
Lobster Quality 2021-2022

Preseason & In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

Final Report

March 2022

Submitted by:

Coldwater Lobster Association

368 Main Street, Suite 105 Lovitt Plaza

Yarmouth, Nova Scotia, B5A 1E9

Tel: (902) 742-5247

www.coldwaterlobster.ca

Karl Mattock

Technician

Centre de recherche et d'innovation sur la qualité du homard (CRIQH)/

Lobster Quality research & Innovation Centre (LQRIC)

Université Sainte-Anne, Centre de recherche marine

Campus de Petit-de-Grat

3433 Route 206

Petit-de-Grat, Nova Scotia, B0E 2L0

Tel: (902) 295-8054

Daniel E. Lane

Interim Director – [CRIQH/LQRIC](#)

TABLE OF CONTENTS

1. Background.....	5
2. Sampling Survey Information and Summary Results in 2021-2022	9
2.1 Sampling Protocols	12
2.2 Sampling Sites and Schedule.....	12
2.3 2021-2022 Report on Conditions and Collections.....	13
2.4 Lobster Quality Category Classification	14
3. Preseason Sampling Data in 2021-2022.....	17
3.1 Lobster Counts Sampling for 2021-2022.....	17
3.2 Berried Females Sampling for 2021-2022	23
3.3. Temperature Data.....	26
3.4 Sites Summary Report.....	26
3.5 Recent Data Variability and Trend	27
4 Analysis of Preseason and In-season Sampling Data in 2021-2022	28
4.1 Blood Protein (BRIX) Distribution: Methodology	28
4.2 Consolidated Data Analysis: Lobster Quality Categories	29
4.3 Site Results and Predictions	29
5 In-season Sampling Data in 2021-2022	46
5.1 Sampling Data	46
5.2 Preseason and In-season Comparison	47
6 Discussion	53
6.1 Annual Lobster Quality and Landings Comparison	53
6.2 Decision Opportunities.....	53
6.3 2022 Preseason Sampling Survey Outlook.....	54
7 References	55
8 Acknowledgements	57

Table of Figures

Figure 1: Banded lobsters in a dry tote.....	5
Figure 2: Survey sampling tools.....	6
Figure 3. View of lobster pleopod under microscope.....	8
Figure 4: Drawing blood for refractometer for BRIX.....	9
Figure 5. Google map of 2021-2022 At-sea survey area and related information.....	13
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 between light and dark range; vertical lines indicate annual consolidated BRIX values outside interquartile range.	15
.....	18
Figure 7. (a) 2021 Preseason Yarmouth Harvest Counts by Sex per Trap for Sample Dates; (b) 2020-2021 Preseason and In-season Yarmouth Harvest Counts by Sex per Trap for Sample Dates.....	18
Figure 8. (a) 2021 Preseason Lobster Bay Harvested Counts per Trap and BRIX Indicators; (b) 2020 Preseason Lobster Bay Harvested Counts per Trap and BRIX Indicators.....	19
.....	20
Figure 9. (a) 2021-2022 Preseason and In-season Port La Tour (Outside) Moulting Stage Counts and Average BRIX by Stage Categories; (b) 2020 Preseason Port La Tour (Outside) Moulting Stage Counts and Average BRIX by Stage Categories	20
Figure 10. 2021-2022 Preseason and In-season St. Mary's Bay (Inside and Outside) Hardness Counts per Trap and Average BRIX by Category	21
Figure 11. (a) 2021 Preseason Outside Areas Harvested Counts per Trap by Sample Date; (b) 2020-2021 Preseason and In-season Outside Areas Harvested Counts per Trap by Sample Date.....	22
Figure 12. Outside Areas Average BRIX by Sample Date.....	23
Figure 13. 2021-2022 Preseason and In-season St. Mary's Bay Berried Females Stages.....	24
and as Percent of Harvested Females.....	24
Figure 14. 2021 Preseason Outside Areas Berried Females Stage 1 Counts	25
Figure 15. Example: Yarmouth Outside BRIX Categories	28
for 3-4 weeks prior to season start 2012-2018	28
Figure 16. Yarmouth Inside 2021 Preseason Sampling BRIX Indicators	30
Figure 17. Yarmouth Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	30
Figure 18. Yarmouth Inside Lobster Quality Categories for 2021 Preseason Sampling Dates	31
Figure 19. Yarmouth Outside 2021 Preseason Sampling BRIX Indicators	32
Figure 20. Yarmouth Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	32
Figure 21. Yarmouth Outside Lobster Quality Categories for 2021 Preseason Sampling Dates	33
Figure 22. Lobster Bay Inside 2021 Preseason Sampling BRIX Indicators.....	34
Figure 23. Lobster Bay Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	34
Figure 24. Lobster Bay Inside Lobster Quality Categories for 2021 Preseason Sampling Dates	35
Figure 25. Lobster Bay Outside 2021 Preseason Sampling BRIX Indicators.....	36
Figure 26. Lobster Bay Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	36
Figure 27. Lobster Bay Outside Lobster Quality Categories for 2021 Preseason Sampling Dates.....	37
Figure 28. Port La Tour Inside 2021 Preseason Sampling BRIX Indicators.....	38
Figure 29. Port La Tour Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	38
Figure 30. Port La Tour Inside Lobster Quality Categories for 2021 Preseason Sampling Dates.....	39
Figure 31. Port La Tour Outside 2021 Preseason Sampling BRIX Indicators	40
Figure 32. Port La Tour Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start.....	40
Figure 33. Port La Tour Outside Lobster Quality Categories for 2021 Preseason Sampling Dates.....	41
Figure 34. St. Mary's Bay Inside 2021 Preseason Sampling BRIX Indicators.....	42
Figure 35. St. Mary's Bay Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	42
Figure 36. St. Mary's Bay Inside Lobster Quality Categories for 2021 Preseason Sampling Dates.....	43
Figure 37. St. Mary's Bay Outside 2021 Preseason Sampling BRIX Indicators.....	44
Figure 38. St. Mary's Bay Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start	44
Figure 38. St. Mary's Bay Outside Lobster Quality Categories for 2021 Preseason Sampling Dates.....	45
Figure 32. Yarmouth Inside Preseason and In-season Sampling BRIX Indicators	47
Figure 33. Yarmouth Outside Preseason and In-season Sampling BRIX Indicators.....	48
Figure 34. St. Mary's Bay Inside Preseason and In-season Sampling BRIX Indicators.....	49
Figure 35. St. Mary's Bay Outside Preseason and In-season Sampling BRIX Indicators.....	50
Figure 36. Port La Tour Inside Preseason and In-season Sampling BRIX Indicators.....	51
Figure 37. Port La Tour Outside Preseason and In-season Sampling BRIX Indicators	52

Table of Tables

Table 1. Lobster Sampling Data Description.....6
Table 2. Lobster Quality Determinants.....7
**Table 3. 2021 Preseason and 2021-2022 In-season Sampling Survey Information
Summary.....10-11**
Table 4. Lobster Quality Category Descriptions15
Table 5. 2006-2020 Historical Lobster Quality Category Assignments.....41
Table 6. Summary of 2021-22 In-season Sampling Data.....46

Appendices

A. Harvested and Sampled Lobster Count Location Graphics.....A.1
B. Berried Females Graphics.....A.8
C. Preseason Sampling Summary Report Predictions.....A.13

Lobster Quality Report 2021-2022

Preseason and In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

1. Background

The 2021-2022 Lobster Quality Preseason Sampling Program continues the long-standing Atlantic Lobster Moulting 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 2022, it represents the largest continuous database of lobster sampling globally with 16 years of uninterrupted sampling. While the lobster industry in Nova Scotia faces many challenges, the quality of the lobsters during the start of the lobster fishing season in Southwest Nova Scotia (LFAs 33 & 34) remains one of the most significant issues.



Figure 1: Banded lobsters in a dry tote.

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, Berry et al 2016). Since 2019, exports of live product to China exceeded that to the US (Fisheries and Oceans Canada 2021). Results of past ALMQ research has shown that lobster quality at harvest is directly related to the timing of lobsters' moulting processes. These processes are affected by a number of different factors including water temperature, available lobster diet, and other ecosystem factors. Understanding the incidences of those factors that control the proportion of soft-shelled lobsters and the annual variation in lobster quality is vital to the sustainability, health, and viability of the live lobster industry in Nova Scotia.

In 2017, the Province of Nova Scotia announced the formation of the Nova Scotia seafood brand 'to bring the highest quality lobster to market' (Nova Scotia 2017a). The announcement of the Nova Scotia Brand was launched together with: (i) a live lobster quality certification initiative with China to 'set a premium quality standard for exported Nova Scotia lobster' (Nova Scotia 2017b); and (ii) the creation of [Université Sainte-Anne's Lobster Quality Research and Innovation Centre](#) (LQRIC, Nova Scotia 2020). Through the initiatives of the [Université Sainte-Anne's Live Lobster Quality Certification Programme](#), the Province of Nova Scotia recently reported that seven lobster companies have now received certification under the Nova Scotia Seafood Quality Program (Nova Scotia 2022). It is incumbent on the Nova Scotia lobster industry to develop appropriate measurable means of grading lobsters for international markets to ensure the requirements of highest quality of the Nova Scotia brand, and to impact positively the live lobster value proposition amid declines in harvest quality. LQRIC has been established to aid in the research and development of lobster product quality through ongoing sampling and analysis of results.

The purpose of this annual report is to evaluate observed lobster quality preseason samples, together with selected in-season sampling, in order to report on lobster quality status for the 2021-2022 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 2021 preseason at-sea sampling conducted by the [Coldwater Lobster Association](#) (Coldwater Lobster Association 2022) 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 took place from August 25 to November 18, 2021. The report also presents selected in-season sampling carried out in 4 LFA34 locations ('inside' and 'outside' areas of St. Mary's Bay and Yarmouth) in December 2021 and January 2022. This sampling represents a continuation of the longstanding Atlantic Lobster Moulting and Quality Project (ALMQ) longitudinal database that has taken place annually since 2006 – the largest known database of lobster stock status, globally.

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:

Table 1. Lobster Sampling Data Description

No.	Individual Lobster Sampling Data Item
1	Depth of string (F, fathoms)
2	Counts of legal and sub-legal lobster captured (only legal lobsters were used in subsequent 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 Moulting stage ('0' – no activity; '1' to '5') – from selected lobster's pleopod removal and post-at-sea sample examination under a microscope (Factor 1995, Figure 3 below)
8	Damage (coded descriptions for visual impacts, e.g., culls, shell disease)
9	Lobster vitality status observed ("weak" / "not weak").



Figure 2: Survey sampling tools.

Data analyses were carried out with the cooperation of the Centre de recherche marine/Marine Research Centre of the Université Sainte-Anne, Petit de Grat Campus and the LQRIC team. These data are designed collectively to proxy lobster quality – live lobster meat content and suitability for storage and

shipping – and are provided in the 2021 preseason summary (Mattock, Mulock, and Lane 2021) 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 2021 preseason and 2021-2022 in-season sampling compared to past years' samples from the same preseason and in-season times and sampling locations over the period 2012-202. This information enables the industry to compare the 2021-2022 sample results to known past years of observed preseason and subsequent in-season lobster quality and status.

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 the analysis enabled the numerical description of each category, and subsequently, the assignment of each of the 2021 sample dates into its most probable Lobster Quality category.

In 2021, 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.

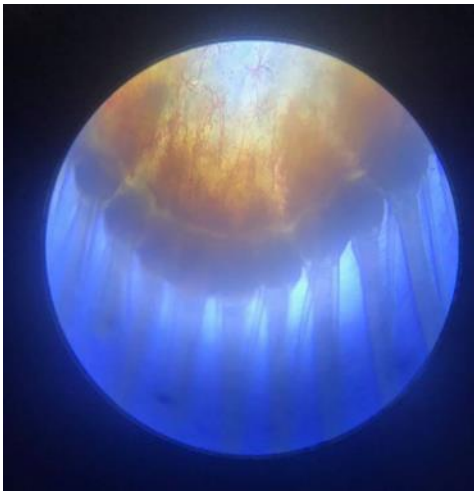
Table 2. Lobster Quality Determinants

Quality:	"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

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 2021-2022, shell hardness measures are poorly correlated with continuously measured BRIX levels and correlations (BRIX versus Hardness) are mostly not significantly different from zero for all sample location-dates. Shell hardness measures cannot be the lone determining factor in lobster quality prediction.

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. 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 lone determining factors in assessing lobster quality but are used as supplemental information overall.



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).

Figure 3. View of lobster pleopod under microscope.

2. Sampling Survey Information and Summary Results in 2021-2022

The objective of the ALMQ project was to develop a monitoring program, based on biological indicators of moult-timing, lobster quality measures, and environmental conditions, in order to predict the quality of lobsters at the start of the lobster commercial fishing season in LFAs 33 and 34. This program requires a combination of continuous at-sea quality monitoring (preseason as well as in-season confirmation of results) as well as the development of a prediction model incorporating historical data records for in-season quality. In addition, and consistent with the processes affecting lobster quality, the program would also benefit from a long-term data series for bottom seawater temperature. The following paragraphs describe the information obtained from the 2021 preseason survey and the 2022 in-season survey.



Figure 4: Drawing blood for refractometer for BRIX

In 2021, a total of 8,389 preseason lobster samples were taken over the 4-month period from August 25 to November 18, a period of approximately 12 weeks. For the in-season survey of December 2021 and January 2022, a total of 1,350 lobster samples were taken in 9 in-season trips over 5 dates for 6 of the 8 sample location-areas, not including Lobster Bay Inside or Outside.

Over the survey, minimal by-catch appeared in the traps, especially as the lobster counts increased (in most locations) toward the latter part of the preseason survey from October through November. In general terms, over all location-areas sampled, it is noted that BRIX levels observed at the beginning of the survey in August deemed to be 'average', generally dropped off as more berried females, soft shell, and "weak" lobsters started appearing more often in the traps (through October). 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 locations averaged 17.55 Fathoms in depth; outside areas over all 4 locations averaged 43.35 Fathoms in depth.

Preseason sampling resulted in total catches of 23,715 lobsters for an average of 12.42 lobsters per trap over the 51 preseason dates (in increase of 33% over the 2020 preseason catch of lobster per trap of 9.31). The average for individual lobsters of the BRIX index was 8.4 units/ml for the 51 preseason sample location-dates. While the BRIX index for the 9 in-season sample location-dates (December 2021-January 2022) was 11.72 units/ml or 40% higher on average than the preseason average of 8.4 units/ml.

Overall, preseason and in-season samples combined, there were 1.80% "Soft" and 10.66% "Weak" lobsters observed. This represents a 50% increase in "Soft" and "Weaks" compared to the 2020-2021 report. These data are summarized below in Table 3 - 2021 Preseason and 2022 In-season Sampling Survey Information Summary.

Table 3. 2021 Preseason and 2021-2022 In-season Sampling Survey Information Summary

Sampling Location	Sampling Subarea	Sampling Date	Harvested Lobsters (Counts#)	Lobsters Sampled (#)	Sample Ave BRIX (units/ml)	Sample % Soft	Sample % Weak
Lobster Bay LFA 34	Inside	August 29, 2021	421	150	8.6	2.00%	3.33%
		September 8, 2021	704	150	8.6	1.33%	6.67%
		September 23, 2021	849	150	8.9	5.33%	19.33%
		October 6, 2021	754	150	8.0	10.67%	16.67%
		November 4, 2021	633	150	9.6	4.00%	31.33%
		November 18, 2021	461	150	9.5	4.00%	33.33%
	Outside	September 7, 2021	433	150	8.1	0.67%	6.00%
		September 22, 2021	425	150	7.9	1.33%	7.33%
		October 5, 2021	558	150	7.5	2.67%	34.00%
		November 3, 2021	818	150	8.3	2.67%	25.33%
Port La Tour LFA 33	Inside	August 26, 2021	226	130	7.9	3.08%	3.85%
		September 9, 2021	140	96	6.7	2.08%	2.08%
		September 22, 2021	520	150	7.2	2.00%	6.00%
		October 7, 2021	566	150	6.9	2.67%	6.00%
		October 20, 2021	595	150	7.8	2.67%	13.33%
		November 3, 2021	527	150	9.6	2.67%	9.33%
		November 16, 2021	387	150	10.8	0.00%	6.67%
		November 18, 2021	489	150	9.9	2.67%	13.33%
		December 30, 2021*	—#	150	13.0	0.67%	0.00%
	Outside	August 25, 2021	7	7	9.5	0.00%	0.00%
		September 8, 2021	3	2	6.5	0.00%	0.00%
		September 21, 2021	59	49	6.0	0.00%	0.00%
		October 5, 2021	70	47	7.0	0.00%	10.64%
		October 19, 2021	270	150	6.8	6.67%	14.67%
		November 2, 2021	672	150	7.7	4.67%	20.00%
		November 17, 2021	544	150	7.8	2.00%	25.33%
December 15, 2021*	—#	150	11.2	0.00%	0.00%		
December 30, 2021*	—#	150	11.5	0.00%	0.67%		
St. Mary's Bay LFA 34	Inside	August 31, 2021	269	150	8.6	0.67%	2.00%
		September 14, 2021	397	150	8.5	1.33%	9.33%
		September 28, 2021	373	150	8.7	0.67%	3.33%
		October 13, 2021	359	150	9.3	0.67%	4.67%
		October 26, 2021	348	150	9.5	0.00%	10.00%
		November 9, 2021	368	150	9.9	0.67%	7.33%
		November 10, 2021	315	150	10.0	0.00%	6.67%

St. Mary's Bay LFA 34	Outside	January 13, 2022*	—#	150	12.0	0.67%	4.00%
		August 30, 2021	120	108	8.6	0.00%	0.93%
		September 13, 2021	226	150	8.4	0.00%	2.67%
		September 27, 2021	554	150	8.5	0.00%	10.67%
		October 12, 2021	707	150	8.3	2.00%	4.67%
		October 25, 2021	865	150	8.4	1.33%	22.00%
		November 8, 2021	775	150	8.4	1.33%	16.00%
		January 13, 2022*	—#	150	11.3	0.00%	2.00%
Yarmouth LFA 34	Inside	September 1, 2021	451	150	8.3	0.00%	4.00%
		September 15, 2021	412	150	8.3	0.67%	10.00%
		September 29, 2021	340	150	8.7	2.00%	3.33%
		October 14, 2021	347	150	9.3	3.33%	8.00%
		October 26, 2021	497	150	8.3	2.00%	18.00%
		November 9, 2021	478	150	8.6	0.67%	14.67%
		November 10, 2021	525	150	8.2	1.33%	12.00%
		December 28, 2021*	—#	150	11.6	1.33%	1.33%
		January 24, 2022*	—#	150	12.2	0.00%	1.33%
	Outside	August 31, 2021	286	150	8.0	0.67%	2.67%
		September 14, 2021	343	150	7.9	1.33%	10.00%
		September 28, 2021	490	150	7.9	0.00%	28.00%
		October 13, 2021	791	150	7.4	8.67%	15.33%
		October 25, 2021	1073	150	8.1	2.67%	26.67%
		November 8, 2021	875	150	8.0	1.33%	27.33%
December 28, 2021*	—#	150	10.7	0.00%	0.67%		
January 24, 2022*	—#	150	12.0	0.00%	0.00%		
TOTALS	8 Subareas	60 Total Sample dates incld 9 In-season dates	23,715 lobsters landed preseason	8,239 samples 1,350 In-season	Overall Ave BRIX: 8.91 units/ml; 11.72 In-season	1.80% Overall Soft	10.66% Overall Weak

*Denotes In-season samples (shaded) for selected sampling locations: Yarmouth (4), St. Mary's Bay (2), and Port La Tour (3).

#No harvest counts of lobster taken for harvests during in-season sampling periods (shaded).

Berried (egg-bearing) females were examined again in the 2021 preseason survey. Each of the 51 location-date preseason combinations captured an average of just under 5 berried females or approximately 1.88% (163) of all female lobsters captured (8,655) during the same preseason sampling dates. Berried female analyses recorded carapace size, clutch fullness, egg stage and condition. Analyses of berried females data are provided in further detail in Section 3.2 below.

2.1 Sampling Protocols

During the 2021-2022 lobster sampling program, the following project outcomes were achieved:

- At-sea quality monitoring – successful observations over 8 locations within LFA33 and LFA34 over 60 sampling dates from August 2021 to January 2022;
- Development of pre-season prediction report for industry – as reported in Mattock, Mulock, and Lane (2021) summary report released on November 24, 2021; see also: https://www.coldwaterlobster.ca/wp-content/uploads/2021/11/LQ_2021-Preseason-Summary-Report-FINAL.pdf
- In-season quality sampling – successful completion of 9 sampling location-dates in December 2021 and January 2022;
- Temperature data collection (pre-season and in season) – incomplete: no temperature data were analysed in the 2021-2022 sampling program;
- Lobster tagging program – not initiated in the 2021-2022 sampling program;
- Base line data on berried females – successful data collection across 51 preseason sampling location-dates; and
- Base line data on catch, including counts of sub-legal & legal male and female lobsters – successful observations of 8 locations and 51 preseason sampling dates.

2.2 Sampling Sites and Schedule

At-sea lobster surveys were conducted in several areas within LFA 33 and 34 to monitor the biological condition of lobster. The data collected during the sampling surveys provided a ‘snapshot’ indication of overall lobster moult through the lobster moult stag data, and the observed condition of the lobster (‘soft’– ‘hard’, or “weak”/ “not weak”) as the season approached.

In LFA 34, sampling was conducted in six areas as indicated in Figure 5 below. These areas are designated as:

- 1) Lobster Bay (Jacquards Ridge) Inside/Outside;
- 2) Yarmouth Inside/Outside; and
- 3) St. Mary’s Bay Inside/Outside.

In LFA 33, sampling was conducted in 2 areas:

- 4) Port La Tour Inside/Outside.

The 2021-2022 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 information about the precise location of the sample harvests (latitude and longitude), as well as time of haul statistics for: (i) sea state (in meters); (ii) surface temperature, F (where available); and (iii) weather description. Additional data includes total lobster harvest count at site, the number of trap hauls, lobster counts per trap, average BRIX in site sample, and the number of “weaks” in site sample. This information is available through Google maps at the following public link:

<https://www.google.com/maps/d/edit?mid=14NsroLb5FWDSst9HQEn7h2J4zodkv7iAD&usp=sharing>

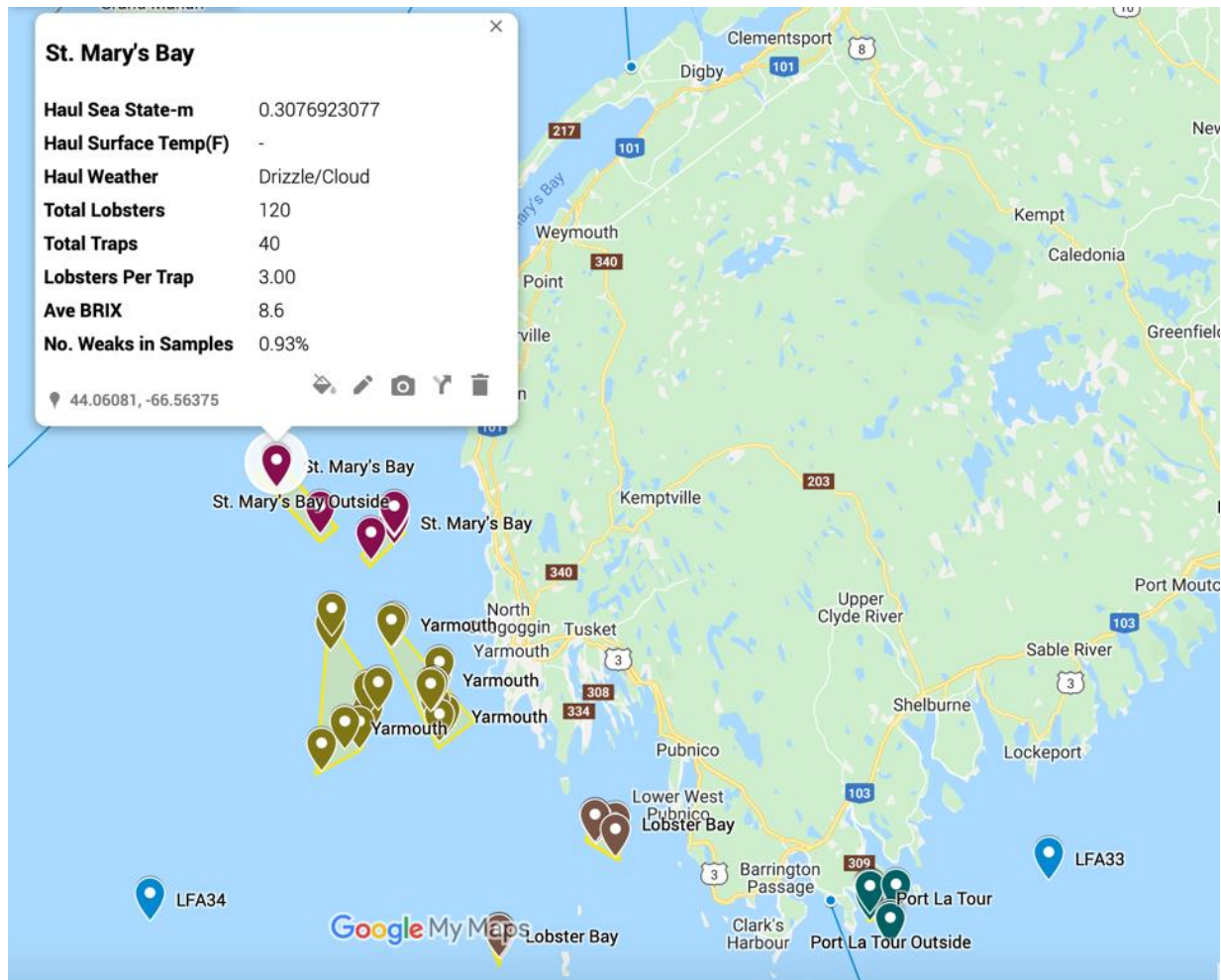


Figure 5. Google map of 2021-2022 At-sea survey area and related information.

