

Bull Kelp Monitoring

October 2024 – September 2025

SEANWS-2023-IsCoPH-00007 / Task 2



During a July Survey at Hoypus Point. Courtesy of Steve Boskovich.



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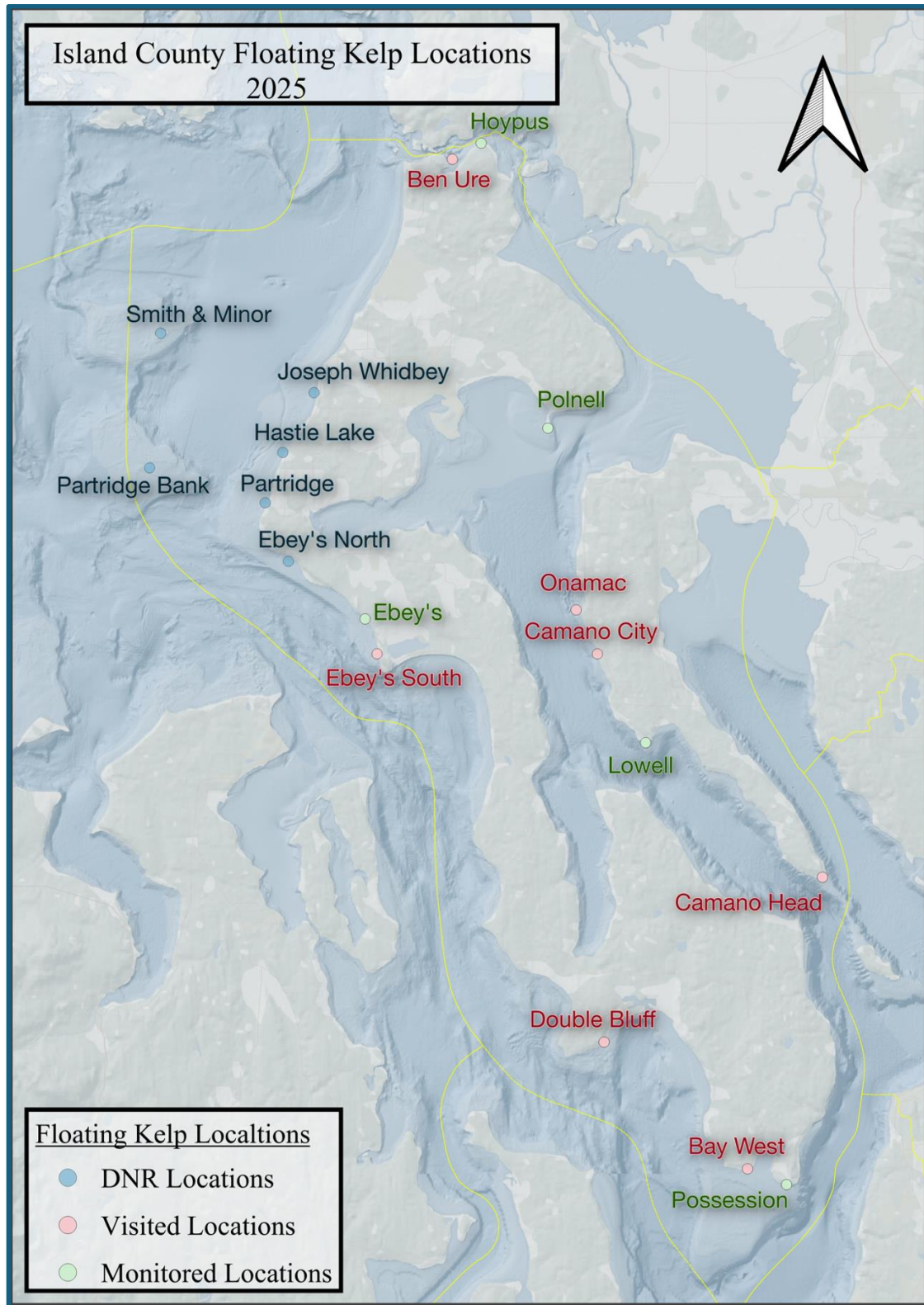


Fig 1. In this figure, Beds of Floating Bull Kelp Expression within Whidbey Basin/Island County are depicted. These beds have been determined by a combination of aerial imagery and community anecdotal knowledge. This list is not exhaustive.

1. Abstract

Island County's Floating Kelp Monitoring Project utilizes local volunteers and government employees to monitor the expression of Bull Kelp. These surveys function as the main indicator of Bull Kelp health in Island County, and thus Whidbey Basin, since 2015. This report summarizes findings from the 2025 monitoring season and their comparison to select historical data.

The Floating Kelp Monitoring Project measures the surface area expression and sea surface temperature of 5 kelp beds in Whidbey Basin. Since its inception the Island County MRC (IC MRC) has used protocol developed by the Northwest Straits Commission (NWSC) and aims to run monthly surveys from June-September. Historically, this has been accomplished using in-situ GPS tracks and thermometers deployed by volunteers who utilize sea kayaks and paddleboards to access the survey sites and kelp beds themselves. Since the start of the 2025 season, volunteers now monitor salinity and temperature profiles from the surface to the benthos at 4 points along the perimeter of the county's Kelp Beds using a YSI manufactured Conductivity, Temperature, & Dissolved Solid (CTD) Monitor.

2025 surveys show that kelp beds around Island County reached their largest recorded sea surface expression to date, with a peak of ~202 acres across all five sites in August. This marks a clear increase compared to the 2024 season and highlighting growth in the total area covered by kelp. It should be noted that much of this increase was seen within the Possession Point bed.

Caution should be taken as volunteers observed changes in density of kelp, which appeared at least 4 sites. Similarly, questions about the overall condition of the plants themselves were considered. While our methods are effective for mapping the size of kelp beds, they are not yet able to provide reliable measures of kelp density or plant health inside the bed boundaries. These remain important areas for future monitoring and development of field methods.

2. Project Goals

Generally, the goal of the Island County Floating Kelp Monitoring project is to work with local volunteers, partners, and stakeholders to assess the health of floating kelp, specifically Bull Kelp, in Island County. As we find out more about the nature of floating kelp here in Whidbey Basin, we aim to take advantage of opportunities laid before us to

improve our understanding of the hydrodynamics, anthropogenic effects, and seasonal changes that affect Bull Kelp.

It is important to remember, however, we are just one of seven MRCs participating in the Floating Kelp Monitoring Project. As we evolve our data collection practices, we must prioritize the maintenance of backwards compatibility with not only our historical data set, but with other MRCs. We will also aim to evolve protocols that can be easily recreated at other MRCs and beyond.

We had several goals for 2025 and these included:

1. Measure the Maximum Surface Expression of 5 kelp beds in Island County/Whidbey Basin. Those bed sites were:
 - Hoypus Point
 - Polnell Point
 - Lowell Point
 - Ebey's Landing
 - Possession Point
2. Solidify protocols for the deployment of YSI CTDs and Garmin Strikers during regular monthly surveys without compromising data quality from established and historical collection protocols.
3. Assess the ability of Island County to introduce, or re-introduce, three new protocols:
 - Introduction of Cross-Shore Transects for Depth & CTD Data Collection
 - Determine If Standard Tidal Indices Could Be Developed
 - Opportunistic Deployment of Drop Cams
4. Create a rich experience through engagement of existing and new volunteers and through outreach to the public.

3. Project Engagement

This project functions as a pillar of eco-literacy efforts within Island County. In monitoring a uniquely biodiverse habitat, a Floating Kelp Monitoring Volunteer, inherently needs to consider a wide range of species, environmental processes, and communities. From forage fish and sea stars to bluff erosion and local neighbors; this is an active place of ecological discovery in Island County. What we learn as a group is then passed on not just

organically from volunteers to our communities, but also through public speaking events such as Sound Water Stewards University. Though it doesn't stop there, we now further integrate these lessons back into the Salish Wide community through engagement in NWSC and WA State MRC's Floating Kelp Workgroup.

Moreover, this project's necessitation for strong safety skills on the water provides long-time paddlers and first-time paddlers alike with safety education and refreshment they may not have otherwise had the opportunity or intent to seek.

Partners/Organizations

- Partners
 - NWSC
 - NWSF
 - Sound Water Stewards (SWS)
- Breakdown
 - Lead: MRC
 - Role of MRC: Recruit and coordinate volunteers, conduct kelp surveys, share data with NWSC.
 - Role of NWSC: Provide regional coordination and support among MRCs.
 - Role of NWSF: Provide training and volunteer liability coverage.
 - Role of SWS: Recruit volunteers from their pool of members.

3.1. Participants

MRC Project Lead: Ken Collins

Kayak surveys: Ken Collins, Carter Webb, Kathryn Tooker, Kelly Webb, Karen Scharer, Steve Boskovich, Linda Rhodes, Vern Brisley, Ron Beier, Jennifer Hickey, Tito Craige, Bill Meyer, Barbara Brock, Wendi Hale, Dan Hale, Michele Rushworth, Doug Palm, Erica Sutehall, Lucius Andrew.

Overall, the 2025 IC Floating Kelp Monitoring project enlisted 20 volunteers. To start the season, we added an additional 7 volunteers. Of the 7 2024 additions, 4 dropped out early for a range of reasons from lack of necessary gear to seasonal work scheduling. Compared to last year's volunteer total of 17, our project saw an overall increase in participation.

A good benchmark for future participation is that of Lowell Point, Camano Island. Their volunteer structure and numbers allow for greater flexibility in date selection, protocol allotment, and potential expansion of methodologies. It would be ideal to have a minimum of 6 active volunteers at each site.

4. Project Methods/Actions

The Island County Floating Kelp Monitoring Project follows generalized NWSC established protocol. These protocols can be reviewed on the [NWS Website here](#). The core structure of these protocols has remained the same since 2014 in an effort to maintain data compatibility across years and MRCs alike.

During the 2025 Monitoring Season, the Island County Bull Kelp Monitoring team successfully collected regular conductivity/salinity and temperature gradients using the deployment of 2 YSI EcoSense 300A CTD monitors. Protocols for this deployment can be reviewed in Appendix 10.

As of the of September 23, 2025, IC Floating Kelp Monitoring has successfully monitored all 5 sites for all scheduled dates in the monitoring window between June-September. 3 of those beds (Hoypus, Lowell, & Possession) were monitored monthly during the seasonal window. Alternatively, the remaining 2 sites (Ebey's & Polnell) were monitored during the month of August, a time that is thought to be the bed's month of maximum expression. Figure 4 shows a detailed breakdown of the 2025 survey schedule.

Once a given survey is complete, a GPS track is produced using the NWSC established protocols. The GPS track is then imported as a GPX file into Quantum Geographic Information Software (QGIS). Polygons are then created inside of each track; this is done using software. The area of this polygon is then recorded. These measurements are typically expressed in the units of meters squared and are multiplied by the conversion factor of 0.000247105 to obtain measurements in the unit of acreage. See figures 4-6 in Results for the processed data.

These data are estimations and thus should be treated as such. Additional representations of the data will be processed by NWSC and are assumed to be more accurate and certainly more consistent across MRCs. Those results will be presented at the annual Data Review.

