Lobster Quality 2022-2023 Preseason & In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

Final Report

March 2023

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1. Background

The 2022-2023 Lobster Quality Preseason Sampling Program continues the long-standing Atlantic Lobster Moult and Quality (ALMQ) project, a collaboration between lobster harvesters, buyers, dealers, and scientists. The ALMQ database originated in 2006 as an initiative of the Fishermen & Scientists Research Society (FSRS 2022). In 2023, it represents the largest continuous database of lobster sampling globally with 18 years of uninterrupted sampling. It is a credit to all collaborators to have the opportunity to produce this final report for the 2022-2023 commercial season. As in the past, we

Figure 1: Banded lobsters in a dry tote.

endeavour to summarize the results of the preseason and in-season sampling program and provide information in this report that will be of direct use to the lobster sector in Nova Scotia. While the lobster industry in Nova Scotia faces many challenges, the quality of lobsters captured at the beginning of the lobster fishing season in southwest Nova Scotia (LFAs 33& 34), the world's largest catch area of *Homarus americanus*, remains a significant issue for improving product valuation.

Since the early 2000s, there have been noted 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. This represents a serious economic challenge for the industry, especially in international markets where, in 2020, over 80% of Canadian lobsters were shipped live to markets in the United States of America (43%), China (47%), and the European Union (<10%) (Fisheries and Oceans Canada 2021). Since 2019, exports of live product to China exceeded that to the US (Fisheries and Oceans Canada 2021). Results of past ALMQ sampling in southwest Nova has shown that lobster quality at harvest is directly related to the timing of lobsters' moulting processes. These processes are affected by 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 at the beginning of the commercial season (last Monday in November, annually) 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 creation of Université Sainte-Anne's Lobster Quality Research and Innovation Centre (LQRIC, Nova Scotia 2020). The LQRIC, renamed the Lobster Quality Centre (LQC) in 2023, has been established to aid in the research and development of live lobster product quality through ongoing sampling and modelling and analysis of the live lobster supply chain. The Lobster Quality Centre acknowledges the financing for this project as part of a Scientific Partnership Grant from the Atlantic Fisheries Fund (AFF) award for 2020-2023 as well as the continuing support of Fisheries and Oceans, Canada, the Nova Scotia Department of Fisheries and Aquaculture and our industry partners.

The purpose of this annual report is to evaluate observed lobster quality from extensive preseason and selected in-season lobster sampling, and to report on the status of lobster quality for the 2022-2023

season in LFAs 33 & 34. 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 2022 preseason at-sea sampling conducted by Coldwater Lobster Association (Coldwater Lobster Association 2023) in 8 locations within LFA33 and LFA34 designated as the 'inside' and 'outside' areas of Lobster Bay, St. Mary's Bay, Yarmouth in LFA34, and Port La Tour in LFA33. Preseason sampling commenced August 29 and continued until November 16, 2022. The report also presents selected in-season sampling carried out in 6 LFA33&34 subareas from December 21, 2022 through February 22, 2023. All sampling was conducted by Coldwater Lobster Association according to the ALMQ protocols established since 2006. Table 1 below describes the samples information gathered on individual lobsters. After observations are taken from sampled legal-sized lobsters, all lobsters are released.

Table 1. 2022 Lobster Sampling Data Description

No.	Individual Lobster Sampling Data Item
1	Depth of string (F, fathoms); typically 4 strings are used for sampling with 10 pots per string
2	Counts of legal and sub-legal lobster captured (only legal lobsters were used in subsequent sampling)
By the protocol, 150 legal-sized lobsters are sampled from the captured counts and the following items recorded for each lobster during preseason sampling:	
3	Lobster Carapace Length (CL, millimetres)
4	Lobster Sex (M-male '1'; F-female '2'; BF-berried female '3')
5	Lobster Shell hardness (Soft '2'; Medium '4'; Hard '5')
6	Lobster Blood protein level – measured via refractometer as the BRIX Index (units/ml, Figure 2)
7	Lobster Moult stage ('0' – no activity; '1' to '5') – from selected lobsters' pleopod removal and post-at-sea sample examination under a microscope (Factor 1995, see also Figure 3 below)
8	Damage (coded descriptions for visual impacts, e.g., culls, as well as "blackened" shell disease)
9	Lobster vitality status observed ("weak"/ "not weak").

Figure 2: Survey sampling tools.

Data analyses of the samples were carried out by the Centre de recherche marine/Marine Research Centre of the Université Sainte-Anne, Petit de Grat Campus and the LQC team. The collected data are designed to proxy lobster quality – live lobster meat content and suitability for storage and shipping. Results of the preseason component of the sampling program are provided in the 2022 preseason summary (Mattock, Mulock, and Lane 2022) 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 2022 preseason and 2022-2023 in-season sampling compared to past years' samples from similar preseason and in-season times and sampling locations over the period 2012-2022. This information enables the industry to compare the 2022-2023 sample results to known past years of observed preseason and subsequent in-season lobster quality and status.

1.1 Lobster Quality Determinants

For the first time in 2021, consolidated data from each sample date by location are classified into lobster quality categories derived from the full ALMQ database (2006-2021). Lobster quality categories for each consolidated location sample and date are based on collective lobster sample characteristics of the 150 sampled lobsters by the protocol for each sampling date. The historical consolidated sample data were categorized into 5 'lobster quality' categories. The results of this analysis enable the numerical description of each category, and subsequently, the assignment of each of the 2022-23 sample dates into the most probable lobster quality category.

1.2 Blood Protein, BRIX Levels

In 2022, 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 perfect determinant of lobster quality and meat content (see also Thériault, David, Frame, Mdaini, and Lane 2021rev). Table 2 below summarizes the BRIX index categories by lobster quality determinants as interpreted in the full ALMQ database.

Table 2. BRIX Levels Lobster Quality Categories

BRIX Quality Category:	"Poor"	"Medium"	"Good"
Meat Content:	Most likely low	Not likely fully-meated	Likely fully-meated
Storage/Shipping:	Not ideal	Concerns	Likely suitable
Observed Lobster Quality Indicators:			
Blood Protein Level, BRIX index (units/ml)	**Less than 6.0**	**6.0 to 7.99**	**8.0 or greater**
Shell Hardness	Potentially "Soft" (2)	Potentially "Medium" (4), recovering from previous moult	Likely "Hard" (5)
Appearance	Pale colour, evidence of carapace abnormalities, and/or shell disease	Acceptable colour, little evidence of carapace abnormalities or shell disease	Spring black-bodied, few carapace abnormalities
Shape/size	Culls, misshapen claws, damage to carapace	Small size, misshapen claws, limited damage to carapace	Commercial size, good body shape

1.3   Lobster Shell Hardness

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 2022-2023, shell hardness measures are poorly correlated with continuously measured BRIX levels, and correlations (between lobster's BRIX and Hardness) are mostly not significantly different from zero for all sample location-dates. It is noted consequently, that shell hardness measures cannot be the lone determining factor in lobster quality prediction.

1.4   Lobster Appearance

Similarly, lobster appearance and lobster carapace shape and size are qualitative quality indicators based on simple accept-reject categories, i.e., if a lobster has carapace abnormalities such as evidence of culls, misshapen claws, missing swimmerets, or poor colour, then such lobsters are rejected for storage or shipping. Lobsters that pass the minimum acceptable appearance and shape inspection are difficult to assess further re quality. Like shell hardness measures, lobster appearance, shape and size cannot be singular determining factors in assessing lobster quality. Rather, the information is used as supplemental to determining lobster quality.

1.5   Lobster Moult Stage
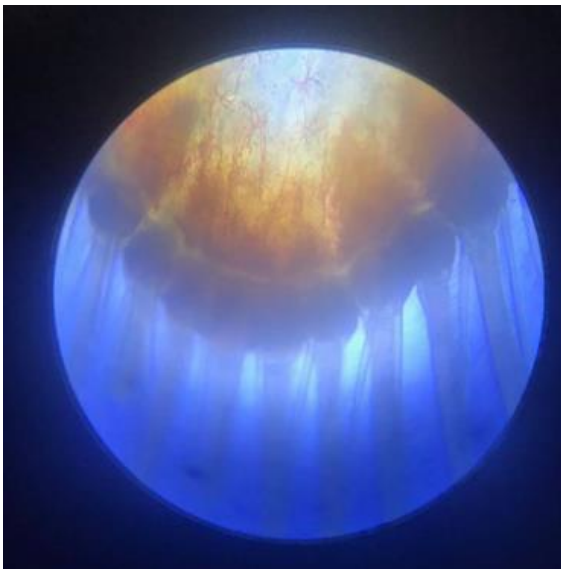
Figure 3. View of lobster pleopod under microscope.

Moult stage analyses are carried out by analysing selected lobsters. According to the ALMQ protocol in place since 2006, 30 lobsters from each sample of 150 lobsters per sampling location-date have their pleopods (swimmeret) removed. Each lobster's moult status is determined by microscopic analysis of the lobster pleopod as per the descriptions provided by Factor (1995) (see also 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 (Factor 1995).

2. Sampling Survey Information and Summary Results in 2022-2023

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 and 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 2022 preseason sampling and the 2022-23 in-season sampling.

Figure 4: Drawing blood for refractometer for BRIX

In 2022, a total of 7,283 preseason lobster samples were taken over the 4-month period from August 29 to November 16, a period of approximately 12 weeks. For the in-season survey of December 2022 through February 2023, a total of 1,800 lobster samples were taken in 12 in-season trips over 9 dates for 6 of the 8 sample location subareas, not including Lobster Bay Inside or Yarmouth Inside.

During sampling, 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). As the weeks went by in the survey, a noticeable shift from higher to lower lobster counts for inside areas occurred, 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 inside locations averaged 19.29 Fathoms in depth; outside areas over all 4 outside locations averaged 41.19 Fathoms in depth.

Preseason sampling in 2022 resulted in total catches of 29,446 lobsters for an average of 15.19 lobsters per trap over the 50 preseason dates (in increase of 22% over the 2021 preseason catch of lobster per trap of 12.42). The average BRIX index for individual lobsters was 9.46 units/ml for the 50 preseason sample location-dates in 2022 (an increase of 13% vs 2021). The BRIX index for the 12 in-season sample location-dates (December 2022 through February 2023) was 10.94 units/ml or 16% higher on average than the preseason average of 9.46 units/ml.

Overall, preseason and in-season samples combined, there were 2.66% "Soft" and 13.29% "Weak" lobsters observed. This represents a 48% increase in "Soft" (vs 1.8% in 2021-22) and a 25% increase in "Weaks" (vs 10.66% in 2021-22) compared to the 2021-2022 report. This represents a second successive year of significant increases in the numbers and percentages of Soft and Weak lobster in the survey samples. These data are summarized below in Table 3 - 2022 Preseason and 2022-23 In-season Sampling Survey Information Summary.

Table 3. 2022 Preseason and 2022-2023 In-season Sampling Survey Information Summary

Sampling Location	Samples Subarea	Sampling Dates	Harvested Counts	Lobsters Sampled	Sample Ave BRIX (units/ml)	Sample% Soft	Sample% Weak
Lobster Bay LFA 34	Inside	30-Aug	747	150	10.25	0.67%	14.67%
		13-Sep	638	150	10.81	4.67%	13.33%
		28-Sep	897	150	10.76	3.33%	16.67%
		13-Oct	592	150	9.98	4.00%	18.00%
		25-Oct	778	150	9.36	4.67%	26.67%
		08-Nov	653	150	9.47	7.33%	31.33%
		09-Nov	717	150	9.73	2.67%	27.33%
	Outside	29-Aug	399	150	10.49	3.33%	2.67%
		12-Sep	685	150	10.21	3.33%	10.00%
		27-Sep	815	150	9.63	3.33%	14.00%
		12-Oct	635	150	8.65	8.00%	18.00%
		24-Oct	769	150	9.07	8.00%	23.33%
		07-Nov	654	150	10.22	3.33%	11.33%
		12-Jan 2023	-#	150	10.55	0.67%	0.00%
Port La Tour LFA 33	Inside	31-Aug	302	150	9.02	7.33%	11.33%
		14-Sep	629	150	8.95	4.67%	18.67%
		28-Sep	288	150	9.35	2.00%	6.67%
		13-Oct	474	150	8.13	1.33%	14.00%
		25-Oct	476	150	9.08	0.67%	14.67%
		08-Nov	288	150	9.60	1.33%	15.33%
		09-Nov	371	150	10.80	0.67%	14.00%
		22-Dec	-#	150	10.85	0.00%	0.00%
		18-Jan 2023	-#	150	11.18	0.00%	0.00%
	Outside	30-Aug	11	8	8.99	25.00%	0.00%
		13-Sep	98	75	8.30	5.33%	14.67%
		27-Sep	222	150	8.22	10.67%	39.33%
		12-Oct	230	150	7.47	6.00%	21.33%
		24-Oct	573	150	7.22	3.33%	24.67%
		07-Nov	709	150	7.34	2.67%	40.67%
		22-Dec	-#	150	10.51	0.67%	0.67%
		18-Jan 2023	-#	150	9.87	0.00%	0.00%
		15-Feb 2023	-#	150	11.01	0.00%	0.00%

St. Mary's Bay LFA 34	Inside	07-Sep	363	150	10.39	2.67%	5.33%
		20-Sep	620	150	9.93	3.33%	10.00%
		05-Oct	561	150	8.92	4.00%	20.00%
		21-Oct	742	150	9.51	0.67%	16.67%
		01-Nov	438	150	10.41	0.67%	10.00%
		16-Nov	380	150	10.53	0.00%	6.67%
		21-Dec	-#	150	10.90	0.67%	4.67%
		25-Jan 2023	-#	150	11.62	0.00%	0.67%
		22-Feb 2023	-#	150	13.63	0.00%	0.00%
	Outside	06-Sep	342	150	10.11	0.67%	4.00%
		19-Sep	825	150	9.60	1.33%	9.33%
		04-Oct	1143	150	8.13	6.67%	27.33%
		20-Oct	859	150	8.89	2.00%	23.33%
		02-Nov	762	150	9.46	1.33%	16.67%
		15-Nov	825	150	9.07	0.67%	23.33%
		21-Dec	-#	150	9.27	0.67%	7.33%
		25-Jan 2023	-#	150	12.10	0.00%	0.00%
Yarmouth LFA 34	Inside	06-Sep	474	150	10.34	0.67%	5.33%
		21-Sep	720	150	10.23	1.33%	6.67%
		04-Oct	650	150	10.54	0.67%	14.00%
		20-Oct	420	150	9.94	2.00%	20.67%
		02-Nov	423	150	9.99	0.00%	7.33%
		16-Nov	402	150	10.49	0.67%	12.00%
	Outside	05-Sep	424	150	9.63	6.00%	10.67%
		20-Sep	703	150	9.69	3.33%	14.67%
		03-Oct	794	150	9.65	6.67%	16.67%
		19-Oct	1018	150	8.32	4.67%	26.00%
		01-Nov	717	150	8.39	4.67%	12.00%
		15-Nov	1191	150	8.78	2.67%	16.67%
		28-Dec	-#	150	9.80	0.00%	0.67%
OVERALL TOTALS	**8 Subareas**	**62 Sampling Dates**	**29,446 Lobsters Landed**	**9,083 Sampled Lobsters**	**9.75 units/ml Average BRIX**	**2.66% Overall % Soft**	**13.29% Overall % Weak**
In-season TOTALS		**12 dates In-season**	**NR# In-season**	**1,800 samples In-season**	**10.94 units/ml In-season**	**0.22% In-season**	**1.17% In-season**

*Denotes In-season samples (shaded) for selected sampling locations: Yarmouth (1), St. Mary's Bay (5), and Port La Tour (5) Lobster Bay (1).   # Zero harvest counts of lobster were taken for harvests during in-season sampling periods (shaded).

2.1   Sampling Protocols

During the 2022-2023 lobster sampling program, the following project outcomes were achieved:

- At-sea quality monitoring – successful observations over 8 locations within LFA33 and LFA34 over a total of 62 sampling dates from August 2022 to February 2023;
- Development of pre-season prediction report for industry – as reported in Mattock, Mulock, and Lane (2022) summary report released on November 26, 2022; see also: https://www.coldwaterlobster.ca/wp-content/uploads/2022/11/LQ_2022-Preseason-Summary-Report-FINAL.pdf
- In-season quality sampling – successful completion of 12 sampling location-dates in December 2022 through February 2023;
- Temperature data collection (pre-season and in season) – incomplete: no temperature data were analysed in the 2022-2023 sampling program;
- Lobster tagging program – not initiated in the 2022-2023 sampling program;
- Base line data on berried females – successful data collection across 62 preseason and in-season sampling location-dates; and
- Base line data on catch, including counts of sub-legal & legal male and female lobsters – successful observations of harvested lobsters in 8 locations and 50 preseason sampling dates.

2.2   Sampling Sites and Schedule

The 2022-2023 sampling schedules, sampling dates, locations, and numbers of lobster harvested, numbers of individual lobster samples made, proportion of soft/weak lobster status, and average location-date BRIX index are provided in Table 3 above. The map of Figure 5 below contains a single screen of mapped information about the precise location of the sample harvests (latitude and longitude of first string), as well as time of haul statistics for: (i) sea state (in meters); (ii) surface temperature, F (where available); and (iii) weather description at time of set haul. Additional data includes total lobster harvest counts at site, the number of trap hauls, lobster counts per trap, average lobster BRIX from site samples, and the number of "weaks" in site sample.

This mapped information for 2022-23, including mapped sampling information for the years 2020-21 and 2021-22, are available for viewing on Google maps. A public link is available at the following site:

https://www.google.com/maps/d/edit?mid=14NsroLb5FWDSt9HQEn7h2J4zodkv7iAD&usp=sharing

(Please send any feedback, questions on the mapped sampling information to D. Lane at Daniel.Lane@usainteanne.ca.)
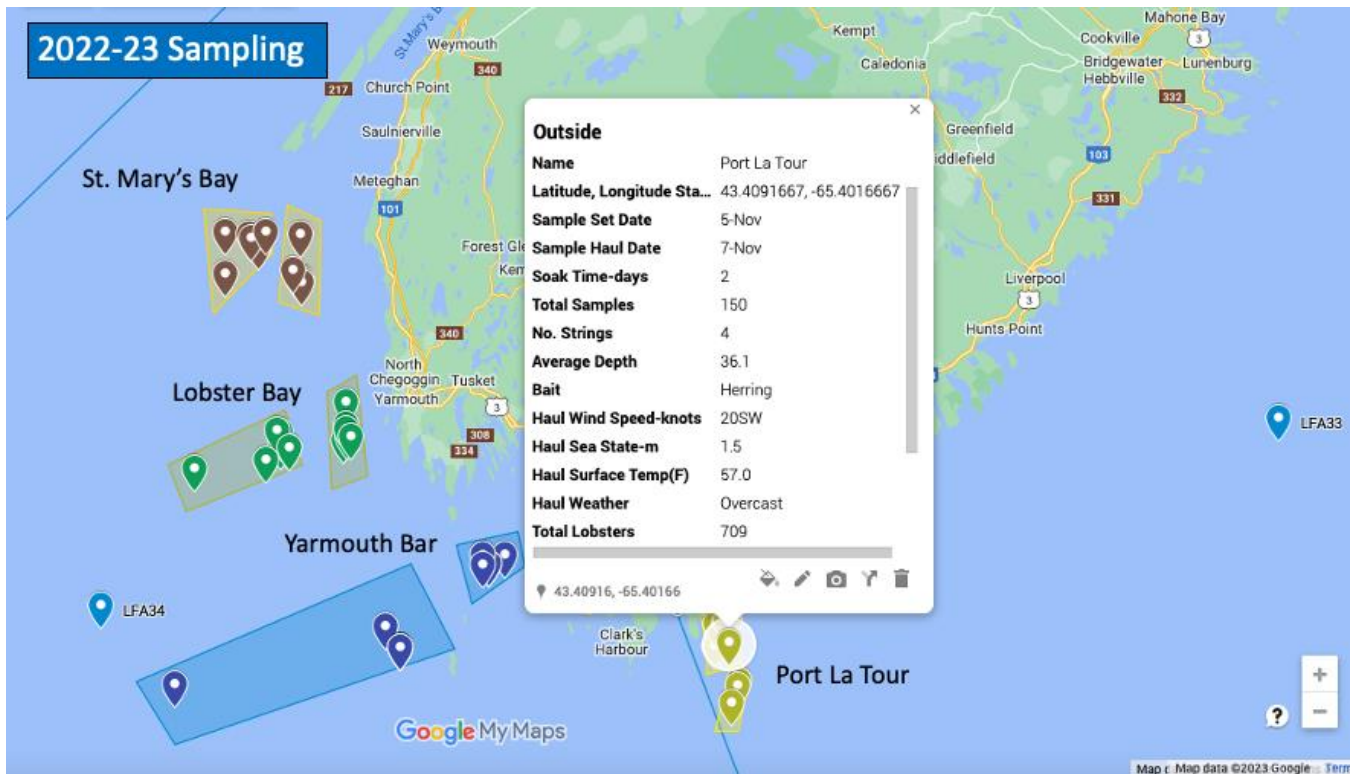
Figure 5. Google map of 2022-2023 At-sea survey area and related information.

2.3   2022-2023 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.

The 2022-2023 commercial lobster fishery was scheduled to open on Monday, November 28, 2022. However, once again this year, weather delayed dumping day in LFA33 and 34. In 2021, there was a two-day delay in dumping day, while in 2020, the delay was 8 days (among the longest in the history of the fishery). On November 28, 2022 Saltwire (https://www.saltwire.com/atlantic-canada/news/new-lobster-fishing-start-date-awaited-in-one-southwestern-zone-100800224/) reported that in southwest Nova Scotia a gale warning for November 28 had been in effect with morning winds of 25 knots increasing to 35 knots. In LFA33, where more vessels fish closer to shore, the industry opted for a Tuesday, November 29 opening. Meanwhile, in LFA34, the opening only took place on Monday, December 5, 2022, one week after the scheduled start of the 2022-23 commercial season.

Again in 2022-2023, 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. In 2022-23 sampling was conducted from depths ranging from 8 Fathoms (St. Mary's Bay Inside) to 63

Fathoms (Yarmouth Outside). It is noted that preseason samples do not provide an indication on the quality of lobsters caught outside the selected areas or 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 60 Fathoms.

In 2022, preseason lobster samples were taken over the approximately 12-week period from August 29 to November 16. Weather conditions for sampling over the 50 preseason trips completed in 2022 were generally quite favourable with light winds and calm seas. The 2022-2023 pre-season and in-season sampling days were achieved through the flexibility of choosing the best fair-weather days each week as there were periods of rough weather during the preseason period which were avoided. The weather turned once the LFA33&34 season opened in southwest Nova Scotia presenting more challenges to achieving sampling days for the month of December. January saw a significant decrease in catch rates on back-to-back hauls therefore captains reduced the number of trips made each week to allow the gear to soak for longer to maintain a respectable harvest on the chosen day fished. The weather allowed for more hauls for the month of January (compared with past seasons) and this, combined with longer soaks, enabled the captains to report an overall increase of lobster caught for the month. Lobster quality increased tremendously near the end of December leading into January, and that, corresponding with a slowly increasing lobster price per pound, helped alleviate the increased price of fuel and bait required. February also proved to be even more challenging as water temperature decreased and more storms passed through the fishing grounds that led to slowing of the catch rate to an economical point and fishing became more about servicing/maintaining the traps as per DFO requirements.

2.4　Lobster Quality Category Classification

For the first time in 2021, consolidated data from each sample date by location are classified into lobster quality categories derived from the extended ALMQ database (2006-2021). Lobster quality categories for each consolidated location sample are based on collective lobster sample characteristics by sample date of – typically – 150 lobster samples for each date. The consolidated sample date data include: the means, medians, ranges, and moments for the 150 lobster BRIX values, and the 150 lobster carapace lengths, as well as sample month and days prior to the season opening. For example, the following graphic (Figure 6) displays the consolidated BRIX (only) data for the Lobster Bay (Inside) area for the 2006-2020 samples (n=158) in this location. The box-and-whisker plot shows the distribution of the summary average BRIX values across all samples in each year for Lobster Bay (Inside).

Of note in Figure 6 is the separation of the distributions of the consolidated annual average BRIX values into 2 notable groups: (1) 2006-2013; and (2) 2014-2020. The first group represents a relatively higher and consistent average BRIX regime. The second group illustrates an apparent shift in lobster average BRIX values to a consistently lower average BRIX regime. This time shift phenomenon occurs in each of the 8 lobster sampling locations and is the expected result of an environmental/ecosystem shift that persists into 2023. With this in mind, a subjective assignment of each year's consolidated annual BRIX values were assigned into one of 5 lobster quality categories. Preseason Lobster Quality categories are particular to the history of each of the 8 locations. These categories are described in Table 4 below.
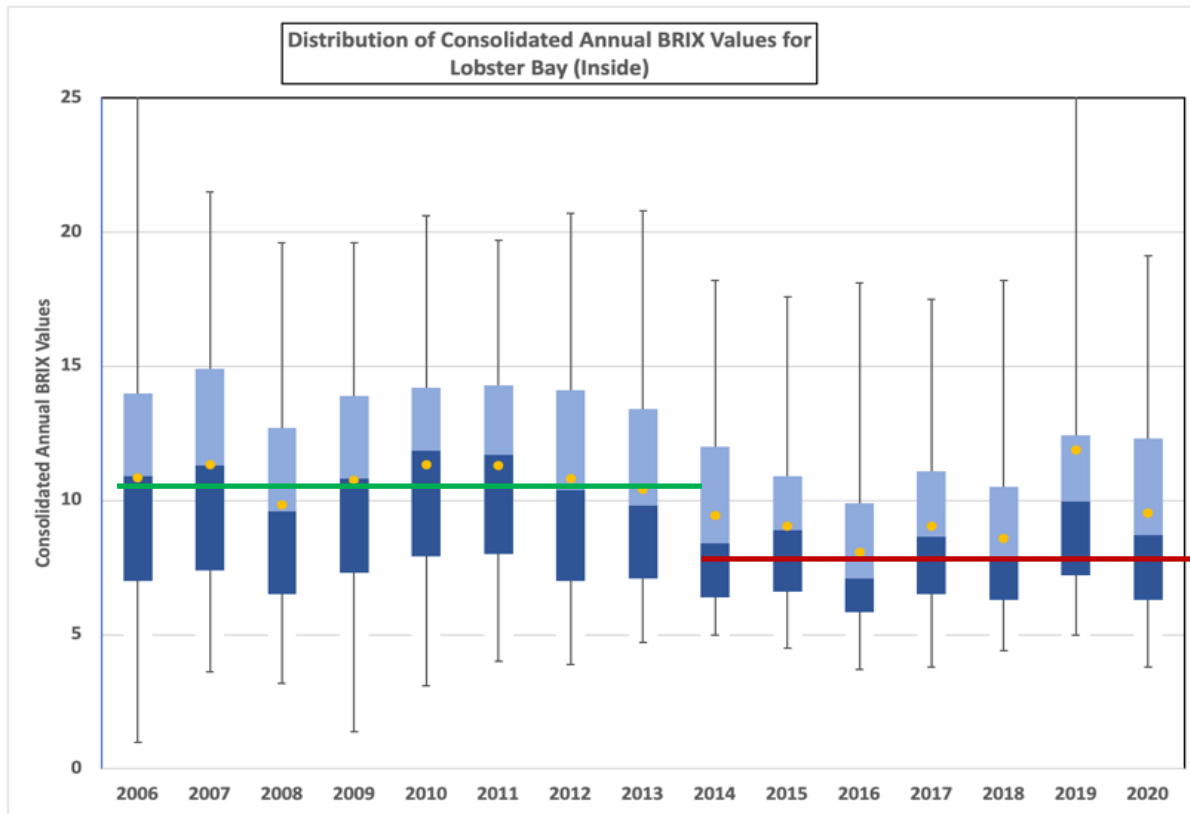
Figure 6. Box-and-Whisker plot of Consolidated Annual BRIX values for Lobster Bay (Inside). Annual mean BRIX values are denoted by yellow dots; rectangles are interquartile ranges; annual median BRIX are lines separating light and dark range; vertical lines (minimum to maximum BRIX) indicate annual consolidated BRIX values outside interquartile range.

Table 4. Lobster Quality Category Descriptions

Level	Lobster Quality Category	Description of Sample Location-Date Distribution
1	High (H)	This category is indicative of a consolidated sample date of 150 lobsters with elevated average BRIX value specific to the location over the database period, e.g., exceeding 10 for most locations, and other positive distribution characteristics, e.g., high relative BRIX median and range
2	Moderate–High (MH)	This category is indicative of a consolidated sample date of 150 lobsters with slightly above-average BRIX values specific to the location over the database period, e.g., approximately between 9.5 and 10 in most locations
3	Moderate (M)	This category is indicative of a consolidated sample date of 150 lobsters with near average BRIX values specific to the location over the database period, e.g., approximately between 8.5 and 9.5 for most locations
4	Moderate–Low (ML)	This category is indicative of a consolidated sample date of 150 lobsters with slightly below-average BRIX values specific to the location over the database period, e.g., approximately between 7.5 and 8.5 for most locations
5	Low (L)	This category is indicative of a consolidated sample date of 150 lobsters with below average BRIX values specific to the location over the database period, e.g., less than 7.5 for most locations

Using linear discriminant analysis, the historical consolidated sample data were categorized into these 5 'lobster quality categories' for each location. The results of the analysis enabled the numerical description of each category, and subsequently, the assignment of each of the 2021-22 and 2022-23 sample dates into its most probable lobster quality category.

Preseason sample results for 2022 by location are compared to past preseason sampling years. If, for example, 2022 preseason sample results for Lobster Bay Inside compare favorably to past preseason survey years of Low (L) Lobster Quality Category for Lobster Bay Inside (historically estimated from the data to have occurred in 2016 and 2018–see also Table 5 below), then the 2022 preseason data may predict that the 2022-2023 commercial season is comparable to the known commercial seasons of 2016-2017 or 2018-2019 that followed these same low survey results.

The 2022 Lobster Quality Category assignments are determined by the categories with the highest likelihood (expected probability) of occurrence. Assigned categories by location and year are based on preseason sampling data and are provided in the following table of assigned Lobster Quality categories for each location over the full database (2006-2021) containing over 800 location-date samples of 150 lobsters (typically) per sample.

Table 5. 2006-2021 Lobster Quality Category Assignments*

Subareas:	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	Total Yrly Dates
2006	MH	H	H	MH	MH	H	H	MH	68
2007	H	H	H	MH	M	-	H	H	61
2008	H	MH	MH	MH	MH	-	MH	MH	60
2009	MH	H	H	MH	MH	MH	M	M	67
2010	H	MH	H	H	H	MH	MH	H	73
2011	MH	M	H	MH	MH	H	MH	-	65
2012	MH	MH	MH	H	M	M	MH	-	63
2013	M	M	MH	H	M	M	M	-	52
2014	ML	ML	M	M	L	ML	-	-	34
2015	ML	ML	ML	M	L	L	-	-	32
2016	L	L	L	L	L	M	ML	ML	52
2017	ML	ML	ML	L	L	L	ML	ML	52
2018	L	ML	L	ML	MH	L	L	L	46
2019	ML	L	M	ML	ML	ML	-	L	13
2020	ML	L	M	ML	ML	ML	ML	M	56
2021	ML	M	M	M	M	M	M	M	51
Total Sample Dates	139	136	164	121	146	47	53	39	845

*2006-2013 (Green)–Historical period of higher relative quality; 2014-2021 (Red)–Current period of lower relative quality.