2.3 2021-2022 Report on Conditions and Collections

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

In 2021, preseason lobster samples were taken over the approximately 12-week period from August 25 to November 18. Weather conditions over the 51 preseason trips completed in 2021 were generally quite favourable with light winds and calm seas.

Approximately six times during the survey, weather conditions presented challenges when traps were initially deployed resulting in fewer lobsters for the overall count on the first haul. However, in only 7 of the 51 trips were there fewer than 150 samples achieved as sought (see also Table 3 above). Survey vessel captains spoke of how the weather was much more conducive for data collection this year (2021-2022) as opposed to the 2020-2021 sampling period including, warmer sea temperature and air temperature.

On Monday, November 29, 2021, the start of the LFA 33 and 34 commercial lobster fishing seasons began on time, as scheduled. (Unlike last year, when the 2020 season opening – originally scheduled for Monday, November 30, 2020 – was delayed for eight days until Tuesday, December 8, 2020 (Dumping Day) due to unfavorable weather conditions.) Pre-season weather conditions for the 2021/2022 sampling period were in most part near perfect up until the official opening of the season when weather conditions deteriorated, described by strong currents, high winds and stormy seas reduced the fishable days by half. Available days for pre-organised sampling became very fickle as captains were unsure when they would be able to harvest their lobsters in traps therefore also reducing the number of opportunities for sampling in the months of December and January.

It continues to be recommended that vessels be chosen for the preseason survey that do not involve captains who may be interested in participating in other fisheries during the preseason sampling period. In 2021-2022, captains have been strongly committed to the preseason lobster sampling survey which greatly simplifies the sampling schedule. As well, having additional vessels on standby if the event that the participating captain cannot deploy at their scheduled times is helpful to ensure that all required sampling dates are met.

Preseason sampling provides a snapshot of lobster quality in selected locations of LFA 33 and LFA 34. Sampling is conducted from depths ranging from 6 fathoms (Port La Tour Inside) to 80 fathoms (St. Mary's Bay Outside). Therefore, it does not provide an indication on the quality of lobsters caught outside the selected areas of outside the noted depth range. During the commercial lobster season in LFAs33 and 34 there is a significant percentage of vessels fishing in depths greater than 80 fathoms. It is desirable for future survey sampling to consider the impact of fishing lobster at depth however, current project operating costs and vessel steam times do not make this possible.

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 sampled lobsters by the protocol. 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 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 BRIX values into 2 notable groups: (1) 2006-2013; and (2) 2014-2020. The first group represents a relatively higher and consistent BRIX regime. The second group illustrates an apparent shift in lobster BRIX values to a consistently lower BRIX regime. This time shift phenomenon occurs in each of the 8 lobster sampling locations and is expected to be the product of an environmental/ecosystem shift that persists. With this in mind, a subjective assignment of each year's consolidated annual BRIX values were assigned into one of the 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.

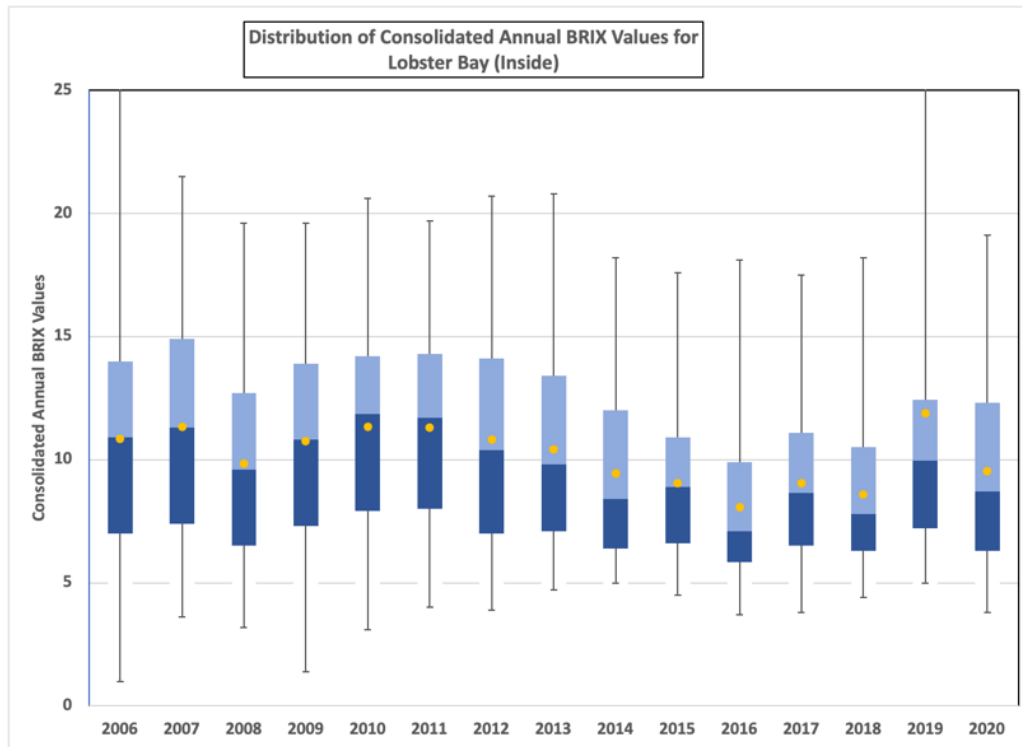


Figure 6. Box-and-Whisker plot of Consolidated Annual BRIX values for Lobster Bay (Inside). Annual mean BRIX values are denoted by yellow dots; rectangles are interquartile ranges; annual median BRIX are lines between light and dark range; vertical lines indicate annual consolidated BRIX values outside 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 sample dates into its most probable lobster quality category.

The comparison of the 2021 preseason sample results by location to past preseason sampling years suggests that the corresponding commercial season years are likewise comparable. For example, if 2020 preseason sample results for Lobster Bay Inside compare favorably to past preseason survey years of Low (L) Lobster Quality for Lobster Bay Inside (historically estimated from the data to have occurred in 2016 and 2018—see also Table 5 below), then the 2020 preseason can be considered to predict that the 2020-2021 commercial season is comparable to the commercial seasons of 2016-2017 or 2018-2019. Lobster Quality Category assignment for the 2020 sample dates are accompanied by likelihood values that the sample data indeed belong to the selected Lobster Quality Category.

The 2021 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 Table 5 of assigned Lobster Quality categories for each location over the database (2006-2020) that contains nearly 800 location-date samples of, typically, 150 sampled lobster at each sample site.

Table 5. 2006-2020 Historical Lobster Quality Category Assignments

Locations:	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 Annual Sample 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	12
2020	ML	L	M	ML	ML	ML	ML	M	56
Total Sample Dates	131	130	158	117	138	40	46	33	793

- Denotes samples not taken in this location during the relevant year.

Table 5 values indicate the annual time series of assigned Lobster Quality Category for each location and each lobster sample date from 2006 to 2020. The relative decline over time of lobster quality across all locations in LFAs 33&34 over the full period 2006 to 2020 is evident. In particular, the designated lobster quality categories exhibit a noticeable shift after 2013 to a regime of lower relative lobster quality from the higher categories (moderate (M) or higher (MH, H)) throughout the period from 2006 to 2013. Since 2014, however, assigned Lobster Quality Categories across the locations are nearly all designated as moderate (M) levels or below (ML, and L). Although it is difficult to identify trends in these consolidated data, 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 2020. These data provide the backdrop for the predictions of lobster quality categories for the 51 preseason sample dates by location in the 2021 preseason period.

Finally, it is noted that this analysis assigns each of the 51 sample dates in 2021 by location to one of the designated Lobster Quality Categories (H, MH, M, ML, or L). A detailed description of the statistical analyses of the consolidated annual data by location is provided in the LQRIC Working Paper (in progress) (Lane et al 2022).

3. Preseason Sampling Data in 2021-2022

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

Alternatively, the existence of the longitudinal database from the 2006 season onward permits direct comparison of pre-season and corresponding in-season samples over multiple years. Knowing the precise history of quality results in the commercial fishery over past years enables comparison of current results to actual quality of the past, e.g., 2011-12 was a high quality season whereas 2015-16 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. 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 commercial fishery.

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

3.1 Lobster Counts Sampling for 2021-2022

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 24, 2021 (Mattock, Mulock, and Lane 2021a). This report contains summary information on the lobster counts harvested and sampled during the 2021 preseason sampling program. Specifics on the 2021-2022 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 2021-2022 sampling, with comparison to the previous year's 2020-2021 sampling.

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 Moulting Stage - Outside area
- 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. As noted by the example of Yarmouth (inside and outside areas) in Figure 7 below, 2021 CPUT measures for inside areas are flat or declining over the course of the preseason sampling dates (Figure 6a and b) and continue to fall during the commercial season (2020-21, Figure 6b). 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.

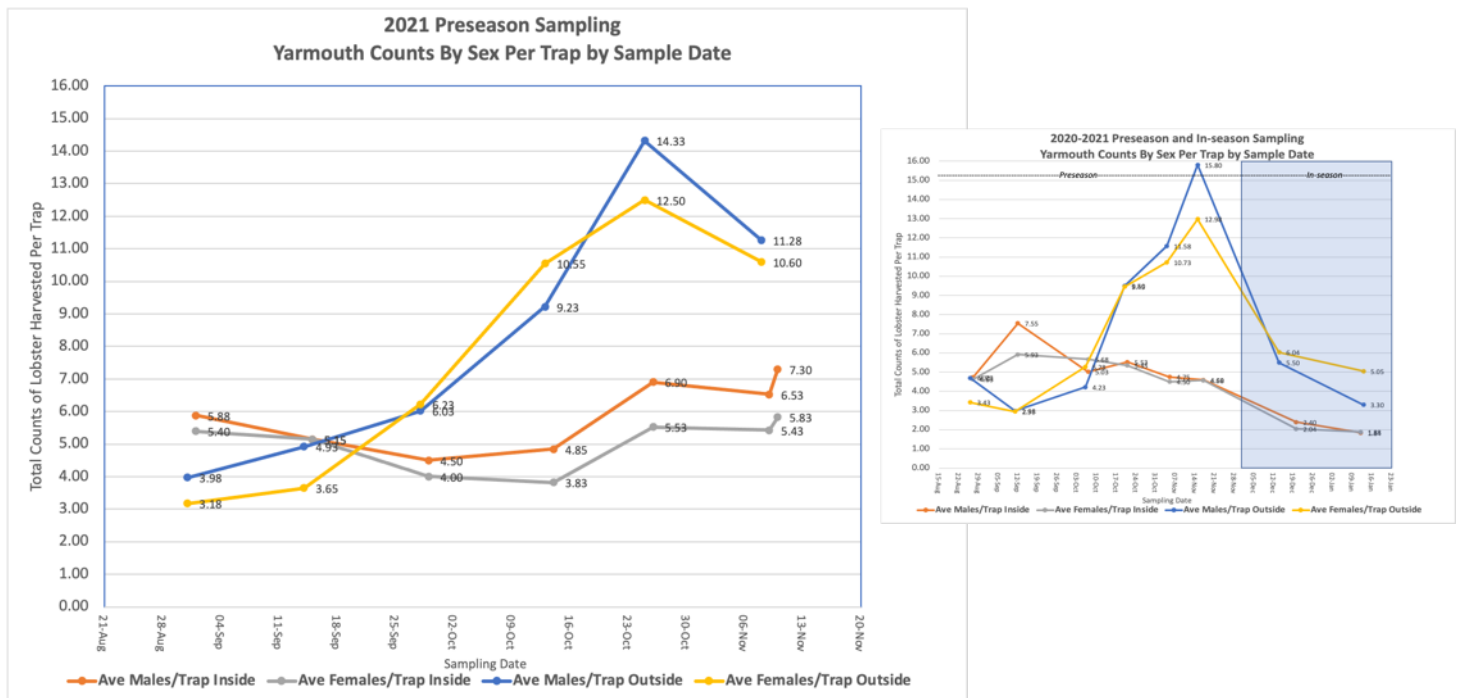


Figure 7. (a) 2021 Preseason Yarmouth Harvest Counts by Sex per Trap for Sample Dates; (b) 2020-2021 Preseason and In-season Yarmouth Harvest Counts by Sex per Trap for Sample Dates

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

Preseason BRIX levels changed over the course of 2021 preseason sampling in all areas. Figure 7 below indicates the BRIX category levels for Lobster Bay. These values indicate initially flat BRIX values in both inside and outside areas from the early preseason sampling dates (August through September) followed by general improvement in BRIX over the period from October through November, especially in the outside subareas. In 2021, inside area BRIX averages were marginally higher than outside areas early in the sampling period. This reversed later in the period of the year – as for Lobster Bay in Figure 8 below – when average BRIX values in the inside areas fell and outside areas’ BRIX rose. This behaviour is similar to what was observed in the 2020 sampling (Figure 8b). (See also Appendix A, pp.A.2 through A.5.)

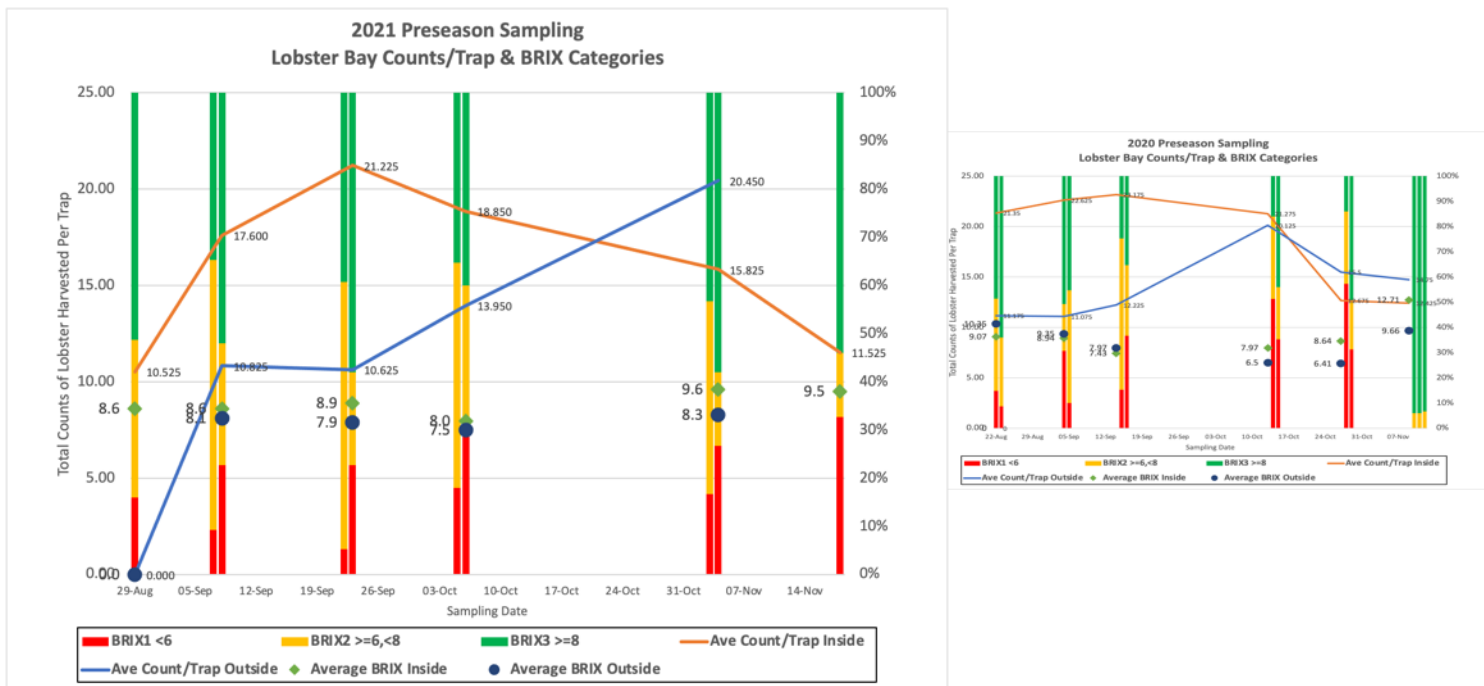


Figure 8. (a) 2021 Preseason Lobster Bay Harvested Counts per Trap and BRIX Indicators; (b) 2020 Preseason Lobster Bay Harvested Counts per Trap and BRIX Indicators

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

The 2021 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 9 below shows the moult stage counts data by stage for Port La Tour outside area preseason sampling. As in 2020 (Figure 8b), early sampling efforts in Port La Tour (Outside) were unable to record significant lobsters (30) in the outside areas fished (Figure 9a). Consequently, pleopod samples were small and resulted in few samples. By mid-October, more lobsters were appearing in the Port La Tour

outside areas resulting in the full complement of 30 vials of pleopods. As for all areas and samples, Figure 9 illustrates that the 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. Stage 3+ observations were limited to approximately 1 observation over the 8 sample dates.

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. These results are comparable to the 2020 preseason sampling (Figure 9b). (See also Appendix A, pp.A.2 through A.5 for moult stage information for all sampled locations.)

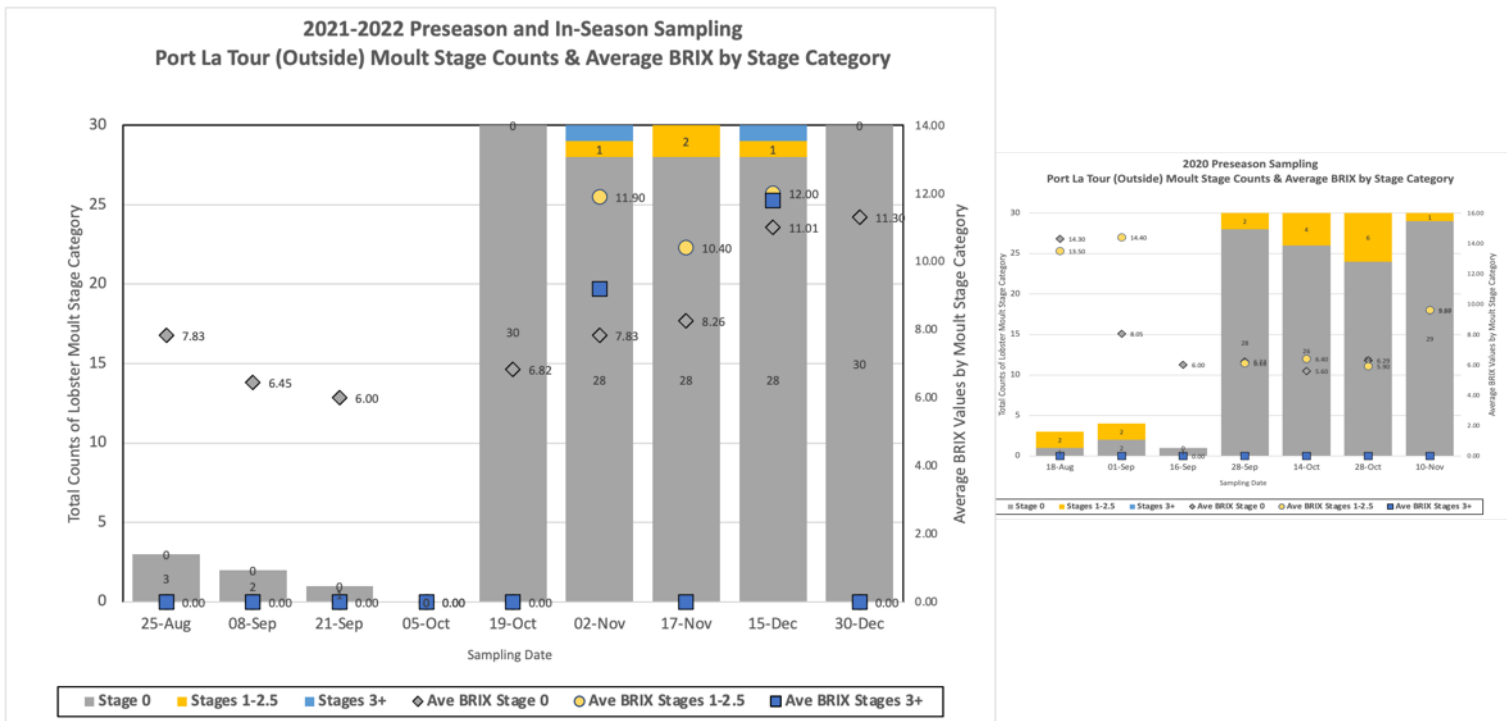


Figure 9. (a) 2021-2022 Preseason and In-season Port La Tour (Outside) Moulting Stage Counts and Average BRIX by Stage Categories; (b) 2020 Preseason Port La Tour (Outside) Moulting Stage Counts and Average BRIX by Stage Categories

(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 10 below provides the hardness measure results for St. Mary’s Bay inside and outside sampling dates.

It is acknowledged that “Medium” and “Soft” lobster have lower BRIX but when only 5% or fewer are judged to be in this category, this measure cannot be used as a sole designator of “quality” (i.e., meat content). The lack of variability in the hardness scale measure does not provide additional useful information. This scale may be used to eliminate only a small proportion (less than 5%) of lobster as acceptable quality for storage and shipment.

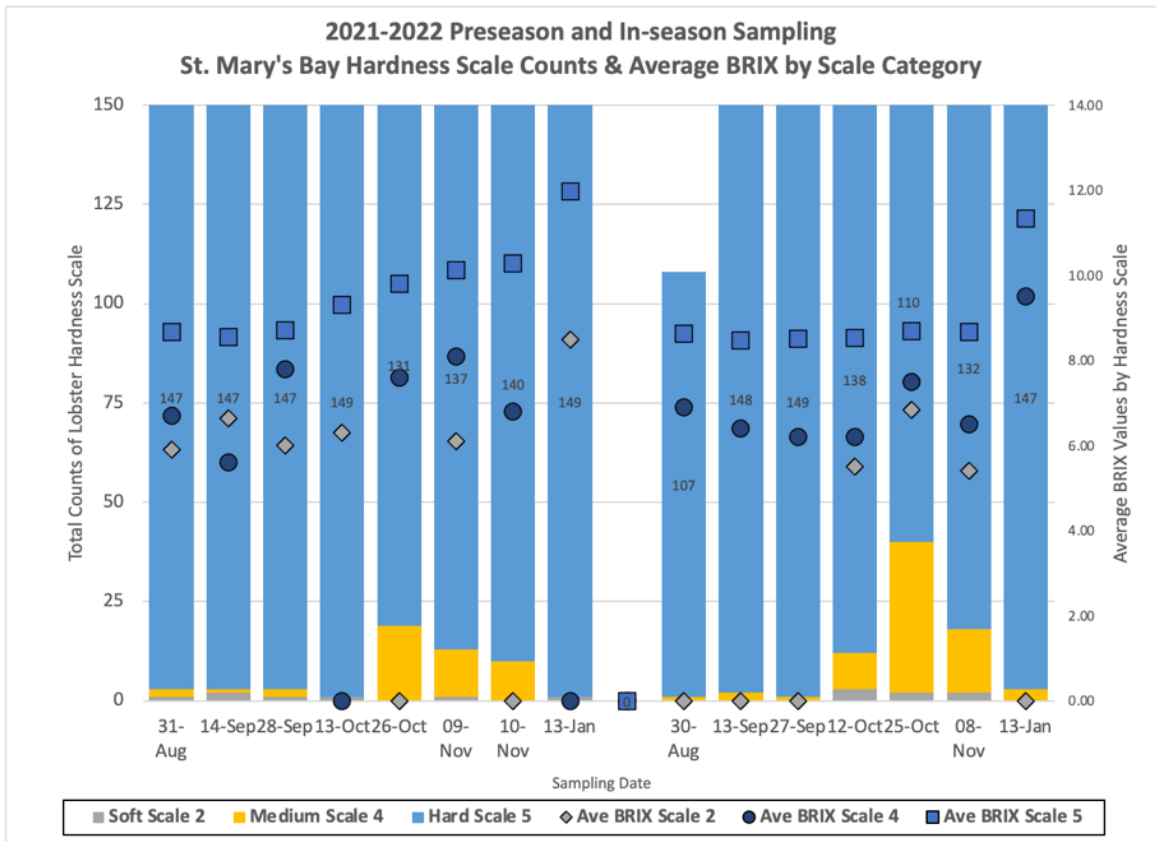


Figure 10. 2021-2022 Preseason and In-season St. Mary's Bay (Inside and Outside) Hardness Counts per Trap and Average BRIX by Category

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

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

Comparative location graphics from the sampling program are as follows:

- a. Counts of lobster harvested per trap by location for Inside areas
- b. Counts of lobster harvested per trap by location for Outside areas
- c. Average BRIX per sample by location of Inside areas
- d. Average BRIX per sample by location of Outside area

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

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

As noted above, catch per unit trap (CPUT) fishing effort measure provides general information about the propensity of available lobster to enter the trap. In 2021, 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 insidelocations (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 2021 preseason period in Figure 11a below. Once the commercial season begins, CPUT is expected to fall appreciably. In 2020-2021 in-season sampling, this fall was by as much as 75% for most locations (Figure 11b). See also Appendix A.2, p.A.6 for more details.

