area were different (Figure 13A). Among the four beds, Ebey's Landing was the only bed with visible kelp by early summer. The largest bed was at Possesion Point while the smallest was at Lowell Point. Surface temperature at Ebey's Landing was consistently the lowest, while temperature at Possession Point was consistently the highest. Unlike previous years, none of the sites exhibited surface temperatures above 17°C. Finally, mean surface salinities were nearly identical at the Ebey's Landing and Possession Point beds during the summer, while salinities at Polnell Point were consistently lower (Figure 13C). One monthly measurement at Lowell Point in August was 28.1 ppt (Appendix 1), which was higher than Polnell Point, but lower than Possession Point at the same time.

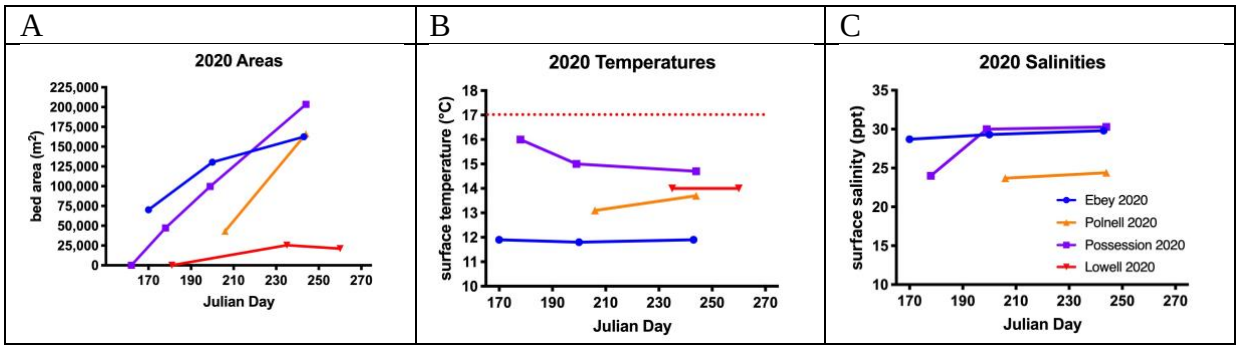


Figure 13. Bed areas, surface temperatures, and surface salinities for all sites surveyed in 2020. (A) Monthly bed areas by site. (B) Mean monthly surface temperatures by site. (C) Mean monthly surface salinities by site.

B. Aerial Imaging

Note: Aerial imaging analysis lags by one year. This report contains results from 2019.

Aerial imaging from a small private airplane was conducted on August 28, 2019. The Island County shoreline was simultaneously photographed using a visible light (RGB) camera and a near infra-red (NIR) camera. More than 1,400 images were collected and georeferenced to the airplane's GPS data. These images were reviewed by two people who had reviewed images from 2017 and 2018, using the same criteria for identifying images containing bull kelp. To reduce time and use the prior experience of the reviewers, images were examined simultaneously by both reviewers, who discussed and resolved discrepancies in real time. Photographs were used to map associated shoreline using Google Earth Pro. In 2019, the estimated amount of shoreline associated with bull kelp was ~ 12.7 miles, which is approximately 6.5% of Island County's shoreline.

A comparison of shoreline miles associated with bull kelp revealed a large difference between the 2017 estimate and subsequent years. The criteria for mapping associated shoreline in 2017 included shoreline likely to impact a bed, whereas only shoreline directly adjacent to kelp was included in 2018 and 2019. For example, all the shoreline in Cultus Bay, which is proximal to the two beds around Possession Point, had been included in the 2017 estimate, but not the 2018 and 2019 estimates. The 2017 results were re-assessed with the more limited criteria, resulting in a lower total estimate that is more similar to totals for 2018 and 2019.

Figure 14 shows the regional distribution of shoreline miles over the three years this aerial assessment was made. A few observations can be made from these results. The majority (~70%) of shoreline associated with bull kelp is along western side and Admiralty Inlet side of Whidbey Island. Regional estimates tended to be similar, although there are year-to-year variations. These variations can result from differences in ability to detect bull kelp in photos due to light angles, surface conditions, or reviewer subjectivity. There is an apparent decline in shoreline in 2019, which we believe is directly attributable to a new 2019 requirement for the airplane to fly at 4,000 feet, rather than 2,000 feet. This resulted in loss of resolution (the

same cameras and focal-length lenses were used all three years), making it more difficult to definitely identify kelp using both the RGB and NIR images. Maps of shoreline associated with bull kelp beds for all three years are displayed in Figure 15.

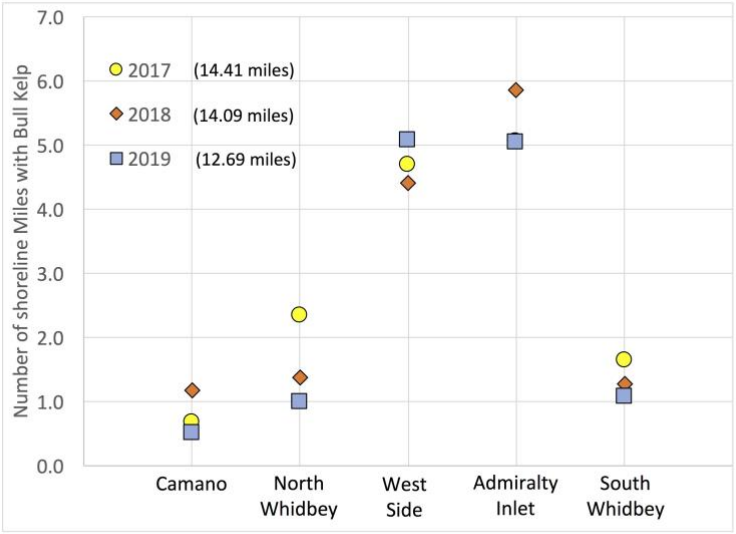


Figure 14. Island County shoreline with associated bull kelp by region and year based on evaluation of aerial photos (RGB and NIR) and manual mapping to satellite imaging.