2025 Island County Floating Kelp Monitoring Schedule Breakdown

Location	Survey Month	Date Scheduled	Weather Alternate(s)		# IC Volunteers	Notes
	If Surveyed	If Used	If Used			
Training						
Possession	May	27-Jul			4	Pre Season Training for YSI and GS Deployment
Lowell	May	25-May			8	Pre Season Training for YSI and GS Deployment
Total Surveys						
2						
Hoypus	June	9-Jun	21-Jun	29-Jun	5	CTD & GS Data Collected
Total Surveys	July	27-Jul	7-Jul	14-Jul	4	CTD & GS Data Collected - Radio Collection Method Tested
	August	5-Aug	7-Aug	11-Aug	4	CTD & GS Data Collected
3	September	7-Sep	18-Sep		3	CTD & GS Data Collected
Lowell	June	23-Jun	24-Jun	25-Jun	7	CTD & GS Data Collected
Total Surveys	July	22-Jul	23-Jul	25-Jul	8	CTD & GS Data Collected
	August	20-Aug	21-Aug	22-Aug	7	CTD & GS Data Collected
3	September	17-Sep	18-Sep	19-Sep	8	CTD & GS Data Collected
Possession	June	8-Jun	16-Jun	29-Jun	2	CTD & GS Data Collected
Total Surveys	July	7-Jul	20-Jul	27-Jul	2	CTD & GS Data Collected
	August	6-Aug	11-Aug	23-Aug	2	CTD & GS Data Collected
2	September	5-Sep	6-Sep	7-Sep	4	CTD & GS Data Collected - Radio Collection Method Tested
Polnell	June	N/A	N/A		N/A	
Total Surveys	July	N/A	N/A		N/A	
	August	6-Aug	19-Aug		2	CTD Data Collected
1	September	5-Sep	18-Sep			
Ebey's	June	N/A	N/A		N/A	
Total Surveys	July	N/A	N/A		N/A	
	August	11-Aug	19-Aug		4	CTD & GS Data Collected
1	September	6-Sep	7-Sep			

Fig 2. In this figure, a detailed breakdown of each site's monitoring schedule for the 2025 season can be seen. If the bed was monitored in a given month, the month's cell will be highlighted green. If the original date scheduled for that month was used, its cell will also be highlighted green. However, if a weather alternate for that month was used its cell will be highlighted red. If new equipment were used in a survey, it will be listed as CTD (EcoSense 300a CTD) or GS (Garmin Striker Cast GPS Sonar)

5. Results

Bull Kelp in Island County saw a marked increase in maximum sea surface expression in 2025. Results showed an increase of ~32.06 acres when comparing survey results from August of 2024 & 2025. Most of this increase is attributed to Possession Point.

5.1. Data Summary

This August, the IC MRC Floating Kelp Monitoring Project recorded ~202 acres of bull kelp across the five monitored beds, an increase from ~170 acres observed in 2024. These results were generated by mapping kelp bed perimeters with QGIS automatic polygon features and are summarized in Figures 4–6. Additional maps showing year-to-year changes in bed size (2024–2025) for all sites, as well as seasonal changes at Possession, Lowell, and Hoypus, can be reviewed in Appendices 1–8.

Beds that saw increases in maximum surface expression were:

- Possession Point ~ +30.51 acres
- Polnell Point: ~ +3.84 acres

Beds that saw decreases were:

- Hoypus Point ~ -0.51 acres
- Lowell Point ~ -1.09 acres
- Ebey's Landing ~ -1.19 acres

Of note, Lowell Point saw continued growth past August, the currently accepted month of maximum sea surface expression, reaching its peak in 2025, at 23.40 Acres in September. When compared to 2024 data, Lowell Point still saw a similar decrease regardless of whether August 2025 vs 2024 data or September 2025 vs 2024 data was used.

August 2025 vs 2024

- $21.53 - 22.62 = -1.09$ acres

September 2025 vs 2024

- $23.40 - 24.93 = -1.52$ acres

Furthermore, efforts to better understand sea surface expression changes with tidal increases were spearheaded. These efforts were completed with the express aim to begin developing Tidal Index measurements, which would allow Island County to monitor kelp beds at tidal heights outside 0' MLLW, when scheduling or weather does not allow.

August 2025 analysis of Tidal Indices, when coupled with the 2015 results, gave us insight into technique, tool, and sources of variability. These learnings will influence design and execution for Tidal Index surveys in the 2026 and 2027 kelp season. Analysis of the August 2025 boat-based surveys will be conducted in Fall, 2025. Initial data processing of Ebey's Landing surveys showed a decrease of roughly 1/4th of bed expression over a 2.3' tidal. These data were processed using Google Earth manual polygon features.

A more in-depth review of methods and results can be reviewed in Appendix 13, including a review of work done in 2015-16. We encourage readers to revisit the 2015-16 IC MRC Bull Kelp Monitoring Report as well, for more information.

5.2. Outcomes

- Island County MRC and NWSC continued an increased focus on safety skills resulting in:
 - 1 on the water safety course hosted by NWSC
 - 16+ volunteer hours dedicated to on the water safety
 - Spread across 5 trainees
- The 5 historically monitored beds in Island County were successfully surveyed for all scheduled dates during 2025 season.
- Data from completed surveys have been:
 - Successfully entered into Kobo Toolbox.
 - Compared to selective historical data.
- 2 new equipment, the EcoSense 300A and Garmin Striker Cast GPS, were successfully deployed and protocol was developed for the YSI EcoSense (See Appendices 9 & 10).
- Tidal Index development was explored at 1 site (Ebey's Landing) and has spurred further conversations between NWSC and other MRCs.

5.3. Outputs

- List of active survey volunteers.
- Data from completed surveys.

- YSI EcoSense 300A Calibration and Deployment Protocols (Appendices 9 & 10)
- Tidal Index Methodologies (Appendix 13)

August 2025 Sea Surface Expression Area Calculations Using QGIS

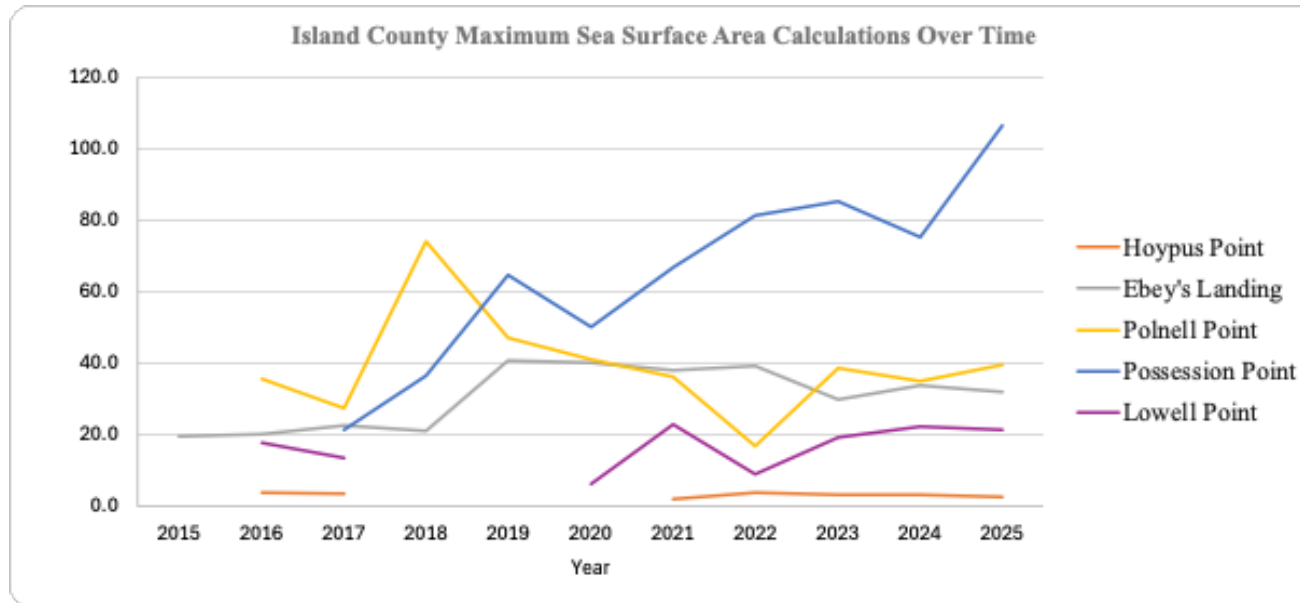
Bed	2025 (ac)	2025 (m ²)	2024 (ac)	2024 (m ²)	Change (m ²)	Change (Acres)	Change (%)
Hoypus	2.89	11699.21	3.40	13769.77	-2070.56	-0.51	-15.04
Polnell	39.55	160061.59	35.72	144538.49	15523.10	3.84	10.74
Lowell	21.53	87135.26	22.62	91550.00	-4414.75	-1.09	-4.82
Ebey's	32.02	129575.51	33.21	134384.88	-4809.37	-1.19	-3.58
Possession	106.39	430564.73	75.89	307103.56	123461.17	30.51	40.20
Totals (m ²)		819036.29		691346.71	127689.586		18.47
Totals (ac)	202.39		170.84			32.06	18.47

Fig 4. In this figure, QGIS area calculations are compared between the 2024 Maximum Sea Surface Area Expression to that of 2025 for all 5 monitored beds in Island County

5.4 Results in context

Island County August/Maximum Sea Surface Area Calculations to Date

Site	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Hoypus Point		4.0	3.6				2.1	4.0	3.5	3.4	2.9
Ebey's Landing	19.8	20.4	22.7	21.3	40.8	40.1	38.0	39.3	29.9	33.7	32.0
Polnell Point		35.8	27.4	74.1	47.3	41.0	36.4	17.0	38.7	34.9	39.6
Possession Point			21.5	36.6	64.8	50.3	66.7	81.4	85.2	75.2	106.4
Lowell Point		18.0	13.7			6.3	23.1	9.0	19.5	22.5	21.5
Totals	19.8	78.2	88.9	132.0	152.9	137.7	166.3	150.6	176.8	169.8	202.4
	18	Sampled in Year and Max Sea Surface Expression (acres)									
	88.9	Sea Surface Expression When All Beds are Sample in Year (acres)									



Figures 5 & 6 compare the Maximum Sea Surface Expression of each bed within a monitoring season from 2015 – 2024 in table and graph form. All numbers are expressed in acreage.

6. 2025 Highlights

During the 2024-2025 offseason, the Island County Bull Kelp Monitoring Leadership Team had a series of meetings to determine new questions and goals that the project could explore. This Project Leadership Team consisted of Linda Rhodes (the project's first Lead and current Polnell Point Site Lead), Ken Collins (the project's current Lead), Kelly Zupich (at that time, the MRC Coordinator), Carter Webb (the current Site Lead for Ebey's Landing, Possession Point, and Hoypus Point), as well as, Bill Meyer, Doug Palm, and Dan Hale (the Site Co-Leads of Lowell Point). The team met on a weekly to bi-weekly basis from November of 2024 through January of 2025. In total, 10 meetings were conducted, with varying attendance, and included in-depth discussions on the following topics:

- Site Expansion
- Fringe Bed Monitoring
- Transect Implementation
- Replicate Perimeter Surveys
- Tide Adjusted Index Surveys (Tidal Indices)
- Drop-Cam Monitoring
- Sargassum Monitoring
- Volunteer Training
- Volunteer Recruitment
- Volunteer Mission Specialist Assignments (Data Collection Assignments and Consistency)

Through these discussions, a series of proposals were created to present during the MRC Board Retreat for potential approval. It should be noted that Volunteer Training, Volunteer Recruitment, and Volunteer Mission Specialist Assignments were omitted from proposal creation as those fall under the guise of Volunteer Enrichment and were adopted outright as part of the project's typical procedures and regular maintenance.

These proposals were then ranked by priority with input from the Leadership Team. The top 3 were presented to the MRC Board as follows:

- 1. Tidal Indices**
- 2. Transects**
- 3. DropCam Monitoring**
4. Bed Expansions
5. Sargassum Monitoring

6. Replicate Perimeters

These discussions underscore the project's, and its members', commitment to moving beyond descriptive, census-based data collection toward a more holistic and inference-driven approach. After further discussion with the DNR and NWSC, Transects were omitted from this season's work due to their complexity and continued improvement by DNR. Tidal Indices are currently being explored. Moreover, Drop-Cam Monitoring is being deployed on an opportunistic basis. Though it is clear, greater volunteer numbers will be needed to successfully deploy these protocols.

Moreover, two on the water training sessions were hosted. These sessions were hosted at Lowell Point and Possession Point and were received with much applause from the volunteers. Requests were made for an increased number of these opportunities in future seasons. These training sessions served to polish individuals understanding of historical NWSC protocols and to gain greater familiarity the newly established YSI CTD and Garmin Striker devices. Of note, the volunteers' eagerness to learn, adopt, and refine the use of these new tools has been both impressive and admirable; though there is quickly becoming an impression of equipment demands exceeding volunteer capacity. Even in this context, each monitoring team expressed resilience and developed its own strategies for overcoming communication hurdles to ensure data quality and ease of use, while still maintaining core collection protocols.