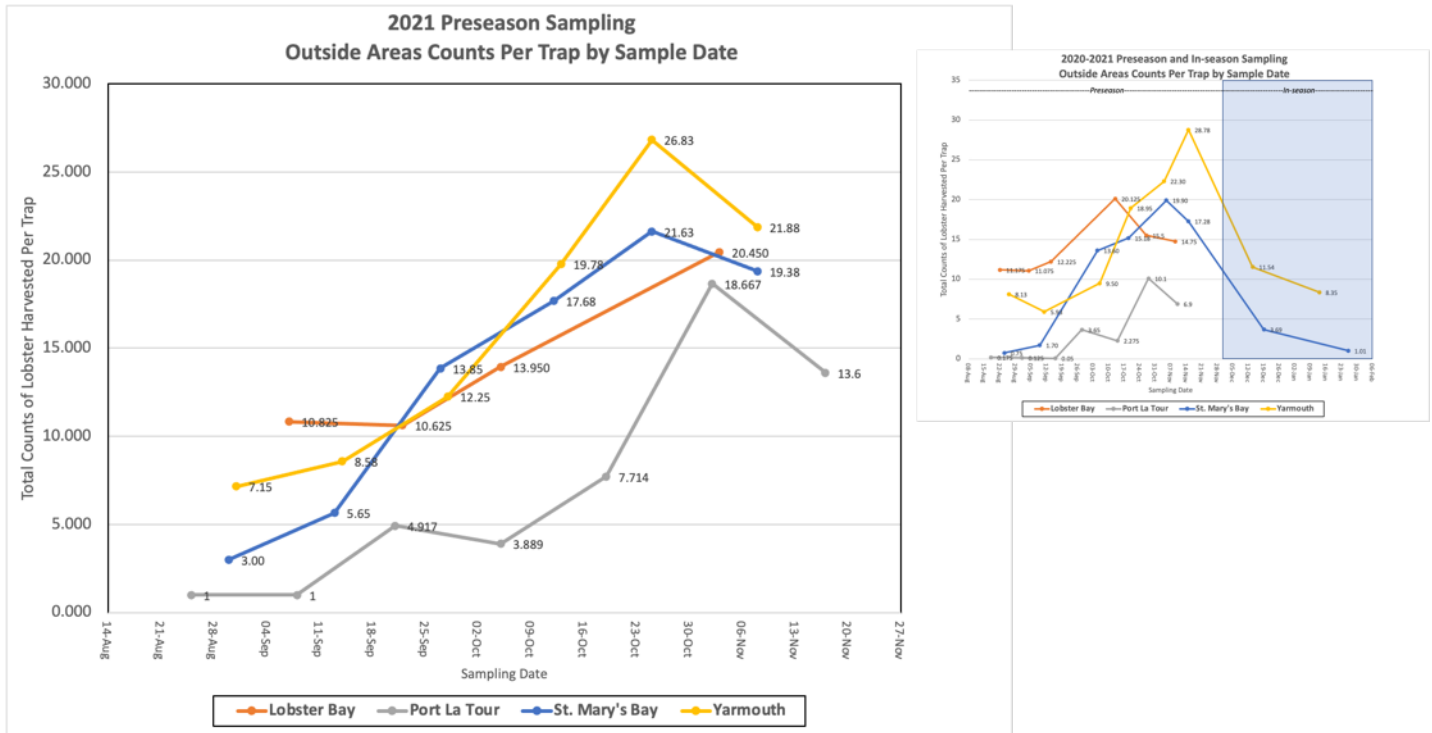


Figure 11. (a) 2021 Preseason Outside Areas Harvested Counts per Trap by Sample Date; (b) 2020-2021 Preseason and In-season Outside Areas Harvested Counts per Trap by Sample Date

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

Comparison of average BRIX levels in the location samples are also provided in Appendix A.2, p.A.6(c) for the inside areas. Generally, in 2021-2022, BRIX values are flat 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

Similar to the inside areas, in 2021, the outside areas average BRIX values per sample were also relatively flat during the preseason sampling period (September to early November), and then rose by 50% across all areas to the beginning of the season. This dynamic behavior with respect to BRIX is illustrated in Figure 12 below. (See also Appendix A.2, p.A.6(d)).

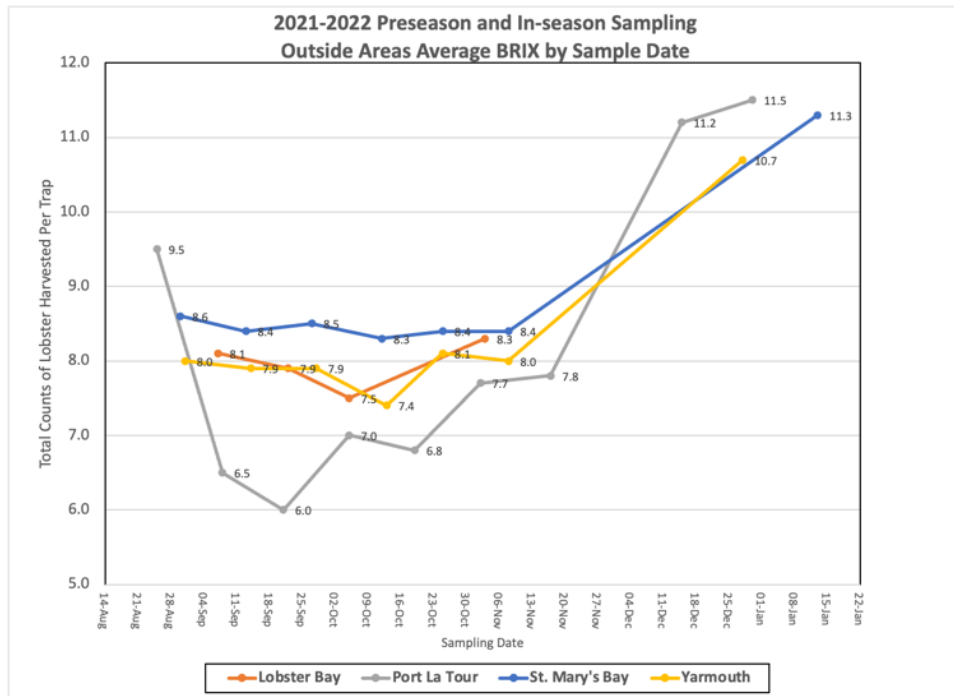


Figure 12. Outside Areas Average BRIX by Sample Date

3.2 Berried Females Sampling for 2021-2022

Data on berried females were compiled as part of the preseason and in-season sampling program in 2021-2022. This report contains summaries of the berried females information on selected harvested lobster counts. This information 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 females data were collected for the 2021-2022 in-season sampling dates). Selected graphics are presented in this report below.

3.2.1 Berried females sampled counts information

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

The sample of berried females in Yarmouth – as for most areas – is variable with respect to counts of lobsters in Stages 1-2 with observations between 2 and 11 berried female lobsters. There is a single observation of Stage 3 over the preseason sampling periods in Yarmouth. The percentage of berried females in the sample of all harvested females in Yarmouth increase from a low of 0.2% to 4%. See also Appendix B.1, p.A.8(1).

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

Berried females counts in Lobster Bay were highest for all locations – doubling that in Yarmouth and St. Mary’s Bay. Counts increase to end October and then fall in November – as in 2020. Lobster Bay berried females counts are dominated by Stage 1 observations. Stage 2 counts (5 berried females) occurred in 4 of the 10 sample dates. Two (2) counts of Stage 3 were recorded in 2 November sample dates. The percentage of berried females in the sample of all harvested females in Lobster Bay varied from a low of 0.75% in August to a high of over 8% at end September. See also Appendix B.1, p.A.8(2).

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

In 2021, berried female counts in Port La Tour are the smallest of all areas with total counts of less than 4 in any sample (as occurred in 2020). In the early months of preseason sampling (August to October 2021), only Stage 1 counts occur. In later November samples, Stage 2 and 3 counts (2) are recorded. The percentage of berried females in the sample of all harvested females in Port La Tour fluctuate but tend to increase from a low of 0% in September to a high of 2.5% in November. See also Appendix B.1, p.A.8(3).

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

Figure 13 below illustrates the berried females report for St. Mary’s Bay in 2021. The counts of berried females fall from August 2021 (3%) to below 2% at mid-October, rebounding to a high of 6% at end October sampling and into November (3-5%) and toward the start of the commercial season. See also Appendix B.1, p.A.8(4).

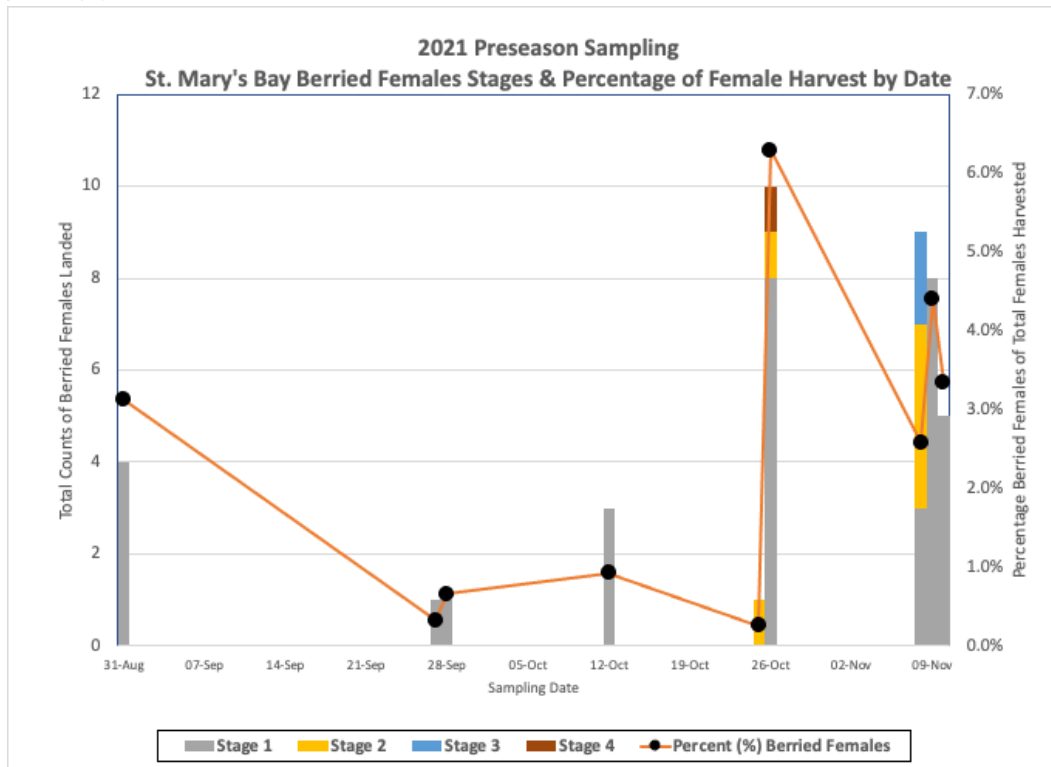


Figure 13. 2021-2022 Preseason and In-season St. Mary’s Bay Berried Females Stages and as Percent of Harvested Females

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 2021, 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 difficult to determine a trend in Stage 1 counts for any location. See also Appendix B.2, p.A.9(a).

b) Berried females Stage 1 counts for Outside areas

Figure 14 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 2021 preseason sampling periods. Lobster Bay Outside has much larger initial counts for the outside areas (reaching 18), while Port La Tour once again has berried female counts in the outside area that are negligible over all samples. See also Appendix B.2, p.A.9(b).

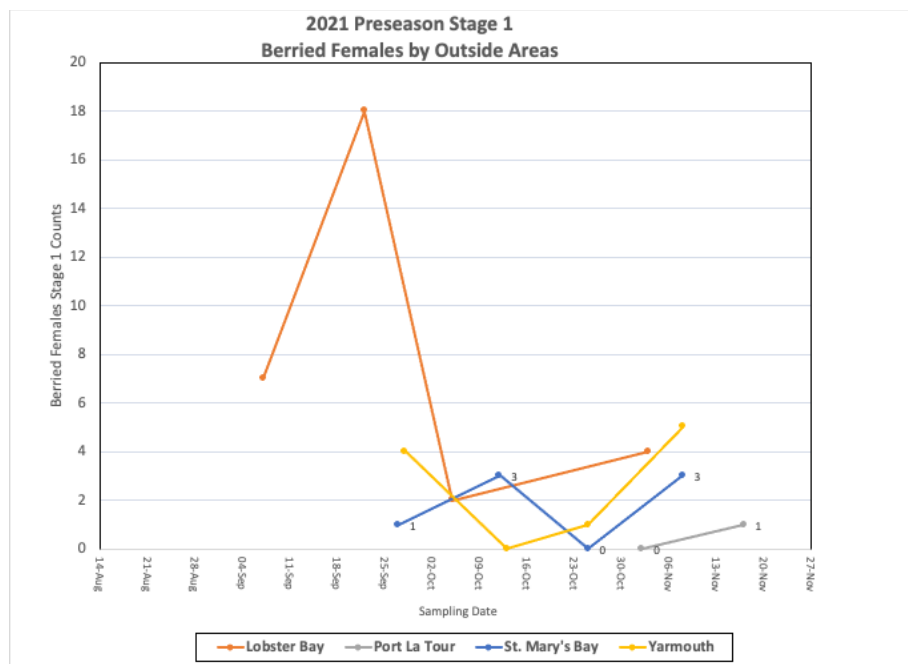


Figure 14. 2021 Preseason Outside Areas Berried Females Stage 1 Counts

c) Berried females Stage 2 counts for Inside areas

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 Yarmouth Inside (3). Port La Tour Stage 2 counts 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. However low, Stage 2 counts tend to rise over the sampling period from a low of 0 counts to October, to highs of 4 in St. Mary's Bay and to 3 in Lobster Bay. See also Appendix B.2, p.A.10(d).

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

The counts of berried females observed to be in Stage 3 or 4 for inside areas over the sampling dates are very few and fluctuate from zero to a count of 1. No time trends are evident in these data. See also Appendix B.2, p.A.11(e).

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

As for the inside areas, the counts of berried females observed to be in Stage 3 or 4 for outside areas over the sampling dates are very few and fluctuate from zero to a count of 2 in any one sample date (St. Mary's Bay, Port La Tour in November samples). See also Appendix B.2, p.A.11(f).

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

3.3. Temperature Data

It is generally recognized that collecting continuous data on bottom temperatures on the lobster fishing areas will provide valuable data and assist in making prediction models for the lobster moult cycle as a key determinant of lobster behaviour. In 2021-2022, temperature data were not specifically collected as part of the lobster sampling surveys (with the occasional exception of water surface temperature at haul dates – see also Google Map above, Section 2.2).

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

3.4 Sites Summary Report

The at-sea sampling summary report for 2021 was compiled as the 'Lobster Quality Preseason Sampling Program–Southwest Nova Scotia LFA33 & LFA34, Preseason Summary Report' (Mattock, Mulock, and Lane 2021) and distributed by Coldwater Lobster Association to the lobster industry and government funders on November 24, 2021. This report contained information on the proportion of soft shell as well as the proportion of low blood protein lobsters for each of the identified sampling areas in the preseason survey.

The 2021 preseason sampling results in LFAs 33 and 34 indicated that lobsters landed at the start of the 2021-2022 season in southwest Nova Scotia, were of overall of moderate-low quality. 2021 preseason samples mean overall BRIX is at the moderate-low level of 8.4 units/ml. 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 Inside, and high (BRIX>9) for post-September samples. Other observations from the preseason summary report include:

- Lobster Bay underperforms in 2021 relative to its BRIX history over the 2006-2020 period – despite the relatively higher mean BRIX (8.9) for Inside. Yarmouth (Inside and Outside) also underperforms in 2021 compared to its better BRIX history in the earlier years of the database.
- Port La Tour (Inside and Outside), while collectively below the overall mean BRIX value of 8.3, performs relatively better in 2021, especially Port La Tour Inside, and for the later sample dates where BRIX means exceed 9.5 in successive samples.
- The incidence of weak lobsters nearly doubled in 2021 compared to 2020 values. Weakness in the Outside locations averaged over 15% per sample; weakness in the Inside locations averaged over 10% per sample (graphics). Lobster Bay Inside dominated the incidence of weakness in the Inside areas, averaging over 18% and increasing from 3% to 33% as sampling progressed. In Outside areas, all locations increased weakness over the sampling period, rising from lows of 0% (Port La Tour) to highs of over 25% (Yarmouth, Lobster Bay, and Port La Tour).

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. Analyses of these hypotheses are explored and presented below.

3.5 Recent Data Variability and Trend

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

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

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

4 Analysis of Preseason and In-season Sampling Data in 2021-2022

The analysis below uses 3 presentations based on the preseason and in-season sampling data for 2021-22 for each of the 8 subareas. These include:

(1) annual comparative graphics for Blood Protein (BRIX) Distribution – graphic results are provided for the BRIX indicator values (“Good”, “Moderate”, “Poor” – Table 2) as well as BRIX sample means for each of the location’s 2021-2022 sampling dates. Annual comparative graphics allow comparison of recent years (2012 to 2022) of sample mean BRIX indicator levels, and BRIX distribution by category at 3 to 4 weeks prior to the start of the commercial season on Monday, November 29,2021;

(2) annual consolidated data analyses from each sample date by location are classified into the 5 lobster quality categories derived from the review of full ALMQ database (2006-2020) (Table 4). The results of the analysis enables the assignment of each of the 2021-2022 sample dates into its most probable Lobster Quality category; and

(3) subarea predictions – the analyses of sample BRIX distributions, and the series of annual consolidated data by subareas enable predictions on start of season lobster quality based on these comparisons.

Sections 4.1, 4.2 and 4.3 below provide additional information on the assignment and interpretation of these analyses of the 2021-2022 sampling data.

4.1 Blood Protein (BRIX) Distribution: Methodology

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).

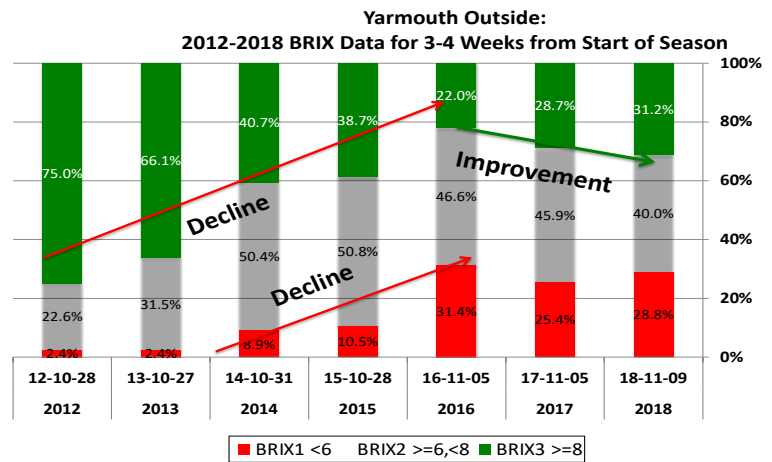


Figure 15. Example: Yarmouth Outside BRIX Categories for 3-4 weeks prior to season start 2012-2018

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

4.2 Consolidated Data Analysis: 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 2021 preseason sample dates into its most probable Lobster Quality category.

The 2021 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 (2006-2020) that contains nearly 800 location-date samples of (typically, 150) lobsters. This analysis assigns each of the 51 preseason sample dates in 2021 by location to one of the designated Lobster Quality Categories (H, MH, M, ML, or L). Summarized results are presented for all sample dates for each location in the pages which follow.

4.3 Site Results and Predictions

The following pages present the survey breakdown of the 2020 BRIX results for each of the 8 lobster sampling locations. These results summarize the results of the ‘Lobster Quality Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report’ (Mattock, Mulock, and Lane 2020) provided to industry collaborators in November 2020 prior to the start of the 2021-2022 commercial season.

In each of the 8 subareas presented below graphic BRIX categories and BRIX means are presented for the 2021 preseason sampling location and dates. Comparative results are also provided by location with previous years’ samples (from 2012 onward) for the approximate same preseason periods: 3-4 weeks prior to the start of the commercial season. Preseason sampling dates are assigned Lobster Quality Classifications according to the discriminant analysis of historical data by location. The sections below enable 2021 predictions on start of season lobster quality based on these comparisons. Appendix C - Preseason Sampling Summary Report Predictions presents the summary (text) predictions for each of the 8 location-areas as provided in the ‘Lobster Quality 2021 Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report’ (Mattock, Mulock, and Lane 2021a).

4.3.1 YARMOUTH INSIDE

Blood Protein (BRIX) Distribution

The 2021 preseason survey results for Yarmouth Inside show a relatively steady set of results for the 7 sample dates in this location. The percent of “Good” category lobsters (BRIX \geq 8) increased slightly until mid-October along with average BRIX values, before declining somewhat thereafter. Correspondingly, the proportion of “Poor” lobsters sampled increases toward the end of the sampling period (October 26 and November 9 and 10 samples) from 6% to 17% (Figure 16).

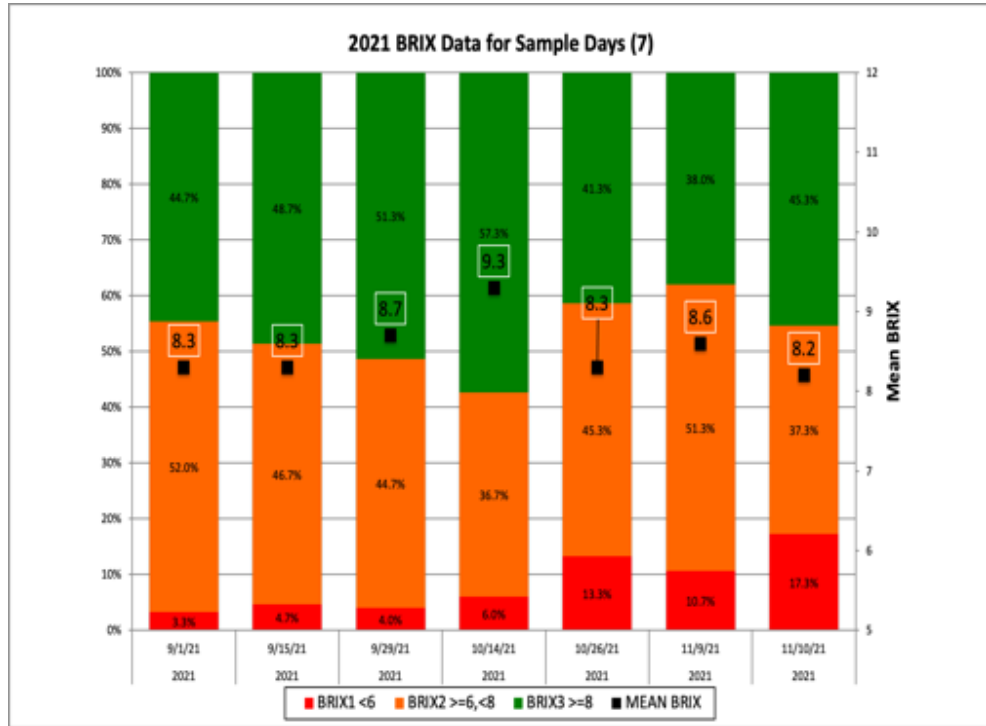


Figure 16. Yarmouth Inside 2021 Preseason Sampling BRIX Indicators

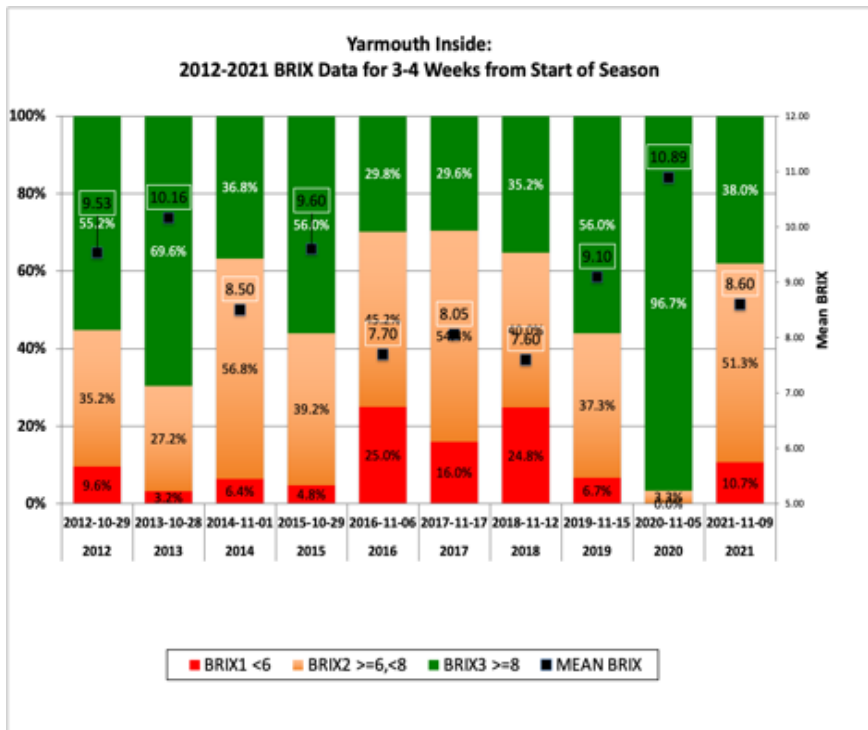


Figure 17. Yarmouth Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Annual samples 3-4 weeks from the start of each commercial harvest season opening (Figure 17) are somewhat variable between 2012 and 2019. The 2021 sample (November 9) falls within the historical results (the spike in BRIX experienced in the November 5, 2020 sample excepted).

The 2021 observations show moderate quality results with a BRIX mean value of 8.6. The BRIX mean and distribution of “Good” (38% in 2021), “Moderate” (51%) and “Poor” (11%) BRIX are most closely comparable to that of the 2014 sample (November 1, 2014).