Table 5 values indicate the annual time series of assigned Lobster Quality Category for each location from 2006 to 2021. The relative decline over time of lobster quality across all locations in LFAs 33&34 over the full period 2006 to 2021 is evident from Table 5 and the example of Figure 5 of the annual box plots for Lobster Bay Inside. Lobster quality categories from 2006 to 2013 exhibit higher categories (moderate (M) or higher (MH, H)) throughout the period from 2006 to 2013 (green line).

Since 2014, however, assigned Lobster Quality Categories across the locations are nearly all designated as moderate (M) levels or below (ML, and L) (Figure 5, red line). Although it is difficult to identifiy trends in the consolidated data (i.e., combined annual survey samples by location), it generally appears that since 2018, there may be the beginning of a recovery of lobster quality indicators from L to ML going forward to

2022. These data provided the backdrop for the predictions of lobster quality categories for the 50 preseason sample dates by location in the 2022 preseason period. Table 6 presents the summary lobster quality category classification for the 2022 preseason sample subarea locations. These results average the lobster quality categories over the preseason sampling dates by subarea locations. Information on average BRIX, average counts of legal-sized lobster per trap, percentage of weaks, and percentage of soft plus medium hardness, as well as most comparable historical years to 2022 are included in Table 6 below. A detailed description of the statistical analyses of the consolidated annual data by location is provided in the LQC Working Paper "Statistical Analyses for Lobster Quality Determinants and Predictions" (in progress) (Lane et al 2022).

Table 6. 2022 Preseason Lobster Quality Category Assignments by Subarea

| Subareas:	Yarmouth Inside	Yarmouth Outside	Lobster Bay Inside	Lobster Bay Outside	Port LaTour Inside	Port LaTour Outside	St.Mary's Bay Inside	St.Mary's Bay Outside	Overall Subareas
Average BRIX (units/ml)	10.25	9.08	10.05	9.71	9.13	7.92	9.95	9.21	9.44
Legal Counts per Trap	8.91	16.86	12.05	12.55	7.09	8.13	10.82	17.80	11.69
%Soft+Medium	18.78%	28.78%	20.57%	21.44%	26.76%	43.61%	23.11%	21.33%	25.55%
%Weaks	11.00%	16.11%	21.14%	13.22%	13.52%	23.44%	11.44%	17.33%	15.96%
Bimodal BRIX Dist? Yes/No	No	No	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Average Lobster Quality Category	**ML**	**ML**	**ML/M**	**ML**	**ML**	**ML**	**MH**	**M**	**ML**
No. Preseason Location-dates	6	6	7	6	7	6	6	6	50
Comparable Years	**2015, 2019**	**2014, 2015**	**2013, 2021**	**2012, 2019**	**2018, 2019**	**2016, 2021**	**2020, 2021**	**2017, 2021**	**2020**
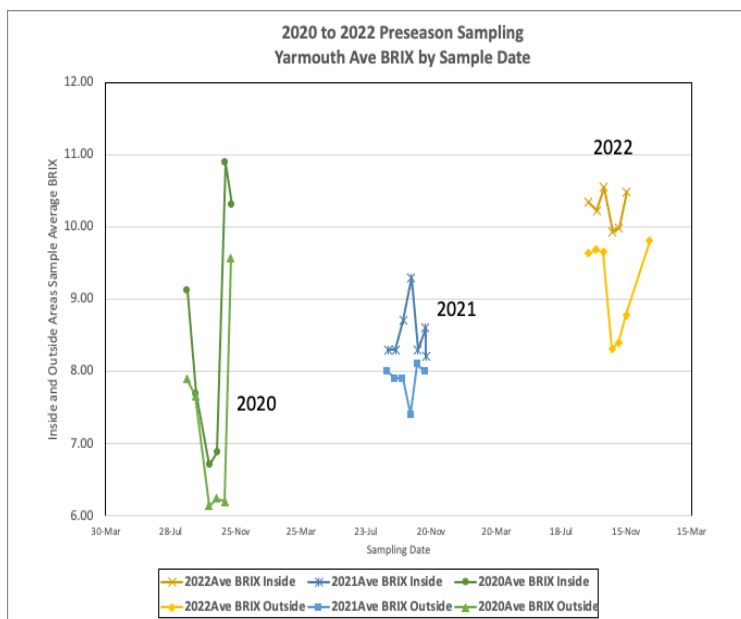
Figure 7. 2020 to 2022 Preseason Yarmouth Average BRIX

In 2022, the average Lobster Quality Category continues the period of lower quality regime experienced since 2014 with most locations exhibiting "ML" – medium to low quality levels indicative of the 2014-2021 period of comparable years (Figure 6). The sole exceptions are the higher average BRIX levels and lobster quality categories of St. Mary's Bay. Finally, the distribution of Lobster Bay BRIX is comparable to the higher quality years of 2012 and 2013.For the 2022 preseason, average BRIX values at sample dates were higher in 2022 compared to 2021 and 2020 (see also Figure 7 for Average BRIX at Yarmouth (Inside and Outside).

This may be considered to indicate higher BRIX levels in this location for the commercial season in 2022-23 compared to the past 2 years. Higher average BRIX levels also occurred in the other locations in 2022.

At the same time, the precent of soft+medium lobster hardness recorded in Table 6 above across all sampling locations increased in 2022 compared to past years. Figure 8 below illustrates this increase for the St. Mary Bay (Inside and Outside) locations. In this case, the change from an average of less than 5% soft+medium lobsters in 2020 to approximately 10% in 2021, pales with the average of over 20% soft+medium lobsters in St. Mary's Bay in 2022 (Table 6, Figure 8). Similar statistics are generally noted in the comparison of the increase in %Weaks in 2022 (Table 6) across all 4 locations compared to 2021 and 2020.
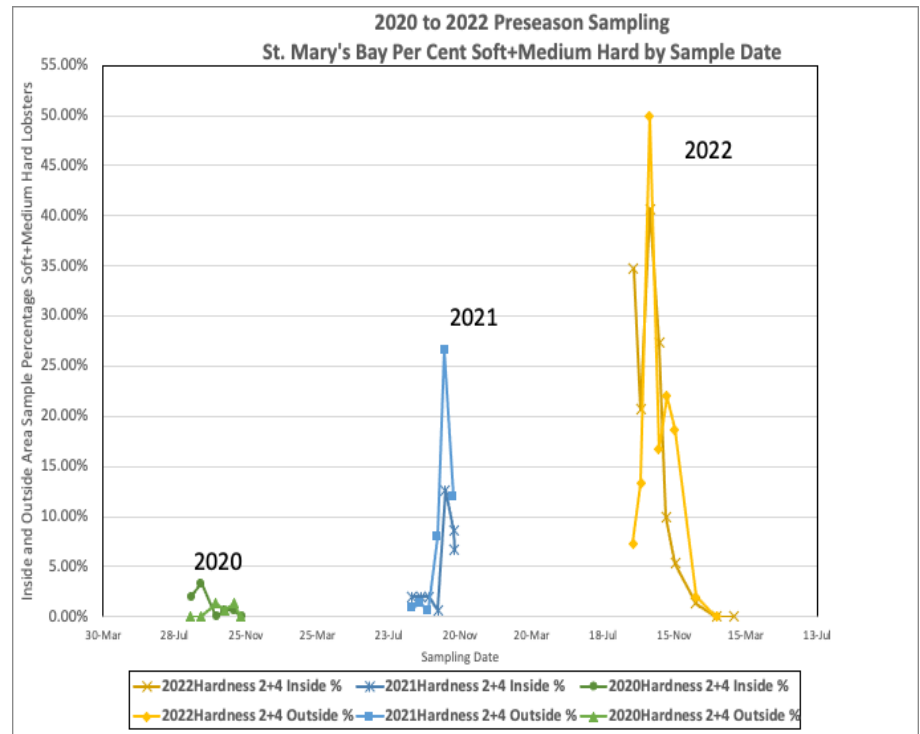

Figure 8. 2020 to 2022 Preseason St. Mary's Bay %Soft+Medium

Table 6 reports on the form of the BRIX distributions for late preseason survey dates (November) reviewed for each subarea. In 2022, the observations of: (i) increased landed lobster counts and counts of lobster per trap, and (ii) the increases of counts of weak and soft and medium hard lobsters, provides indications of lower lobster quality across southwest Nova Scotia. However, these lower quality indicators are tempered by higher overall BRIX values that indicate better quality among the sampled lobster population. A review of the BRIX distributions by location in Section 4.5 below provides further explanation for this apparent confounding set of observations based on expected dynamic BRIX distributions.

3. Preseason Sampling Data

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 a generalized prediction about lobsters' average moult time was difficult to make.

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., the 2011-12 commercial season was a "high quality" season whereas the 2015-16 commercial season was a very poor-quality year throughout LFAs33&34. New preseason sampling results that compare well with the 2011-12 preseason sampling data should therefore be a good indicator of quality to follow into the commercial season. Similarly, preseason sampling that compares more closely to the 2015-16 preseason sampling data would suggest a prediction for poor quality to follow in the comparable commercial fishery.

To this end, we evaluate historical annual quality status and compare recent results to the history. This analysis begins with a view of the distribution of the lobster data collected as presented below.

3.1   Lobster Counts Sampling for 2022-2023

The at-sea sampling data were compiled into the '*Preseason Summary Report*' and distributed by Coldwater Lobster Association to the lobster industry and government funders on November 26, 2022 (Mattock, Mulock, and Lane 2022). This report contains summary information on the lobster counts harvested and sampled during the 2022 preseason sampling program. Specifics on the 2022 preseason survey 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 for each location is presented in Appendix A of this report for 2022-2023 sampling, with comparison to the previous year's 2020-2021 and 2021-22 lobster counts sampling results.

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

Location graphics results of lobster counts from the sampling program are as follows:

(a) Counts of lobsters harvested per trap by sex for Inside & Outside areas
(b) Counts of lobsters harvested per trap and BRIX for Inside & Outside areas
(c) Counts of lobsters sampled by Moult Stage - Outside areas
(d) Counts of lobsters 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 lobsters 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 during preseason sampling. As noted by the example of Yarmouth (Inside and Outside areas) in Figure 9 below, CPUT measures (males and females) for 2022(a), 2021(b), and 2020-21(c) for inside areas are flat or declining over the course of the preseason sampling dates (Figure 9a,b,c) and continue to fall during the commercial season (2020-21, Figure 9c).

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.

Finally, comparison of annual CPUT in Figure 9 shows that 2022 preseason catch rates were on average, higher than that of the two previous years. These results would suggest that catch rates at the start of the commercial fishery in 2022-23 would be better than those of 2021 and 2020.
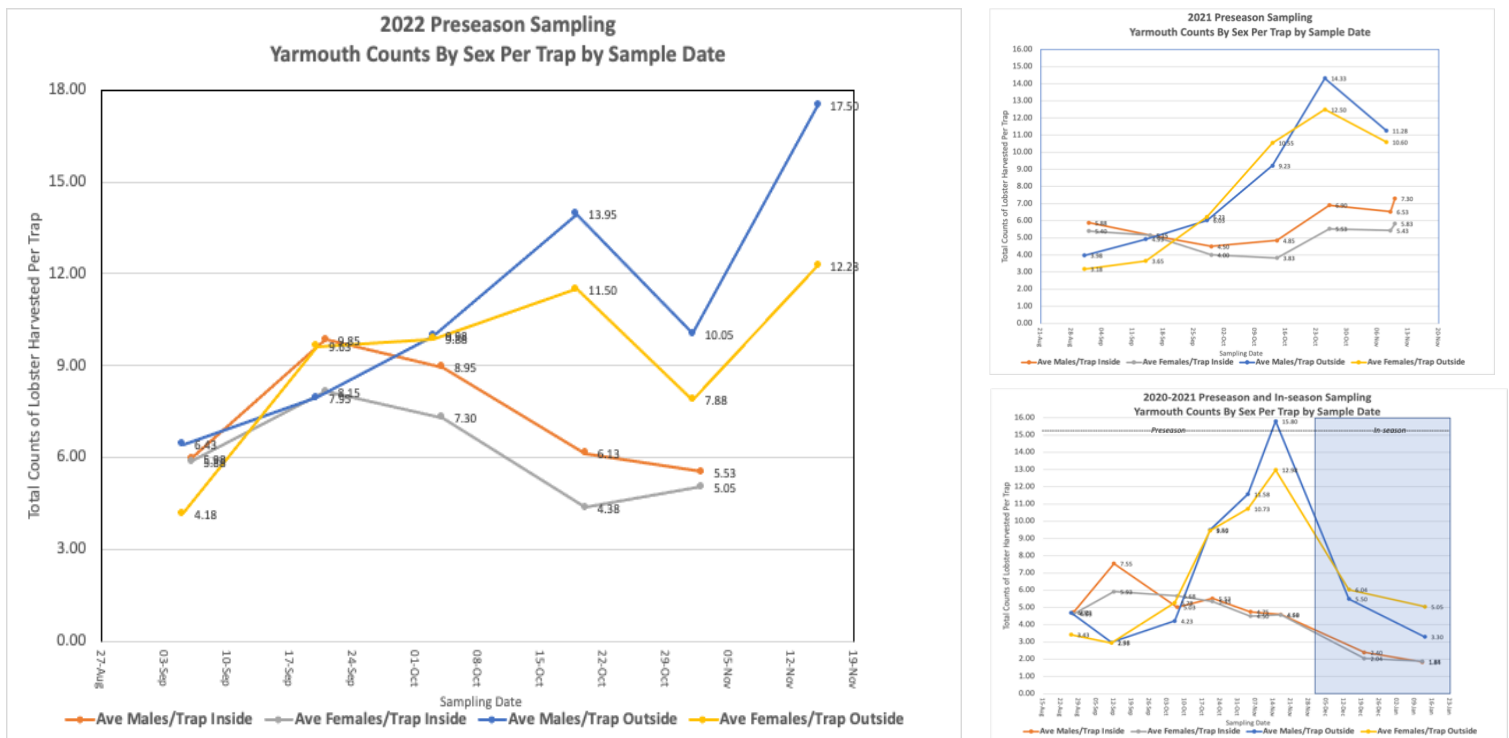

Figure 9. (a) 2022 Preseason Yarmouth Counts by Sex per Trap for 2022 Sample Dates; (b) 2021 Preseason Yarmouth Counts by Sex per Trap for 2021 Sample Dates; (c) 2020-2021 Preseason and In-season Yarmouth Counts by Sex per Trap for 2020-21 Sample Dates

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

Preseason BRIX levels shift slightly over the course of preseason sampling in all areas. Figure 10 below indicates the BRIX category levels for Lobster Bay. BRIX values tend to be flat initially in both inside and outside areas from the early preseason sampling dates (August through September) followed by a slight decline in value through October followed by a rise into early and mid-November at the end of the preseason sampling period. In 2022 (Figure 9(a)) – as in 2021(b) and 2020(c) – inside area BRIX averages were marginally higher than outside areas early in the sampling period. This reversed later in the period of the year when average BRIX values in the inside areas tended to fall, and outside areas' BRIX tended to rise. This behaviour was observed in all years 2022(a), 2021(b), and 2020(c). Similarly, average counts were initially higher in Inside samples. Outside counts rose in later sampling dates in all years. (See also Appendix A, pp.A.2 through A.5.)
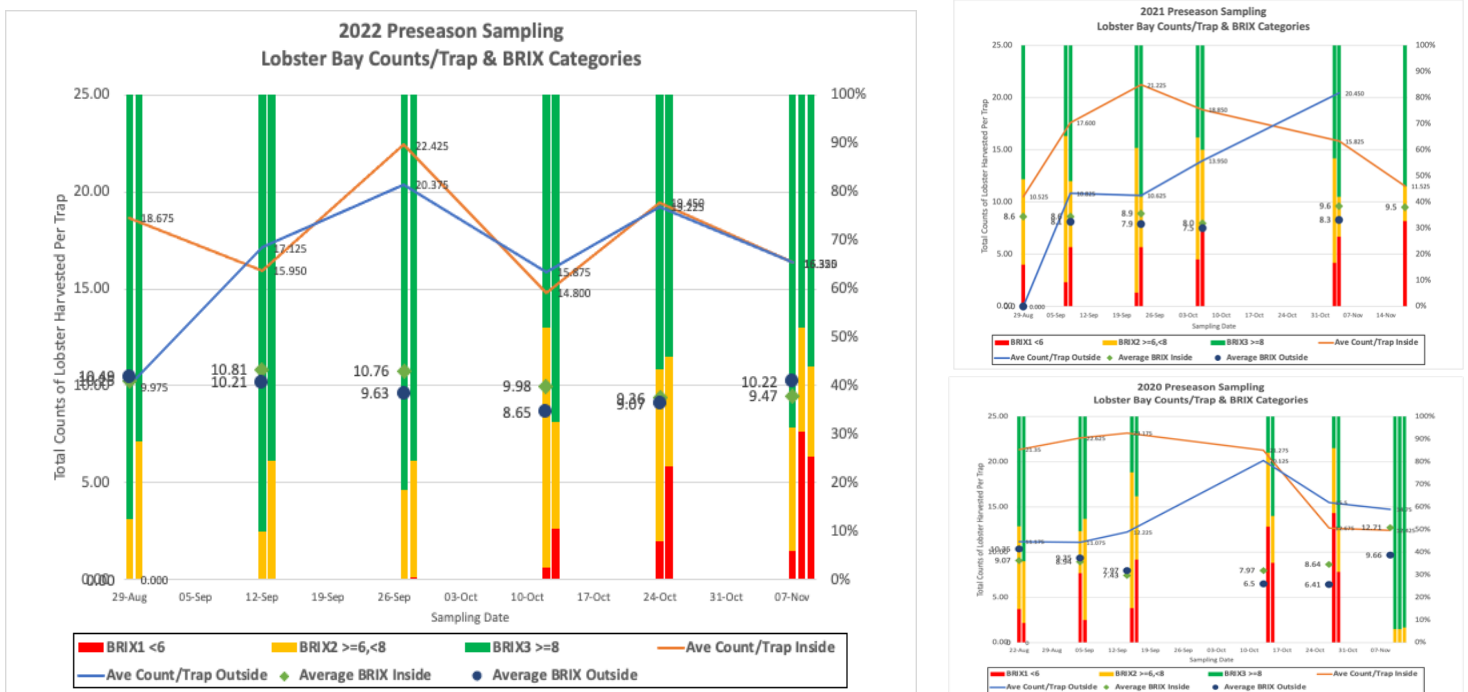

Figure 10. (a) 2022 Preseason Lobster Bay Counts per Trap and BRIX Indicators; (b) 2021 Preseason Lobster Bay Counts per Trap and BRIX Indicators; (c) 2020 Preseason Lobster Bay Counts per Trap and BRIX Indicators

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

As for 2020 and 2021, the 2022 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 (as available) for each of the 8 sampling areas and for each preseason and in-season sampling date.

Figure 11a,b,c below shows the moult stage counts data by stage for Port La Tour Outside area preseason sampling. As in 2020 and 2021 (Figure 11b,c), early sampling efforts in Port La Tour (Outside) during 2022 sampling were unable to harvest significant legal lobsters (30) during the August 30, 2022

sampling period (Figure 11a). By mid-September 2022, more lobsters were appearing in the Port La Tour Outside areas resulting in the full complement of 30 vials of pleopods. This represents an improvement in Port La Tour Outside lobster availability compared to 2020 (end-September 2020) and 2021 (mid-October 2021). These results for Port La Tour (Outside) are consistent with the improved availability of lobster in all sampled areas in 2022.

Figure 11 illustrates that the Port La Tour (Outside) samples in the remainder of the preseason and into the in-season sampling period result in a clear majority (90% or greater) of Stage 0 (no moult activity) samples. There are few (less than 5 samples) of Stage 2 lobsters and very limited Stage 3+ observations across all sample dates over all 3 years.

Among the 30 pleopod samples per location-date, roughly 1-2 vials recorded evidence of cement glands in female lobster ("CS", Factor's D2 and D3). Otherwise, zero moult activity stage is observed in Port La Tour (Outside) for the third successive year of sampling there. (See also Appendix A, pp.A.2 through A.5 for moult stage information for all sampled locations.)
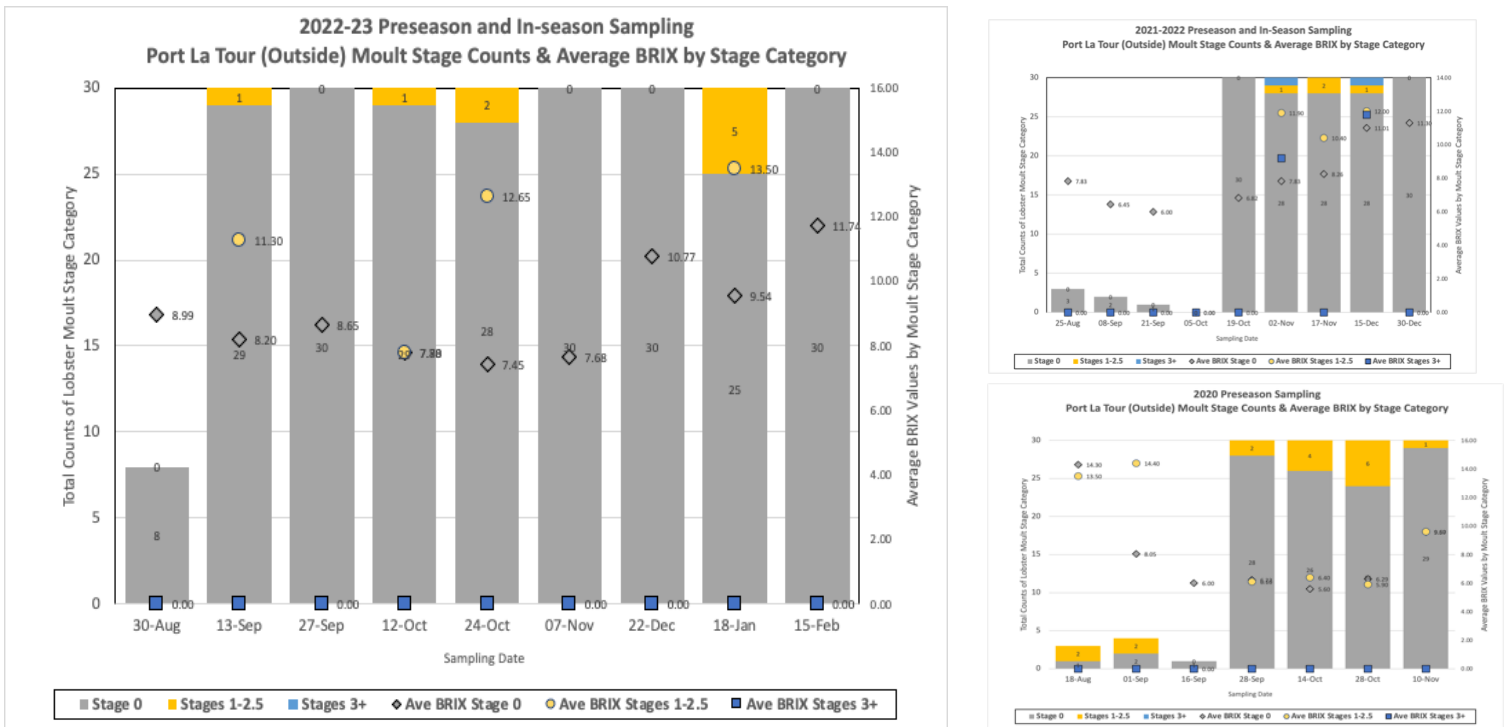

Figure 11. (a) 2022-2023 Preseason and In-season Port La Tour (Outside) Moult Stage Counts & Average BRIX by Stage Categories; (b) 2021 Preseason Port La Tour (Outside) Moult Stage Counts & Average BRIX by Stage Categories; (c) 2020 Preseason Port La Tour (Outside) Moult Stage Counts & Average BRIX by Stage Categories

(d) Counts of lobsters 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 at harvest. 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 12 below provides the hardness measure results for St. Mary's Bay Inside and Outside sampling dates. In 2020 (Figure 12(c)), less than 5% of all

sampled lobsters were assigned a "Soft" or "Medium" hardness level, i.e., almost all (95%+) lobster were assigned a "Hard" level. In 2021 (Figure 12(b)), more "Medium" lobster were assigned in the St. Mary's Bay samples. Numbers of "Soft" and "Medium" lobster in 2022 (Figure 12(a)) increased markedly in this location – and across the other locations – to the highest levels seen in the database since 2006.

It is noted that subjectively measured "Medium" and "Soft" lobster have lower BRIX values. However, the lack of variability in the hardness scale measure makes it difficult to obtain additional information about lobster quality from this subjective measure. As such, this determinant of lobster quality may be used to eliminate a small proportion (less than 10%) of lobster as unacceptable quality for storage and shipment. Appendix A.1, pp.A.2 through A.5, also contains hardness information for all sampled locations.
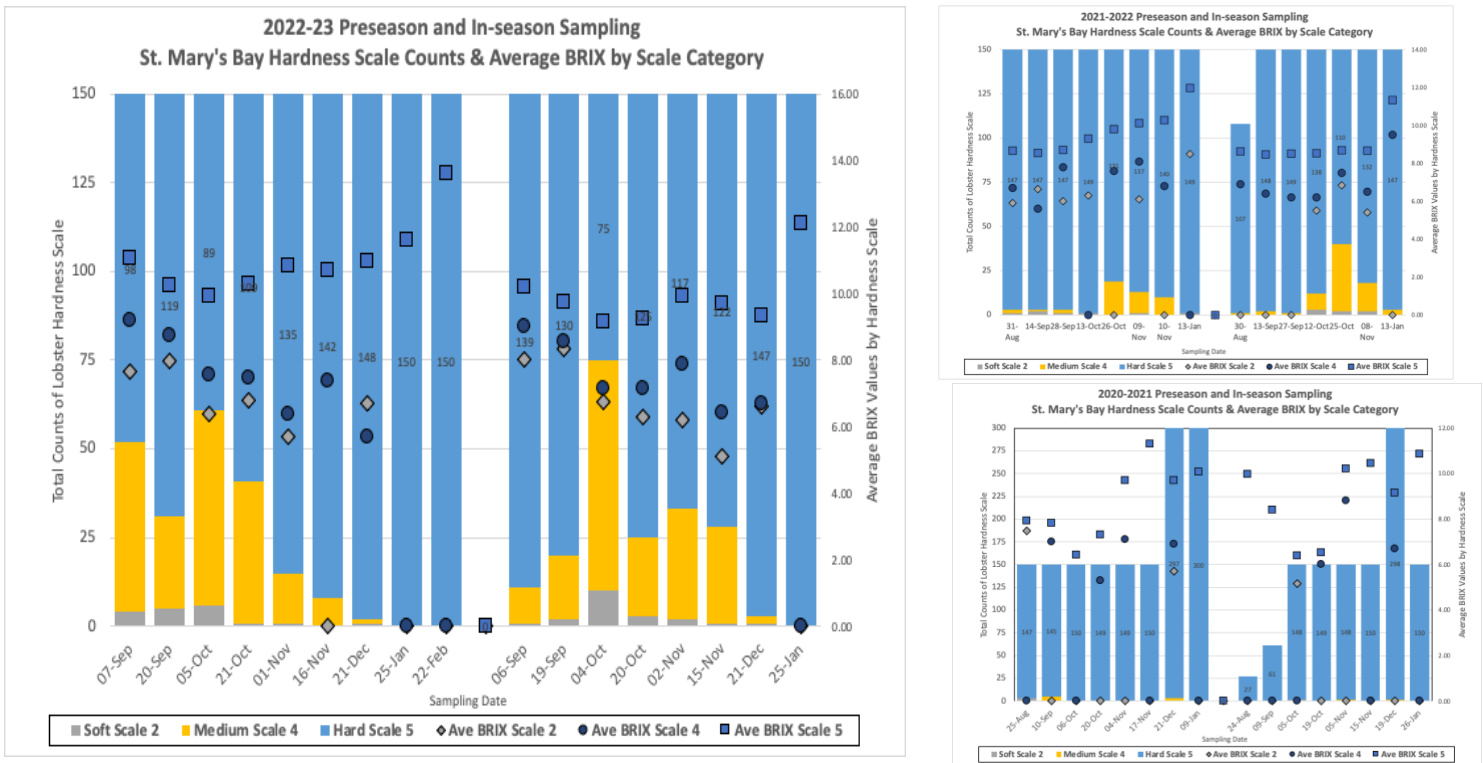

Figure 12. 2022-2023 Preseason and In-season St. Mary's Bay (Inside and Outside) Hardness Counts per Trap & Average BRIX by Category

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 in Section 3.1.1(a), catch per unit trap (CPUT) fishing effort measure provides general information about the propensity of available lobster to enter the sampling trap. In 2022, the trend across all inside locations is for CPUT to remain relatively flat 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 Inside has nearly twice the CPUT than the other inside locations (Port La Tour excepted) over the preseason sampling periods. 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 locations is for CPUT to rise as lobster move into their associated outside areas over the preseason as is indicative of a movement of lobster from inside to outside areas over the sampling period August to November. This is illustrated by the trend seen in the 2022 preseason period in Figure 13a below. In 2022 (Fgure 13(a)), CPUT was higher than 2020(c) and 2021(b) in the earlier sampling dates. Once the commercial season begins, CPUT is expected to fall appreciably as market lobsters are fished down. In 2020-2021 in-season sampling (Figure 13(c)), this fall was by as much as 75% for most locations. See also Appendix A.2, p.A.6 for more details.
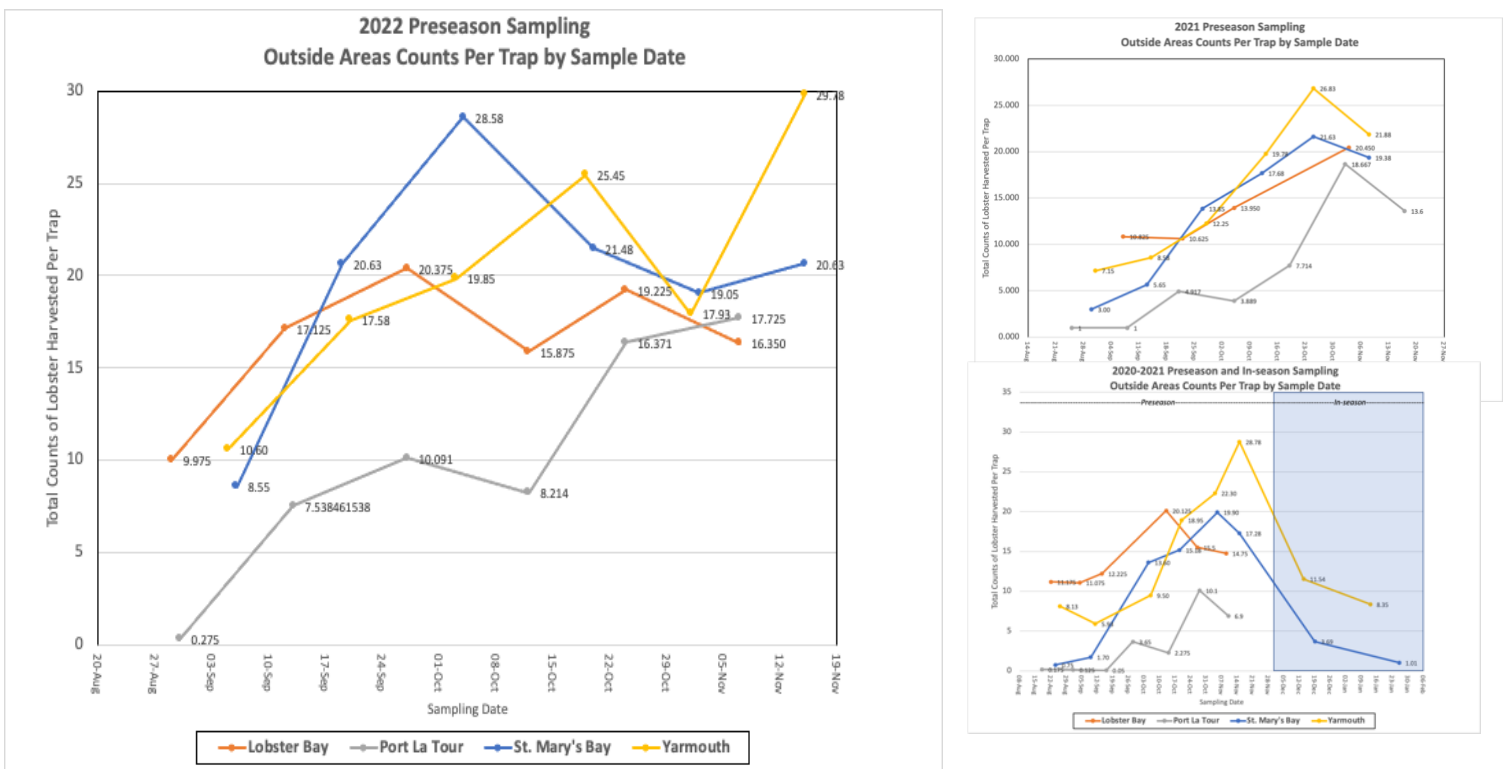

Figure 13. (a) 2022 Preseason Outside Areas Counts per Trap by Sample Date; (b) 2021 Preseason Outside Areas Counts per Trap by Sample Date; (b) 2020-21 Preseason and In-season Outside Areas Counts per Trap by Sample Date

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

Comparison of average BRIX levels in the inside location samples are also provided in Appendix A.2, p.A.6(c) for the inside areas. Generally, in 2022-2023, as in the past years, Inside BRIX values are flat and/or in decline in the preseason sampling period (September and October), followed by a significant (50%) rise thereafter to the start of the commercial season at end November. See also Appendix A.2, p.A.6(c).

