Lobster Quality 2020-2021 Preseason & In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

Final Report

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1. Background

The 2020-2021 Lobster Quality Preseason Sampling Program is the continuation of the long-standing Atlantic Lobster Moult and Quality Project (ALMQ), a collaboration between lobster harvesters, buyers, dealers, and scientists. While the lobster industry in Nova Scotia faces many challenges, the quality of the lobsters during the start of the lobster fishing season in Southwest Nova Scotia remains one of the most significant issues.

Figure 1: Banded lobsters in a dry tote.

Since the early 2000s, there have been fluctuations in the quality of lobster landed in southwest Nova Scotia with higher proportions of soft-shell and lower-meated lobsters landed, resulting in lower quality live lobster product that represents a serious economic challenge for the industry, especially in international markets where over 80% of Nova Scotia lobsters are shipped live to markets in the United States of America (50%), China (30%), and the European Union (15%) (Berry et al 2016).

Results of past ALMQ research has shown that lobster quality at harvest is directly related to the timing of the lobsters' moulting processes. These processes are affected by a number of different factors including water temperature, available lobster diet, and other ecosystem factors. Understanding the incidences of those factors that control the proportion of soft-shelled lobsters and the annual variation in lobster quality is vital to the sustainability, health, and viability of the live lobster industry in Nova Scotia.

In 2017, the Province of Nova Scotia announced the formation of the Nova Scotia seafood brand 'to bring the highest quality lobster to market' (Nova Scotia 2017a). The announcement of the Nova Scotia Brand was launched together with a live lobster quality certification initiative with China to 'set a premium quality standard for exported Nova Scotia lobster' (Nova Scotia 2017b) and the creation of the Université Sainte-Anne's Lobster Quality Research and Innovation Centre (LQRIC, Nova Scotia 2020). It is incumbent on the Nova Scotia lobster industry to develop appropriate measurable means of grading lobsters for international markets to ensure the requirements of highest quality of the Nova Scotia brand, and to impact positively the live lobster value proposition amid declines in harvest quality.

The purpose of this annual report is to evaluate observed lobster quality preseason samples, together with selected in-season sampling, in order to determine lobster quality status for the 2020-2021 season in LFAs 33 & 34 in comparison with the annual ALMQ database time series since 2006. The report follows the directives of the Report of the Maritime Lobster Panel for changes to 'improve the quality of lobster being landed in the Maritime Provinces' that include the development of 'industry grading standards' (Thériault et al 2013, pp.44-43).

This report provides the detailed results of 2020 preseason at-sea sampling conducted by the Coldwater Lobster Association (Coldwater Lobster Association 2020) in 8 locations within LFA 33 and LFA 34 (designated 'inside' and 'outside' areas of Lobster Bay, St. Mary's Bay, Yarmouth in LFA34, and Port La Tour in LFA33) from August 18 to November 17, 2020. The report also presents selected in-season sampling carried out in 4 LFA34 locations ('inside' and 'outside' areas of St. Mary's Bay and Yarmouth) in December 2020 and January 2021. This sampling represents a continuation of the longstanding Atlantic Lobster Moult and Quality Project (ALMQ) longitudinal database that has taken place annually since 2006.

All sampling was conducted by Coldwater Lobster Association according to the ALMQ protocols. Samples data include individual lobster data on:

(1) Depth of string (F, fathoms)
(2) Legal or Sub-legal lobster (only legal lobsters were used in subsequent sampling)
(3) Carapace Length (CL, millimetres)
(4) Sex (M-male '1'; F-female '2')
(5) Shell hardness (Soft '2'; Medium '4'; Hard '5')
(6) Blood protein level – measured via refractometer as the BRIX Index (units/ml, Figure 2)
(7) Moult stage ('0' – no activity; '1' to '5') – from selected lobster's pleopod removal and post-at-sea sample examination under a microscope (Factor 1995, Figure 3)
(8) Damage (coded descriptions for visual impacts, e.g., culls, shell disease)
(9) Lobster status observed ("weak"/"not weak").

Figure 2: Survey sampling tools.

Data analyses were carried out with the cooperation of the Centre de recherche marine/Marine Research Centre of the Université Sainte-Anne, Petit de Grat Campus.

These data are designed collectively to proxy lobster quality – live lobster meat content and suitability for storage and shipping – and are provided in the 2020 preseason summary (Mattock, Mulock, and Lane 2020) as an indicator to the Nova Scotia lobster industry about the early season status of the post-moult lobster harvest in the designated sampling areas of LFAs 33 & 34.

The results presented here focus on the distribution of the recorded BRIX levels for 2020 preseason and 2021 in-season sampling compared to past years' samples from the same preseason and in-season times and sampling locations over the period 2012-2020 in the ALMQ database. This information enables the industry to compare the 2020-2021 sample results to known past years of observed preseason and subsequent in-season lobster quality and status.

In 2020, as per the protocol in the past, blood protein levels, represented by the BRIX index, are a key indicator of individual lobster quality. BRIX index values below 6.0 units/ml in the samples provide a

probable indication of poor quality and less than fully-meated lobster that are less suitable for storage and shipping. These lobsters often appear weak, potentially soft shell, and would not be ideal for holding or shipping. BRIX index values between 6.0–7.99 indicate that lobsters may still be recovering from their prior moult and may still be of concern with respect to quality. BRIX levels at 8 or above are indicative of good quality, are more fully-meated lobsters and are likely more suitable for storage and shipping. It is noted that BRIX levels are not a prefect determinant of lobster quality and meat content (see also Thériault, Frame, Lane 2020). Table 1 below summaries the likelihood of the BRIX index interpretation in the ALMQ.

Table 1. BRIX Index Categories

Indicator: \	Blood Protein Level, BRIX index (units/ml)		
	Less than 6.0	*6.0 to 7.99*	*8 or greater*
Meat Content	Most likely low	Not likely fully-meated	Likely fully-meated
Shell Hardness	Potentially "soft"	Potentially "medium", still recovering from previous moult	Likely "hard"
Storage/Shipping	Not ideal	Concerns	Likely suitable
Quality	Poor	Concerns	Good

The manual assessment of shell hardness is a subjective indicator of lobster quality. Guidelines are in place for manual estimates of each sampled lobster's shell hardness using a subjective non-numeric scale of 2 ("soft"), 4 ("medium"), and 5 ("hard"). In 2020-2021, shell hardness measures are poorly correlated with BRIX levels and correlations are mostly not significantly different from zero for all sample location-dates. Shell hardness measures cannot be the lone determining factor in lobster quality prediction.

Moult stage analyses are carried out by analysing selected lobsters (30 lobsters from each sample of 150 lobsters per sampling location-date). Each lobster's moult status is determined by microscopic analysis of the lobster pleopod (swimmeret) as per the descriptions provided by Factor (1995) (Figure 3).

Moult stage levels of zero indicate no moult activity is pending. Advanced moult stages (Stages 3+) indicate the moult is approaching. Pleopod analysis in female lobsters may also indicate the onset of the egg-bearing cycle.

Figure 3. View of lobster pleopod under microscope.

2. Sampling Survey Information in 2020-2021

The objective of the ALMQ project was to develop a monitoring program, based on biological indicators of moult-timing, lobster quality measures, and environmental conditions, in order to predict the quality of lobsters at the start of the lobster commercial fishing season in LFAs 33 and 34. This program requires a combination of continuous at-sea quality monitoring (preseason as well as in-season confirmation of results) as well as the development of a prediction model incorporating historical data records for in-season quality. In addition, and consistent with the processes affecting lobster quality, the program would also benefit from a long-term data series for bottom seawater temperature. The following paragraphs describe the information obtained from the 2020 preseason survey and the 2021 in-season survey.

Figure 4: Drawing blood for refractometer

In 2020, a total of 6,940 preseason lobster samples were taken over the 4-month period from August 4 to November 17, a period of approximately 16 weeks. For the in-season survey of December 2020 and January 2021, a total of 2,250 lobster samples were taken in 8 in-season trips over 8 dates for each of the sample location-areas.

Over the survey, minimal by-catch appeared in the traps, especially as the lobster counts increased (in most locations) toward the latter part of the preseason survey from October through November. In general terms, over all location-areas sampled, it is noted that BRIX levels observed at the beginning of the survey in August deemed to be 'average', generally dropped off as more berried females, soft shell, and "weak" lobsters started appearing more often in the traps (through October). However, as the weeks went by in the survey, a noticeable shift from higher to lower lobster counts for inside areas was occurring, while lower to higher counts of lobster began appearing in corresponding outside locations along with increased BRIX levels and reductions in soft and weak lobsters.

Inside areas over all 4 locations averaged 18.5 Fathoms in depth; outside areas over all 4 locations averaged 43 Fathoms in depth. These data are summarized in Table 1 - 2020 Preseason and 2021 In-season Sampling Survey Information Summary below.

Preseason sampling resulted in total catches of 23,870 lobsters for an average of 11.5 lobsters per trap over the 52 preseason dates. In-season sampling resulted in total catches of 3,950 lobsters for an average of 4.3 lobsters per trap over the 8 in-season dates. Overall average for individual lobsters of the BRIX index was 8.38 units/ml in the 52 preseason sample location-dates. The BRIX index for the 8 in-season sample location-dates was 9.15 units/ml or 9% higher on average than the overall preseason average. With respect to the high BRIX index values of the season ending location-dates, the average preseason ending sample date BRIX index for the 8 locations is 10.5 units/ml or 14% higher than the average in-season BRIX index.

Sampling Location	Area	2020-2021 Sampling Date*	Total Harvested Count (#)	Numbers of Samples (#)	%Soft/ %Weak	Average BRIX levels (units/mL)
St. Mary's Bay	Inside	August 25	290	150	0%/2.67%	7.91
		September 10	262	150	2%/2.67%	7.79
		October 06	550	150	0%/6.67%	6.44
		October 20	440	150	0%/6.67%	7.30
		November 04	329	150	0%/1.33%	9.69
		November 17	362	150	0%/2.67%	11.29
		December 21*	440	300	0.3%/0%	9.66
		January 9*	395	300	0%/1%	10.07
	Outside	August 24	30	27^	0%/0%	9.97
		September 09	68	61^	0%/0%	8.40
		October 05	544	150	1.3%/6.67%	6.38
		October 19	607	150	0%/12%	6.52
		November 05	796	150	0%/2%	10.17
		November 15	691	150	0%/1.33%	10.44
		December 19*	332	300	0%/0%	9.14
		January 26*	137	150	0%/0%	10.87
TOTALS	Preseason: In-season: All:	52 preseason 8 in-season 60 total dates	23,870 3,950 27,820	6,940 2,250 9,190	Weighted Ave: 1.4%/10.4% 0.13%/0.26% 1.2%/8.1%	Overall Ave: 8.38 units/ml 9.15 units/ml 8.47 units/ml

*Underlined table value denote In-season samples for Yarmouth and St. Mary's Bay sampling locations only.
^Weather related challenges during these periods prevented sampling of the 150 lobster protocol.

Berried (egg-bearing) females were examined again in the 2020-2021 survey. Each of the 52 location-date preseason combinations captured an average of over 5 berried females or approximately 2.5% (270) of all female lobsters captured (10,851) during the preseason survey. The inclusion of in-season berried females over 60 location-dates averaged 2.75% (357) of all 12,977 female lobsters in the total catch. Berried female analyses recorded carapace size, clutch fullness, egg stage and condition. Analyses of berried females data are provided in detail in this report in Section 3.2 below.

2.1   Sampling Protocols

During the 2020-2021 lobster sampling program, the following project outcomes were achieved:

- At-sea quality monitoring – successful observations of 8 locations and 60 sampling dates;
- Development of pre-season prediction report for industry – as reported in Mattock, Mulock, and Lane (2020) summary report released on November 24, 2020;
- In-season quality sampling – successful completion of 8 sampling location-dates in December 2020 and January 2021;
- Temperature data collection (pre-season and in season) – incomplete: no temperature data were analysed in the 2020-2021 sampling program;
- Lobster tagging program – not initiated in the 2020-2021 sampling program;

2.3   2020-2021 Report on Conditions and Collections

In the past, weather conditions, described by strong winds and a blustery sea state, presented great challenges for scheduling sampling days. Sampling during the months of October and November is typically difficult as there were weeks in southwest Nova Scotia where it is expected that only a small window of moderate weather would allow for gear to be set and sampling to occur.

In 2020, preseason lobster samples were taken over the approximately 16-week period from August 4 to November 17. Weather conditions over the 52 preseason trips completed in 2020 were generally quite favourable with light winds and calm seas.

Approximately six times during the survey, weather conditions presented challenges when traps were initially deployed resulting in fewer lobsters for the overall count on the first haul. However, in only 9 of the 52 trips were there fewer than 150 samples achieved as sought (see also Table 1 above). Survey vessel captains spoke of how the weather was much more conducive for data collection this year as opposed to the 2019-2020 sampling period including, warmer sea temperature and air temperature.

The start of the LFA 33 and 34 commercial lobster fishing season – originally scheduled for Monday, November 30 – was delayed for eight days (one of the longest delays in the LFAs' history) until Tuesday, December 8, 2020 (Dumping Day) due to unfavorable weather conditions. But, once the fisherman had the gear offloaded the weather settled considerably for the remainder of December. Despite the interruption in the beginning of the commercial season, the weather overall for December and January was relatively fair and noticeably warmer for these months compared to previous years. The in-season sampling days for Yarmouth Inside and Outside areas, and St. Mary's Bay Inside and Outside areas were of light winds and calm seas assisting in the completion of the ALMQ survey with ease.

Due to the ongoing fisheries dispute in southwestern Nova Scotia in the Fall of 2020, lobster sampling activities were temporarily disrupted between September 21 to November 1 in several areas. Coldwater Lobster Association took cautionary steps to ensure the safety of all participants in the survey and temporarily suspended sampling activities in Lobster Bay, Yarmouth Bay and St. Mary's Bay during this period. A total of six preseason trips were initially postponed and ultimately, two final inside areas samples in Yarmouth Bay and St. Mary's Bay were not completed as planned. These areas were instead designated as in-season sampling locations and resulted in 8 additional samples for the two inside and two outside areas in Yarmouth Bay and St. Mary's Bay. These in-season samples were taken in December 2020 and January 2021 (see also Table 1 above).

It continues to be recommended that vessels be chosen for the preseason survey that do not involve captains who may be interested in participating in other fisheries during the preseason sampling period. In 2020-2021, captains have been strongly committed to the preseason lobster sampling survey which greatly simplifies the sampling schedule. As well, having additional vessels on standby if the event that the participating captain cannot deploy at their scheduled times is helpful to ensure that all required sampling dates are met.

Preseason sampling provides a snapshot of lobster quality in selected locations of LFA 33 and LFA 34. Sampling is conducted from depths ranging from 6 fathoms (Port La Tour Inside) to 80 fathoms (St.

Mary's Bay Outside). Therefore, it does not provide an indication on the quality of lobsters caught outside the selected areas of outside the noted depth range. During the commercial lobster season in LFAs33 and 34 there is a significant percentage of vessels fishing in depths greater than 80 fathoms. It is desirable for future survey sampling to consider the impact of fishing lobster at depth however, current project operating costs and vessel steam times do not make this possible.

3. Preseason Sampling Data in 2020-2021

Since 2006, preseason and in-season data have been collected annually on lobsters in selected harvest areas of LFA33 and 34. Previously, these data have been used in each year independently to estimate average moult times over all subareas and to predict lobster quality on the basis of overall moult conditions at the start of each season. In hindsight, the estimate of a general moult time was subject to considerable uncertainty and spatial and temporal variation such that the generalized estimate was not conducive to industry decision making

Alternatively, the existence of the longitudinal database from the 2006 season onward permits direct comparison of pre-season and corresponding in-season samples over multiple years. Knowing the precise history of quality results in the commercial fishery over past years enables comparison of current results to actual quality of the past, e.g., 2012 was a high quality year whereas 2016 was a very poor-quality year. New preseason sampling results that compare well with the 2012 preseason sampling data should therefore be a good indicator of quality to follow. Similarly, preseason sampling that compares more closely to the 2015 preseason sampling data would suggest a prediction for poor quality to follow in the commercial fishery.

To this end, we endeavour to evaluate historical annual quality status and then apply statistical analyses to compare the preseason survey results with past quality performance. This analysis begins with a view of the distribution of the lobster data collected as presented below.

3.1   Lobster Counts Sampling for 2020-2021

The at-sea sampling data were compiled into the '*Preseason Prediction Report*' and distributed by Coldwater Lobster Association to the lobster industry and government funders on November 24, 2020 (Mattock, Mulock, and Lane 2020). This report contained summary information on the lobster counts harvested and sampled. Specifics on the 2020-2021 lobster counts are provided in more detail here. This information includes: (1) section 3.1.1: lobster count location graphics per trap by sex, average BRIX indicator value, moult stage analysis, and manual hardness measures; and (2) section 3.1.2: comparative location results of catch per trap, and average BRIX indicator value. Complete graphics information on lobster counts sampling is presented in Appendix A of this report.

3.1.1 Location graphics (4 pages) - lobster counts (harvested and sampled) information (Appendix A.1)

Location graphics results of lobster counts from the sampling program are as follows:
   a. Counts of lobster harvested per trap by sex for Inside & Outside areas
   b. Counts of lobster harvested per trap and BRIX for Inside & Outside areas
   c. Counts of lobster sampled by Moult Stage - Outside area
   d. Counts of lobster sampled by Hardness and BRIX for Inside & Outside areas

Appendix A.1 – "Harvested and Sampled Lobster Count Location Graphics" contains the complete graphic record of this information for all locations, inside and outside areas by preseason and in-season sampling dates. Selected graphics are presented in this report below.

(a) Counts of lobster harvested by Location per Trap by Sex for Inside and Outside Areas

The catch per unit trap (CPUT) fishing effort measure provides general information about the propensity of available lobster to enter the trap. As noted by the example of Yarmouth (inside and outside areas) in Figure 6 below, CPUT measures for inside areas tend to decline over the course of the preseason sampling dates and continue to fall during the commercial season. For outside areas, preseason CPUT tends to rise over the preseason and then fall during the commercial season suggesting a movement of lobster from inside to outside areas over the preseason period August-November. High CPUT for males and females in the outside areas during the later preseason sample dates are indicative of good catch rates at the start of the commercial season in these areas. The exception to this in the 2020 preseason sampling program is Lobster Bay which experienced high CPUT rates from the beginning of the sampling period in both inside and outside areas (see also Lobster Bay graphic (a) in Appendix A, p.A3).
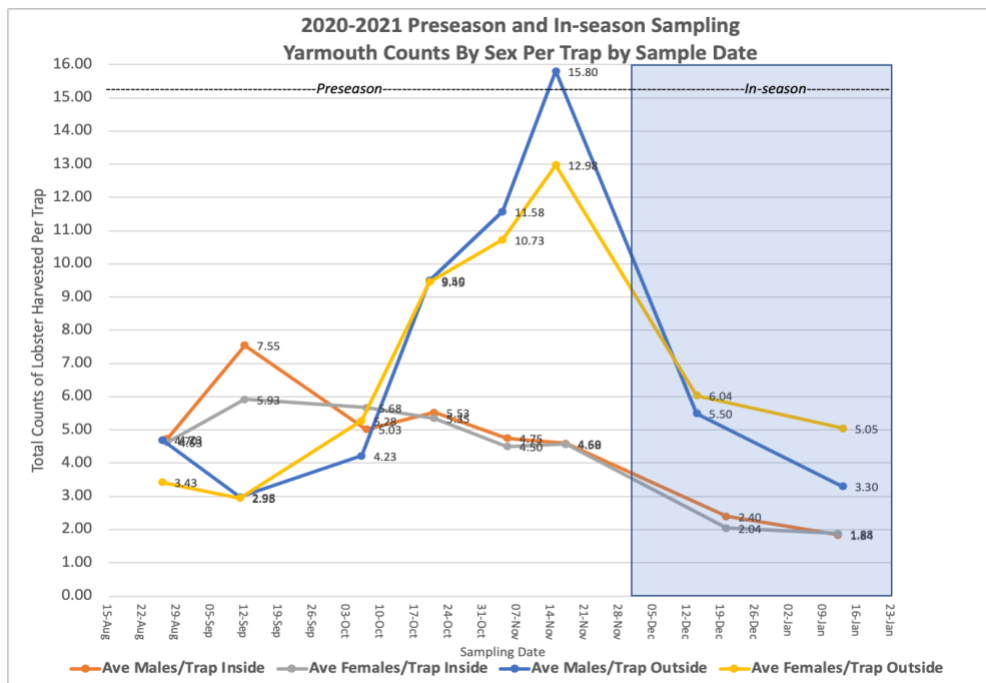
Figure 6. Yarmouth Harvest Counts by Sex per Trap for Sample Dates

(b) Counts of lobster harvested per trap and BRIX for Inside & Outside areas

Preseason BRIX levels changed dynamically over the course of preseason sampling in all areas. Figure 7 below indicates the BRIX category levels for Lobster Bay. These values indicate initial declines in BRIX values from the early preseason sampling dates (August through September) followed by general improvement in BRIX over the period from October through November. In most sampling locations, outside area BRIX averages were higher than inside areas early in the sampling period. This reversed later in the period – as for Lobster Bay in Figure 7 below – when average BRIX values in the inside areas exceeded those of the outside areas. (See also Appendix A, pp.A.2 through A.5.)
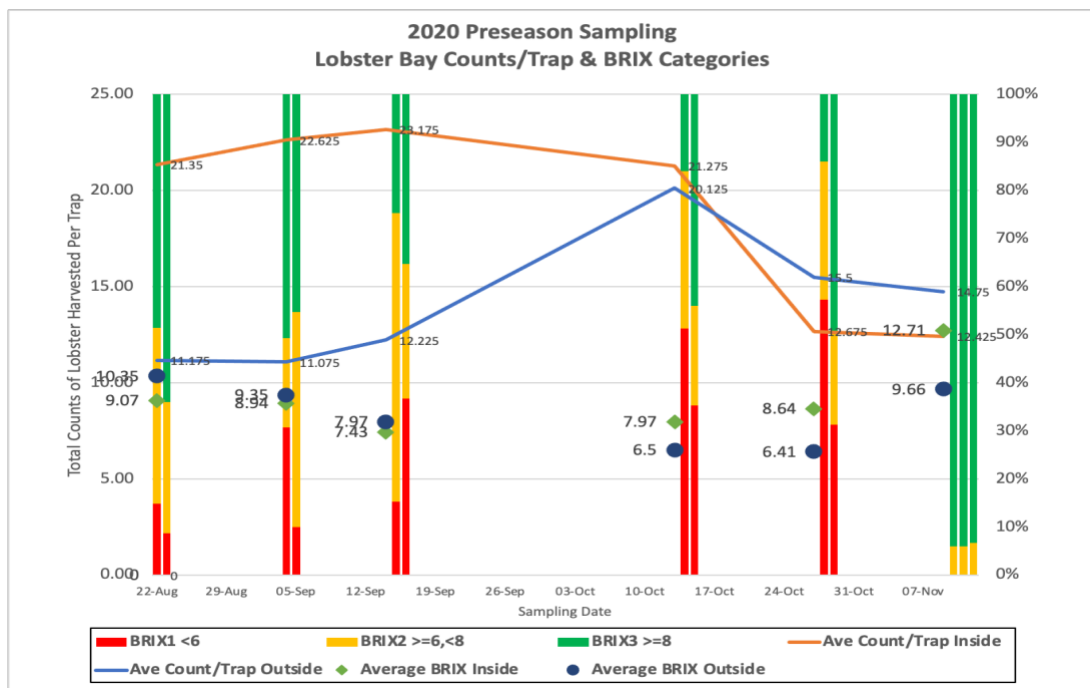
Figure 7. Lobster Bay Harvested Counts per Trap and BRIX Indicators

(c) Counts of lobster sampled by Moult Stage – Pleopod Data

The 2020 preseason sampling program examined selected lobster's moult staging through the analysis of lobster pleopod (swimmeret) data under the microscope. As per Factor (1995, p.223), lobster moult categories are defined as: (1) Stage 0 (C4); (2) Stage 1-2.5 (D0); (3) Stages 3+ (D1). Moult stage information was recorded in 30 vials for each of the 8 sampling areas and for each preseason and in-season sampling date.