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Yarmouth Inside are provided in Figure 18 below. Based on the historical sampling in this location, the 7 sample dates in 2021 are all classified as ML – Moderate Low. The likelihood of the Yarmouth Inside samples being in the ML category is largest at 70% whereas the likelihood of the Yarmouth Inside samples being from all of the higher quality categories H, MH or M is only 20%. Similarly, the likelihood that the Yarmouth Inside samples in 2021 are representative of the L category is estimated at only 10%.

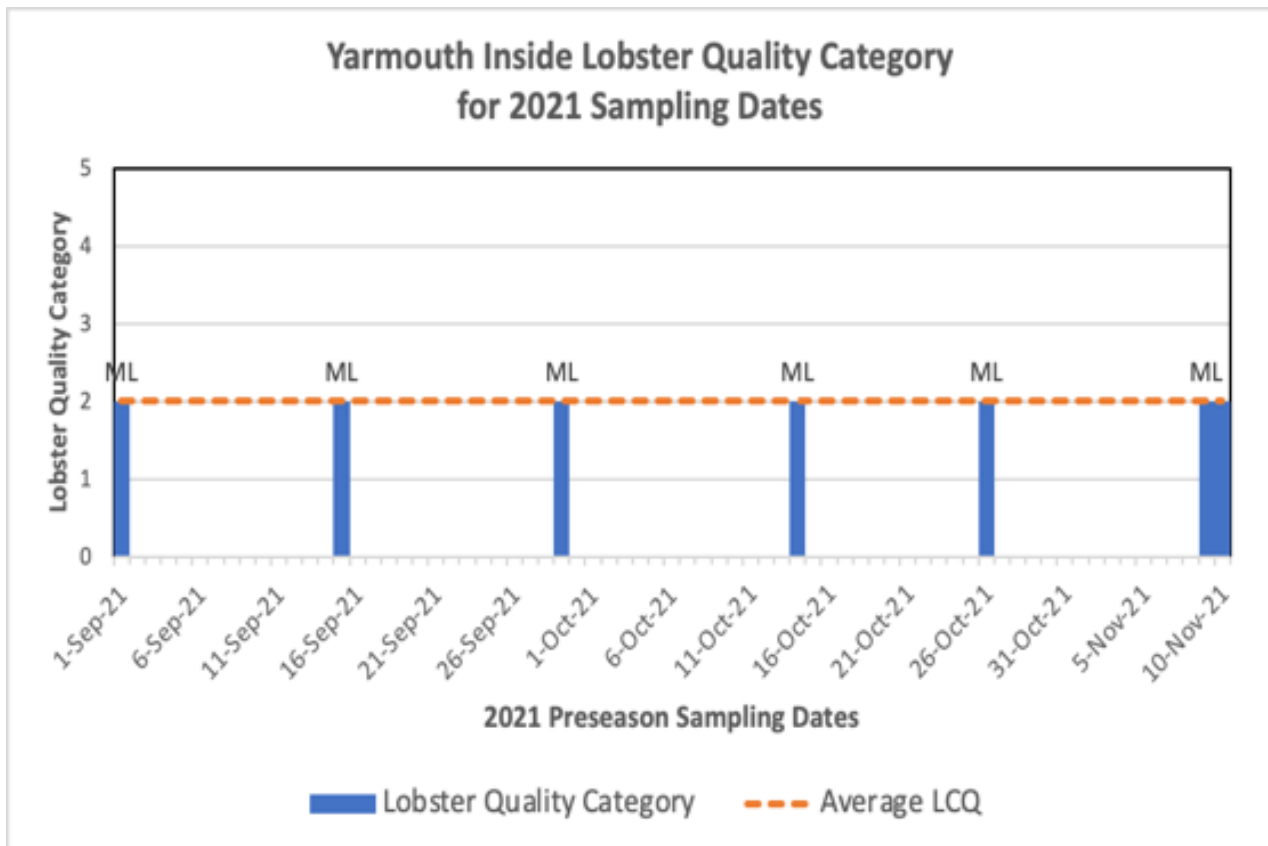


Figure 18. Yarmouth Inside Lobster Quality Categories for 2021 Preseason Sampling Dates

Historically, Lobster Quality classifications for Yarmouth Inside of Moderate-Low (ML) have occurred in 2014, 2015, 2017, 2019 and 2020 (as per Table 5, p.15 above). Accordingly, the 2021 preseason classification for Yarmouth Inside implies that the 2021-2022 commercial season is most comparable to the 2014-15, 2015-16, 2017-18, 2019-20, or the 2020-21 commercial seasons. These years are all part of the post-2013 lobster quality decline period, and indicate that Yarmouth Inside remains in the reduced quality range relative to the full 2006-2021 database.

4.3.2 YARMOUTH OUTSIDE

Blood Protein (BRIX) Distribution

The 2021 preseason samples for Yarmouth Outside, like Yarmouth Inside, show a relatively steady set of BRIX distribution results (Figure 19). The historically moderate-to-low mean BRIX values vary in the range of 8.1 (October 25) to 7.4 (October 13) with overall BRIX mean of 7.9 for the 6 sample dates in this location. The percent of “Good” category lobsters (BRIX \geq 8) vary in the range between 29% (October 13) to 46% (October 25); the range for “Poor” category (BRIX $<$ 6) varied between a low of 3% (September 14) to a high of 13% (October 13).

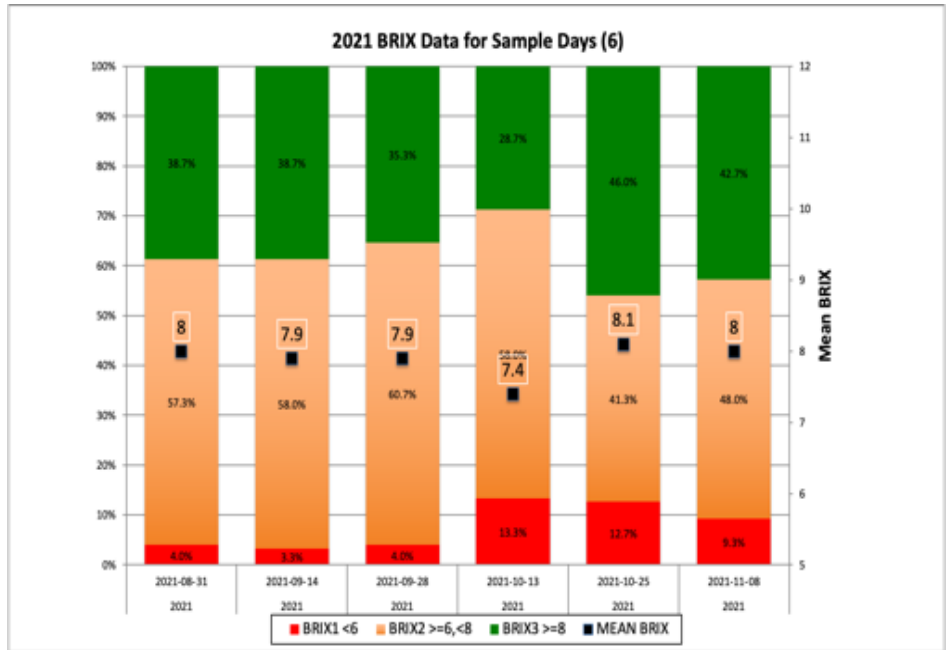


Figure 19. Yarmouth Outside 2021 Preseason Sampling BRIX Indicators

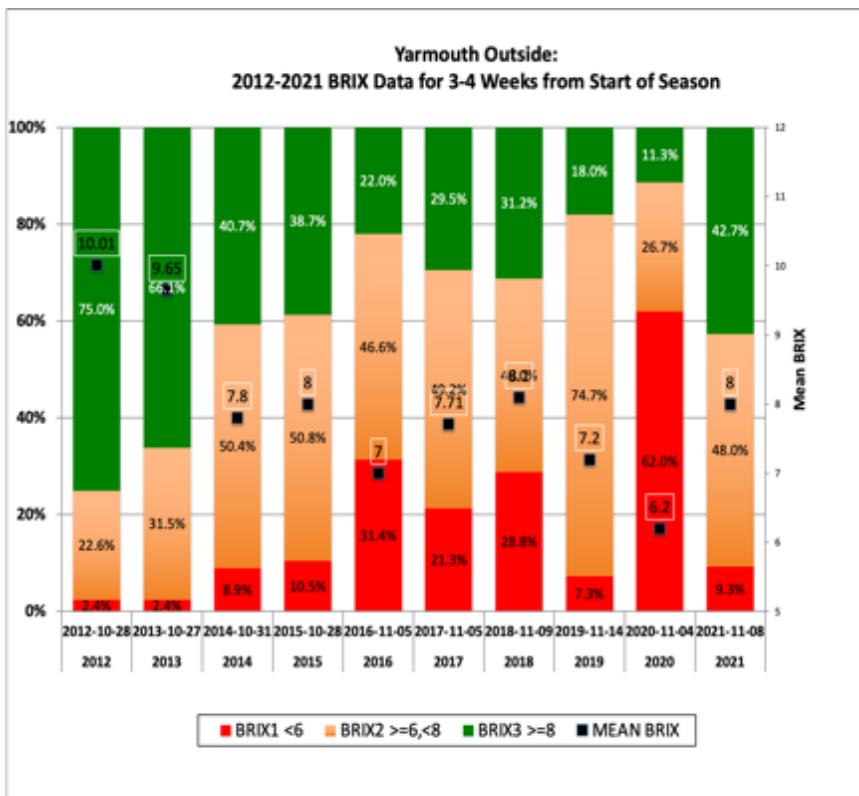
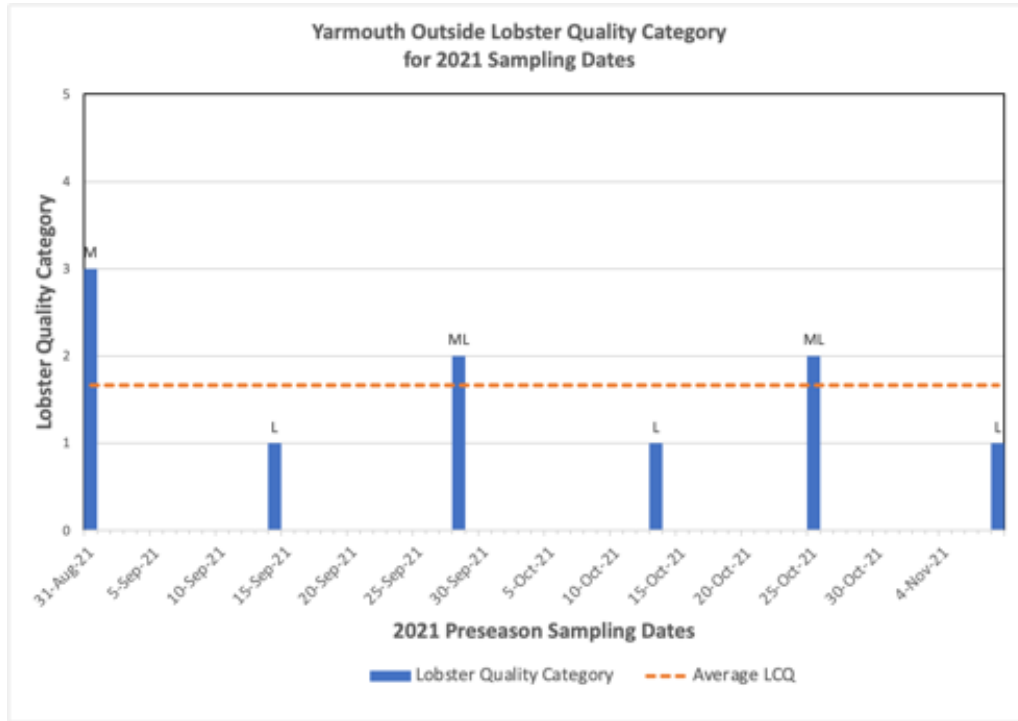


Figure 20. Yarmouth Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Yarmouth Outside sample BRIX distribution annual results, for 3-4 weeks from the start of the commercial harvest season opening, show a trend over time of declining high BRIX and increasing low category BRIX values from 2012 to 2020 (Figure 20). However, the 2021 sample (November 8) suggests that this declining trend in Yarmouth Outside may have reversed in this current year. The 2021 sample 3-4 weeks before the start of the season is comparable to the earlier 2014 and 2015 samples with respect to the mean BRIX value (8) and the similar distribution of the 3 BRIX categories.

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Yarmouth Outside are provided in the graphic below. Based on the historical sampling in this location since 2006, the 6 sample dates in 2021 are classified as L (3 sample dates), ML (2 sample dates) or M (1 sample date).



The likelihood of the Yarmouth Outside samples being in the ML category is largest at approximately 50% whereas the likelihood of the Yarmouth Outside samples being from the lower quality category L is 30%. Finally, the likelihood that the Yarmouth Outside samples in 2021 are representative of the higher lobster quality categories H, MH, or M is collectively estimated at 20% (Figure 21).

Figure 21. Yarmouth Outside Lobster Quality Categories for 2021 Preseason Sampling Dates

4.3.3 LOBSTER BAY INSIDE

Blood Protein (BRIX) Distribution

2021 preseason survey results for Lobster Bay Inside were relatively stable from August through November for BRIX means ranging from a high of 9.6 (November 4) to a low of 8 (October 6) with overall moderate-high BRIX mean of 8.9 and comparable BRIX distribution categories over the sample dates (Figure 22). BRIX values appear to have rebounded between the low mean of 8 (October 6) and the highs of 9.6 and 9.5 in the last two November sample dates. “Good” category BRIX exceeded 50% in all but one sample date (October 6). “Poor” category BRIX averaged approximately 25% across the 6 samples in 2021 (Figure 22).

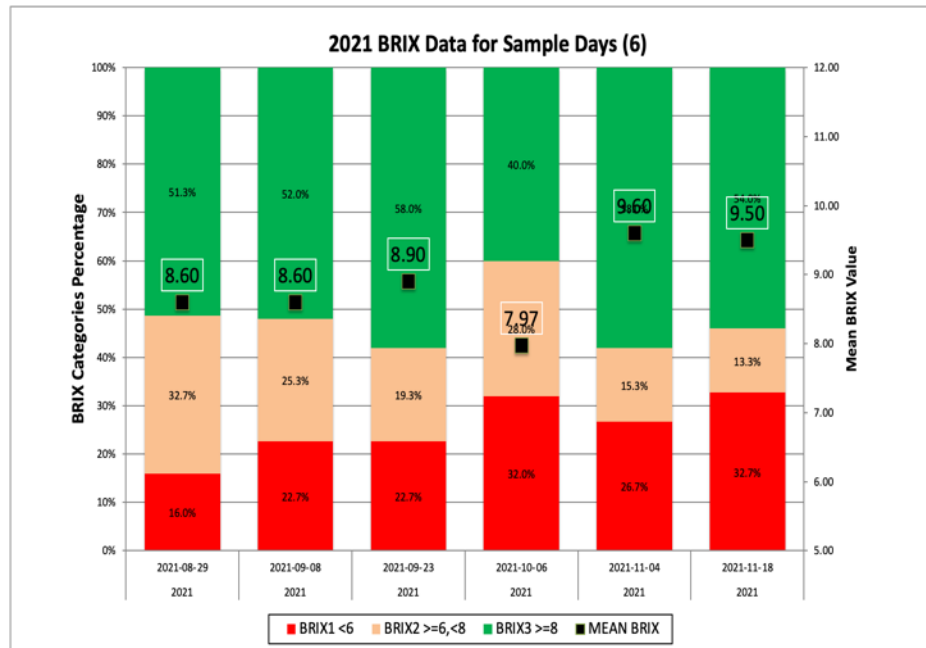
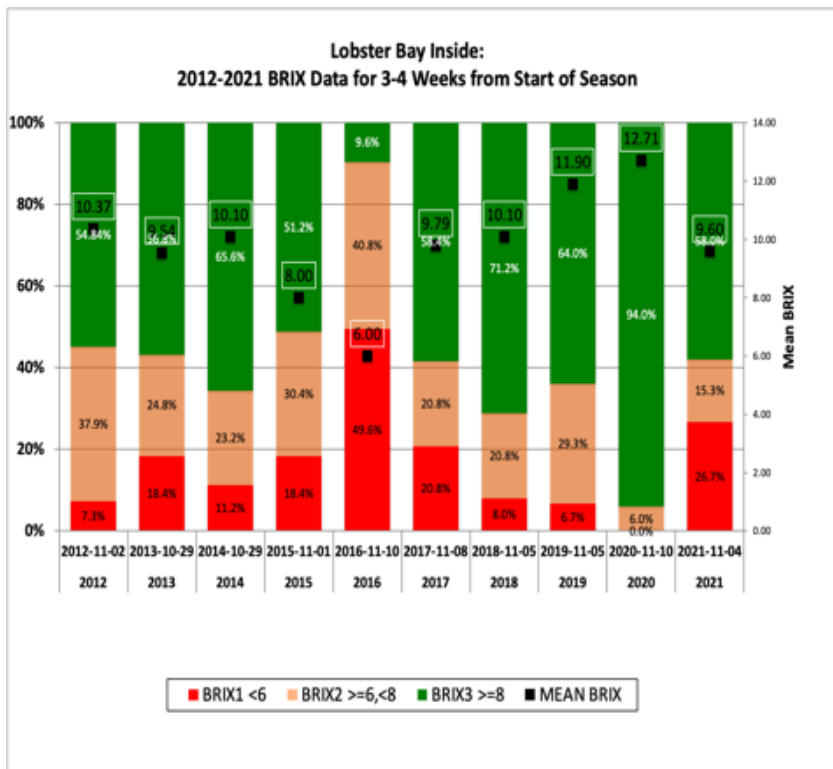


Figure 22. Lobster Bay Inside 2021 Preseason Sampling BRIX Indicators

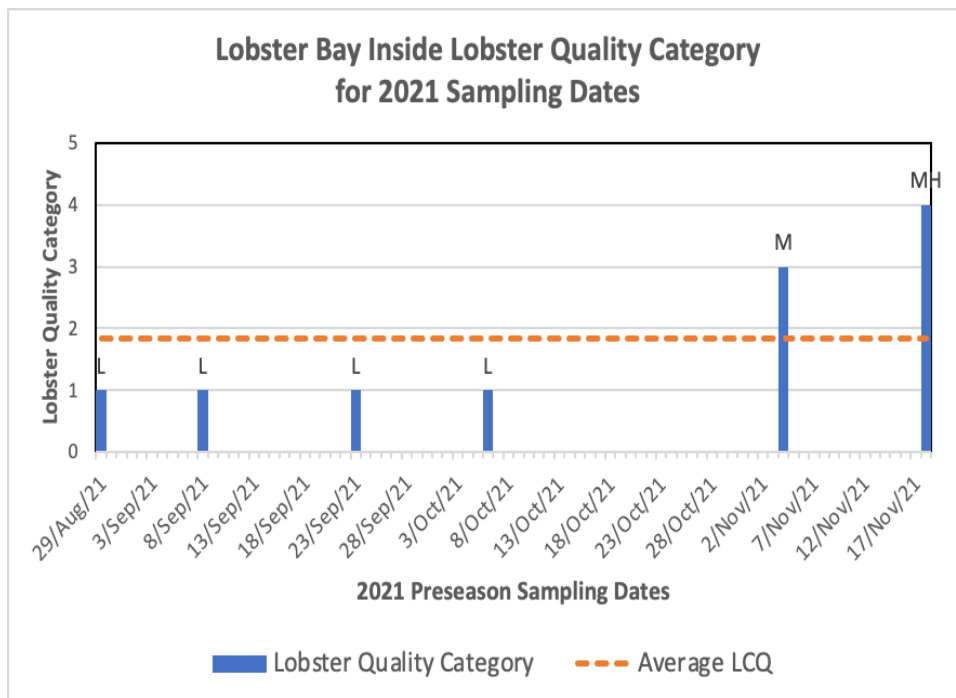


The 2021 Lobster Bay Inside sample results for 3-4 weeks from the start of the commercial harvest season opening vary considerably from an extreme low (mean BRIX of 6) in 2016 to an extreme high (mean BRIX of 12.7) in the 2020 spike (Figure 23). The 2021 sample year returns to a mean BRIX value of 9.6, close to the overall (2012-2020) mean of 9.8. The 2021 sample has a relatively high proportion of “Good” BRIX values (58%) and “Poor” BRIX values (27%) in comparison to the other samples in the series. 2021 is most comparable to the 2013 and 2017 samples 3-4 weeks before the scheduled openings of those commercial seasons (Figure 23).

Figure 23. Lobster Bay Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Lobster Bay Inside are provided in the graphic below. Based on the historical sampling in this location, the 6 sample dates in 2021 are classified as L (4 sample dates), M (November 4), improving to MH (November 18). For the initial 4 sample dates in Lobster Bay Inside, the maximum likelihood of the samples over all categories is the L lobster quality category estimated at 50%. However, the final sample likelihood of that sample being from the MH quality category is estimated to be 60%. This result indicates a marked improvement in Lobster Bay Inside quality by the end of the preseason sample period.



With respect to the last 2 November sample dates (November 4 and 18), the likelihood that Lobster Bay Inside is representative of moderate or higher lobster quality category (M, MH, or H) is estimated as 85% (Figure 24). Similarly, the likelihood of lower quality category (ML or L) for these final samples is averaged at only 15% (Figure 24).

Figure 24. Lobster Bay Inside Lobster Quality Categories for 2021 Preseason Sampling Dates

4.3.4 LOBSTER BAY OUTSIDE

Blood Protein (BRIX) Distribution

2021 preseason survey results for Lobster Bay Outside were relatively constant over 4 sample dates from September through November with lower to moderate BRIX means ranging from a minimum of 7.5 (October 5) to 8.3 (November 3), and overall low BRIX mean of 7.9. The “Good” category BRIX exceeded 35% in all dates and averaged 38% over the 4 dates; “Poor” category BRIX averaged 12% across the 4 sample dates (Figure 25).

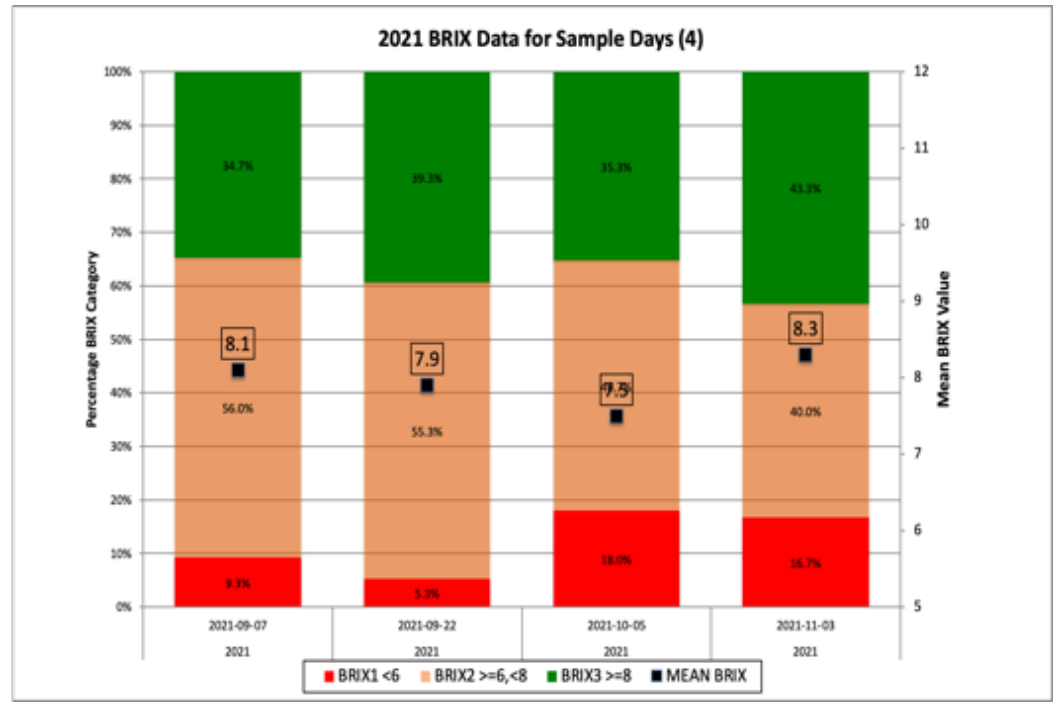
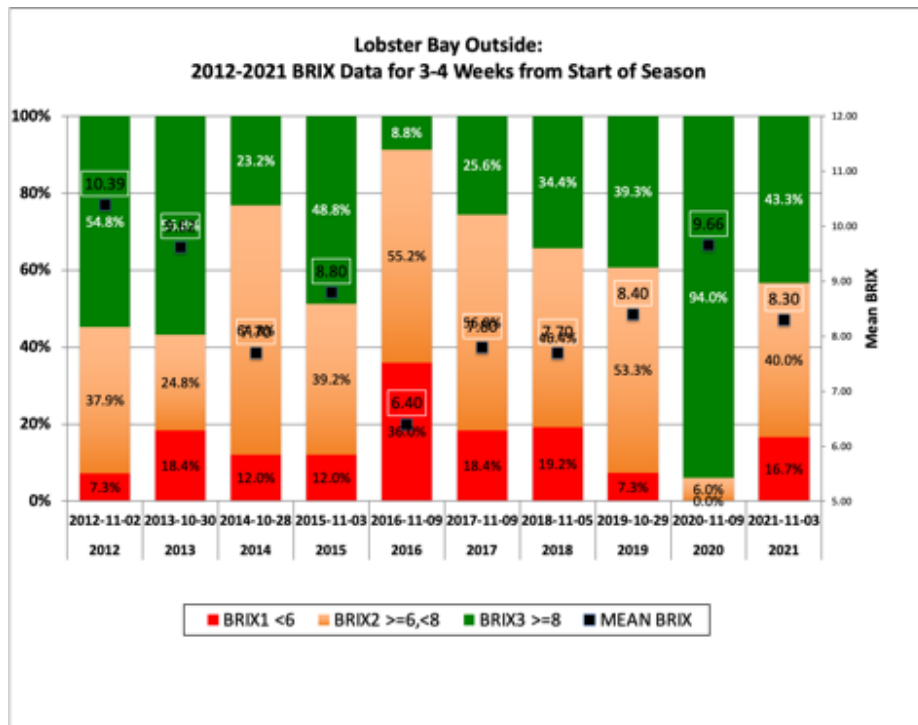


Figure 25. Lobster Bay Outside 2021 Preseason Sampling BRIX Indicators



The 2021 Lobster Bay Outside annual results in the graphic for 3-4 weeks from the start of the commercial harvest season opening show an improving trend since 2016 both in terms of increasing “Good” and decreasing “Poor” category BRIX values in each sample date. Similarly, the mean BRIX value increases marginally to a moderate-low level of 8.3 in the 2021 sample (November 3) (the anomalous high of 2020, excepted) (Figure 26).