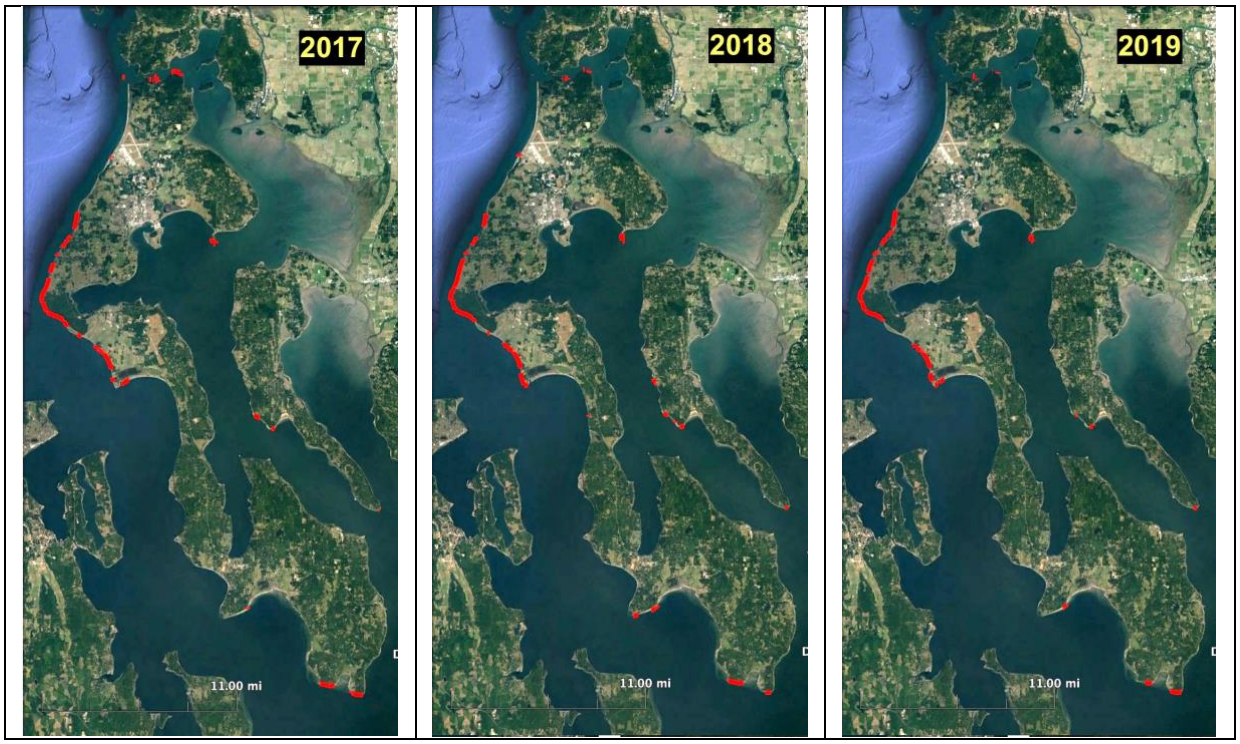


Figure 15. Maps of Island County showing shoreline (highlighted in red) with associated bull kelp beds in 2017, 2018, and 2019.

Recommendation: Aerial imaging offers a relatively rapid method for evaluating bull kelp county-wide. Air-time for collecting images was approximately two hours, and there is a well-defined protocol for image collection. Using both RGB and NIR for identifying bull kelp can reduce false positive identifications (based on our ground-truthing of a few suspect identifications). Because photographs have considerable overlap, reviewer consistency can be high. Once limited criteria were established, mapping associated shoreline to satellite images can produce consistent results. This project was extremely fortunate to engage an experienced private pilot (Gregg Ridder) with a pre-defined protocol for orthogonal shoreline imaging. If this type of assessment is considered in the future and this pilot is not available, it may be possible to transfer the protocol to a volunteer organization, such as Lighthawk Conservation Flying (https://www.lighthawk.org).

C. Deploy temperature loggers for measuring temperatures at multiple depths

A system of Onset temperature loggers that could be deployed from a kayak or small boat was created and tested in 2018. Among the 3 loggers, one is positioned at ~ 1 foot from the surface, one at ~ 1 foot from the bottom, and one at ~ halfway of the water depth. This allows a basic measurement of temperatures in the water column, which are experienced by kelp throughout the survey season. In 2020, this system was deployed by two of the kayak survey teams (Ebey's Landing, Polnell Point, Possession Point) and a separate volunteer team conducting strictly temperature logger measurements at Possession Point independent of bed surveys and tidal height requirements.

At Ebey's Landing, mean temperatures exhibited little variation across survey season and low variation in the water column (Figure 16), suggesting good vertical mixing. Nonetheless, logger results showed that temperatures in the water column increased as the survey season progressed. At Polnell Point, there was also little difference in vertical temperatures, also suggesting good mixing at that site (Figure 16). There was no difference between the two survey dates in July and August. At both sites, none of the measurements approached 17°C, a potential threshold for a physiologically detrimental temperature to bull kelp.