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

Outside areas average BRIX values per sample tend to fall initially (August through September) from average levels of approximately 9-10 units/ml, remain flat through October (at levels of 7-8 units/ml) before rising by as much as 50% (to levels of 11-13 units/ml) across all areas. This dynamic behavior with respect to BRIX is illustrated in Figure 12 below for all locations. (See also Appendix A.2, p.A.6(d)).

Figure 14. (a) 2022 Outside Areas Average BRIX by Sample Date; (b) 2021 Outside Areas Average BRIX by Sample Date; (c) 2020 Outside Areas Average BRIX by Sample Date

3.2   Berried Females Sampling for 2022-2023

Berried (egg-bearing) females were examined again in the 2022-23 preseason and in-season survey. Each of the 50 preseason location-dates captured an average of 4.9 berried females in all moult stages or 1.97% (245) of all female lobsters captured (12,434) during the preseason sampling dates. Berried female analyses recorded carapace size, clutch fullness, egg stage and condition for each berried female lobster.

Data on berried females were compiled as part of the preseason and in-season sampling program in 2022-2023. This report contains summaries of the berried females information on selected harvested lobster counts. This information below includes: (1) Section 3.2.1 – berried females sampled counts

information; and (2) Section 3.2.2 – berried females 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 sampling dates (no berried female counts data were collected for the 2022-2023 in-season sampling dates). Selected graphics are presented in this report below.

3.2.1   Berried females sampled counts information

1)   Berried females sampled in 2022 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. Most observations are Stage 1(28 on 36 observations or 78% over all sampling dates) with observations between 0 and 7 berried female lobsters in a single sample. In 2022, there are 6 Stage 2 observations (17%) and only 2 Stage 3 observations (6%). There are zero Stage 4 lobsters observed in Yarmouth overall preseason and in-season sampling dates. In 2022, the percentage of Yarmouth berried females observations is 14% (36 Yarmouth observations on 265 total) of all berried female samples over all locations. See also Appendix B.1, p.A.8(1).

2)   Berried females sampled in 2022 and percent of harvest for Lobster Bay Inside & Outside areas

Berried females counts in Lobster Bay accounted for 32% (87 on 265 observations) of all berried females observations across all locations. Stage 1 counts increase to end October and then fall in November – as happened in 2021 and 2020. Lobster Bay berried females counts are dominated by Stage 1 observations accounting for 91% (79 observations on 87 total). There are 8 Stage 2 counts with 7 of these observed in early November 2022 in both Inside (4) and Outside (3) subareas. In 2022, there were zero counts of Stage 3 or Stage 4 lobster. See also Appendix B.1, p.A.8(2).

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

Again in 2022 (as in 2020 and 2021), berried female counts in Port La Tour are the smallest of all areas with total counts of 21 (8% of total) and less than 4 in any one sample. Stage 1 counts (9 observations) occur only in the Inside area. Stage 3 observations (4) all occur in one late sample date Outside during the In-season period (February 2023). The only Stage 4 observation over all locations occurred in September in Port La Tour (Outside). 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 15a,b,c below illustrates the berried females report for St. Mary's Bay in 2022(a). The counts of berried females in this location were highest over all locations in 2022 represented by 121 observations or 46% of all observations. Berried female counts in St. Mary's Bay (Inside) fell in early sampling from September 2022 (9 observations) to 2-4 observations through end-October, rebounding to highs of 15 and 27 observations in November. Similarly, in Outside areas, observations rose into November to single dates samples of 19 berried females. Only 1 observation of a Stage 3 lobster was observed (October).

All other observations were Stages 1 and 2. From Figure 15, it is noted that berried females counts in 2022(a) exceeded those in 2021(b) and 2020-21(c) by a factor of 2 or 3. See also Appendix B.1, p.A.8(4).
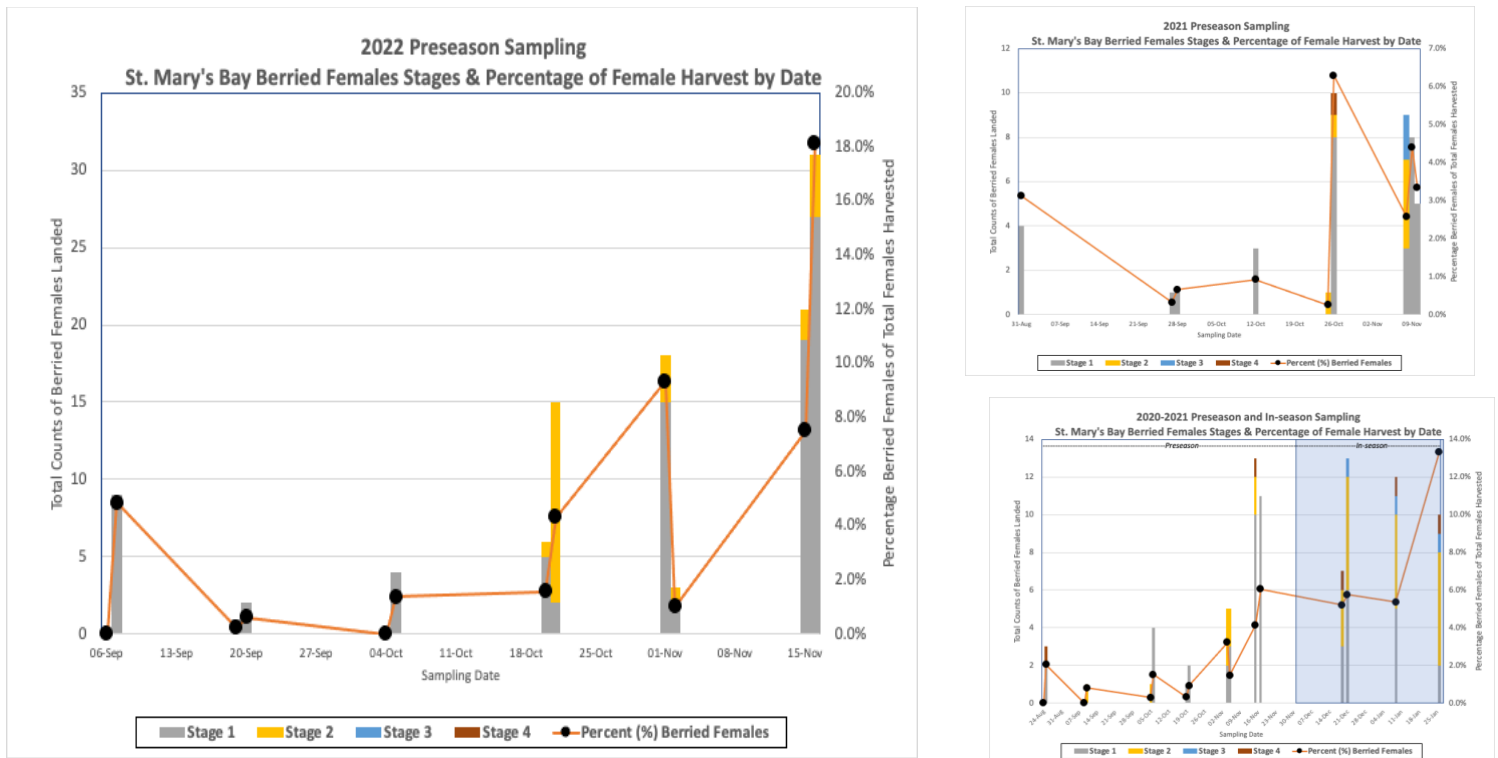

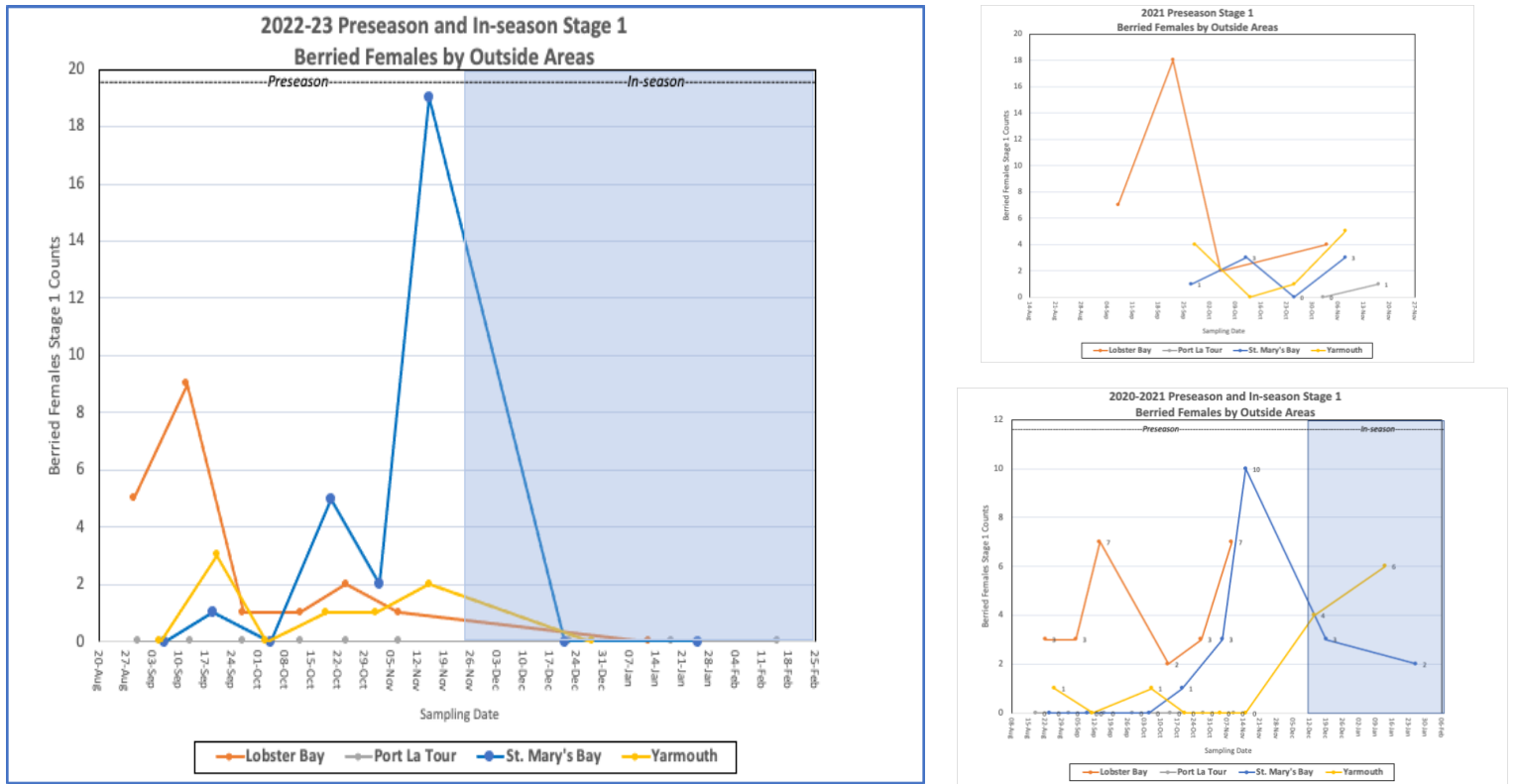Figure 15. (a) 2022 Preseason St. Mary's Bay Berried Females Stages and Percent of Females; (b) 2021 Preseason St. Mary's Bay Berried Females Stages and Percent of Females; (c) 2020-21 Preseason and In-season St. Mary's Bay Berried Females Stages and Percent of Females

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. In 2022, Stage 1 inside area counts fluctuate by location with St. Mary's Bay Inside having the highest counts of Stage 1 berried females (totals of 8) and Port La Tour Inside having the lowest counts (1 or 2). It is not possible 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 16 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 2022 preseason sampling periods. In 2022 (as in 2020 – Figure 16c), St. Mary's Bay Outside has much larger initial counts for the Outside areas (reaching 19), while Port La Tour once again has berried female counts in the Outside area that are negligible over all samples (Figure 16a). Lobster Bay Outside dominated berried females counts in 2021 (Figure 16b). See also Appendix B.2, p.A.9(b).

Figure 16. (a) 2022-23 Preseason and In-season Outside Areas Berried Females Stage 1 Counts; (b) 2021 Preseason Outside Areas Berried Females Stage 1 Counts; (c) 2020-21 Preseason and In-season Outside Areas Berried Females Stage 1 Counts.

c) Berried females Stage 2 counts for Inside areas

In 2022, Stage 2 berried female counts in the Inside areas are less than the corresponding Stage 1 counts. Stage 2 inside area berried females counts are largest in St. Mary's Bay Inside with a single sample observation of 13 counts in October 2022. Stage 2 counts in Yarmouth and Port La Tour are negligible. See also Appendix B.2, p.A.10(c).

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 4 or fewer for all sample preseason periods. Yarmouth records a single sample period of 4 Stage 2 observations at the end of the sample period (November 15). 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 negligible with only 1 single count that occurred in St. Mary's Bay during the February 22, 2023 In-season sample. 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 single count of 4 that occurred in a single sample at Port La Tour during the February In-season sample. 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 (in the Spring of the year, March-May) and after the end of the commercial season in LFAs33 and 34 when lobster 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 (i.e., in June and July). They are not a concern for the start of the commercial season (November-December). These data are recorded here for potential use with in-season observations aligned with the lobster moulting cycle during Spring and Summer months.

3.3.   Temperature Data

It is recognized that collecting continuous data on bottom temperatures on the lobster fishing areas will provide valuable information and assist in making prediction models for the lobster moult cycle as a key determinant of lobster behaviour including as a trigger for moulting, and/or for disease conducive conditions. Again in 2022-2023, temperature data were not specifically collected as part of the lobster sampling surveys with one exception, namely, occasional water surface temperature at sampling location during haul dates. (See also Section 2.2 above, re information provided on Google Map of sampling locations above.)

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 are being considered. Data loggers that were originally deployed during a portion of the ALMQ survey are no longer available. Alternative temperature collection means are being explored for future sampling programs also with respect to warming water temperatures with the changing climate, and the potential corresponding incidence of epizootic shell disease (ESD).

4 Analysis of Preseason and In-season Sampling Data in 2022-2023

The at-sea sampling summary report for 2022 was compiled as the 'Lobster Quality Preseason Sampling Program–Southwest Nova Scotia LFA33 & LFA34, Preseason Summary Report' (Mattock, Mulock, and Lane 2022) and distributed by Coldwater Lobster Association to the lobster industry and government funders on November 26, 2022. This report contains 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.

As in 2021, the 2022 preseason sampling results in LFAs 33 and 34 indicated that lobsters landed at the start of the 2022-2023 season in southwest Nova Scotia, were of overall of Moderate-Low (ML) quality (see also Table 6, Section 2.4 above). 2022 preseason samples mean overall BRIX is higher than the past 2 years but remains at a 'Moderate-Low' (ML) level of 9.46 units/ml (versus 8.4 (2021) and 8.37 (2020)). Preseason results vary by location. St. Mary's Bay (Inside and Outside) is the only location that collectively outperforms the overall mean with highest mean BRIX value for St. Mary's Bay Inside (9.5 units/ml), and high (BRIX>9) for all post-September samples. Other observations from the preseason summary report include:

- During the early preseason sampling periods (August and September), all sample results in all 8 locations show elevated BRIX with no "Poor" observations (below 6) in any sample. BRIX values tend to decline/dip in late September/early October and then increase moderately or level off in the mid-October samples and toward the end of the sampling period in mid-November.

- In 2022, weaks in the Inside locations averaged 14.5% per sample. Weaks in the Outside locations averaged over 18% per sample. Lobster Bay dominated the incidence of weaks in the Inside (average 21%) and Port La Tour dominated the Outside areas (average 23%), compared to the overall average of weaks in all areas of 16% in 2022 (versus 12.5%(2021) and 10.4%(2020)).

- In comparison to the 2021 and 2020 preseason data, weaks in the 2022 preseason sampling were larger. The overall average Inside area weaks moved from 10%(2021) to over 12% in 2022. The overall average Outside weaks moved from 15.8% in 2021-2022 to over 14.3% in 2022.

- Overall lobster hardness measurements also shifted in the 2022 preseason in comparison to the 2021 and 2020 preseason survey results. Counts of soft plus medium lobster increased from negligible amounts (less than 5%) in 2020 to 50% of samples in selected sampling dates in 2022 (Figure 8, Section 2.4 above). These shifts are evident in all areas in 2022, notably Port La Tour (Outside) (44%), Lobster Bay (Outside) (21%), Yarmouth (Outside) (29%), and St. Mary's Bay (Inside) (23%). (See also Table 6, Section 2.4 above.)

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

The prediction of lobster quality at the start of the commercial season is based on three analyses of the preseason and in-season sampling data for 2022-23 for each of the 8 subareas, as follows:

(1) Annual comparative graphics of Blood Protein (BRIX) Distribution – graphic results are provided for the BRIX indicator values ("Good", "Moderate", "Poor" – Table 2) for each of the location's 2022-2023 sampling dates. Annual comparative graphics allow comparison of recent years (2012 to 2023) of sample mean BRIX indicator levels, and BRIX distribution by category at 3 to 4 weeks prior to the scheduled start of the commercial season on Monday, November 28, 2022;

(2) Annual consolidated data analyses of 5 Lobster Quality Categories – for each sample date by location derived from the review of full ALMQ database (2006-2021) (Table 4). The results of the analysis enable the assignment of each of the 2022-2023 sample dates into their most probable Lobster Quality category; and

(3) Dynamic BRIX distributions – the pattern of BRIX distributions for November sampling dates (at the end of the sampling period) provides direct insight into the potential BRIX levels to be anticipated at the scheduled start of the commercial season on November 28, 2022.

Sections 4.1, 4.2, 4.3 and 4.4 below provide additional explanation of the application and interpretation of these analyses of the 2022 preseason sampling data leading to the presentation of the location lobster quality predictions for the start of the 2022-23 commercial season (Section 4.4 below).

4.1   Annual Blood Protein (BRIX) Distribution

The BRIX analyses compare sample annual data of past years with the preseason and in-season sample data of the current year and looks for observations of 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).
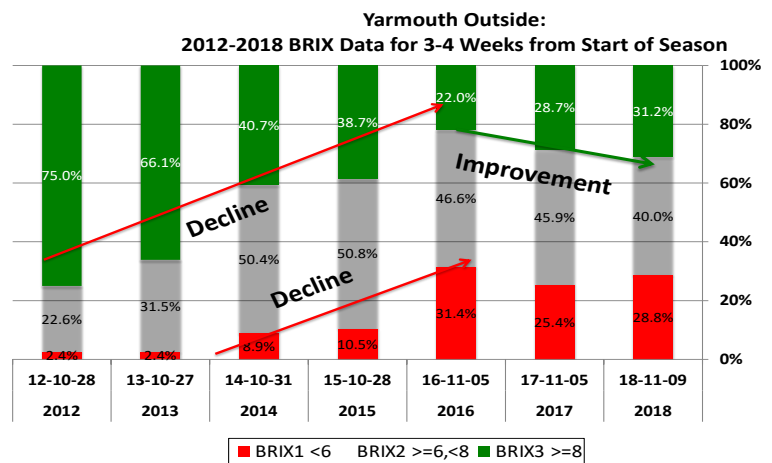
Figure 15. Example: Yarmouth Outside BRIX Categories for 3-4 weeks prior to season start 2012-2018

From Figure 15 and since 2016, preseason quality indicators have shown improvement. The 2016 low of BRIX values in the high category (Green) of 22% rises again from 28.7% (2017) to 31.2% (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, the 2019 preseason samples 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. This result may indicate that in Yarmouth in 2019, the quality improvement had stalled.)

4.2　Consolidated Data Lobster Quality Categories

Lobster quality categories for each consolidated location sample are based on collective lobster sample characteristics (of 150 sampled lobsters by the protocol) including: BRIX values and carapace length means, medians, ranges, and moments, as well as sample month and days prior to the season opening. Using linear discriminant analysis, the historical consolidated sample data were categorized into 5 'lobster quality' categories (as defined in Table 2 above) for each location. The results of the analysis enabled the numerical description of each category, and subsequently, the assignment of each of the 2022 preseason sample dates into its most probable Lobster Quality category.

The 2022 Lobster Quality Category assignments are determined by the categories with the highest likelihood (expected probability) of occurrence. Assigned categories by location and year are based on preseason sampling data and are provided by the historical table (Table 4) of assigned Lobster Quality categories for each location over the full database (2006-2021) that contains over 800 location-date samples of (typically, 150) lobsters per sample. This analysis assigns each of the 50 preseason sample dates in 2022 by location to one of the designated Lobster Quality Categories (H, MH, M, ML, or L). Summarized results are presented for all 2022 sample dates for each location below.

4.3　Dynamic BRIX Distributions

In each of the 8 subareas, graphic BRIX distributions are presented for the last sampling dates of 2022 (mid-November). Using basic moult dynamics principles, expected BRIX distributions at the end-November (scheduled start of the commercial season) are determined as a means of predicting lobster quality at the start of the commercial season.

4.4　Site Results and Predictions

Start of season lobster quality predictions are based on the analyses described in Sections 4.1, 4.2, and 4.3 above. Appendix C - Preseason Sampling Summary Report Predictions presents the summary (text) predictions for each of the 8 location-areas as previously provided in the 'Lobster Quality 2022 Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report' (Mattock, Mulock, and Lane 2022). The following pages present the breakdown of the 2022 preseason results. These results are taken directly from the 'Lobster Quality Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report' (Mattock, Mulock, and Lane 2022) provided to industry collaborators in November 2022 prior to the start of the 2022-2023 commercial season.

4.4.1 YARMOUTH INSIDE

(1) Blood Protein (BRIX) Distribution

The 2022 preseason survey results for 6 sample sites in Yarmouth Inside show a small dip in average BRIX in mid-October but relatively constant level of high BRIX (10) with the percentage of "Good" category lobsters (BRIX≥8) at or exceeding two-thirds in each sample. The proportion of "Poor" lobsters sampled moves from zero levels in the early surveys to less than 10% in the later surveys after the mid-October dip.
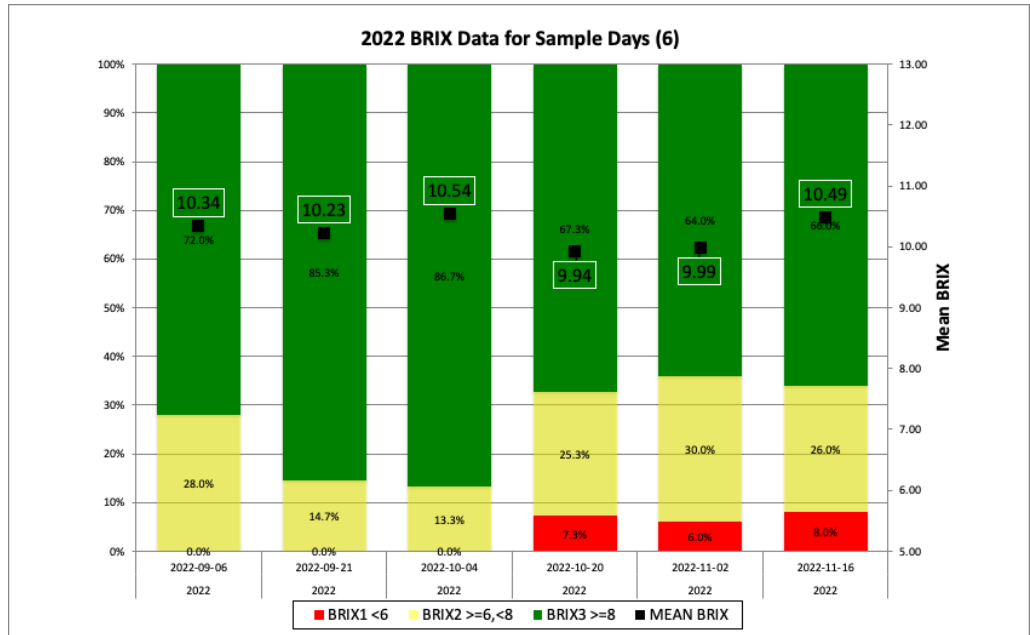
Figure 16. Yarmouth Inside 2022 Preseason Sampling BRIX Indicators
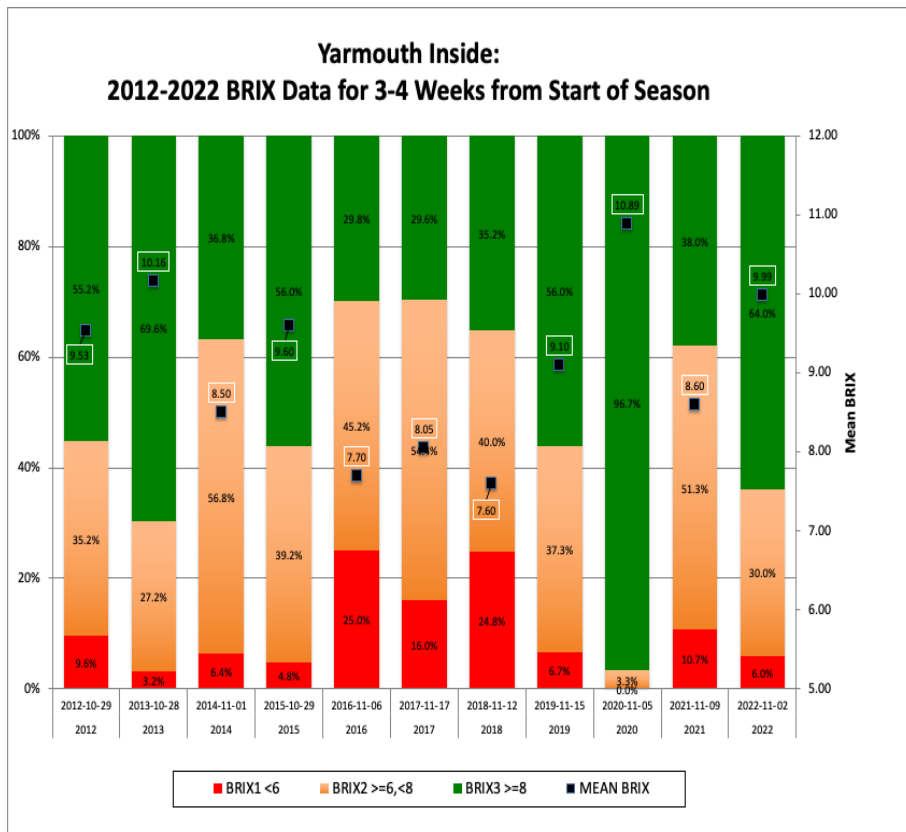
Figure 17. Yarmouth Inside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Annual samples 3-4 weeks from the start of each commercial harvest season opening are variable across the series from 2012 to 2022. The 2022 sample (November 2) has the third highest BRIX average (9.99) in the series. The November 9, 2022 sample is comparable to the October 28, 2013 sample categories with a closely matching BRIX average of 10.2.

Other comparable years to 2022 may include 2019 and 2015 however, both of these years had somewhat lower BRIX averages (9.1 and 9.6 respectively) which indicate that the 2022 samples included "Good" BRIX values that were higher in this category.

(2) Lobster Quality Category Classification The assignment of the Lobster Quality categories for Yarmouth Inside are developed from Table 4 above. Based on the historical sampling 2006-2021 in this location, the 6 sample dates in 2022 are all classified as "ML" – Moderate-Low quality. The likelihood of the Yarmouth Inside samples being in the ML category is largest at 70%.