Figure 26. Lobster Bay Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Lobster Bay Outside are provided in the graphic below. Based on the historical sampling in this location, the 4 sample dates in 2021 are classified as M (the first and last sample dates), and L (2 intermediate sample dates) (Figure 27).

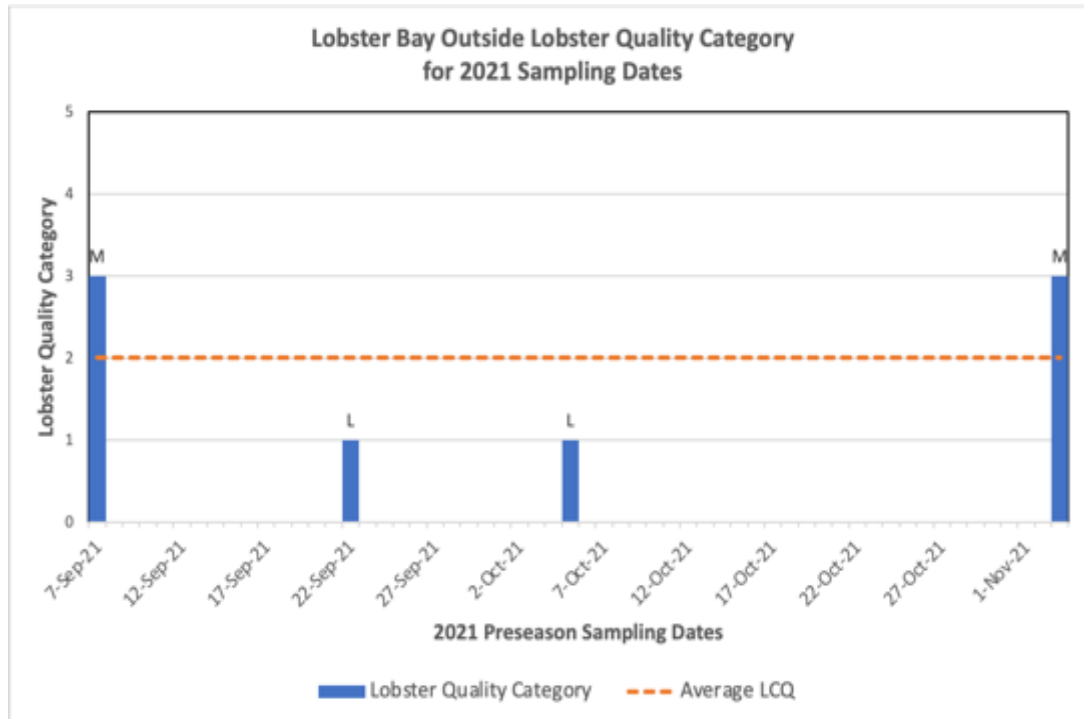


Figure 27. Lobster Bay Outside Lobster Quality Categories for 2021 Preseason Sampling Dates

The average over all 2021 sample dates is a lobster quality category of ML (between M and L). The likelihood that the results are representative of either M or L categories for this location are estimated each at 30%. The last sample (November 3) maximum likelihood is 38% for the M (moderate) lobster quality category for Lobster Bay Outside with highest sample mean BRIX of 8.3.

4.3.5 PORT LA TOUR INSIDE

Blood Protein (BRIX) Distribution

2021 preseason survey results for Port La Tour Inside were variable but improving over 8 sample dates from end August through mid-November. BRIX means moved from a minimum of 6.7 (September 9) to a maximum of 10.8 (November 3) near the end of the sampling period. The “Good” category BRIX exceeded 66% for all 3 November sample dates; “Poor” category BRIX for November were steady at 11%. The 3 November mean BRIX values averaged over 10 – exceeding mean BRIX in the earlier sample dates by almost 40%.

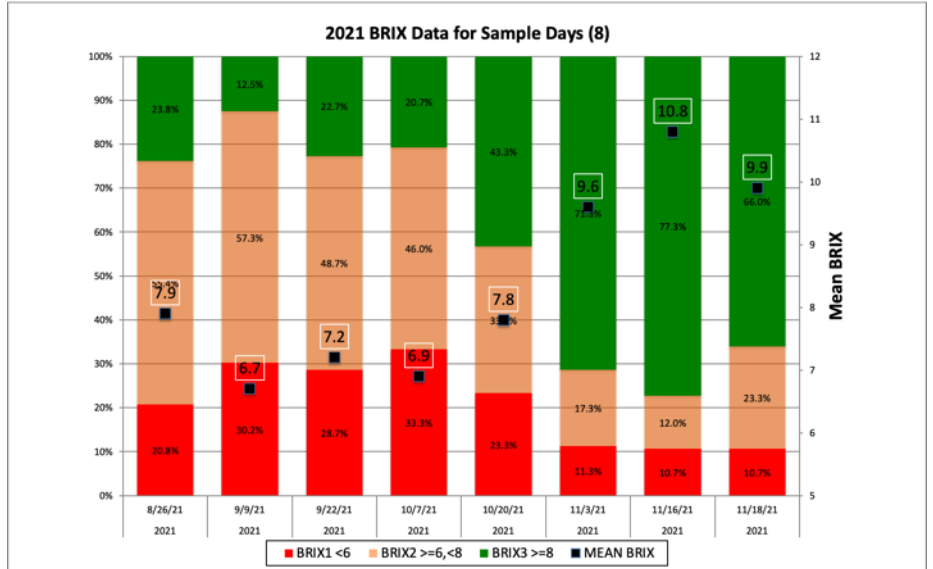
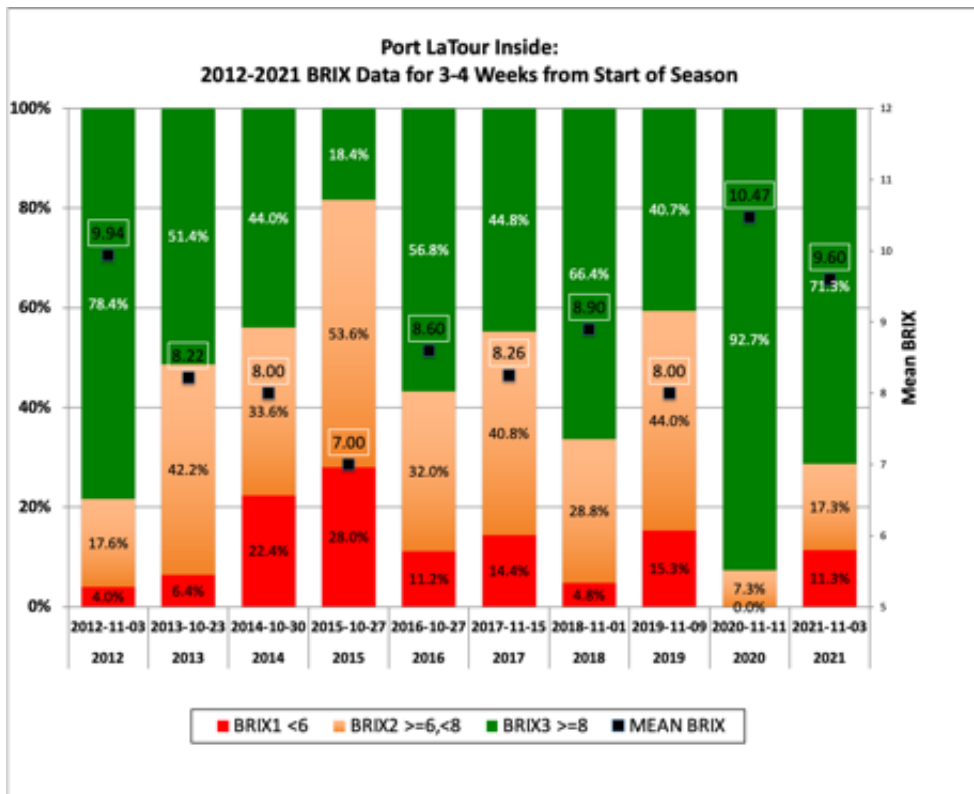


Figure 28. Port La Tour Inside 2021 Preseason Sampling BRIX Indicators



2021 Port La Tour Inside results in the graphic for 3-4 weeks from the start of the commercial harvest season opening are variable over the period from 2012 to 2021. These results have shown improvement since 2016 with “Good” BRIX reaching over 70% in 2021 (November 3 sample) and relatively low “Poor” category BRIX (11%). At the same time, the mean BRIX value in 2021 is among the highest (9.6) in this time series (the 2020 spike excepted) (Figure 29).

Figure 29. Port La Tour Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Port La Tour Inside are provided in the graphic below. Based on the historical sampling in this location, the 8 sample dates in 2021 are classified as a mix of L (3 dates), ML (2 dates), M (1 date) and MH (2 dates). While the overall lobster quality category is slightly above ML, evidence from the last 3 sample dates indicate that the lobster quality category of Port La Tour Outside has improved to M or above. The likelihood of M or greater in the last 3 samples has estimate of 55% (Figure 30).

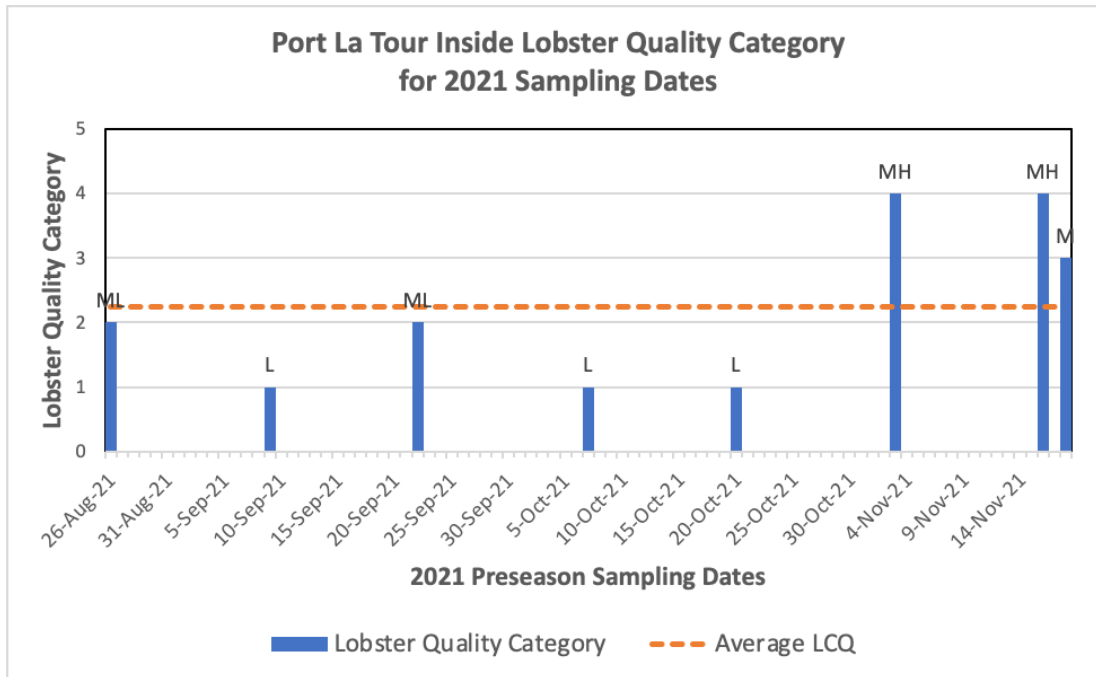


Figure 30. Port La Tour Inside Lobster Quality Categories for 2021 Preseason Sampling Dates

4.3.6 PORT LA TOUR OUTSIDE

Blood Protein (BRIX) Distribution

2021 preseason survey results for Port La Tour Outside were variable over 7 sample dates from end August through mid-November. Beginning in October, mean BRIX values tended to increase from low mean values below 7 to close to 8 by the end of the sample period. The proportion of “Good” category lobsters increased while “Poor” category proportions diminished somewhat over this same period (from 30%, October 5 to 15%, November 17) (Figure 31).

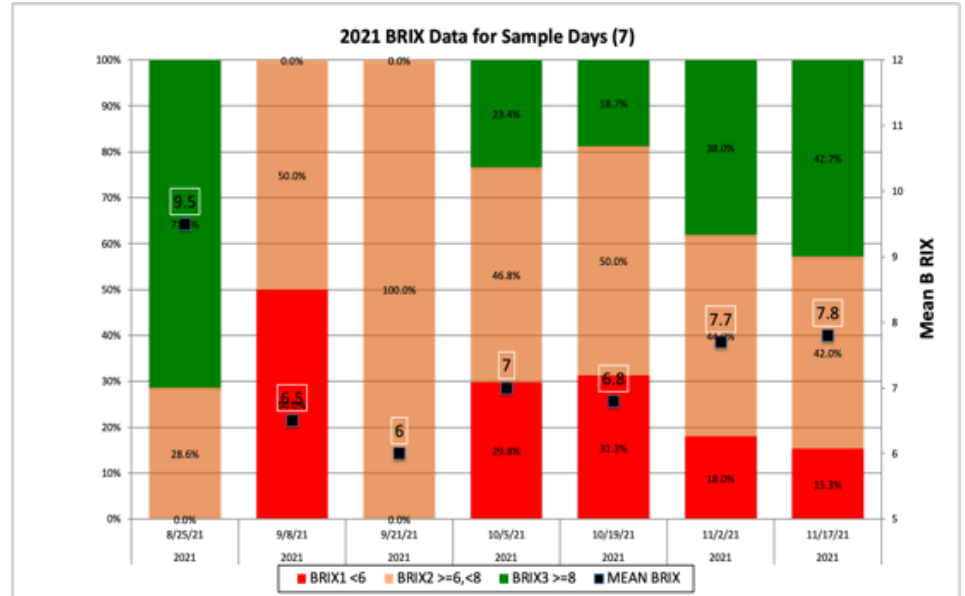
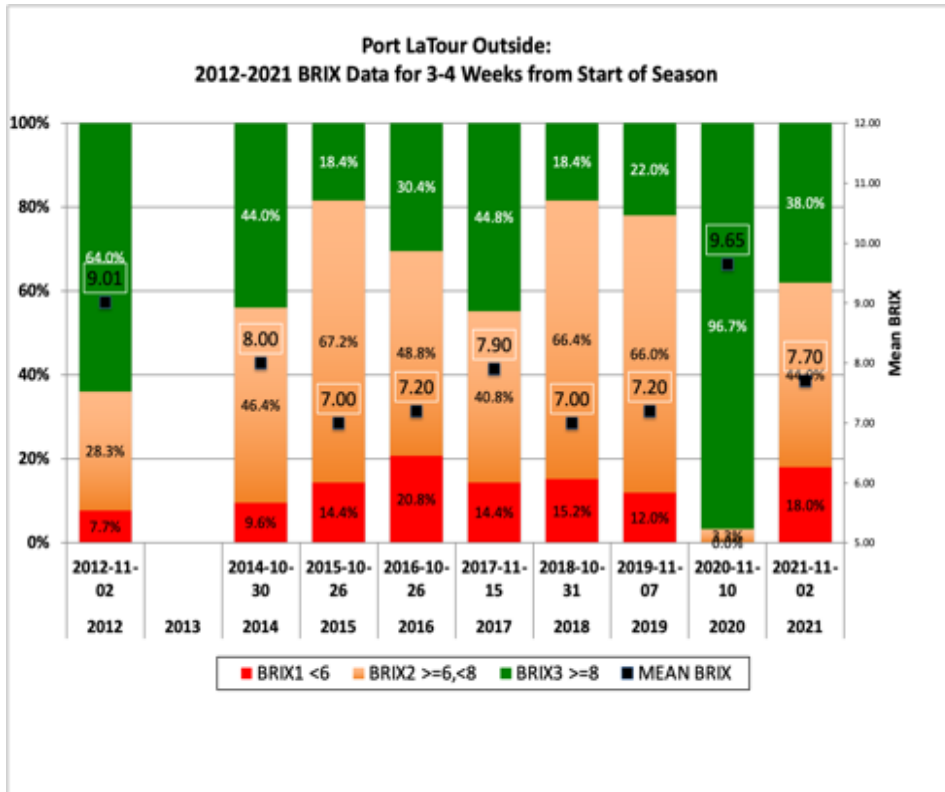


Figure 31. Port La Tour Outside 2021 Preseason Sampling BRIX Indicators

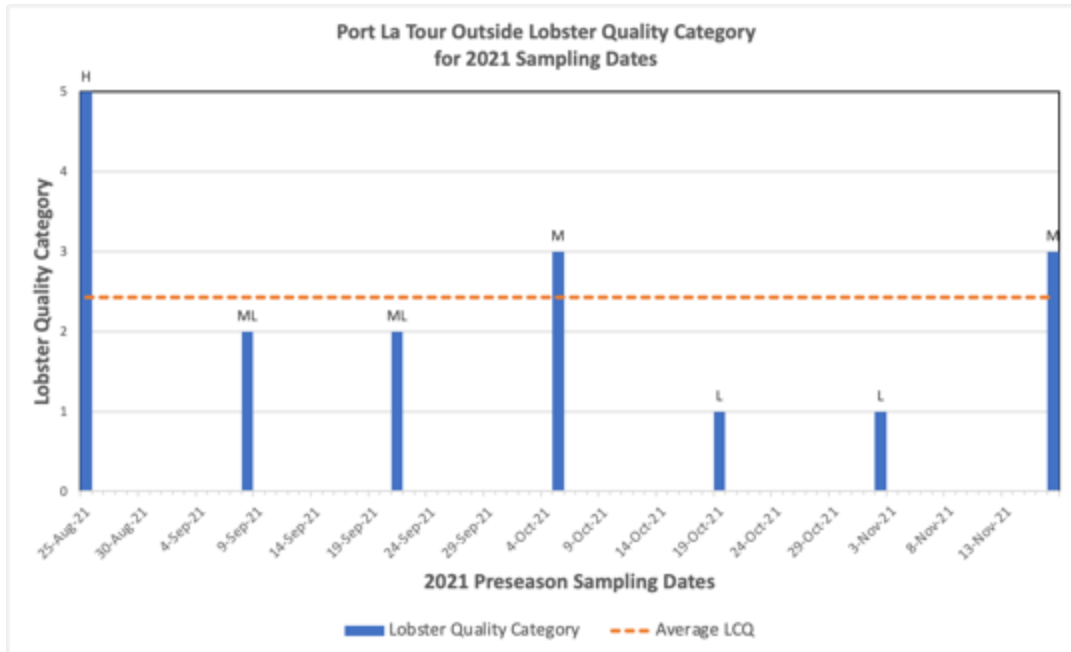


The annual results for Port La Tour Outside sampling exhibit a similar behaviour to the Port La Tour Inside results for the case of 3-4 weeks before the start of the season. These results show an improvement since 2018 and a small rise in the relatively low mean BRIX values from 7 (2018) to 7.7 (2021) (not taking into account the 2020 spike). “Good” category BRIX in 2021 attained almost 40% whereas the “poor” category was below 20% of the 2021 sample (November 2) (Figure 32).

Figure 32. Port La Tour Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in Port La Tour Outside are provided in the graphic below. Based on the historical sampling in this location, the 7 sample dates in 2021 are classified initially as H moving to ML, M, and L before terminating at Lobster Quality category M.



The overall mean category is between M and ML for all sample dates. The likelihood that the overall Lobster Quality category is M or lower (ML to L) is estimated at 70% for Port La Tour Outside (Figure 33).

Figure 33. Port La Tour Outside Lobster Quality Categories for 2021 Preseason Sampling Dates

4.3.7 ST. MARY'S BAY INSIDE

Blood Protein (BRIX) Distribution

2021 preseason samples for St. Mary's Bay Inside over 7 sample dates exhibit a gradual improvement from moderately lower mean BRIX (8.5) at the mid-September sample to maximum high mean BRIX (10) at the final 2021 November 10 sample. "Poor" BRIX values remain below 10% across all the 2021 samples; "Good" category BRIX proportions move from 50% (September 14) to over 60% at the end of the sample period (November 10) (Figure 34).

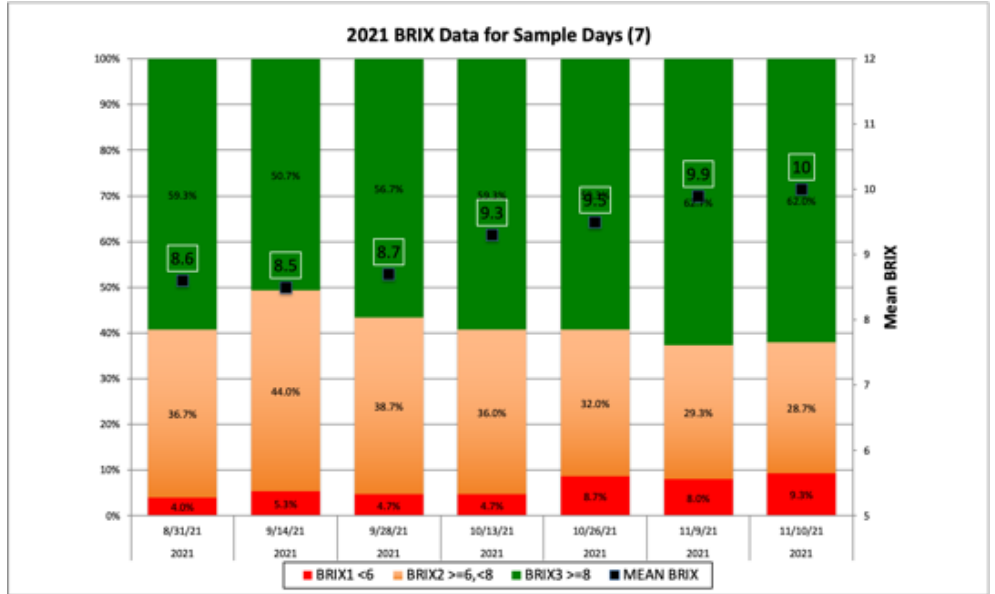


Figure 34. St. Mary's Bay Inside 2021 Preseason Sampling BRIX Indicators

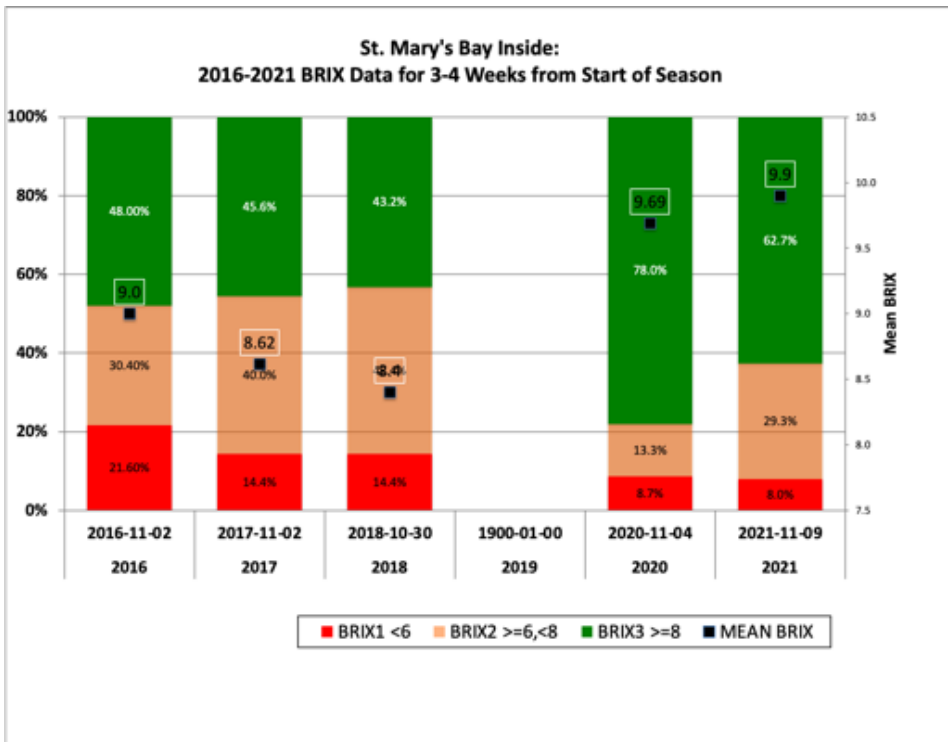


Figure 35. St. Mary's Bay Inside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

The annual trend in the graphic for 3-4 weeks prior to the start of the season shifts toward higher BRIX values as evidenced by the 2020 and 2021 samples with mean BRIX values near 10. These mean BRIX values exceed all values in this series and lends to a positive prediction for good quality in St. Mary's Bay Inside for the 2021-2022 season (Figure 35).