7. Lessons Learned

Protocol expansion is challenging. As expected, it has the tendency to rock the boat, so to speak. The volunteers of Island County, however, can be expected to take it in stride and even contribute to considerable improvements during the refinement of these protocols. Consistency in the organization's framework, however, is key to the longevity of these new initiatives. Island County's Bull Kelp Monitoring Team saw the shift of not only our MRC Coordinator, but the transformation of leadership in three of our five monitoring sites, throughout the 2025 season. While both historic and new initiatives have been maintained, it highlights the fragility of an important MRC project. In addition, the recruitment of volunteers who may be interested in becoming Site Leads is imperative for upcoming seasons. It may be important to create the position of Co-Lead for all sites to fill the shoes of outgoing leads at any given time. The maintenance of these projects through this season's volatility are testaments to the current volunteer base, and the excellence of previous site leads who are willing to fill in when necessary.

With increased scientific demand, added protocols, and increased volunteer numbers this season, hurdles, especially communication issues, were bound to arise. One such hurdle included the need to develop a new data collection system to handle the increased

amount of data collected on the water. Michele Rushworth of the Camano Island/Lowell Point team graciously developed a wonderful data sheet, inspired by NWSC currently accepted data sheet, which can be viewed in Appendix 12.

Other lessons came about with the greater use of new equipment such as the EcoSense 300A. The device has the propensity to shut off during surveys whether due to volunteers mechanically hitting the off button or due to the manufactured auto shutoff. At times, this caused confusion as to whether uncompensated conductivity (the default mode) or salinity (the desired mode) measurements were being taken. Thankfully, post survey debriefs made it simple to recognize the difference between the measurements. Work began on a function that was compiled by Carter Webb in R (See Appendix 11 for R Markdown) which allows the conversion of uncompensated conductivity to salinity to create consistency in in-situ measurements. Our teams now collect uncompensated conductivity only which are then converted to salinity, post survey. Both metrics are then submitted to Kobo Toolbox for data storage for transparency.

Additionally, this season was a stark reminder that health and area of kelp expression do not necessarily equate. While some sites saw an overall increase in expression during the 2025 season, images 5-8 highlight the significant signs of stress that was prevalent amongst many beds as early as June. Time will tell if this has impacts on the seasons to come.

8. Next Steps

- Increase Volunteer Participation
 - Actively recruit Site Leads and volunteers with relevant experience.
 - Increase volunteer numbers at all sites.
 - Solidify Mission Specialist assignments and training to reduce cross volunteer variability.
 - Continue to refine and foster volunteer provided data sheets tailored for Island County's needs.
- Continue to improve on survey consistency and precision.
 - Develop plans to mitigate weather related cancellations.
 - Continue to develop Tidal Indices with regular nonzero tide surveys.
 - Consider monthly or bi-monthly surveys for all 5 sites.
- Continue to Assess Ability to Incorporate/Re-Incorporate additional protocols.
 - Transect Implementation
 - Drop Cam Deployment
- Make progress to monitor sites in a more holistic and comprehensive way.

- Refer to DNR and NWS literature as a framework to evolve data collection protocols.
 - [Long-term kayak monitoring of floating kelp in Puget Sound: Results through 2024](#)
 - [Kelp forest monitoring with volunteer kayak surveys: Data synthesis and recommendations for the MRC Volunteer Kelp Monitoring Program](#) (NWS)
 - For example, those recommendations found in 4.3.
- [Long-term kayak monitoring of floating kelp in Puget Sound: Results through field year 2023](#) (DNR)
 - For example, assess the efficacy of transect creation in select IC beds.
- [Puget Sound Kelp Conservation and Recovery Plan](#) (DNR)
 - For example, address questions posed in 1.3 (Environmental Stressors) and 1.9 (Biological Stressors - Invasive Algae Competition).
- Further the use of new equipment.
 - Protocol Maturation
 - Training
- Expand to unmonitored sites where volunteer numbers allow.
- Increase collaboration with interested stakeholders
 - Sound Toxins
 - Salish Sea Model
 - Reef Check
 - UW Researchers

Images



Image 1. Shows Carter Webb, Kelly Webb &, Kathryn Tooker. During a July Survey at Hoypus Point. Courtesy of Steve Boskovich.



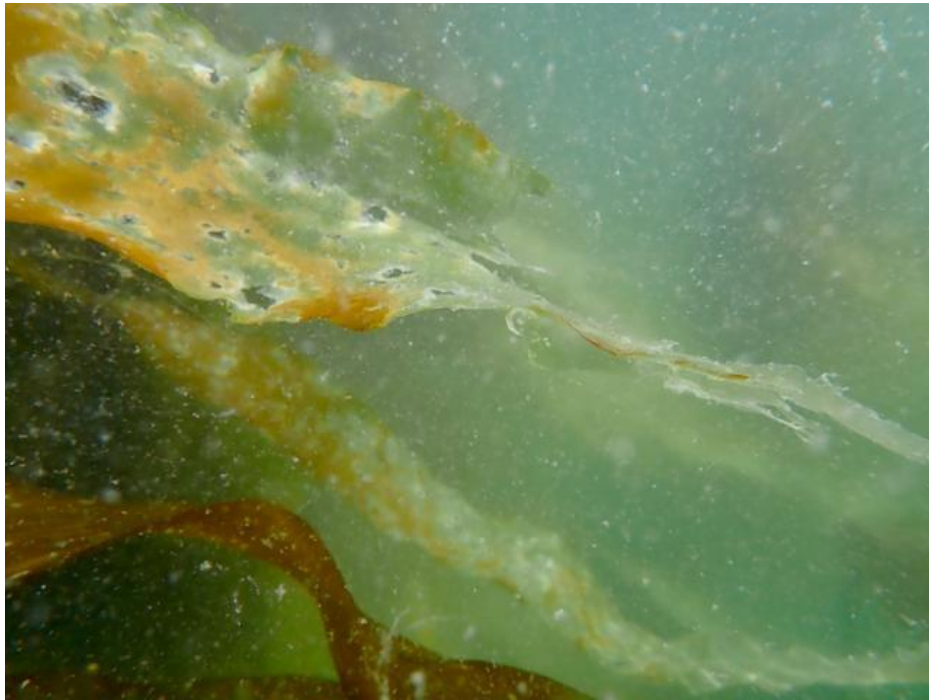
Image 2. Shows Bill Meyer & Dane Hale (Wendi Hale in the Background) with YSI CTD, Garmin Striker, & New Data Sheet in use. Taken during a July Survey at Lowell Point. Courtesy of Doug Palm.



Image 3. Shows Carter Webb & Michelle Rushworth Discussing the Relevance of Sori during a July Survey at Lowell Point. Courtesy of Doug Palm.



Image 4. Shows simple measures taken by the Lowell Point Team to extend the lifetime of the YSI EcoSense 300As. Courtesy of Doug Palm.



*Image 5. Shows intense, early fraying at Lowell Point in June (Similar events seen at Possession Point).
Courtesy of Doug Palm.*



Image 6. Shows intense fraying at Possession Point in July (Similar events seen at Lowell Point and Ebey's Landing). Courtesy of Carter Webb.



Image 7. Shows Potential Streblonema Endophytes at Hoypus Point in July, Formal ID Necessary (Similar events seen at Possession Point). Courtesy of Kathryn Tooker.



*Image 8. Shows Curled Blade Growth at Possession Point in July (Similar events seen at Hoypus Point).
Courtesy of Carter Webb.*

