Summary of 2019 DKP Eelgrass Surveys

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NOTE: The original report contained a data error resulting from improperly formatted columns in Excel. There were also stations with incorrect locations in the original spreadsheets. This report is the updated report and all graphs have the correct data and maps use the corrected latitude and longitude. This report added an assessment of the proximity of the sampled points to the planned points and maps with the average percent cover of eelgrass in 2018 and 2019.

SURVEY DETAILS:

Preparations for the second annual Duxbury, Kingston and Plymouth Bays' "Eelgrass Survey Blitz" began in June of 2019. Previous eelgrass monitoring efforts and protocol modifications were discussed during multiple conference calls, followed by an in-person meeting at the North and South Rivers Watershed Association (NSRWA) on June 27th. At the meeting, the Massachusetts Division of Marine Fisheries (DMF) showed the NSRWA staff how to maintain and operate the monitoring equipment. One monitoring kit was left at the NSRWA office. The rest of the kits were delivered by DMF on July 30th.

Volunteers were recruited by NSRWA through multiple modalities: emails and phone calls to existing volunteers and local contacts, 'Call for Boaters' flyers posted at local businesses and harbormasters' offices in Duxbury, Kingston and Plymouth, and a special event page added to the nsrwa.com website. A survey was sent out to potential volunteers through NetworkForGood to determine their availability and boat dimensions. A total of 7 boat captains were able to participate, as well as 10 additional citizen science volunteers and 3 members of the NSRWA staff.

The on-land volunteer training was held at the Plymouth Harbor public boat launch area from 10am-12pm on Sunday, August 11th. NSRWA ran the training, which included going over DMF's 2018 standard operating procedure for 'Citizen Science Eelgrass Monitoring', setting up two monitoring kits, and running mock-sampling drills off the dock to familiarize volunteers with the equipment.

Full-day surveys were originally scheduled to occur Monday, August 12th through Friday, August 16th, but Tuesday 8/13 was rescheduled to Monday 8/19 due to inclement weather and a small craft advisory. Teams of three to four people (boat captain, 1-2 lead NSRWA scientists and 1-2 volunteers) were scheduled to fill each available boat, with adjustments made as needed throughout the week. Due to the limited number of boats and boat captains available, only 1-3 teams went out each day from approx. 9am-4pm. Stations were grouped into clusters of 10-13 according to geographical location (Figure 1). Each boat was assigned stations within one or more clusters depending on which stations had already been surveyed, often including ones that were on the way to other assigned stations. The goal was to increase efficiency by reducing unnecessary travel time on the water.

On the first survey day, Monday 8/12, one team surveyed all 12 stations in Cluster E – the most northeastern survey area between Clark's Island and Saquish. On the second day, Wednesday 8/14, two teams went out and surveyed a total of 17 stations within Clusters C (NW Plymouth Harbor) and G (just south of Clark's Island). Three teams went out on Thursday 8/15 and completed a total of 35 stations within 6 different clusters. On Friday 8/16, another 3 teams participated and surveyed 37 stations total, spanning 5 clusters including most of Clusters A (Plymouth Harbor, just outside breakwater) and J (NW, Central & NE Duxbury Bay), as well as all of Cluster I (mainly NW Duxbury Bay). The remaining 18 stations were surveyed on Monday 8/19 by two teams that launched from Duxbury instead of Plymouth because both boats were conveniently located there. Figure 1 shows the station cluster map.

Over the course of 60.5 "boat hours" spread across 20 participants, 11 teams, 7 boats and five days, all 119 stations were monitored for eelgrass presence and percent cover using an underwater camera mounted to a standardized 0.25m^2 PVC quadrat frame. Of those stations, 109 were "indicator" stations that underwent eelgrass sampling when there was some growing. Eelgrass was collected either via a free-diving snorkeler or Danforth anchor thrown overboard to retrieve 3 shoots from each corner of the boat where eelgrass was observed. Shoots were then measured, photographed and assessed for wasting disease and epiphytic cover. Environmental data including wind speed & direction, sea state, percent cloud cover and tide were recorded at each station, as well as the secchi and water depth (via the secchi disk or boat's depth gauge when available). NSRWA staff's personal smartphones or (when applicable) the boats' built-in GPS units were used to collect latitude and longitude data. All data was recorded on paper datasheets in the field.

Following each day's surveys, the NSRWA eelgrass intern charged the Splashcams, saved all underwater & above-water photographs to an external hard drive, assessed the status of the kits, making proper adjustments as needed, and planned the next day's surveys. The datasheets were later scanned and transcribed into Excel, cruise reports for each day were generated, and all these data components were saved onto the external hard drive with the corresponding photographs. Data quality control was conducted by NSRWA during this process. In early October, DMF picked up the remaining eelgrass kits and the hard drive from NSRWA. Both groups have complete data archives including electronic copies of the datasheets and digital photographs from each station.

QUALITY CONTROL:

All the data recorded on the paper datasheets in the field was transcribed into the Excel spreadsheet titled 'EelgrassBlitz2019_final' in August and September, following completion of the 2019 DKP Eelgrass Survey Blitz. Trip, site and secchi disc information was entered as-is with one minor exception. Many of the datasheets were leftover copies of previous years' versions, so a handful of them use slightly different phrasing under the 'Sea State' categories. Specifically, 'small ripples' was previously 'small wavelets' and 'small waves' was previously 'small breakers'. These terms were treated interchangeably in the field. As such, 'small ripples' was entered into Excel anytime 'small wavelets' was circled on a datasheet, and 'small waves' was entered anytime 'small breakers' was circled on a datasheet. All trip, site and secchi disc information can be found under the spreadsheet's 'site&secchi' tab.

Next, the drop-frame data recorded on the field sheets was compared to their corresponding photographs while being transcribed into Excel. (*Note: all 'Drop-Frame Data Collection' values can be found under the spreadsheet's 'photocollect' tab)* With the Splashcam's monitor visibility being subpar in the field (especially on sunny days), photos can often be misinterpreted during data collection. As a result, quality control is necessary to determine exactly what sediment type, eelgrass percent cover and other notable objects or organisms (e.g. crabs, snails, shells, algae, eelgrass fragments, etc.) are present in each of the station's four sample areas. In most cases, the sediment type did not need to be altered during transcription. If two sediment types were circled, they were both entered in Excel with a forward slash separating them.

The 'eegrass percent cover' ranges initially circled in the field were typically accurate. If later determined that a range should be adjusted, the originally circled range would be crossed out and the preferred one circled. In a few instances (e.g. station 9088), the percent cover box was left blank or with a question mark due to poor underwater visibility or the presence of algae that could be misinterpreted as eelgrass. These datasheets were updated during the photographic analysis stage and transcribed accordingly in Excel. Similarly, any updates to the 'Notes' section for 'Drop-Frame Data Collection' would be made directly to the datasheet and then entered into Excel. Occasional misidentified species were crossed out and new findings added. For example, station 9063 had mussels present in all four photographed quadrants, but they were not detected and recorded until this later analysis stage.