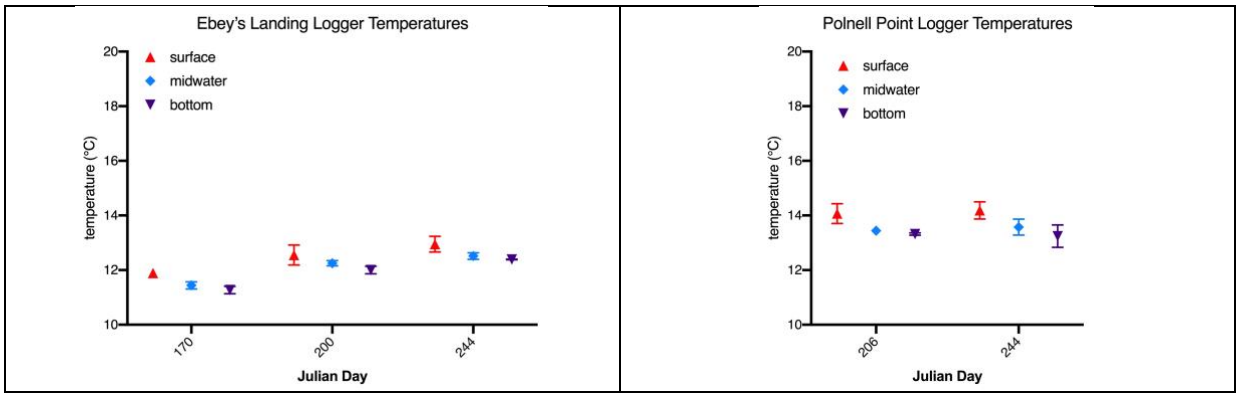


Figure 16. Mean water column temperatures (with standard deviations) collected by Onset temperature loggers during the zero-tide surveys at Ebey's Landing (left) and Polnell Point (right). Loggers are deployed near the surface, near the bottom, and at approximately half of the water depth.

At Possession Point, temperature loggers were deployed by both the survey team and a dedicated temperature logger team. The latter team was able to collect data at a higher frequency throughout the season than the survey team. Figure 17 displays logger measurements by both teams for 2019 and 2020 at the three depths across the survey seasons. A comparison of 2019 and 2020 shows surface temperatures were similar until later in the season, where 2019 surface temperatures were dramatically higher (Figure 17A). In contrast, 2020 midwater and bottom temperatures were higher during the midseason in late June to late July (Figure 17B and 17C). Nonetheless, only one of the 2020 temperatures at Possession approached the 17°C threshold throughout the survey season (Figure 17A).

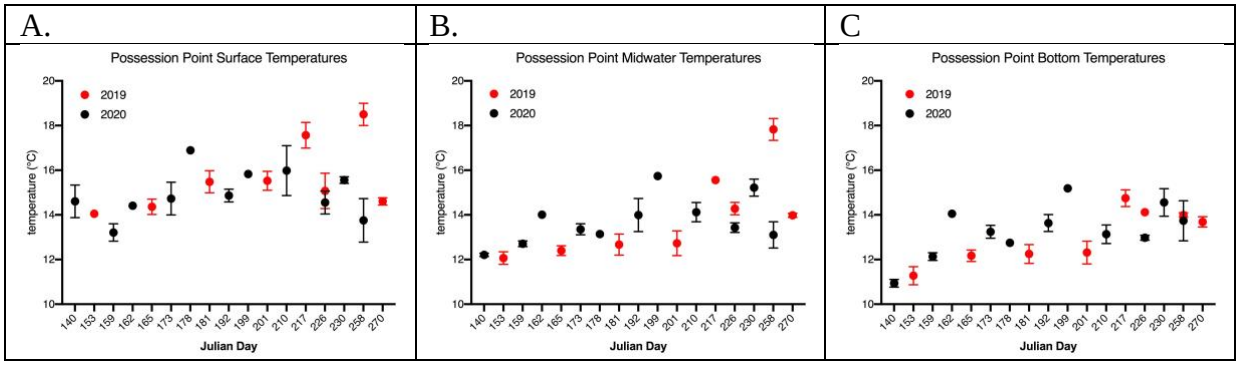


Figure 17. Mean water column temperatures (with standard deviations) collected by Onset temperature loggers at Possession Point throughout the 2019 and 2020 survey seasons. Loggers are deployed (A) near the surface, (B) near the bottom, and (C) at approximately half of the water depth.

Recommendation: Surface temperature fluctuates considerably, even within short time periods (i.e., minutes), and do not reflect temperatures experienced by kelp during most of the growing season. Also, obtaining accurate thermometers has been a problem. Small, programmable temperature loggers are easy to use, allow profile measurements, and have better quality control than inexpensive analog thermometers. We developed and tested a rig that can be easily deployed and retrieved in a kayak or small power boat that can measure temperature at multiple depths. After two years of experience among three teams, this system demonstrated it can produce much better temperature information. One team collected data independently of surveys and at much higher frequency throughout the season (Figure 17), providing better resolution on temperature trends within the kelp bed. Until more permanent monitoring equipment can be placed within kelp beds, this system offers a feasible, reasonably priced opportunity for quality data collection.

D. Collect images of animals and plants within kelp beds

All field-recorded observations of animals and plants are in Appendix 2. The Marine Resources Committee bull kelp project page has links to videos (https://www.islandcountymrc.org/projects/bull-kelp-monitoring/).

Birds are some of the most readily and frequently observed animals in kelp beds. Pigeon guillemot, murrelets, and murre-like birds are frequently observed at Possession Point and Ebey's Landing, sometimes actively fishing. In beds with high densities of kelp, great blue heron are often seen fishing while standing on kelp stipes. Bald eagle and osprey are also observed cruising kelp beds, sometimes grabbing fish from the water.

The most frequently seen marine mammal is harbor seal, especially at beds where there are haul-out rocks available, such as Possession Point and Polnell Point. Harbor seal also spend time in kelp beds (title page photo), either hunting or just loafing. Other marine mammals in or near kelp beds include sea lion (Possession Point) and large (probably grey) whales (Polnell Point).

Many smaller fish, including schools, were observed in all of the beds in 2020. Underwater video and photos allowed identification of Pacific herring (Figure 18A), Pacific sand lance (title page photo), and shiner perch (Figure 18B) as prominent users of kelp beds. At Possession Point, small salmonids were also observed jumping from the water. Occasionally, other distinctive species such as tubesnouts could be identified feeding in the bed.

Kelp crab were widely observed in 2020. All beds, except Polnell Point, reported kelp crab in higher abundances than in previous years. Lowell Point surveyors reported a wide range of sizes in the bed during the September visit.