Figure 8 below shows the moult stage counts data by stage for Port La Tour outside area preseason sampling. Early sampling efforts in Port La Tour were unable to record significant lobsters in the outside areas fished. Consequently, pleopod samples were small and resulted in few samples but with high BRIX. By the end of September, more lobsters were appearing in the Port La Tour outside areas resulting in

the full complement of 30 vials of pleopods. As for all areas and samples, Figure 8 illustrates that the majority of samples in the remainder of the preseason and into the in-season sampling period resulting in a clear majority (80% or greater) of Stage 0 (no moult activity) samples. Stage 3+ observations were limited to approximately 1 observation every second sample.

Among the 30 pleopod samples per location-date, roughly 3-5 vials recorded evidence of cement glands in female lobster ("CS", Factor's D2 and D3). In these cases, zero moult activity stage is observed. (See also Appendix A, pp.A.2 through A.5 for moult stage information for all sampled locations.)
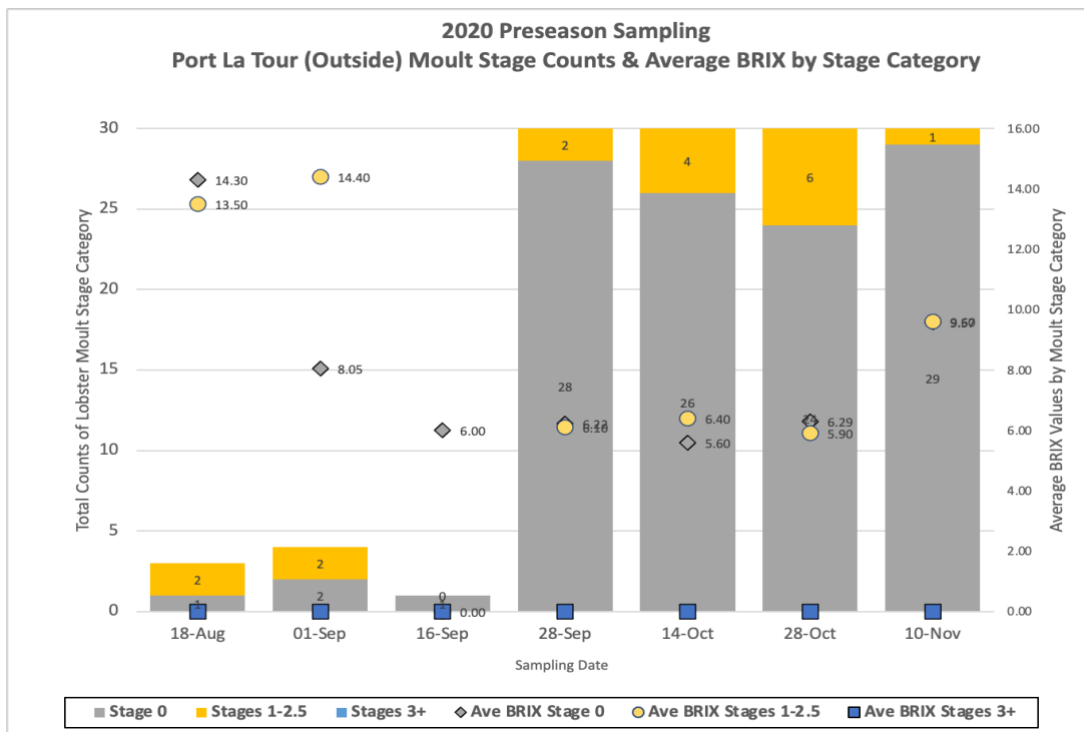
Figure 8. Port La Tour Moult Stage Counts and Average BRIX by Stage Categories

(d) Counts of lobster sampled by Hardness and BRIX for Inside & Outside areas

Lobster sampling included recording the manual hardness scale found by gently squeezing the lobster's carapace. In the 2020 sampling program, the evidence is that more than 90% of all sampled lobsters are recorded as "Hard" (scale "5"). This measure is not well-correlated with the much wider variation in lobsters' corresponding BRIX index values. Figure 9 below provides the hardness measure results for St. Mary's Bay inside and outside sampling dates.

It is acknowledged that "Medium" and "Soft" lobster have lower BRIX but when only 5% or fewer are judged to be in this category, it is difficult to see how this can be useful as a designator of "quality" (i.e., meat content). The lack of variability in the hardness scale measure does not provide additional useful information. This scale may be used to eliminate only a small proportion (less than 5%) of lobster as acceptable quality for storage and shipment.
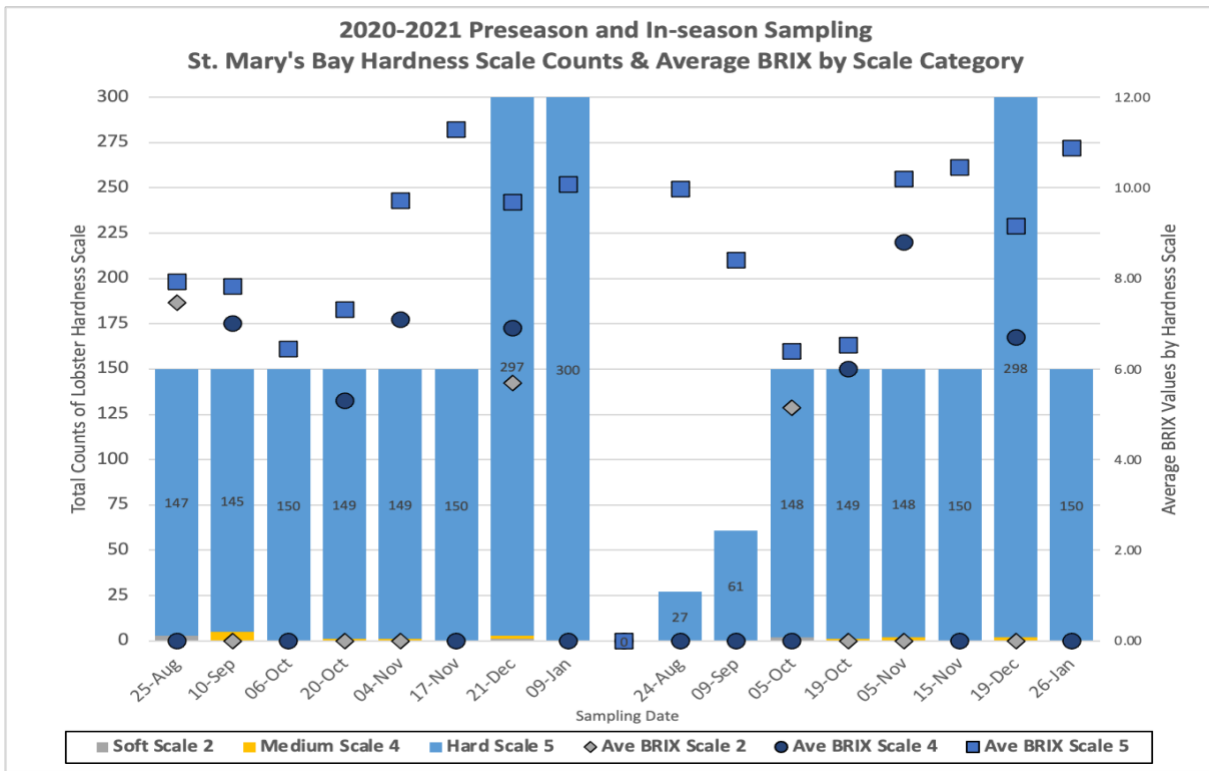
Figure 9. St. Mary's Bay Hardness Counts per Trap and Average BRIX by Category

Appendix A.1, pp.A.2 through A.5, also contains similar hardness information for all sampled locations.

3.1.2   Comparative Location graphics (1 page) - lobster (harvested and sampled) counts information:

Comparative location graphics from the sampling program are as follows:
   a.   Counts of lobster harvested per trap by location for Inside areas
   b.   Counts of lobster harvested per trap by location for Outside areas
   c.   Average BRIX per sample by location of Inside areas
   d.   Average BRIX per sample by location of Outside area

Appendix A.2 – "Comparative Location Graphics" contains the complete graphic record of this information. Selected graphics are presented in this report below. Selected graphics from Appendix A.2 are presented in this report below.

(a) Counts of lobster harvested per trap by location for Inside areas

As noted above, catch per unit trap (CPUT) fishing effort measure provides general information about the propensity of available lobster to enter the trap. The trend across all inside locations is for CPUT to fall from the beginning of the preseason sampling period and into the in-season period. Differences do exist among the different inside locations. Notably, Lobster Bay has twice the CPUT than the other

locations over the preseason sampling periods. As well, Lobster Bay inside CPUT appears to show an upswing near the end of preseason sampling – as does Port La Tour. As expected, CPUT for inside areas during in-season sampling follows off appreciably and represents approximately 25% of peak CPUT overall. See also Appendix A.2, p.A.6(a) for the inside area graphic by location.

(b) Counts of lobster harvested per trap by location for Outside areas

The trend across all outside areas location is for CPUT to rise as lobster move into their associated outside areas over the preseason as is indicative of a movement of lobster form inside to outside areas over the sampling period August to November. Once the commercial season begins, CPUT falls appreciably by as much as 75% for most locations. This is illustrated by the declining trend seen at the end of the preseason period in Figure 10 below.
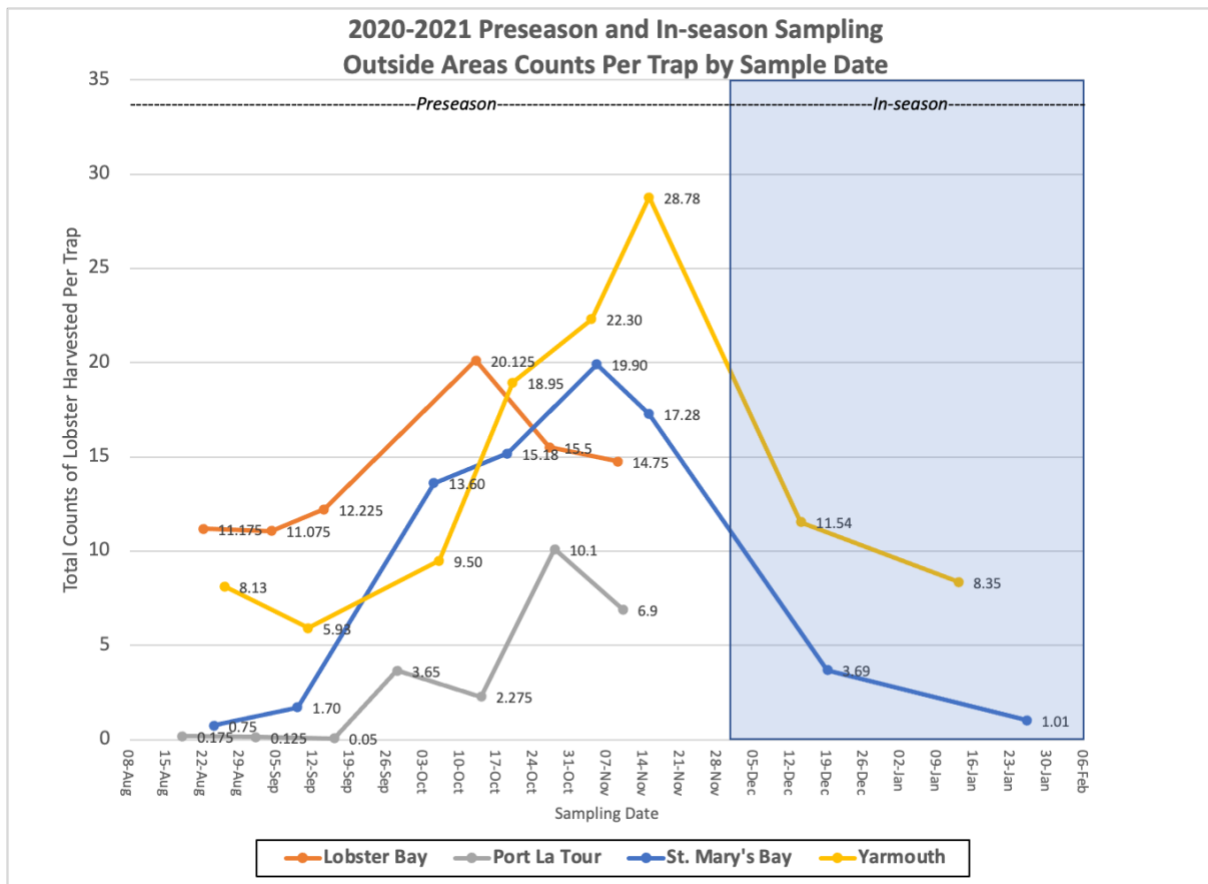
Figure 10. Outside Areas Harvested Counts per Trap by Sample Date

In is notable that Port La Tour and St. Mary's Bay initially lag in CPUT at the start of the preseason sampling with CPUT rates that are only 20% (or less) compared to that of Lobster Bay and Yarmouth. In later sampling, St. Mary's Bay rebounds to 'catch up' with Yarmouth and to surpass Lobster Bay. However, Port LA Tour remains at approximately 50% CPUT of the other areas. See also Appendix A.2, p.A.6 for more details.

(c) Average BRIX per sample by location of Inside areas

Comparison of average BRIX levels in the location samples are also provided in Appendix A.2, p.A.6(c) for the inside areas. Generally, in 2020-2021, BRIX values are u-shaped with locations experiencing a dip in the middle of the preseason sampling period (September and October), followed by a significant rise thereafter and finally a levelling off into the in-season sampling periods. Lobster Bay has the highest overall average BRIX values and Port La Tour has lowest at 50-75% below Lobster Bay BRIX. Inside BRIX values are relatively close among the 4 sampling locations compared to the differences in the inside areas CPUT measures noted above. See also Appendix A.2, p.A.6(c).

(d) Average BRIX per sample by location of Outside areas

Similar to the inside areas, the outside areas also experience a dip in the middle of the preseason sampling period (September and October), followed by a rise thereafter and a levelling off into the in-season sampling periods. This dynamic behavior with respect to BRIX is illustrated in Figure 11 below. (See also Appendix A.2, p.A.6(d)).

Figure 11. Outside Areas Average BRIX by Sample Date

3.2   Berried Females Sampling for 2020-2021

Data on berried females were compiled as part of the preseason and in-season sampling program in 2020-2021. This report contains summaries of the berried females information on selected harvested lobster counts. This information in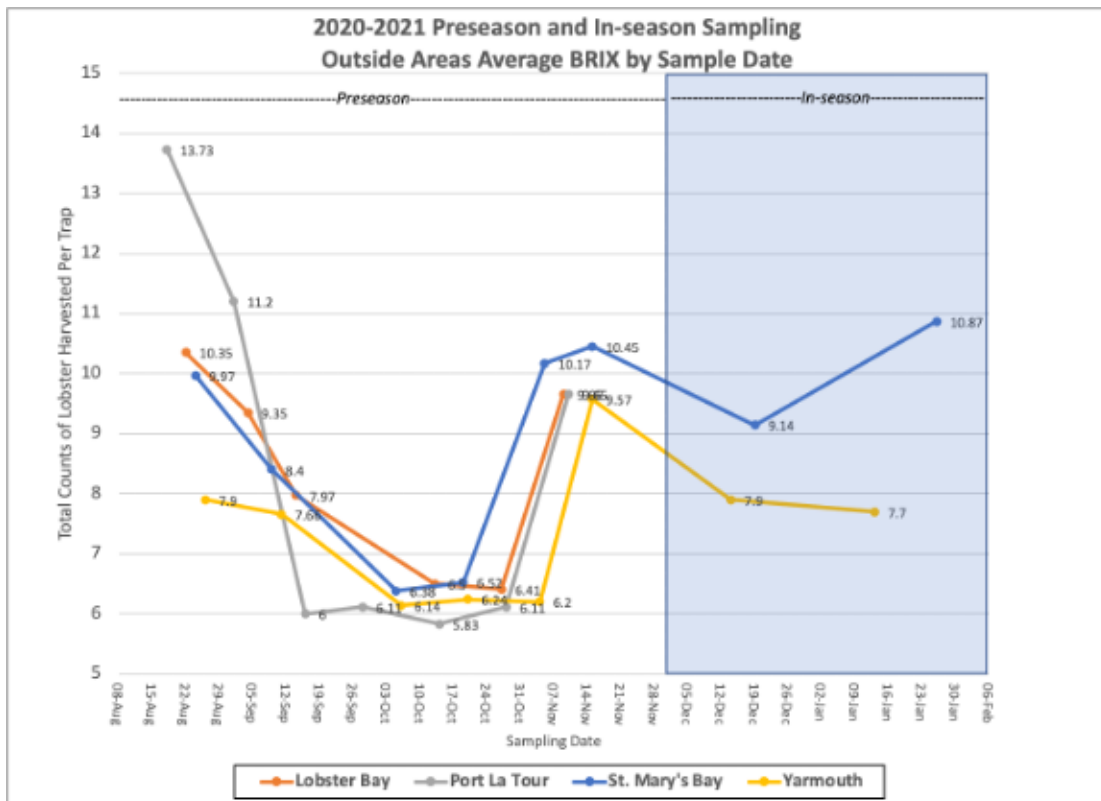cludes: (1) section 3.2.1: location graphics (4 pages) – berried females sampled counts information; and (2) section 3.2.2: comparative Location Graphics (2 pages) – berried female sampled stage counts information.

Appendix B.1 – "Location graphics – berried females sampled counts information Graphics" contains the complete graphic record of this information for all locations, inside and outside areas by preseason and in-season sampling dates. Selected graphics are presented in this report below.

3.2.1   Location graphics (4 pages) – berried females sampled counts information

1) Berried females sampled and percent of harvest for Yarmouth Inside & Outside areas

The sample of berried females in Yarmouth – as for most areas – is variable with respect to counts of lobsters in Stages 1-2. There are zero observations of Stages 3 or 4 over the preseason and in-season sampling periods. Stage 1 counts tend to increase over time after the August sampling periods. Similarly, the percentage of berried females in the sample of all harvested females in Yarmouth increase from a low of 0% to 5% in the January in-season final sample. See also Appendix B.1, p.A.8(1).

2) Berried females sampled and percent of harvest for Lobster Bay Inside & Outside areas

As for Yarmouth, Lobster Bay berried females counts increase to end October and then fall precipitously in November. The count of berried females in Lobster Bay represents the largest counts over all locations reaching a maximum of nearly 50 berried females or 33% of females in the sample by the end of October preseason sample. The increasing counts tend to belong to Stage 1. Stage 2 counts (5 berried females) are greatest in the November final preseason samples in Lobster Bay. See also Appendix B.1, p.A.8(2).

3) Berried females sampled and percent of harvest for Port La Tour Inside & Outside areas

Berried female counts in Port La Tour are the smallest of all areas with total counts of less than 4 in any sample. In the early months of preseason sampling (August), only Stage 1 counts occur, whereas in later periods (October and November), only Stage 2 counts are recorded. The percentage of berried females in the sample of all harvested females in Port La Tour fluctuate but tend to increase from a low of 0% in September to a high of 3% in October and fall off to 0.5-2% in the ending samples of November. See also Appendix B.1, p.A.8(3).

4) Berried females sampled and percent of harvest for St. Mary's Bay Inside & Outside areas

Figure 12 below illustrates the berried females report for St. Mary's Bay. The counts of berried females tend to increase steadily from lows of 0-2% in August to highs of 6-14% into the in-season sample dates of January.
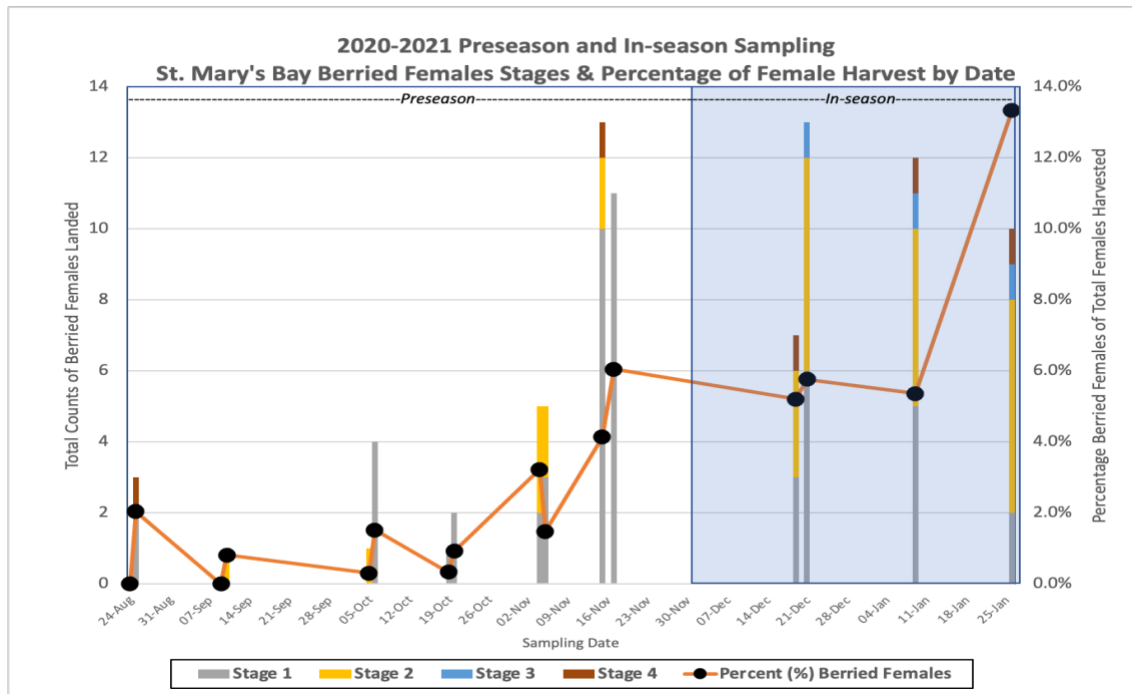
Figure 12. St. Mary's Bay Berried Females Stages and as Percent of Harvested Females

St. Mary's Bay also exhibits differences in berried female counts in inside versus outside areas. Inside samples have higher incidences of berried females counts than their corresponding outside samples. This occurs in every inside-outside sample pairing with one exception – the samples of November 4 (outside) and November 5 (inside). Finally, the percentage of berried females in the sample of all harvested females in St. Mary's Bay increase from a low of 0% in September to a high of nearly 14% at the in-season sample at end January. See also Appendix B.1, p.A.8(4).