For stations that had eelgrass present and samples collected, their above-water photographs were also examined more closely on a computer monitor during the transcription phase. By zooming in on the photographs of the eelgrass samples, wasting disease, epiphyte coverage and the longest shoots' length and width measurements were able to be checked against what was recorded in the field. The only recurring mistake during this stage of data collection was some of the width measurements being recorded as half the correct measurement. This was a result of the smallest marks on the tape measure being 2mm wide and accidentally being misread as 1mm during shoot width measurements. The inaccurate recordings were erased and replaced with the accurate ones for the following stations: 9128, 9090, 9089, 9066, 9140, 9145, 9134, 9138, 9139, 9141, 157, 9201, 9074, 9092, 9117, 9115. This transcribed data can be found on the spreadsheet's 'indicator' tab. (*Note: station 157 is NOT an indicator site, but it is included in the analysis because eelgrass samples were collected there)*

It is also important to note the instances in which the Danforth anchor was used to retrieve eelgrass samples and they came up incomplete. At station 9207, only one shoot was retrieved for two of its samples (samples 3 & 4) after the anchor was thrown 5 times for each. Stations 9133 (sample 1) and 9108 (sample 2) both also had only one shoot measured and recorded for one of their samples. In an unusual instance, only 1 eelgrass shoot was measured for sample 1 at station 9201 despite 3 shoots being collected and photographed. Two shoots were measured and recorded for sample 3 at station 9076 and since no photograph was taken of them, it is assumed that only two samples were collected.

Once the data was received by DMF, it was reviewed for accuracy and the GPS locations were verified using ArcGIS Pro 2.4. There were 119 sampled stations and 1 station did not record the latitude and longitude. This station was kept in the eelgrass data analysis but was not mapped. There were 21 stations that had location errors. All 21 were rectified by reviewing the original logsheets and the GPS fixes are described in Appendix A. To determine how far apart the planned and actual locations were, the XY to Line tool in ArcGIS was used to draw a line between start points (the planned station locations) and end points (the actual sampled locations). Line lengths were calculated in feet. The minimum distance of a sampled station from the planned station was 1.1 ft. The maximum was 638 ft. The mean was 73 ft, the median 40 ft, and the standard deviation was 101 ft. 73 of the stations were <=50 ft from the planned station (Figure 2).

DATA ANALYSIS:

Shoot Size:

Once the 2019 data was corroborated by photographs and transcribed, it was then analyzed within the same 'EelgrassBlitzData2019_final' spreadsheet. On the '*length&width'* tab, a table consolidates all the eelgrass shoot length and width measurements in just two columns. This allowed a pivot table to be generated, displaying the average length (cm) and width (mm) measurements for each station. On the *'LxW_analysis'* tab, the average shoot size (length x width in cm^2) for each station was also generated in a pivot table after each individual shoot's area was calculated. Summary statistics for all of the stations' average shoot size was then produced using the 'Descriptive Statistics' Data Analysis tool. Average shoot length (cm) and width (mm) for all stations were also calculated and compared to those from 2018.

On the '*2018_comparison'* tab, there is a table containing the previously calculated average shoot length (cm) and size (i.e. area, cm^2) at each station where eelgrass was sampled in 2018 and 2019. The table provides an opportunity for side-by-side comparison from one year to the next. Anytime 'N/A' is written under these four columns, it signifies that no eelgrass shoot samples were collected in that instance, and therefore no data was gathered. The percent change in average shoot length and size (i.e. area) are also provided for each station with eelgrass samples taken in both 2018 and 2019. On a separate tab, t-tests (two-sample assuming equal variances) were conducted to compare the 2018 and 2019 length, width and size (i.e. area) measurements.

Wasting Disease & Epiphyte Cover:

Wasting disease (WD) and epiphyte cover were analyzed on the '*WD&EPI_analysis'* tab. Using pivot tables, the total count of eelgrass shoots described as having none/low/medium/high coverage of wasting disease and epiphytes was calculated. These values were converted to percentages by dividing them by the total number of samples. The percent change from 2018 to 2019 was also calculated for each category. *Reminder: each sample contains 3 shoots and there are 1-4 samples taken per station with eelgrass present.*

As seen on the '*WD&EPI_stations'* and '*2018_comparison'* tabs, a *single* coverage description (none/low/medium/high) for WD and epiphytes at each station was determined for both 2018 and 2019. Since non-numerical values cannot be averaged, the 'most common' description for each station was selected whenever possible. For example, out of the four samples taken at station 9097 in 2019, three were described as having medium-level WD and one was described as having low-level WD, resulting in a 'medium' coverage description. When there was no clear majority, a middle split was conducted. For example, for WD coverage in 2019, one low and one high recording for the station 9072 samples resulted in a 'medium' description, as did station 9118's low, medium and high (one of each) split. For tie breakers (i.e. equal counts of two adjacent coverage descriptions), the 'less coverage' description was selected. For example, one medium and one low recording for station 9146's eelgrass epiphyte coverage in 2018 resulted in a 'low' description. The exception to this rule is when there are one or two ‘low’ descriptions with one or two ‘none’ descriptions, respectively, in which case ‘low’ would be used instead of ‘none’. This is intended to avoid suggesting that no epiphytes were present when indeed they were observed on one or more shoots, as was the case at stations 9074 & 9117 in 2018. The remaining unconventional combinations resulted in the following:

- 2019 WD- Stations 9076 & 9109: 1 low, 1 medium, 2 highs → medium
- 2018 Epiphytes- Station 9134: 3 low, 2 medium, 3 high → medium
- 2018 Epiphytes- Station 9141: 2 low, 1 medium, 1 high → medium
- 2019 Epiphytes- Station 157: 1 low, 2 medium, 1 high → medium
- 2019 Epiphytes- Station 9074: 2 low, 1 medium, 1 high → medium
- 2019 Epiphytes- Station 9108: 1 low, 1 medium, 2 high → medium

Average Eelgrass % Cover:

The average eelgrass percent cover for each of the stations surveyed in 2019 was calculated via the same bin analysis that was used in 2018. On the *‘%cover_bin_analysis’* tab, the percent cover ranges (0%, 1-10%, 11-30%, 30-75%, 75-100%) are listed for all four quadrants at each station. Using ‘if/then’ analysis, the averages (‘AVERAGE’) and highest values (‘HighestValue’) were generated. Their corresponding bins (‘NewAvgBin’ & ‘NewHiBin’) were then entered manually.

In order to track changes in average eelgrass percent cover over the last year, the average percent cover values at the 45 stations that were sampled in both years and had eelgrass present in either year are included in the ‘*2018_comparison’* table. The change in average percent cover and the percent change in average eelgrass cover from 2018 to 2019 was also calculated in the ‘*2018_percovcomparison’* table. ‘

Regional Analysis:

In order to conduct location-based analysis, pivot tables were created on the *‘regional_analysis’* tab using data from the *‘%cover_strata’* table. Two of the pivot tables show the number of stations surveyed within each DEP-designated waterbody (Duxbury Bay & Plymouth Harbor), as well as each DMF-designated sampling region within those waterbodies. Two corresponding pivot tables show the number of stations *containing eelgrass* in each sampling area and waterbody. Four more pivot tables were generated in the same fashion, except that they provide more detail as to what average percent eelgrass cover was observed across the stations within each sampling region and waterbody. Four additional tables were created by converting the average percent eelgrass coverage values into their corresponding bins (0%, 1-10%, 11-30%, 30-75% or 75-100%).