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality categories for each sample date in St. Mary’s Bay Inside are provided in the graphic below. Based on the historical sampling in this location, the 7 sample dates in 2021 are classified overall as M with the last 3 sample dates all at category MH. The likelihood that these 3 sample dates are taken from the MH category is estimated at just over 50%. For these last 3 sample dates, the likelihood that the Lobster Quality category is M or less (M, ML, or L) is collectively estimated as approximately 40% (Figure 36).

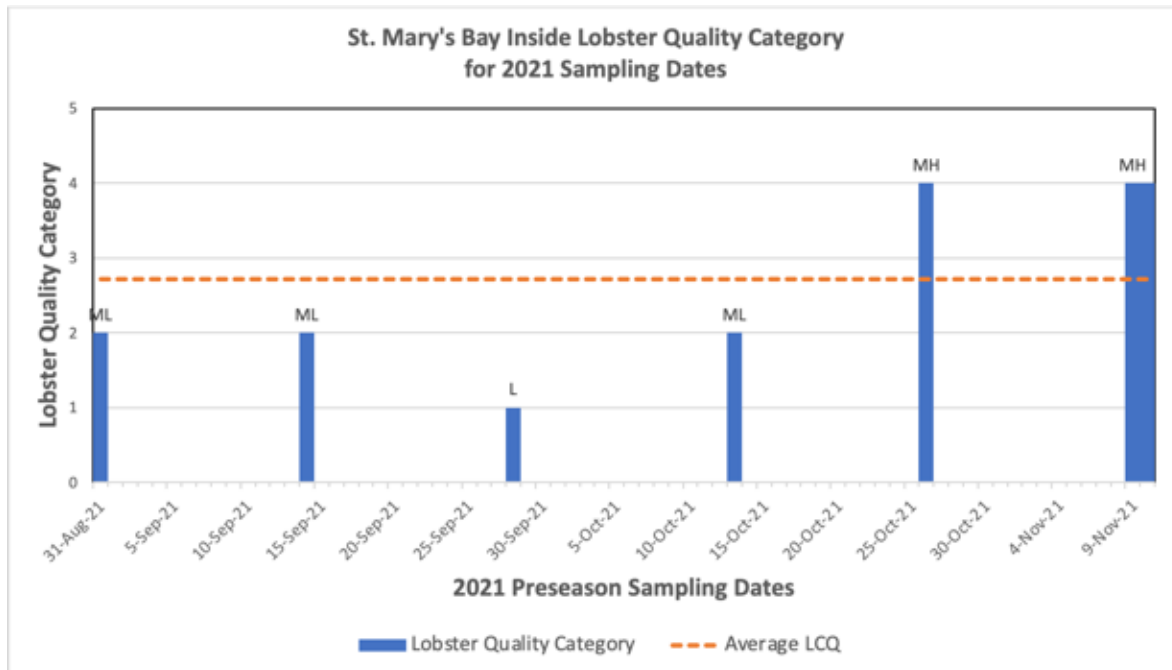


Figure 36. St. Mary’s Bay Inside Lobster Quality Categories for 2021 Preseason Sampling Dates

4.3.8 ST. MARY'S BAY OUTSIDE

Blood Protein (BRIX) Distribution

2021 preseason samples in St. Mary's Bay Outside exhibit a near constant set of mean BRIX values and proportional distributions across the 6 sample dates. The overall mean BRIX values fall in a tight range of moderate mean BRIX values from a minimum of 8.3 (October 12) to a maximum of 8.6 (August 30) with overall moderate mean BRIX of 8.4 (Figure 37).

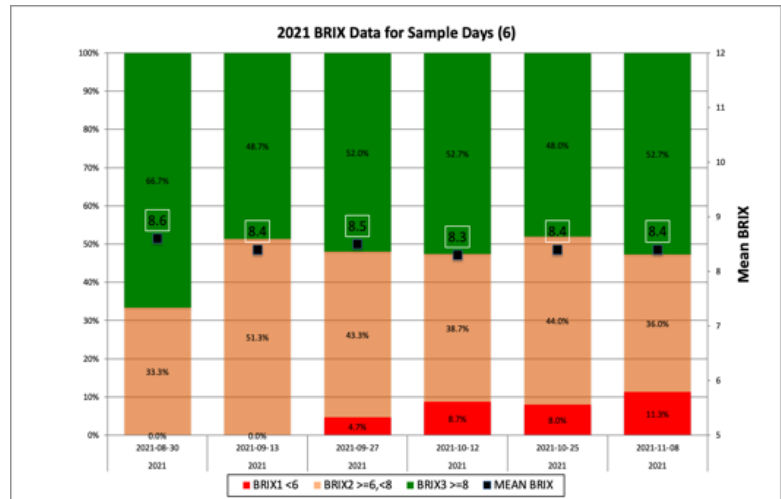


Figure 37. St. Mary's Bay Outside 2021 Preseason Sampling BRIX Indicators

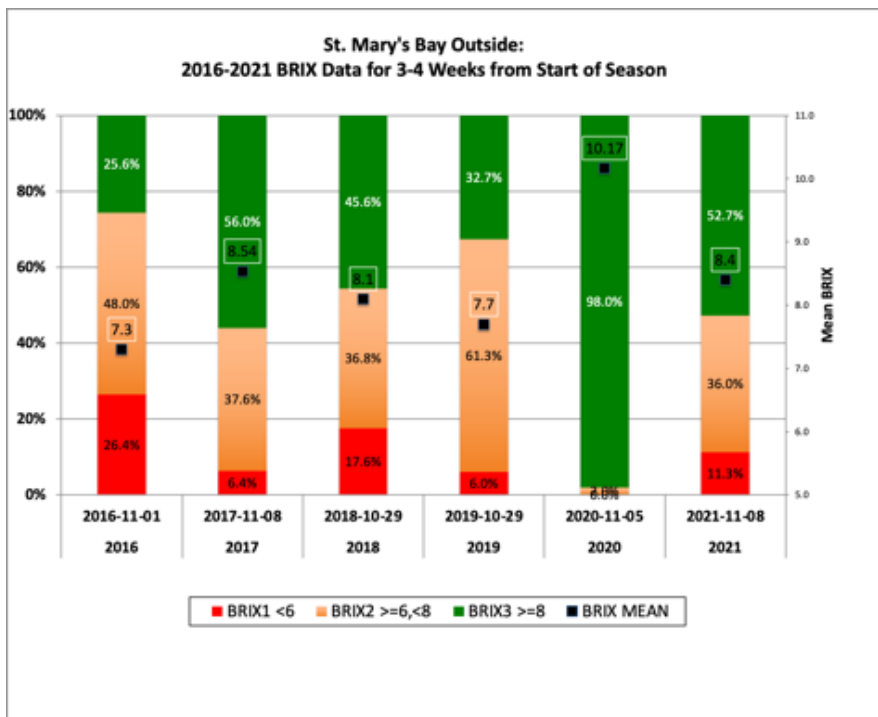


Figure 38. St. Mary's Bay Outside 2012-2021 Preseason Sampling BRIX Indicators 3-4 weeks prior to season start

The annual trend in the graphic for 3-4 weeks prior to the start of the season also shows a moderate mean BRIX of 8.4 for the 2021 sample (November 8). This value is among the highest for this location and time series (the 2020 spike excluded) (Figure 38).

This result is directly comparable to the 2017 BRIX distribution with its mean BRIX value (8.54). "Good" BRIX category proportion for 2021 is over 50%; "Poor" BRIX category proportion is just over 10%.

Consolidated Data Analysis: Lobster Quality Category Classification

The assignment of the Lobster Quality class for each sample date in St. Mary’s Bay Outside are provided in the graphic below. Based on the historical sampling in this location, the 6 sample dates in 2021 are classified as ML (3 dates) or M (2 dates) with the exception of L (first 2021 sample date, August 30).

The overall maximum likelihood category for St.Mary’s Bay Outside is ML estimated at 56%. The likelihood that these data are taken from either the M (30%) or ML (60%) Lobster Quality category is estimated at over 90% considering the last 5 sample dates.

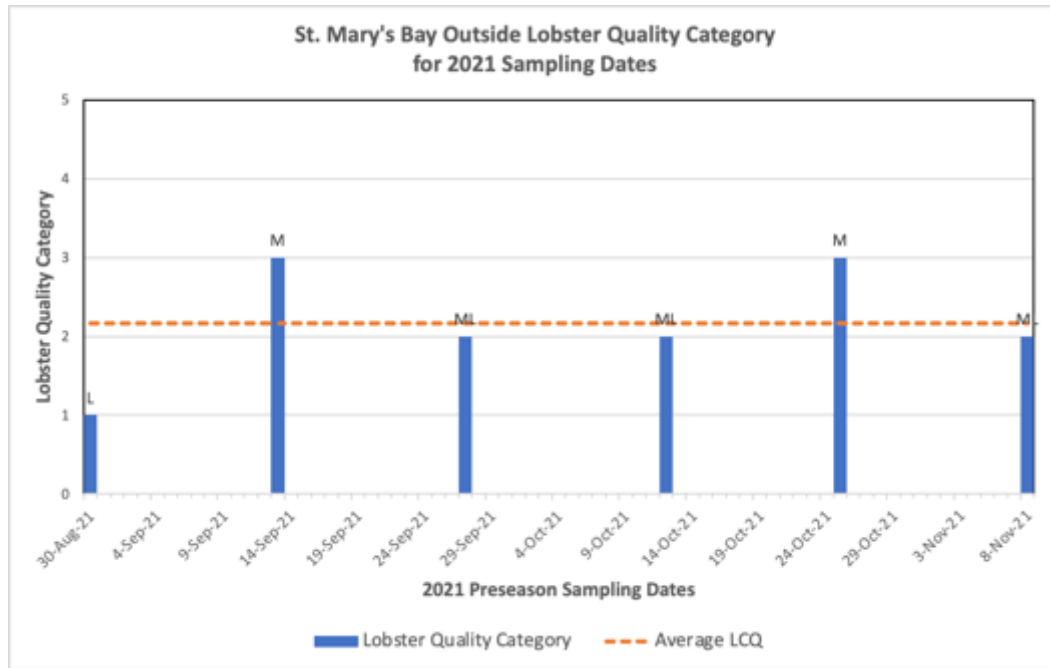


Figure 38. St. Mary’s Bay Outside Lobster Quality Categories for 2021 Preseason Sampling Dates

5 In-season Sampling Data in 2021-2022

The 2021-2022 sampling program included 9 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 5 dates during the last half of December 2020 (15th, 28th, and 30st) and in January 2021 (13th and 24th).

5.1 Sampling Data

In-season samples took place in all inside and outside areas of Yarmouth, Port La Tour, and St. Mary's Bay as summarized in Table 3 below. (In-season samples scheduled in late January for Lobster Bay inside and outside were cancelled due to inclement weather). As per the sampling protocol, in-season samples were comprised of 150 lobsters per location-date.

Table 6. Summary of 2021-22 In-season Sampling Data

Sampling Location	Sampling Subarea	Sampling Date	Harvested Lobsters (Counts#)	Lobsters Sampled (#)	Sample Ave BRIX (units/ml)	Sample % Soft	Sample % Weak	Mean BRIX % Change*
Port La Tour LFA 33	Inside	December 30, 2021	–#	150	13.0	0.67%	0.00%	+56%
		December 15, 2021	–#	150	11.2	0.00%	0.00%	+38%
	Outside	December 30, 2021	–#	150	11.5	0.00%	0.67%	
St. Mary's Bay LFA 34	Inside	January 13, 2022	–#	150	12.0	0.67%	4.00%	+30%
	Outside	January 13, 2022	–#	150	11.3	0.00%	2.00%	+34%
Yarmouth LFA 34	Inside	December 28, 2021	–#	150	11.6	1.33%	1.33%	+40%
		January 24, 2022	–#	150	12.2	0.00%	1.33%	
	Outside	December 28, 2021	–#	150	10.7	0.00%	0.67%	+44%
		January 24, 2022	–#	150	12.0	0.00%	0.00%	
TOTALS	6 Subareas[^]	9 In-season Sampling dates	_#	1,350 Samples In-season	Overall Ave In-season BRIX: 11.72	0.30% In-season Soft	1.11% In-season Weak	Average % Change +40%

#No harvest counts of lobster taken for harvests during in-season sampling periods.

[^]Zero In-season samples were taken in Lobster Bay in 2021-2022.

*Mean BRIX % change compares average preseason BRIX means by location with average in-season BRIX means.

In-season samples had improved overall BRIX indicators over all areas with means exceeding 10 in all in-season sampling dates and overall in-season BRIX mean of 11.72 (versus overall preseason BRIX mean of 8.42 units/ml – Table 3). In-season samples also showed %Soft and %Weak values respectively

of 0.30% and 1.11% on 1,350 samples versus preseason %Soft and %Weak values of 2.09% and 12.49% respectively on 7,039 samples – a decrease of over 85% in %Soft/%Weak values.

The following section compares the in-season BRIX category results for the preseason samples by locations (3) and inside/outside areas.

5.2 Preseason and In-season Comparison

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

5.2.1 Yarmouth Inside In-season Results

There were 9 total sampling periods for Yarmouth Inside including 2 in-season samples in December 2021 and January 2022. As noted previously, the BRIX category pattern was relatively constant over the preseason with steady BRIX mean values between 8.2 and 9.3 over the preseason sampling period and overall preseason mean BRIX of 8.52. (See also Section 4.3.1 – Yarmouth Inside.)

The two in-season samples are both considerably higher than the preseason values with high mean BRIX values of 11.6 and 12.2 units/ml), as indicated in Figure 32 below.

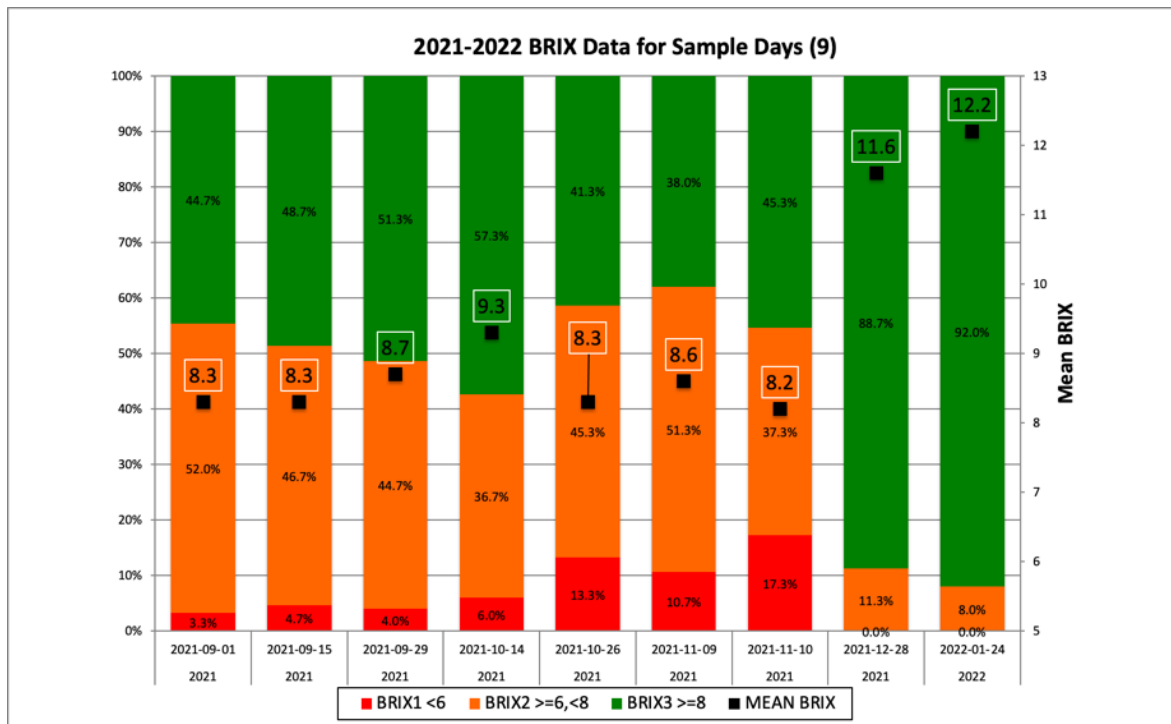


Figure 32. Yarmouth Inside Preseason and In-season Sampling BRIX Indicators

The overall in-season BRIX average (11.9) represents an increase of almost 40% compared to the preseason BRIX average (8.52). Yarmouth Inside BRIX levels improve, as may be expected, as the lobster season progresses, and lobster becomes fully-meated while they may be considered moving from

post-moult into the pre-moult period of the coming calendar year. Thus, for Yarmouth Inside, by end January 2022, lobsters are generally of high quality and considered acceptable for all markets.

5.2.2 Yarmouth Outside In-season Results

There was a total of 8 sampling periods for Yarmouth Outside including 2 in-season sample dates in December 2021 and January 2022. As noted previously, the BRIX category pattern was relatively constant over the preseason with steady BRIX mean values at lower levels between 7.4 and 8.1 over the preseason sampling period and overall preseason mean BRIX of 7.9. (See also Section 4.3.2 – Yarmouth Outside.)

The two in-season samples (mid-December and mid-January) represent marked improvements over the lower preseason BRIX means as noted in Figure 33 below.

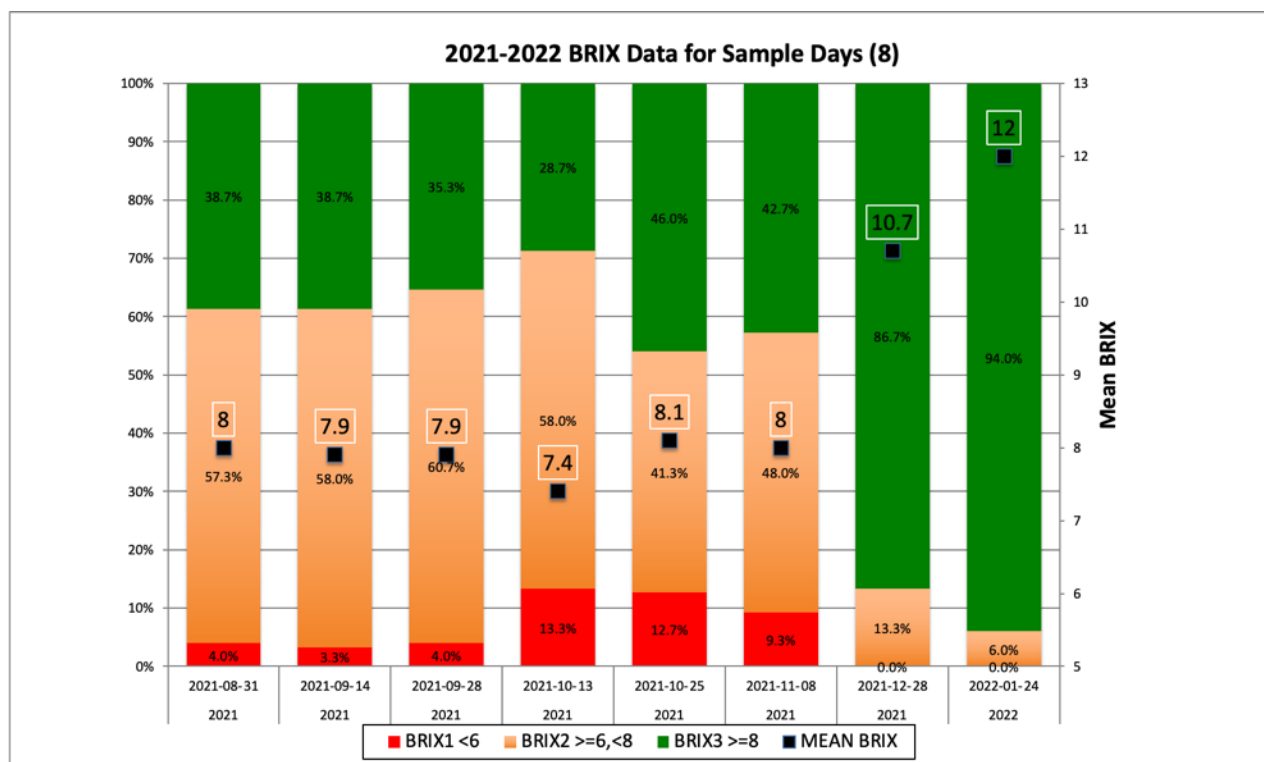


Figure 33. Yarmouth Outside Preseason and In-season Sampling BRIX Indicators

The overall in-season BRIX average (11.35) represents an increase of over 40% compared to the preseason BRIX average (7.9). Yarmouth 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 of the coming calendar year. Thus, for Yarmouth Outside, by end January 2022, lobsters are generally of high quality and considered acceptable for all markets.

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

There were 8 total sampling periods for St. Mary’s Bay Inside including the one in-season sampling date in mid-January 2022. The BRIX category pattern over the preseason period showed a gradual but steady

improvement in mean BRIX values from 8.5 (September) to 10.0 by mid-November. (See also Section 4.3.7 – St. Mary’s Bay Inside.)

The single in-season sample (13th January 2022), shows a jump in mean BRIX to 12 with no incidence of “poor” level BRIX in these samples, as indicated in Figure 34 below.

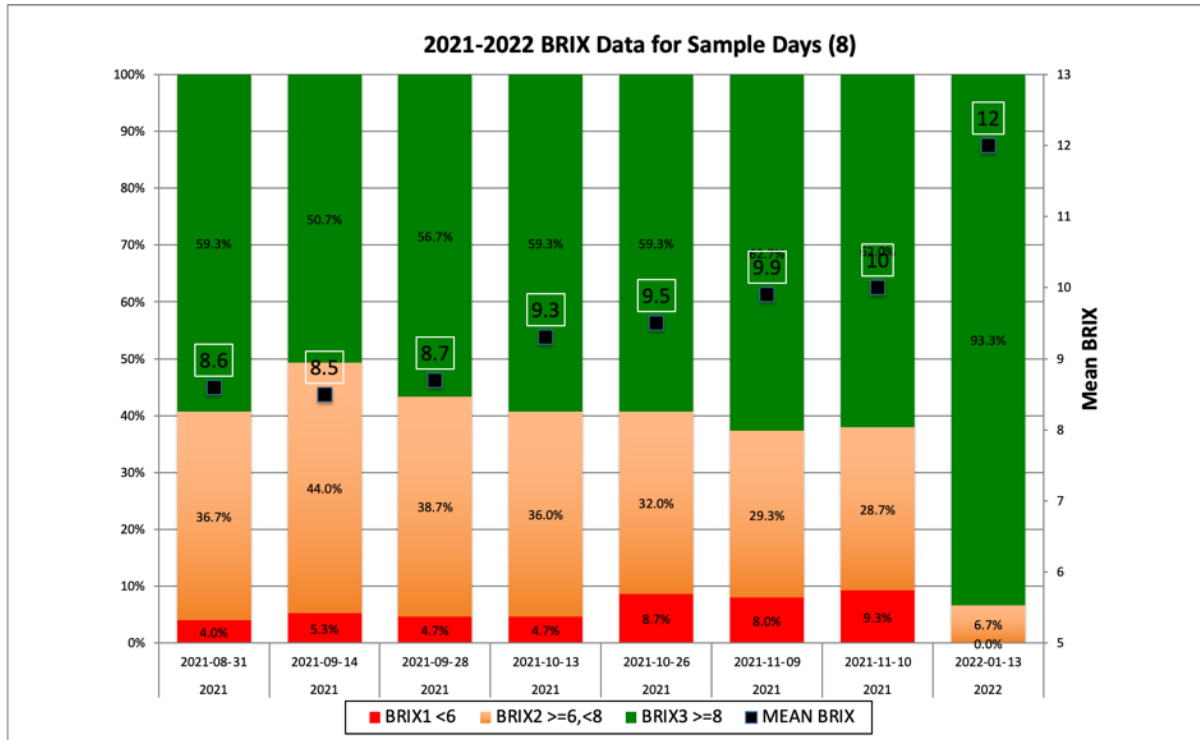


Figure 34. St. Mary’s Bay Inside Preseason and In-season Sampling BRIX Indicators

For St. Mary’s Bay Inside, the mean BRIX of the single in-season sample represents an average increase of +30% over the preseason average mean BRIX value of 9.2. 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 mid-January 2022, lobsters are generally of high quality and considered likely acceptable for all markets.

5.2.4 St. Mary’s Bay Outside

There were 7 total sampling periods for St. Mary’s Bay Outside, including one in-season sample on 13th January 2022 as noted in Figure 35 below. As noted previously, the BRIX category pattern for St. Mary’s Bay Outside was constant over the preseason with BRIX mean values varying only between 8.3 and 8.6 and overall preseason mean BRIX of 8.4. (See also Section 4.3.8 –St. Mary’s Bay Outside.)

The single in-season sample denotes a marked increase to 11.3 or +34% compared to the overall preseason BRIX mean of 8.4. Once again, 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 year 2022.