Historically, Lobster Quality classifications for Yarmouth Inside of Moderate-Low (ML) have occurred in 2014, 2015, 2017, 2019, 2020 and 2021 seasons (as per Table 4 above). These years are all part of the post-2013 lobster quality decline period, and indicate that Yarmouth Inside remains just below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the November 16, 2022 (final) sample period with mean BRIX of 10.49 illustrates a pattern of BRIX values that are "expected". The majority of "Medium" BRIX lobsters (BRIX ≥6, < 8) (50+%) are deemed to be recovering from a recent moult and are expected to fill their shells moving into December and January during the commercial season. The 40+% lobsters already in the "Good" category (BRIX ≥ 8) with high BRIX are expected to be available for harvest at season opening.
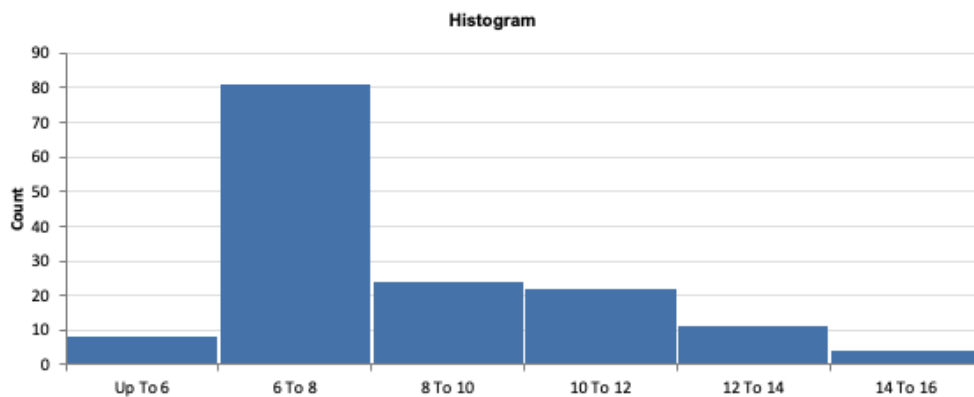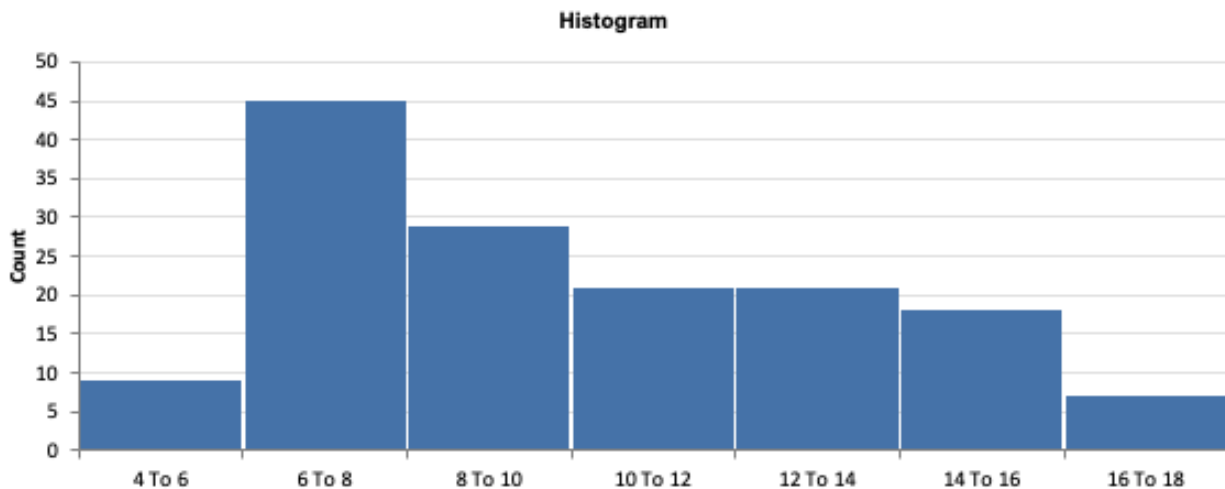

Figure 18. Yarmouth Inside November 16, 2022 Preseason Sampling BRIX Distribution

4.4.2 YARMOUTH OUTSIDE

(1)Blood Protein (BRIX) Distribution

Figure 19. Yarmouth Outside 2022 Preseason Sampling BRIX
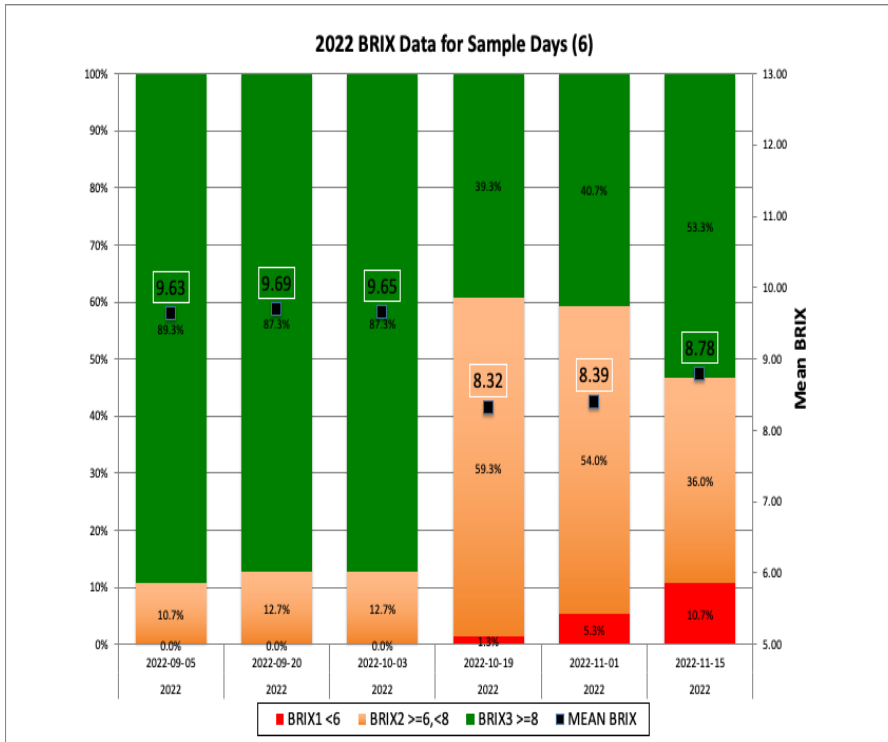
The 6 preseason samples in 2022 for Yarmouth Outside, like Yarmouth Inside, show a dip in average BRIX in mid-October with relatively constant level of high BRIX (8-9+) with the percentage of "Good" category lobsters (BRIX≥8) at 40+% in most samples. Early samples (September through early October) show no "Poor" BRIX, marginal "Medium BRIX (≤15%), and dominant samples of "Good" BRIX (87+% per sample). In the last three samples of 2022, "Poor" BRIX increase from 1% to just over 10%, and "Medium" BRIX are over one-third in these samples.

Yarmouth Outside sample BRIX distribution annual results for 3-4 weeks from the start of the commercial harvest season are compared to the series from 2012-2022. The 2022 sample (November 1) has the third highest BRIX average (8.39) in the series exceeded only by the good quality years of 2012 and 2013. The 2022 BRIX category distribution is most comparable to 2014 and 2015 but with higher average BRIX.
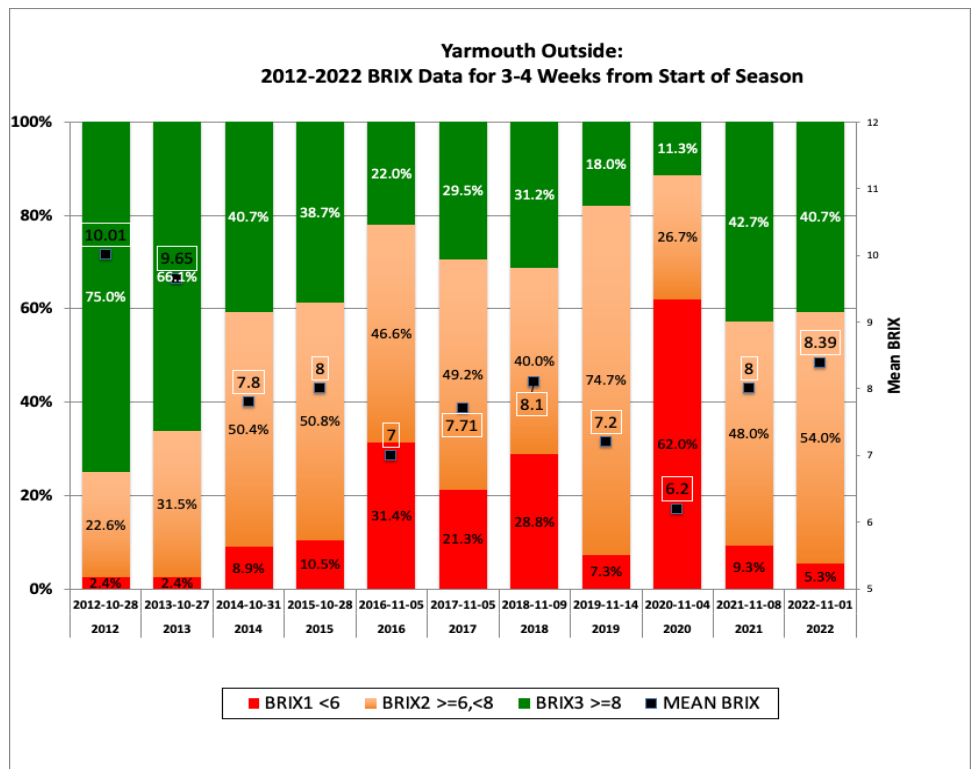
Figure 20. Yarmouth Outside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

(2)Lobster Quality Category Classification Based on the historical sampling in this location since 2006, the 6 sample dates in 2021 are collectively classified as "ML" – Moderate Low quality in comparison to the other years' samples (Table 4). The likelihood of the Yarmouth Outside samples being in the ML category is largest at 66%.

Historically, Lobster Quality classifications for Yarmouth Outside of Moderate-Low (ML) have occurred in 2014, 2015, 2017, and 2018 seasons (as per Table 4 above). These years are all part of the post-2013 lobster quality decline period, and indicate that Yarmouth Outside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the final November 15, 2022 Yarmouth Outside sample period with mean BRIX of 8.8, also illustrates a pattern of BRIX values, as for Yarmouth Inside, that may be "expected". "Medium" BRIX lobsters (BRIX ≥6, < 8) represent the maximum counts cell of 30% of all November 15 samples. Lobsters from this group may be recovering from a recent moult and are expected to fill their shells moving into December and January during the commercial season. Consequently, nearly two-thirds of Yarmouth Outside lobsters are already in the "Good" category (BRIX ≥ 8). However, many of these (20%) are experiencing very high BRIX (>14) levels not typically seen in this location. The availability of these lobsters at the start of the commercial season is uncertain.
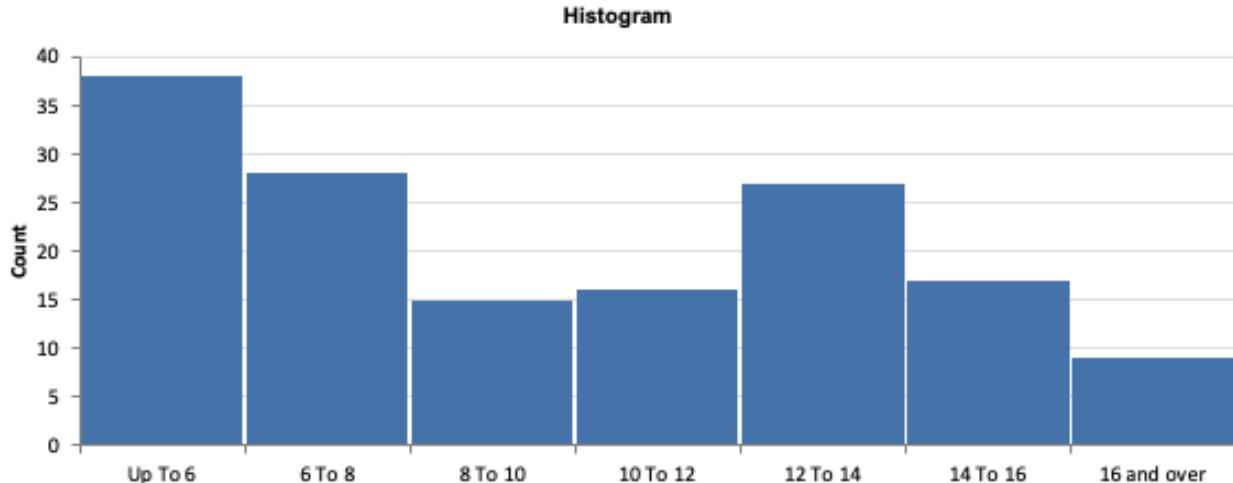

Figure 21. Yarmouth Outside November 15, 2022 Preseason Sampling BRIX Distribution

4.4.3 LOBSTER BAY INSIDE

(I) *Blood Protein (BRIX) Distribution*

The 2022 preseason survey results for 7 sample sites in Lobster Bay Inside show a relatively constant level of high BRIX (9-10) with the percentage of "Good" category lobsters (BRIX≥8) at nearly 50% or over in each sample. The proportion of "Poor" lobsters sampled moves from zero levels in the early surveys (through September) to 25-30% in the later 3 surveys after mid-October.
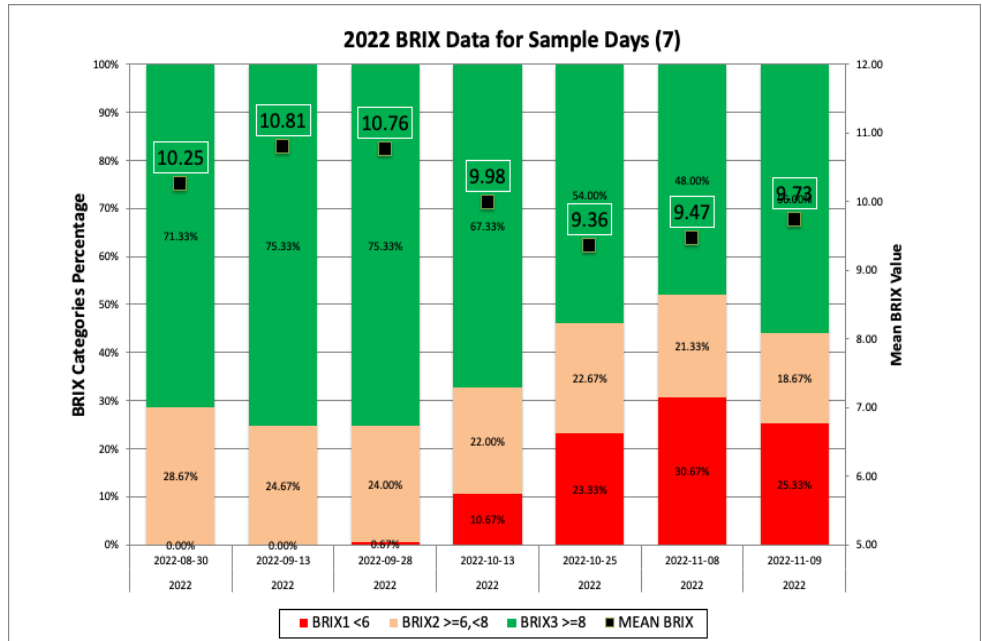
Figure 22. Lobster Bay Inside 2022 Preseason Sampling BRIX
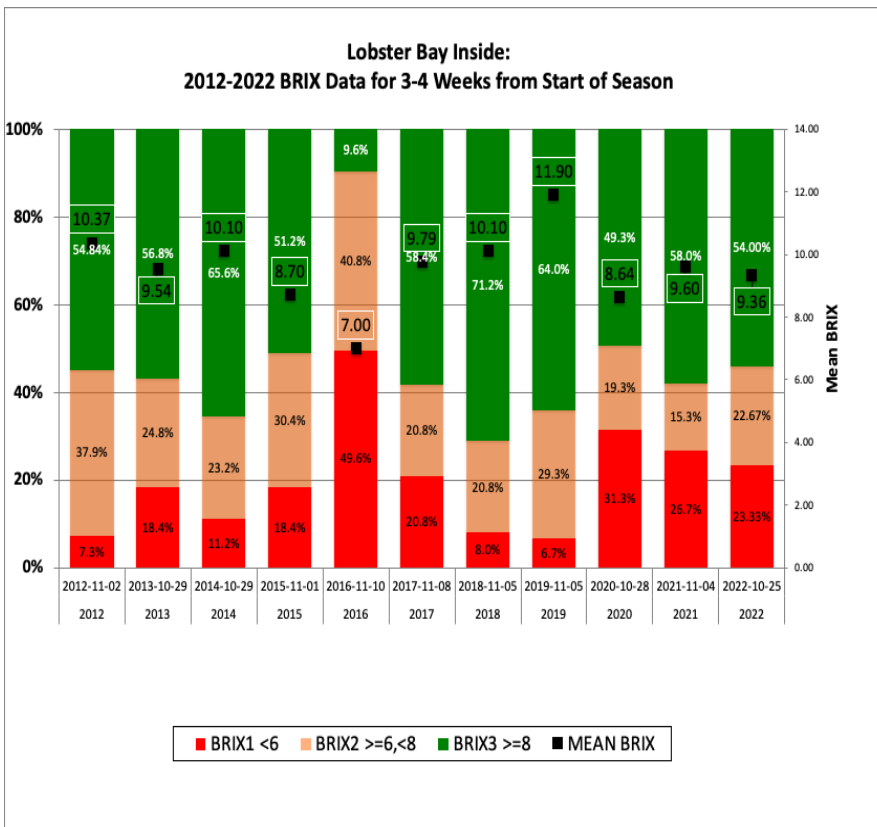
Figure 23. Lobster Bay Inside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

The 2022 Lobster Bay Inside sample results for 3-4 weeks from the start of the commercial harvest season are variable over the time series from 2012 to 2022. The October 25, 2022 sample average BRIX value of 9.4 is the 4th lowest in the series ahead of low quality years 2014-15 and 2020. The 2022 average BRIX value (9.4) trails high average BRIX of 11.9 (2019), 10.4 (2012), 10.1 (2014, 2018), and approximates the average BRIX of 2013 (9.5) and 2021 (9.6).

The October 25, 2022 samples compare well with 2013 and 2021 with respect to the BRIX categories and average BRIX values.

(2)Lobster Quality Category Classification Based on the historical sampling in this location, the 7 sample dates in 2022 are collectively classified as "Moderate" (M) quality in comparison to the other years' samples (Table 4). The likelihood of the Lobster Bay Inside samples being in either the M or ML categories is nearly 60%.

Historically, Lobster Quality classifications for Lobster Bay Inside of Moderate (M) have also occurred in 2014, and since 2019-2021 seasons (as per Table 4 above). These years are all part of the post-2013 lobster quality decline period, and indicate that Lobster Inside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the final November 9, 2022 Lobster Bay Inside sample period with mean BRIX 9.7 illustrates a particular pattern of BRIX values that may not be as expected. "Poor" BRIX lobsters (BRIX <6) represent the maximum counts cell of 25% of all November 9 samples. "Medium" BRIX lobsters (BRIX ≥6, < 8) represent the second largest cell or almost 20% of all samples. Collectively, lobsters from these groups comprise only 44% of potentially recovering lobsters from a recent moult. More significantly, a second mode of the BRIX histogram occurs at the high BRIX cell of 12-14. Consequently, nearly 60% of Lobster Bay Inside lobsters are already in the "Good" category (BRIX ≥ 8). However, many of these (nearly 20%) are experiencing very high BRIX (>14) – BRIX levels not typically seen in this location. The availability of these significant lobsters at the start of the commercial season is uncertain.
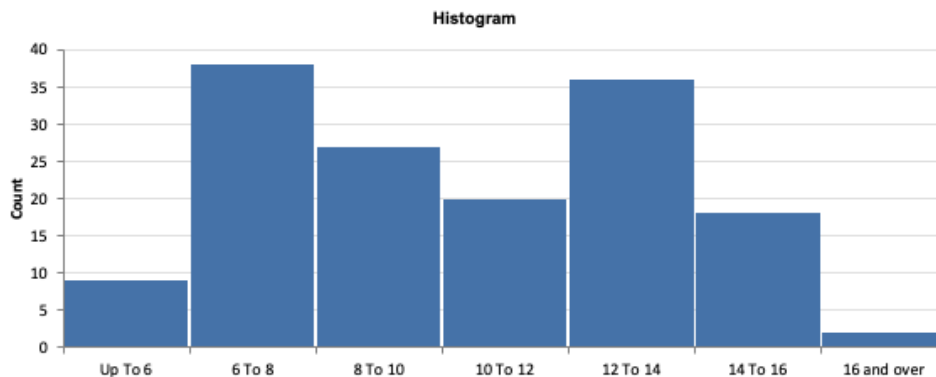

Figure 24. Lobster Bay Inside November 9, 2022 Preseason Sampling BRIX Distribution

4.4.4 LOBSTER BAY OUTSIDE

(1) Blood Protein (BRIX) Distribution
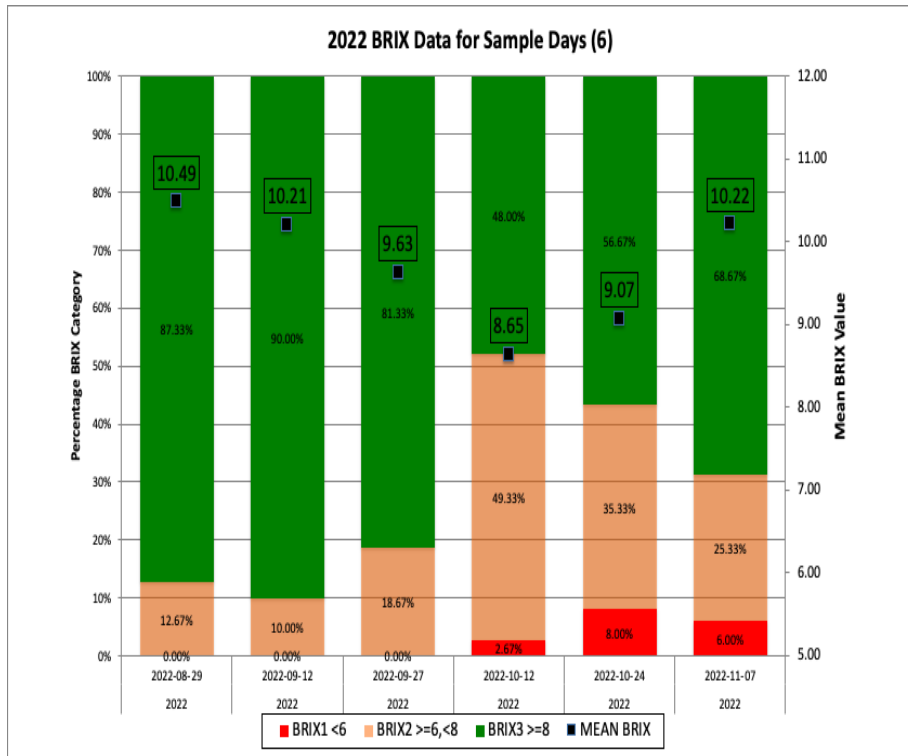
The 2022 preseason survey results for 6 sample sites in Lobster Bay Outside show a stronger pattern of declining average BRIX to mid-October followed by increasing average BRIX to the end of sampling on November 7.

Average BRIX levels are high (8.6-10.5) with the percentage of "Good" category lobsters (BRIX≥8) at or over 50% in each sample. As for Lobster Bay Inside, Lobster Bay Outside samples of "Poor" lobsters moves from zero levels in the early surveys (through September) to less than 10% in the later 3 surveys after September.

Figure 25. Lobster Bay Outside 2022 Preseason Sampling BRIX

The 2022 Lobster Bay Outside sample results for 3-4 weeks from the start of the commercial harvest season are variable over the time series from 2012 to 2022. The November 7, 2022 sample average BRIX value of 10.2 is the 2nd highest in the series behind good quality year 2012 (10.4). As such, the November 7, 2022 samples compare well with the sample of November 2, 2012 with respect to the 3 BRIX categories and average BRIX value.
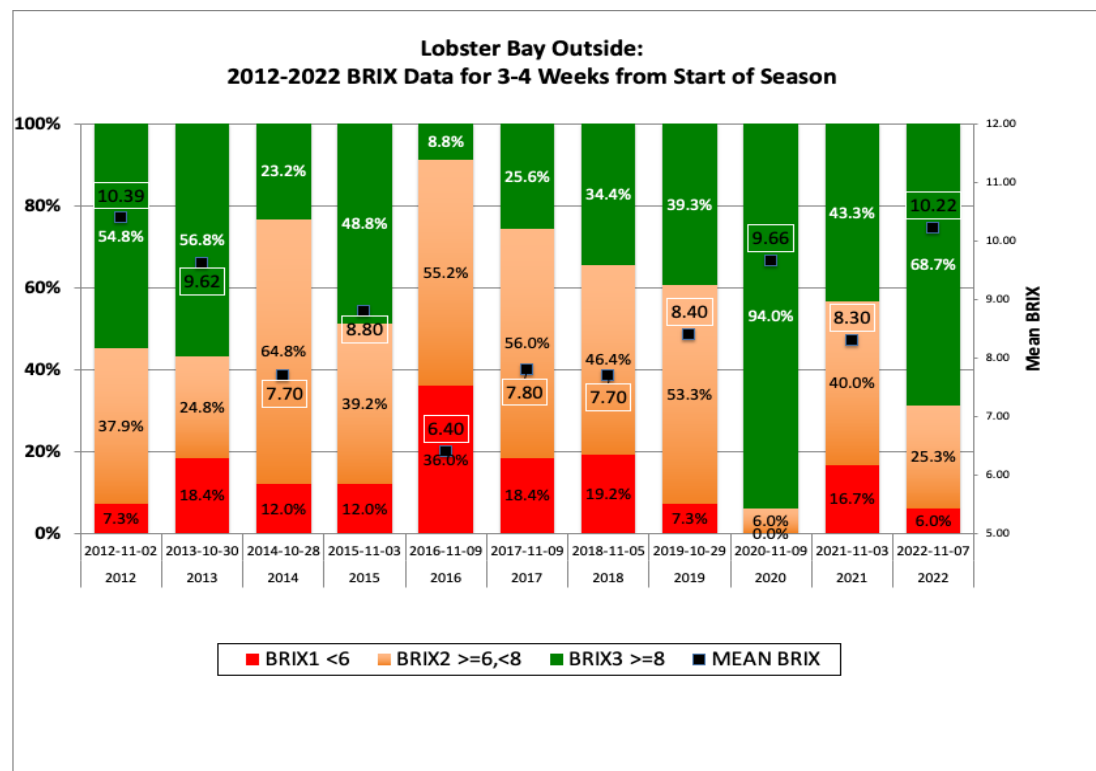
Figure 26. Lobster Bay Outside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

(2)Lobster Quality Category Classification Based on the historical sampling in this location, the 6 sample dates in 2022 are collectively classified as "Moderate-Low" (ML) quality in comparison to the other years' samples (Table 4). The likelihood of the Lobster Bay Outside samples being in the ML category is largest at 56% and likelihood of being from categories ML or L is estimated at 70%.

Historically, Lobster Quality classifications for Lobster Bay Outside of Moderate-Low (ML) have also occurred during the 2018 to 2020 seasons (as per Table 4 above). These years are all part of the post-2013 lobster quality decline period, and indicate that Lobster Outside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the November 7, 2022 (final) Lobster Bay Outside sample period with mean BRIX of 10.2 illustrates a particular pattern of BRIX values that, like Lobster Bay Inside, may not be as expected. "Medium" BRIX lobsters (BRIX ≥6, < 8) represent the largest cell of only 25% of all samples. Collectively, lobsters from the Medium and Poor (BRIX<6) groups comprise approximately one-third of potentially recovering lobsters from a recent moult. More importantly, a second significant mode of the BRIX histogram occurs at the high BRIX cell of 12-14 (24%). Consequently, over two-thirds of Lobster Bay Outside lobsters are already in the "Good" category (BRIX ≥ 8). However, many of these (nearly 40%) are experiencing high BRIX (>12). The availability of these lobsters at the start of the commercial season is uncertain.
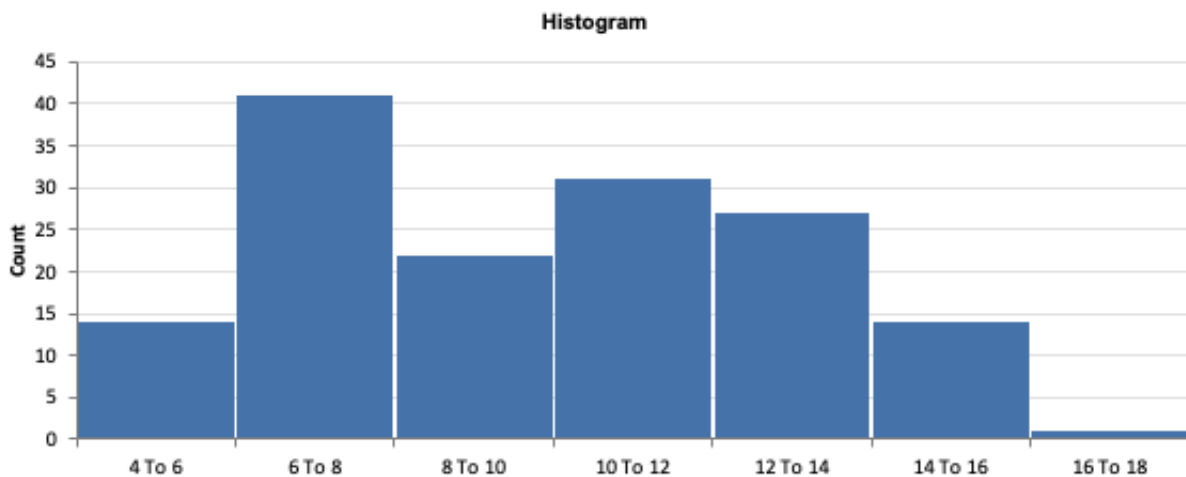

Figure 27. Lobster Bay Outside November 7, 2022 Preseason Sampling BRIX Distribution

4.4.5   PORT LA TOUR INSIDE

(1)Blood Protein (BRIX) Distribution

The 2022 preseason survey results for 7 sample sites in Port La Tour Inside show a relatively increasing level of high BRIX (8 to10) – after a dip in mid-October – over the survey period with the percentage of "Good" category lobsters (BRIX≥8) at over 40% in each sample. The proportion of "Poor" lobsters sampled moves from zero levels in the early surveys (through September) to up to 16% in the later 3 surveys since mid-October.
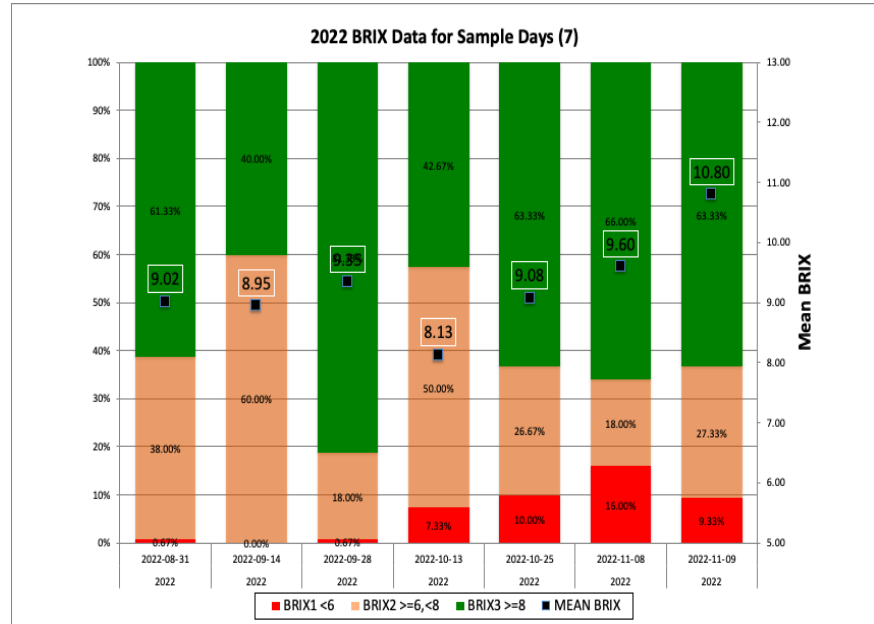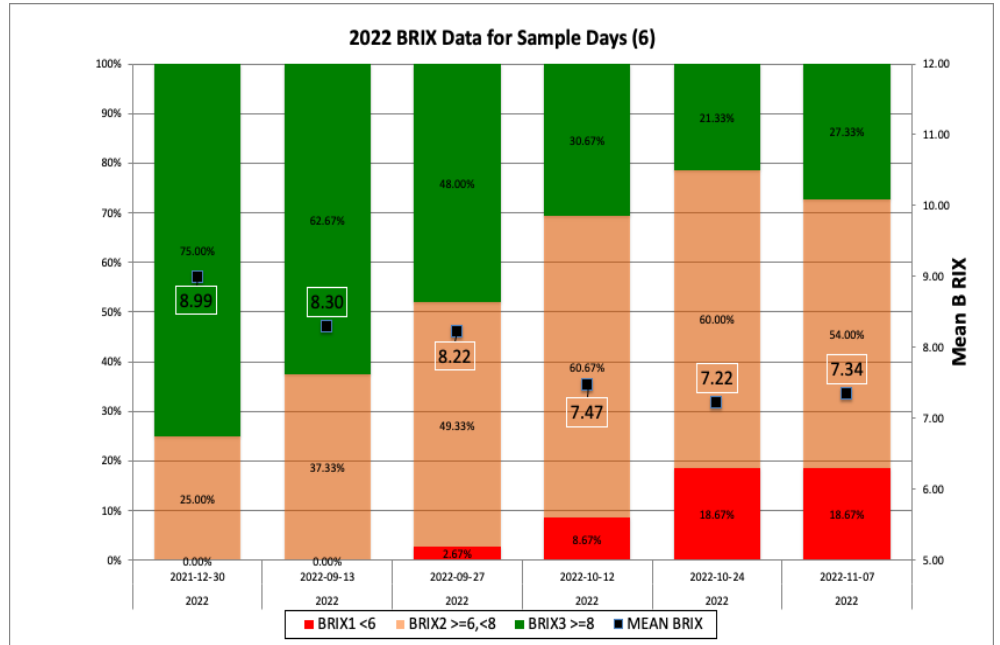

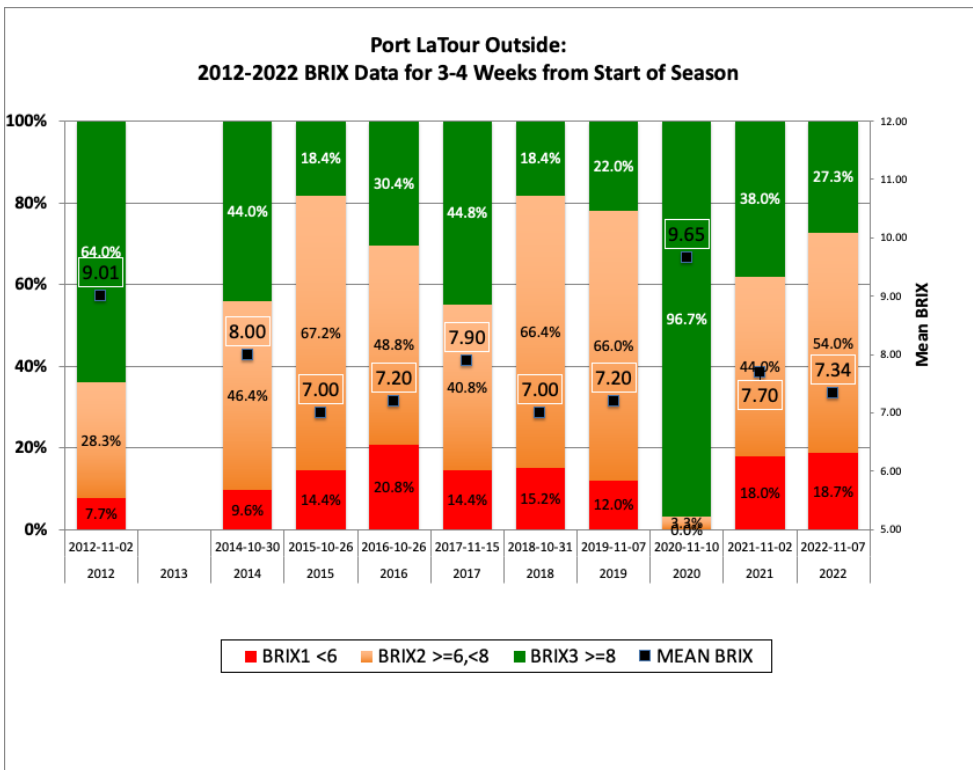Figure 28. Port La Tour Inside 2022 Preseason Sampling BRIX

2022 Port La Tour Inside results for the October 25 sample, 3-4 weeks from the start of the commercial harvest season, are part of the variable trend over the period from 2012 to 2022. The October 25, 2022 sample has average BRIX (9.1) among the highest in the series. These results have shown some improvement since 2016 with higher "Good" category samples and lower "Poor" quality samples.