Like most of the other tables in this spreadsheet, the *‘%cover_strata’* table is based off the tab by the same name in ‘EelgrassBlitzData2018_final’. ‘Actual Lat’ and ‘Actual Long’ are the exact coordinates where sampling took place this year. Values for ‘Avg%CovCalue’, ‘Avg%CovBin’, ‘HighestValue’ & ‘HighestBin’ come directly from the 2019 *‘%cover_bin_analysis’* table. ‘Stratum’ values are copied from the 2018 spreadsheet, as they signify number of instances eelgrass was identified during prior acoustic surveys. The sampling regions are also the same as last year, except for the new 2019 sites which received new ‘Sampling Region’ descriptions based on their general geographic locations and the surrounding grouping pattern previously used. Columns were added for ‘Cluster’ (A-J), ‘Sitetype’ (‘Original [i.e. since 2018] or ‘New’) and ‘Eelgrass Present in 2018’ (true, false or blank if new site). ***Note*: *The 'Dist_from_Pt(M)' column has been left blank as it requires fine-scale calculations to determine the distance between GPS points in meters.***

RESULTS OF ANALYSIS:

Of the 119 total stations surveyed in August 2019, 110 were also surveyed in 2018 and 9 were new in 2019. Thirty-eight had eelgrass in at least one of the four quadrants off the boat. Twenty-six stations had eelgrass in both 2018 and 2019: 157, 9066, 9067, 9072, 9073, 9074, 9076, 9083, 9089, 9090, 9092, 9097, 9101, 9108, 9109, 9111, 9117, 9118, 9128, 9133, 9134, 9138, 9139, 9140, 9141 & 9145. The following 9 stations had eelgrass not detected in 2018: 9053, 9059, 9060, 9068, 9103, 9113, 9114, 9115 & 9136. In contrast, the following 10 stations had eelgrass detected in 2018 but not in 2019: 215, 247, 249, 9088, 9131, 9132, 9135, 9144, 9146 & 9147. And 3 of the 9 new stations that were added in 2019 had eelgrass: 9201, 9205 & 9207. Since they were not sampled in 2018 it is unknown whether eelgrass was present a year ago or not.

Average Eelgrass % Cover:

Eelgrass is highly clustered in the DKP embayment, with the main meadows located on Ichabods Flat, just to the north of the main Plymouth Harbor, and around Clark's Island and Saquish Neck (Figure 3).

The average eelgrass percent cover (at stations with eelgrass) remained the same from 2018 to 2019 at the following 5 stations: 157 (78.9%), 9076 (87.5%), 9083 (1.375%), 9090 (87.5%), 9092 (70.2%). There was an increase in average percent cover at 21 stations (Table 1). The greatest increase in average percent cover over the last year was 64.25% increase at station 9118 (Figure 4).

Table 1. DKP eelgrass survey stations that had an increase in average eelgrass percent cover from 2018 to 2019 (in descending order)

Station	2018 avg % cover	2019 avg % cover	change 2018-2019
9118	1.4	65.6	64.3
9117	28.6	87.5	58.9
9066	1.4	57.0	55.6
9108	6.5	62.1	55.6
9101	35.1	87.5	52.4
9067	23.3	70.2	47.0
9136	0.0	36.7	36.7
9111	13.2	40.2	27.0
9089	40.2	65.6	25.4
9109	62.1	87.5	25.4
9113	0.0	21.9	21.9
9073	24.9	35.1	10.3
9097	78.9	87.5	8.7
9103	0.0	5.1	5.1
9115	0.0	4.1	4.1

9138	61.6	65.6	4.1
9114	0.0	2.8	2.8
9053	0.0	1.4	1.4
9059	0.0	1.4	1.4
9060	0.0	1.4	1.4
9068	0.0	1.4	1.4

The greatest decrease in average percent cover over the last year was observed at station 9146, which went from 87.5% eelgrass cover in 2018 to having no eelgrass detected in 2019 (Table 2). Stations 9088 and 9132 are tied for the second greatest decrease with a drop from 78.9% average eelgrass cover in 2018 to 0% detected in 2019 (Table 2). A total of 19 stations experienced some sort of decrease in average eelgrass percent cover. The following 10 stations went from some eelgrass being detected in 2018 to none being observed in 2019: 215, 247, 249, 9088, 9131, 9132, 9135, 9144, 9146 & 9147.

Table 2. DKP eelgrass survey stations that had a decrease in average eelgrass percent cover from 2018 to 2019.

Station	2018 avg % cover	2019 avg % cover	change 2018-2019
9146	87.5	0	-87.5
9088	78.85	0	-78.85
9132	78.85	0	-78.85
9139	78.85	14.6	-64.25
9072	87.5	40.225	-47.275
9147	44.8	0	-44.8
9133	49.7	10.25	-39.45
9135	35.1	0	-35.1
247	27	0	-27
9145	87.5	61.55	-25.95
9134	87.5	62.1	-25.4
9140	87.5	65.625	-21.875
9128	78.85	58.35	-20.5
9141	44.8	24.625	-20.175
9131	14.6	0	-14.6
9074	87.5	78.85	-8.65
9144	4.125	0	-4.125
215	1.375	0	-1.375
249	1.375	0	-1.375

As for the stations newly sampled in 2019, only 3 had eelgrass detected (9201, 9205, 9207). These stations were selected based on aerial and acoustic imagery that had identified eelgrass at least 4 times previously so it was expected that all 9 new stations would have eelgrass.

When looking at all of this data, it is important to keep in mind that the actual latitude and longitude where the surveys took place could vary greatly from year to year depending on how far and in which direction the survey boat ended up in relation to the original coordinates selected.

Percent Cover by Region:

Of the 119 stations surveyed this year, 88 of them are contained in the DEP-designated Duxbury Bay waterbody and 31 of them fall within the DEP-designated Plymouth Harbor waterbody. A total of 38 (32%) of all the stations surveyed in both waterbodies contained eelgrass. Eelgrass was observed in 29 (33%) of the 88 stations in Duxbury Bay and 9 (29%) of the stations in Plymouth Harbor. See Figure 1 for their distribution. According to DMF-designated sampling areas, eelgrass was recorded at ten (40%) of the 25 stations surveyed in central Duxbury Bay, six (26%) of the 23 stations surveyed in Kingston Bay, nine (43%) of the 21 stations surveyed in NE Duxbury Bay, three (18%) of the 17 stations surveyed in NW Duxbury Bay, and ten (30%) of the 33 stations surveyed in Plymouth Harbor (Figures 5 and 6).

In Duxbury Bay, the average percent eelgrass cover in 2019 across all 88 stations is 16%. In Plymouth Harbor, the average percent eelgrass cover in 2019 across all 31 stations is 14%. When taking into account just the stations where eelgrass was observed, Duxbury Bay had 65% average eelgrass cover and Plymouth Harbor had an average eelgrass cover of 50%. Central Duxbury Bay was the region with the greatest average percent eelgrass cover across all its survey stations (27%), as well as the greatest average percent eelgrass cover of its stations containing eelgrass (74%).

Shoot Size:

A total of 292 eelgrass shoot samples were analyzed at 33 stations. When looking at all the stations sampled for eelgrass in 2019, the average shoot length was 62.6 cm, the average shoot width was 4.8 mm and the overall average shoot size (i.e. area) was 31.0 cm^2. In 2018, a total of 305 eelgrass shoot samples were collected from 30 stations. The average shoot length in 2018 was 61.9 cm, the average shoot width was 4.5 mm and the average shoot size (i.e. area) was 29.6 cm^2. While all three 2019 averages are slightly greater than those from 2018 (suggesting eelgrass shoot growth over the last year), only the width values had a statistically significant p-value <0.05 (see Table 3 below).