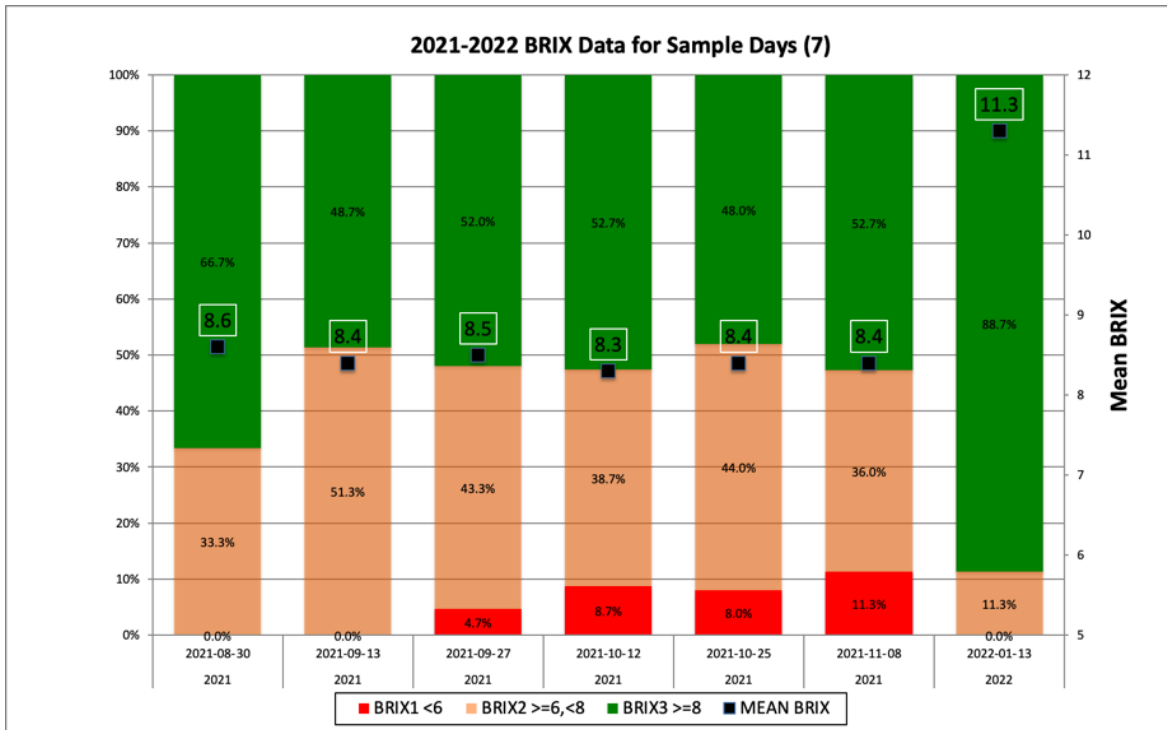


Figure 35. St. Mary’s Bay Outside Preseason and In-season Sampling BRIX Indicators

For St. Mary’s Bay Outside, based on the in-season mid-January 2022 sample, lobsters there are generally of high quality and considered likely acceptable for all markets.

5.2.5 Port La Tour Inside In-season Results

There were 9 total sampling periods for Port La Tour Inside including the one in-season sampling date of 30th December 2021. The BRIX category pattern over the preseason period showed a strong improvement in mean BRIX values from 6.7 (September) to approximately 10 from the beginning of November over 3 sample dates to the beginning of the commercial season. (See also Section 4.3.5 – Port La Tour Inside.)

The single in-season sample (13th January 2022), shows a jump in mean BRIX to 13 with no incidence of “poor” level BRIX in these samples, as indicated in Figure 36 below. For Port La Tour Inside, the mean BRIX of the single in-season sample (13) represents an increase of +56% over the preseason average mean BRIX value of 8.35. 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 2022, lobsters there are generally of high quality and considered likely acceptable for all markets.

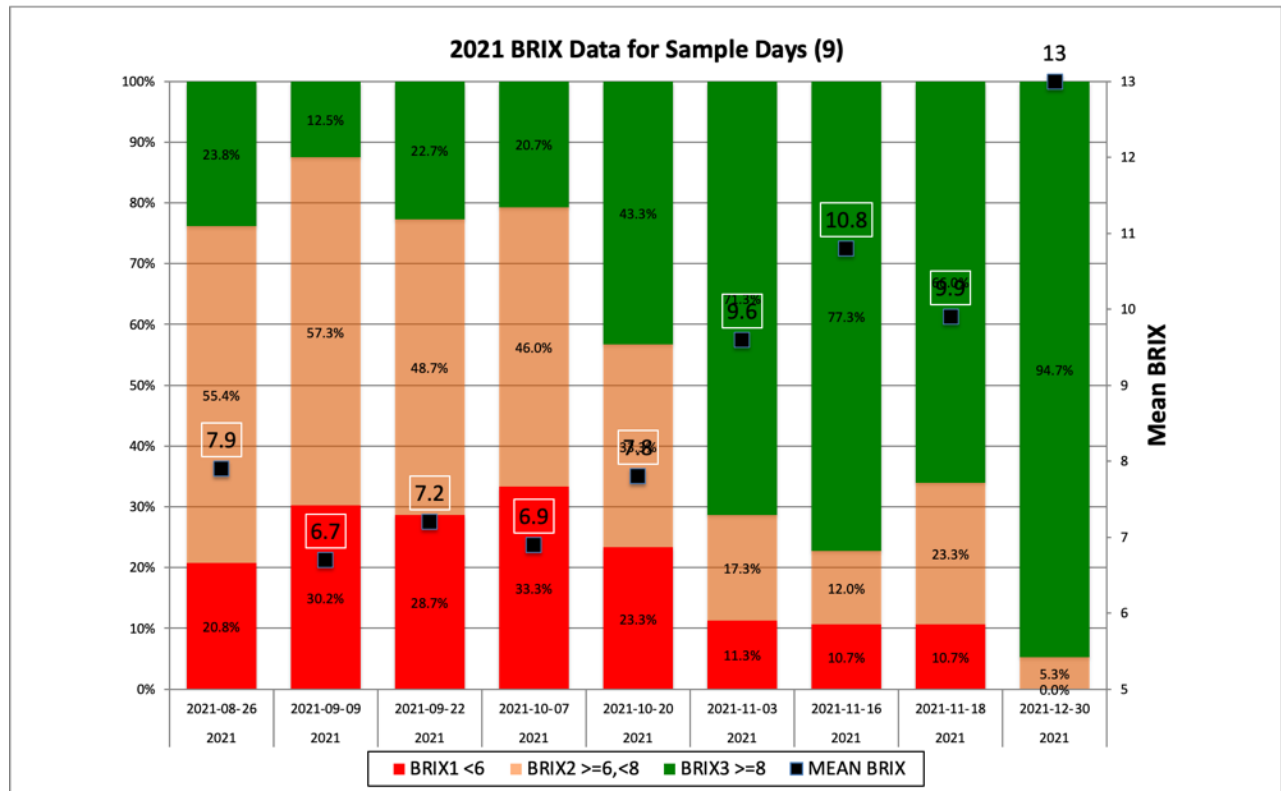


Figure 36. Port La Tour Inside Preseason and In-season Sampling BRIX Indicators

5.2.6 Port La Tour Outside

There were 9 total sampling periods for Port La Tour Outside, including two in-season sample dates in December (13th and 30th) 2021 as noted in Figure 37 below. As noted previously, the BRIX category pattern for Port La Tour Outside exhibits gradual improvement over the preseason with BRIX mean values moving from a low of 6 (end September sample) to a high of 7.8 (mid-November sample) with overall preseason mean BRIX of 7.06. (See also Section 4.3.6 – Port La Tour Outside.)

The two in-season sample denotes a marked increase to an average of 11.35 or +38% compared to the overall preseason BRIX mean of 7.06. Once again, 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 year 2022.

For St. Mary's Bay Outside, based on the in-season mid-January 2022 sample, lobsters there are generally of high quality and considered likely acceptable for all markets.

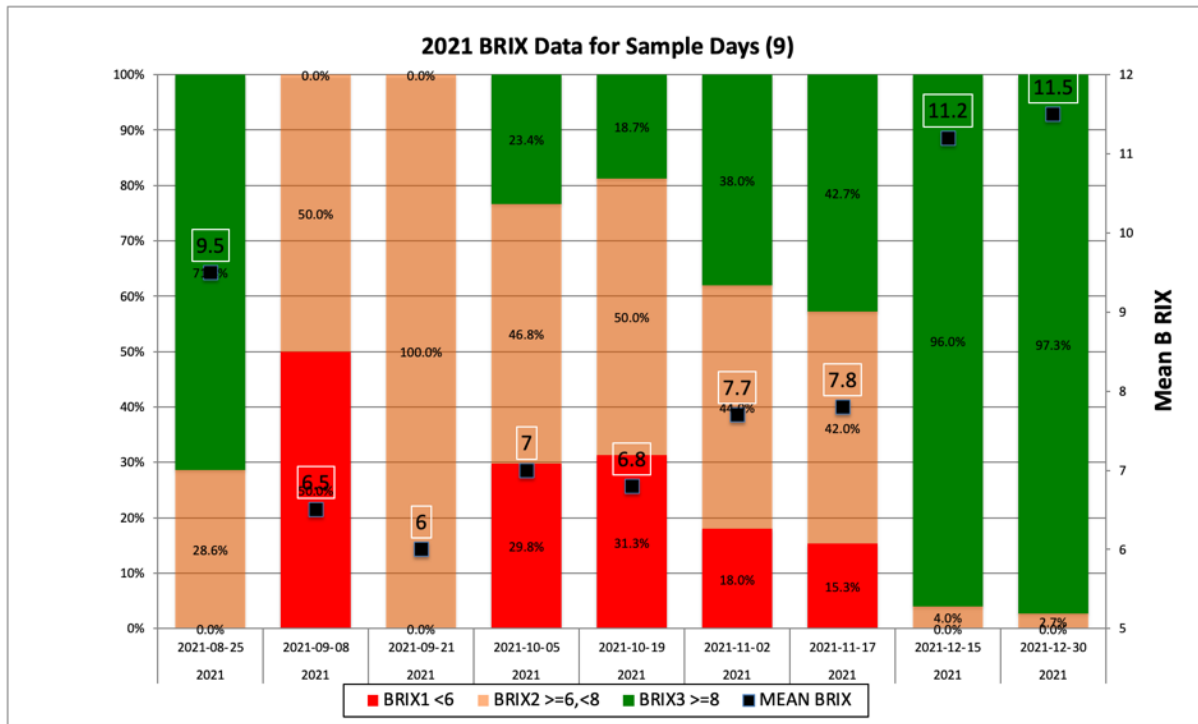


Figure 37. Port La Tour Outside Preseason and In-season Sampling BRIX Indicators

Overall, it is clear that the 9 in-season samples in every one of the 6 sampling locations yields results that show marked improvement when compared to the preseason BRIX category indicators by location. As noted in Table 6 above, the average mean BRIX improvement of preseason over in-season values is just over +40%.

From a statistical perspective, the hypothesis that the in-season mean BRIX values come from the same population as the preseason BRIX values is not accepted at the 5% level. In other words, we reject, with 95% confidence, the null hypothesis that the in-season BRIX values are derived from the same population as the preseason BRIX values. For details, see also Lane et al (2022, In progress).

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

6.1 Annual Lobster Quality and Landings Comparison

In the 2021 report, 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 final report 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 therefore 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).

Consequently, 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

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

processed product until such time as the BRIX levels improve.

These options can be evaluated in advance and based on modelling of the historical annual lobster BRIX observations into the commercial season combined with price trends and dynamic behaviour, e.g., based in inventories, 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.

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 2022 Preseason Sampling Survey Outlook

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

Furthermore, future reports will seek:

- to establish a lobster grading function consistent with industry grading schemes (e.g., A,B,C);
- to initiate a program of bottom temperature data collection and/or modelling analyses together with analyses associated with the changing marine climate, and the potential for creating conditions that may lead to increased incidences of shell disease;
- to develop data on lobster movement via a site-specific and directed tagging initiative designed to test defined hypotheses on lobster movement, e.g., west-east movement across the Gulf of Maine into Scotia-Fundy;
- to develop a specific Quality Indicator time series for each location and inside-outside area that combines lobster landings, BRIX, and other quality measures across the subareas of LFA34;
- to analyses lobster data at depth re impact on BRIX, movement patterns from inside to outside areas at different depths;
- to develop statistical analyses using the information in the entire ALMQ database 2006-2022 to discriminate years into quality categories for direct comparison and future analysis and prediction; and, finally,
- to develop a prediction score in order to evaluate the performance of the preseason summary report predictions compared to the start of the LFA33 and 34 commercial seasons.

7 References

- Atlantic Canada Lobster. 2009. Glossary of Lobster Terms. "Quarters". Accessed March 26, 2020 at: https://www.tastelobster.ca/eng_home.php?lang=eng3&page=13
- Berry, B., Thériault, M., and Lane, D. 2016. Lobster Quality Monitoring Program: Southwest Nova Scotia (LFA 33 and 34). Presentation to the Minister of Fisheries and Oceans, Canada, Pubnico, N.S., July 27. Prepared by the Centre de recherche marine, Université Sainte-Anne, 15p.
- Coldwater Lobster Association. 2022. Fishermen working together for a better future. Accessed March 7, 2022 at: <https://www.coldwaterlobster.ca>
- Factor, J.R. (Ed.) 1995. Biology of the Lobster (*Homarus americanus*). Academic Press: San Diego. 528p.
- Fisheries and Oceans Canada. 2021. Maritimes Region Lobster Economic Update. Prepared for the Maritimes Region Lobster Advisory Committee, September 24. 41p.
- Fisheries and Oceans Canada. 2020. Lobster Fishing Areas 27 – 38: Integrated Fisheries Management Plan. (Updated 3-31-2020.) Accessed March 5, 2021 at: <https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/maritimes/2019/inshore-lobster-eng.html>
- Fisheries and Oceans Canada. 2018. Seafisheries Landings 2014-2018. Accessed March 31, 2020 at: <http://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm>
- FSRS. 2022. Fishermen & Scientists Research Society. Atlantic Lobster Moulting and Quality Project, 2006-2015. Accessed March 7, 2022 at: <https://fsrsns.ca/atlantic-lobster-moult-and-quality-almq/>
- Gardner, M., Marriott, H., Rodger, R., Sackton, J. 2010. From Trap to Table - A Long Term Value Strategy for the Canadian Lobster Industry. October. Prepared for the Lobster Council of Canada by Gardner-Pinfold Associates. 160p.
- Gooch, M., Marenick, N., Fewer, J., Arenburg, H., Phillips, K., Laplain, D., Dent, B. 2015. To determine how Nova Scotia's lobster industry can increase its competitiveness and profitability — a pilot project. Final Report for the Catch-to-Plate Committee. January 28. 34p.+appendix.
- Gorman, M. 2016. Lobster-quality monitoring project already paying off. CBC News. September 16. Accessed March 31, 2020 at: <https://www.cbc.ca/news/canada/nova-scotia/lobsters-quality-fishermen-eastern-shore-1.3765682>
- Lane, D., Gurney, B., Mulock, H., Mattick, K., Thériault, M., and Mdaini, Z. 2022. Statistical Analyses for Lobster Quality Determinants and Predictions. Working Paper #11, Lobster Quality Research and Innovation Centre (LQRIC) Working Paper Series. Centre de recherche marine, Université Sainte-Anne. 25p. (In progress)
- Mattock, K., Mulock, H., and Lane, D. 2021a. Lobster Quality 2021 Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report. November. 27p. Accessed March 7, 2022 at: <https://www.coldwaterlobster.ca/atlantic-lobster-moult-and-quality-project/>

- Mattock, K. Mulock, H., and Lane, D. 2021b. Lobster Quality 2020-2021 Preseason and In-Season Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Final Report. March. 45p. + appendices. Accessed March 7, 2022 at: <https://www.coldwaterlobster.ca/atlantic-lobster-moult-and-quality-project/>
- Mattock, K., Mulock, H., and Lane, D. 2020. Lobster Quality 2020 Preseason Sampling Program, Southwest Nova Scotia LFA33 & LFA34: Preseason Summary Report. November. 24p. Accessed March 7, 2022 at: <https://www.coldwaterlobster.ca/atlantic-lobster-moult-and-quality-project/>
- Nova Scotia. 2022. Seafood Certification Promotes Nova Scotia Companies to World Markets. Nova Scotia Department of Fisheries and Aquaculture, News Release. February 25. Accessed March 7, 2022 at: <https://novascotia.ca/news/release/?id=20220225001>
- Nova Scotia. 2020. Lobster Quality Research and Innovation Centre to Help Fishery. Nova Scotia Department of Fisheries and Aquaculture, News Release. February 26. Accessed March 6, 2020 at: <https://novascotia.ca/news/release/?id=20200226009>
- Nova Scotia. 2017a. Nova Scotia Launches International Seafood Brand. Department of Fisheries & Aquaculture, Commercial Fisheries. Accessed July 5, 2018 at: <https://novascotia.ca/news/release/?id=20170302005> and <https://www.nsseafood.com/seafood/canadian-lobster>
- Nova Scotia. 2017b. Province Announces Nova Scotia-China Live Lobster Quality Project. Department of Fisheries & Aquaculture, Commercial Fisheries. Accessed July 5, 2018 at: <https://novascotia.ca/news/release/?id=20170215001>
- Retzlaff, A., R. Claytor, B. Petrie, C. Frail, J. Tremblay, D. Pezzack, and J. Lavallée. 2007. Variation in molt timing and market quality in the American lobster *Homarus americanus*. Bedford Institute of Oceanography: 2006 in Review. Cat. No. Fs101-3/2006E, ISBN: 978-0-662-46177-7, ISSN: 1499-9951. 22–26.
- Thakur, K., Revie, C., Stryhn, H., Scott Tibbetts, S., Lavallee, J., Vanderstichel, R. 2017. Risk factors associated with soft-shelled lobster *Homarus americanus*) in southwestern Nova Scotia, Canada. FACETS. 2:15-33.
- Thériault, G., Hanlon, J., and Creed, L. 2013. Report of the Maritime Lobster Panel. November. 96p. Accessed March 31, 2020 at: <https://novascotia.ca/fish/documents/Maritime-Lobster-Panel-Report-NOV1.pdf>
- Thériault, M., David, A., Frame, S., Mdaini, Z., and Lane, D. 2021 (revised). Lobster Quality Determinants for Product Grading. Working Paper #8, Lobster Quality Research and Innovation Centre (LQRIC) Working Paper Series. Centre de recherche marine, Université Sainte-Anne. 29p. (Revision in progress)
- Université Sainte-Anne. 2022. Live Lobster Quality Certification Programme. Accessed March 7, 2022 at : <https://www.usainteanne.ca/en/lqcp>
- Université Sainte-Anne. 2020. Lobster Quality Research & Innovation Centre. Accessed March 6, 2020 at : <https://www.usainteanne.ca/en/community-and-industry-liaison>

8 Acknowledgements

Université Sainte-Anne and Coldwater Lobster Association acknowledges, with thanks, the Fishermen & Scientists Research Society (FSRS) for the indispensable use of their historical longitudinal dataset, 2006-2015. We also take this opportunity to thank those who contributed to the 2021-2022 Preseason and In-season Lobster Moults & Quality Survey. Your financial support toward the continuation of the lobster survey in LFAs 33 & 34 allows for a better understanding of the factors that control the variation in lobster quality. This information can be used for more accurate decision-making regarding resource management, live storage and shipping and ultimately, increase the value to the industry. As an industry, we must collaborate to ensure that the lobster industry remains strong and vibrant. We appreciate and thank all of you for your continued support for this important scientific study for the benefit of the lobster sector in southwest Nova Scotia.

To the captains and crew of the *Betty Ann & Brats*, *Candace Hannah*, *Little Lady I*, and *Marg and I*, thank you for your valuable contribution. Your commitment to this scientific data gathering, particularly during the challenging 'fisheries dispute' within the coastal waters of St. Mary's Bay and off of Yarmouth, is commendable and demonstrates industry's invested interest in fisheries science. Lastly, to our dedicated fisheries technician, 'Kiwi Karl' – thank you for your unwavering commitment to fisheries research and providing your expertise and insight into the lobster fishery.



Contact:

**Coldwater Lobster Association 368 Main Street,
Suite 105 Yarmouth, NS, B5A 1E9
(902) 742- 5247**

Email: admin@coldwaterlobster.ca

Website: www.coldwaterlobster.ca

Contact:



**Centre de recherche et d'innovation sur la qualité du homard/
Lobster Quality Research & Innovation Centre
Centre de recherche marine, Université Sainte-Anne
3433 route 206, Petit de Grat, Nouvelle-Ecosse B0E 2L0
(902) 295-8095**

Email : Daniel.Lane@uSainteAnne.ca

Website: <https://www.usainteanne.ca/centre-de-recherche-marine>
<https://www.usainteanne.ca/en/lqric>

Lobster Quality 2021-2022

Preseason & In-season Sampling Program

Southwest Nova Scotia LFA33 & LFA34

Final Report:
APPENDICES

March 2022

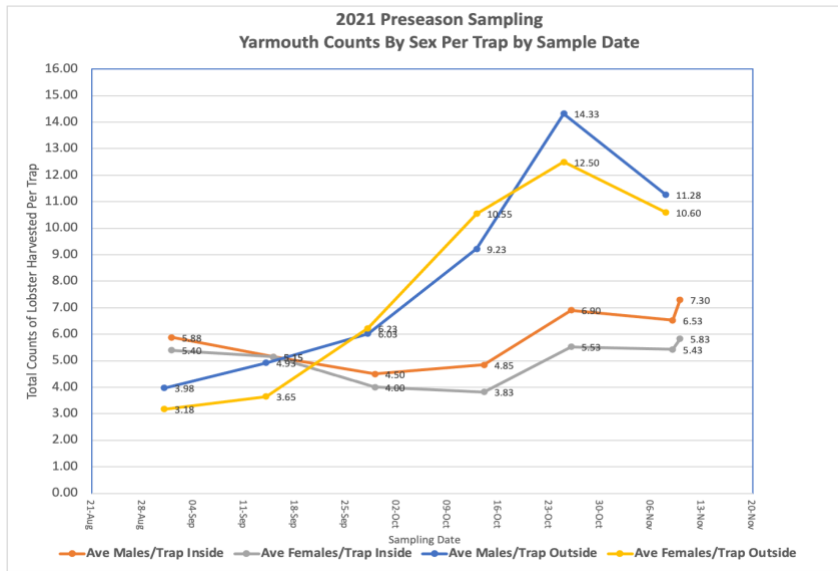
Appendices

Appendix A

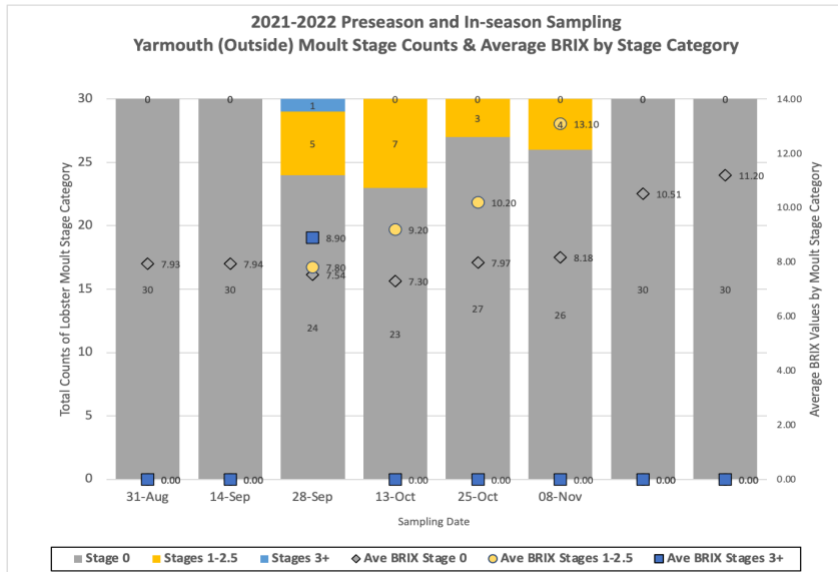
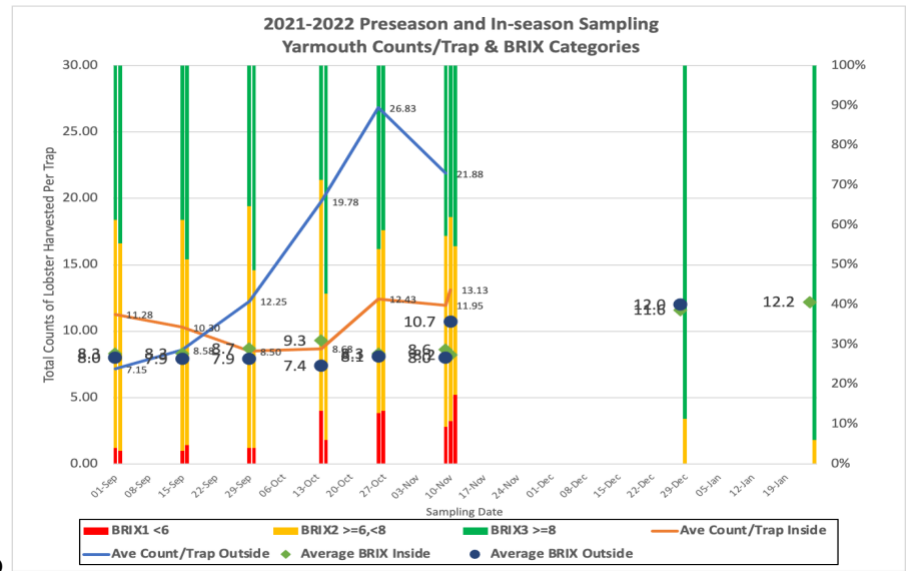
Harvested and Sampled Lobster Count Location Graphics

This appendix presents the graphical data summary of the 2021-2022 pre-season 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.