The 2022 sample is most comparable to the November 1, 2018 sample.

Figure 29. Port La Tour Inside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

(2)Lobster Quality Category Classification Based on the historical sampling in this location, the 7 sample dates in 2022 are collectively classified as "Moderate-Low" (ML) quality in comparison to the other years' samples (Table 4).

Historically, Lobster Quality classifications for Port La Tour Inside of Moderate-Low (ML) have also occurred during the 2019 and 2020 seasons (as per Table 4 above). These recent years, as years of the post-2013 lobster quality decline period, indicate that Lobster Inside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the final November 9, 2022 Port La Tour Inside sample period with average BRIX of 10.8 illustrates a particular pattern of BRIX values that, like Lobster Bay Inside and Outside, may not be as expected. "Medium" BRIX lobsters (BRIX ≥6, < 8) represent the largest cell of just over 25% of all samples. Collectively, lobsters from the Medium and Poor (BRIX<6) groups comprise approximately 37% of potentially recovering lobsters from a recent moult. More importantly, a second significant mode of the BRIX histogram occurs at the high BRIX cell of 10-12 (20%). Consequently, nearly two-thirds of Port La Tour Inside lobsters are already in the "Good" category (BRIX ≥ 8). However, many of these (45%) are experiencing high BRIX (>10). The availability of these lobsters at the start of the commercial season is uncertain.
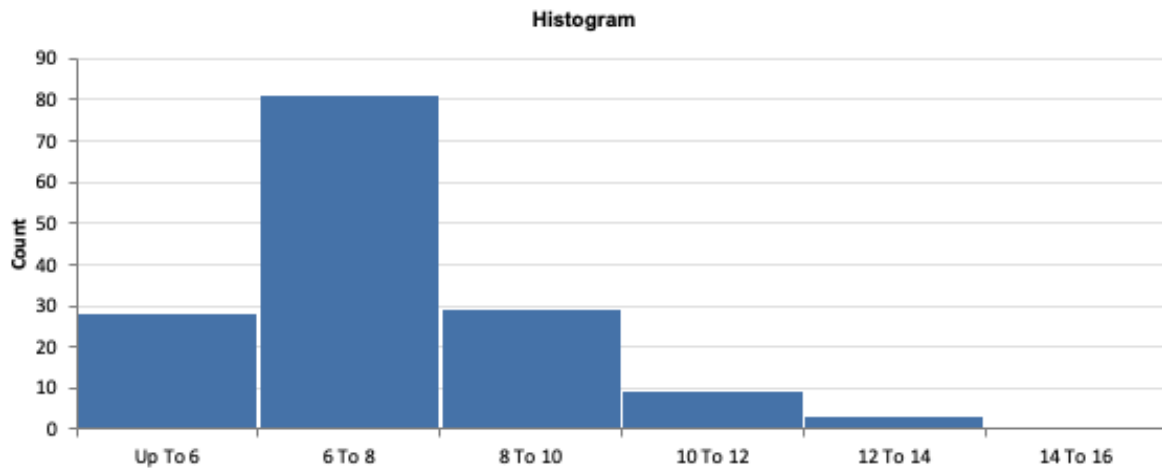

Figure 30. Port La Tour Inside November 9, 2022 Preseason Sampling BRIX Distribution

4.4.6   PORT LA TOUR OUTSIDE

(1)Blood Protein (BRIX) Distribution

The 2022 preseason survey results for 6 sample sites in Port La Tour Outside show a declining level of average BRIX (from 9 to 7.3) over the survey period including a decline in mid-October to 7.5. The percentage of "Good" category lobsters (BRIX≥8) fall over the period from 75% to under 30%. The proportion of "Poor" lobsters sampled moves from zero levels in the early surveys (through September) to up to 19% in the later 2 surveys since mid-October.

Figure 31. Port La Tour Outside 2022 Preseason Sampling BRIX

Figure 32. Port La Tour Outside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

The annual results for Port La Tour Outside and the case of 3-4 weeks before the start of the season for 2012 to 2022 are relatively stable between 2014 and 2022 (2020 excepted) with average BRIX between 7 and 8 ("Medium") and "Poor" category BRIX between 15% and 20%. The November 7, 2022 sample has average BRIX (7.3) which is consistent with the historical average BRIX levels.

The November 7, 2022 sample is most comparable to the October 26, 2016 sample.

(2)Lobster Quality Category Classification Based on the historical sampling in this location, the 6 sample dates in 2022 are collectively classified as "Moderate-Low" (ML) quality in comparison to the other years' samples (Table 4).

Historically, Lobster Quality classifications for Port La Tour Outside of Moderate-Low (ML) have also occurred during the 2014, 2019 and 2020 seasons (as per Table 4 above). These years are recent years as part of the post-2013 lobster quality decline period, and indicate that Lobster Inside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The distribution histogram (below) of 150 samples from the November 7, 2022 (final) sample period with mean BRIX of 7.3 illustrates a pattern of BRIX values that are "expected". The majority of "Medium" BRIX lobsters (BRIX ≥6, < 8) (50+%) are deemed to be recovering from a recent moult and are expected to fill their shells moving into December and January during the commercial season. The 25+% lobsters already in the "Good" category (BRIX ≥ 8) with high BRIX are expected to be available for harvest at season opening.
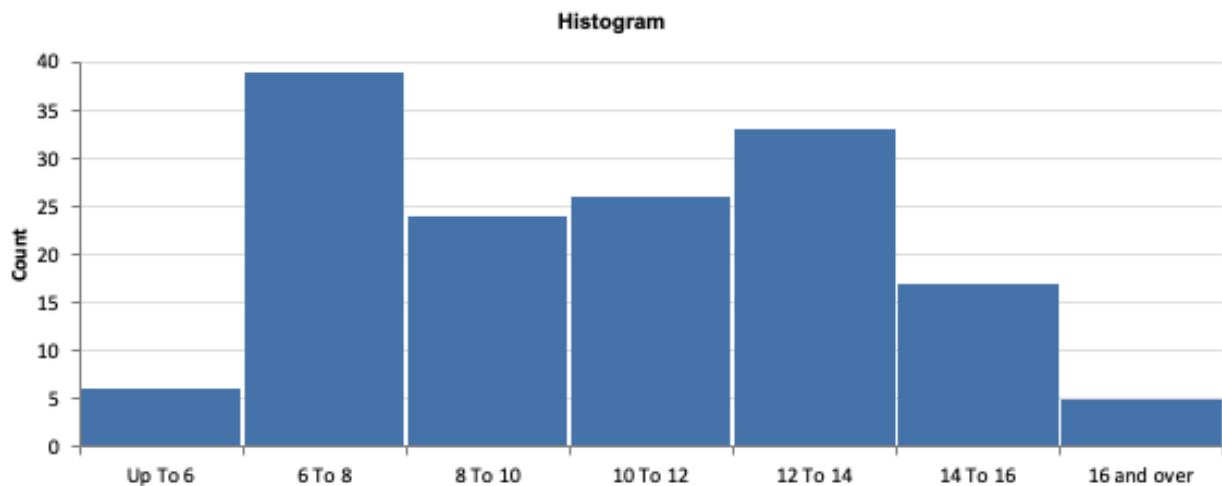

Figure 33. Port La Tour Outside November 7, 2022 Preseason Sampling BRIX Distribution

4.4.7 ST. MARY'S BAY INSIDE

(1)Blood Protein (BRIX) Distribution

2022 preseason samples for St. Mary's Bay Inside over 6 sample dates exhibit an initial decline in average BRIX of over 10 in early September to below 9 by early October. Thereafter, average BRIX shows gradual improvement from mean BRIX (8.5) to maximum high mean BRIX over 10 at the final 2022 November 16 sample. As in other locations, early samples show zero "Poor" BRIX samples. St. Mary's Bay is characterized by "Poor" BRIX below 10% for all samples in 2022.
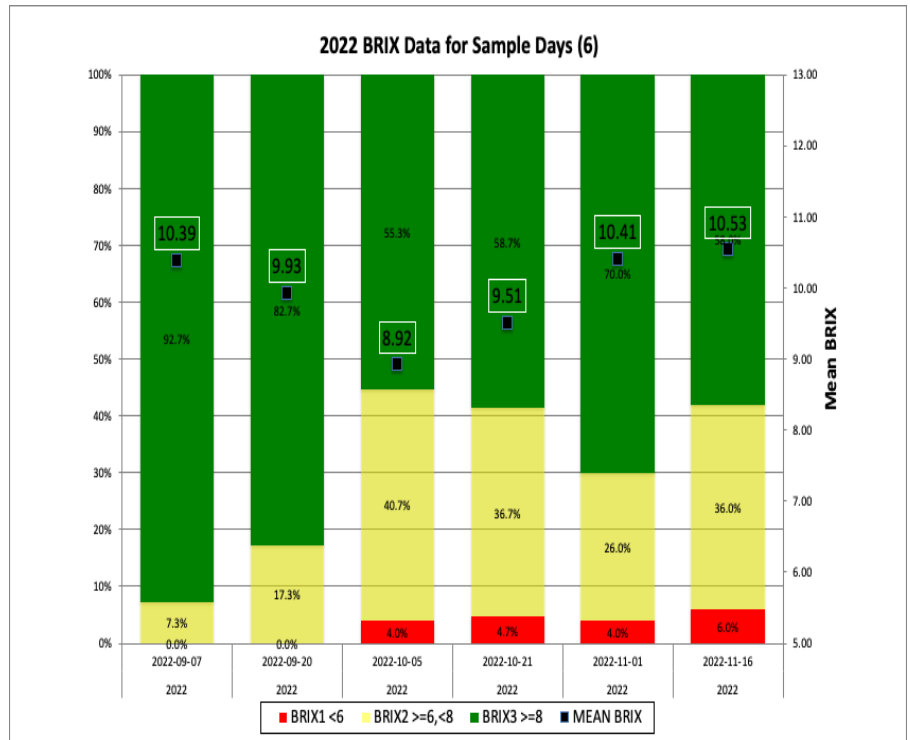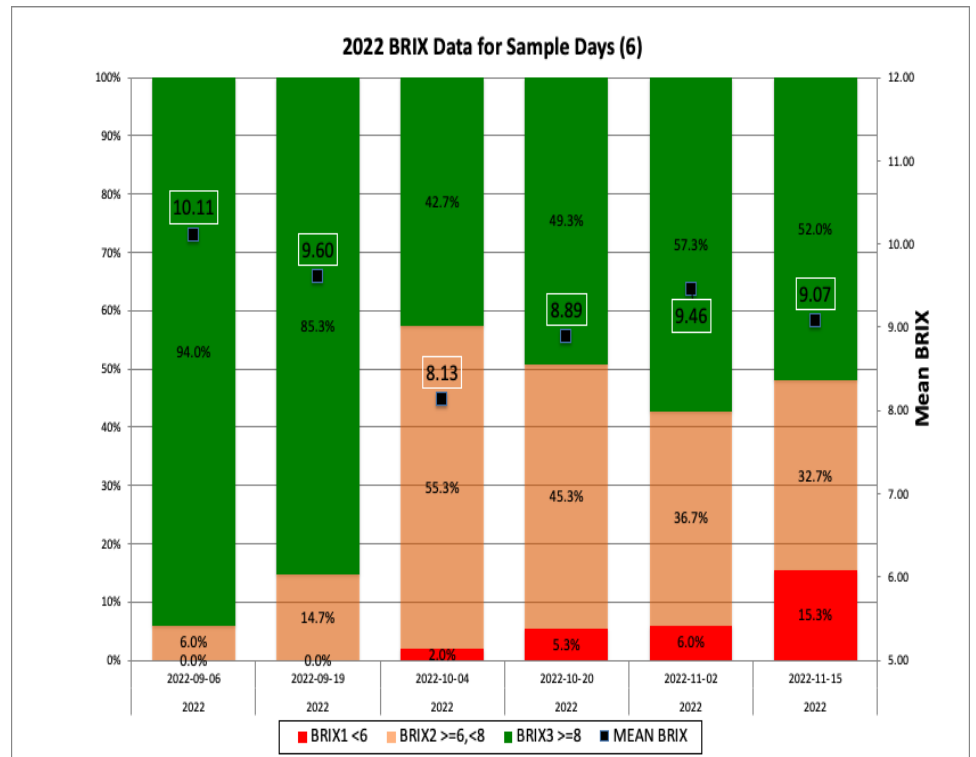

Figure 34. St. Mary's Bay Inside 2022 Preseason Sampling BRIX
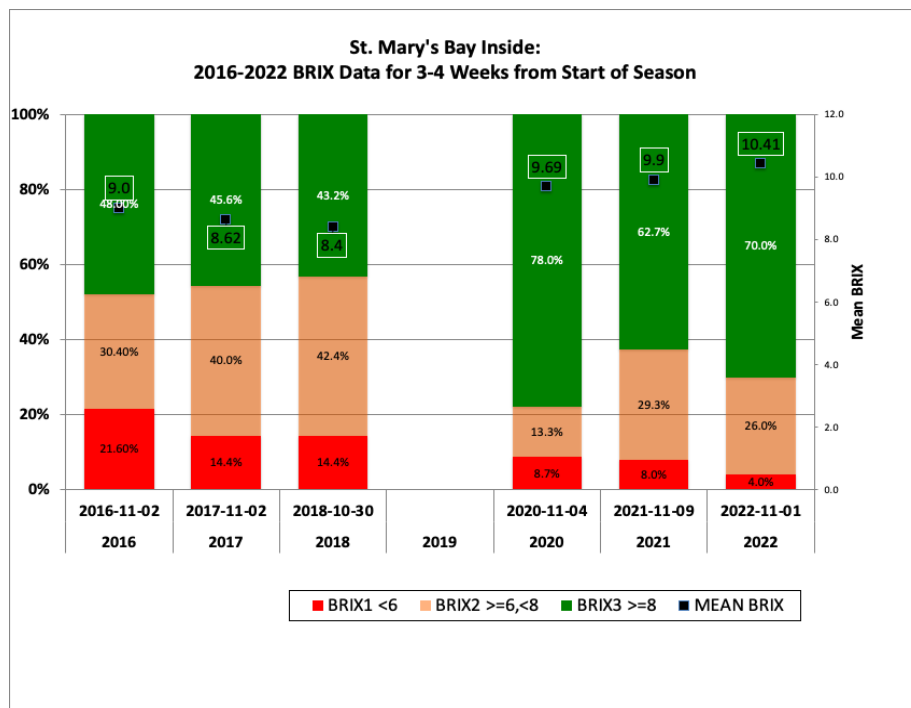
Figure 35. St. Mary's Bay Inside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

2022 St. Mary's Bay Inside results for the November 1 sample, 3-4 weeks from the start of the commercial harvest season, show a relatively constant trend over the period from 2016 to 2022. The November 1, 2022 sample has the highest average BRIX (10.4) in the series. This sample also has the lowest "Poor" BRIX results over the series.

The 2022 sample is most comparable to the recent November samples in 2020 and 2021 with similar average BRIX values.

(2)Lobster Quality Category Classification   Based on the historical sampling in this location, the 6 sample dates in 2022 are collectively classified as "Moderate-High" (MH) quality in comparison to the other years' samples (Table 4). This is the highest quality classification of the BRIX distributions since prior to 2013 and the location of higher quality lobster throughput LFAs 33 and 34.

Historically, Lobster Quality classifications for St. Mary's Bay Inside of Moderate-High (MH) have also occurred during the 2008, and 2010 to 2012 seasons (as per Table 4 above). These results indicate that in 2022 St. Mary's Bay Inside exhibits higher overall quality comparable to the period from 2006 to 2013 in the full preseason survey database.

(3)BRIX Distribution The BRIX distribution histogram (below) of 150 samples from the final November 16, 2022 St. Mary's Bay Inside sampling period with mean BRIX of 10.5 illustrates a particular pattern of BRIX values that may not be as expected. "Poor" and "Medium" BRIX lobsters (BRIX < 8) represent only 30% of all samples of potentially recovering lobsters from a recent moult. A second mode of the BRIX histogram occurs at the high BRIX cell of 12-14 (over 20%). Consequently, 70% of St. Mary's Bay Inside lobsters are in the "Good" category (BRIX ≥ 8) with many of these (37%) with very high BRIX (>12). The availability of these lobsters at the start of the commercial season is uncertain.
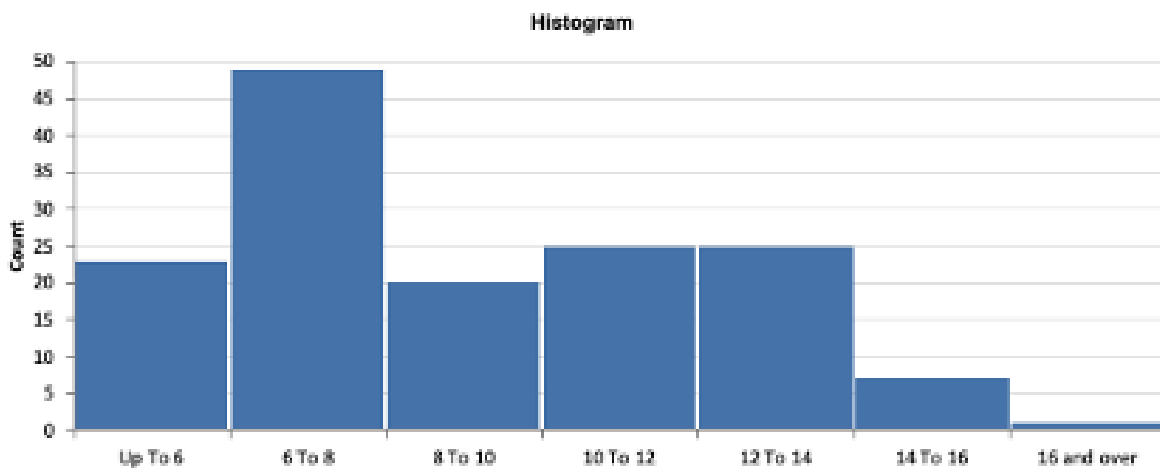

Figure 36. St. Mary's Bay Inside November 16, 2022 Preseason Sampling BRIX Distribution

4.4.8 ST. MARY'S BAY OUTSIDE

(1)Blood Protein (BRIX) Distribution

2022 preseason samples in St. Mary's Bay Outside exhibit a pattern similar to St. Mary's Bay Inside with initially declining average BRIX levelling off by early October, and stabilizing to high levels (near 9) by the end of the survey period in mid-November. "Poor" BRIX are initially zero in the early samples (as in other locations) rising to a high of 15% by the mid-November sample. The high average BRIX for this sample indicates that some BRIX may be very high.

Figure 37. St. Mary's Bay Outside 2022 Preseason Sampling BRIX

The annual trend of the BRIX distribution categories 3-4 weeks prior to the start of the season also shows a moderately stable time series from 2016 to 2022 (2020 excepted). In the November 2, 2022 sample the average BRIX (9.5) is elevated and highest in the series (2020 excepted). "Poor" BRIX are marginal (6%) with well over 50% in the "Good" category.

The 2022 sample is comparable to that of the November 8 samples in 2017 and 2021 but with higher average BRIX value well over 9.

Figure 38. St. Mary's Bay Outside 2012-2022 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

(2)Lobster Quality Category Classification   Based on the historical sampling in this location, the 6 sample dates in 2022 for St. Mary's Bay Outside are collectively classified as "Moderate" (M) quality in comparison to the other years' samples (Table 4). The likelihood of the St. Mary's Bay Outside samples being in either the M or ML classification is over 90%.

Historically, Lobster Quality classifications for St. Mary's Bay Outside of Moderate (M) have also occurred during the 2009, and the past 2 seasons 2020-2021 (as per Table 4 above). The recent years 2020-2021 are part of the post-2013 lobster quality decline period, and indicate that St. Mary's Bay Outside remains below the higher quality regime in the reduced quality range relative to the full 2006-2021 database.

(3)BRIX Distribution The BRIX distribution histogram (below) of 150 samples from the final November 15, 2022 St. Mary's Bay Outside sample period with mean BRIX of 9.1 illustrates a BRIX pattern that may not be as expected. "Poor" and "Medium" BRIX lobsters (BRIX < 8) represent nearly 50% of all samples of potentially recovering lobsters from a recent moult. A second mode of the BRIX histogram may occur at the high BRIX cells of 10-12 and 12-14 (33%). Consequently, 50% of St. Mary's Bay Inside lobsters are in the "Good" category (BRIX ≥ 8) with most of these (39%) with high BRIX (>10). The availability of these lobsters to be caught at the start of the commercial season is uncertain.

Figure 39. St. Mary's Bay Outside November 15, 2022 Preseason Sampling BRIX Distribution

4.5   Blood Protein (BRIX) Dynamic Distribution Analysis

In the 2022-23 preseason and in-season sampling program, it was alleged that evidence of warmer ocean waters coupled with the evidence of more soft and medium-soft lobsters in the samples were perhaps the result of commercial-sized lobsters moulting over a longer period (i.e., Spring to Fall), and that some lobsters may be moulting 'more than once' in the same calendar year, e.g., in the Spring and again in the Fall. To investigate this proposition, this report examined the distribution of BRIX levels for the 150 lobsters sampled per location-date at the end of the preseason sampling period (mid-November) across the 8 sampling subareas, as reported above in Section 4.4, Site Results and Predictions.

What was observed (as reported in Table 6 above) were November 2022 BRIX distributions in relative histograms that, in some sampled areas, exhibited bimodal or more than one peak counts of sampled lobster at more than one BRIX level (typically 6-8 units/ml and 12-14 units/ml). These results were particularly evident at Lobster Bay (Inside and Outside), (Figures 24 and 27), Port La Tour (Inside) (Figure 30) and St. Mary's Bay (Inside and Outside) (Figures 36 and 39). In other areas, including Yarmouth (Inside and Outside) (Figures 18 and 21), and Port La Tour (Outside) (Figure 33) the BRIX distributions were unimodal (one peak) that all occurred at the BRIX level of 6-8 units/ml. Based on a review of past years' BRIX distributions at mid-November samples for 2020 and 2021, nearly all samples by area were of the unimodal type, i.e., one peak in the distribution at lower levels, typically 6-8 units/ml (as in the Yarmouth sample BRIX distributions for 2022 of Figures 18 and 21). As such, 2022-23 stands out as a 'different year' for the distribution of BRIX in samples prior to the start of the commercial season whereby 5 of the 8 subareas had clear bimodal BRIX distributions (as reported in Table 6 above). The 2022 samples prompted a review of BRIX distribution dynamics and raised the question of how looking at these BRIX distributions as "dynamic", i.e., shifting over time, could help predict BRIX levels for each of the 8 subareas at the start of the commercial season at end November annually. We begin by stating a set of simple definitions relevant to lobster BRIX transitions over time:

Definition 1. Focus on lobster "quarters", i.e., legal-sized lobsters (>82.5mm carapace) that are approximately 1.25 pounds by weight, or between 560 and 670 grams. It is suggested that quarters are dominant in LFA33 and 34 catches during the preseason.
Definition 2. Consider BRIX level categories as "cells" ($c=0,1,2,3,4,5,6,7$), where $c=1$ denotes lobster with BRIX levels between 4 and 6 units/ml, etc., as previously defined (see also the cells of the histograms of Figures 18,21,24,27,30,33,36, and 39 above).

Definition 3. Time units are represented by 2-week periods of which there are 26 2-week periods per year; Period $t=1$ denotes January 1-14 and Period $t=26$ denotes December 14-31. Sampling logistics are such that information about lobster BRIX distributions is available for the 2-week periods 18 through 23 in all 8 subareas. Period $t=24$ (November 19 to December 2) covers the scheduled start of the commercial season and represents the initial forecast period.

Definition 4. Lobsters change BRIX levels (cells) dynamically over the course of the year as part of their moult cycle. In some cells, e.g., $c=0$ (lowest BRIX level, less than 4 units/ml), and $c=7$ (highest BRIX level, greater than 16 units/ml), lobsters are not available to the traps, i.e., catchability is zero as they recover from a recent moult.

Definition 5. Three time frames are designated to describe lobster status; these are: (1) pre-moult period, Periods 1 to 4 (January 1 to February 25); (2) moult activity period, Periods 5 to 21 (February 26 to October 21); and (3) post-moult period, Periods 22 to 26 (October 22 to December 31). During the pre-moult and post-moult periods, lobsters are not expected to change BRIX levels as they lie in relative stasis during periods of colder water temperatures.

Definition 6. Lobster catchability, i.e., the possibility that lobster come to the trap, are describable by a function of the BRIX level cell, as shown in Table 7 below. Table 7 describes illustrative lobster biological moult conditions that enable (or not) lobster catchability. These illustrative conditions and catchability levels are purely arbitrary as a function of the BRIX level cells.

Table 7. Lobster BRIX Dynamics and Catchability Description

Cell #	BRIX Lower	BRIX Upper	Moult Status Information	Out-of-System/ Not Recruited	Available to Trap/ Recruited
0	0	4	Newly moulted, soft shell, isolating/hiding, not available for trap	100%	0%
1	4	6	New moult, soft shell, still shy to trap	75%	25%
2	6	8	Hungry, filling carapace, increased available to trap	0%	100%
3	8	10	Hungry, filling carapace, 100% available to trap	0%	100%
4	10	12	Still hungry, still filling carapace, 100% available to trap	10%	90%
5	12	14	Preparing for moult, still available to trap with reduced recruitment	25%	75%
6	14	16	Readying for moult, reduced availability to trap, may be isolating	50%	50%
7	16	18+	Moulting imminent, isolating/hiding, not seeking trap	100%	0%

Definition 7. The count (or percentage) of lobsters in a given BRIX level cell at a given time period is determined by the count (or percentage) of lobsters in BRIX level cells in the previous period. Figure 40 below illustrates the dynamic flow of lobsters at time t in BRIX cell c. As noted, in this network flow diagram, the count (or percentage) of lobsters, $n_c(t)$ at time t in BRIX cell c is determined by lobsters in cell $c-1$ in the previous period, $t-1$ or $n_{c-1}(t-1)$, as well as lobsters in cell c in the previous period, $t-1$ or $n_c(t-1)$ whose BRIX level has not changed. Lobsters are subject to 2-week natural mortality rate, m a continuous rate. Newly moulted lobsters ($c=0$) may be recruited to the count at period t from lobsters in $c=7$ in the previous period. Finally, it is assumed that some lobsters at level c may enter (immigrate) or leave (emigrate) to/from the count (or percentage) of lobsters, $n_c(t)$ at time t in BRIX cell c. Independent recruitment and immigration and emigration rates, as well as cell level 'movement factors' are dynamic parameters that define the periodic shift in lobsters' BRIX levels noted in Figure 40 below. Recruitment and movement are not expected to occur in either the pre-moult or the post-moult periods.
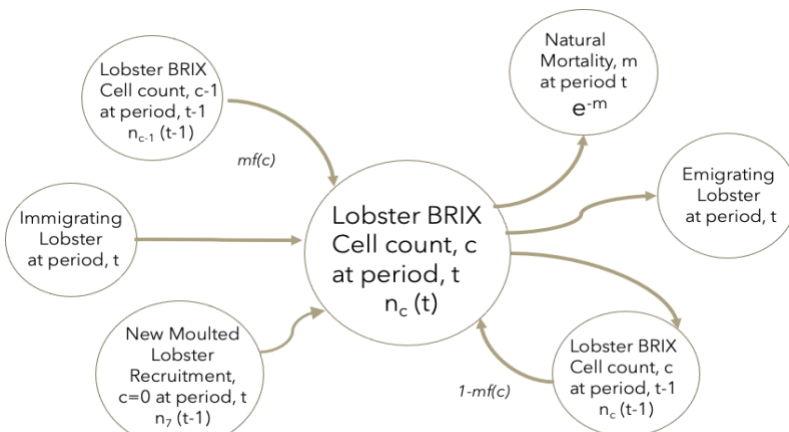
Figure 40. Lobster Dynamic BRIX Flowchart

The histograms of sampled BRIX distributions described above provide the basis for examining the parameters of the 2-week dynamic BRIX cell shifts. The results to-date are summarized below and illustrate how this network flow model of dynamic BRIX distributions can be used to provide predictions of BRIX and catches by subarea at the start of the commercial season (in Period 24, or November 19-December 2).
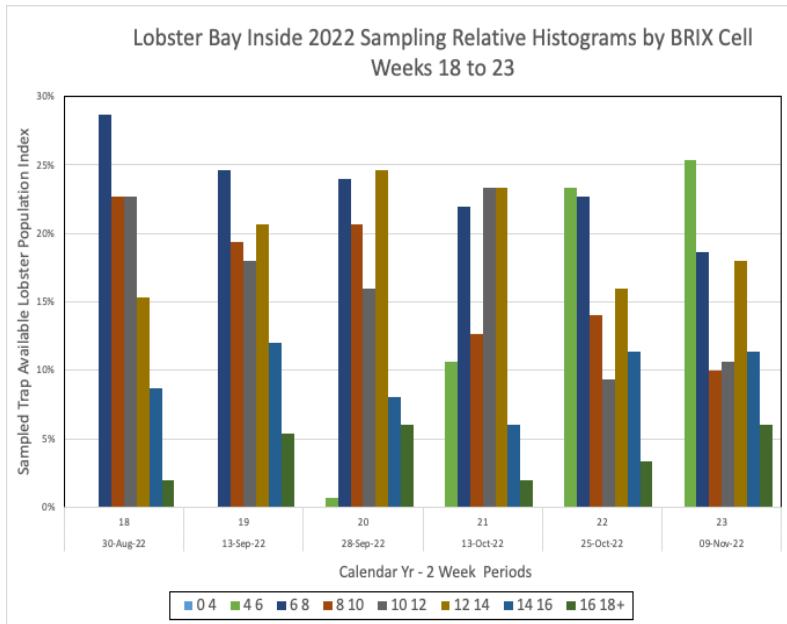
4.5.1 Dynamic BRIX Illustrative Results

Figure 41. Lobster Bay Inside 2022 Sample BRIX Distributions

The above definitions can be used to develop a forecast of start of year (Period 24) BRIX distribution cells content as well as expected legal-sized catch counts per trap based on sample statistics by area. We use the case of Lobster Bay Inside to illustrate modelled results. Figure 41 displays the dynamic BRIX distributions for the 6-2022 preseason sampling dates for Lobster Bay Inside by BRIX cell, *c=0 to 7*. The multimodal peaks in Period 23 (November 9 sample) for BRIX levels 4 to 6, 6 to 8 AND 12 to 14 (see also Figure 24) are also evident here.