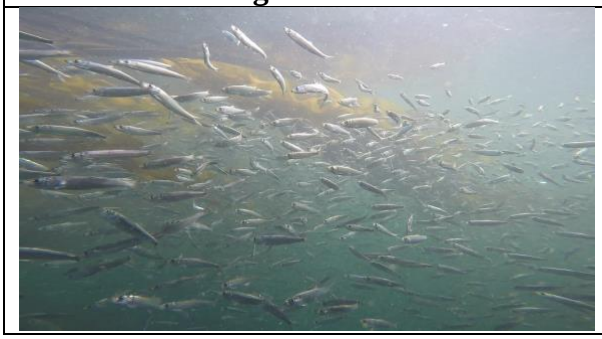
A. Pacific herring	**B. Shiner perch**
	

Figure 18. Underwater images of (A) Pacific herring in the Ebey's Landing bed and (B) shiner perch in the Lowell Point bed (L. Rhodes).

A. Kelp crab decorated with red algae	**B. Kelp crab at surface**
	

Figure 19. Underwater image of (A) kelp crab in the Ebey's Landing bed (L. Rhodes) and

(B) surface image of kelp crab at the Lowell Point bed (J. Roman).

Although no explicit parameters of bull kelp health have been established, we have been recording subjective estimates of bryozoan (probably *Membranipora*) density on fronds, stipes, and bulb (Appendix 1). Although there is a seasonal trend of increased bryozoan colonies later in the season, there are differences among the beds. Polnell Point had abundant bryozoan colonies by mid-summer (July), while Possession Point and Lowell Point had moderate bryozoan abundance at the end of the summer. In contrast, Ebey's Landing had low bryozoan abundance throughout the season. Other epiphytes appear on bull kelp later in the season, including a possible filamentous red algae (Figure 20A).

After the survey season ended, Kelly Zupich (Sound Water Stewards) reported an unusual-appearing bull kelp on the beach at Ebey's Landing (Figure 20B). Thomas Mumford (Marine Agronomics) identified the surface growth as a *Streblonema* (now *Laminariocolax*) species, an endophytic filamentous brown algae that is a known cause of disease in bull kelp.

A. Red algal epiphyte on bull kelp	B. Diseased bull kelp with endophytic brown algae
	

Figure 20. (A) Possible filamentous red algal epiphyte commonly observed on late season bull kelp (R. Beier). (B) Bull kelp affected with *Streblonema* / *Laminariocolax* brown algal endophyte (K. Zupich).

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	2016 (0' tide height)				2017 (0' tide height)					2018 (0' tide height)	
	June	**July**	**mid August**	**late August**	**May**	**June**	**July**	**August**	**September**	**June**	**July**
bed area (m2)	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
perimeter length (m)	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
mean surface temp (°C)	12.2	11.9	13.3	12.2	8.9	9.6	11.7	12.4	11.1	11.9	12
minimum bed depth (m)	0.30	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.1	0.1
maximum bed depth (m)	4.42	3.96	5.79	5.88	3.81	3.81	---	5.79	6.10	2.3	4.4
mean bed depth (m)	2.36	2.21	2.89	2.94	1.90	1.90	---	2.90	3.05	1.6	2.3
minimum salinity (ppt)	---	---	---	---	---	---	---	---	---	---	---
maximum salinity (ppt)	---	---	---	---	---	---	---	---	---	---	---
mean salinity (ppt)	---	---	---	---	---	---	---	---	---	---	---
kelp crab abundance	---	---	---	---	---	---	---	---	---	absent	absent
sori abundance	---	---	---	---	---	---	---	---	---	present (abundant)	present (abundant)
bryozoan abundance	---	---	---	---	---	---	---	---	---	present (few)	present (few)

Notes "xx" indicates area & perimeter cannot be accurately determined because inner perimeter can not be tracked

	2016 (0' tide height)			2017 (0' tide height)		2018 (0' tide height)		
	July	**August**	**September**	**June**	**July**	**June**	**July**	**August**
bed area (m2)	16,315	15,008	13,722	5,496	14,585	---	19,624	30,287
perimeter length (m)	1,200	898	829	620	827	---	644	837
mean surface temp (°C)	14.2	14.4	12.6	9.42	9.63	12.3	12.8	12.5
minimum bed depth (m)	0.30	0.30	0.15	0.17	0	0.6	---	---
maximum bed depth (m)	4.42	4.27	4.72	3.96	3.35	5.5	---	---
mean bed depth (m)	2.36	2.28	8.00	1.98	1.68	2.6	---	---
minimum salinity (ppt)	---	---	---	---	---	---	---	---
maximum salinity (ppt)	---	---	---	---	---	---	---	---
mean salinity (ppt)	---	---	---	---	---	---	---	---

	2016 (0' tide height)				2017 (0' tide height)			2020 (0' tide height)	
	July	**August**	**September**	**September (2nd bed)**	**June**	**July**	**August**	**August**	**September**
bed area (m2)	51,543	71,187	72,775	1,652	0	15,995	55,631	25,447	21,076
perimeter length (m)	1,800	1,900	1,840	407.5	0	750	1,708	1,798	1,635
mean surface temp (°C)	17.0	17.7	14.4	14.4	15.5	14.0	14.4	14.0	14.0
minimum bed depth (m)	2.74	1.83	2.74	---	---	2.74	2.7	3.7	2.7
maximum bed depth (m)	4.57	6.10	7.01	---	---	8.23	5.9	4.6	5.3
mean bed depth (m)	3.66	3.91	4.67	---	---	5.09	4.13	---	---
minimum salinity (ppt)	26	---	---	---	---	---	---	28.0	---
maximum salinity (ppt)	27	---	---	---	---	---	---	28.1	---
mean salinity (ppt)	26.7	---	---	---	---	---	---	28.1	---
kelp crab abundance								few	abundant
sori abundance								abundant	moderate
bryozoan abundance								abundant	moderate