Table 3. Average eelgrass shoot measurements for DKP stations sampled in 2018 and 2019, with associated p-values (two-tail) generated using t-test analysis (two-sample assuming equal variances)

	2018	**2019**	**P-value**
Avg Length (cm)	61.94	62.63	0.71
Avg Width (mm)	4.50	4.76	**0.01**
Avg Area (cm^2)	29.68	31.04	0.25

Of the 22 stations where eelgrass was sampled both years, shoot area was on average 7.3 cm^2 larger in 2019 than in 2018 and 16 stations (73%) had a larger average shoot area in 2019 than in 2018. Shoot length was on average 7.8 cm longer in 2019 than in 2018 and 13 stations (59%) had a longer average shoot length in 2019 than in 2018 (Figure 7). Shoot width was on average 3 mm narrower in 2019 than in 2018 even though 17 stations (77%) had a wider average shoot width in 2019 than in 2018.

Station 9111 showed the greatest net increase in average shoot length and overall size: 60.67 cm and 36.23 cm^2, respectively (Table 4). On the other hand, station 9117 had the greatest percent increase in both average shoot length and overall size: 120% and 153%, respectively (Table 4). The longest average shoot length (115.67 cm) was recorded at station 9111 in 2019 (Figure 7). Last year, site 9134 had the longest average shoot length of 87.16 cm (Figure 7). Meanwhile, station 9139 had the greatest average shoot size both years: 48.83 cm^2 in 2018 and 47.65 cm^2 in 2019.

Table 4. Changes in average shoot length & overall size from 2018-2019 for the top 7 DKP eelgrass survey stations with the greatest percent *increase* in average shoot length & size (*in descending order by avg shoot length % change)*

Station #	Δ Avg Shoot Length (cm)	Avg Shoot Length % Change	Δ Avg Shoot Size (cm^2)	Avg Shoot Size % Change
9117	39.39	**119.9%**	19.35	**153.2%**
9111	**60.67**	110.3%	**36.23**	141.4%
9108	31.85	90.1%	17.38	126.4%
9092	22.05	74.2%	12.63	121.5%
9101	29.55	54.2%	24.93	135.4%
9073	20.50	52.6%	16.10	127.6%
9074	13.08	23.5%	17.17	84.9%

Six stations (27%) had a decrease in average shoot area between 2018 & 2019. At 9 stations (41%), there was a decrease in average shoot length (cm) (Figure 7). A decrease in *both* the average shoot length and overall size (cm^2) was observed at the following 5 stations: 9072, 9090, 9133, 9134 and 9139. Station 9076 also saw a decrease in average shoot size (Δ= -4.42cm^2), despite a minor 2.6% increase in average shoot length (Δ= 2.23cm). Although minor decreases in average shoot length were observed at stations 9066 and 9145, they both saw increases in average overall size. Station 9090 showed the greatest percent decrease in both average shoot length and overall size: -25.5% and -33.7%, respectively (Table 5). Station 9139 showed the greatest net decrease in average shoot length (Δ = -18.23cm) and station 9133 showed the greatest net decrease in average shoot size (Δ = -14.88) (Table 5).

Table 5. Changes in average shoot length & size from 2018-2019 for the top 5 DKP eelgrass survey stations with the greatest percent *decrease* in average shoot length & size (*in ascending order by avg shoot length % decrease)*

Station #	Δ Avg Shoot Length (cm)	Avg Shoot Length % Change	Δ Avg Shoot Size (cm^2)	Avg Shoot Size % Change
9090	-18.20	**-25.5%**	-13.45	**-33.7%**
9139	**-18.23**	-22.7%	-1.17	-2.4%
9072	-16.28	-19.6%	-0.44	-1.2%
9133	-15.90	-19.2%	**-14.88**	-35.7%
9134	-11.54	-13.2%	-2.22	-4.6%

Wasting Disease & Epiphyte Cover:

Compared to last year, 2019 saw an increase in the overall severity of both wasting disease and epiphyte cover. Despite a 50% increase in the 'none' category for wasting disease, the 'low' category saw a 38% decrease, while the 'medium' category increased 175% (Table 6). Additionally, the 'high' category went from no reports in 2018 to 14% of the samples being described as having high levels of wasting disease in 2019 (Table 6, Figure 8). So, while the total percentage of eelgrass samples with evidence of wasting disease decreased from 92% in 2018 to 88% in 2019, the levels of wasting disease observed on those samples increased.

Similar trends were observed for changes in epiphyte cover from 2018 to 2019. The 'low' level of epiphyte cover category saw a percent change of -64%, while the 'medium' and 'high' categories yielded high positive percent changes: 108% and 113%, respectively (Table 6). This confirms that overall epiphyte cover on eelgrass in DKP has increased over the past year. There was also a slight decrease in the percentage of samples with no epiphytes observed, reinforcing the notion that more eelgrass hosts epiphytes now than it did in 2018 (Figure 9).

Table 6 Percentage of all eelgrass samples exhibiting varying levels of epiphytes and wasting disease in 2018 & 2019, as well as the annual percent change for each category

Level of Coverage	2018 Epiphytes	2019 Epiphytes	Epiphyte % Change	2018 WD	2019 WD	WD % Change
None	15%	14%	-7%	8%	12%	50%
Low	53%	19%	-64%	84%	52%	-38%
Medium	24%	50%	108%	8%	22%	175%
High	8%	17%	113%	0%	14%	undefined

Of the 22 stations where eelgrass was sampled in both 2018 and 2019, 12 stations (55%) exhibited no change in their wasting disease description (none, low, medium or high) from one year to the next. 11 of those stations fell under the 'low' category, while the samples taken at station 9111 reported no wasting disease both years. A decrease in the level of wasting disease was observed at just two stations: station 9089 (from 'low' to 'none') and station 9134 (from 'medium' to 'low'). An increase in wasting disease coverage from 'low' in 2018 to 'medium' in 2019 was observed at the following 6 stations: 9072, 9076, 9097, 9109, 9133 & 9141. Additionally, a two-level increase from 'low' in 2018 to 'high' in 2019 was reported at the two remaining stations: 9073 & 9108.

The same level of epiphyte cover was observed both years at six (27%) of the stations where sampling occurred. Station 9117 still had 'low' levels of epiphytes present on the eelgrass sampled, while the following five had 'medium' levels of epiphytes recorded both years: *9066*, *9128*, 9134, 9141 & *9145* (*Note: Station 9117 & the three others in italics also exhibited unchanged 'low' levels of wasting disease).* A complete loss of epiphytes was observed at stations 9067, 9076 & 9097, which went from 'medium' or 'low' epiphyte cover in 2018 to 'none' in 2019. An increase in epiphyte cover from 'low' to 'medium' was observed at nine (41%) of the stations. Station 9133 underwent a one-level increase from 'medium' to 'high', while stations 9072 and 9073 both underwent two-level increases: 'none' to 'medium' and 'low' to 'high', respectively. The greatest increase in epiphyte cover was observed at station 9111, which went from no epiphytes recorded in 2018 to a 'high' level of them in 2019.