On the basis of these observed BRIX distribution samples of recruited lobsters in this area, and the definitions (above) of flow dynamics during the post-moult period at the start of the season, we are able to make a reasonable prediction of the Period 24 BRIX distribution by following the dynamics of each of the BRIX cells over the sampling dates. For Lobster Bay Inside, the modelled forecast is given in Figure 42. Figure 42 updates the Lobster Bay Inside BRIX distribution to the start of the commercial season.

To complete the start of season forecast, we need to estimate the expected catch per trap at Period 24. This information can be determined from the expectation of counts per trap at Period 24 as implied by Figure 9 and 10
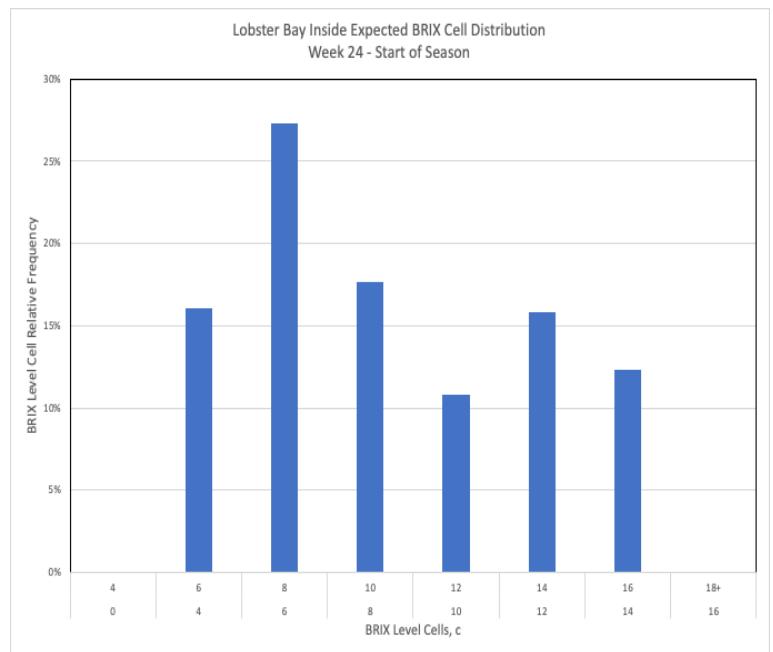
Figure 42. Lobster Bay Inside 2022 Start of Season Forecast BRIX Levels Distribution

above for counts per trap dynamics and by extending the legal-sized lobster catch counts per trap series for the 2022 sampling dates. Legal-sized catch counts per trap in Lobster Bay Inside are recorded for each of the BRIX level cells. These results similarly reflect the activity of the BRIX level cells and exhibit trends that are readily understandable into Period 24 at the start of the commercial season. Figure 43 shows the legal catch counts per trap from the 6 sample dates for Lobster Bay Inside. Trends for each BRIX level cell legal catch per unit trap are extended to Period 24 and the expected values used in the

calculation of the forecast of legal catch per unit trap and expected average BRIX for the start of the commercial season, denoted as Period 24. The illustrative 'forecast' results for Lobster Bay Inside at the scheduled start of the commercial season are presented in Table 8 below.

Similar analyses can be developed for each of the 8 subareas and a complete start of season forecast for all 8 subareas can be developed.

For Lobster Bay Inside at the start of the commercial season, Table 8 forecasts the shift in the expected catch by BRIX
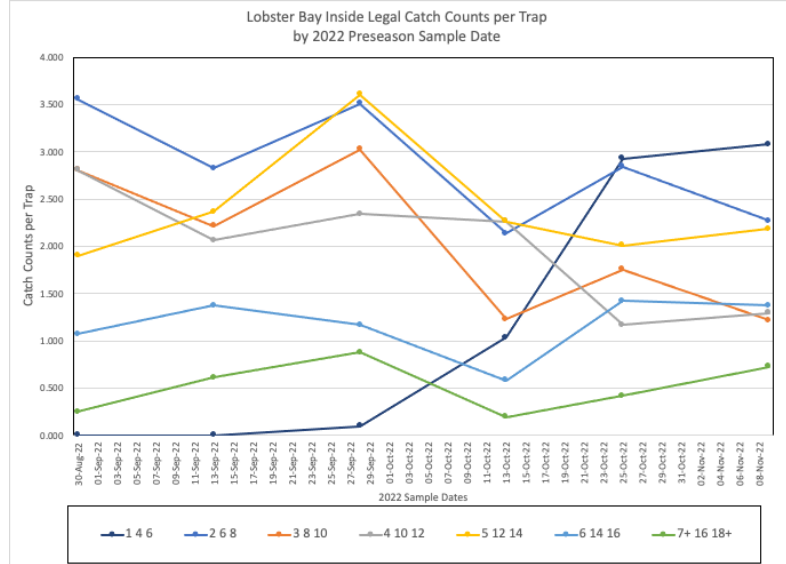
Figure 43. Lobster Bay Inside 2022 Sample Dates Legal Counts per Trap

level as well as the catch counts of lobster per trap. The overall catch counts per trap at the start of the season are expected to fall marginally. As well, the forecast of the average BRIX of the start of season catch in Lobster Bay Inside (9.4 units/ml) is 3% lower than the (actual) last sample (9.71 units/ml).

This average BRIX change is marginal and still represents a favorable average BRIX level. It is noted that continuing forecasts for this area may lead to a continuing reduction in post-moult BRIX levels as lobsters with high BRIX levels experience natural mortality and lobsters with low BRIX levels begin to enter the system after late moulting. In fact, this appeared to be the experience in December 2022 when average BRIX levels were strong at the start of the season (early December), but then deteriorated in some areas until recovery again in January.

Table 8. Lobster BRIX Dynamics Forecast for Start of 2022 Season

		Sample Date:	09-Nov-22			28-Nov-22		
		Period, t	Actual 23			Predicted 24		
BRIX Cell	BRIX (L)	BRIX (R)	Post-moult Period					
Number,c	Lower	Upper	Actual			Forecast		
			Recruited Lobster	CPUT (#Lobster/trap)	Ave BRIX	Recruited Lobster	CPUT (#Lobster/trap)	Ave BRIX
0	0	4	0.00%	0.00	0.00	0.00%	0.000	0.00
1	4	6	25.33%	3.08	1.27	16.10%	3.250	0.80
2	6	8	18.67%	2.27	1.31	27.29%	2.000	1.91
3	8	10	10.00%	1.22	0.90	17.68%	1.000	1.59
4	10	12	10.67%	1.30	1.17	10.80%	1.000	1.19
5	12	14	18.00%	2.19	2.34	15.83%	2.500	2.06
6	14	16	11.33%	1.38	1.70	12.30%	1.250	1.85
7	16	18	6.00%	0.73	1.02	0.00%	1.000	0.00
		Totals	100.00%	12.15	9.71	100%	12.00	9.40

4.5.2 Dynamic BRIX Forecasts for the Start of the 2023-24 Commercial Season

The above sections present the framework description of the dynamic BRIX level forecast. The first opportunity to develop a testable BRIX level forecast will take place for the start of the 2023-24 commercial season in LFAs33 and 34. The model presented here will be developed and tested from past data and more precise model parameters determined according to the historical data trends evident in the database. The results will be prepared for the 2023 Preseason Sampling Program Preseason Summary Report and provided to industry in a timely matter before the start of the new commercial season.

We believe this information, presented in a style that will be more relevant to industry members – including forecast estimates on average catch counts per trap and forecast average BRIX levels – will be more timely, accurate, and testable, and provide more useful information for industry decision making at the start of the season.

This work will be presented formally in the Lobster Quality Centre Working Paper #16 in progress, "Lobster Dynamic BRIX Level Modelling: Start of Year Average BRIX and Catch per Trap Forecasts" (David et al 2023).

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5 In-season Sampling Data in 2022-2023

The 2022-2023 sampling program included 12 sampling location-dates that took place after the beginning of the commercial lobster fishing season (Monday, November 29, 2021) in LFAs 33 and 34. These samples were carried out in 8 dates during the last half of December 2022 (21st, 22nd, and 28th), January 2023 (12th,18th, and 25th), and February 2023 (15th, and 22nd).

5.1   In-season Sampling Data

In-season samples took place in Inside areas of Port La Tour, and St. Mary's Bay, and all Outside areas of Lobster Bay, Port La Tour, Yarmouth, and St. Mary's Bay as summarized in Table 9 below. As per the sampling protocol, in-season samples were comprised of 150 lobsters per location-date.

Table 9. Summary of 2022-23 In-season Sampling Data

Sampling Location	Samples Subarea	Sampling Dates	Total Samples	Sample Ave BRIX	% Change Ave BRIX	Sample% Soft	Sample % Weak
Lobster Bay LFA34	Outside	12-Jan	150	10.55	+9%	0.67%	0.00%
Port La Tour LFA 33	Inside	22-Dec	150	10.85	+17%	0.00%	0.00%
		18-Jan	150	11.18	+21%	0.00%	0.00%
	Outside	22-Dec	150	10.51	+33%	0.67%	0.67%
		18-Jan	150	9.87	+25%	0.00%	0.00%
		15-Feb	150	11.01	+39%	0.00%	0.00%
St. Mary's Bay LFA 34	Inside	21-Dec	150	10.90	+10%	0.67%	4.67%
		25-Jan	150	11.62	+17%	0.00%	0.67%
		22-Feb	150	13.63	+37%	0.00%	0.00%
	Outside	21-Dec	150	9.27	+1%	0.67%	7.33%
		25-Jan	150	12.10	+31%	0.00%	0.00%
Yarmouth LFA 34	Outside	28-Dec	150	9.80	+8%	0.00%	0.67%
	6 subareas^	**12 In-season Dates**	**Lobsters Sampled**	**Average BRIX**	**Ave %BRIX Change**	**Overall % Soft**	**Overall % Weak**
	IN-SEASON TOTALS		**1,800**	**10.94**	**+12%**	**0.22%**	**1.17%**

^Zero In-season samples were taken in Lobster Bay (Inside) and Yarmouth (Inside) in 2022-2023.
*Mean BRIX % change compares average preseason BRIX means by location with average in-season BRIX means.

In-season samples consistently show improved overall BRIX indicators over all areas with means exceeding 9.27 units/ml in all in-season sampling dates and overall in-season BRIX mean of 10.94 (versus overall preseason and in-season BRIX mean of 9.75 units/ml – Table 3). In-season samples also showed lower %Soft and %Weak values respectively of 0.22% and 1.17% on 1,800 samples versus preseason %Soft and %Weak values of 2.66% and 13.29% respectively on 9,083 preseason samples – a decrease of 80% in %Soft/%Weak values from preseason to in-season samples (Table 3).

The following section compares the in-season BRIX distribution category results for the preseason samples by locations and inside/outside areas for the 12 in-season sample location-dates.

5.2   Preseason and In-season Comparison

The following graphs, Figures 44-49 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 for a given location with the in-season samples.

5.2.1   Lobster Bay Outside In-season Results

There were 7 total sampling periods for Lobster Bay Outside including 1 in-season sample date (January 12, 2023), 6 weeks after the start of the commercial season. The mean BRIX category time series declined from the early sample dates in Lobster Bay (Outside) to a low BRIX mean of 8.65 units/ml and then improved after mid-October to a high mean of 10.22 at the end of preseason sampling (November 7). (See also Section 4.4.4 – Lobster Bay Outside above.)

The single in-season sample represents an increase in mean BRIX over the preseason samples to the highest mean BRIX in the sampling series of 10.55 units/ml (Figure 44 below).
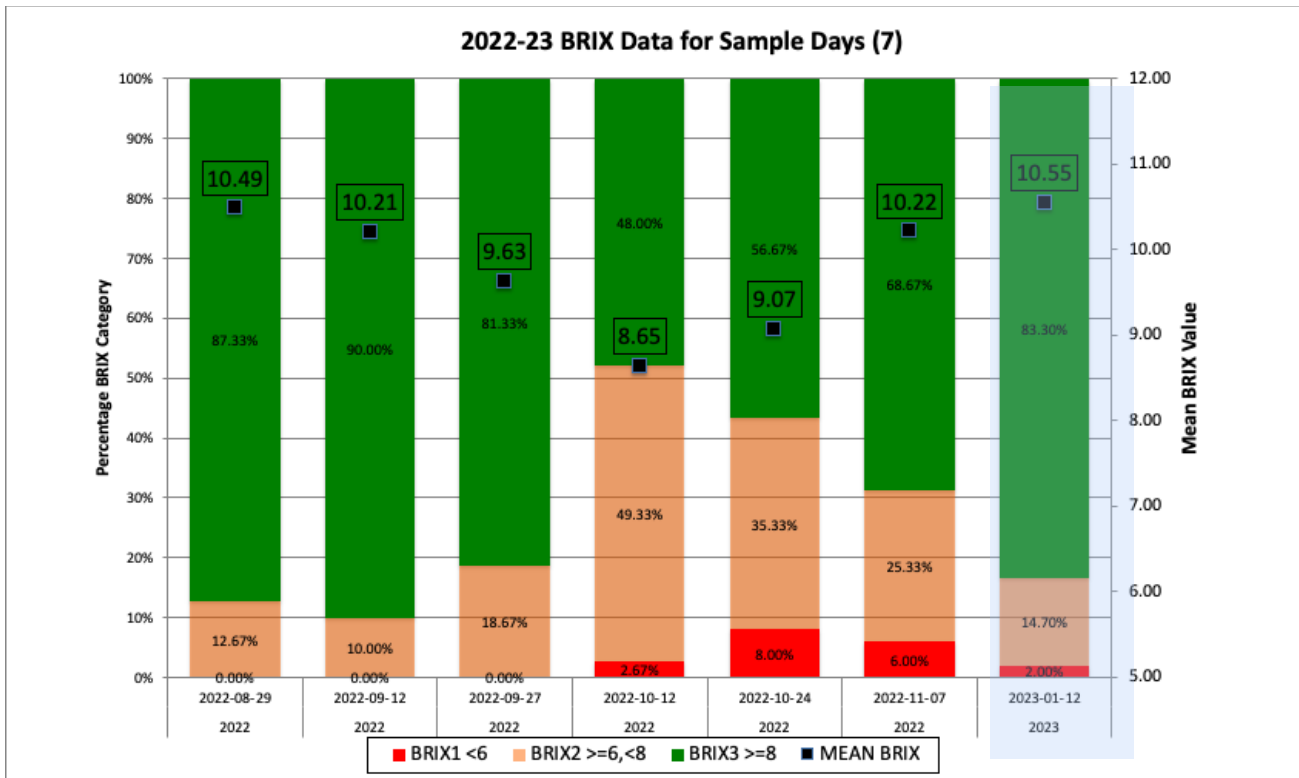
Figure 44. Lobster Bay Outside Preseason and In-season Sampling BRIX Indicators

Lobster Bay Outside 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 into the coming calendar year. Thus, for Lobster Bay Outside, by end January 2022, lobsters are predominantly (80%+) of high quality and considered acceptable for long-term storage and all markets.

5.2.2 Port La Tour Inside In-season Results

There were 9 total sampling periods for Port La Tour Inside including two in-season sampling dates at December 22, 2022 and January 18, 2023. The mean BRIX time series over the early preseason (August through October) sampling period varied slightly between a high of 9.35 units/ml (September 28, 2022) and a low of 8.13 units/ml (October 13, 2022) and then increased thereafter to the end of preseason sampling to the highest preseason mean BRIX of 10.8 (November 9, 2022). (See also Section 4.4.5 – Port La Tour Inside above.)

The two in-season samples continued the mean BRIX increase from 10.85 to 11.10 as shown in Figure 45 below. It is understood that BRIX levels are expected 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. Thus, for Port La Tour Inside, by the start of the New Year 2023, lobsters are 70%+ considered to be of high quality and considered acceptable for long-term storage and all markets.
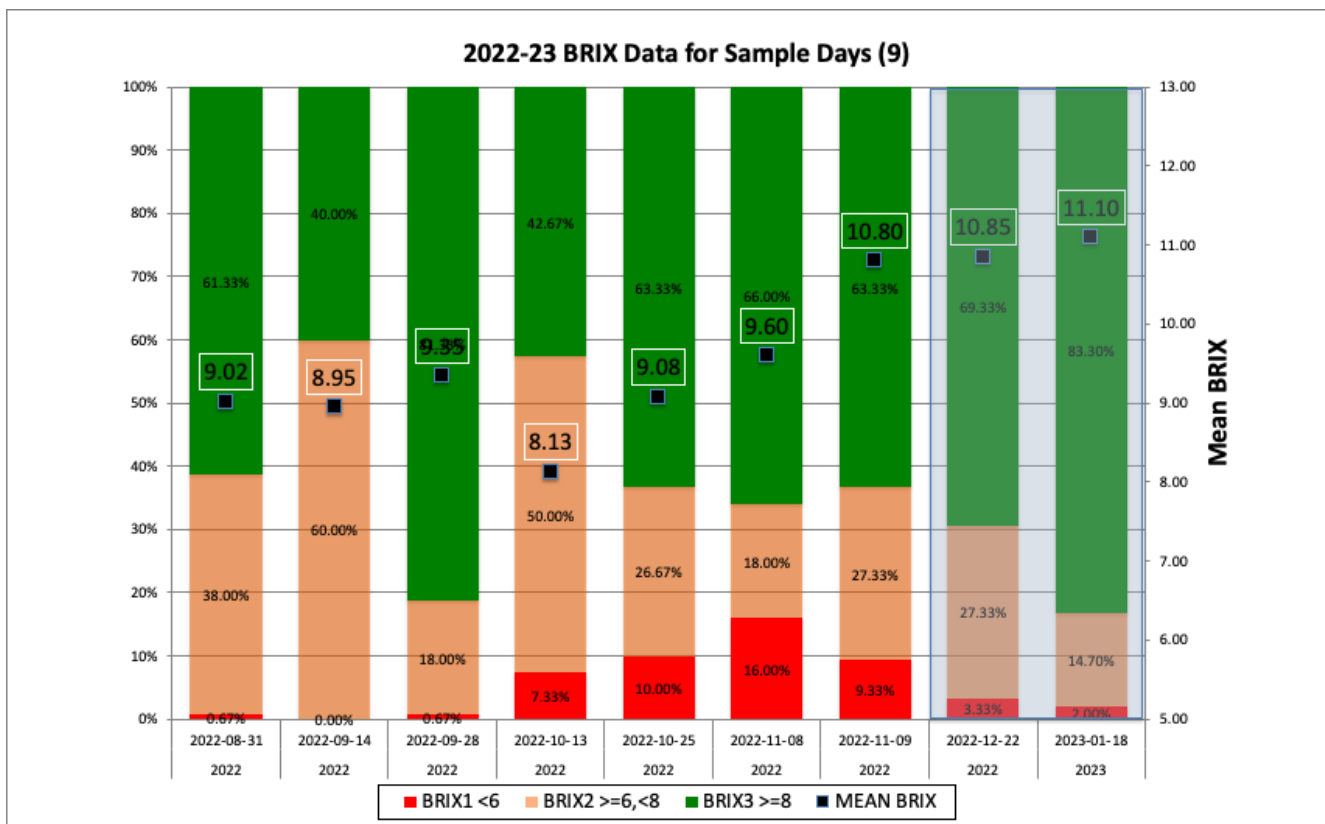
Figure 45. Port La Tour Inside Preseason and In-season Sampling BRIX Indicators

5.2.3 Port La Tour Outside In-season Results

There were 9 total sampling periods for Port La Tour Outside, including three in-season sample dates – December 12, 2022, January 18, 2023, and February 15, 2023 as noted in Figure 46 below. The mean BRIX time series for Port La Tour Outside exhibits a decline in value from 8.99 units/ml at the start of preseason sampling to 7.22 at end October sampling and 7.34 in early November. (See also Section 4.4.6 – Port La Tour Outside above.)

The three in-season samples denote a marked increase to mean BRIX of well over 9 units/ml with a series maximum mean of 11 at the final in-season sample date (February 15, 2023). It is apparent that the in-season improvement results as lobster becomes more fully-meated as they move from post-moult into the pre-moult period of the coming 2023 calendar year.

For Port La Tour Outside, based on the in-season samples, lobsters here are 75%+ of high quality and considered acceptable for long-term storage and all markets.
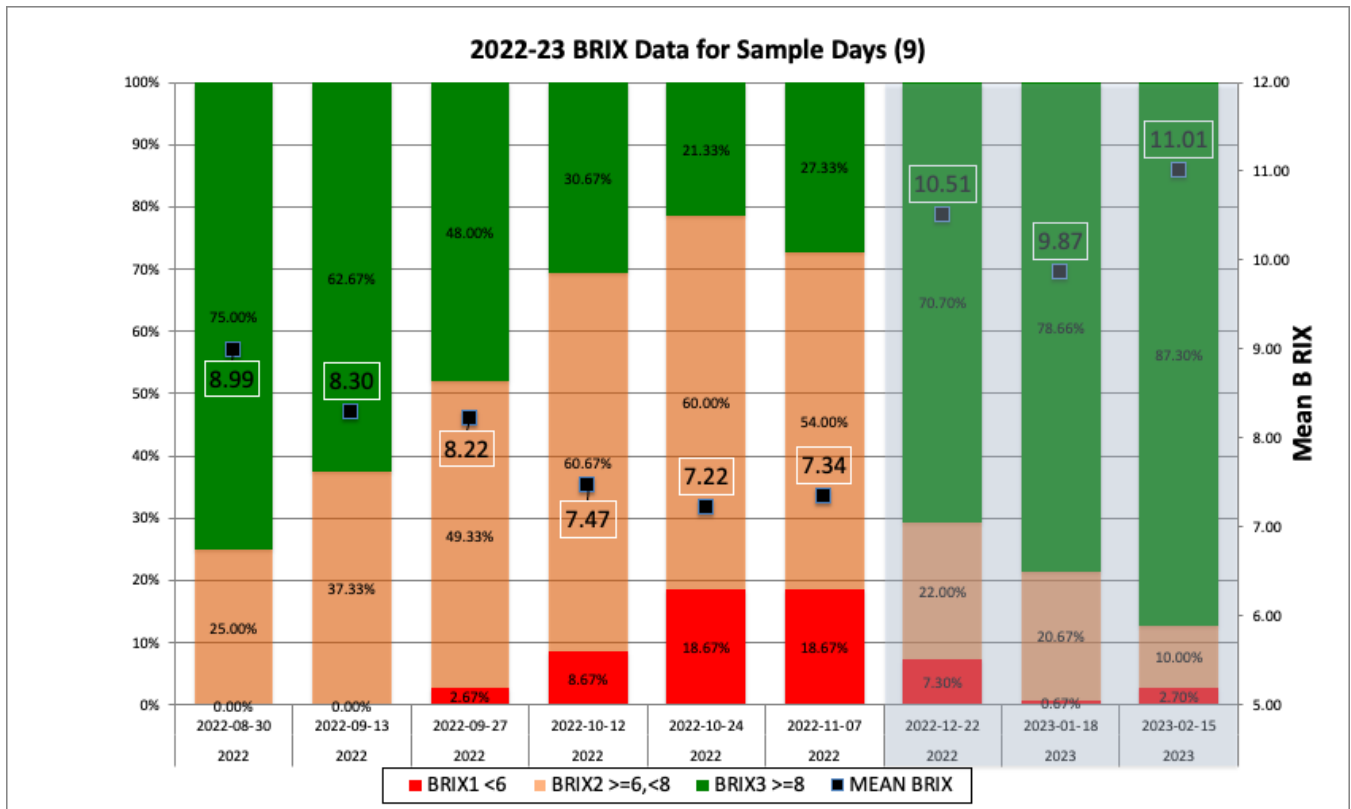
Figure 46. Port La Tour Outside Preseason and In-season Sampling BRIX Indicators

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

There are 9 total sampling periods for St. Mary's Bay Inside including three in-season sampling dates (December 12, 2022, January 25, 2023, and February 22, 2023) as highlighted in Figure 47 below. The mean BRIX time series over the preseason period showed an initial decline to early October followed by a gradual but steady improvement in mean BRIX values from 8.92 units/ml (October) to 10.53 by mid-November at the end of preseason sampling. (See also Section 4.4.7 – St. Mary's Bay Inside above.)

The three subsequent in-season samples continue the mean BRIX substantial increase to over 13 units/ml – the highest value in the time series.
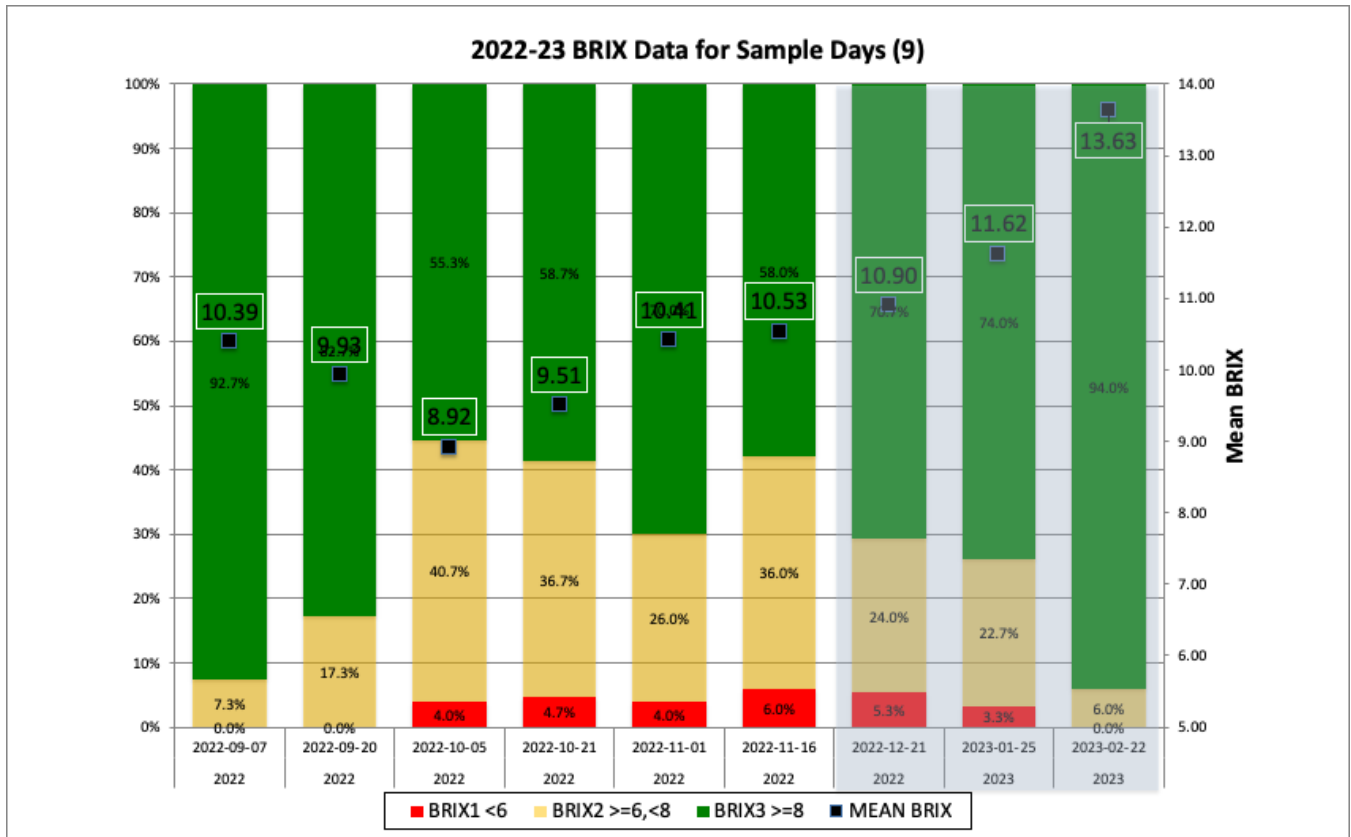
Figure 47. St. Mary's Bay Inside Preseason and In-season Sampling BRIX Indicators

Once again, it is understood that BRIX levels are expected 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. Thus, for St. Mary's Bay Inside, by January 2023, lobsters are 75%+ of high quality and considered acceptable for long-term storage and all markets.

5.2.5 St. Mary's Bay Outside In-season Results

There were 8 total sampling periods for St. Mary's Bay Outside, including two in-season samples (December 21, 2022 and January 25, 2023) as noted in Figure 48 below. The mean BRIX time series for St. Mary's Bay Outside declined slightly during preseason sampling from a high of 10.11 units/ml to a low of 8.13 in early October sampling, and rebounding to a mean BRIX of 9 by mid-November. (See also Section 4.4.8 – St. Mary's Bay Outside above.)

In-season sampling increased mean BRIX marginally in December and then jumped to a series high of over 12 units/ml in the last sampling date of January 25, 2023. It is yet again apparent that the in-season improvement results as lobster becomes more fully-meated as they move from post-moult into the pre-moult period of the coming 2023 calendar year.