	2015 (0 - 0.5' tide height)				2015 (4 - 5' tide height)				2016 (0' tide height)			2017 (0' tide height)				2018 (0' tide height)			2019 (0' tide height)				2020 (0' tide height)		
	June	July	August	September	June	July	August	September	June	July	August	June	July	August	September	May	July	August	June	July	August	September	June	July	August
bed area (m2)	38,384	59,151	74,302	79,992		48,419	56,004	64,460	73,946	82,492	76,781	56,802	81,554	84,713	91,759	18,662	74,876	86,136	90,447	143,123	165,084	130,537	70,120	130,375	162,428
perimeter length (m)	1,288	1,448	1,931	2,092		1,287	1,609	1,770	1,600	1,900	1,700	1,400	1,500	1,500	2,240	1,100	1,800	2,000	2,300	2,300	1,740	1,840	2000	2900	2900
transect length (m)	148	483	483	644		483	644	483	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
bulb density (bulbs m-2)	1.95	1.50	1.55	2.02		0.78	0.64	0.87	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
mean surface temp (°C)	11.0	13.5	13.0	12.0		13.0	14.0	12.5	14.3	12.0	12.7	11.0	12.3	13.0	10.8	10.3	11.9	12.1	11.9	12.2	12.6	11.4	11.9	11.8	11.9
minimum bed depth (m)	1.22	1.83	2.29	1.22		3.05	3.35	3.05	1.52	1.68	1.37	---	1.68	1.40	1.07	0.80	1.80	2.10	---	---	---	---	---	---	---
maximum bed depth (m)	4.42	5.49	7.01	0.76		6.40	7.01	7.01	6.10	6.25	7.32	5.49	6.25	7.62	7.32	7.50	6.40	6.70	6.10	7.01	7.32	7.6	5.2	6.1	6.4
mean bed depth (m)	2.92	3.58	4.42	4.11		4.50	5.27	4.83	3.96	4.17	4.32	---	3.76	4.20	4.14	5.50	4.20	4.00	---	---	---	---	4.8	5.4	6
minimum salinity (ppt)	---	---	---	---		---	---	---	---	34.0	33.0	32.0	32.0	32.5	33.5	---	32.5	34.0	29.9	30.3	30.4	30.7	28.6	29.1	29.7
maximum salinity (ppt)	---	---	---	---		---	---	---	---	34.0	34.0	33.0	33.0	33.0	34.0	---	33.5	34.5	30.5	30.3	30.6	30.8	28.7	29.3	29.8
mean salinity (ppt)	---	---	---	---		---	---	---	---	34.0	33.5	32.5	32.2	32.8	33.8	---	33.0	34.2	30.3	30.3	30.5	30.7	28.7	29.3	29.8
kelp crab abundance	---	---	---	---		---	---	---	---	---	---	---	---	---	---	absent	1 seen	absent	absent	absent	absent	absent	moderate	few	few
sori abundance	---	---	---	---		---	---	---	---	---	---	---	---	---	---	many	many	many	many	many	many	moderate	many	many	abundant
bryozoan abundance	---	---	---	---		---	---	---	---	---	---	---	---	---	---	absent	few	few	moderate	few	few	absent	few	few	few

sori older at west end

blades ragged

byozoans are small

bryozoans are tiny; sori large throughout bed; only 1 kelp crab seen

many "punched out" sori

bryozoans larger at west end

many other epiphytes

most kelp crab seen in this bed

	2016 (0' tide height)			2017 (0' tide height)				2018 (0' tide height)				2019 (0' tide height)				2020 (0' tide height)	
	July	early August	late August	June	July	August	September	June	July	August	September	June	July	August	September	July	August
bed area (m2)	19,117	71,187	145,003	1,471	5,321	29,340	110,908	0	24,687	70,348	300,040	23,270	58,263	166,409	191,303	43,154	166,101
perimeter length (m)	1,211	1,900	3,500	200	377	1585	2,877	0	1,800	3,400	4,200	1,100	2,620	3,100	3,000	1,950	4,550
mean surface temp (°C)	17.0	17.7	16.7	15.0	15.0	15.5	12.0	13.8	17.4	16.0	13.4	12.5	14.7	16.7	13.8	13.1	13.7
minimum bed depth (m)	2.74	1.83	3.96	0.61	0.61	---	1.83	1.20	0.80	3.00	2.44	---	---	---	---	---	2.1
maximum bed depth (m)	3.66	6.10	6.10	0.61	2.44	---	4.57	6.10	3.50	4.70	5.49	2.10	4.88	4.57	5.48	7.3	6.1
mean bed depth (m)	3.15	3.91	5.28	0.61	1.52	4.15	3.35	3.00	2.20	3.90	3.72	---	---	---	---	---	4.3
minimum salinity (ppt)	---	20.5	16.0	15.0	27.5	---	29.5	19.0	23.0	19.5	29.5	21.7	19.1	23	22.7	23.7	23.4
maximum salinity (ppt)	---	24.0	17.5	15.0	28.0	---	30.0	21.0	24.0	24.5	30.0	25.5	26.3	23.7	24.7	23.7	25.1
mean salinity (ppt)	---	22.2	16.8	15.0	27.8	15.8	29.6	20.4	23.8	21.3	29.9	23.6	22.3	23.2	23.6	23.7	24.4
kelp crab abundance	---	---	---	---	---	---	---	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent
sori abundance	---	---	---	---	---	---	---	present	moderate	many	few	many	many	many	moderate	moderate	moderate
bryozoan abundance	---	---	---	---	---	---	---	few	few	abundant (southern bed); moderate (western bed)	> 50% unaffected, but affected plants heavily infested	absent	few	many	moderate (large colonies mostly on stipes)	abundant	abundant
Notes						Parameters for only beds 1,2,3,& 6 included here, because could not measure beds 4 & 5 in September	Parameters for beds matching those reported for August.	only few bulbs present, near shore						bryozoans dense & large on east side; fewer on west side	blades narrow or missing; bryozoans large & on stipes on west side; bryozoans on blades & stipes on south side		