FINAL THOUGHTS & RECOMMENDATIONS:

The 2019 DKP Eelgrass Survey Blitz was a major success in multiple ways. Every assigned station was surveyed, and the citizen scientists involved seemed to really enjoy themselves. However, each stage of the project came with some challenges. Prior to the survey “blitz” event, NSRWA experienced incredible difficulty getting enough boaters to respond to their exhaustive outreach efforts. Direct communication (rather than flyers) seemed to be the most effective way to reach people. But all forms of soliciting should begin earlier in the spring or summer before potential volunteers make other plans. Many people who showed interest in the project were on vacation that week or were otherwise busy. For example, the Duxbury Bay Maritime School (DBMS) ran its final week of camp the same week the “blitz” began, so receiving their help on Monday 8/19 occurred mainly by chance. Although selecting the week for surveys is largely tide-dependent, being able to conduct it during the last week in August might be more conducive to increased volunteer availability. Alerting the harbormasters earlier and requesting that they send a notice out to their boaters might accrue more support as well.

Since this was the first year utilizing local watercraft resources, it is not surprising that more effort was required to recruit boat captains. Luckily, enough boats were acquired to complete the surveys; however, only one boat captain was available to participate in more than 1 or 2 field days. As a result, teams were constantly changing and there was a notable learning curve each day as everyone on the new teams figured out their role on the boat. But by the end of the day, each team would be operating smoothly. If possible, having more multi-day boat captains and recurring teams would eliminate the need to “start fresh” each morning. Even having just two of the same people as the basis of each team would likely increase the efficiency of data collection operations. Now that NSRWA has worked closely with several boaters and communicated with others who were interested but unable to help, there is a good chance more will be able to commit to participating in future surveys if they are contacted early enough.

During the surveys, some equipment challenges arose. Most of the PVC drop frames’ connecting pieces had not been glued together, so they would eventually pop apart after being tossed overboard enough times. Simple reinforcement with PVC glue was conducted and is recommended before launching for future surveys. The slate that is attached to each drop frame via zip ties could also use some adjusting as they tended to flip up under water, making it so the station and sample number written on the slate were not visible in some photographs. But this is not as critical because the time stamp on each photograph provides a more accurate and reliable way to match photographs to their sample location. Some experimentation is needed, however, to better secure the camera in place within the drop-frames. The holes in the plastic exterior of the camera and PVC pipes became so large within a few days of use that the screws began falling out of them. Luckily this only resulted in the camera tilting within the frame during deployment; the ports are so tightly fitted that the camera did not fall out when the screws weren’t secured.

When handling the equipment next year, it is important to keep in mind that the connections on the Splashcam monitor are very fragile and can easily be bumped or splashed with saltwater when being used on small boats. Keeping the case shut as much as possible and wiping down the equipment at the end of each survey day will prevent further damage. Providing boat captains and/or team leads with their stations’ coordinates the day before can also be helpful in case they want to enter them in their phone or boat’s GPS unit ahead of time. Including both versions (decimal degrees *and* degrees, minutes, seconds) is recommended in case they have a preference. Finally, incorporating snorkeling more into the SOP and recruiting more volunteers who are interested in snorkeling will likely increase the efficacy of shoot collection. Plucking eelgrass by hand makes it easier to gather complete samples without disturbing the seafloor, as often occurs during multiple anchor throws which do not guarantee sample retrieval. Ensuring that boats have accessible swim steps or ladders will make it easier for more people to participate.

Despite the challenges experienced during the planning and implementation phases of this year's DKP Eelgrass Survey Blitz, everything ran relatively smoothly, and the necessary data was successfully collected. Continuing to conduct these surveys each summer will provide important insights into the overall health of the DKP through monitoring changes in eelgrass coverage, size and disease prevalence.

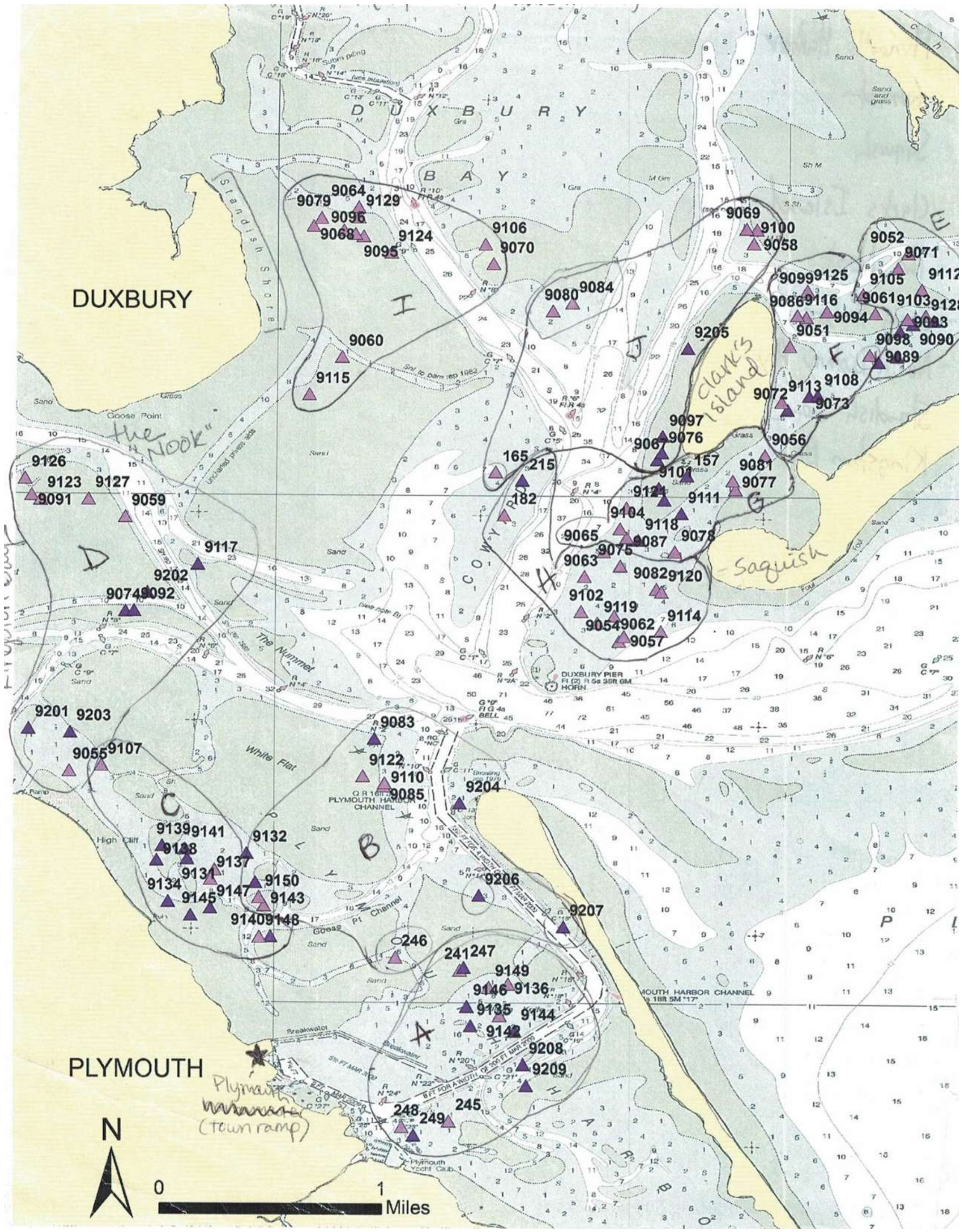

Figure 1. Map of the DKP embayment showing all 119 eelgrass stations surveyed in August 2019, separated into clusters (A-J) according to geographic location