For St. Mary's Bay Outside, based especially on the in-season end-January 2023 sample, lobsters here are 70%+ of high quality and considered acceptable for long-term storage and for all markets.
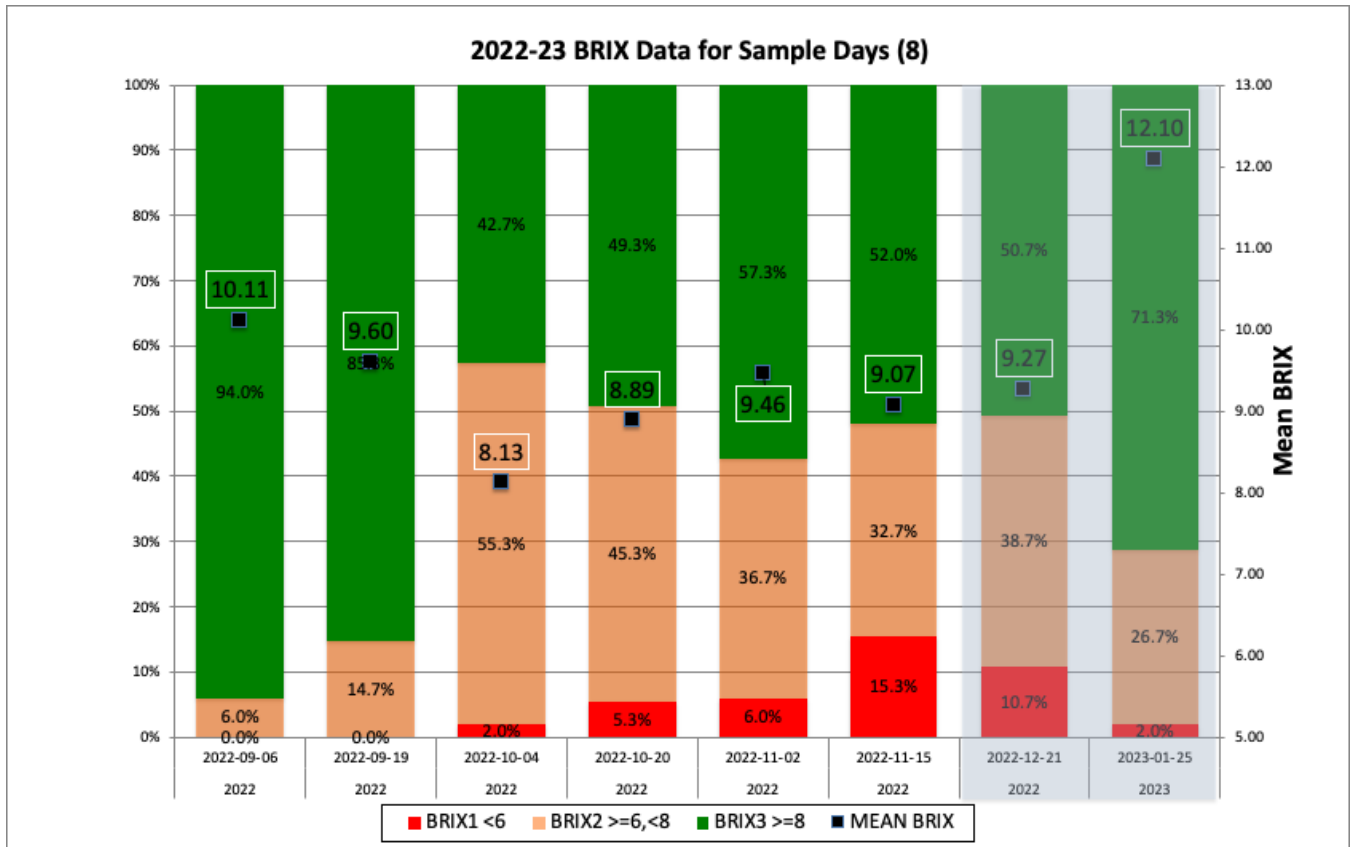
Figure 48. St. Mary's Bay Outside Preseason and In-season Sampling BRIX Indicators

5.2.6 Yarmouth Outside In-season Results

There are a total of 7 sampling periods for Yarmouth Outside including a single in-season sample date, December 28, 2022. The mean BRIX time series pattern was relatively constant (at 9.6 units/ml) over the preseason with a slight dip in mean BRIX to 8.3 units/ml in October and November 2022 samples. (See also Section 4.4.2 – Yarmouth Outside above.)

The single in-season sample shows a slight improvement over the preseason higher mean BRIX (9.6) to a mean BRIX of 9.8 as shown in Figure 49 below.
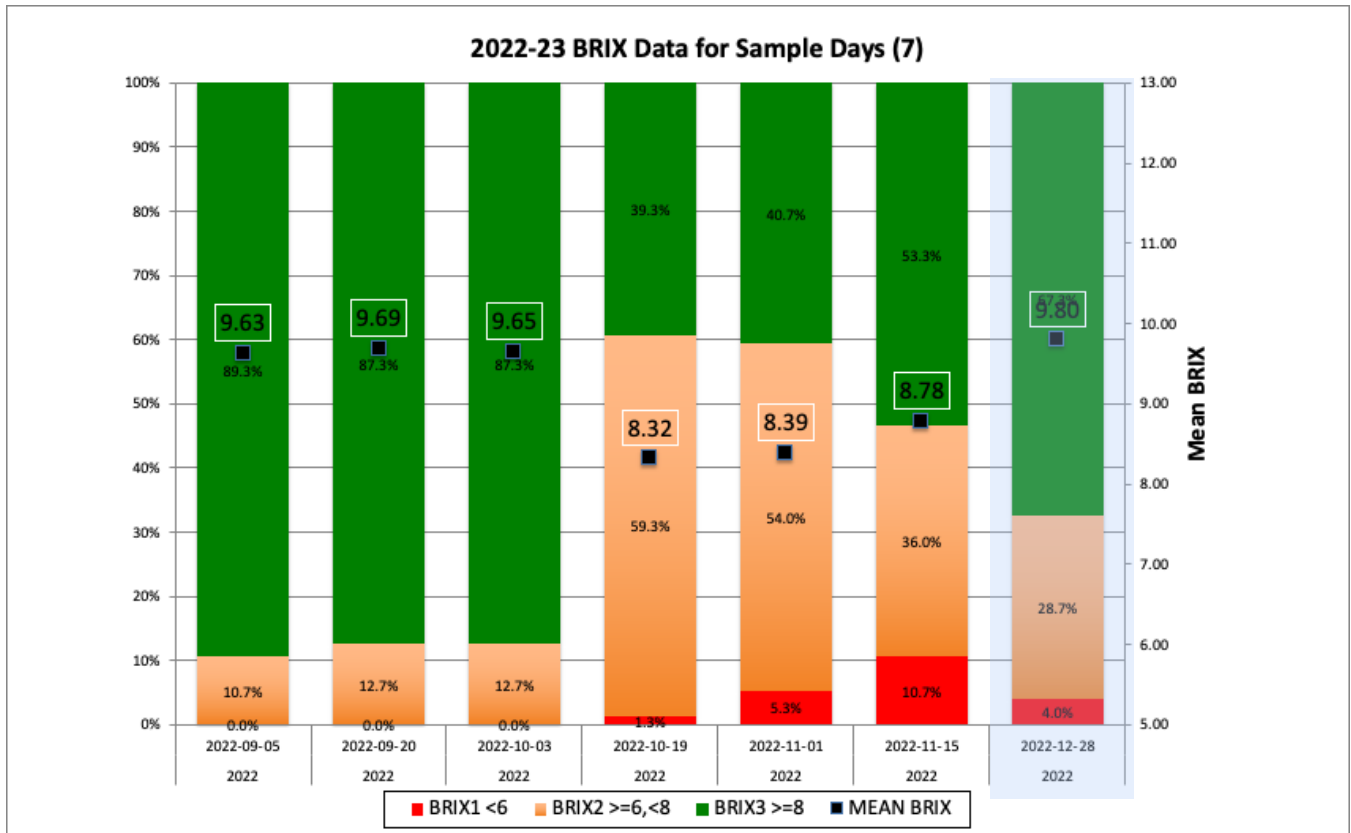
Figure 49. Yarmouth Outside Preseason and In-season Sampling BRIX Indicators

Yarmouth Outside mean BRIX levels are expected to improve into the season, as lobsters become more fully-meated while they may be considered moving from post-moult into the pre-moult period of the coming calendar year, 2023.

Thus, for Yarmouth Outside, by the New Year 2023, lobsters are approximately 70% of high quality and considered acceptable for long-term storage and for all markets.

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 by location is to carry out a structured, statistical analysis of year-over-year comparisons to gauge the early season prediction of lobster quality by fishing areas. This information, we believe, is of benefit to Nova Scotia harvesters, processors, and decision makers looking to prepare inventories for live and processed markets that yield most value to the lobster sector.

The following discussion considers the outlook for the preseason and in-season lobster sampling program in LFAs33&34 and presents issues for continuous improvement of this report for the benefit of the lobster industry for the coming commercial seasons.

6.1   Annual Lobster Quality and Landings Comparison

In the 2020-2021 final report (Mattock, Mulock, and Lane 2021a), it was reported that there was a negative correlation between LFA34 seasonal landings and Overall Average BRIX for all 8 sampling areas, i.e., it was conjectured that as overall quality (measured by BRIX levels) degrades, total seasonal catches appear to increase and vice versa (as lobster quality (BRIX levels) increases, catches fall).

It was also reported in last year's 2021-2022 final report (Mattock, Mulock, and Lane 2022a) that overall predictions of lobster quality and lobster landings in LFAs 33 and 34 can be seen as independent time series that move annually according to detectible and comparable trends. We caution that a strict time series analysis approach may ignore exogenous factors that clearly affect lobster fishing effort (i.e., numbers of trap hauls) and subsequent landings independent of lobster quality, 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).

Again this year, this final report does not report on commercial landings compared to the preseason and in-season lobster sampling for quality as determined primarily by BRIX values. Further research on the dynamic determinants of lobster effort and catches by LFA – including predicted and perceived quality – is required in order to prepare a sufficient analysis of the potential impacts of perceived quality on catch and effort for lobster. Future final 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

Our ability to compare historical data by selected sites may allow industry to consider options about when and where to harvest higher quality lobster. For example, industry may consider setting harvesting openings, e.g., if the prediction on quality expects harvests with low BRIX (and corresponding meat levels), and high offloading losses, then it may be preferable to shift harvesting to alternative locations (Outside areas preferred to Inside areas) that have better expected BRIX performance to enable storage and shipment of higher valued quality product. Alternatively, lower BRIX levels may trigger industry decisions to move product from storage and shipment for live markets into processed product until BRIX

levels improve.

These options can be evaluated in advance and based on modelling of the historical annual lobster BRIX observations into the commercial season combined with price trends and dynamic behaviour, e.g., based on inventory levels, 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 to the lobster sector over the course of the commercial seasons.

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

6.3   2023 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 seeks to ensure the availability to industry of annual LFA 33 and 34 information on the status of lobster quality including individual lobster statistics, lobster harvests by location-area samples, lobster sample counts, moult stages (pleopod analyses), and hardness scale analyses.

Finally, future reports will seek:

- to establish and apply a lobster grading function consistent with industry grading schemes (e.g., A,B,C);
- to initiate a consistent program of temperature data collection and/or temperature modelling analyses (e.g., regression of surface temperatures to estimate bottom temperatures) associated with the changing marine climate, and the potential for creating conditions that may lead to increased incidences of epizootic shell disease (ESD);
- to develop data on lobster movement via site-specific data on trace metals, lobster diet and lipids and lobster genomics to test and evaluate 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 across the subareas of LFA34;
- to develop statistical analyses using the information in the entire ALMQ database 2006-2022 to discriminate years into quality categories for direct comparison and future analysis and prediction;
- to develop a dynamic BRIX level model for the 8 locations in order to track sample BRIX level changes over the 2023 preseason sampling period and to prepare a forecast of (i) BRIX level distributions and (ii) average BRIX estimates for the start of the commercial season at end November 2023 to be presented in the Preseason Summary of the 2023-24 commercial season;
- to develop a prediction score based on industry feedback at the start of the season to evaluate the performance of the preseason summary report predictions compared to actual results at the start of the LFA33 and 34 commercial seasons; and, finally,
- to match lobster quality analyses with ongoing feedback from industry as to the usefulness of the information for improved industry value and decision making.

-30-

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8   Acknowledgements

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Lobster Quality 2022-2023 Preseason & In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

Final Report:

APPENDICES

March 2023

Appendices

Appendix A

Harvested and Sampled Lobster Count Location Graphics

This appendix presents the graphical data summary of the 2022-2023 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

(a)

(b)

(c)

(d)
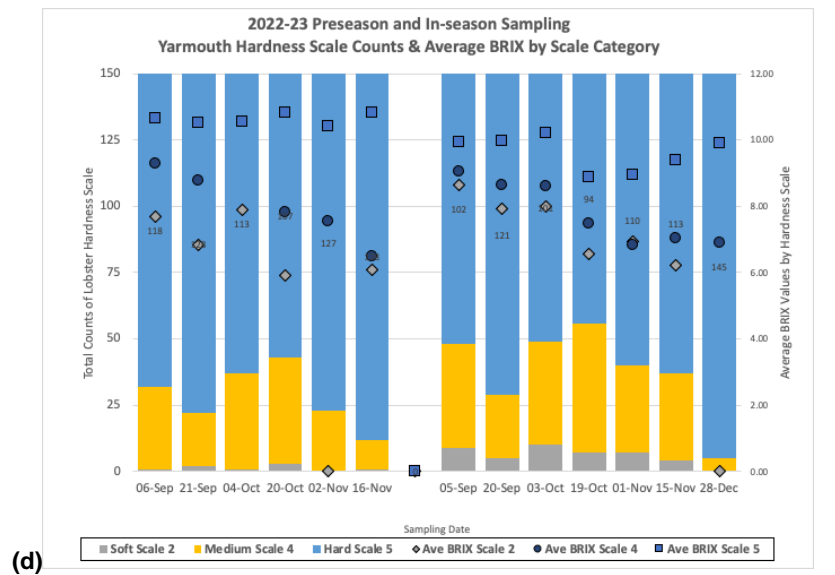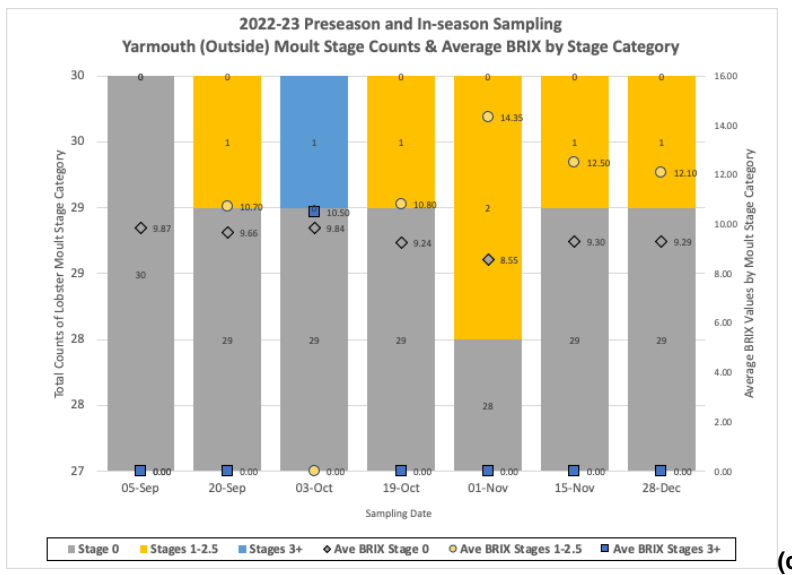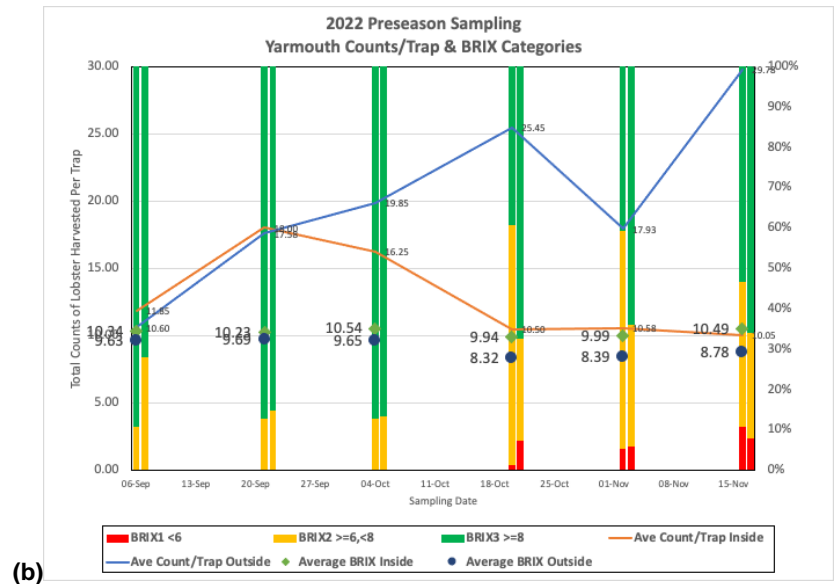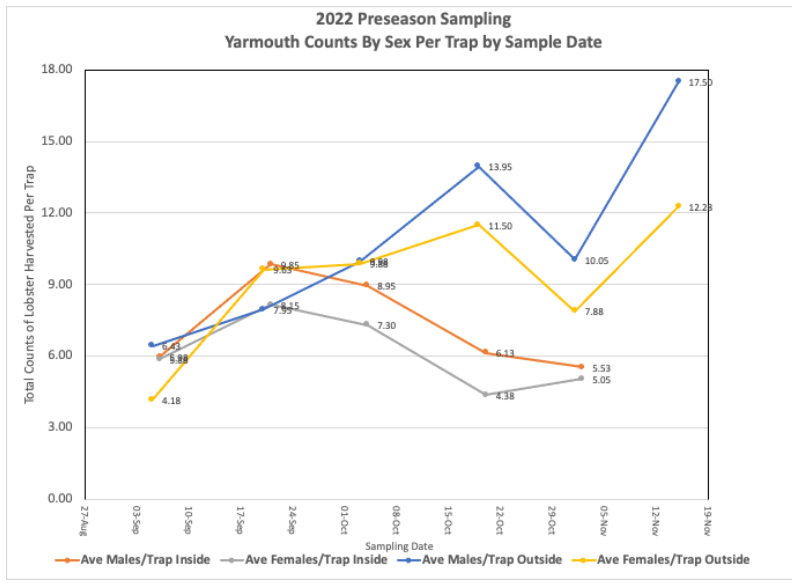
(1) Yarmouth Graphics: (a) Top left-Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right-Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left-Counts of lobster sampled by Moult Stage-Outside area; (d) Bottom right–Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)
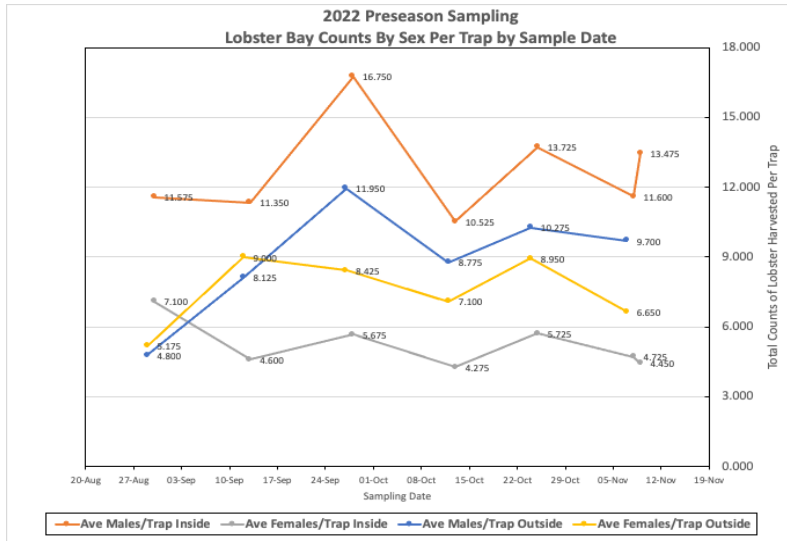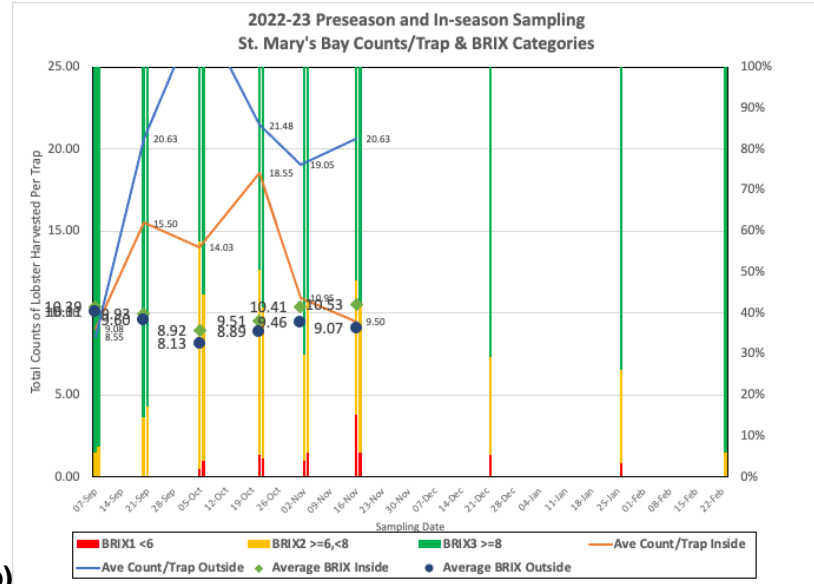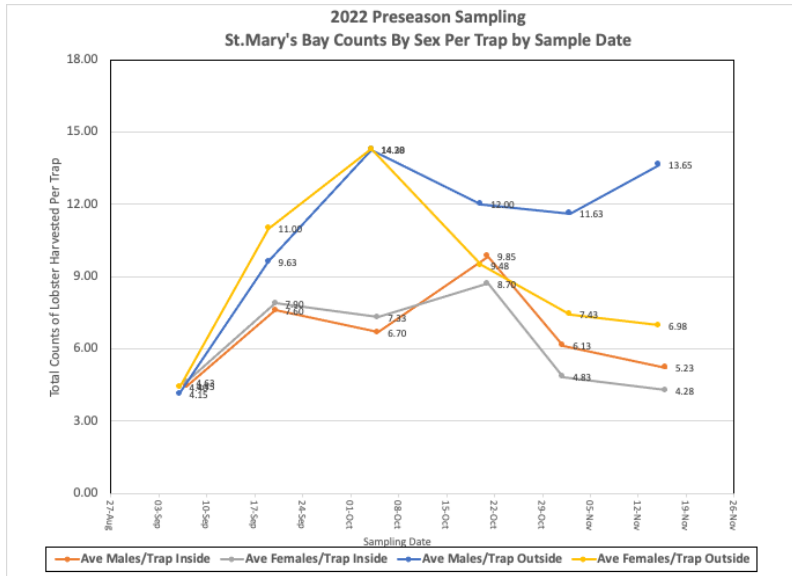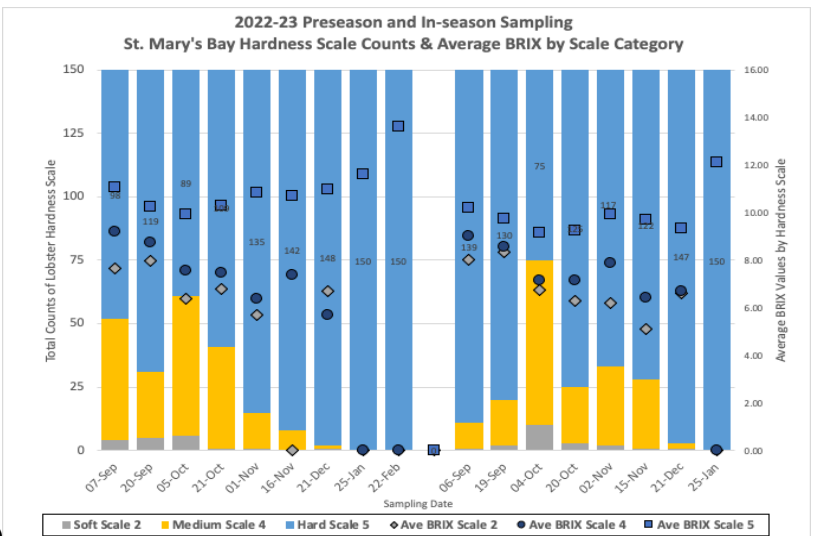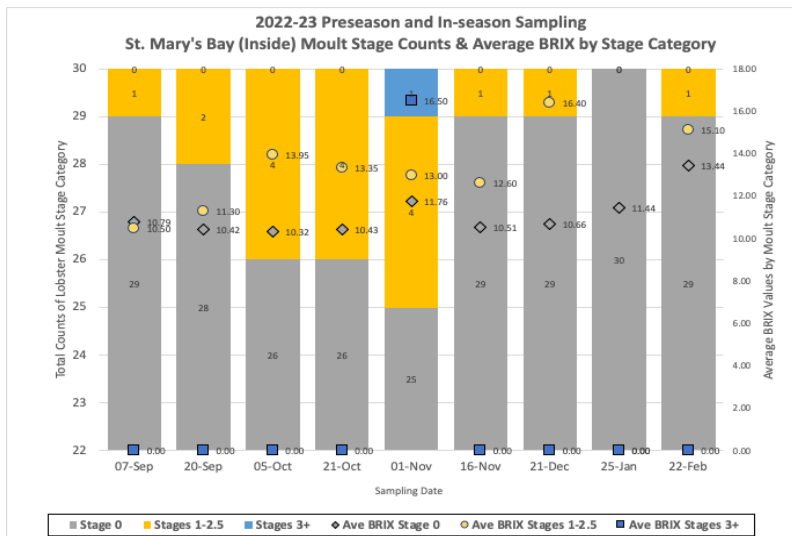
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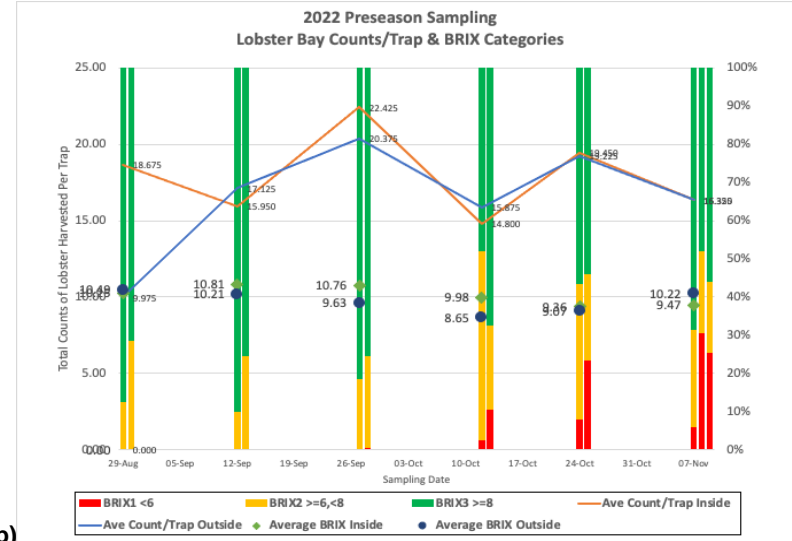
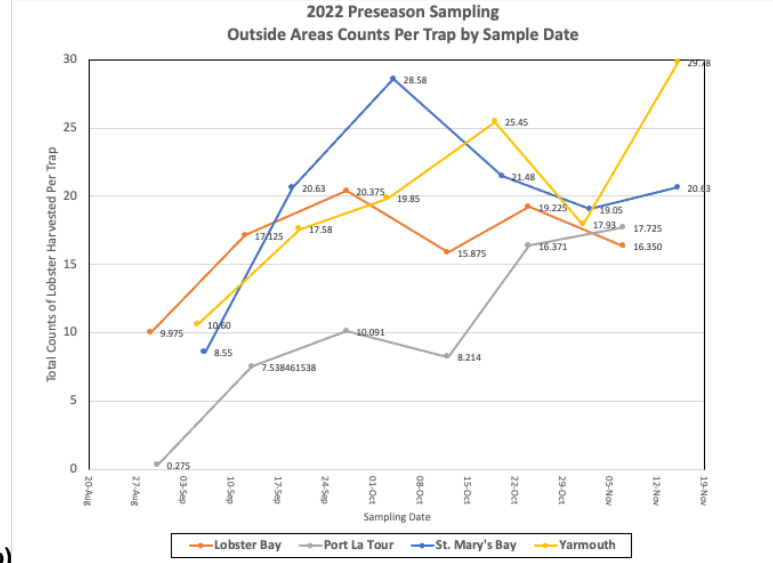

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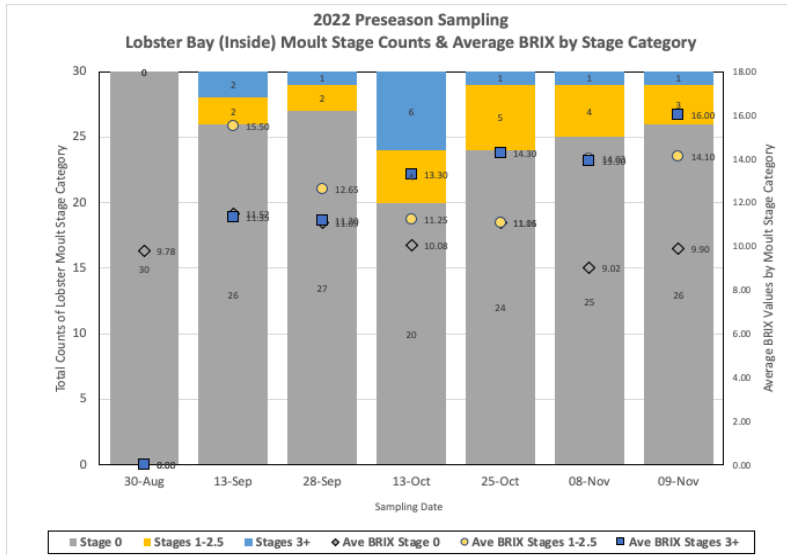
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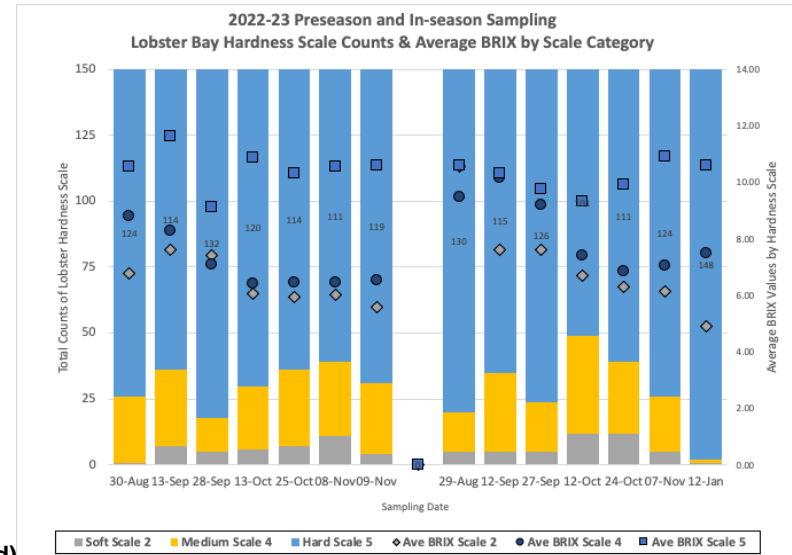
(d)