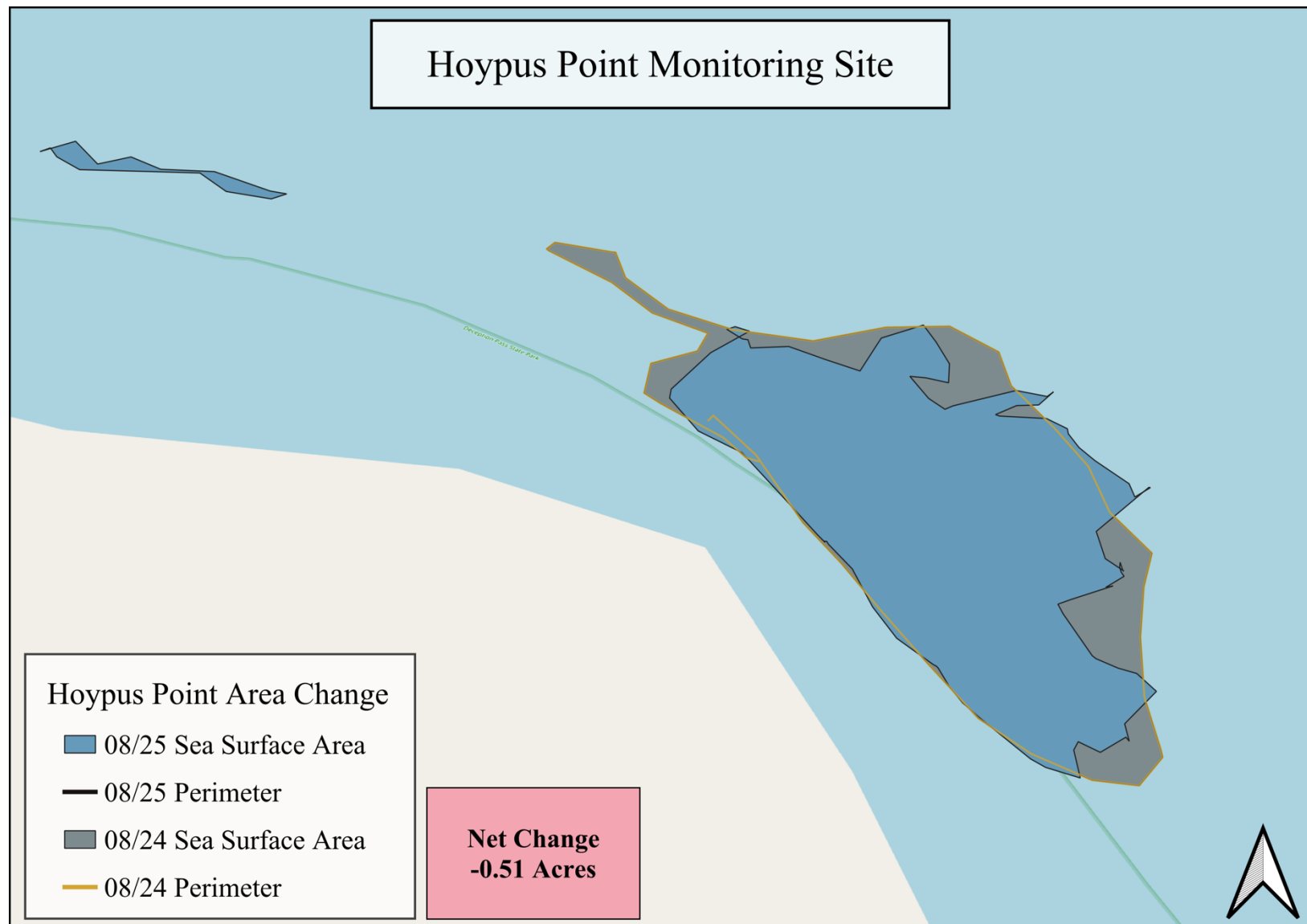
Appendices and Links

Useful Links

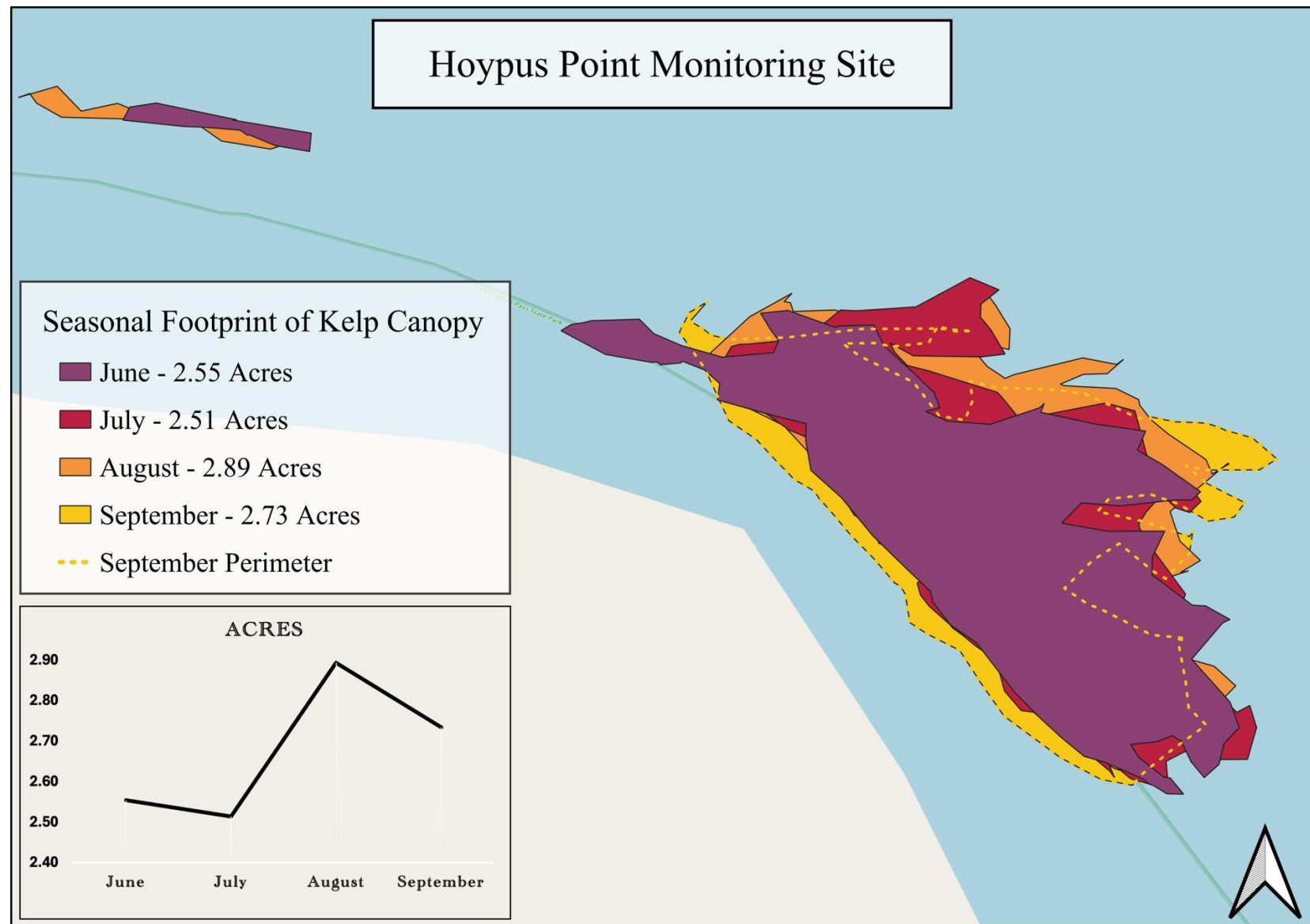
- YSI EcoSense 300a: [Specs](#) and [Manual](#)
- Garmin Striker Cast GPS: [Manual](#)
- [NWS Floating Kelp Monitoring Protocol](#)
- [Kelp forest monitoring with volunteer kayak surveys: Data synthesis and recommendations for the MRC Volunteer Kelp Monitoring Program \(NWS\)](#)
- [Long-term kayak monitoring of floating kelp in Puget Sound: Results through field year 2023 \(DNR\)](#)
- [Puget Sound Kelp Conservation and Recovery Plan \(DNR\)](#)
- [Long-term kayak monitoring of floating kelp in Puget Sound: Results through 2024 \(DNR\)](#)
- Kelp Monitoring Research Workgroup Recordings (Hosted by DNR)

Where Does Our Data Go?

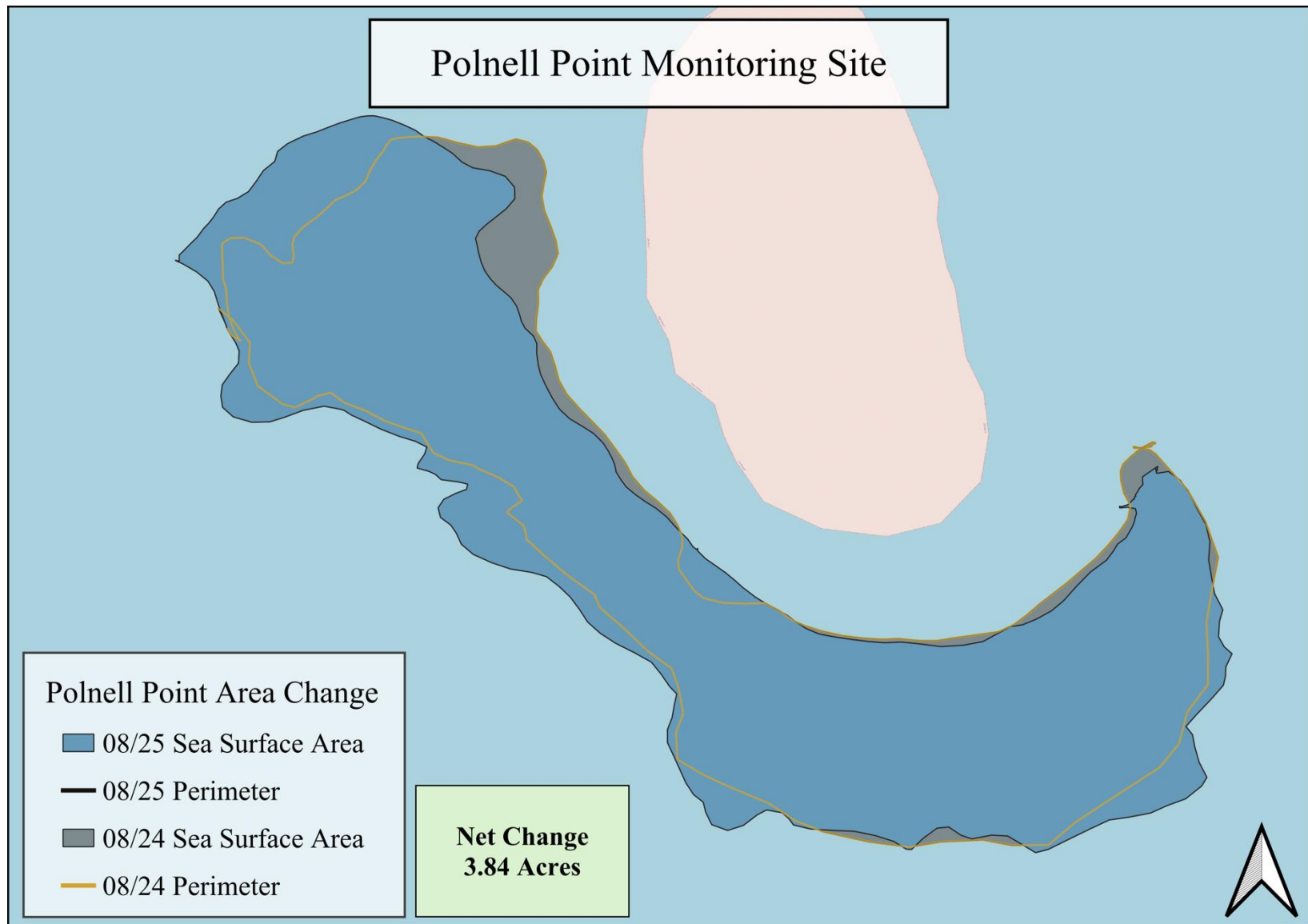
- [Northwest Straits Initiative Story Map](#)
- [SoundIQ](#)
- [WA State Floating Kelp Indicator](#)
- [Washington Floating Kelp Linear Extent Data Viewer](#)



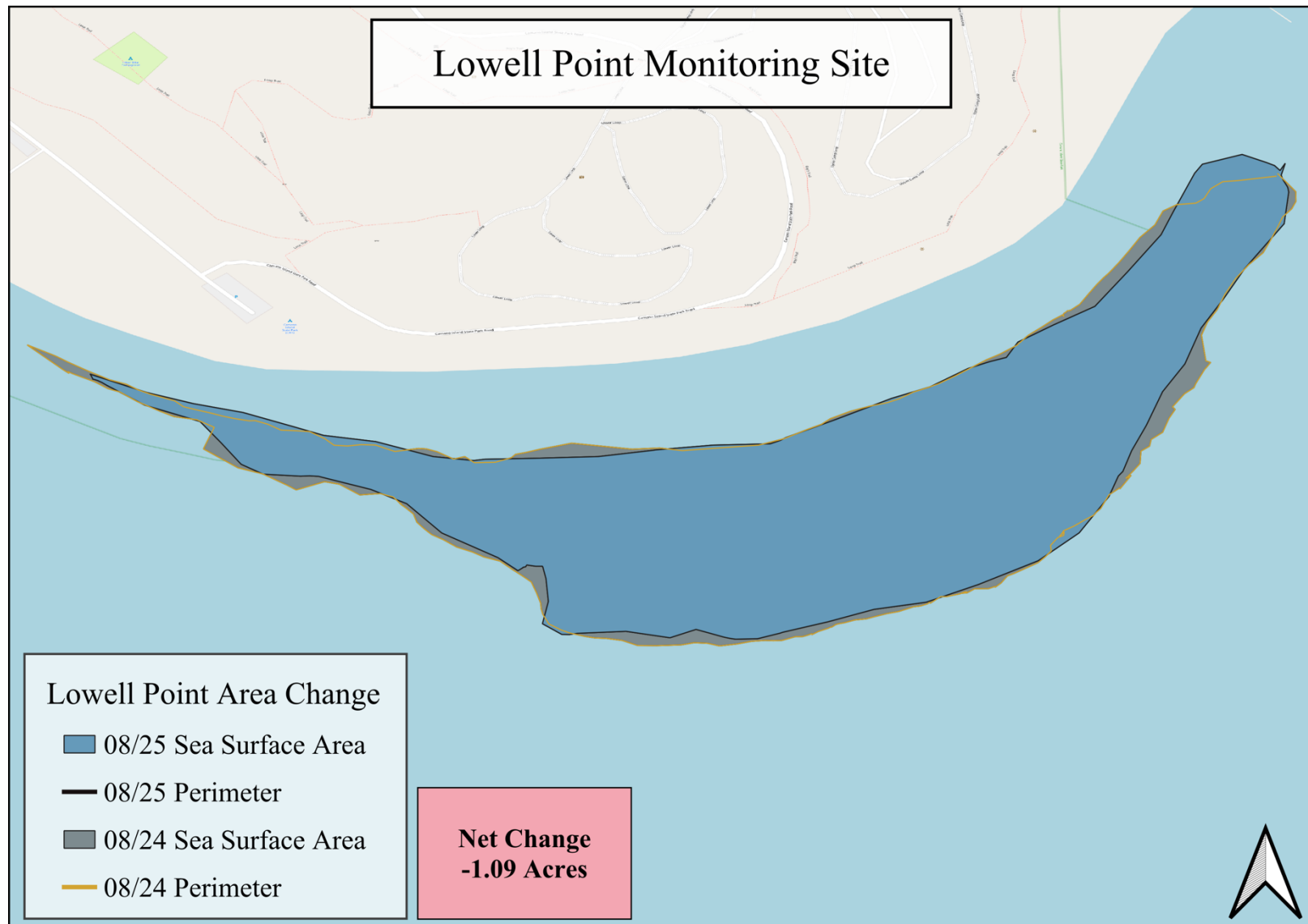
Appendix 1. Compares the Maximum Sea Surface Expression in August 2024 (gray) with that of August 2025 (blue) at the Hoypus Point Monitoring Site. Their respective perimeters are outlined in gold and black.