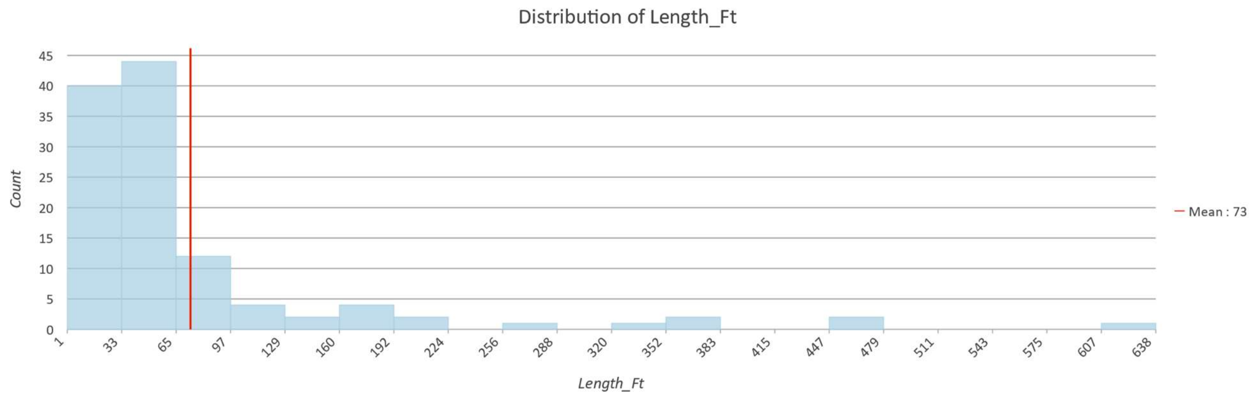

Figure 2. Histogram of distances between planned and actual station locations.

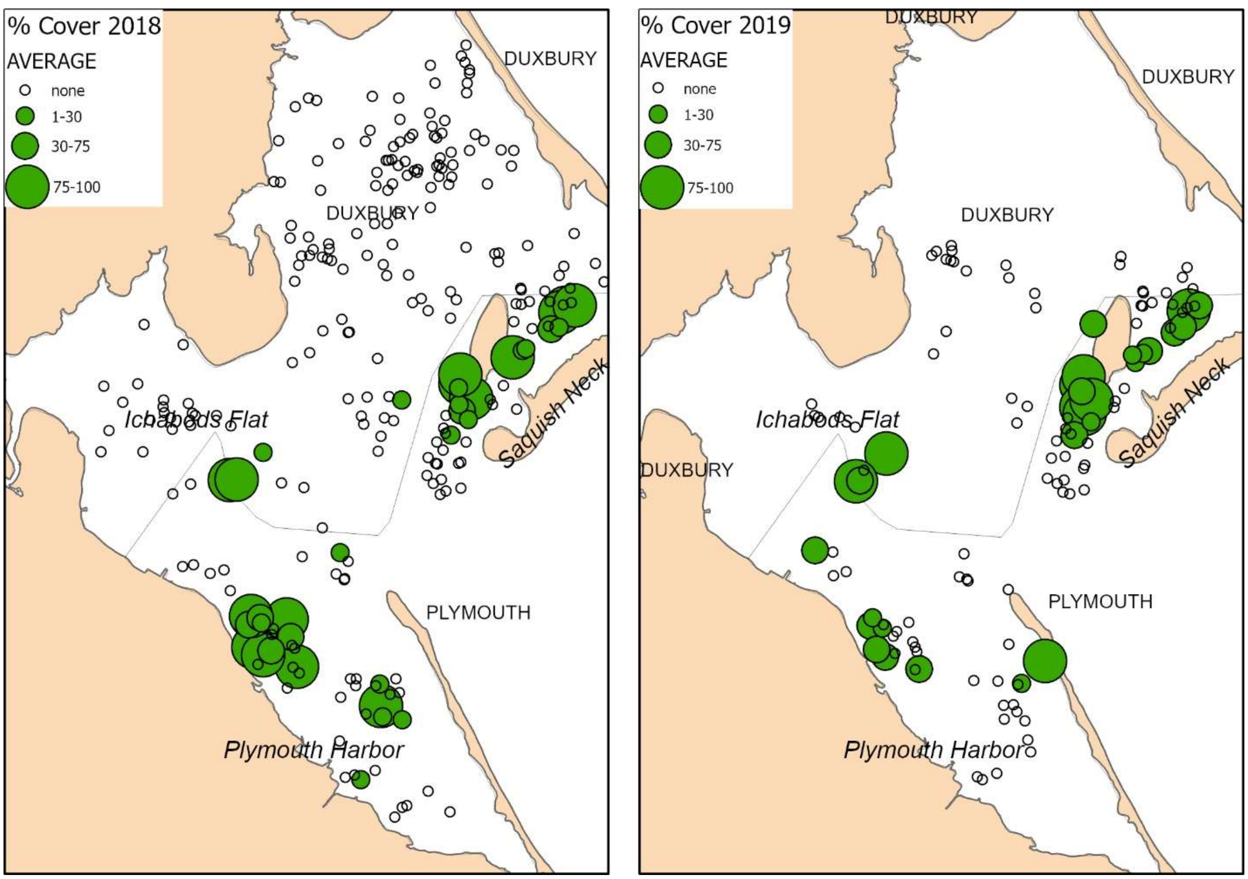

Figure 3. Distribution of eelgrass cover in DKP in 2018 (left) and 2019 (right).

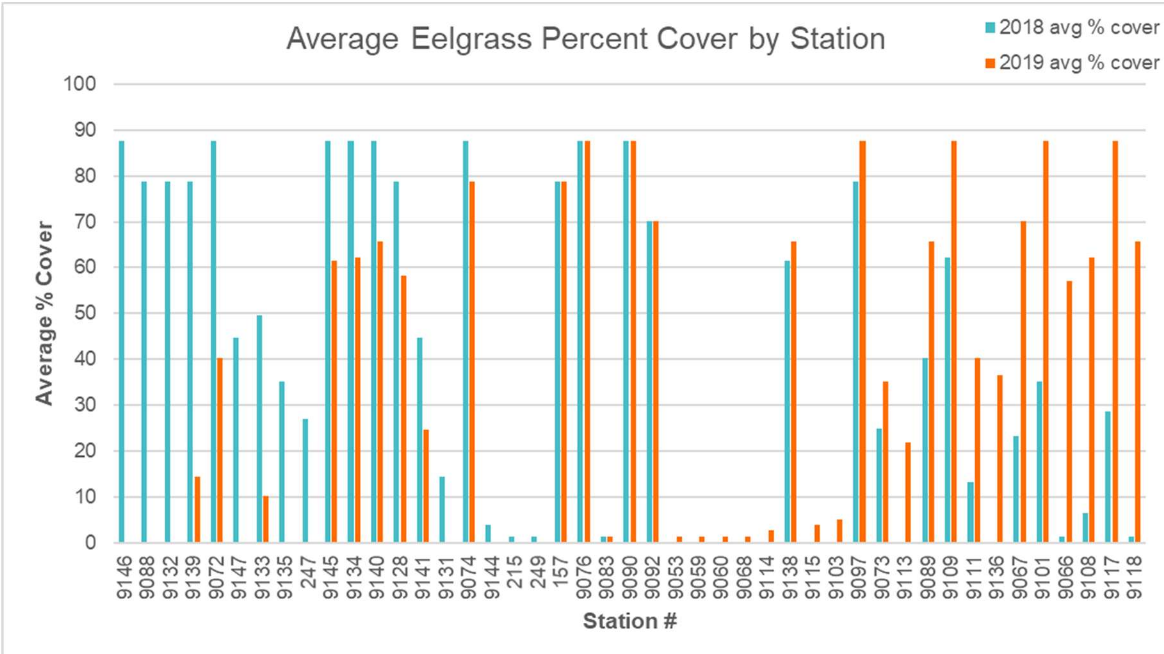

Figure 4. Comparison chart depicting average eelgrass percent cover at every DKP station where eelgrass was detected during the 2018 and/or 2019 surveys, organized by annual % change