(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-Inside area; (d) Bottom right–Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)
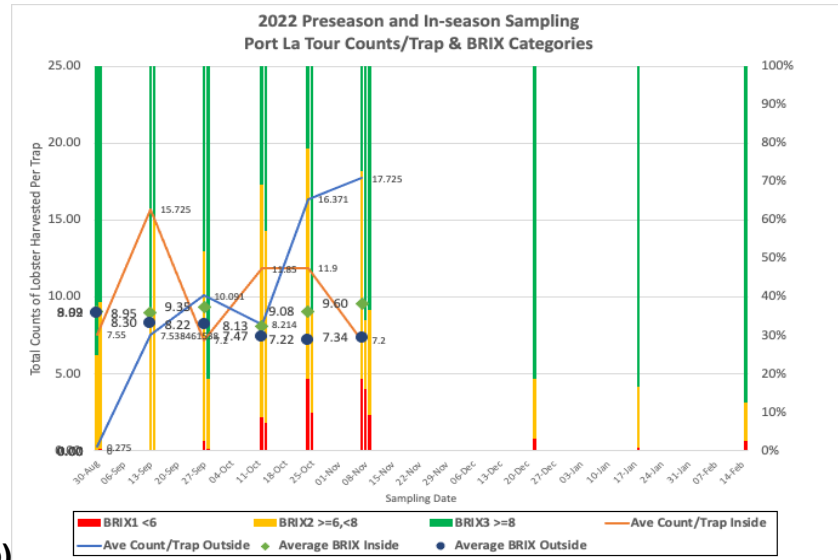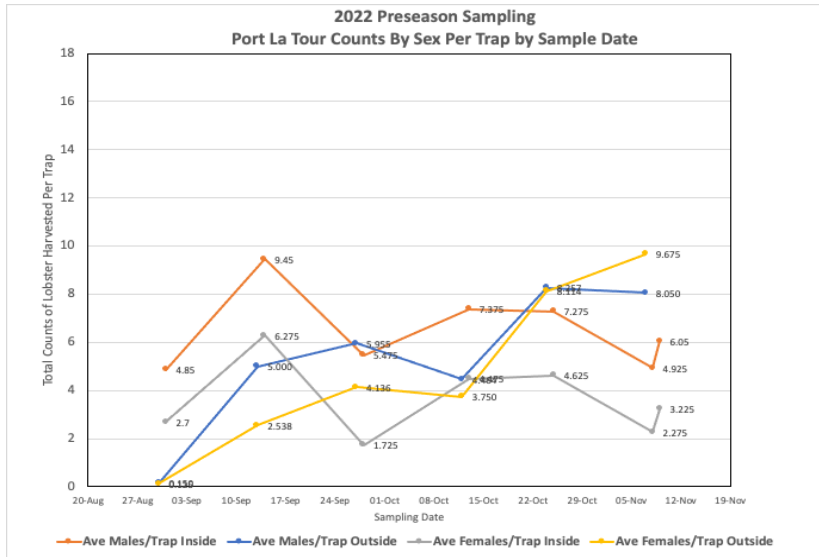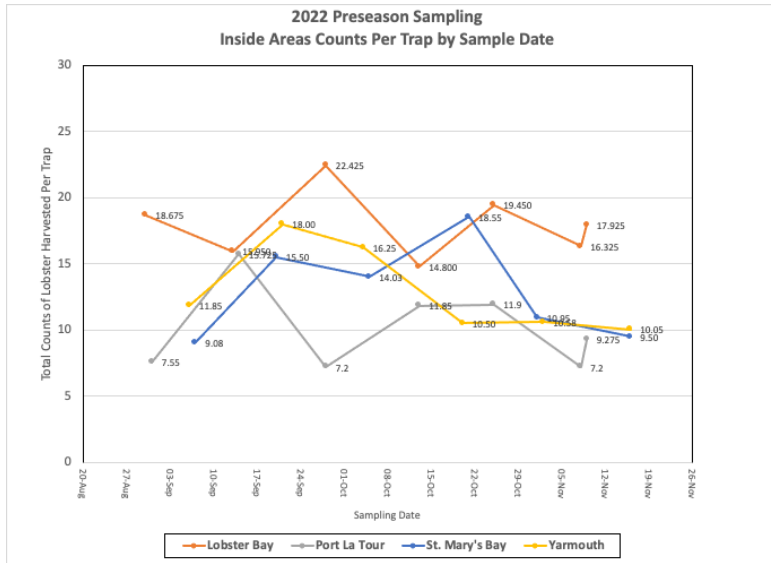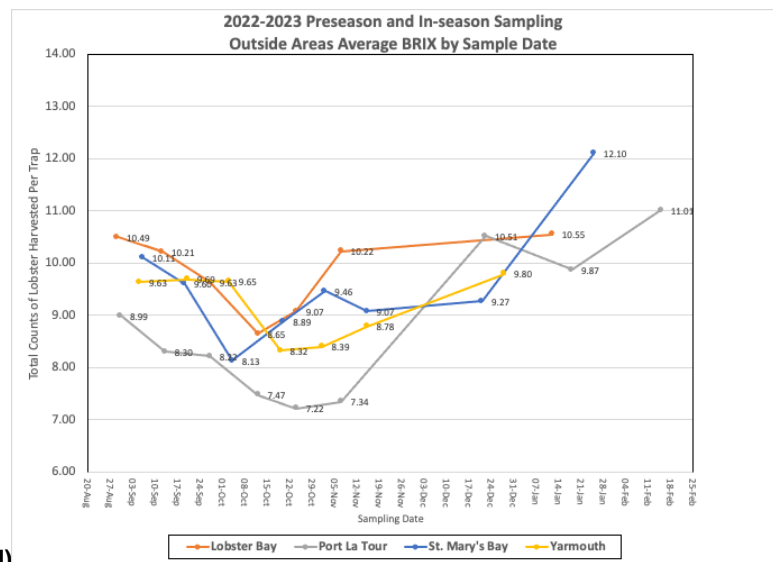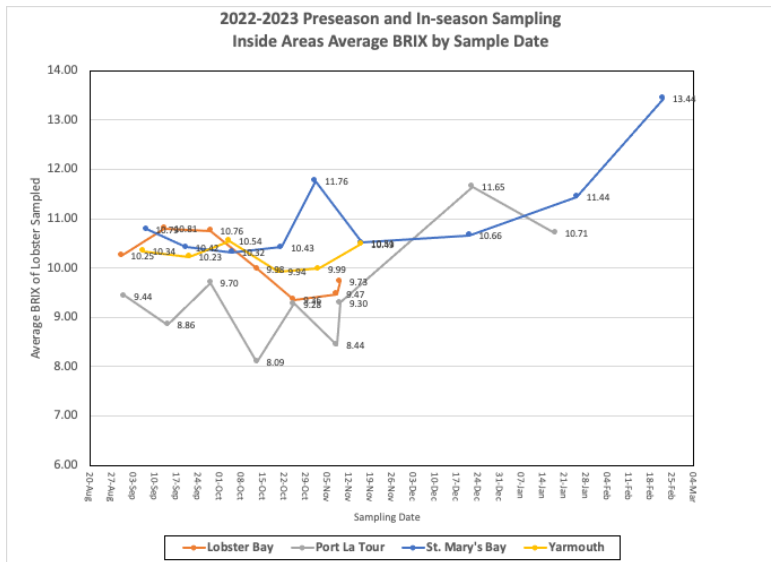
(a)   . (b)
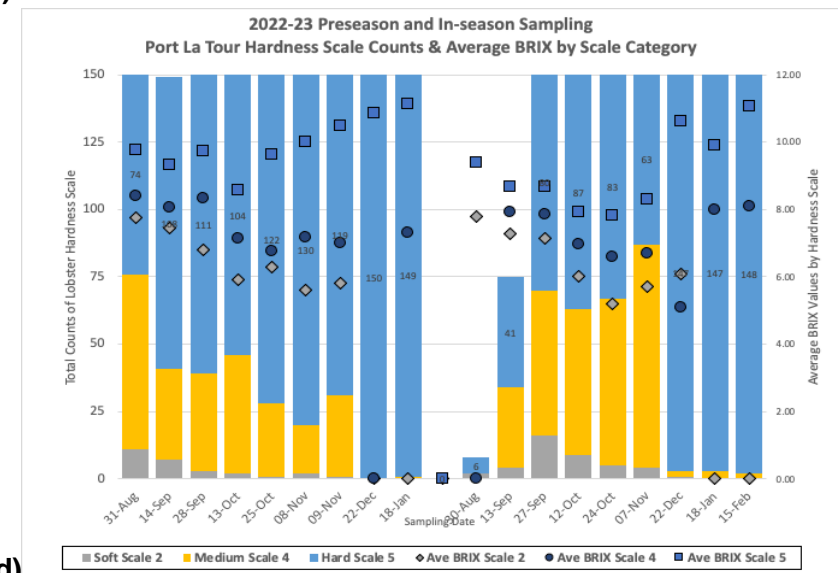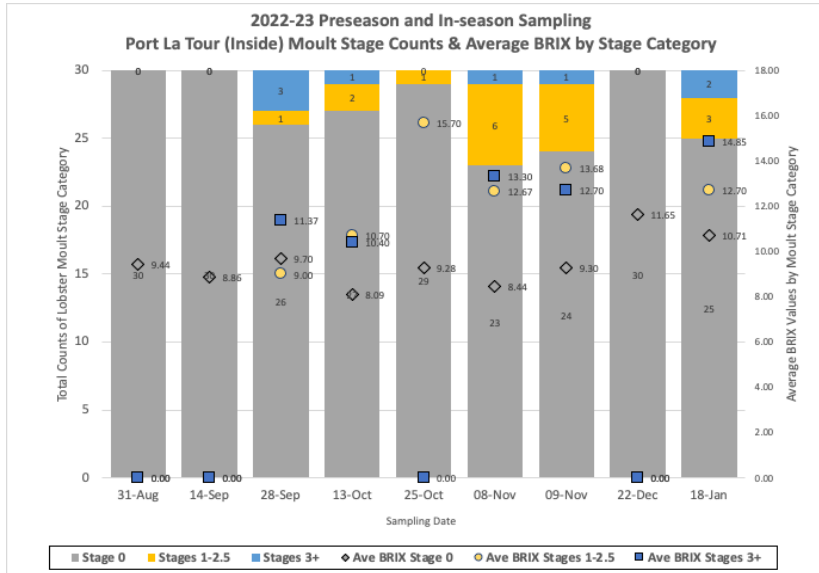
(c)…….(d)

(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 - Inside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)

(a)……..(b)

(c)… ……(d)

(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 - Inside area; (d) Bottom right – Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)

(a)..........(b)

(c)..........(d)

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
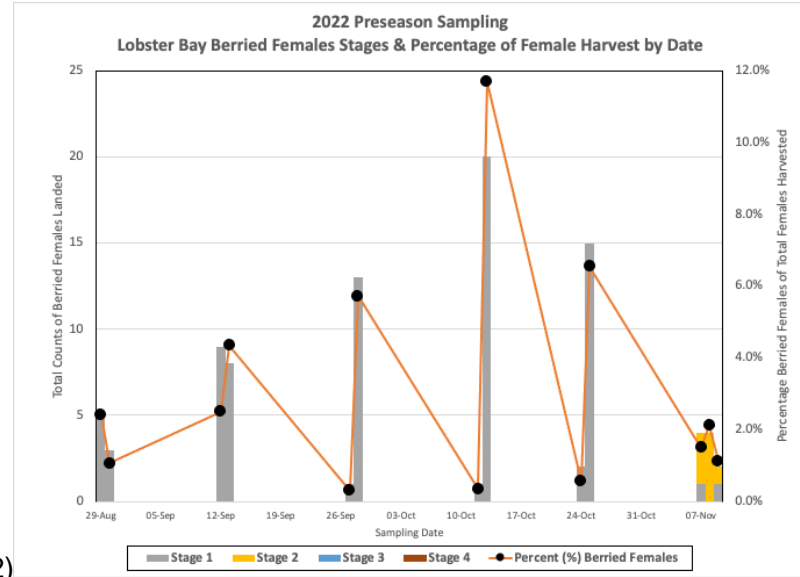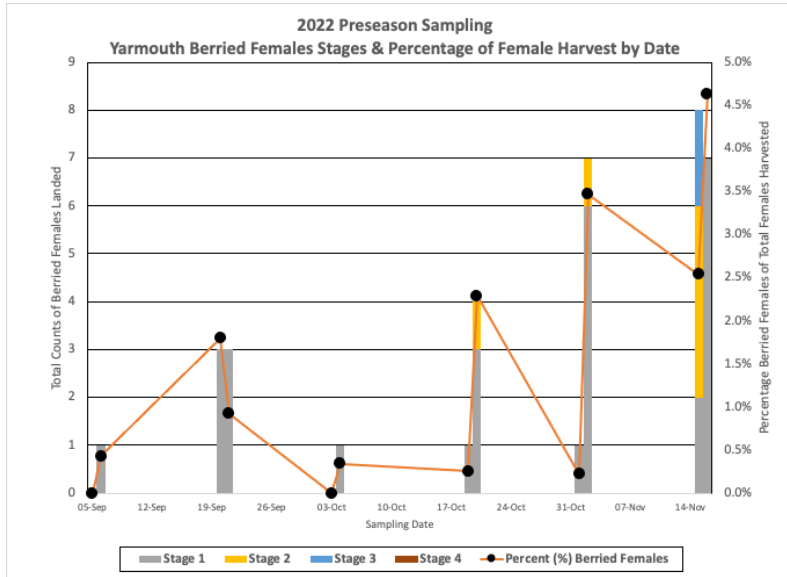
Appendix B

Berried Females Graphics

This appendix presents the berried females graphical data summary of the 2022-2023 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.

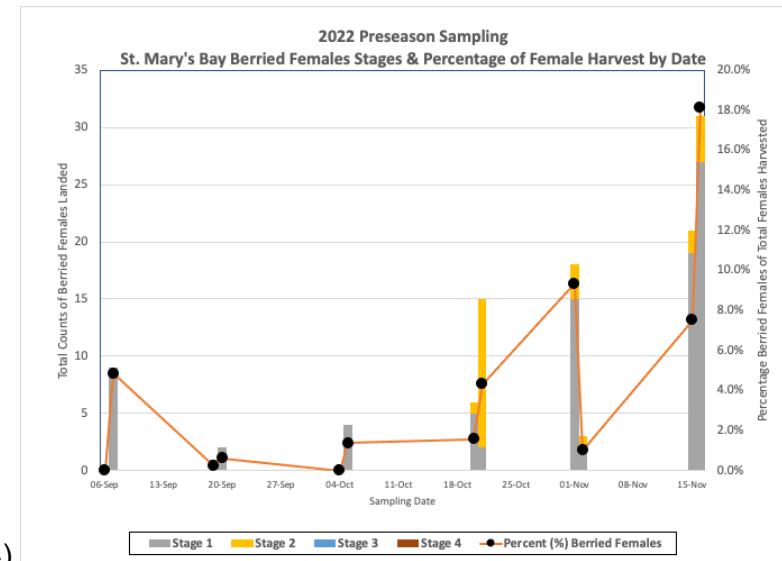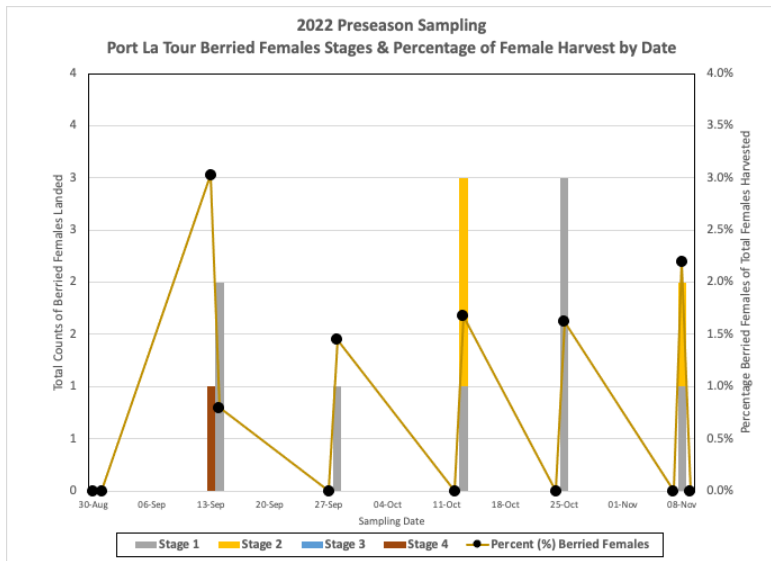B.1   Location graphics (1 page) – berried females sampled counts information:

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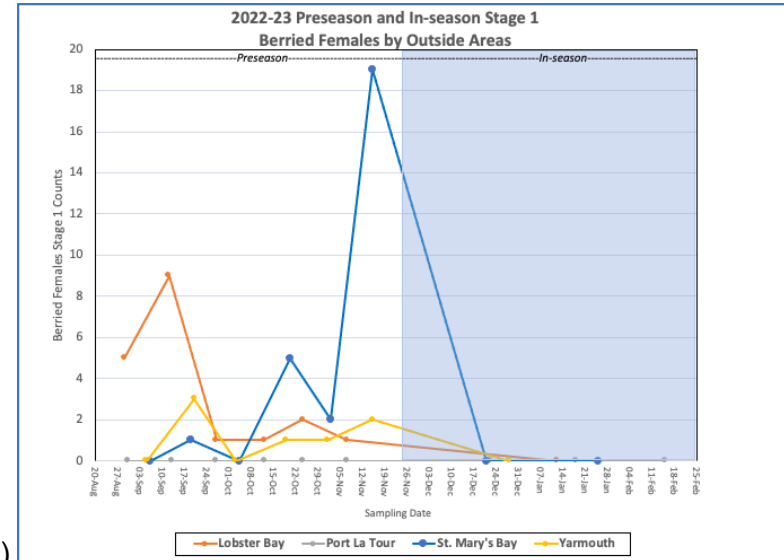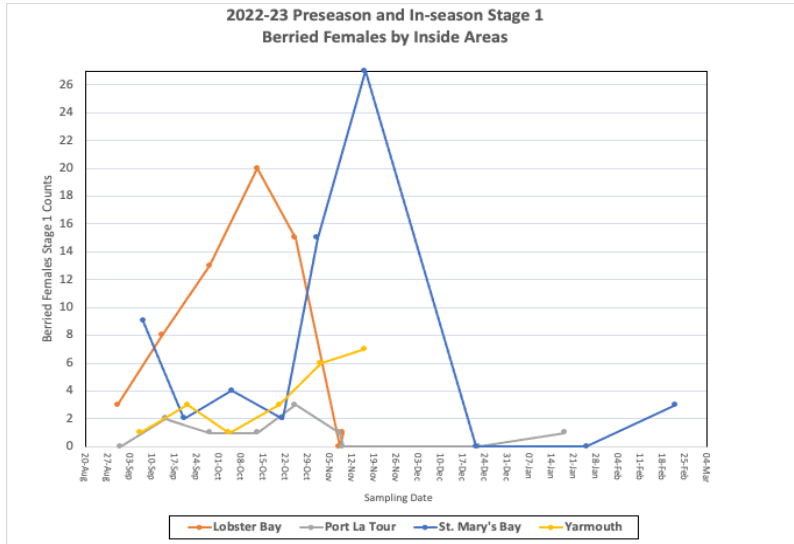f) Berried females Stages 3 & 4 counts for Outside areas

2022 Preseason Sampling
Yarmouth Berried Females Stages & Percentage of Female Harvest by Date

2022 Preseason Sampling
Lobster Bay Berried Females Stages & Percentage of Female Harvest by Date

(1)…… .(2)

2022 Preseason Sampling
Port La Tour Berried Females Stages & Percentage of Female Harvest by Date

2022 Preseason Sampling
St. Mary's Bay Berried Females Stages & Percentage of Female Harvest by Date
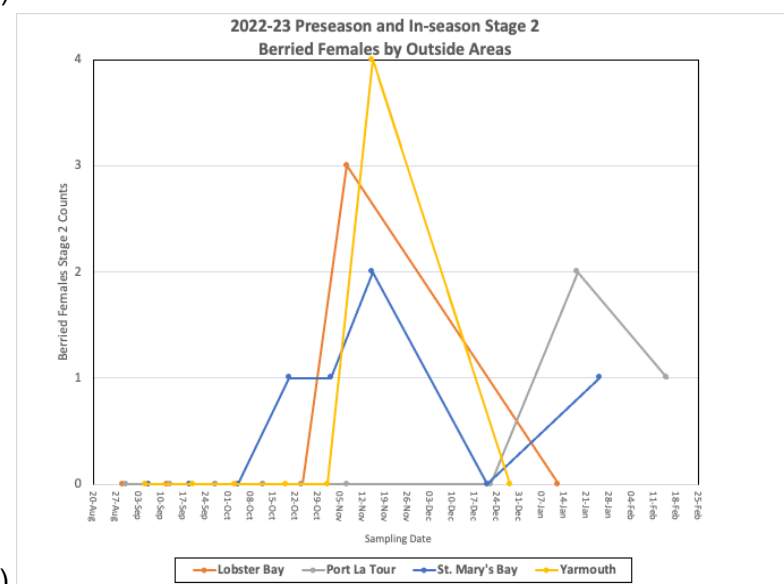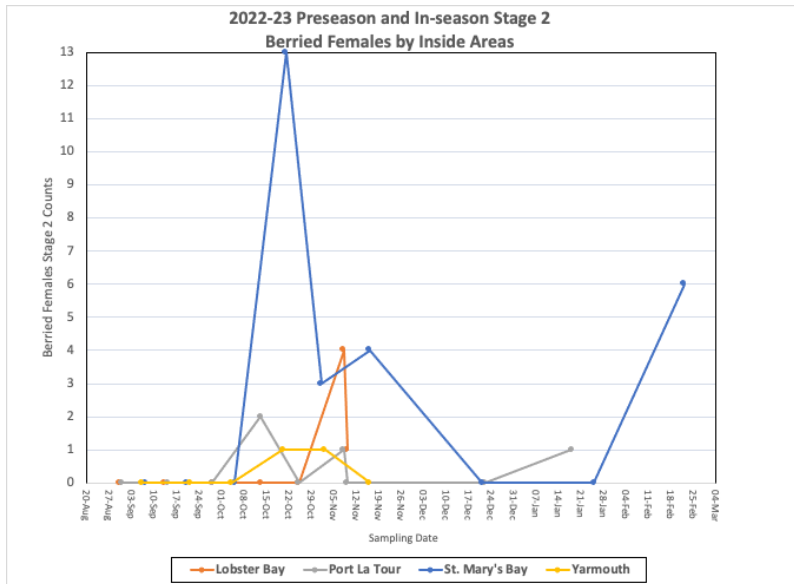
(3)………..(4)

Locations Graphics: (1) Top left–Yarmouth Berried Females Stages Count & Percent Females; (2) Top right–Lobster Bay Berried Females Stages Count & Percent Females; (3) Bottom left–Port La Tour Berried Females Stages Count & Percent Females; (4) Bottom right–St. Mary's Bay Berried Females Stages Count & Percent Females
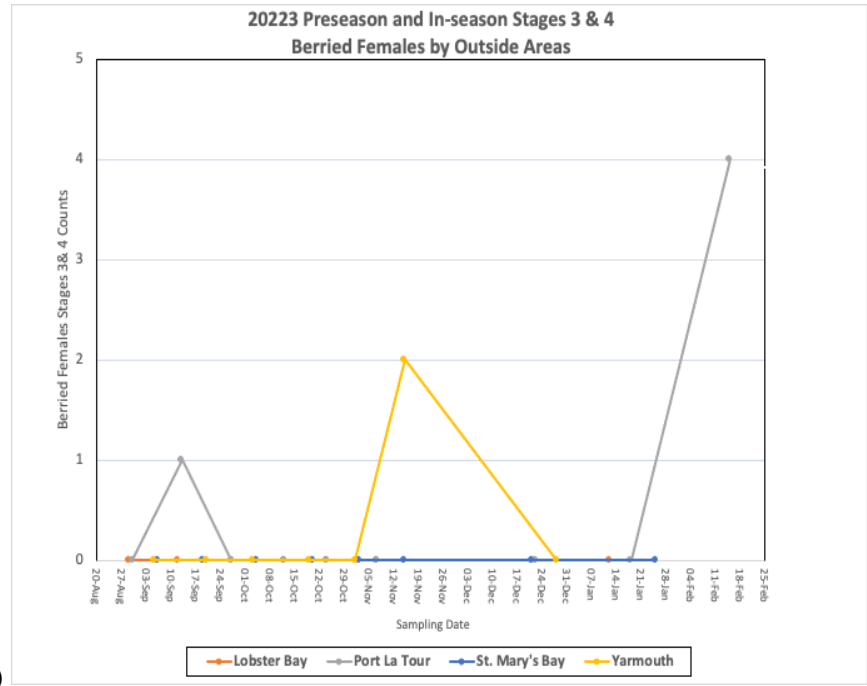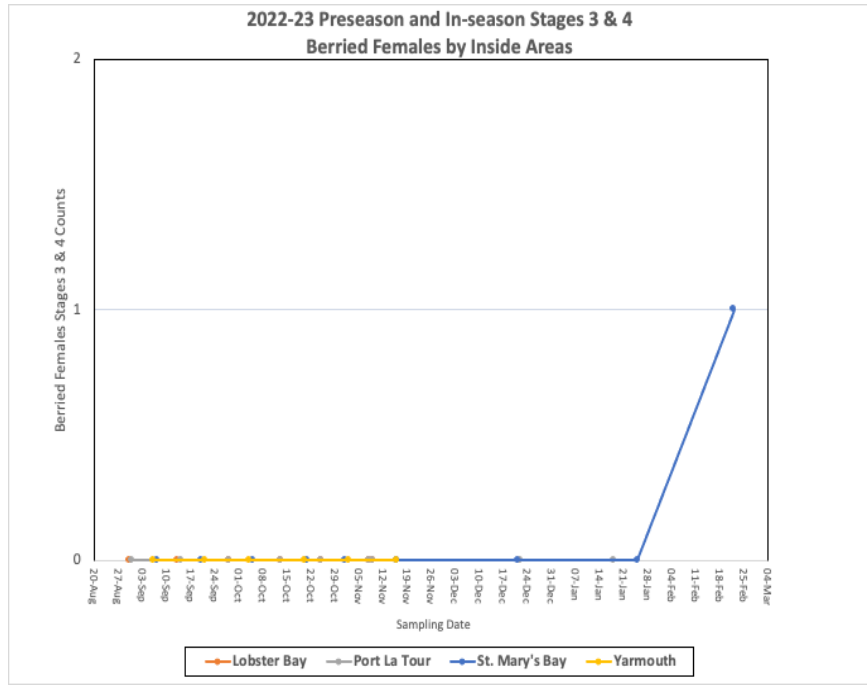
(a)………..(b)

(c)……..…(d)

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) 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 2022) released on November 26, 2022 prior to the beginning of the 2022-2023 commercial lobster season in LFA 33 and 34.

The following table summarizes the predictions by sampling location as provided in text below. Highlighted text in the pages below indicates the start of season 2022-23 Quality Prediction for each location.

Sampling Location	Area	2022-23 Overall Quality Prediction/ Likelihood	Comparable Preseason Year(s) to 2022	Remarks on 2022 Preseason Sampling
Yarmouth	1. Inside	MODERATE-LOW (ML) (70%)	2015, 2019	ML class includes all low quality regime years, 2014-2021
	2. Outside	MODERATE-LOW (ML) (66%)	2014, 2015	ML class includes all low quality regime years with higher BRIX
Lobster Bay	3. Inside	MODERATE-LOW (ML)/LOW (L) (60%)	2013, 2021	November samples rebound to improve to MH, higher BRIX
	4. Outside	MODERATE-LOW (ML) (56%)	2012, 2019	November samples improve to M, higher BRIX
Port La Tour	5. Inside	MODERATE-LOW (ML)	2018, 2019	Improving BRIX from L to MH over sampling period
	6. Outside	MODERATE-LOW (ML)	2016, 2021	ML class includes all low quality regime years, 2014-2021
St. Mary's Bay	7. Inside	MODERATE-HIGH (MH)	2020, 2021	Improvement in BRIX over sampling period to H
	8. Outside	MODERATE (M)/ MODERATE-LOW (ML) (90%)	2017, 2021	Near constant M BRIX levels over sampling period

Summary : YARMOUTH INSIDE –

1) After a small decline in mid-October, 2022 samples exhibit relatively constant BRIX behaviour over the preseason sampling period at "Good" quality levels (BRIX of 10); the November 9, 2022 sample is most comparable to October 28, 2013 preseason sample 3-4 weeks before the start of the commercial season

2) ==*Lobster quality category for 2022 samples is classified as "Moderate-Low" (ML) with estimated 70% likelihood of occurrence*==

3) Past years with ML classification include 2014, 2015, 2017, 2019, 2020 and 2021 – all years at the post-2013 lower quality regime

Summary : YARMOUTH OUTSIDE –

1) 2022 samples exhibit relatively constant BRIX (9) over the preseason sampling period, after a slight decline in mid-October (to 8.32), at relatively good quality levels, most comparable to the good quality years of 2012 and 2013 preseason samples 3-4 weeks before the start of the commercial season

2) ==*Lobster quality category for samples classified as ML has highest estimated likelihood of 66%*==

3) Past representative years with ML classification include 2014, 2015, 2017, and 2018– years of the post-2013 lower quality regime

Summary : LOBSTER BAY INSIDE–

1) 2022 samples exhibit stable BRIX behaviour from the early sample periods to the end of the preseason sample period when poor BRIX lobsters also appear

2) 2022 samples are most comparable to the 2013 or 2021 preseason samples 3-4 weeks before the start of the commercial season

3) Lobster quality category for 2022 samples is classified as "Moderate" (M) with estimated likelihood of only 34% and comparable to 2014 and 2019 to 2021; likelihood that data comes from a "Moderate-Low" (ML) quality population is 23%

Summary : LOBSTER BAY OUTSIDE–

1) 2022 samples demonstrate average "Good" BRIX values (≥8) that decrease until mid-October and then increase to the end of the sampling period

2) 2022 preseason samples 3-4 weeks before the start of the commercial season continue the improving trend from low BRIX results to higher BRIX since the lower results of the 2016 preseason sample

3) Overall Lobster Quality classification for the 2022 samples average to ML with likelihood of ML estimated as 56%

Summary : PORT LA TOUR INSIDE–

1) 2022 samples exhibit a dip in average BRIX in mid-October and variable but improving BRIX behaviour over the 7 preseason sampling dates from low and moderate-low quality to moderate-high BRIX levels by the end of the survey period

2) 2022 preseason sample 3-4 weeks before the start of the commercial season on October 25 has mean BRIX value (9.6) among the highest in the time series

3) Overall Lobster Quality classification for the 2022 samples average to ML; however, maximum likelihood is estimated at 56% for ML or lower (L) despite high average BRIX values at 10

Summary : PORT LA TOUR OUTSIDE–

1) 2022 samples exhibit declining average BRIX behaviour over the 6 preseason sampling dates from average BRIX levels of 9 to 7.3 by the end of the sampling period including a notable dip in the mid-October survey

2) November 7, 2022 preseason sample 3-4 weeks before the start of the commercial season is comparable to the BRIX distribution in 2016

3) Overall Lobster Quality classification for the 2022 samples average ML; estimated likelihood that Port La Tour Outside Lobster Quality category is ML or L is estimated as 77%

Summary : ST. MARY'S BAY INSIDE–

1) 2022 samples exhibit an initial decline to early-October and thereafter a gradual improvement in moderately high BRIX levels from 8.9 moving to a high average BRIX of 10.5 by the end of the sample period

2) November 1, 2022 preseason sample 3-4 weeks before the start of the commercial season continue the trend of higher mean BRIX levels since 2018

3) Overall Lobster Quality classification for the 2022 samples approaches MH levels with likelihood of over 75% for classifications MH, M, or ML combined

Summary : ST. MARY'S BAY OUTSIDE–

1) 2022 samples exhibit an initial decline in average BRIX to mid-October (from 10.11 to 8.13) followed by a small increase to 9.1 by the end of the sampling period

2) 2022 preseason sample of November 2, 3-4 weeks before the start of the commercial season, is comparable in BRIX categories to 2017 and 2021 samples but with higher average BRIX value (9.5)

3) Overall Lobster Quality classification for the 2021 samples is at the "Moderate" (M) quality level directly comparable to the 2020 and 2021 categories

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