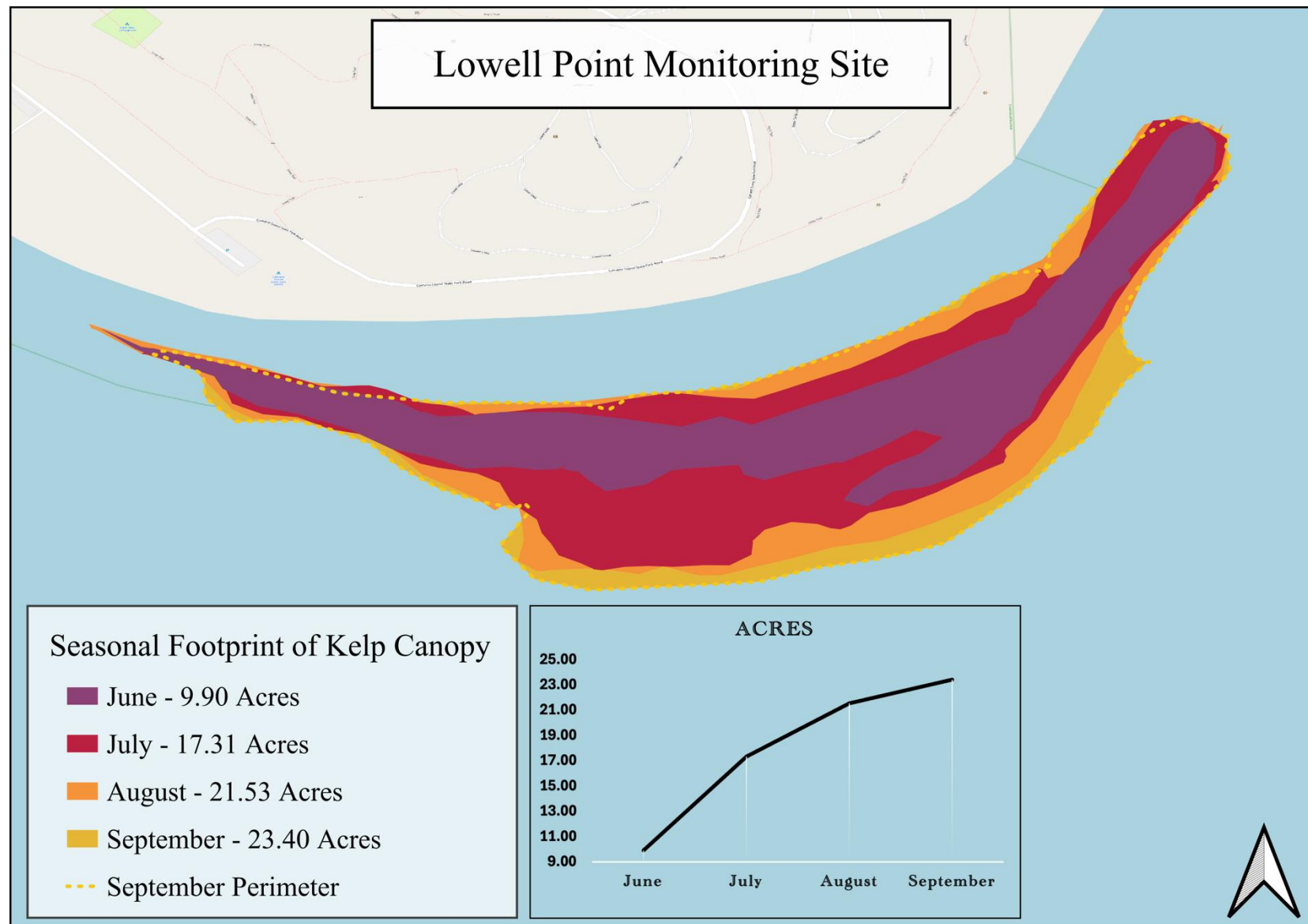
Appendix 2. Compares the Sea Surface Expression During the Full Monitoring Season from June - September at the Hoypus Point Monitoring Site.



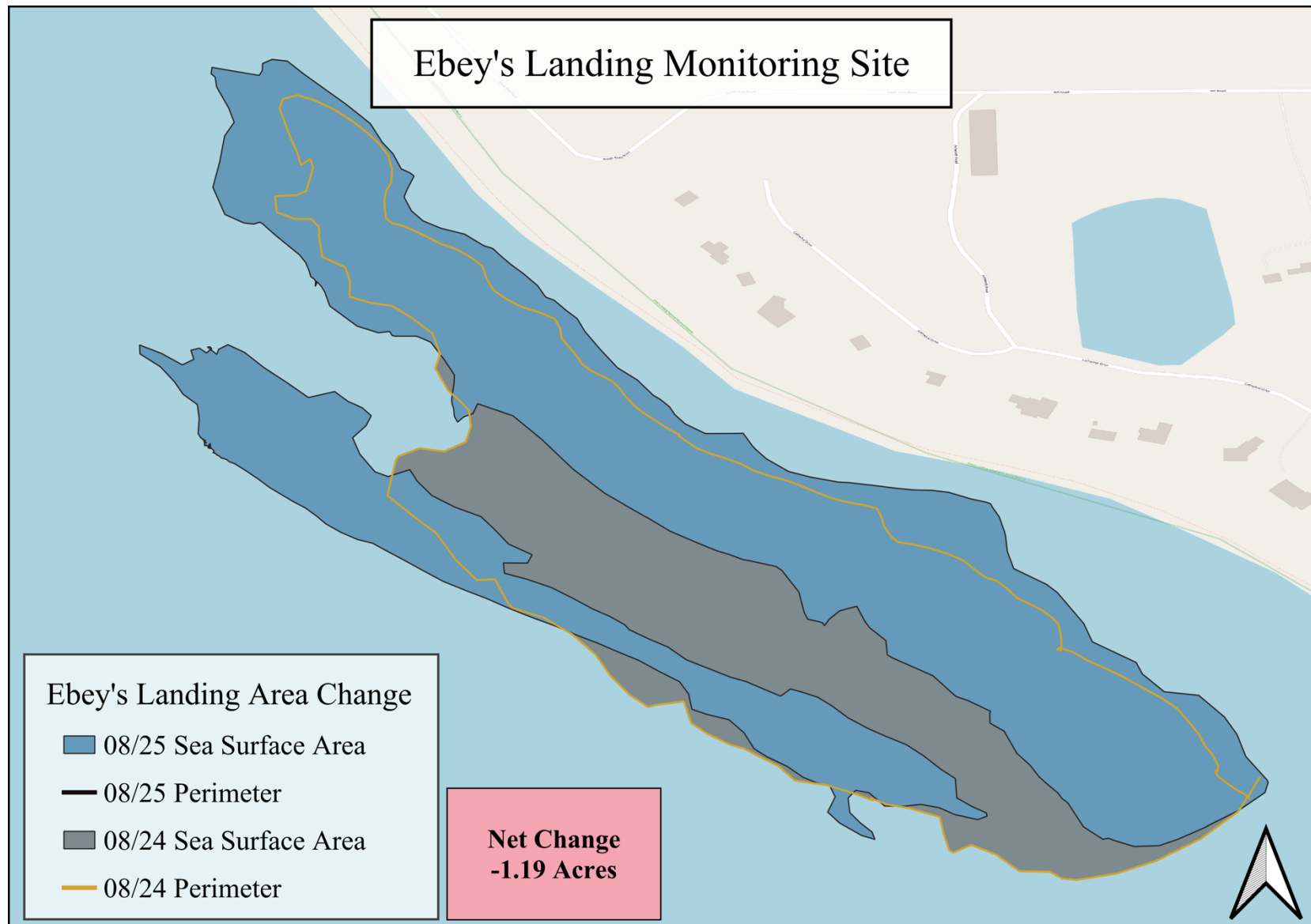
Appendix 3. Compares the Maximum Sea Surface Expression in August 2024 (gray) with that of August 2025 (blue) at the Polnell Point Monitoring Site. Their respective perimeters are outlined in gold and black.



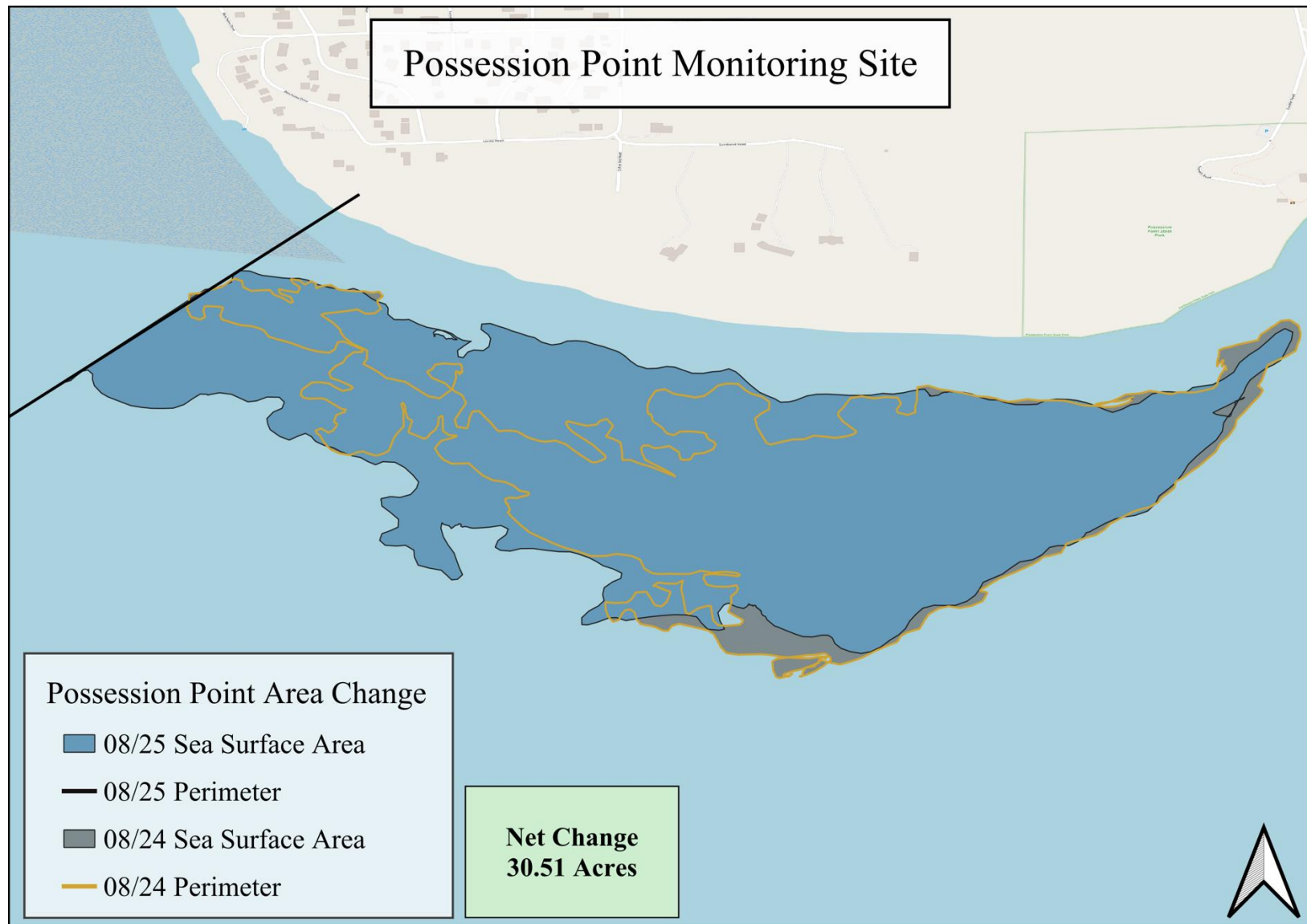
Appendix 4. Compares the Maximum Sea Surface Expression in August 2024 (gray) with that of August 2025 (blue) at the Lowell Point Monitoring Site. Their respective perimeters are outlined in gold and black.