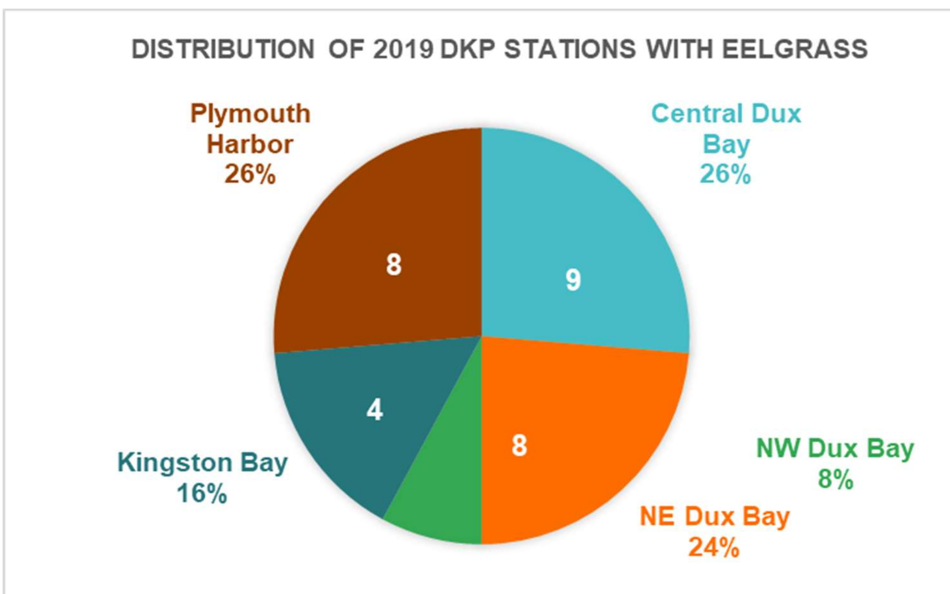

Figure 5. Pie chart showing the distribution of eelgrass stations containing eelgrass during the 2019 surveys across the five DMF-designated sampling regions in the DKP

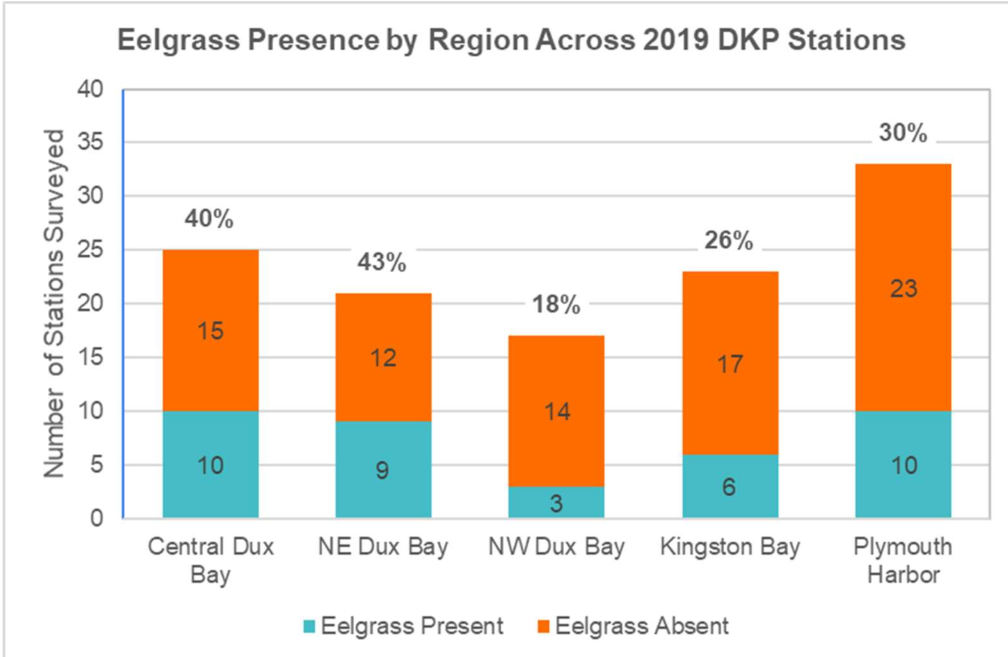

Figure 6. Stacked column chart showing the total number of stations surveyed and percentage of stations containing eelgrass within each DMF-designated sampling area in August 2019

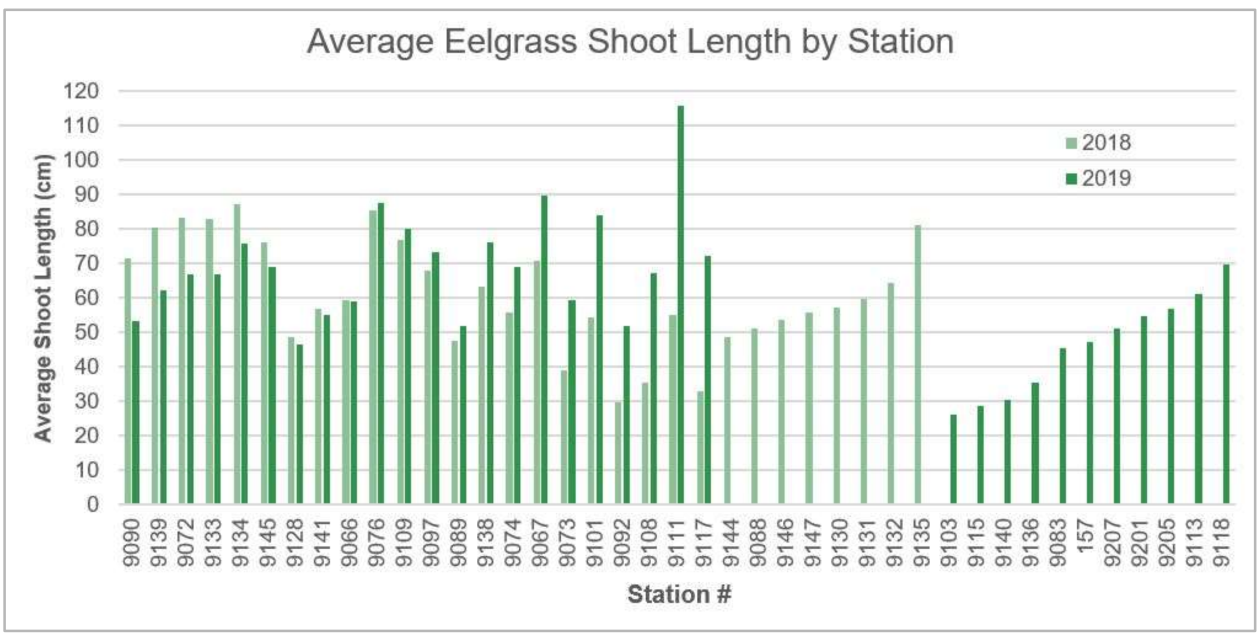

Figure 7. Comparison chart depicting average eelgrass shoot length at every DKP station where eelgrass was sampled during the 2018 and/or 2019 surveys, organized by annual % change