3.2.2 Comparative Location Graphics (2 pages) – berried female sampled stage counts information:

a) Berried females Stage 1 counts for Inside areas

Stage 1 berried females represent the largest counts of all stages for the inside areas. The Stage 1 inside area counts fluctuate by location with Lobster Bay counts the greatest of all areas (reaching levels of 36 and 45) and Port La Tour the lowest (near zero over the sampling periods). It is difficult to determine a trend in Stage 1 counts for any location. See also Appendix B.2, p.A.9(a).

b) Berried females Stage 1 counts for Outside areas

Figure 13 illustrates the graphic of Stage 1 counts for outside areas by location. As for Stage 1 inside counts, there is no evident trend in outside counts for any or all areas over the sampling periods and into

the in-season samples. Lobster Bay and St. Mary's Bay have larger counts for the outside areas. Port La Tour berried female counts in the outside areas are negligible. See also Appendix B.2, p.A.9(b).
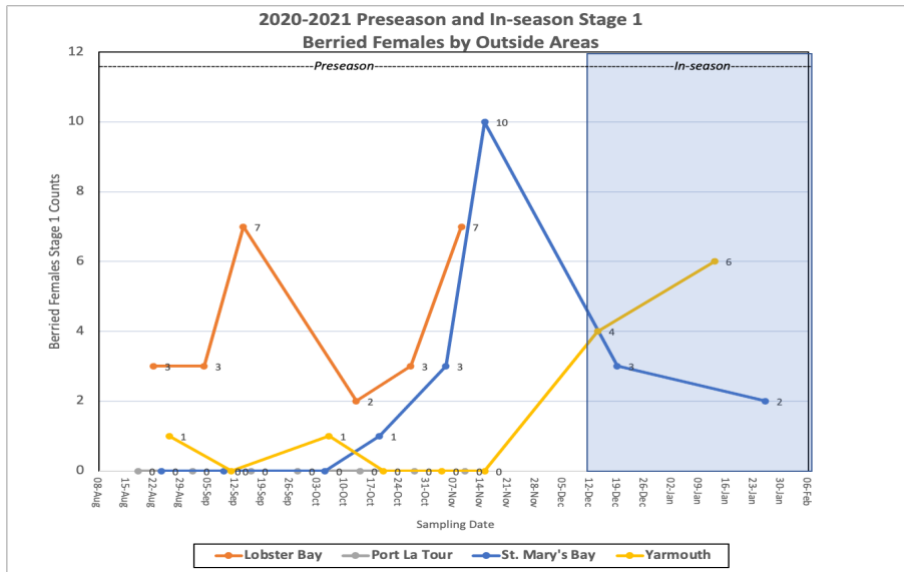
Figure 13. Outside Areas Berried Females Stage 1 Counts

c) Berried females Stage 2 counts for Inside areas

Stage 2 berried female counts (Figure 14) in the inside areas are less than the corresponding Stage 1 counts. As for the Stage 1 inside areas, Stage 2 inside area counts are dominated by Lobster Bay observations followed by St. Mary's Bay and then Yarmouth. Port La Tour Stage 2 counts are negligible. See also Appendix B.2, p.A.10(c).
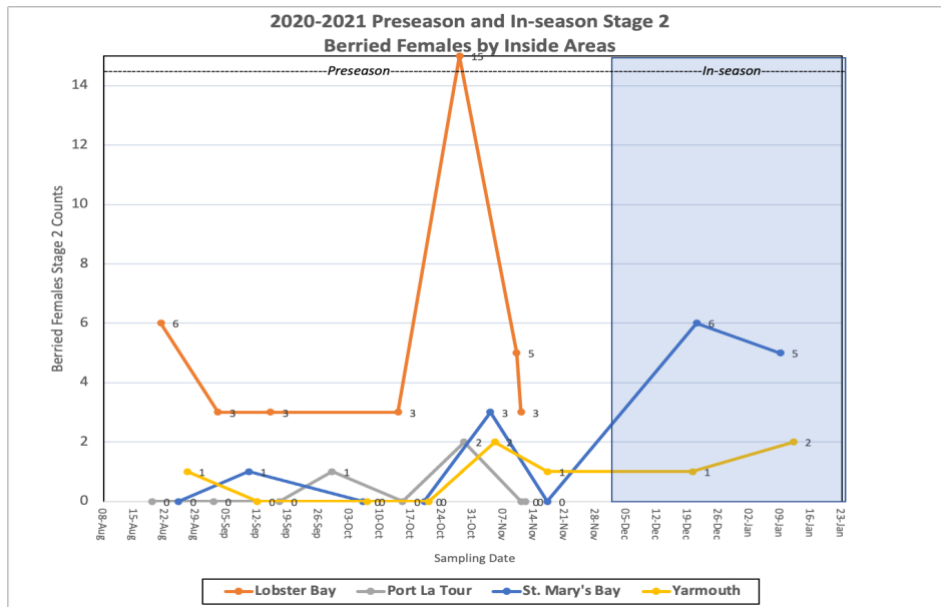

Figure 14. Inside Areas Berried Females Stage 2 Counts

d) Berried females Stage 2 counts for Outside areas

There are few observations of berried females in Stage 2 for the outside areas with counts of 6 or fewer for all sample preseason and in-season periods. The few counts demonstrate fluctuations from zero and make it difficult to identify a trend by location or for all locations. See also Appendix B.2, p.A.10(d).

e) Berried females Stages 3 & 4 counts for Inside areas

The counts of berried females observed to be in Stage 3 or 4 for inside areas over the sampling dates are very few and fluctuate from zero to a maximum of 4 in any one sample date (Yarmouth and Port La Tour). No time trends are evident in these data. See also Appendix B.2, p.A.11(e).

f) Berried females Stages 3 & 4 counts for Outside areas

As for the inside areas, the counts of berried females observed to be in Stage 3 or 4 for outside areas over the sampling dates are very few and fluctuate from zero to a maximum of 6 in any one sample date (Lobster Bay, August). See also Appendix B.2, p.A.11(f).

In general, the counts of berried females over all locations and areas are expected to be low for the higher Stages 3 and 4 during the preseason and the in-season sampling period. Appreciable counts of higher moult stages climb significantly and are expected to be seen before the sampling period and after the end of the commercial season in LFAs33 and 34 when the eggs are released during the months of June and July and before the August sampling dates. Low counts of Stage 3 and 4 berried females are more of a concern after the end of the commercial season. They are not a concern for the start of the season. Similarly,

3.3. Temperature Data

It is generally recognized that collecting continuous data on bottom temperatures on the lobster fishing areas will provide valuable data and assist in making prediction models for the lobster moult cycle as a key determinant of lobster behaviour. In 2020-2021, temperature was not collected as part of the lobster sampling surveys.

In future surveys, deploying additional temperature loggers to cover a wider range of depths across the two LFA's and for the different depths of the inside and outside areas is being considered. The data loggers that were deployed during a portion of the ALMQ survey are no longer available. Alternative temperature collection means are being explored for future sampling programs.

3.4 Sites Summary Report

The at-sea sampling summary report for 2020 was compiled as the 'Lobster Quality Preseason Sampling Program–Southwest Nova Scotia LFA33 & LFA34, Preseason Summary Report' (Mattock, Mulock, and Lane 2020) and distributed by Coldwater Lobster Association to the lobster industry and government funders on November 24, 2020. This report contained information on the proportion of soft shell as well as the proportion of low blood protein lobsters for each of the identified sampling areas in the preseason survey.

The 2020 preseason sampling results in LFAs 33 and 34 indicated that lobsters landed at the start of the 2020-2021 season in South West Nova Scotia, were of overall very good quality. When compared to past years of the preseason surveys, the last survey points overall average BRIX results in 2020 were superior to all years of the survey's history since 2006.

In all 8 survey locations, inside and outside areas for the final (early to mid-November dates) survey observations, were reporting zero incidence of lower category BRIX values, i.e., all lobsters surveyed in mid-November have BRIX values exceeding 6. Moreover, over 90% of all lobsters surveyed by mid-November had "Good" BRIX values in the high range of 8 units/ml or greater. These results were not thought to be spurious or a function of biased equipment or readings that have been regularly tested and verified. Nevertheless, the consistent overall rebound in all areas was remarkable and does not permit a clear explanation as to why this event had occurred.

It is instructive to note the anecdotal evidence from the Bay of Fundy lobster opening in LFA35 on October 15, 2020 whereby high quality lobsters at the beginning of the season have been followed by deteriorating lobster quality as the season progressed. It is similarly unlikely that the high BRIX observations of the mid-November observation of this survey in the LFA33 and 34 sampling areas will be maintained throughout the 2020-2021 season.

Finally, it is acknowledged that years when preseason quality has been observed to be high, e.g., 2012 and 2013, catch per trap has been relatively lower. Conversely, seasons of relatively lower preseason quality lobster (2015, 2017) have resulted in relatively higher catches. Analyses of these hypotheses are explored and presented below.

3.5   Recent Data Variability and Trend

For several years now, samples have become more and more variable. Consequently, the sample data make the estimate of moult time and start of season quality predictions more and more unreliable. In addition, there appears to be a trend – attributed, in part, to the warming of water temperatures throughout the Gulf of Maine – of changes in lobster moult activity and an overall deterioration of lobster quality (i.e., less fully-meated lobsters) especially in the early post-moult season harvests of LFA34.

Figure 15 below compares the blood protein level (BRIX) groups for poor quality (Red – BRIX values < 6.0), medium quality (Orange – BRIX values between 6.0 and 8.0), and good quality (Green – BRIX values of 8.0 and greater) for 2012 to 2018. The pattern of declining BRIX values over the years indicates the apparent decline trend in shell hardness (quality) indicated here for Yarmouth Outside from 2012 to 2016 and the slight improvement trend from 2017 to 2018.

Evidence of these trends has become the basis for the annualized comparison methodology of the preseason and in-season sampling analysis described below.

4 Analysis of Preseason Sampling Data in 2020-2021

4.1   Methodology

The analysis compares sample annual data of the past years with the preseason sample data of the current year and determines the best match of a past year with the current year's sampling observations. The most closely matched historical year then becomes the basis for predicting the status and quality of lobster at the start of the current commercial fishery.

For example, consider Figure 15 below for Yarmouth Outside 2012-2018, from sampled data 3-4 weeks before the start of the respective season. The indication from these results is that 2016 is a low-quality year in a series of declining quality beginning in 2012. Since 2012, the poor BRIX values (Red category) are seen to be increasing from a low of 2.4% (2012) to a high of 31.4% (2016). Similarly, the extent of the high-quality BRIX values (Green category) decreases from a high of 75% (2012) to a low of 22% (2016).

Since 2016, preseason quality indicators show improvement. The 2016 low of high BRIX values (Green) of 22% rises again from 28.7% (2017) to 31.2% in 2018. Similarly, but less dramatically, the poor BRIX category (Red) falls from 31.4% in 2016 to 25.4% in 2017 with a similar value in 2018 of 28.8%. Based on this graphic, there may be expectation – assuming the annual trend since 2016 continues for Yarmouth Outside – that the 2019-2020 preseason season will mark improved quality over the lows of 2016 with marginal improvement over 2017 and 2018. In fact (see also Figure xx below), the 2018-2019 preseason sampling season yielded high BRIX values (Green) of only 18%, and low BRIX values (Red) of 7.3% for an overall average BRIX of 7.2 – a decline of -11% versus the 2018-2019 average BRIX of 8.1.
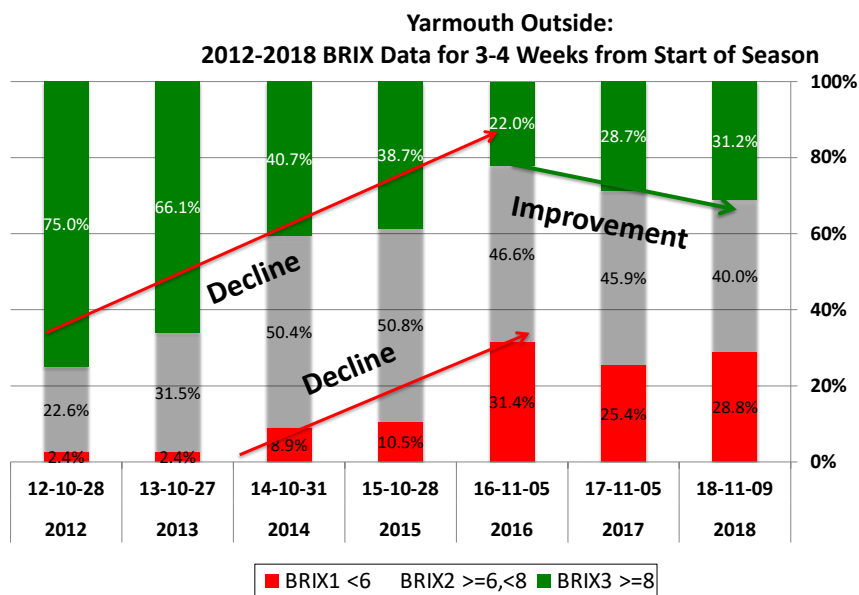

Figure 15. Example: Yarmouth BRIX Categories for 3-4 weeks prior to season start 2012-2018

4.2   Site Results and Predictions

The following pages present the survey breakdown of the 2020 BRIX results for each of the 8 lobster sampling locations. These results summarize the results of the 'Lobster Quality Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report' (Mattock, Mulock, and Lane 2020) provided to industry collaborators in November 2020 prior to the start of the 2020-2021 commercial season.

Graphic results are provided for the BRIX categories and BRIX means for 2020 sampling location and dates. Results are also provided by location compared to previous years' samples (from 2012 onward) for the approximate same preseason periods: 3-4 weeks prior to the start of the commercial season. Comparative annual graphics allow the reader to compare recent years of BRIX levels leading up to the start of the current 2020-2021 season as per the methodology described in Section 4.1 above. The sections below enable predictions on start of season lobster quality based on these comparisons.

Appendix C - Preseason Sampling Summary Report Predictions presents the summary predictions for each of the 8 location-areas as provided in the 'Lobster Quality Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report' (Mattock, Mulock, and Lane 2020).

4.2.1   Yarmouth Inside

The 2020 preseason survey results for Yarmouth Inside show the percent of "Good" category lobsters (BRIX>=8) declined until mid-October and then rebounded to very high proportions in November attaining levels of over 90% by the last survey dates in mid-November (the 5th and the 17th).
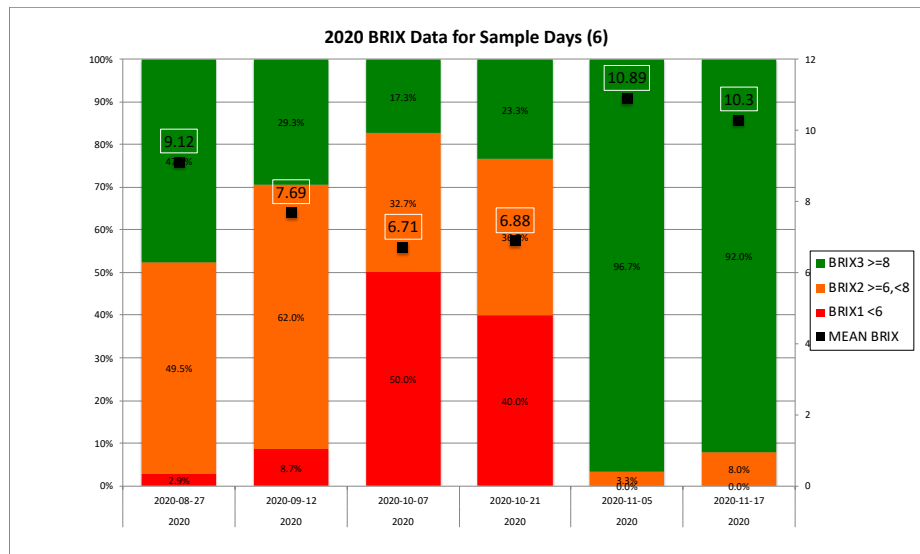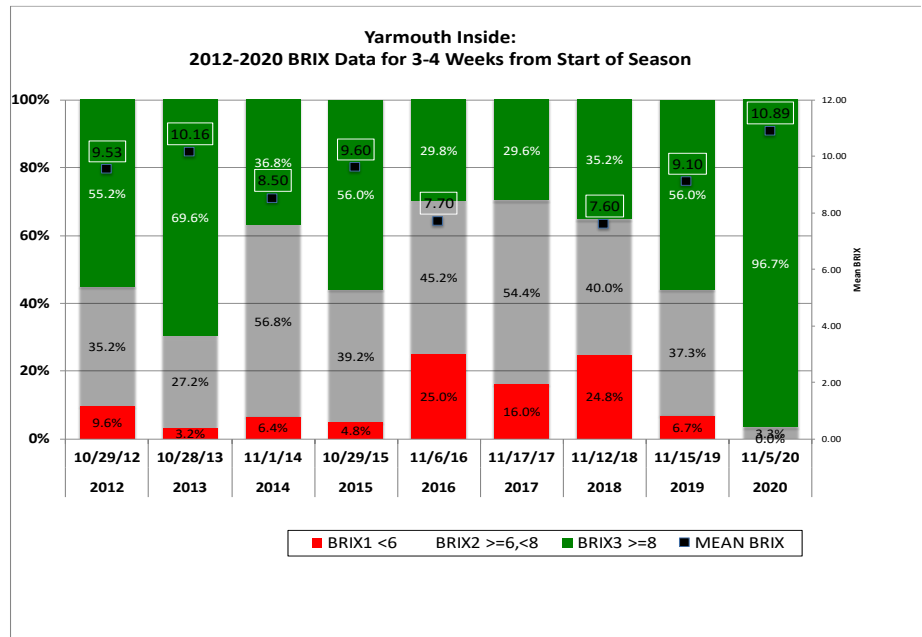

Figure 16. Yarmouth Inside 2020 Preseason Sampling BRIX Indicators

The 2020 3-4 weeks from the start of the commercial harvest season opening results are not easily comparable to past years. The 2020 observations show remarkably high quality results with all BRIX values for sampled lobster greater than 6, the low BRIX category.

Figure 17. Yarmouth Inside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

The November 5 sample records the highest average BRIX level in the 2020 series (with a slight drop off in the subsequent November 17 observations) and the largest percentage of high BRIX category lobsters (97%) in the entire series to date. The rapid turnaround of the BRIX observations this area are grounds for caution. In the absence of a trend and based on a single data observation at the end of the time series, the evidence of a sustained high quality for Yarmouth Inside remains promising but uncertain.

4.2.2 Yarmouth Outside

As for Yarmouth Inside, the 2020 preseason survey results for Yarmouth Outside show the percent of "Good" category lobsters (BRIX>=8) declined throughout October and until mid-November then rebounded to very high proportions attaining levels of over 90% by the last survey dates in mid-November.
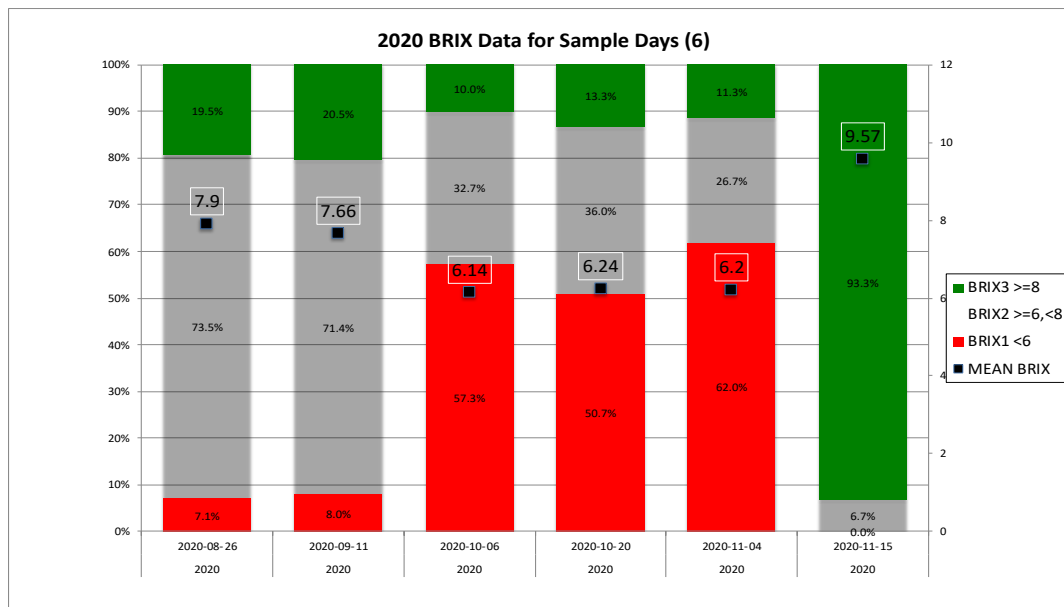

Figure 18. Yarmouth Outside 2020 Preseason Sampling BRIX Indicators

The 2020 Yarmouth Outside results in the graphic for 3-4 weeks from the start of the commercial harvest season opening show a similar trend over time of declining high BRIX and increasing low category BRIX values from 2012 to 2020 as was the case for the 5-6 week graphic above. In the 2020 sample, the percent of "Good" BRIX category lobsters (>=8) was only 11% in the November 4 sample. This percent represents the lowest "Good" category for 3-4 weeks before the season in the 2012-2020 time series. As well, the November 4 sample records the highest percent of "Poor" BRIX category lobsters (<6) at 62% in the entire series from 2012-2020.

Yarmouth Outside:
2012-2020 BRIX Data for 3-4 Weeks from Start of Season

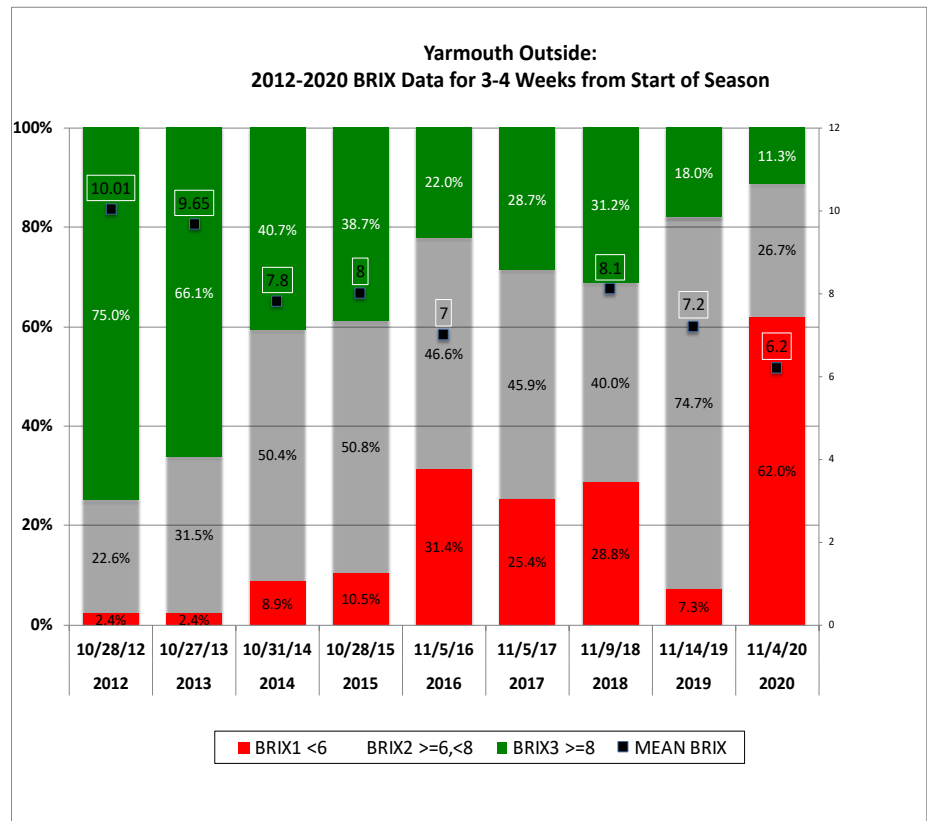| Date	BRIX1 <6	BRIX2 >=6,<8	BRIX3 >=8	MEAN BRIX
10/28/12 2012	2.4%	22.6%	75.0%	10.01
10/27/13 2013	2.4%	31.5%	66.1%	9.65
10/31/14 2014	8.9%	50.4%	40.7%	7.8
10/28/15 2015	10.5%	50.8%	38.7%	8
11/5/16 2016	31.4%	46.6%	22.0%	7
11/5/17 2017	25.4%	45.9%	28.7%	
11/9/18 2018	28.8%	40.0%	31.2%	8.1
11/14/19 2019	7.3%	74.7%	18.0%	7.2
11/4/20 2020	62.0%	26.7%	11.3%	6.2

Figure 19. Yarmouth Outside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Taking into account these relatively poor observations for the November 4 sample for this area, the subsequent reporting of the last 2020 survey point of November 15 is surprising. The 2020 Yarmouth Outside results for November 15 show a rebound toward high quality whereby the percent of "Poor" category lobsters (<6) was 0%, i.e., no low BRIX lobsters were found in the November 15 sample. As a consequence, the percentage of high BRIX (>=8) for November 15 was a remarkable 93%, i.e., of the 150 samples in this area on this date, 140 attained BRIX values of 8 or more. The rapid turnaround of this area are grounds for caution. It may be conjectured that the inside to outside movement of lobster over this time period (November 4 to November 15) may contribute to a BRIX gain. However, it is acknowledged that, in the absence of a trend, and based on a single data observation at the end of the time series, the evidence of a sustained high quality for Yarmouth Outside remains uncertain.