	2017 (0' tide height)	2018 (0' tide height)					2019 (0' tide height)				2020 (0' tide height)		
	August	early June	late June	July	August	September	June	July	August	September	June	July	August
bed area (m2)	86,896	0	108,798	62,277	148,047	144,405	88,291	215,140	244,824	262,152	47,272	99,635	203,461
perimeter length (m)	1,500	0	1,600	1,400	2,100	2,300	1,600	3,259	3,200	2,600	1,601	1,800	2,500
mean surface temp (°C)	13.0	12.9	14.7	15.9	16.4	13.7	14.6	15.3	16.4	14.1	16.0	15.0	14.7
minimum bed depth (m)	3.1	0.8	1.8	0.9	1.8	2.1	---	0.9	1.8	2.3	1.8	2.9	1.2
maximum bed depth (m)	4.0	4.6	4.3	4.6	4.6	5.5	3.5	4.7	4.9	5.8	3.5	3.2	5.5
mean bed depth (m)	3.5	3.1	3.0	2.7	2.9	3.5	---	2.8	3.4	3.7	2.9	3.0	3.0
minimum salinity (ppt)	30.0	27.5	---	---	---	---	29	29	29	30	25	30	30
maximum salinity (ppt)	30.5	28.0	---	---	---	---	29	30	30	31	23	30	31
mean salinity (ppt)	30.1	27.7	---	---	---	---	29	29.3	29.5	30.7	24	30	30.3
kelp crab abundance	---	---	few	many (n = 50)	many (many ≥1 per stalk)	many (fewer than in July)	few	moderate	moderate	few	none	moderate	moderate
sori abundance	---	---	present (many)	present (many torn & empty)	present (new & torn)	present	absent	many	many	few	none	few	abundant
bryozoan abundance	---	---	medium	high	high	high	absent	many	moderate	moderate	none	few	moderate
notes		only few bulbs present, near shore				stalks fuzzy with growth	kelp crab predom on east edge of bed		more bryozoans along east & shore sides of bed	south lobe of perimeter may not have been captured in August due to rough conditions; kelp condition deterioratin g with rotting stipes, missing blades, epiphytic green algae; bulbs not pliable; total number of kelp decreased	surface kelp sparse with blades in good condition; measured 2 separate beds in proximity to each other	Density & size of bulbs less than July 2019; blades in good condition; many bryozoans on some blades but most with few; kelp crab evenly distributed throughout bed	bryozoans more along east & south edge of bed; kelp crab large & primarily at center of bed; bed density appears lower than last year

Appendix 2. Anecdotal observations in bull kelp beds by site and month of survey. Number observed, estimate of density, and/or estimate of distribution. "---" indicates no observation made.

Site	Month, Year	Birds	Mammals	Fish	Invertebrates
Ebey's Landing	June, 2015	Great blue heron fishing (2)	---	---	Dungeness crab zoea (high density throughout bed)
	July, 2015	Great blue heron fishing (1)	---	---	---
	August, 2015	Great blue heron fishing (2)	---	Unidentified small fish schools (few throughout bed)	---
	September, 2015	Heerman's gulls (>50); glaucous winged gulls (few); Western gulls (few)	---	Schools of small (<100 mm) salmonid-like fish; occasional jumping adult salmonids; perch-like fish (many throughout bed)	*Aurelia* jelly (few)
	June, 2016	Great blue heron fishing (1)	---	---	---
	July, 2016	Great blue heron fishing (2); rhinoceros auklet resting (1); bald eagle fishing (1); pigeon guillemot fishing (6)	river otter fishing & eating large sculpin (1)	Schools of small (4-6 cm) forage fish (high density throughout bed)	*Phacellophora* jellies (2); *Aurelia* jelly (1)
	August, 2016	Harlequin ducks fishing (8, females); bald eagle fishing (1); great blue heron fishing (1); pigeon guillemot fishing (1)	---	Schools of small (4-6 cm) forage fish (high density throughout bed); aggregates of shiner perch (multiple throughout bed)	*Phacellophora* jellies (2); bryozoans on fronds (numerous); large kelp crab (1)

	June, 2017	bald eagle (1); common loons fishing (2); great blue heron on kelp (1)	---	large school of forage fish in bed	---
	July, 2017	great blue heron on kelp (2); bald eagle (1); cormorant fishing (2)	---	many schools of small (≤5 cm) shiner perch	*Aurelia* sp. jellies (few)
	August, 2017	great blue heron fishing (3); Heermans gulls (6)	---	tubesnouts loafing in kelp blads (~24); many schools of herring ~ 25 mm TL; numerous schools of medium-large (6-10 cm TL) shiner perch	---
	September, 2017	Western grebe diving at margin (1); great blue heron on kelp (1); Heermans gulls (6); common loons (1 male, 1 female, 2 juveniles)at margin (4)	sea lion cruising margin (1)	NO forage fish schools	*Phacellophora* jellies (4); bryozoan colonies (*Membranipora* sp.) covering all submerged & exposed kelp parts
	May, 2018	< 6 Bonaparte's gulls (male & female)	---	few small schools (< 20 fish) of small fish (< 30 mm)	---
	July, 2018	bald eagle (hungting by skimming); 3 pair pigeon guillemots fishing within bed	harbor seal at bed perimeter (1)	multiple schools of forage fish; scattered shiner perch schools; school of tiny (< 20 mm) stickleback-like fish feed at surface)	---
	August, 2018	great blue heron hunting from kelp (1); 5-12 pigeon guillemots fishing within bed	harbor seal at bed perimeter (1)	numerous large schools of forage fish & perch	---