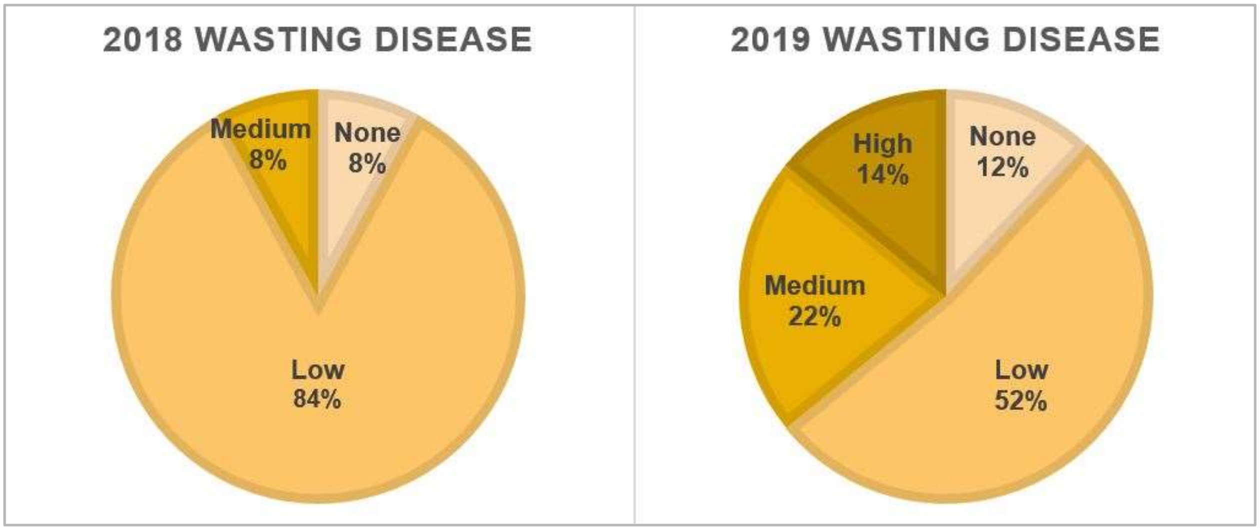

Figure 8. Pie charts comparing the percentage of wasting disease coverage across all DKP eelgrass samples from the August 2018 & 2019 surveys

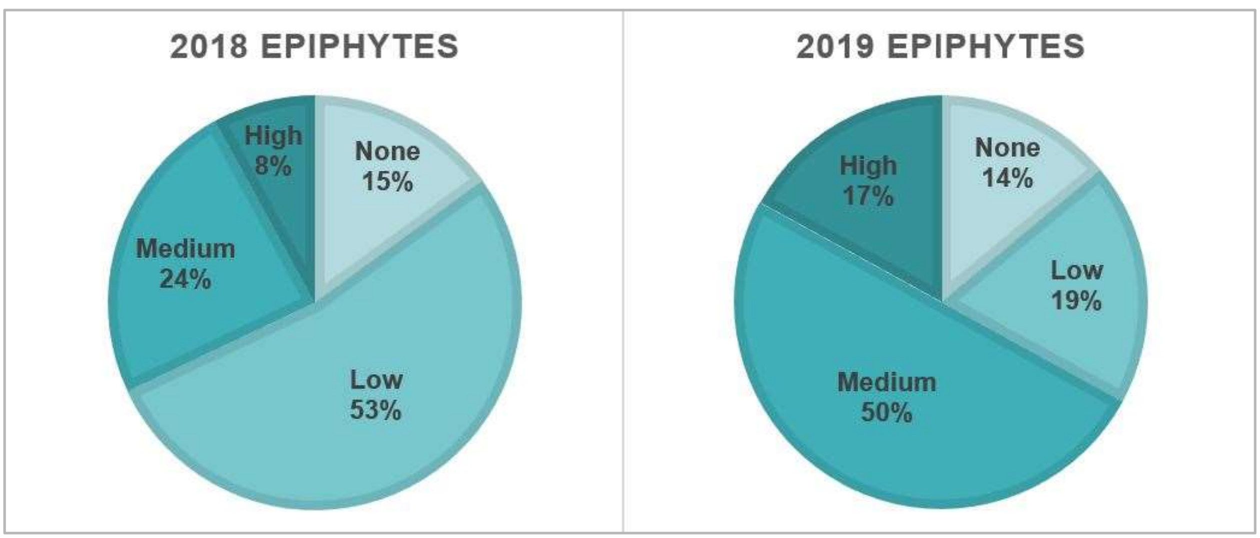

Figure 9. Pie charts comparing the percentage of epiphyte coverage across all DKP eelgrass samples from the August 2018 & 2019 surveys

APPENDIX A: GPS coordinate fixes made to original dataset

Date	Boat	Stn#	ActualLat	ActualLong	GPS
8/19/2019	DBMS	182	41.99876	-70.651764	used 42 instead of 41
8/19/2019	PMC	247	41.969000	-70.6519444	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/19/2019	DBMS	9062	41.9922	-70.644623	used 42 instead of 41
8/19/2019	DBMS	9063	41.99472	-70.646541	used 42 instead of 41
8/15/2019	Inky	9075	41.99494	-70.64445	datasheet was correct, transcription was wrong, used 42 instead of 41
8/19/2019	PMC	9080	42.01186	-70.6486389	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/19/2019	DBMS	9083	41.98393	-70.660040	used 42 instead of 41
8/19/2019	PMC	9084	42.01347	-70.6488611	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/15/2019	Inky	9087	41.99746	-70.6435	hard to read data sheet
8/16/2019	Purple Pickle	9094	42.01231	-70.6309231	error on datasheet; manually edited the latitude; other stations this boat did were very accurate and based on time this one must have been done close to the planned station
8/19/2019	DBMS	9102	41.99247	-70.647195	used 42 instead of 41
8/12/2019	Red Stripe	9105	42.01341	-70.6286962	datasheet was correct, transcription was wrong
8/19/2019	PMC	9110	41.98106	-70.6595833	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/19/2019	DBMS	9114	41.99112	-70.641528	used 42 instead of 41
8/19/2019	DBMS	9119	41.99185	-70.645707	used 42 instead of 41
8/19/2019	DBMS	9120	41.99388	-70.641404	used 42 instead of 41
8/19/2019	PMC	9122	41.98136	-70.6607778	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/19/2019	PMC	9136	41.96917	-70.6514444	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/16/2019	Bumpa's Boat	9142	41.96594	-70.652188	datasheet was correct, transcription was wrong
8/19/2019	PMC	9204	41.97983	-70.65333	data entered on datasheet as d-m-s, but inconsistent (and incorrect) notation made it hard to properly convert
8/16/2019	Bumpa's Boat	9209	41.96135	-70.650161	hard to read data sheet --6s and 5s hard to differentiate