4.2.3   Lobster Bay Inside

The 2020 preseason survey results for Lobster Bay Inside show the percent of "Good" category lobsters (BRIX>=8) remained relatively stable from August through October. However, the proportion of low category BRIX doubled during that same period (from 14% in August to 31% by end October). However, in November the observed high BRIX values for this area exceeded all previous observations with zero incidences of any low BRIX lobster in the samples.
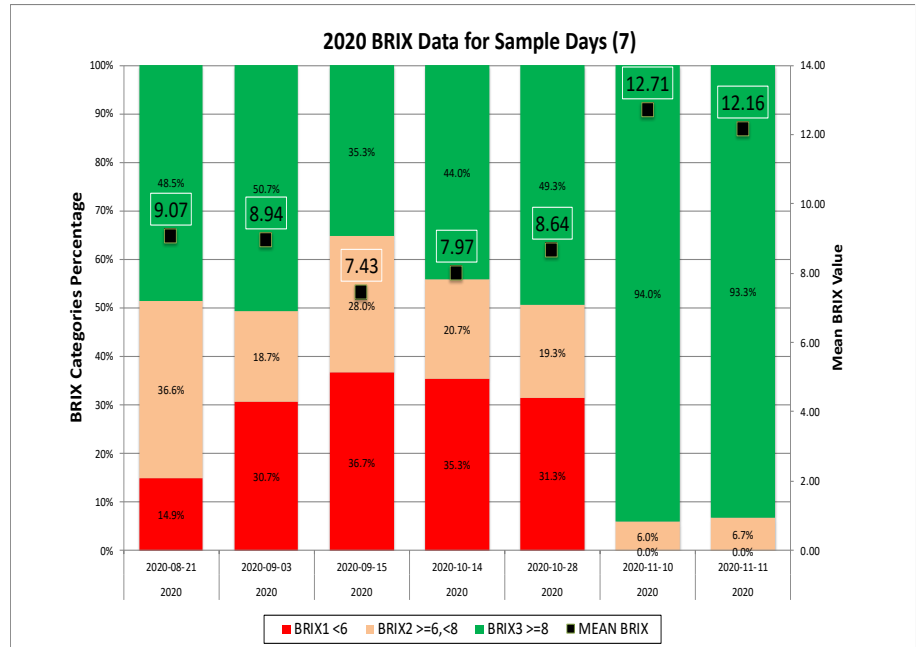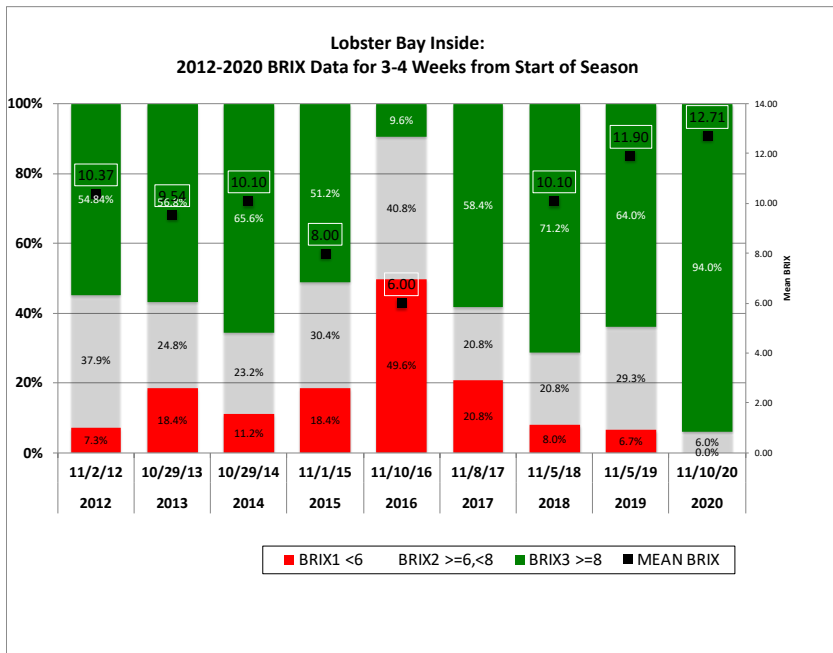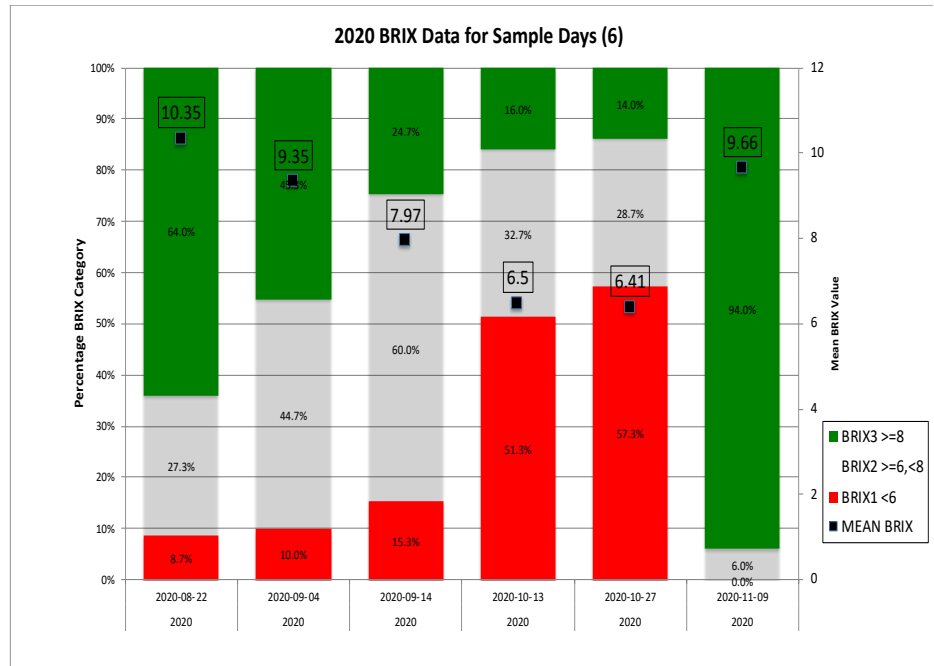

Figure 20. Lobster Bay Inside 2020 Preseason Sampling BRIX Indicators

The 2020 Lobster Bay Inside results for 3-4 weeks from the start of the commercial harvest season opening show the strong difference of the 2016 observations. They also show that the 2020 sample year is remarkably positive with the highest BRIX "Good" category (at 94%) and the lowest "Poor" category BRIX (at 0%) in the entire series. As such, the 2020 observations continue the positive high BRIX trend since the very weak 2016 observations culminating in the very high BRIX results of 2020.

The 2020 BRIX distribution is indicative of positive lobster quality for Lobster Bay Inside for the start of the 2020-2021 season.

Figure 21. Lobster Bay Inside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

4.2.4   Lobster Bay Outside

The 2020 preseason survey results for Lobster Bay Outside up to the end of October showed an evident trend toward declining "Good" BRIX values and increasing "Poor" BRIX values. However, sampling in this area in November revealed a remarkable rebound of lobster BRIX values. The sample of November 9, three weeks before the start of the commercial season, shows that the percent of "Good" category lobsters (BRIX>=8) exceeded 90% on that date and found zero samples of BRIX below 6.0. Given the evident trend in the area sample to November, this dramatic shift was not anticipated.

Figure 22. Lobster Bay Outside 2020 Preseason Sampling BRIX Indicators

The 2020 Lobster Bay Outside results in the graphic for 3-4 weeks from the start of the commercial harvest season opening show the percent of "Good" category lobsters greater than 8 was over 90% with a "Poor" (<6) category of 0% in the November 9 sample.
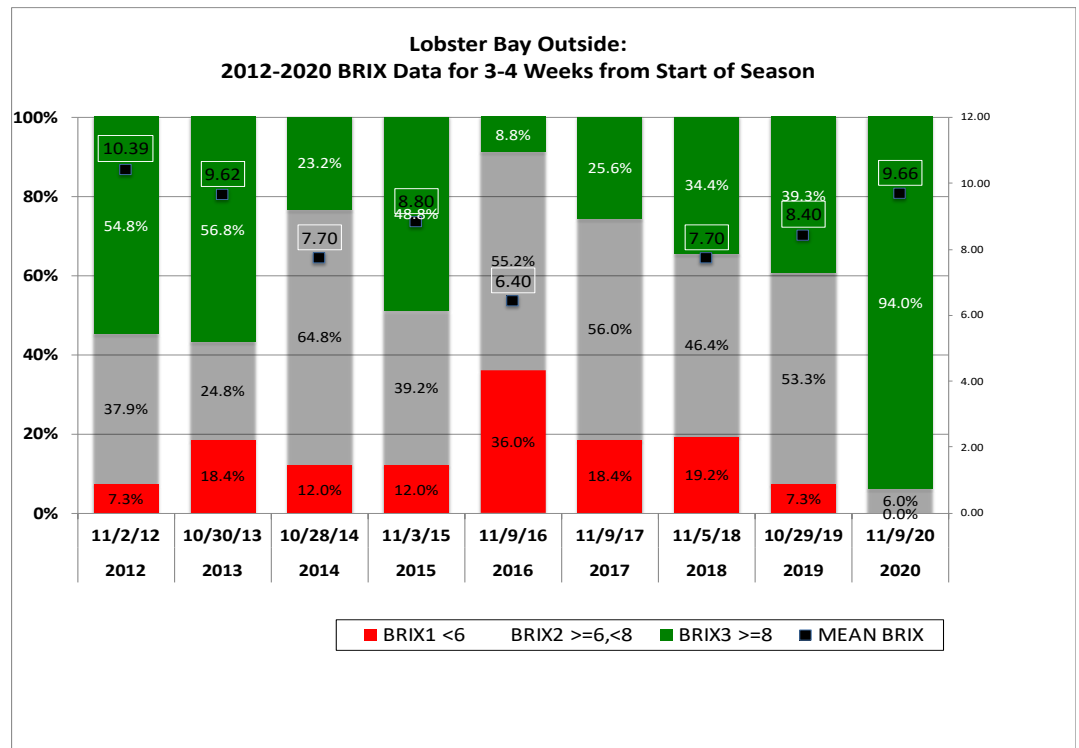

Figure 23. Lobster Bay Outside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

This shift continues the trend of improved BRIX levels since 2016 at 3-4 weeks prior to season opening. The 2020 values for this site are the best BRIX performance in the entire series from 2012 to 2020. These results are consistent with the rebound in November for the Lobster Bay Inside results and the BRIX gain may, in part, be attributed to inside to outside movement of lobster over the early November time period. However, it is also acknowledged that, in the absence of a trend, and based on a single data observation at the end of the time series, the evidence of a sustained high quality for Lobster Bay Outside remains uncertain.

4.2.5 Port La Tour Inside

The 2020 preseason survey results for Port La Tour Inside show improvement in BRIX category levels and mean values from mid-September into November 2020. The final 2 sample points for this area are one day apart (November 11 and 12) and they confirm the very high BRIX observations for both these samples. As such, the November samples are the best in the 2020 series with "Good" category lobsters (BRIX>=8) over 90% each day and zero "Poor" category observations (BRIX<6).
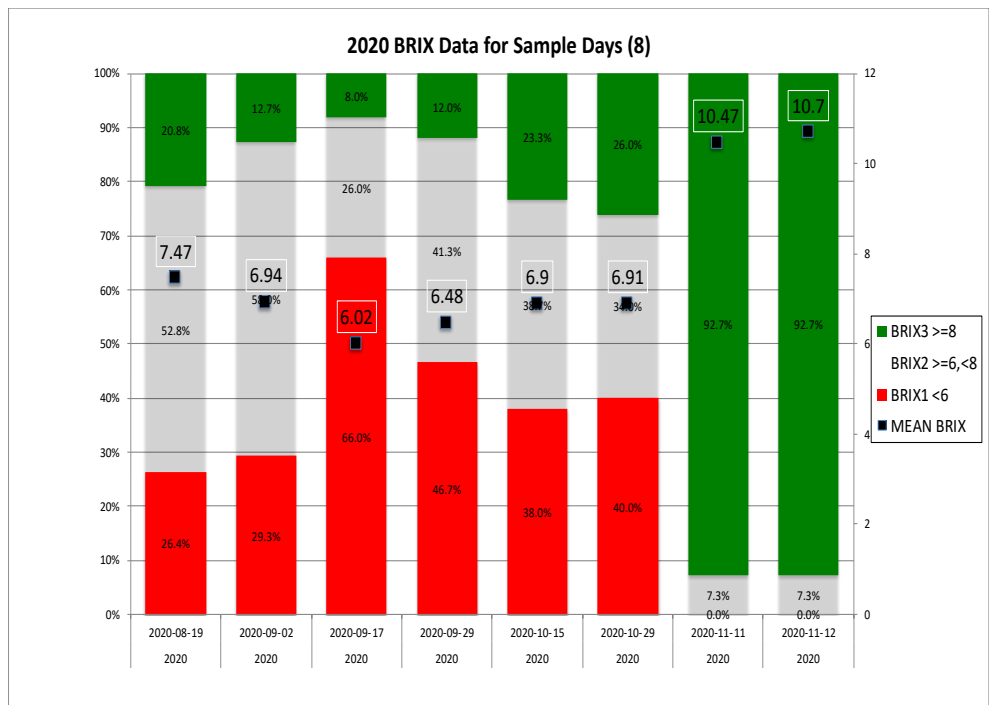

Figure 24. Port La Tour Inside 2020 Preseason Sampling BRIX Indicators

The graphic for 3-4 weeks before the opening of the season does not show any evident trend year-over-year in the 2012-2020 time series. However, the 2020 sample is clearly the best of the series with high BRIX category percentage of over 90% and zero low BRIX values observed. The 2020 results are thus comparable to the 2012 samples – a year of high quality and relatively lower abundance in this area.

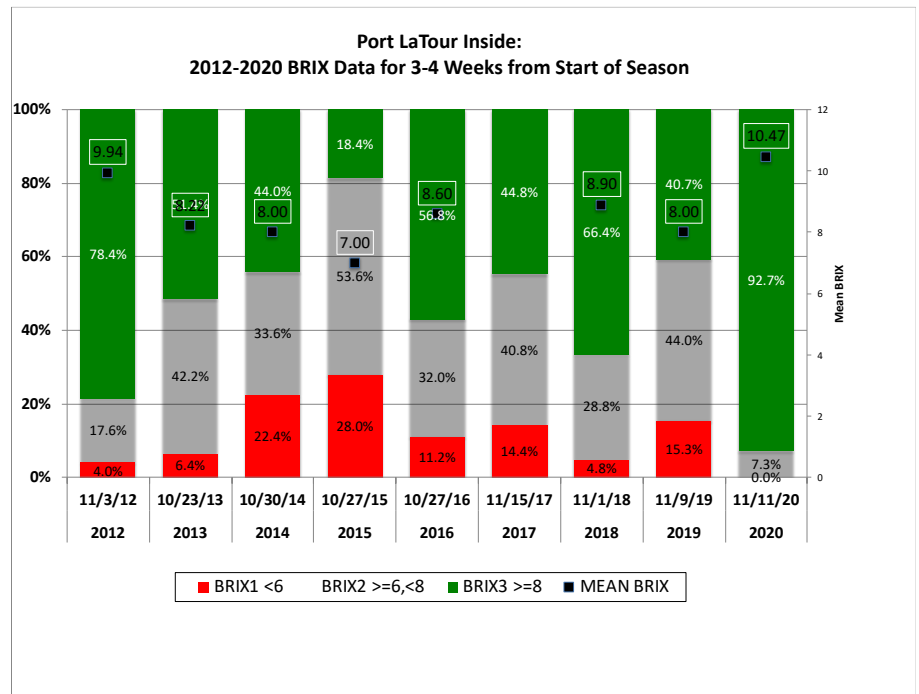The anticipation is that the 2020-2021 start of year harvest will be of very good quality.

Figure 25. Port La Tour Inside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

4.2.6   Port La Tour Outside

The 2020 preseason survey results for Port La Tour Outside show an initial worrying decline trend from August through October with a remarkable rebound of BRIX values in the final sample observation in early November. "Poor" BRIX values climbed to over 66% in mid-October sampling and "Good" BRIX effectively evaporated after a very strong initial showing in August and early September.
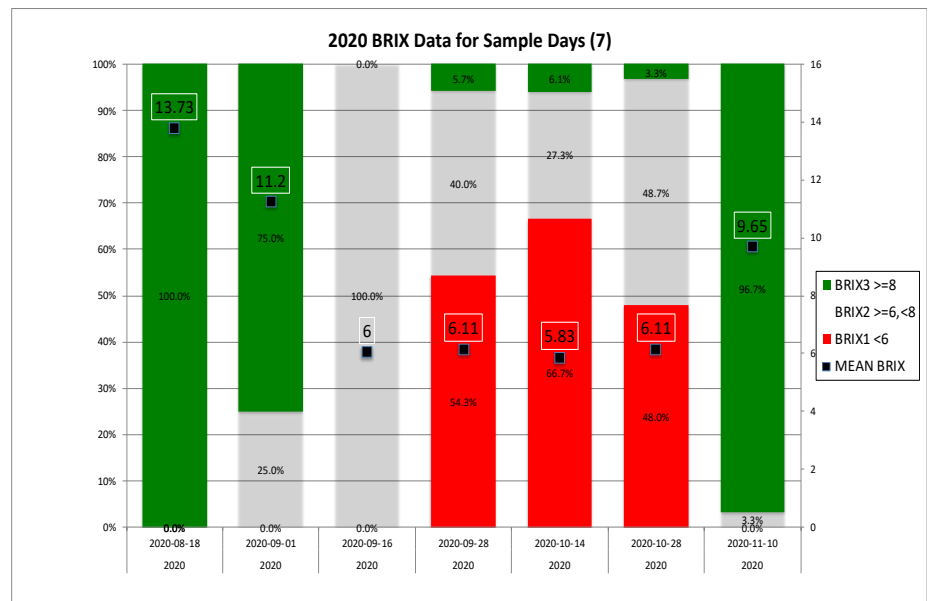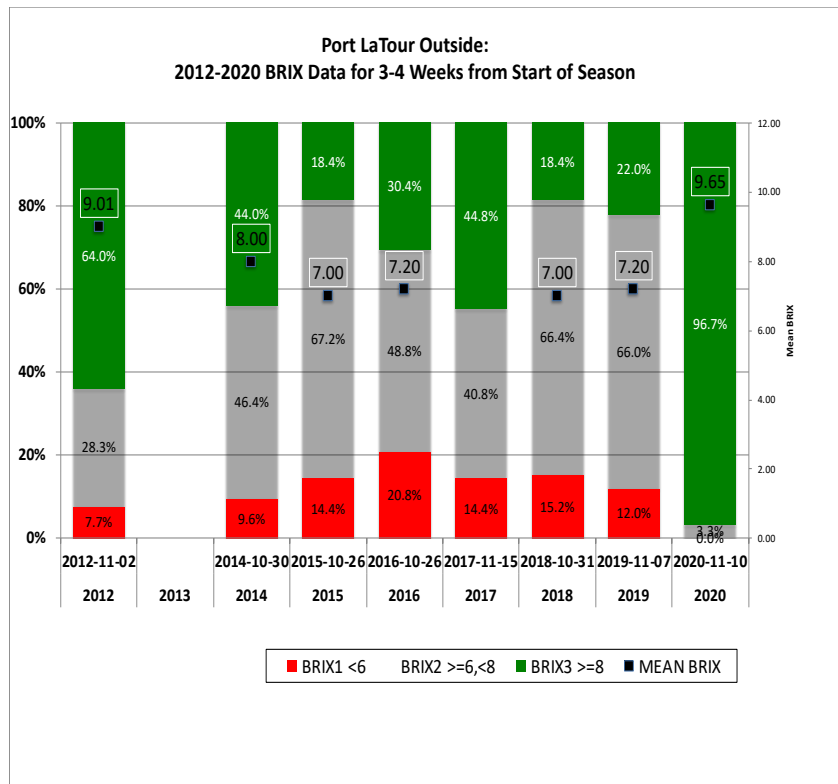

Figure 26. Port La Tour Outside 2020 Preseason Sampling BRIX Indicators

The results for Port La Tour Outside sampling exhibit a similar behaviour to the Port La Tour Inside results. For the case of 3-4 weeks before the start of the season, the 2020 sample data (for November 10) show a marked rebound in BRIX values. The 2020 sample point attains the highest "Good" category percentage of almost 97% with zero "Poor" category lobsters in the sample. As for Port La Tour Inside, the 2020 observations are clearly the best in the 2012-2020 series. These results are comparable only to the very good BRIX values observed in the 2012 series – as was the case for Port La Tour Inside.