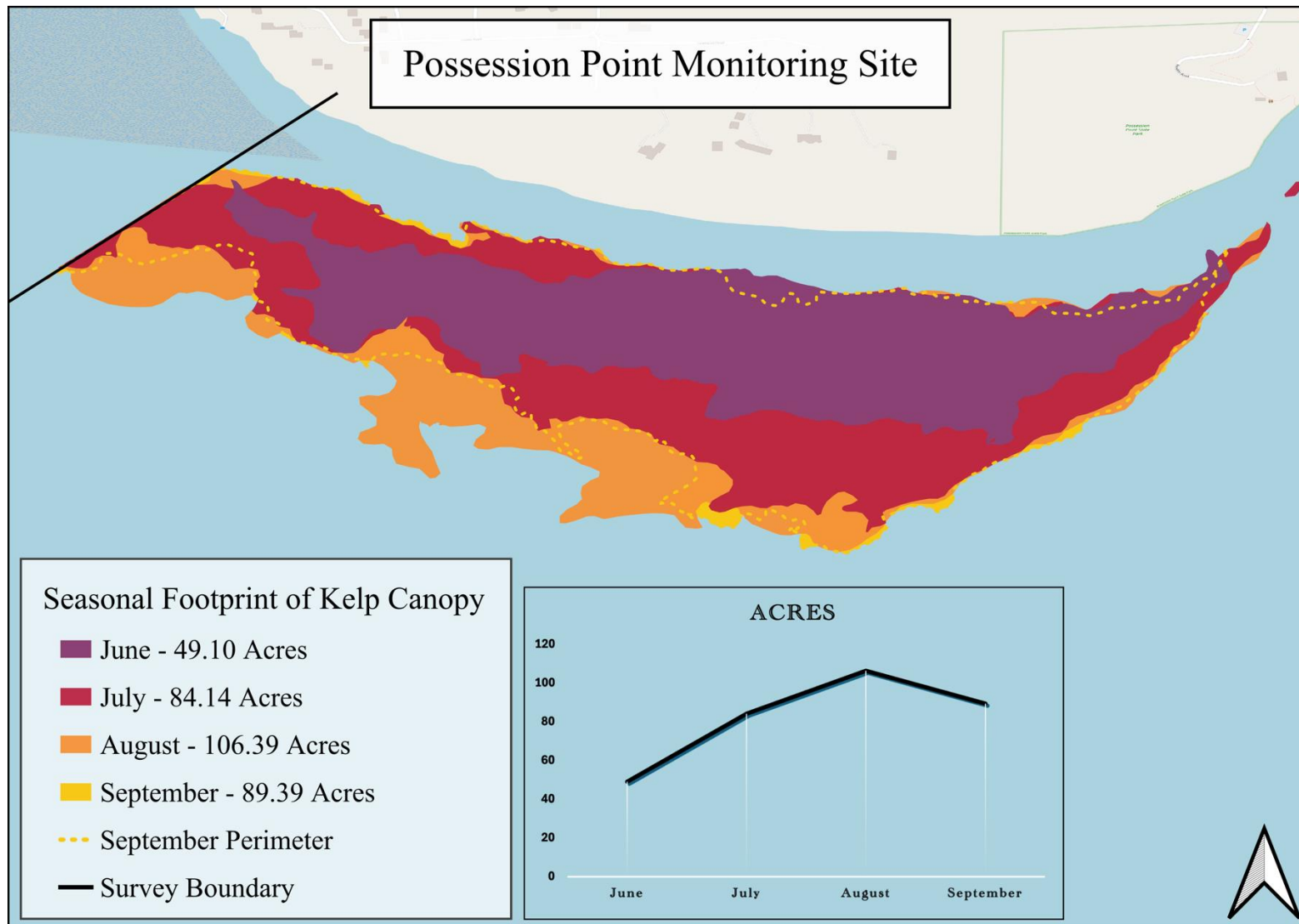
Appendix 5. Compares the Sea Surface Expression During the Full Monitoring Season from June - September at the Lowell Point Monitoring Site



Appendix 6. Compares the Maximum Sea Surface Expression in August 2024 (gray) with that of August 2025 (blue) at the Ebey's Landing Monitoring Site. Their respective perimeters are outlined in gold and black.



Appendix 7. Compares the Maximum Sea Surface Expression in August 2024 (gray) with that of August 2025(blue) at the Possession Point Monitoring Site. Their respective perimeters are outlined in gold and black.



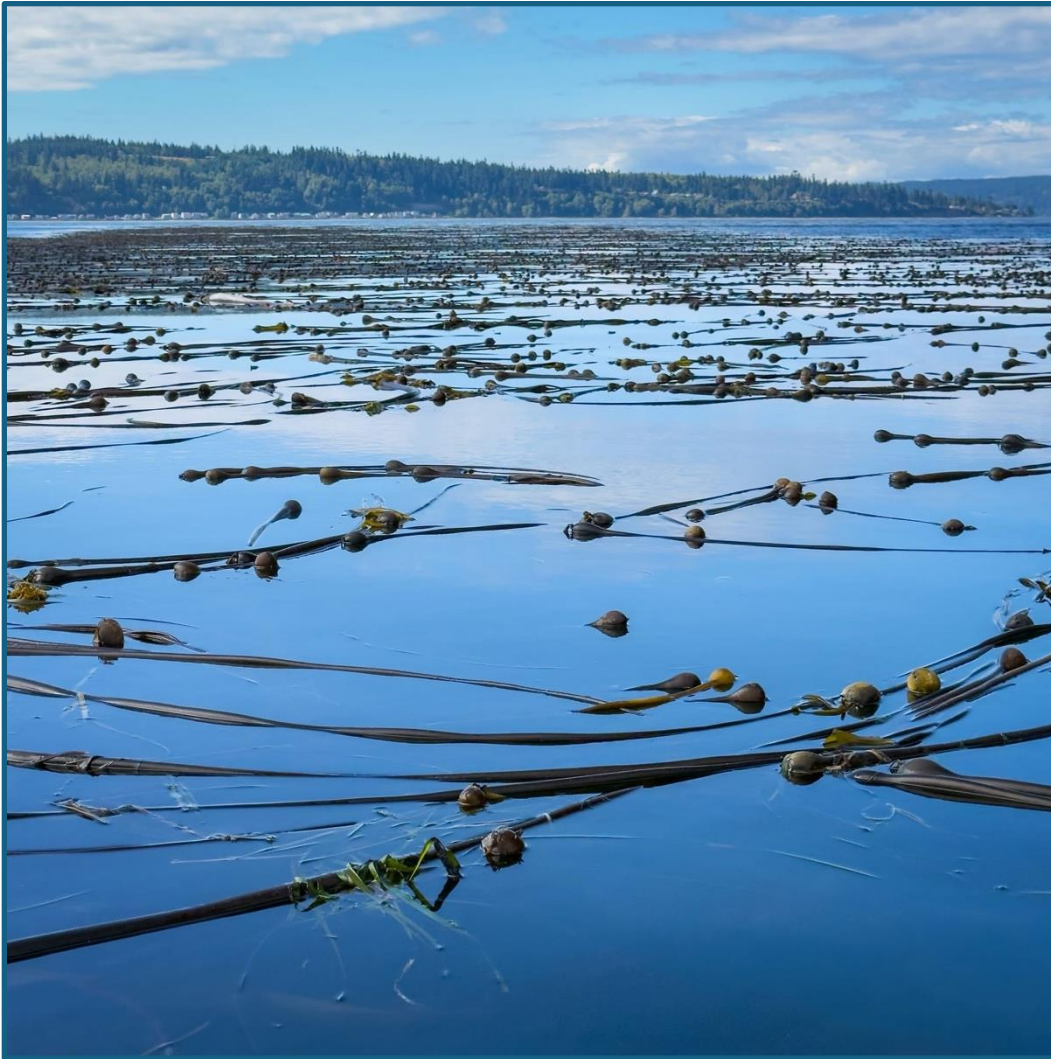
Appendix 8. Compares the Sea Surface Expression During the Full Monitoring Season from June - September at the Lowell Point Monitoring Site.

Appendix 9.**YSI EcoSense 300A Calibration Protocols for Bull Kelp Monitoring**

Intended for use only as an additional layer to NWSC's [A kayak-based survey protocol for Bull Kelp in Puget Sound Survey Protocols](#)

*Developed for the Island County MRC
Developed by Carter Webb*

Photo Courtesy of Dan Hale



First read relevant sections of the User Manual: **Calibration (pg 7), Saving and Deleting Data (pg 8), Maintenance (pg 13 before offseason storage).**

YSI Brand, NIST Certified, 50,000 μ S Calibration Fluid is Recommended for one Point Calibration

Prep/Cleaning

- Dip Sensor Tip into Distilled, RO or Deionized Water.
- Give the sensor a light shake to expel air bubbles that may have been trapped in the

electrodes.

- Ensure both flow through openings are fully submerged, one at the bottom/underside of the sensor and another at the side near the base, where the sensor attaches to the cable.

- Let sit to begin dissolving dried salt/precipitate that may have built up along electrodes.
- Grab sensor brush that is provided with YSI model (a small black brush roughly 1-2 inches long with metal handle).
- Take sensor out of water bath and brush the interior of the electrodes (the two holes you can find at the bottom/underside of the sensor housing). Be gentle but thorough.
- Dip back into original water bath.
- Brush a second time.
- Pour clean Distilled, RO, or Deionized Water over sensor through upper opening and through bottom holes.
- Pour water onto a microfiber and wipe handheld housing and accessible portions cable attachment.

Calibration

- Find a sheltered, relatively temperature-controlled environment. Such as your garage or preferred workstation.
- Turn on handheld.
- rANGE should display with a temperature reading in the lower right corner.
- Allow temperature to level out.
- Hit CAL
- First, the TDS (Total Dissolved Solid) Coefficient
 - If it reads 0.65
 - Hit ↵ (Enter)
 - If it does not, use up and down arrows to return to 0.65
 - Then, Hit ↵ (Enter)
- Second, Cell (based on geometry of electrodes)
 - This value is set by the sensor itself
 - It typically reads 5.00
 - Hit ↵ (Enter)
 - It can drift slightly overtime.
 - Hit ↵ (Enter), as this value cannot be changed manually.

- Third, Temp Coefficient
 - If it reads 1.91%
 - Hit ↵ (Enter)
 - If it does not, use up and down arrows to return to 1.91%
 - Then, Hit ↵ (Enter)
- Fourth, Temp of Ambient Air
 - If the larger display matches the current temp displayed in the lower right corner.
 - Hit ↵ (Enter)
 - If it does not, use up and down arrows to return to the displayed temp.
 - Then, Hit ↵ (Enter)
- Lastly, S (Siemens) Calibration
 - This is our main goal of the calibration.
 - Prepare your 50,000 μS calibration solution, by pouring into smaller receptacle (up to just below neck).
 - Dip Sensor Tip into Calibration Solution, the solutions should completely cover the upper opening of the sensor, add calibration solution as necessary.
 - Give the sensor a light shake to expel air bubbles that may have been trapped.
 - The display should show rANGE, after which it will begin to display a number.
 - The device will display your measured conductivity in Siemens ($\mu\text{S}/100 = \text{S}$).
 - This number could be very close to 50 or not close to 50 depending on the stability of your thermal environment.
 - Let the number settle.
 - **If it settles lower than 30, or higher than 70, turn it off and restart calibration with new batch of calibration fluid (the fluid may have become ionized from the electrodes sitting in there too long).**

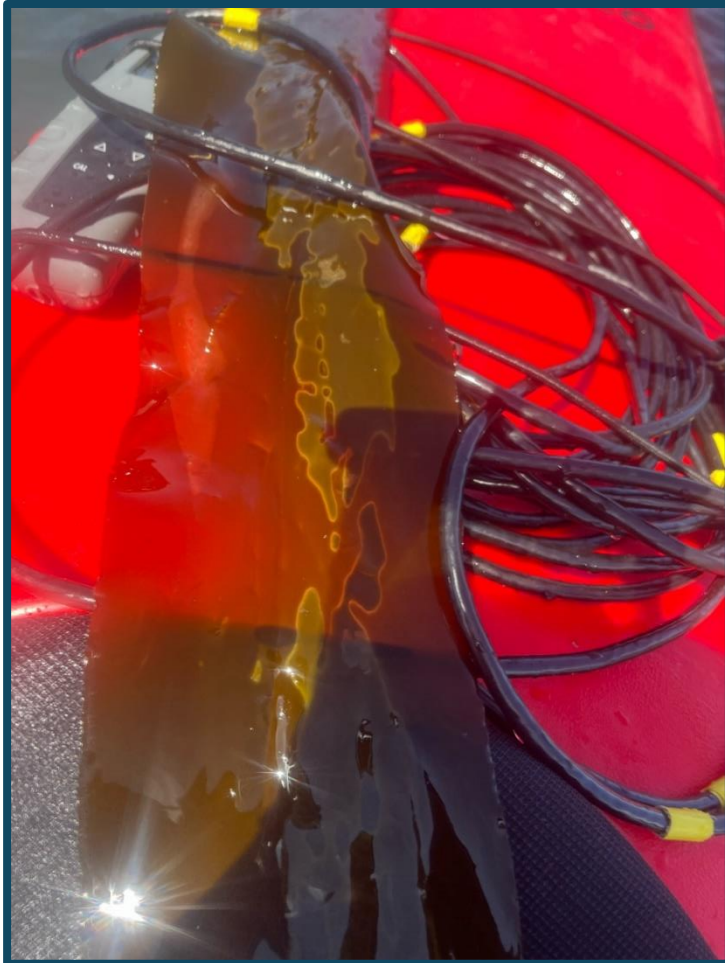
FOR EXAMPLE

- Let us say it settles at or around 42.12. Use the up arrow to return the number to 50.00, indicating to the device that it should be reading 50,000 μS .