	June, 2019	pigeon guillemot fishing (2)	---	many small schools of shiner perch throughout bed	abundant aggregates of crab zoea in western portion of bed (photos, collected)
	July, 2019	~10 Heermans gulls, resting; 2 pigeon guillemot, fishing; 3 great blue heron, fishing on kelp	1 river otter fishing in shallow part of bed (may have a nest nearby because of possible kit squeals)	few schools of possible herring in kelp	---
	August, 2019	~12 Heermans gulls, feeding; ~ 12 other types of gulls, feeding; 2 rhinoceros auklets (male & female), fishing; 2 great blue heron, fishing on kelp	sea lion, cruising along outer margin of bed	numerous herring schools in kelp, feeding at surface	---
	September, 2019	>30 gulls, including ~ 10 Heermans gulls, feeding; 2 common loons, fishing; 3 great blue heron, fishing on kelp	---	few large herring schools in kelp	---
	June, 2020	5-6 pigeon guillemots at periphery of bed	---	many tiny (< 20 mm) jumping fish; few schools of <20 mm fish & larger (~60 mm) herring; few larger (~50 mm) shiner perch	few jellies: small moon jellies (<20 mm), 1 larger ctenophore (~40 mm); many adult kelp crab, ~ 10 observed (see videos) with decorated shells
	July, 2020	3 adult bald eagles squabbling over a fish; 4 pigeon guillemot fishing in bed	---	moderate # of shiner perch (5-8 cm) throughout bed; few schools of 4-6 cm fish (some are herring,	few jellies: small (2-3 cm) moon jellies, one 10-14 cm lions mane jelly

				some may be sand lance); few schools of tiny (< 2 cm) fish in nearshore (mixed eelgrass, *Pterygophora*, feather boa, bull kelp)	
	August, 2020	2 ospreys fishing at bed edge; 13 cormorants on kelp drying themselves; ~12 Heermans gulls feeding on fish in bed; 1 great blue heron on kelp, feeding; adult bald eagle fishing just outside of bed	---	one school of juvenile sand lance; closter of tube snouts feeding; many schools or clusters of small (<6 cm) fisher everywhere	---
Ben Ure Island (Cornet Bay)	June, 2016	---	---	---	---
	July, 2016	Pigeon guillemot fishing (1); many other birds heard; great blue heron (several)	---	---	large Dungeness crab (1); *Nucella* sp. (numerouos throughout); *Sabellidae* sp (1 colony); *Evasteria* sp (1); *Pisaster ochraceus* (1); *Strongylocentrotus droebachiensis* (1); limpets (few); *Katharina tunicata* (1); unidentified invertebrate (see data sheet);
	August, 2016	gulls; loons	harbor seal (1)	---	*Strongylocentrotus droebachiensis*; *Cucumaria miniata* (several);

					Phacellophora jellies (many)
	September, 2016	gulls; pigeon guillemots (fly-bys);	harbor seal (1)	unidentified fish jumping	*Phacellophora* jellies (many)
	May, 2017	bald eagles	---	small fish splashing at surface at margin	*Pisaster ochraceus*; sea cucumber; *Strongylocentrotus droebachiensis* (14); chitons; *Katarina tunicata; Tonicella lineata*
	June, 2017	pigeon guillemots (fly-bys)	---	small fish splashing at surface	*Evasteria troschelii*; orange sea cucumbers; chitons (many)
	July, 2017	---	---	---	orange sea cucumbers
	August, 2017	Pigeon guillemots fishing (2-4)	---	---	---
	September, 2017	Great blue herons (3); pigeon guillemots; kingfisher	harbor seal (2)	---	orange sea cucumbers
	July, 2018	pigeon guillemots actively fishing throughout bed; bald eagle (1); great blue heron (1)	harbor seal (1)	slender silver fish jumping near outer bed border	numerous *Cucumaria miniata* above waterline
Hoypus Point	July, 2016	Pigeon guillemot in bed (1); many other birds above & from land	---	Unindentified fish (6-12" TL) jumping (3)	---
	August, 2016	Great blue heron on kelp (3)	harbor seal (1)	unidentified large fish jumping (1)	*Phacellophora* jellies (many)
	September, 2016	great blue herons on shore (3); gulls on kelp (many); loons (3)	---	unidentified large fish jumping (1)	*Phacellophora* jellies (many)
	June, 2017	---	---	---	---
	July, 2017	---	---	---	---

Polnell Point	July, 2016	Pigeon guillemot with gunnel-like fish & sculpins (2); great blue heron resting (8-10); bald eagle resting (1); apparent pigeon guillemot nests in cliffs	harbor seal on rock (1)	perch-like fish (few)	*Phacellophora* jellies (few)
	early August, 2016	Great blue heron resting (2); pigeon guillemot fishing (2)	harbor seals on rocks (3)	perch-like fish schools (numerous throughout bed)	*Phacellophora* jelly (1); bryozoans on fronds (numerous)
	late August, 2016	Great blue heron resting (1); harlequin ducks in bed (2, females); unidentified gulls (few)	harbor seals on rocks (3)	shiner perch schools (few)	*Phacellophora* jellies (numerous, 1-5' bells); bryozoans on fronds (numerous, ≤ 1.5" diameter)
	June, 2017	bald eagle (1); pigeon guillemots (2); great blue heron (2)	harbor seals on rocks (7)	shiner perch schools of ~20-30 fish	---
	July, 2017	pigeon guillemots (2); great blue heron (1); large osprey picked up large (~20-25 cm) perch from bed, then chased by bald eagle, dropped fish which was recovered by eagle	harbor seals on rocks (5 adults, 1 pup)	small (< 5 cm) shiner perch schools (few)	---
	August, 2017	pigeon guillemot fishing (5); bald eagle (1)	harbor seal in water (3)	small (≤ 2.5 cm) shiner perch schools (numerous)	*Phacellophora* jellies (12)
	September, 2017	bald eagle (1); great blue heron on rock (1)	---	---	*Phacellophora* jellies (3); bryozoan colonies (*Membranipora* sp.) on all submerged kelp parts