Figure 27. Port La Tour Outside 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

4.2.7   St. Mary's Bay Inside

The 2020 preseason survey results for St. Mary's Bay Inside show an initial decline in BRIX from the initial end-August into early October followed by a marked improvement (rising "Good" BRIX values, and declining "Poor" BRIX values) from October into mid-November. The final two samples in November (4th and 17th) are the most positive with respect to rising BRIX in the 2020 series. As noted, the average BRIX values continue to climb from 6.4 units/ml in October to over 11 by November 17.
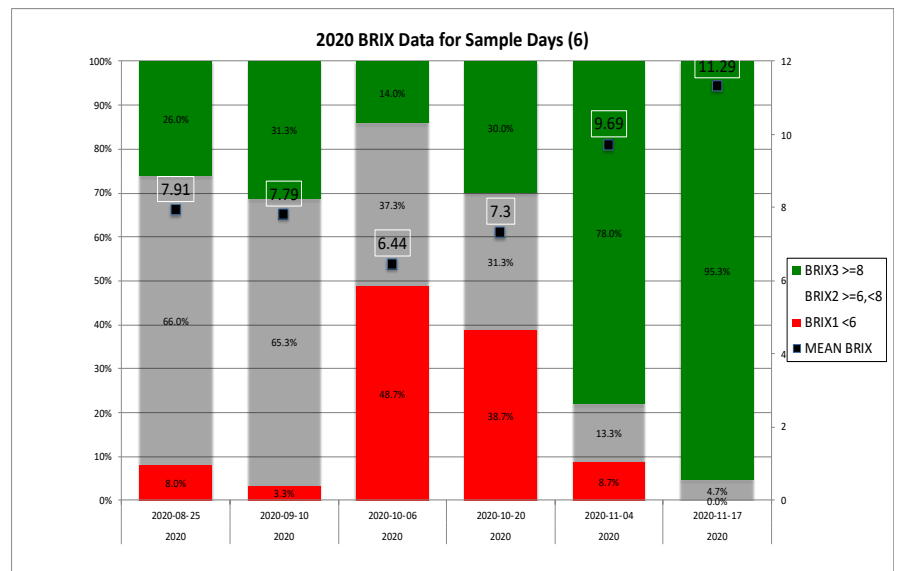

Figure 28. St. Mary's Bay Inside 2020 Preseason Sampling BRIX Indicators

Similarly, the annual trend in the graphic for 3-4 weeks prior to the start of the season appears to be shifting toward higher BRIX values as evidenced by the 2020 sample of November 4. The average BRIX of 9.69 exceeds all annual values in this series and lends to a positive prediction for good quality in St. Mary's Bay Inside for the 2020-2021 season..
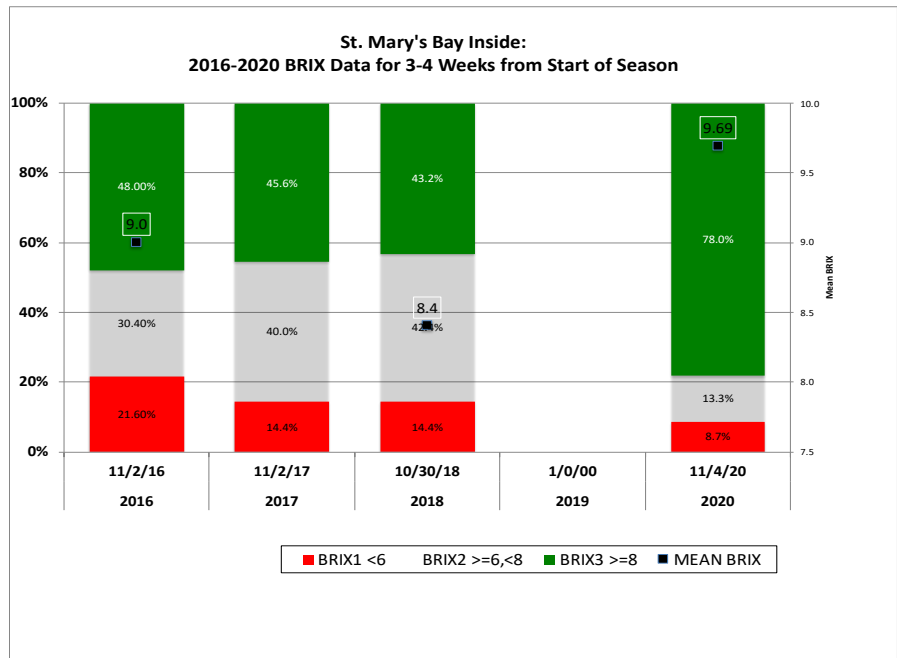

Figure 29. St. Mary's Bay Inside 2016-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

4.2.8 St. Mary's Bay Outside

The 2020 preseason survey results for St. Mary's Bay Outside show an apparent decline in BRIX valuations from the start of the survey at end-August through to mid-October. However, this trend was reversed with the sample results of November whereby observations of the "Good" BRIX category exceeded 95% in both the November 5 and November 15 sample dates. These sequential results can be said to confirm the positive BRIX rebond for this area and provide the basis for a robust quality outlook for St. Mary's Bay Outside.
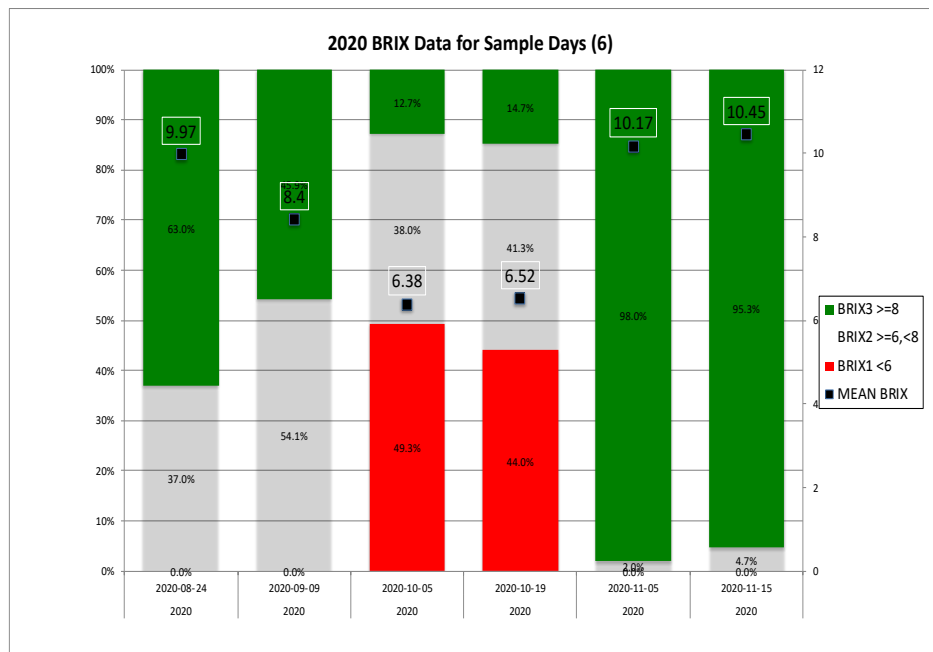

Figure 30. St. Mary's Bay Outside 2020 Preseason Sampling BRIX Indicators

The annual sample results for 3-4 weeks before the start of the season include the November 2020 positive sample.It can be stated that St. Mary's Bay Outside has been trending negatively since 2017 based on samples 3-4 weeks before the season with lower "Good" BRIX and higher "Poor" BRIX percentages by category. However, the remarkable positive observations (including 0% low BRIX observations and mean BRIX of over 10) for the two November 2020 samples turn this trend around completely. These results provide a positive quality outlook for St. Mary's Outside for the 2020-2021 start of the season.
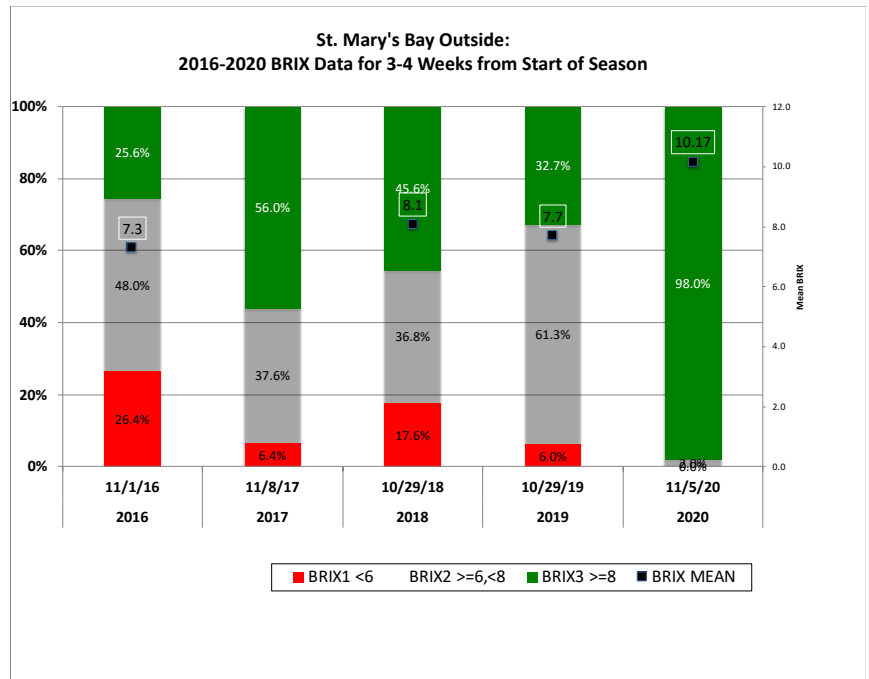
Figure 31. St. Mary's Bay Outside 2016-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

These results are also consistent with the rebound in November for the St. Mary's Bay Inside results. As such, the BRIX gain may be attributed to inside to outside movement of lobster over the early to mid-November time period. However, it is also acknowledged that, in the absence of a trend, and based on the November observations at the end of the time series, the evidence of a sustained high quality for St. Mary's Bay Outside remains uncertain.

5. In-season Sampling Data in 2020-2021

The 2020-2021 sampling program included 8 sampling location-dates that took place after the beginning of the commercial lobster fishing season (November 30, 2020) in LFAs 33 and 34. These samples were carried out in the last half of December 2020 (14th to 21st) and throughout January 2021 (9th to 26th).

5.1   Sampling Data

In-season samples took place in inside and outside areas of Yarmouth and St. Mary's Bay as summarized in Table 3 below. Additional samples (300 samples per location-date) over and above the preseason protocols (150 samples per location-date) were taken during these in-season sample dates.

Table 3. Summary of 2020-21 In-season Sampling Survey

Sampling Location	Area	2020-2021 Sampling Date	Total Harvested Count (#)	Numbers of Samples (#)	%Soft/ %Weak	Average BRIX levels (units/mL)
Yarmouth	Inside	December 20	533	300	0.7%/0%	8.60
		January 12	613	300	0%/0.7%	9.25
	Outside	December 14	623	300	0%/0%	7.90
		January 13	877	300	0%/0.3%	7.70
St. Mary's Bay	Inside	December 21	440	300	0.3%/0%	9.66
		January 9	395	300	0%/1%	10.07
	Outside	December 19	332	300	0%/0%	9.14
		January 26	137	150	0%/0%	10.87
TOTALS	**In-season:**	**8 in-season Location-dates**	**3,950**	**2,250**	**Weighted Ave: 0.13%/0.26%**	**Overall Ave: 9.15 units/ml**

In-season samples had improved overall BRIX indicators over all areas (9.15 versus 8.38 units/ml) and reduced %Soft and %Weak values (0.13%/0.26% versus 1.4%/10.4%). The following section compares the in-season BRIX category results with those for the preseason samples by the 2 locations and the inside/outside areas.

5.2   Preseason and In-season Comparison

The following graphs, Figures 32-35 show the preseason and in-season sample results for the BRIX indicators for each location-area as indicated in Table 3. These results compare the corresponding preseason samples and the in-season samples over the sampling period.

5.2.1   Yarmouth Inside In-season Results

There were 8 total sampling periods for Yarmouth Inside. As noted previously, the BRIX category pattern initially showed a decline from August to end October followed by a significant improvement in November at the end of preseason sampling period. (See also Section 4.2.1 – Yarmouth Inside.)

The two in-season samples, as had been expected, are less positive than the November results but nevertheless show high overall average BRIX values (8.65 and 9.25 units/ml), as indicated in Figure 32.
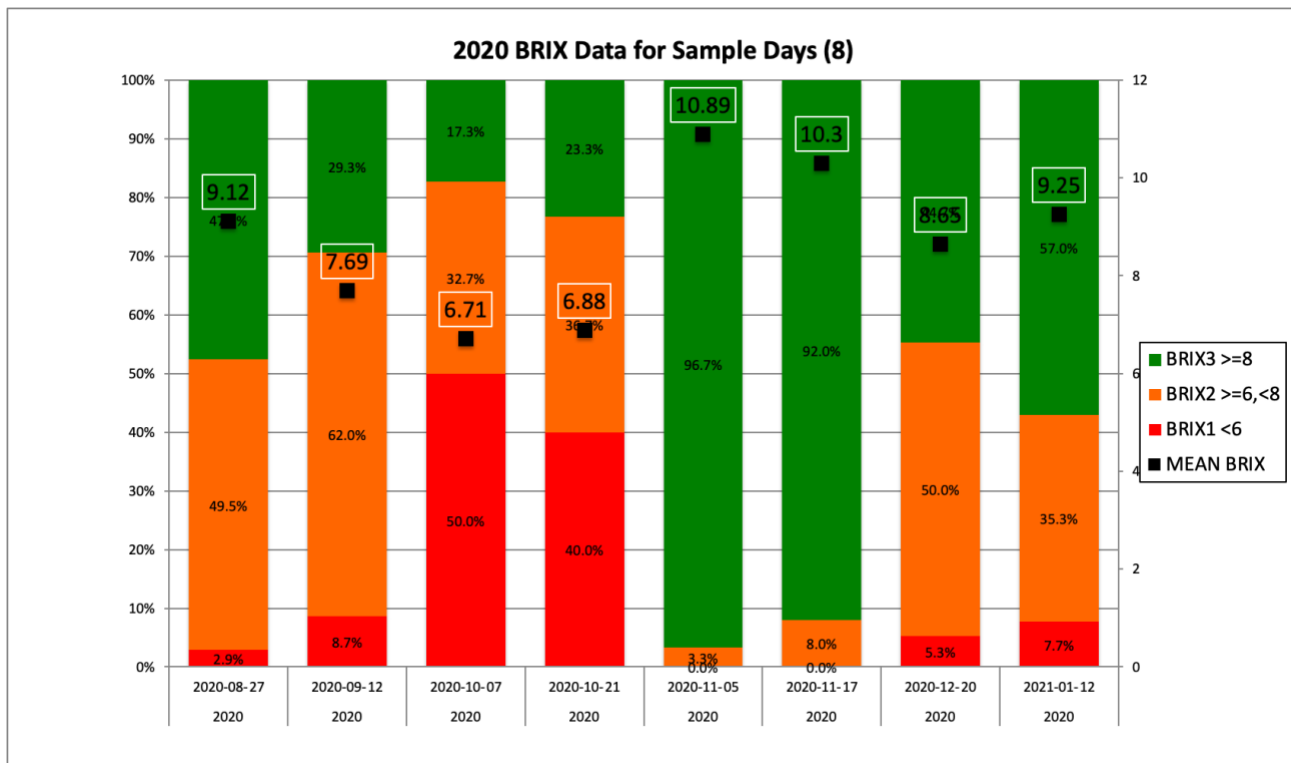
Figure 32. Yarmouth Inside Preseason and In-season Sampling BRIX Indicators

The BRIX levels improve, as may be expected, as the lobster season progresses, and lobster becomes fully meated while they may be considered moving from post-moult into the pre-moult period of the coming year. The in-season results of Figure 32 do not disprove the high quality prediction that was predicated on the very high November samples.

5.2.2   Yarmouth Outside In-season Results

There were also 8 total sampling periods for Yarmouth Outside. As also noted previously, the BRIX category pattern for this area was initially poor and declining throughout the early preseason sampling from August through to the beginning of November. These poor BRIX results were followed by a remarkable improvement in the mid-November sample. (See also Section 4.2.2 – Yarmouth Outside.)

The two in-season samples (mid-December and mid-January) represent improvements over the poor initial BRIX, but a 16% reduction in the November improvement as noted in Figure 33 below.
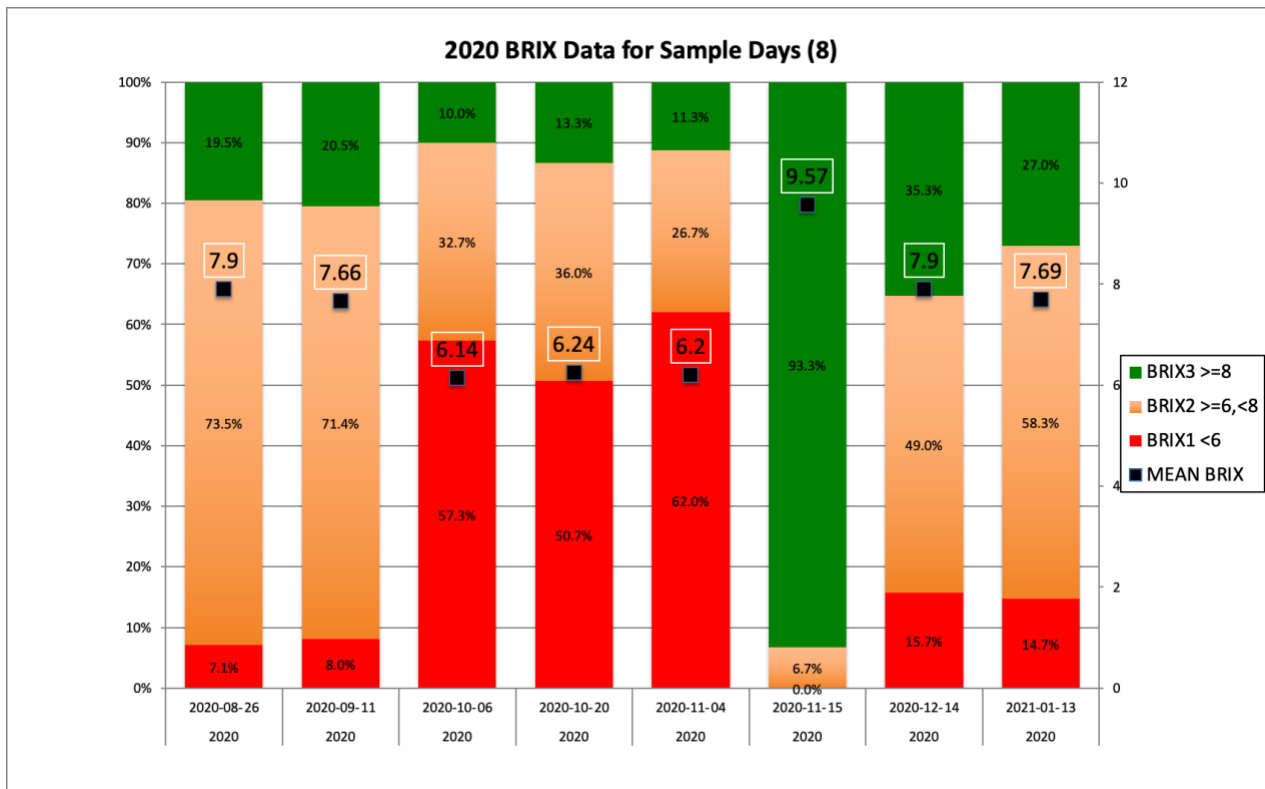
<div align="center">Figure 33. Yarmouth Outside Preseason and In-season Sampling BRIX Indicators</div>

Unlike Yarmouth Inside, BRIX levels cannot be said to improve as the successive in-season samples move forward, i.e., the two in-season samples yield similar BRIX results that average in the "medium" BRIX category and below the desired BRIX level of 8 units/ml. The in-season results of Figure 33 are consistent with the quality prediction for Yarmouth Outside that caution was predicated on the very high November preseason sample ending.

5.2.3   St. Mary's Bay Inside In-season Results

There were 8 total sampling periods for St. Mary's Bay Inside including the two in-season samples in late December 2020 and early January 2021. The BRIX category pattern over the preseason and in-season sampling periods initially showed a decline from August to early October followed by an improvement into mid-November at the end of preseason sampling period when average BRIX values were at series high levels (11+). (See also Section 4.2.7 – St. Mary's Bay Inside.)

The two in-season samples, as had been expected, are less positive than the November results but nevertheless show high overall average BRIX values (9.66 and 10.07 units/ml) – well within the "good" BRIX category, as indicated in Figure 34 below.
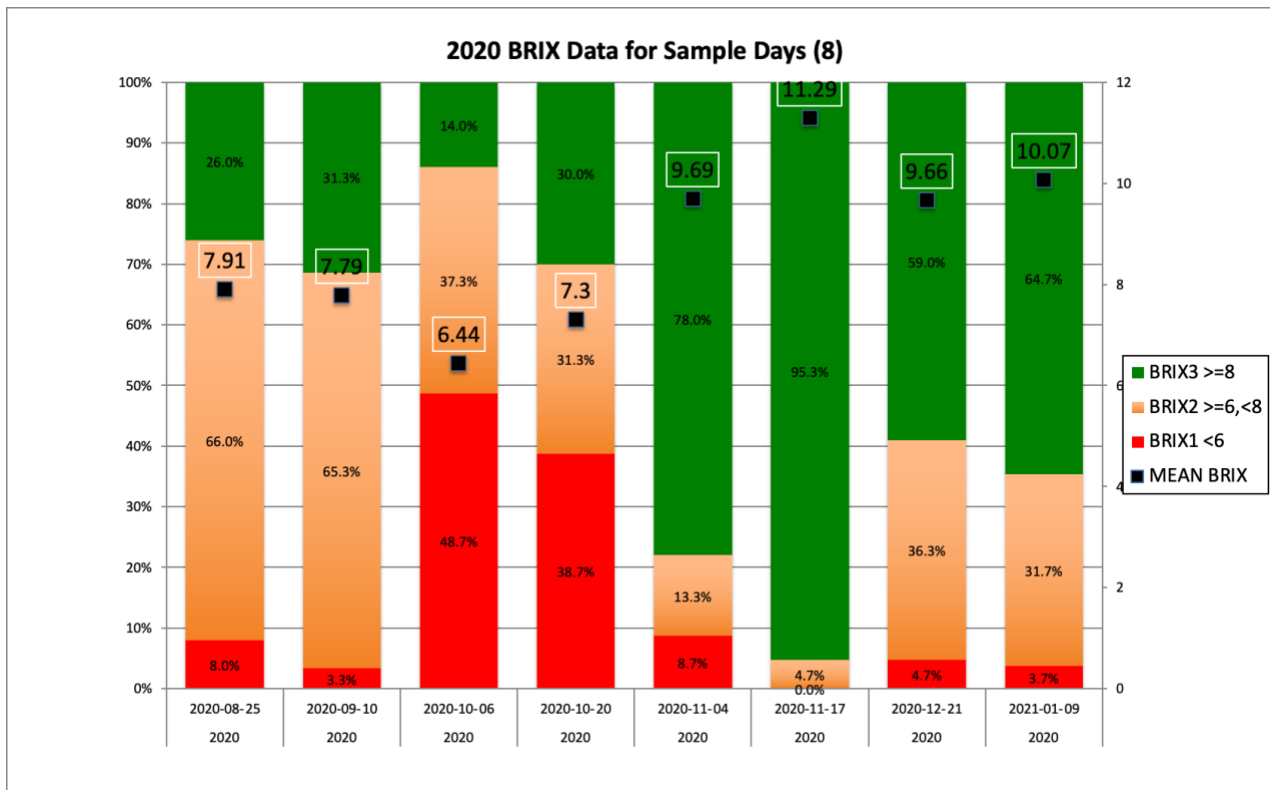
Figure 34. St. Mary's Bay Inside Preseason and In-season Sampling BRIX Indicators

As for Yarmouth Inside, St. Mary's Bay Inside area BRIX levels appear to improve as the lobster season progresses, and lobster becomes fully meated as they move from post-moult into the pre-moult period of the coming year. The in-season results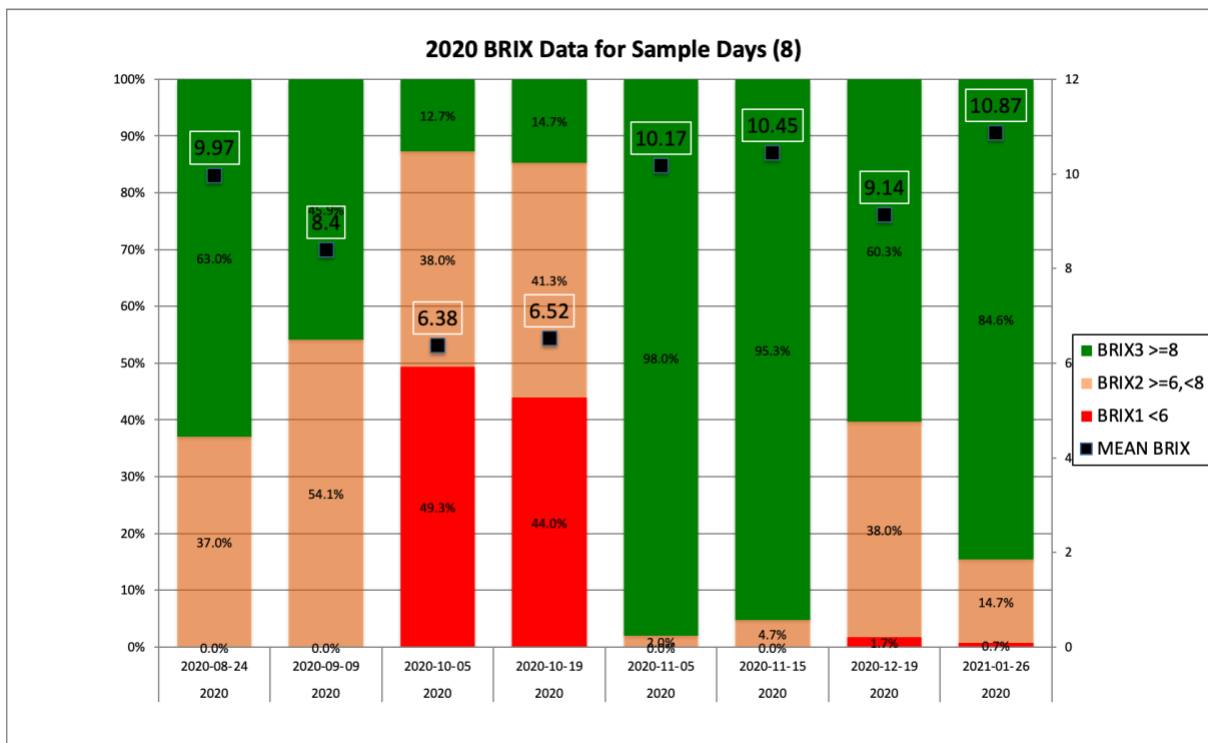 of Figure 34 do not disprove the high quality prediction that was predicated on the improving trend and the very high November samples for St. Mary's Bay Inside.