- Hit ↵ (Enter)
- You have now calibrated the device!
- Store your used calibration fluid where you will not confuse it with unused fluid and begin your survey with the device on.

On the Water (abbreviated, see *YSI EcoSense 300A Deployment Protocols for Bull Kelp Monitoring* for a more in depth protocol)

- While you paddle out to your first Data Point, the temperature of the sensor will have increased.
- Once at the waypoint place the sensor into the water and allow it to cool down to equilibrium.
- While it is cooling, check it is reading Salinity (ppt).
- You are ready to take a surface reading of temperature and salinity.
 - As you read off the salinity and temp, Hit ↵ (Enter), to save that data point to return to incase something is amiss after the survey.
 - They may not match exactly, though it will be useful if a data point is completely lost in translation or is simply not written down.
- Repeat for the rest of the 2ft intervals until you have reached just before the sea bottom.
- Repeat for all data points.

Appendix 10.**YSI EcoSense 300A Deployment Protocols for Bull Kelp Monitoring**

Intended for use only as an additional layer to NWSC's [A kayak-based survey protocol for Bull Kelp in Puget Sound Survey Protocols](#)

*Developed for the Island County MRC
Developed by Carter Webb*

Materials

- A Calibrated [YSI EcoSense EC300A Conductivity Meter](#) Handheld
 - These protocols are largely applicable to a EC300M model as well.
 - If uncalibrated refer to *YSI EcoSense 300A Calibration Protocols*.
- 10 meters or ~32 foot, [YSI EcoSense EC300A Conductivity Field Cable](#)
 - If unmarked or new, mark this cable every 2 feet from the tip of the sensor with brightly colored duct tape (or analogous marking) up to the base that attaches to the handheld.
 - There should be 16 markings in total, with the final segment near the handheld slightly longer than 2ft (~2.8’).
- A Write in the Rain notebook or NWSC analogous waterproof datasheet.

OPTIONAL

- 2 waterproof, floating radios
 - For radio of data to n additional “Scribe” volunteer in the intertidal or another kayak.
 - This addition allows for typical NWSC data to be collected simultaneously without overwhelming a single scribe or speaking over one another.

Safety

- It is important to remember, deployment of cables into a kelp forest inherently have the risk of entanglement.
- **THE DEVICE SHOULD NOT BE ATTACHED TO YOUR PERSON or KAYAK IN ANY WAY SHAPE OR FORM**
- Weighted cables may provide more accurate data but also increase the chances of entanglement. It is best, if you are weighting your cables, to ensure deployment of the sensor takes place entirely outside, though as close as safely possible, to the kelp perimeter.
 - For the time being, Island County has decided not to weight our cables.

Best Practices

- It is best practice for CTD deployment to be the only task for any given volunteer.
 - This volunteer is from here on out termed the “Sensor”
- It is best practice to have a second “Scribe” to write down CTD data, only.

- That is, one volunteer writes down NWSC standard data like, waypoint number, time, depth, and observations at that point. While another records CTD recorded, surface to benthos, temperature and Conductivity/Salinity data.
- It is best practice to have the Sensor and CTD Scribe communicate via Radio.
 - This cuts down on time and drift from waypoint as both NWSC data and CTD data can be collected simultaneously.
 - This cuts down on communication errors due to speaking over one another on the water.
 - This opens the CTD scribe to be shoreside making intertidal observations or, as a kayaker, be a safe distance inside the bed making observations about the health of sporophytes inside the perimeter of the bed.

Pre-Survey Prep

- Check to ensure the cable is adequately tightened (finger tight) to the handheld and the rubber sleeve has been pushed down nearly flush with the handheld.
 - This will prevent water damage as well as reduce corrosion of the metal fastener on the cable.
- Decide,
 - Am I going to take Uncompensated Conductivity and convert my salinity measurements post survey? If yes, turn the device on and it is ready for data collection.
 - This can be checked in the upper portion of the handheld screen where you will see two bold boxes saying **UNCOMPENSATED** & **CONDUCTIVITY**
 - See *Uncompensated Conductivity to Salinity (PSS-78) Calculator* R Markdown (2025) for code that can allow for conversion of data.
 - If no, am I going to take Compensated Conductivity measurements which corrects temperature? If yes, turn the device on, then hit the **MODE** button ONCE.
 - This can be checked in the upper portion of the handheld screen where you will see two bold boxes saying **COMPENSATED** & **CONDUCTIVITY**
 - If no, am I going to directly take Salinity measurements corrected for temperature as you descend in the water column. If yes, turn the device on, then hit the **MODE** button TWICE.

- This can be checked to the left of the data where it will have a bold box that says **SALINITY**
- Of note, the device can regularly turn off during a survey, so this mode switch will need to happen regularly during a survey and can be a source of data inconsistency. For this reason, Island County has defaulted to Uncompensated Conductivity collection with post survey conversion.
- Finally, has the device been calibrated and the electrode cleaned with distilled water recently?

On the Water Protocols

- Using established NWSC's [*A kayak-based survey protocol for Bull Kelp in Puget Sound Survey Protocols*](#), travel to designated data points.
 - Typically, two shore side, and two deposite waypoints along the perimeter of the bed.
- As other volunteers measure depth and temperature, the Sensor should submerge the electrode into the water to equilibrate from the hot temperatures of the sunbaked bow deck of a kayak, to the colder temperatures of the surface water.
 - This may take some time (~30 seconds or more)
- Once temperature readings have stabilized the Sensor can read off surface Conductivity/Salinity measurements (Siemens/ppt) and Temperature (°C) to the scribe.
 - Repeat these readings at 2ft pre-marked intervals along the CTD cable from the surface to just above the benthos.
 - At each interval the Sensor should wait 5-15 seconds, depending on current and weather conditions, for readings to stabilize, though 10 seconds is recommended.
 - Conductivity/Salinity is unlikely to fully stabilize, however, look for it to bounce between values rather than increase or decrease steadily.
 - After reading off each pair of measurements hit the ↵ (Enter) button to save measurement in case it is found there was missed measurements when you return to shore.

FOR EXAMPLE

- If the depth at a data point is found to be 13ft, the sensor will have 7 CTD Reading Pairs of Conductivity/Salinity and Temperature.
- Data may look like (assuming salinity and temp or collected):
 - **Surface - 29.0 ppt – 14.0°C**
 - **2ft - 29.4 ppt – 13.9°C**
 - **4ft - 31.0 ppt – 13.0°C**
 - **6ft - 31.0 ppt – 13.0°C**
 - **8ft – 31.1. ppt – 12.8°C**
 - **10ft - 31.0 ppt – 12.8°C**
 - **12ft – 31.2 ppt – 12.8°C**
- Repeat these steps for all NWSC Kelp Perimeter Data Points.

Post Survey

- Check with the CTD scribe that all data points and surface to benthos intervals have the necessary data collected. (See Submitting Data to Kobo for more information)
- Debrief about improvements in communication and collection.

Submitting Data to Kobo

- Upload your written data to an excel sheet.
 - It is important to prioritize the written data over saved data whenever possible.

- If a data point is missing from the written data, cycle through the MODE button until you reach RECALL, Hit ↵ (Enter), use the up and down arrows to cycle through data points, using similar readings from the written data as a benchmark to know what 2ft interval or data point you are at.
- Submit the excel sheet into the final section of Kobo Toolbox data sheet where it says spread sheet data.
- Include all calibration standards and coefficients in your submission. These will include:
 - TDS Coefficient (0.65)
 - Cell (5.00, variable depending on age of device)
 - Temp Coefficient (1.91%)
 - Calibration Temp (Variable depending on environment of calibration)
 - Calibration Solution Used (50,000 µS)

Deleting Past Data

- Once you have submitted your data to Kobo, use the MODE to cycle to DELETE, Hit ↵ (Enter).
- All will display and blink, Hit ↵ (Enter) a second time to delete all data.
 - Or cycle up and down to delete each entry by hitting enter on the EACH selection.
- For the EcoSense 300A, only 50 data points can be saved at a time, so it is important to delete these once you have submitted the data.
 - The above is not true for EcoSense 300M

Pat yourself on the back, this is not easy, we are learning together!!

Appendix 11.

Uncompensated Conductivity to Salinity (PSS-78) Calculator

Carter Webb

August 1, 2025

Overview

This R Markdown document converts conductivity (S/cm) to practical salinity (PSU/ppt) using a UNESCO PSS-78–based approach. The function below is adapted from Jan Schulz’s seawater algorithms and refined with ChatGPT input, then compiled and verified by **Carter Webb**.

- Reference: Jan Schulz, *Conversion between Conductivity and PSS-78 Salinity*
- http://www.code10.info/index.php?option=com_content&view=article&id=65:conversion-between-conductivity-and-pss-78-salinity&catid=54:cat_coding_algorithms_seawater&Itemid=79
- Primary Source Reference: Full PDF Form of Algorithms for Computation of Fundamental Properties of Seawater UNESCO 1983
- https://www.researchgate.net/publication/33549403_Algorithms_for_Computation_of_Fundamental_Properties_of_Seawater
- Instrument context: For Use with YSI EcoSense 300A/M with reference conductivity 42.914 S/cm at 35 PSU, 15 °C, 0 dbar.

Function: Convert Conductivity (S/cm) to Salinity (PSU/ppt)

The function implements the core UNESCO PSS-78 relationships with temperature and optional pressure corrections and includes basic input validation.

If you do not have a separate device measuring pressure other than the YSI EcoSense 300A/M, leave pressure vector = 0.

These devices DO NOT correct for pressure.