	June, 2018	bald eagle (1) water strike; great blue heron on shore (2); pigeon guillemot fishing (4)	harbor seals on rocks & in water (4)	schools of small (~ 3 cm) shiner perch	---
	July, 2018	great blue heron on rocks (2); medium-sized falcons around bluff & vocalizing (2); pigeon guillemot fishing (4-5)	harbor seals on rocks & in water (5)	few small perch-like fish	---
	August, 2018	great blue heron on rocks (2); rhinoceros auklet fishing (1); pigeon guillemot fishing (2)	harbor seals on rocks & in water (5)	multiple schools of perch-like fish	numerous ochre stars on larger rocks, 2-8" size
	September, 2018	great blue heron fishing from kelp (1); bald eagles on bluff (2)	harbor seals on rocks & in water (5)	---	---
	June, 2019	bald eagle hunting from rock (1)	harbor seals on rocks & in water (6)	few small (<5 cm) sculpin-like fish in shallows	abundant "marine snow"-like deposits on submerged aquatic vegetation
	July, 2019	2 great blue heron on rocks in bed; 2 pigeon guillemot, fishing	11 harbor seals on rocks (including 3 pups); 1 harbor seal in water	many small schools (< 20 individuals) of smal fish (< 4 cm total length) in kelp; few pile perch (~ 12 cm total length) darting among kelp	abundant "marine snow"-like deposits on submerged aquatic vegetation; few seastarts on rocks & on bottom
	August, 2019	1 great blue heron, fishing in shallow kelp; 4 pigeon guillemot, fishing in bed; 6-8 pigeon guillemot fishing at southern	4 harbor seals on rocks & in water	many small schools of small fish(< 4 cm total length), often feeding at surface; primarily shiner perch & few larger pile perch	sea stars on rocks & on bottom

		margin; 2 rhinoceros auklets (male+female) fishing at edge of bed			
	September, 2019	1 great blue heron, fishing on kelp; 1 pigeon guillemot, fishing; 1 rhinoceros auklet, fishing in bed; 1 black oystercatcher along shoreline	2 harbor seals on rocks; 1-2 harbor seals in water	few small schools of small fish (< 4 cm total length), feeding at surface	---
	July, 2020	---	harbor seals on rocks (2 adult + 1 pup; 1 adult + 1 pup); 1 adult in water; solitary traveling large whale (possible grey) exhaling plumes ~ 300 m south of bed	---	[many crab pots are set]
	August, 2020	3-4 murre-like birds in bed	large whale (possible grey) moving south from Cresent Harbor into Saratoga Passage; 6 adult harbor seals on rock	numerous small fish flashing at surface throughout bed (probably shiner perch)	---
Lowell Point (Camano Island State Park)	July, 2016	Pigeon guillemot fishing (6); Bonaparte gulls (numerous)	---	perch-like fish (numerous throughout bed)	Bryozoans on fronds (up to 40% of surface area); kelp crab on fronds (4-5); *Phacellophora* jellies (3)

	August, 2016	None observed	---	---	Bryozoans on fronds; *Phacellophora* jellies (4)
	June, 2017	---	---	---	---
	July, 2017	---	---	---	bryozoan colonies very small (*Membranipora* sp.)
	August, 2017	---	---	---	---
	August, 2020	solitary Bonaparte's gull in bed	---	many small (2-3 cm) fish schools, behaving like shiner perch	kelp crab variable in size (small to large)
	September, 2020	---	harbor seal forage in bed (stayed ≥ 20 minutes)	---	lots of kelp crab!
Possession Point	August, 2017	Caspian terns diving (8)	harbor seal (2) & sea lion (1) on rock in bed	numerous large forage fish schools in bed; multiple large (~ 12") jumpers, possibly salmon; multiple small (<2") shiner perch schools	~20% of kelp have ≥1 kelp crab (numerous bulbs eaten away); live amphipods on water surface
	June, 2018	bald eagle water strike (1); great blue heron on shore (4); few auklet-like birds; pigeon guillemot (2)	sea lion in water (1); harbor seals on rocks & in water (6)	school of smal (~ 3 cm) shiner perch; few smaller schools of tiny (< 2 cm) fish	red rock crab (1)
	July, 2018	---	---	---	many kelp crab
	August, 2018	---	harbor seals (2)	schools of 2-3" fish; starry flounder (2)	many kelp crab
	September, 2018	---	---	starry founder (1)	many kelp crab
	June, 2019	pigeon guillemot (2); bald eagle fishing;	harbor seals (3-5)	few small fish (mostly 1", one is 8")	segmented worm on kelp; small white jellyfish ~ 30 mm (5)

		kingfisher; great blue herons fishing (3)			
	July, 2019	3 great blue heron; tern, fishing in bed; 6 pigeon guillemot, fishing for gunnels in bed	4 harbor seal	many schools of small fish, 4-12 cm in length, some may be salmonids	many red rock crab on bottom
	August, 2019	2 great blue heron, fishing; 1 pigeon guillemot	8-10 harbor seal on offshore rocks	schools of ~ 5 cm fish	---
	September, 2019	1 common loon; 1 great blue heron, fishing; grebe, many cormorant; several species of Alcids (possibly auklets, murrelets, guillemots)	harbor seal; harbor porpoise at outer bed edge	---	---
	June, 2020	2 bald eagles, 2-3 great blue herons; several pigeon guillemots & murrelets	4-8 harbor seals on offshore rocks; sea lions heard at stationary buoy	schools of small (2-3 cm) fish	few 6 cm jellys among kelp; several red rock crab on bottom
	July, 2020	3 great blue herons; many pigeon guillemots; few murrelets	3-6 harbor seals	many small fish (12-15 cm) jumping along eastern bed edge	red rock crabs on bottom; 1 lions mane jelly; several small moon jellies
	August, 2020	6-8 great blue heron	sea lions at buoy	many schools of small (2-3 cm) fish; small (10-15 cm) salmonids jumping along east bed edge	many red nudibranchs on bottom