5.2.4   St. Mary's Bay Outside

There were also 8 total sampling periods for St. Mary's Bay Outside as noted in Figure 35 below. The BRIX category pattern for this area was initially good (average 9.97) at start of the preseason sampling period and then declined through to mid-October. These results were followed by a considerable improvement in the early and the mid-November samples. (See also Section 4.2.2 – Yarmouth Outside.)

The two in-season samples (mid-December and late January) represent very good BRIX results (9.14 and 10.87 units/ml) that show apparent in-season on-going improvement as lobster becomes more fully meated as they move from post-moult into the pre-moult period of the coming year.

Figure 35. St. Mary's Bay Outside Preseason and In-season Sampling BRIX Indicators

As for St. Mary's Bay Inside, the in-season results of Figure 35 do not disprove the high quality prediction that was predicated on the improving trend and the very high November samples for St. Mary's Bay Outside.

6. Discussion

Since 2006, there have been some years of excellent quality (2012, 2013) and others of poorer and deteriorating quality (2015, 2016) as measured by the distribution of BRIX values from the preseason samples. Our ability to discriminate each year's sample improves as we collect and consider more years of historical data. The objective of the preseason and in-season sampling program is to carry out a structured, statistical analysis of year-over-year comparisons to gauge the early season prediction of lobster quality by area in order to prepare inventories for live and processed markets that yield most value to the sector.

The following subsections consider the outlook for the sampling program and discusses issues for improvement in the coming lobster commercial seasons.

6.1   *Annual Lobster Quality and Landings Comparison*

Figure 36 and Table 4 below compares the annual average BRIX by the 4 sampling locations and their inside and outside area with the seasonal landing of lobster in LFA34 from 2012 to 2019.
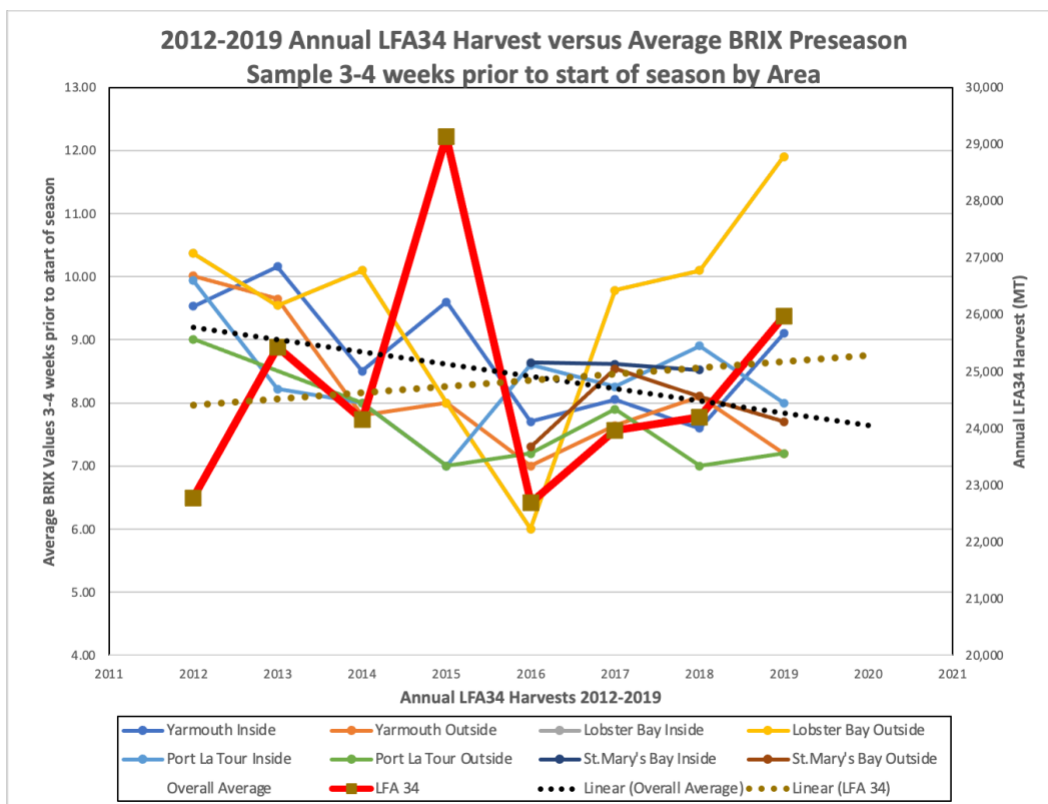
Figure 36. 2012-2020 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start for all areas and Annual LFA34 Harvests comparison

It is noted that in most location-areas, the trend over 2012-2019 is for average BRIX levels to fall over the period from 2012 to 2016 with a less pronounced rebound from 2017 to 2019 in some (but not all) areas. Similarly, the landings trend in LFA34 (Source: DFO 2020 – Lobster IFMP), follows a reverse pattern as a rise from 2012 to a peak in 2015, then a fall in 2016 followed by a gradual increase from 2017 to 2019. It is noted that this analysis assumes landings are measured by catch data from the DFO IFMP (Fisheries and Oceans 2020) for LFA34 over 2012-2019 where catch statistics in the IFMP are reported as 'preliminary' from 2014 to 2019 with no reporting as yet for the 2020-2021 commercial season currently ongoing.

The correlation coefficient of LFA34 landings with with Overall Average BRIX (all areas, Table 4 below) is -0.64 indicating that there is evidence that annual landings appear to be affected by lobster "quality".

Table 4. Annual Landings (LFA34) and Average BRIX by Location-Area for 3-4 weeks prior to season

Season	Landings LFA34 (MT)	BRIX (units/ml 3-4 weeks before start of each season)								Overall Average	Quality Ranking	Landing Ranking
		Yarmouth Inside	Yarmouth Outside	Lobster Bay Inside	Lobster Bay Outside	Port La Tour Inside	Port La Tour Outside	St.Mary's Bay Inside	St.Mary's Bay Outside			
2012-13	22,770	9.53	10.01	10.37	10.39	9.94	9.01	–	–	9.88	2-VH	7
2013-14	25,427	10.16	9.65	9.54	9.62	8.22	–	–	–	9.44	3-VH	3
2014-15p	24,148	8.50	7.80	10.10	7.70	8.00	8.00	–	–	8.35	5-H	5
2015-16p	29,131	9.60	8.00	8.00	8.80	7.00	7.00	–	–	8.07	8-M	1
2016-17p	22,684	7.70	7.00	6.00	6.40	8.60	7.20	8.64	7.30	7.35	9-L	8
2017-18p	23,958	8.05	7.64	9.79	7.80	8.26	7.90	8.62	8.54	8.32	6-H	6
2018-19p	24,198	7.60	8.10	10.10	7.70	8.90	7.00	8.52	8.10	8.25	7-M	4
2019-20p	25,969	9.10	7.20	11.90	8.40	8.00	7.20	–	7.70	8.50	4-H	2
2020-21p	–	10.89	6.20	12.71	9.66	10.47	9.65	9.92	10.17	9.96	1-VH	–
Averages	24786	9.01	7.96	9.83	8.50	8.60	7.87	8.93	8.36	8.68		

p – denotes preliminary landings statistics

From Table 4 we note that:

- Overall BRIX Averages exceeding 9 units/ml (2020-to-date, 2012, 2013) are considered "Very High (VH)" in Quality ranking;
- Overall BRIX Averages less than 9 but exceeding 8.3 units/ml (2019, 2014, 2017) are considered "High (H)";
- Overall BRIX Averages less than 8.3 but exceeding 8 units/ml (2018, 2015) are considered "Medium (M)"; and
- Overall BRIX Averages less than 8 units/ml (2016) is considered "Low (L)".

These grading designations are useful for comparing current preseason sampling results with past years' BRIX performance. This enables direct comparison with decision making for harvesting and processing lobster product by time and area (see also section 6.2 below). As well, overall predictions of lobster quality and lobster landings in LFAs 33 and 34 can be seen as a time series that moves annually according to detectible trends. We caution that a strict time series analysis approach may ignore exogenous factors that clearly affect landings, e.g., fishing effort, weather conditions, access and allocation disputes, shore prices, international markets, as well as global socioeconomic conditions (i.e., global public health issues in a pandemic, or economic fluctuations).

Future full reports of the preseason and in-season sampling program will seek to define quality rankings and grading definitions in further detail based on the historical and the current BRIX observations.

6.2   Decision Opportunities

The ability to compare historical data by selected sites, e.g., inside and outside fishing areas, also allow us to consider industry options about when and where to harvest higher quality lobster. For example, industry may consider setting harvesting openings, e.g., if the prediction expects harvests with low BRIX (and corresponding meat levels), and high offloading losses, then it may be preferable to delay harvesting, or move harvesting to an alternative inside or outside area that has better expected BRIX performance to enable storage and shipment. Alternatively, lower BRIX levels may trigger industry decisions to move product from storage and shipment for live markets into processed product until such time as the BRIX levels improve.

These options can be evaluated in advance and based on modelling of the historical annual lobster BRIX observations combined with price structures in order to help lobster harvesters and the industry to make decisions on where and when to fish to improve harvest quality and overall value.

Future full reports will endeavour to model the value implications of alternative decisions that are a consequence of the observed BRIX profiles of the preseason sampling program.

6.3   2021 Preseason Sampling Survey Outlook

Future preseason sampling surveys will continue to follow the traditional ALMQ protocols toward maintaining the integrity of the longitudinal database – one of the world's longest marine scientific databases. This continuation will ensure the information on individual lobster statistics, lobster harvests by location-area samples, lobster sample counts, moult stages (pleopod analyses), hardness scale analyses.

Furthermore, future reports will seek:

- to establish a lobster grading function consistent with industry grading shemes (e.g., A,B,C);
- to initiate a program of bottom temperature data collection together with analyses associated with the changing marine climate;
- to develop data on lobster movement via a site-specific and directed tagging initiative designed to test defined hypotheses on lobster movement, e.g., west-east movement across the Gulf of Maine into Scotia-Fundy;
- to develop a specific Quality Indicator time series for each location and inside-outside area that combines lobster landings, BRIX, and other quality measures;
- to analysis lobster data at depth re impact on BRIX, movement patterns from inside to outside areas at different depths;
- to develop statistical analyses using the information in the entire ALMQ database 2006-2020 to discriminate years into quality categories for direct comparison and future analysis and prediction; and, finally,
- to develop a prediction score in order to evaluate the performance of the preseason summary report predictions for the start of the LFA33 and 34 commercial seasons.

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Appendices

Appendix A

Harvested and Sampled Lobster Count Location Graphics

This appendix presents the graphical data summary of the 2020-2021 preseason and in-season sampling surveys for the 4 sample locations that include the inside and outside areas of the locations: (1) Yarmouth; (2) Lobster Bay; (3) Port La Tour; and (4) St. Mary's Bay.

A.1   Location graphics (4 pages) - lobster counts (harvested and sampled) information:

   a. Counts of lobster harvested per trap by sex for Inside & Outside areas
   b. Counts of lobster harvested per trap and BRIX for Inside & Outside areas
   c. Counts of lobster sampled by Moult Stage - Outside area
   d. Counts of lobster sampled by Hardness and BRIX for Inside & Outside areas

A.2   Comparative Location graphics (1 page) - lobster (harvested and sampled) counts information:

   a. Counts of lobster harvested per trap by location for Inside areas
   b. Counts of lobster harvested per trap by location for Outside areas
   c. Average BRIX per sample by location of Inside areas
   d. Average BRIX per sample by location of Outside areas
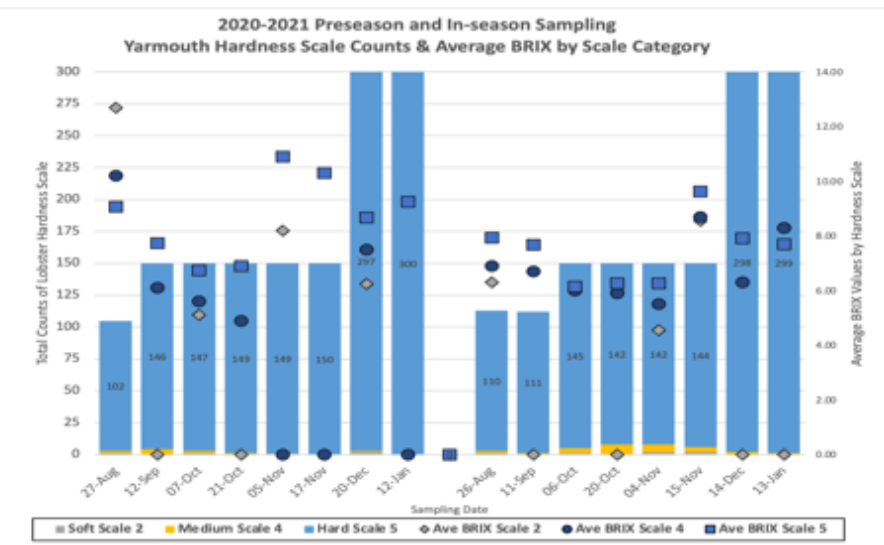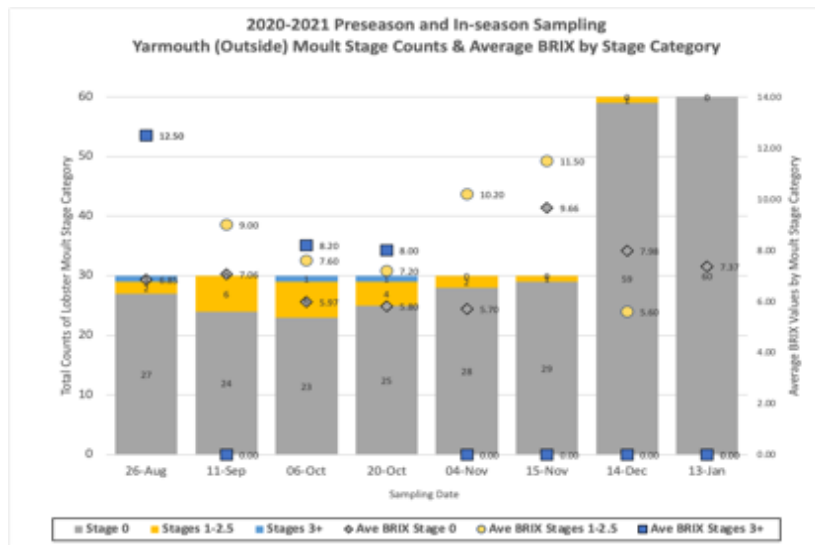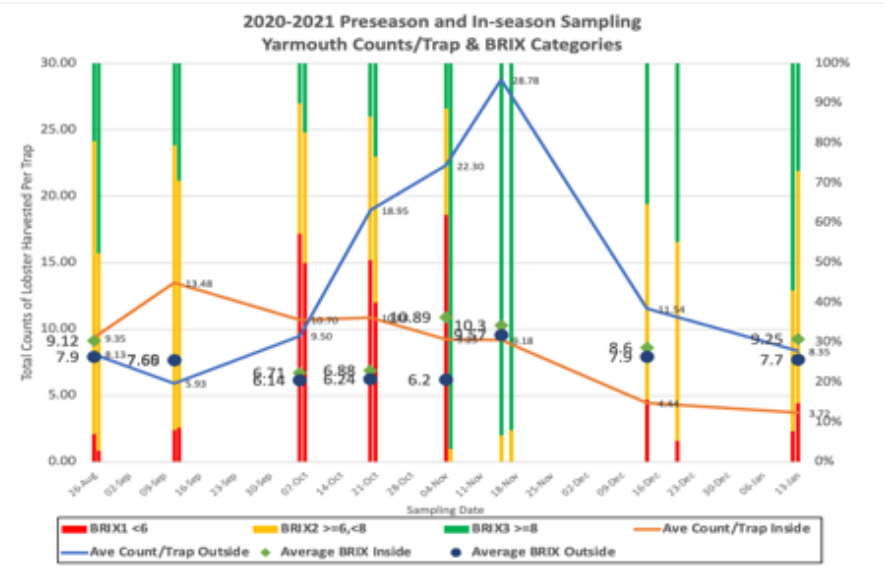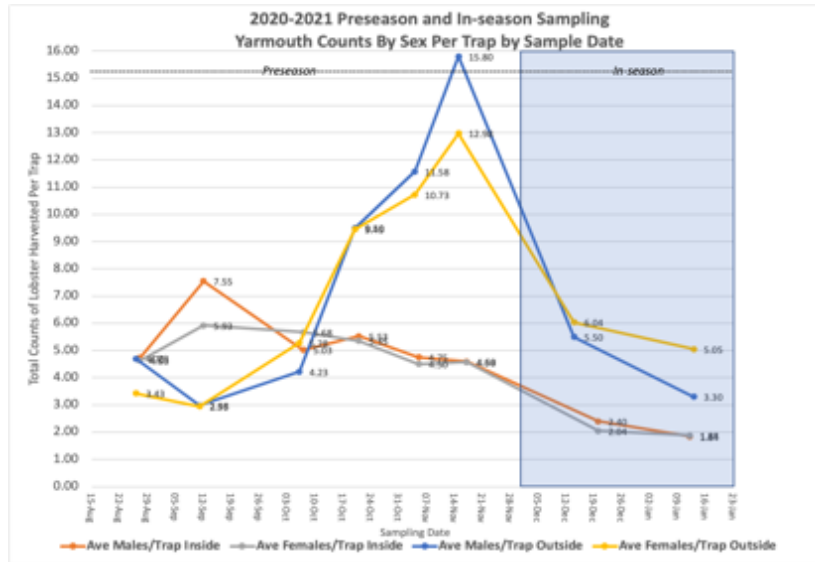
(1) Yarmouth Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moult Stage - Outside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)
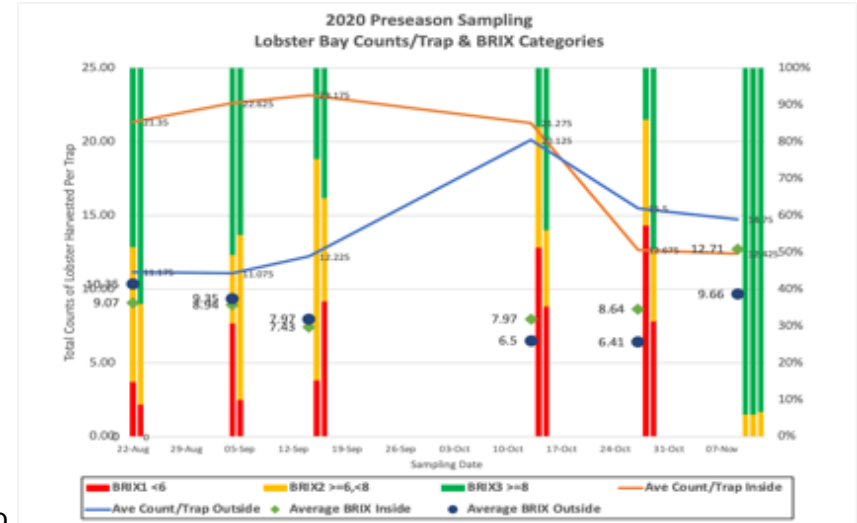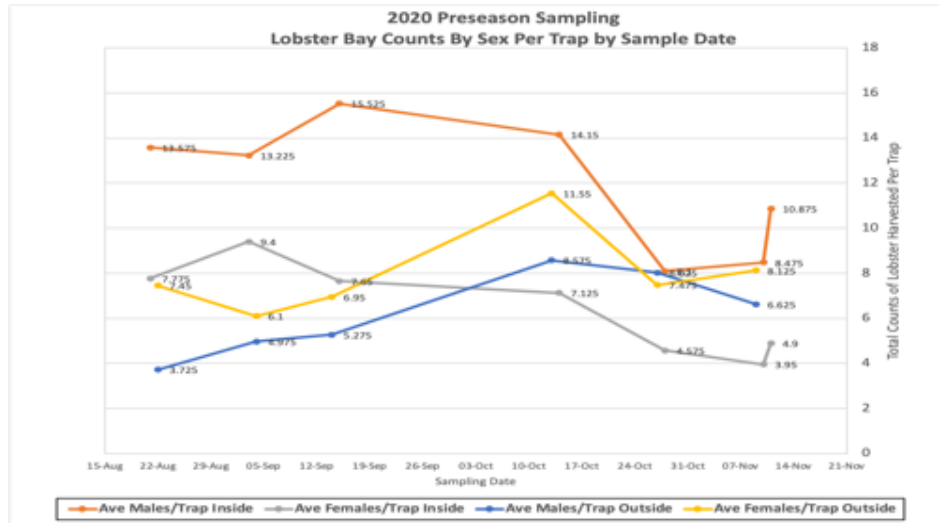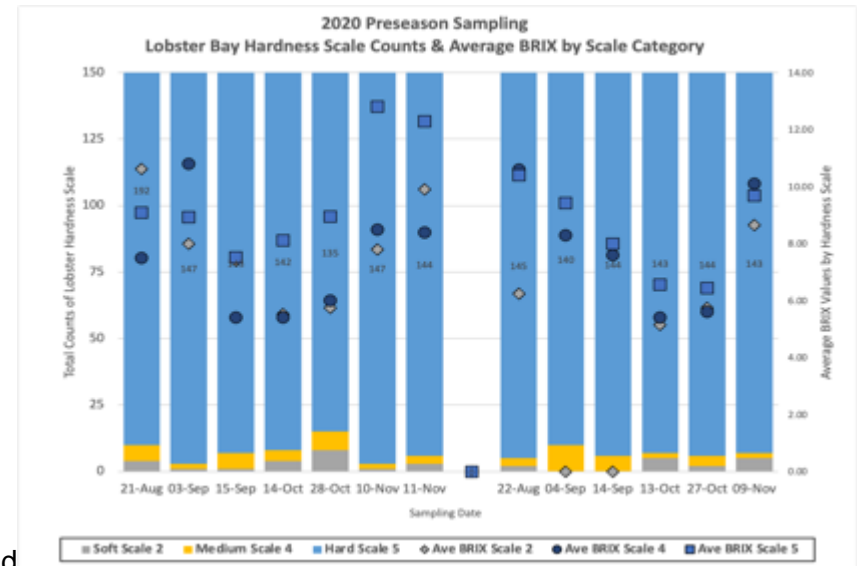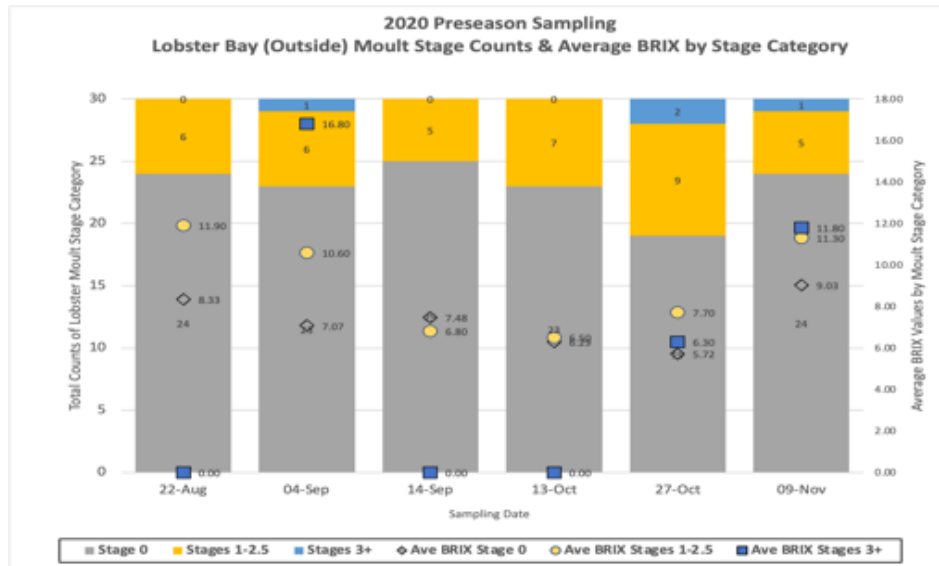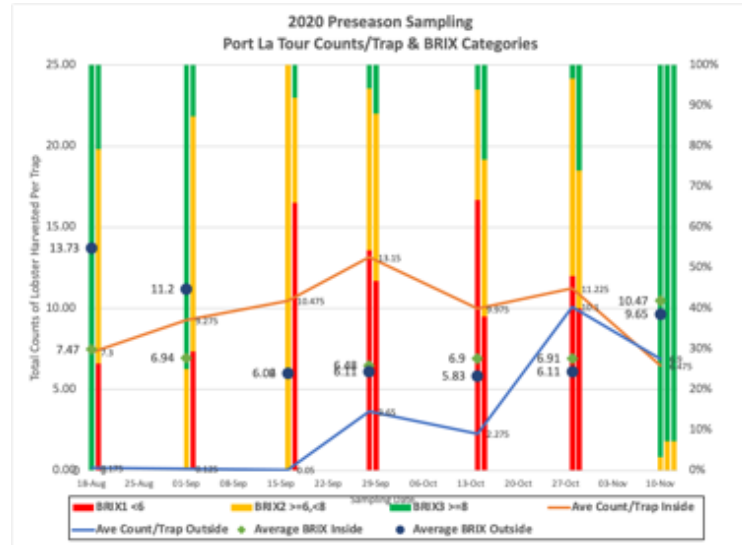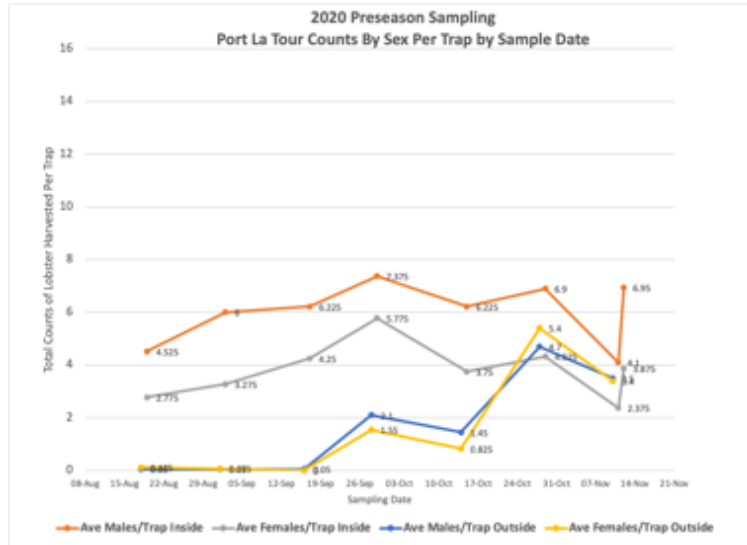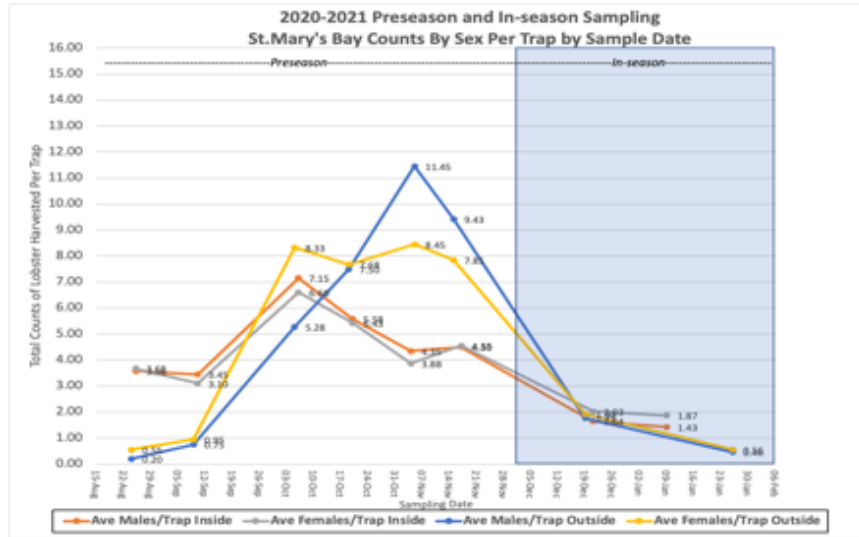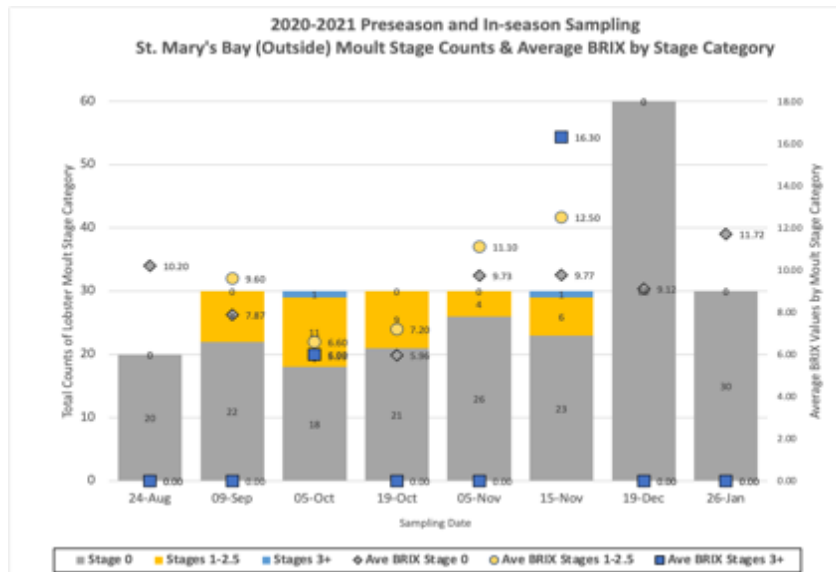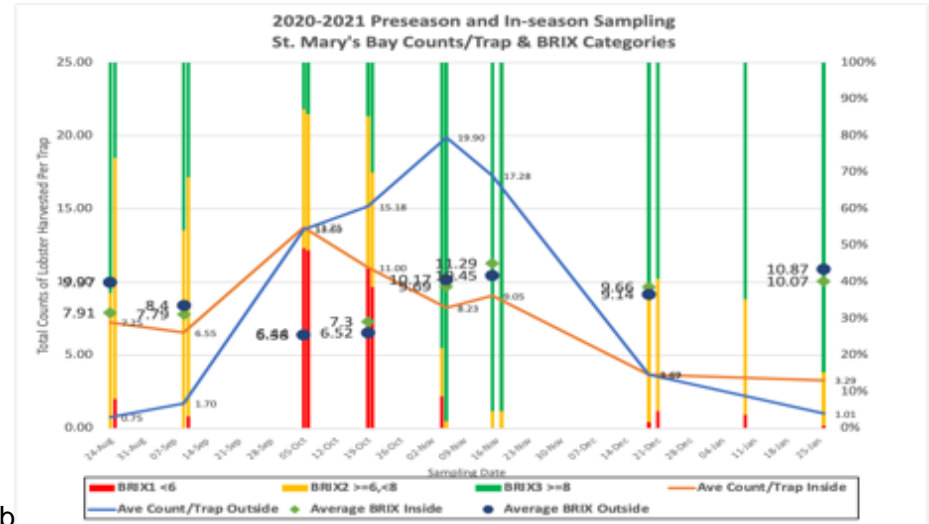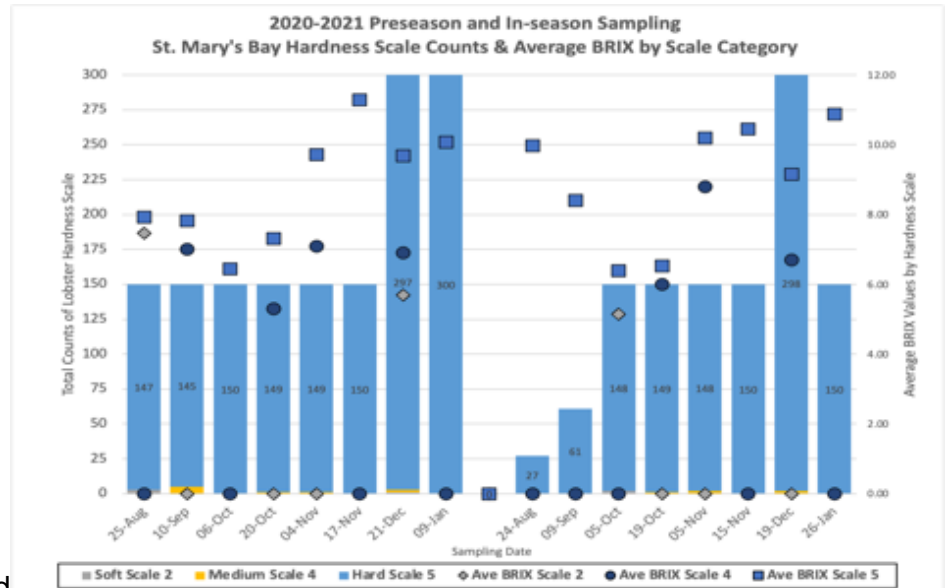
(2) Lobster Bay Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moult Stage - Outside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)
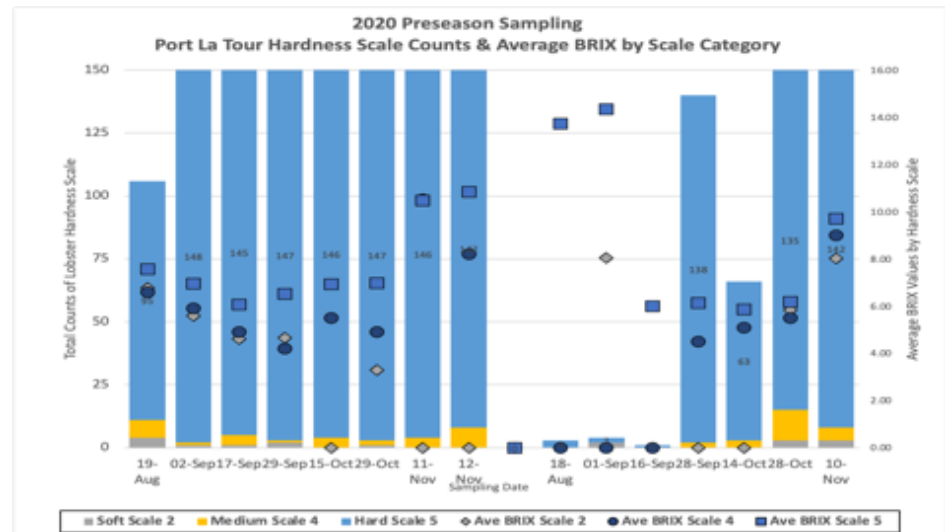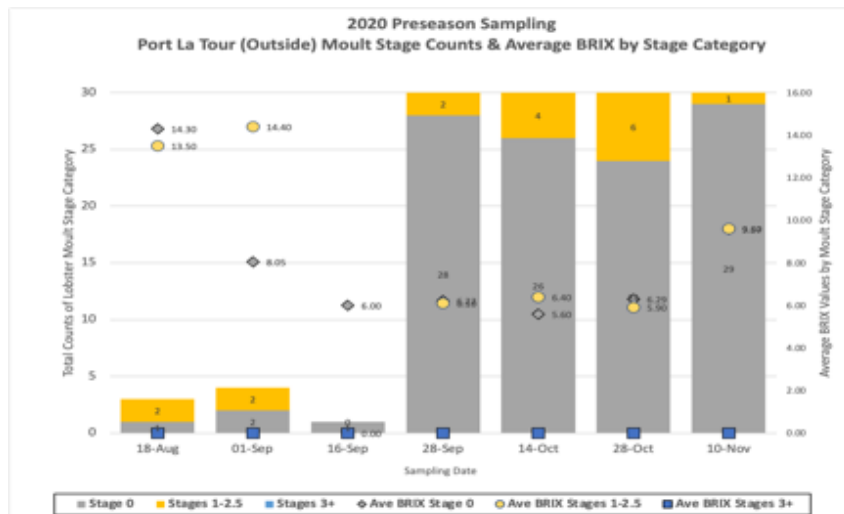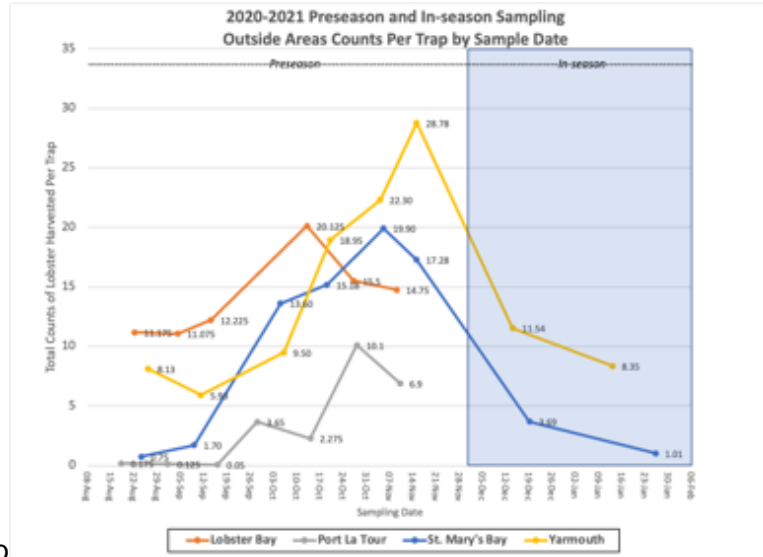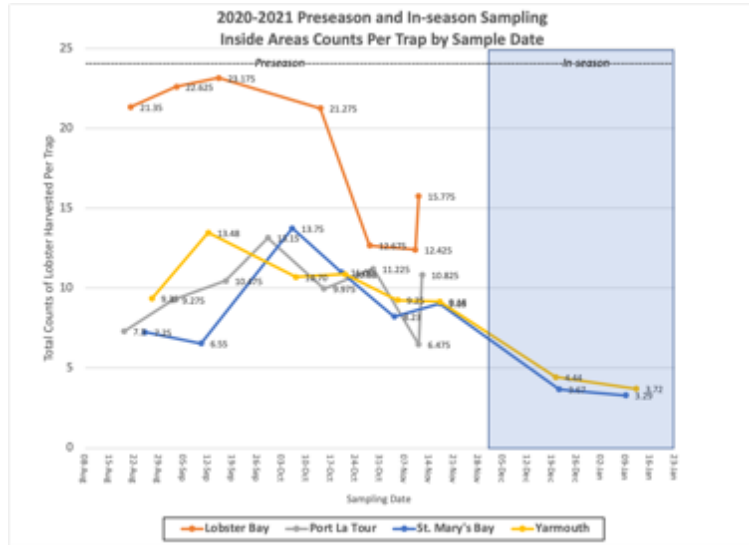
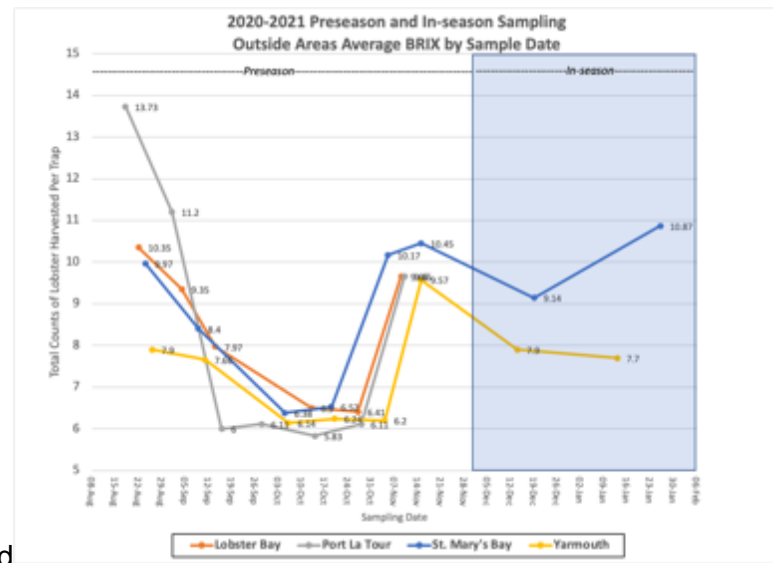**(3) Port La Tour Graphics**: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moult Stage - Outside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)
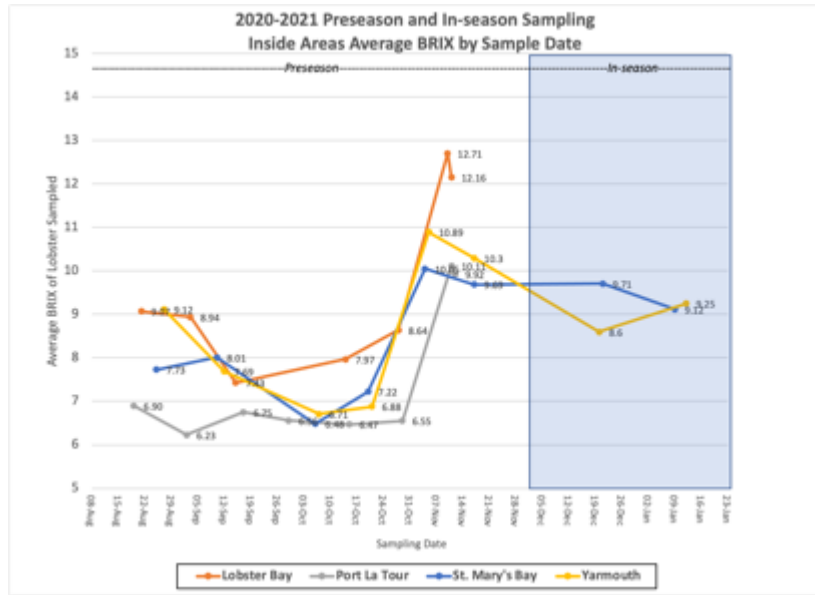
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(4) St. Mary's Bay Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moult Stage - Outside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)

Comparative Locations Graphics: (a) Top left - Counts of lobster harvested per trap by location for Inside areas; (b) Top right - Counts of lobster harvested per trap by location for Outside areas; (c) Bottom left - Average BRIX per sample by location of Inside areas; (d) Bottom right – Average BRIX per sample by location of Outside areas

**Appendix B**

Berried Females Graphics

This appendix presents the berried females graphical data summary of the 2020-2021 preseason and in-season sampling surveys for the 4 sample locations that include the inside and outside areas of the locations: (1) Yarmouth; (2) Lobster Bay; (3) Port La Tour; and (4) St. Mary's Bay.

B.1   Location graphics (4 pages) – berried females sampled counts information:

       1) Berried females sampled and percent of harvest for Yarmouth Inside & Outside areas
       2) Berried females sampled and percent of harvest for Lobster Bay Inside & Outside areas
       3) Berried females sampled and percent of harvest for Port La Tour Inside & Outside areas
       4) Berried females sampled and percent of harvest for St. Mary's Bay Inside & Outside areas