Function Set-Up - Reference Calculations - Range Warnings

```
cond2sal78 <- function(C, T, P = 0) {
  # C: conductivity in mS/cm
  # T: temperature in °C
  # P: pressure in dbars (default 0)

  # Reference conductivity at 35 PSU, 15°C, 0 dbar (S/cm)
  # Standard used by YSI EcoSense to Convert
  C_ref <- 42.914

  # Fit Functions with Constants
  # All Relevant Equations on Page 11 of UNSECO 1983
  RT35 <- function(T) {
    (((1.0031e-9 * T - 6.9698e-7) * T + 1.104259e-4) * T + 2.00564e-2)
    * T + 0.6766097)
  }

  A <- function(T) { -3.107e-3 * T + 0.4215 }

  B <- function(T) { (4.464e-4 * T + 3.426e-2) * T + 1.0 }

  Cfunc <- function(P) { ((3.989e-15 * P - 6.37e-10) * P + 2.07e-5) * P }
```

```

SAL <- function(XR, XT) {
  # XT = T - 15
  # XR = sqrt(RT)
  # XR, XT defined later in Step 4
  # Polynomial fit for salinity as function of sqrt(RT) and temp difference
  (((((2.7081 * XR - 7.0261) * XR + 14.0941) * XR + 25.3851)
   * XR - 0.1692) * XR + 0.0080) + (XT / (1 + 0.0162 * XT)) *
  ((((-0.0144 * XR + 0.0636) * XR - 0.0375) * XR - 0.0066) * XR - 0.0056)
  * XR + 0.0005)
}

# Input validation
if (C <= 0.2) {
  warning("Conductivity below valid range (< 0.2 mS/cm). Returning NA.")
  return(NA_real_)
}

# Step 1: Compute conductivity ratio R (no units)
R <- C / C_ref

# Step 2: Compute DT = T - 15 (°C)
DT <- T - 15

# Step 3: Calculate RT (intermediate conductivity ratio corrected for T and P)
RT <- R / (RT35(T) * (1 + Cfunc(P) / (B(T) + A(T) * R)))
RT <- sqrt(abs(RT)) # sqrt of absolute value to avoid NaNs

# Step 4: Calculate salinity (According to UNESCO PSS-78)
salinity <- SAL(RT, DT)

# Validity check (typical salinity range)
if (salinity < 2 || salinity > 42) {
  warning("Salinity out of valid range (2-42 PSU). Result may be unreliable.")
}

```

```

    # return salinity anyway
  }

  return(salinity)
}

```

Example: Vectorized Calculation with `mapply()` (also known as automated for looping for vectors)

Provide conductivity, temperature, and pressure vectors (in CSV form), then compute salinity for each triplet.

```

# Example inputs
C_vec <- c(35.84) # mS/cm
T_vec <- c(16.2) # °C
P_vec <- rep(0, length(C_vec))
# dbar
#YSI EcoSense does not compensate for pressure
#Ensure Pressure = 0 and matches length of conductivity vector
#This will catch errors if T_vec (length) != C_vec (length)

# Vectorized conversion
salinity_vec <- mapply(cond2sal78, C_vec, T_vec, P_vec)

# Results
salinity_vec

#> [1] 27.77991

```

Data Reference:

Collected during Possession Point July 20th Survey 2025 at Waypoint 10.

Compared to In-Situ Reading for Salinity from YSI Ecosense 300A at Surface = 27.8.

Tabular Summary

```
data.frame(  
  Conductivity_mS_cm = C_vec,  
  Temperature_C = T_vec,  
  Pressure_dbar = P_vec,  
  Salinity_PSU = salinity_vec  
)  
  
#>   Conductivity_mS_cm Temperature_C Pressure_dbar Salinity_PSU  
#> 1         35.84         16.2         0 27.77991
```

Notes

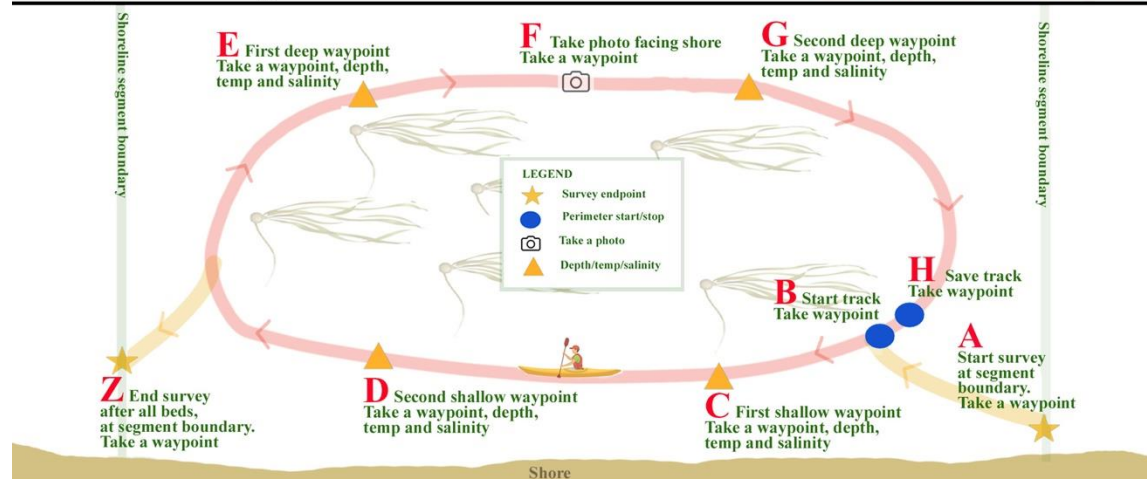
- The function emits warnings if inputs are outside typical validity ranges.
- It is recommended that you submit your data **with the original conductivity values** for transparency and potential reprocessing.
- For batch processing, you can pass longer vectors to `C_vec`, `T_vec`, and `P_vec`.

Appendix 12.

Kelp Survey On-the-Water Data Sheet

Updated June 25, 2025

Follow letters clockwise starting with A



Site Location _____ Date _____ Kelp Bed # _____ Survey start time _____ Observed slack time _____ End _____

A Start survey at segment boundary. Take a waypoint _____ Time _____

Notes

B Start track. Take a waypoint _____ Time _____

C First shallow waypoint: Time _____ Waypoint # _____ Striker depth _____ Striker temp _____

YSI	Location	Temp	Salinity	Location	Temp	Salinity
	Surface			8 feet down		
	2 feet down			10 feet down		
	4 feet down			12 feet down		
	6 feet down			14 feet down		

D Second shallow waypoint: Time _____ Waypoint # _____ Striker depth _____ Striker temp _____

YSI	Location	Temp	Salinity	Location	Temp	Salinity
	Surface			8 feet down		
	2 feet down			10 feet down		
	4 feet down			12 feet down		
	6 feet down			14 feet down		

E First deep waypoint: Time _____ Waypoint# _____ Striker depth _____ Striker temp _____

YSI	Location	Temp	Salinity	Location	Temp	Salinity
	Surface			8 feet down		
	2 feet down			10 feet down		
	4 feet down			12 feet down		
	6 feet down			14 feet down		

F Take photo facing shore. Take a waypoint _____ Time _____

G Second deep waypoint: Time _____ Waypoint # _____ Striker depth _____ Striker temp _____

YSI	Location	Temp	Salinity	Location	Temp	Salinity
	Surface			8 feet down		
	2 feet down			10 feet down		
	4 feet down			12 feet down		
	6 feet down			14 feet down		

H Save track. Take a waypoint _____ Time _____

Z End survey after all beds, at segment boundary. Take a waypoint _____

Appendix 12. Shows the Data Sheet Meant for In-Situ Data Collection. Developed by Michele Rushworth, of the Lowell Point Team, This Sheet Saw Great Applause from Many Volunteers Around the County

Appendix 13.

Tidal Index Methodology, Results & Protocols

Developed for the Island County MRC

Developed by Ken Collins

We will conduct the Tidal Index project in the 2025-2026 funding cycle. We conducted early work in August 2025 to assess our approach using the Ebey Landing bed. That work is summarized here.

Overview

The kayak-based protocol is to survey a bed at 0', ideally with no current. This is not always possible due to weather, waves, or logistics. In addition, some access points become dangerous when low tide exposes slippery rocks. To provide better survey coverage and safety, we will determine if there is a consistent correlation index, for an individual site, that allows us to survey at low tides other than 0' (2', 4', etc). By holding current consistent, surveying temporally near a standard (0') survey, and allowing low tide level to vary we hope to establish the quantitative relationship between surface expression and water level.

If a consistent correlation exists, this provides more options for a survey, albeit at the cost of an additional source of variance. This could also provide a mechanism to standardize data from other survey methods (drone, boat) that may be conducted at “non-zero” tide levels.

For a single bed, we will survey it a low tide for consecutive days (at least 3) as slack tide increases. We would record the surface area expression (SAE) at each tide level. By repeating this process throughout the season, we hope to gather enough data to measure a coefficient and its variance.

Earlier work (2015 for the Ebey bed) addressed this issue. The data (Figure 1) supports the hypotheses that a consistent coefficient may exist. When the bed was surveyed at +5' tide in three different months, the ratio of 5'/0' SEA (about .8) was similar.

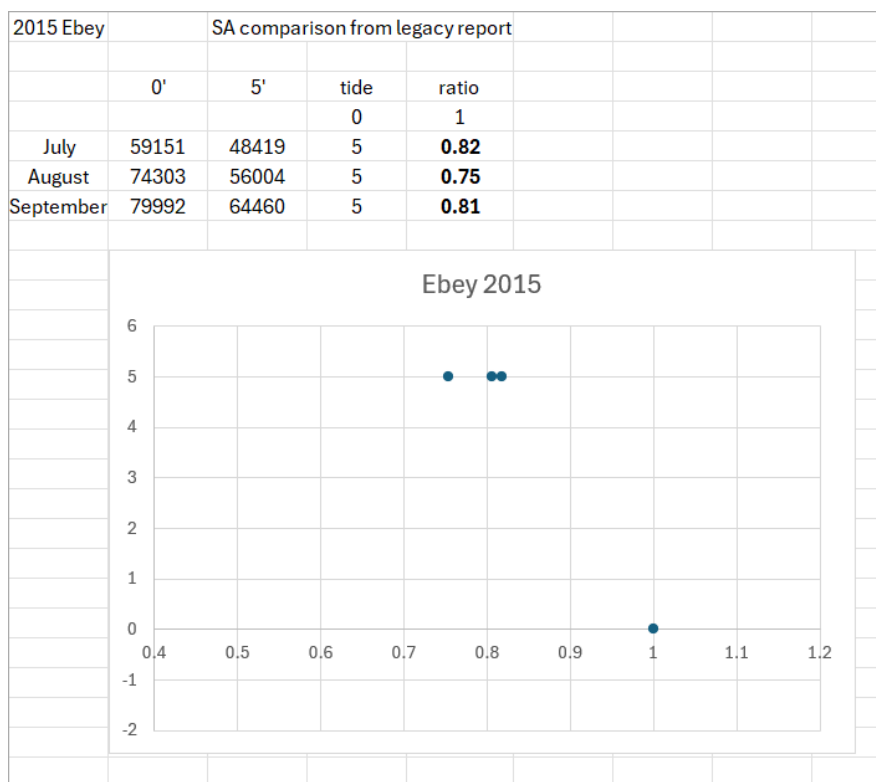


Figure 1. The ratio of SEA at 5' as a percentage of the 0' SEA on three occasions in 2015

Variance

We have several sources of variance to control for:

- Variance in measurement by an individual surveyor
- Differences between surveyors, although this is addressed by existing protocol.
- Methodology of survey (kayak, boat, drone, etc)
- Date since (or until) the baseline survey at 0' was collected
- Current
- Wind
- Year (any changes that cause pattern of expression to change)

In 2015, the team held the surveyor, method, date, and current constant, surveying at 5' on the day the 0' survey was done.

2025 test of approach

The bed used for comparison was Ebey Landing. In August 2025, the bed consisted of two beds; one nearshore and one offshore. Both beds were surveyed by kayak with the standard protocol on 8/19/25 at a -.5' tide.

The nearshore bed was surveyed in replicate (two surveyors) by kayak on 8/25 at a +1.8 tide. After discussion one of those surveys was used rather than an average. The offshore bed was surveyed by boat on 8/28. Results of the kayak survey of the nearshore bed follow. Image 1 shows the nearshore bed with the two surveys overlaid.



Image 1. Kayak surveys of Ebey Landing nearshore bed for 8/19/25 (grey plus white) and 8/25/25 (olive).

The South end of the bed stops at a line determined by a shore segment. The two surveyors did not use the same Southern stopping point. The white polygon is area surveyed on 8/19 but not on 8/25.

Two calculation approaches were used. This allowed us to use both the track area calculation in the Garmin GPS and the polygon area calculation in Google Earth Pro for comparison.

Approach 1

- Use a single GPS to calculate SAE from GPX files.
- Load GPX files into Google Earth Pro
- Draw polygon (white) for the area not surveyed 8/19 and calculate the surface area.
- Subtract the area of the white polygon from the area of the 8/19 survey.
 - SAE - 8/25 – **59,691**.
 - SAE - 8/19 – 96,234 – 16,103 (white polygon) – **80,131**

For a ratio of **.745** at a tidal difference of 2.3'

Approach 2

- Open both GPX files in Google Earth Pro
- Draw polygons for both tracks, excluding the area not surveyed on 8/25 South of the shore segments. This introduces some variance based on the drawing skills of the analyst.
 - SAE 8/25 = 59,719
 - SAE 8/19 = 79,974

For a ratio of **.75** at a tidal difference of 2.3'