B.2   Comparative Location Graphics (2 pages) – berried female sampled stage counts information:
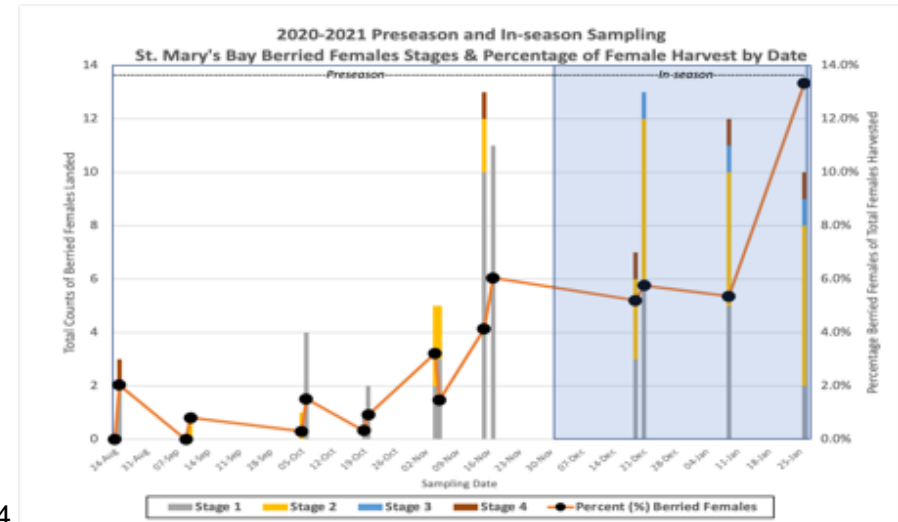
       a) Berried females Stage 1 counts for Inside areas
       b) Berried females Stage 1 counts for Outside areas
       c) Berried females Stage 2 counts for Inside areas
       d) Berried females Stage 2 counts for Outside areas
       e) Berried females Stages 3 & 4 counts for Inside areas
       f) Berried females Stages 3 & 4 counts for Outside areas
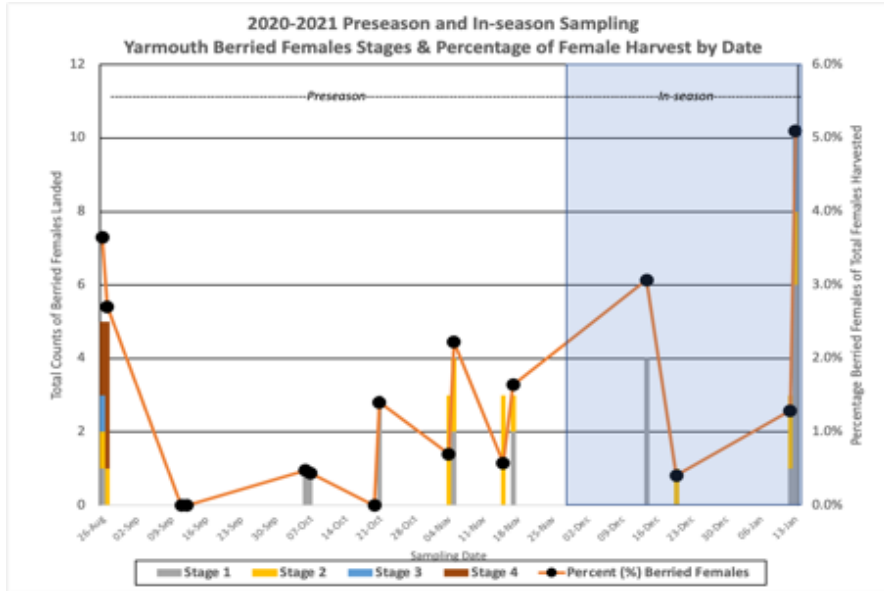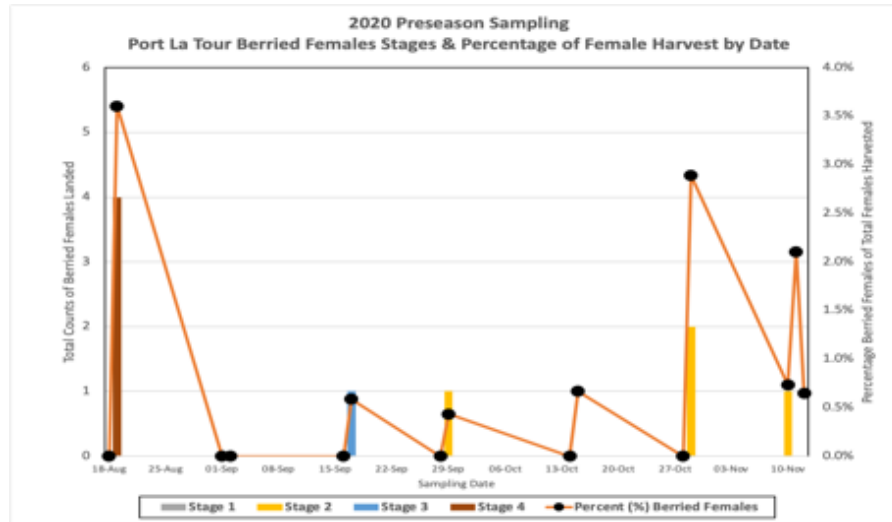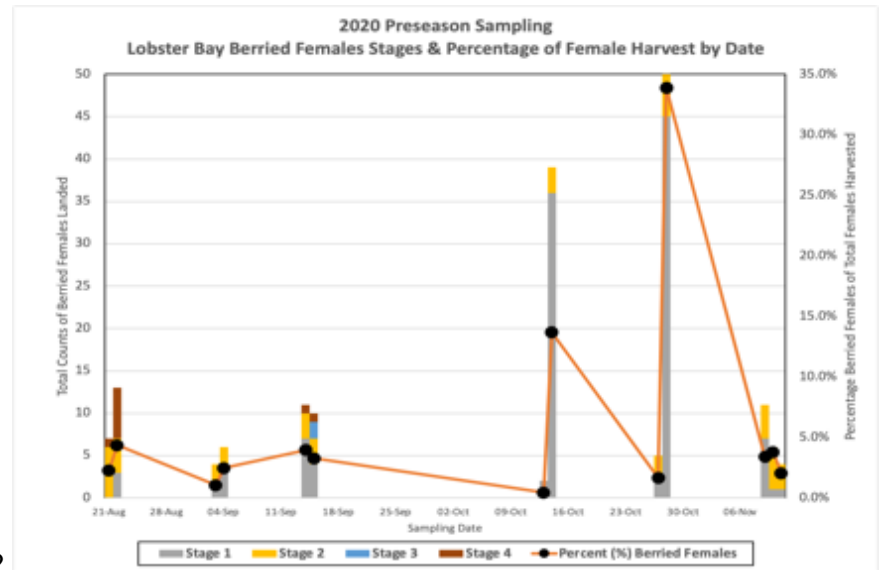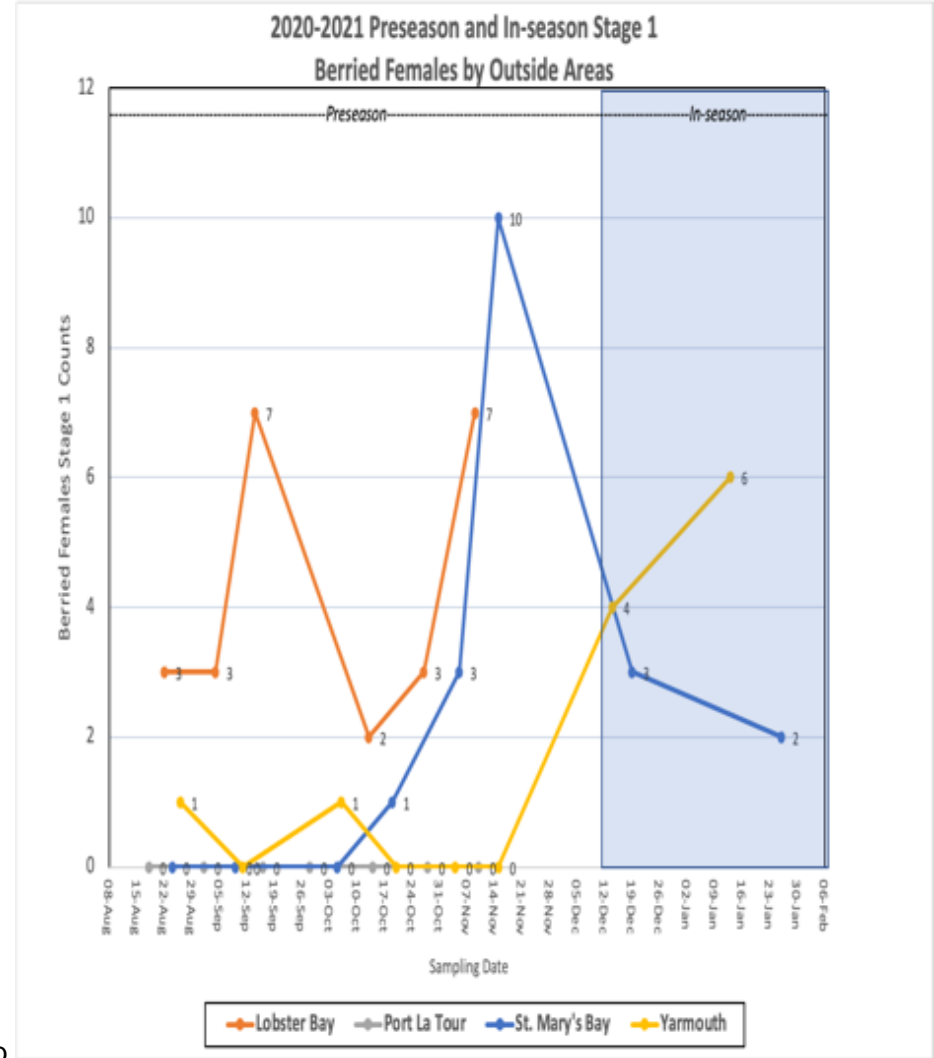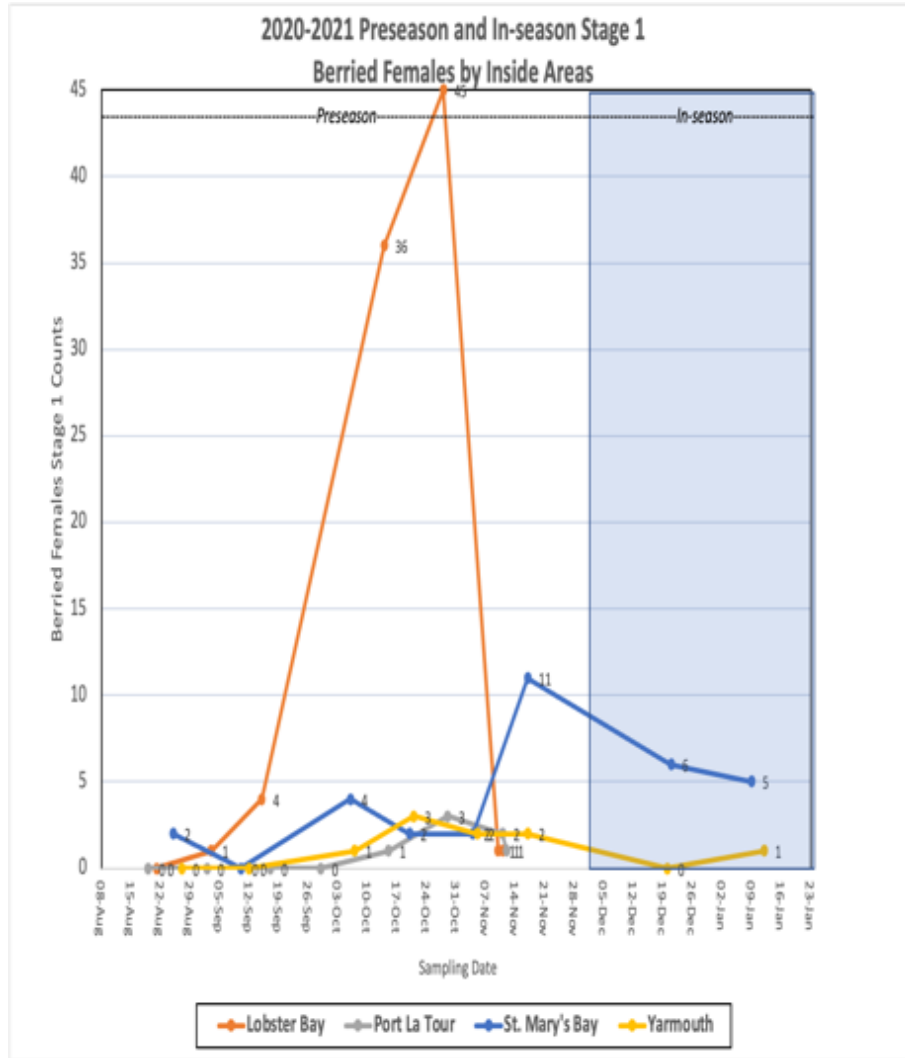
Locations Graphics: (a) Top left–Yarmouth Berried Females Stages Count & Percent Females; (b) Top right–Lobster Bay Berried Females Stages Count & Percent Females; (c) Bottom left–Port La Tour Berried Females Stages Count & Percent Females; (d) Bottom right–St. Mary's Bay Berried Females Stages Count & Percent Females

Comparative Locations Graphics: (a) Left - Counts of berried females in samples of Stage 1 for Inside areas; (b) Right - Counts of berried females in samples of Stage 1 for Outside areas.
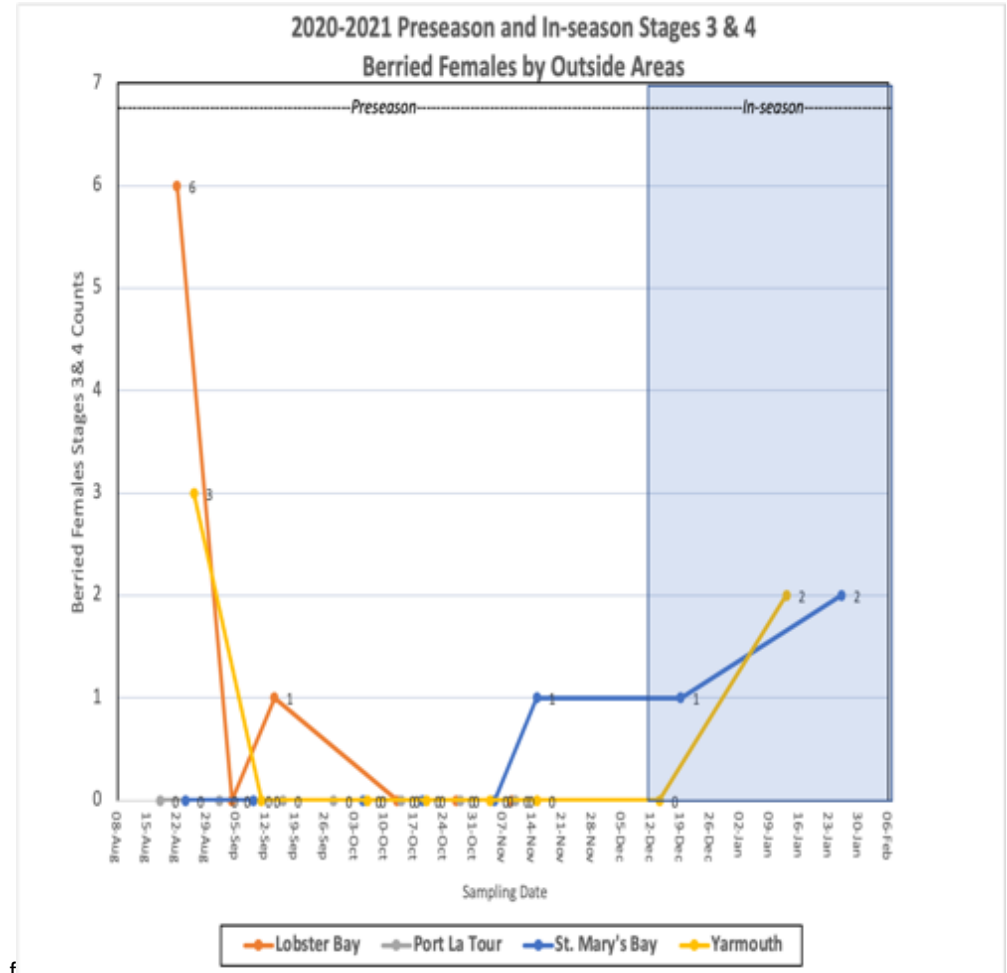
c d
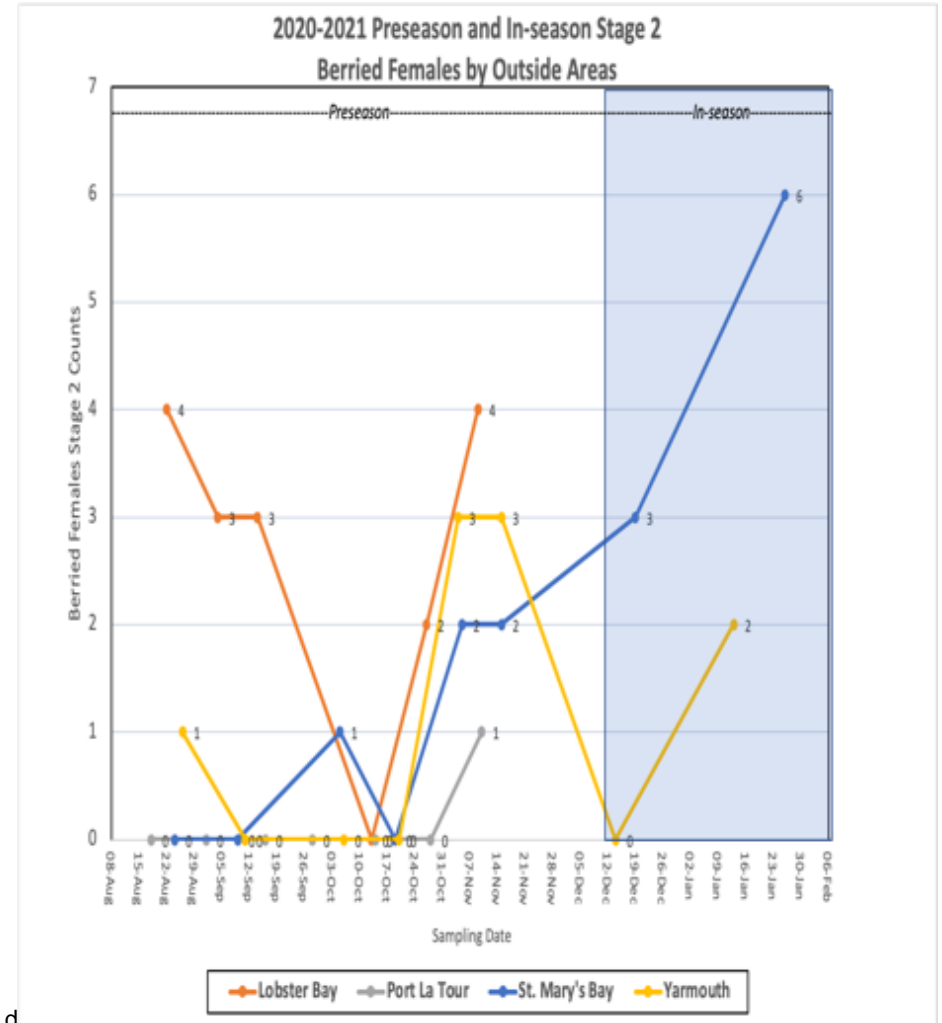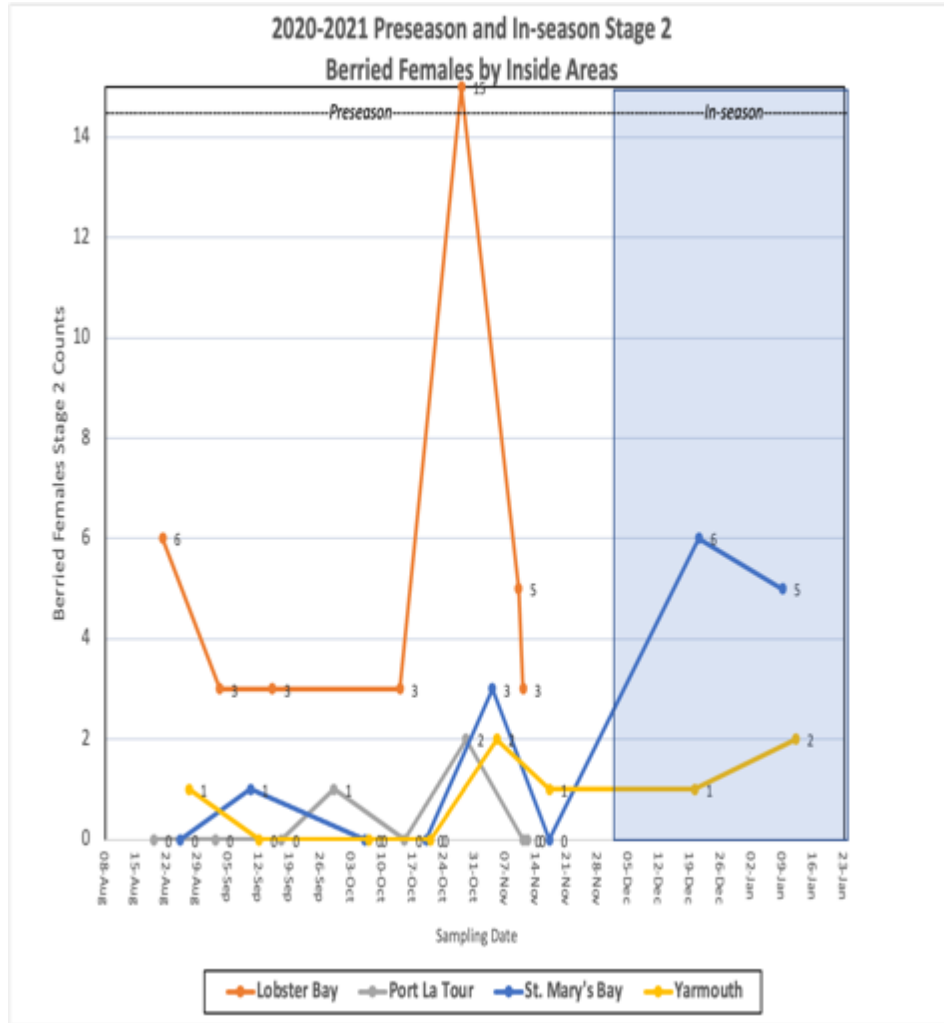
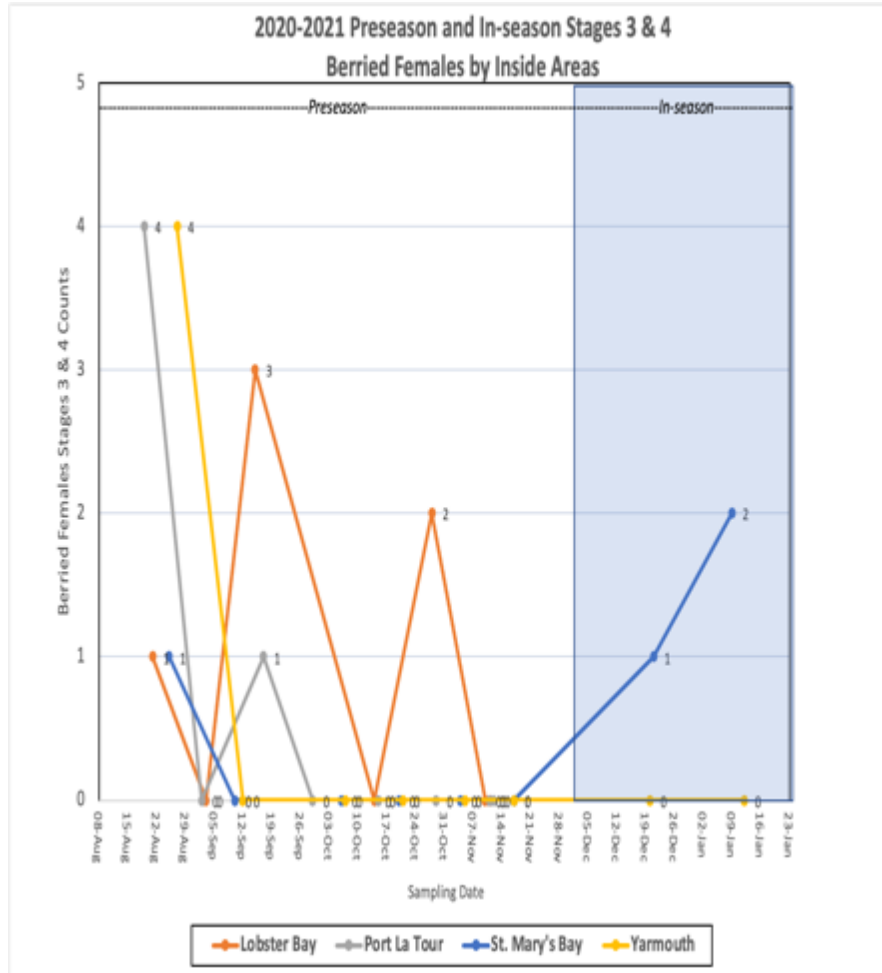**Comparative Locations Graphics**: (c) Left - Counts of berried females in samples of Stage 2 for Inside areas; (d) Right - Counts of berried females in samples of Stage 2 for Outside areas.

e   f

Comparative Locations Graphics: (e) Left - Counts of berried females in samples of Stages 3 & 4 for Inside areas; (f) Right - Counts of berried females in samples of Stages 3 & 4 for Outside areas.

Appendix C

Preseason Sampling Summary Report Predictions

This appendix presents the preseason sampling summary report predictions for the 8 location-areas as issued in the Preseason Summary Report (Mattock, Mulock, and Lane 2020) released on November 24, 2020 prior to the beginning of the 2020-2021 commercial lobster season in LFA 33 and 34.

The following table summaries the predictions by sampling location as provided in text from below.

Sampling Location	Area	2020 Quality Prediction	Comparable Year	Remarks
Yarmouth	Inside	Very High	2013-2014	Best preseason BRIX in series 2006-2020
	Outside	High	–	Caution warned
Lobster Bay	Inside	Very High	2018-2019; 2019-2020	–
	Outside	High	–	Caution warned
Port La Tour	Inside	Very High	2012-2013	–
	Outside	High	–	Caution warned
St. Mary's Bay	Inside	Very High	2018-2019	–
	Outside	High	–	Caution warned

1) YARMOUTH INSIDE

2020 SUMMARY OF RESULTS

Summary : Preseason sampling results for YARMOUTH INSIDE closest to the start of the season suggest that quality at the start of the 2020 season will be of ***VERY HIGH*** *quality comparable to and out-performing the 2013-2014 season – the previous best preseason BRIX result for this area.*

2) YARMOUTH OUTSIDE

2020 SUMMARY OF RESULTS

Summary : Late preseason sampling results for YARMOUTH OUTSIDE show that quality at the start of the 2020-2021 season is expected to be ***HIGH****. Caution is noted that major improvements in quality were observed only in the final preseason sample and that it is unlikely that this level may be sustainable beyond the start of the 2020-2021 season.*

3) LOBSTER BAY INSIDE

2020 SUMMARY OF RESULTS

Summary : Preseason sampling results for LOBSTER BAY INSIDE suggest that quality at the start of the 2020 season will be of ***VERY HIGH*** *quality comparable to the recent results of the 2018-2019 and 2019-2020 seasons.*

4) LOBSTER BAY OUTSIDE

2020 SUMMARY OF RESULTS

Summary : Late preseason sampling results for LOBSTER BAY OUTSIDE show that quality at the start of the 2020-2021 season is expected to be HIGH. Caution is noted that major improvements in quality were observed only in the final preseason sampling observations and that it is unclear whether or not this level may be sustainable beyond the start of the 2020-2021 season.

5) PORT LA TOUR INSIDE

2020 SUMMARY OF RESULTS

Summary : Preseason sampling results for PORT LA TOUR INSIDE suggest that quality at the start of the 2020 season will be of VERY HIGH quality comparable to the results of the 2012-2013 season.

6) PORT LA TOUR OUTSIDE

2020 SUMMARY OF RESULTS

Summary : Late preseason sampling results for PORT LA TOUR OUTSIDE show that quality at the start of the 2020-2021 season is expected to be HIGH. Caution is noted that poor quality observations throughout the 2020 sample periods shifted only in the final preseason sampling observation and that it is unclear whether or not this level may be sustainable beyond the start of the 2020-2021 season.

7) ST. MARY'S BAY INSIDE

2020 SUMMARY OF RESULTS

Summary : Preseason sampling results for St. MARY'S BAY INSIDE suggest that quality at the start of the 2020 season will be of VERY HIGH quality comparable to or exceeding the results of the 2018-2019 season in this area.

8) ST. MARY'S BAY OUTSIDE

2020 SUMMARY OF RESULTS

Summary : Late preseason sampling results for ST. MARY'S BAY OUTSIDE show that quality at the start of the 2020-2021 season is expected to be HIGH. Caution is noted that major improvements in quality were observed in the final preseason sampling observations erase an apparent declining trend. It is therefore acknowledged that this positive trend may not be sustainable beyond the start of the 2020-2021 season.