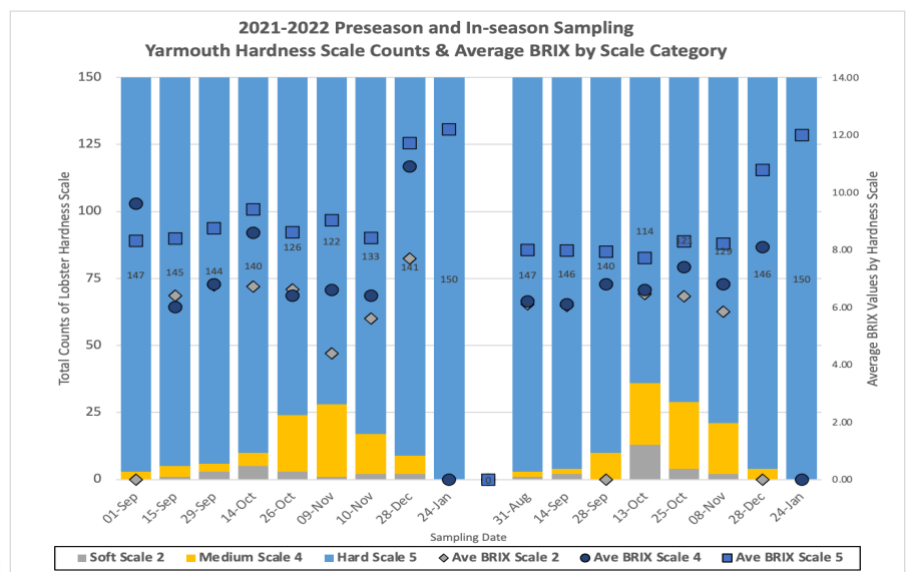
- A.1 Location graphics (4 pages) - lobster counts (harvested and sampled) information:
 - a. Counts of lobster harvested per trap by sex for Inside & Outside areas
 - b. Counts of lobster harvested per trap and BRIX for Inside & Outside areas
 - c. Counts of lobster sampled by Molt Stage - Outside area
 - 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



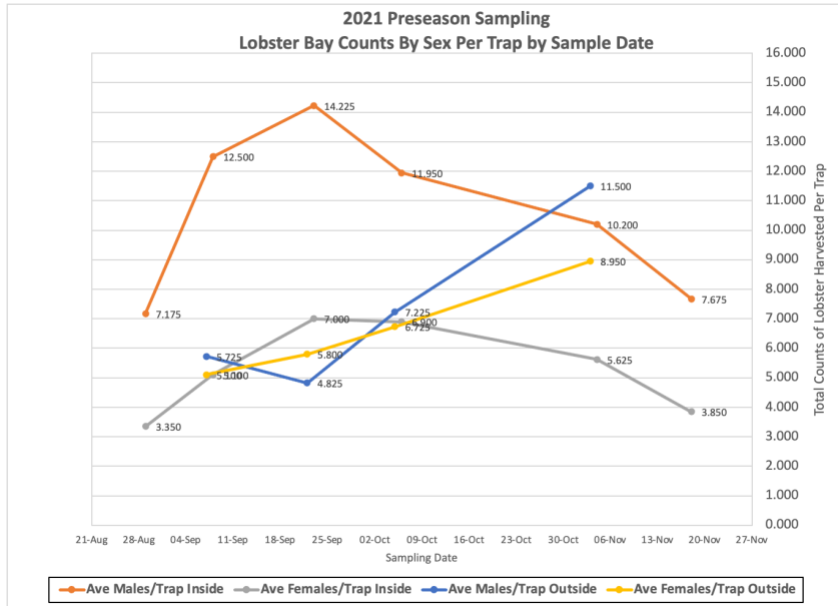
a b



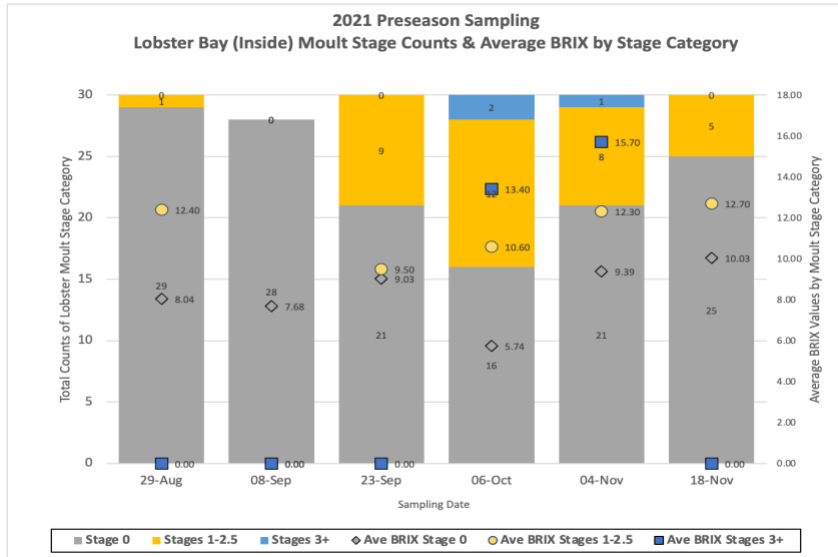
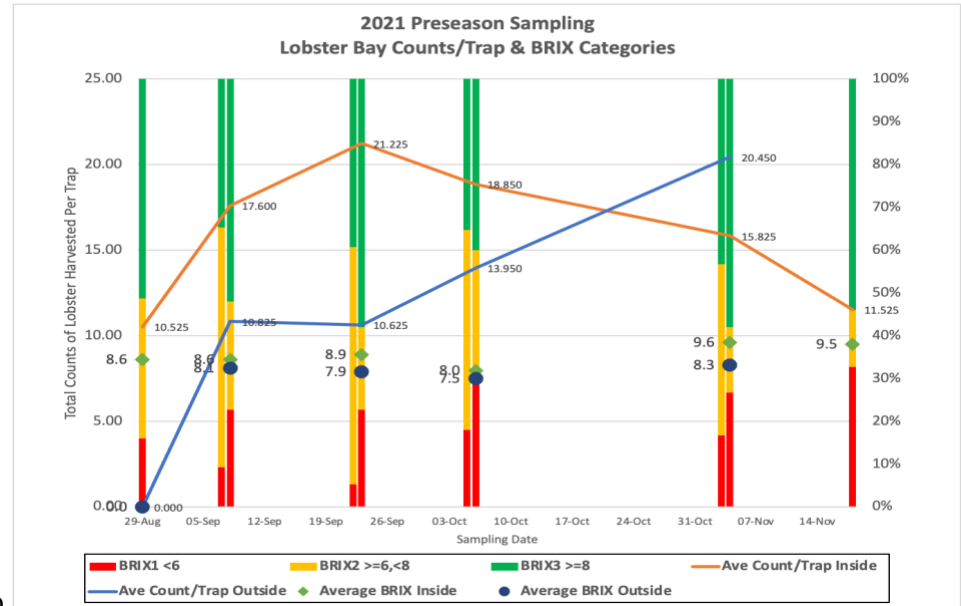
c d



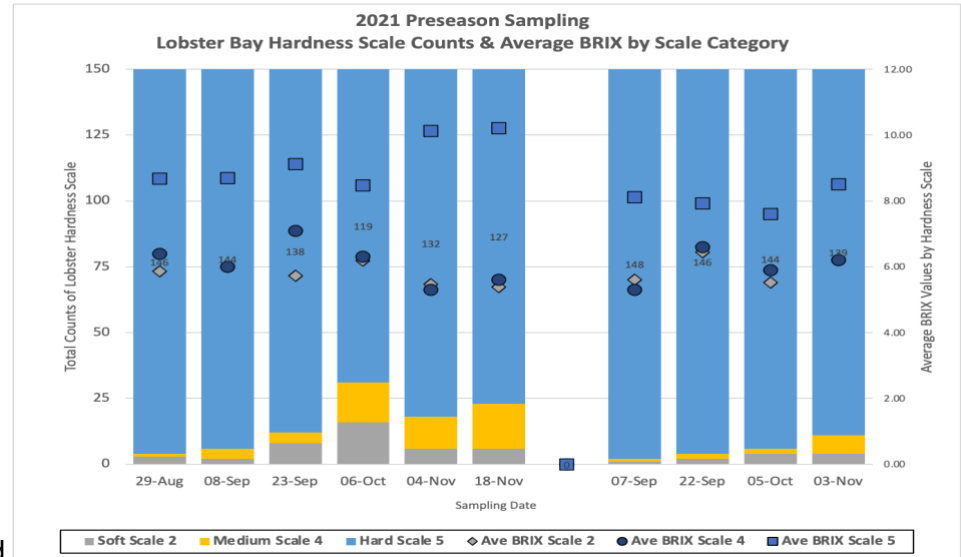
(1) Yarmouth Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moulting Stage - Outside area; (d) Bottom right – Counts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



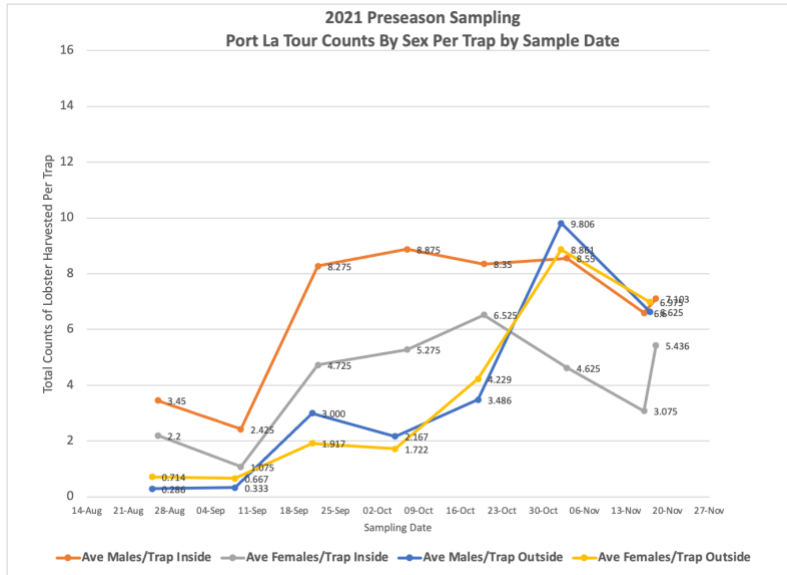
a b



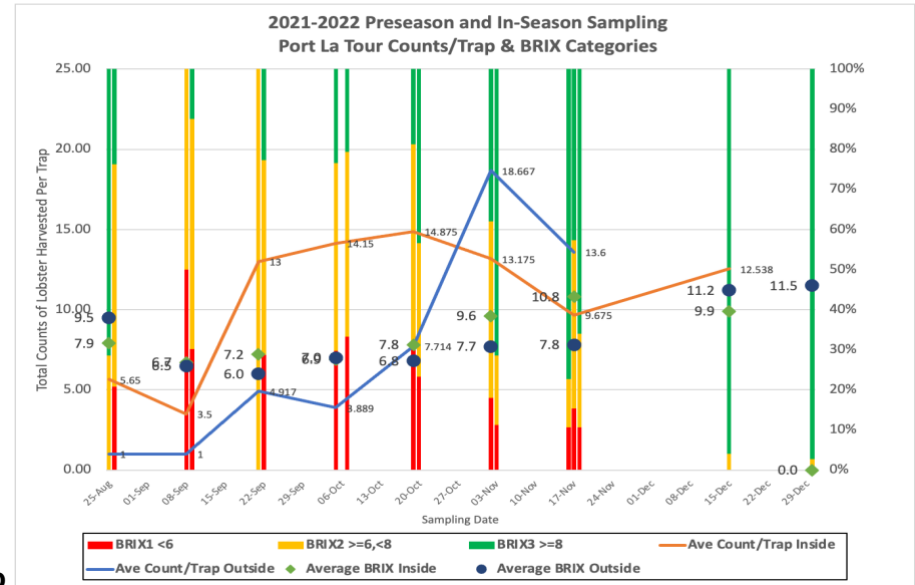
c d



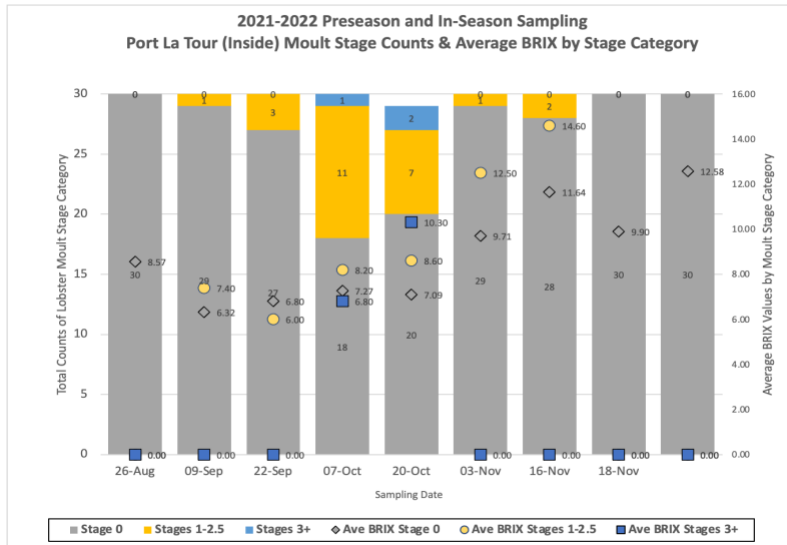
(2) Lobster Bay Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moulting Stage - Inside area; (d) Bottom right - Counts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



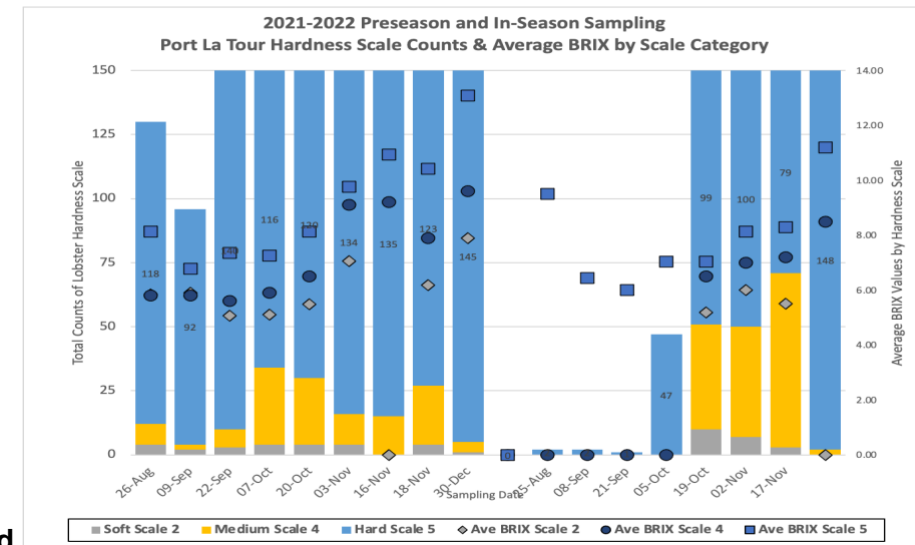
a



b

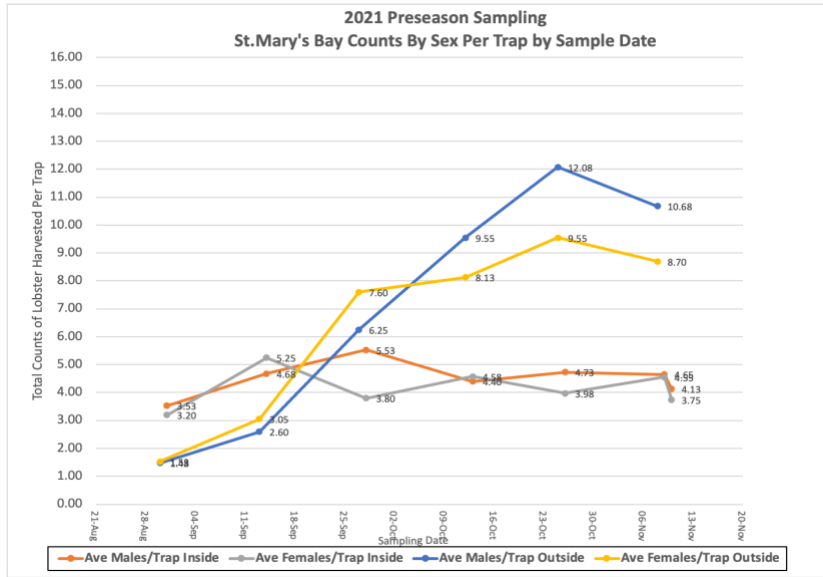


c

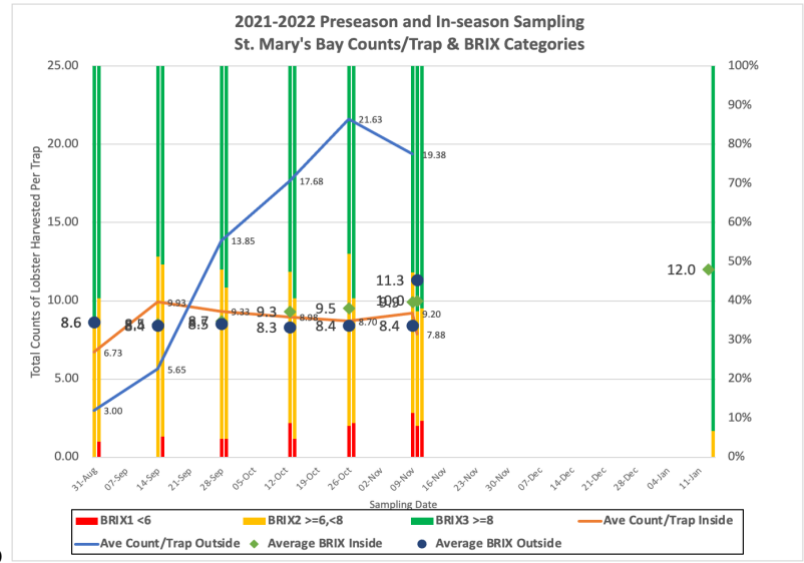


d

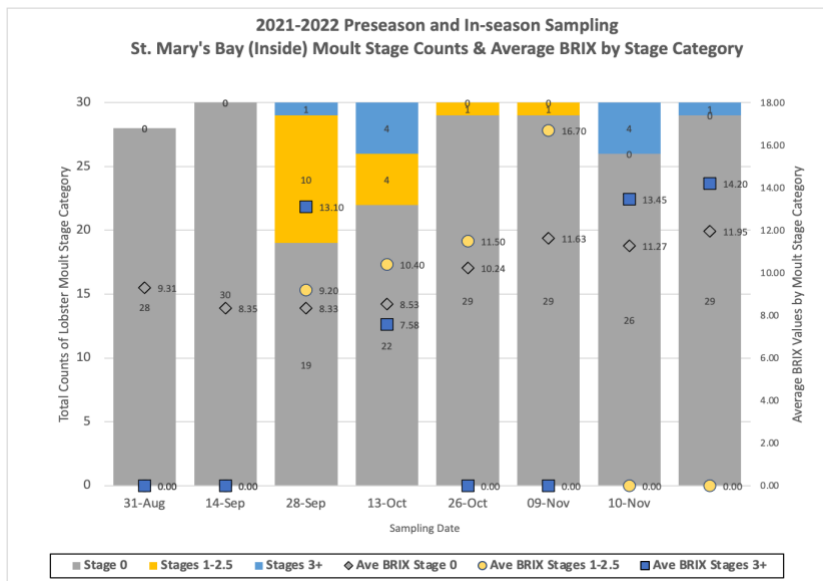
(3) Port La Tour Graphics: (a) Top left - Counts of lobster harvested per trap by sex for Inside & Outside areas; (b) Top right - Counts of lobster harvested per trap and BRIX for Inside & Outside areas; (c) Bottom left - Counts of lobster sampled by Moulting Stage - Inside area; (d) Bottom right - Counts of lobster sampled by Hardness and BRIX for Inside (left dates) and Outside areas (right dates)



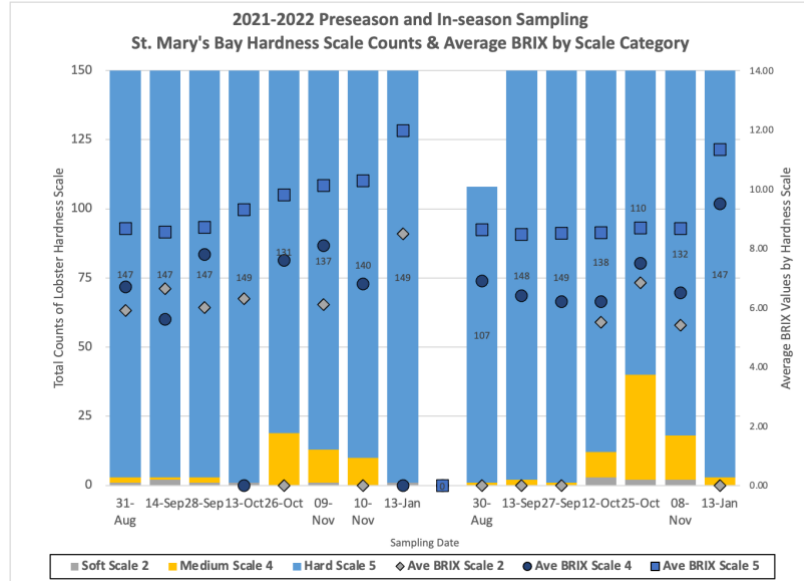
a



b

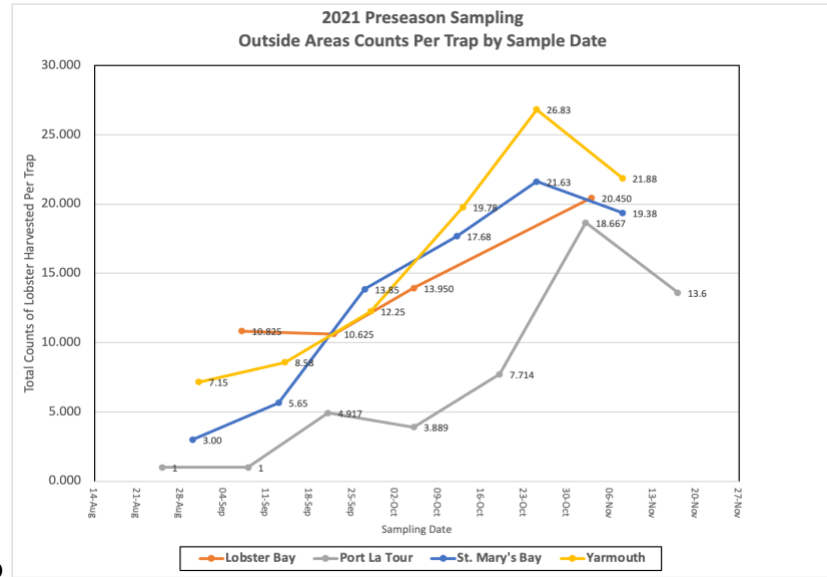
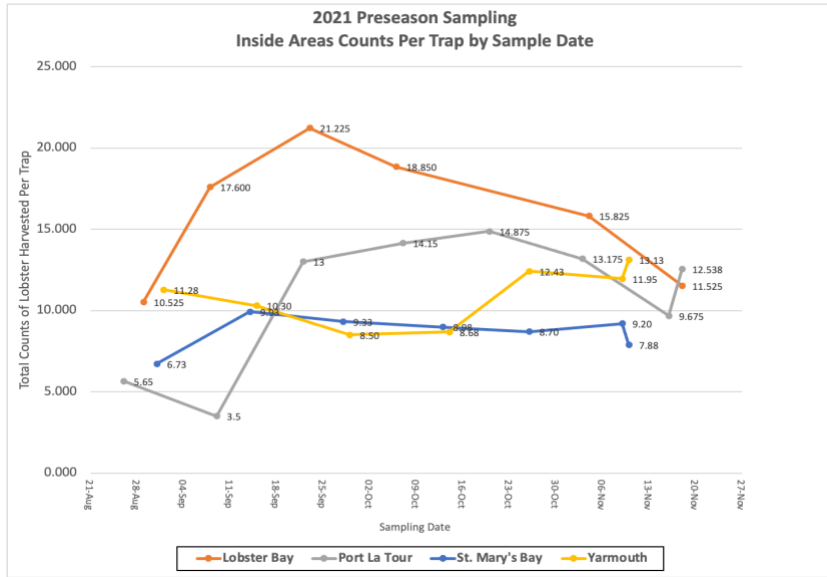


c

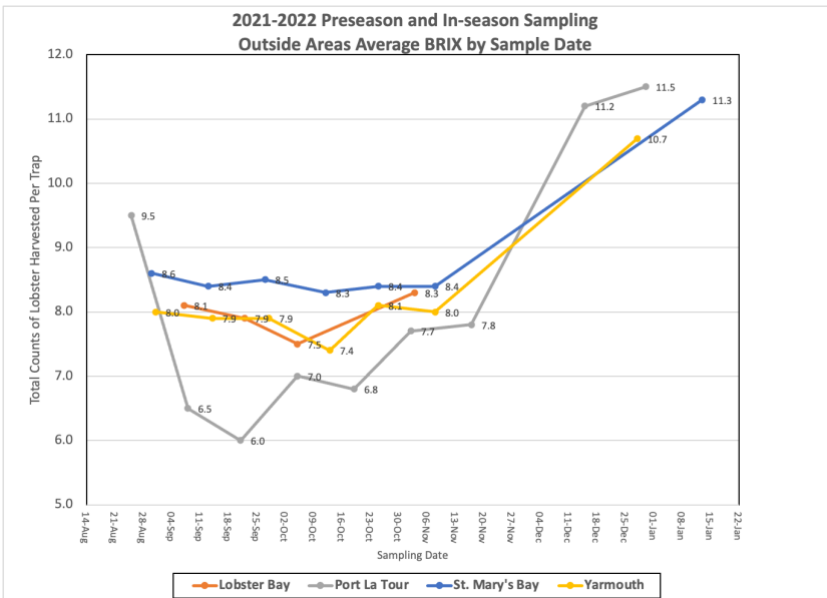
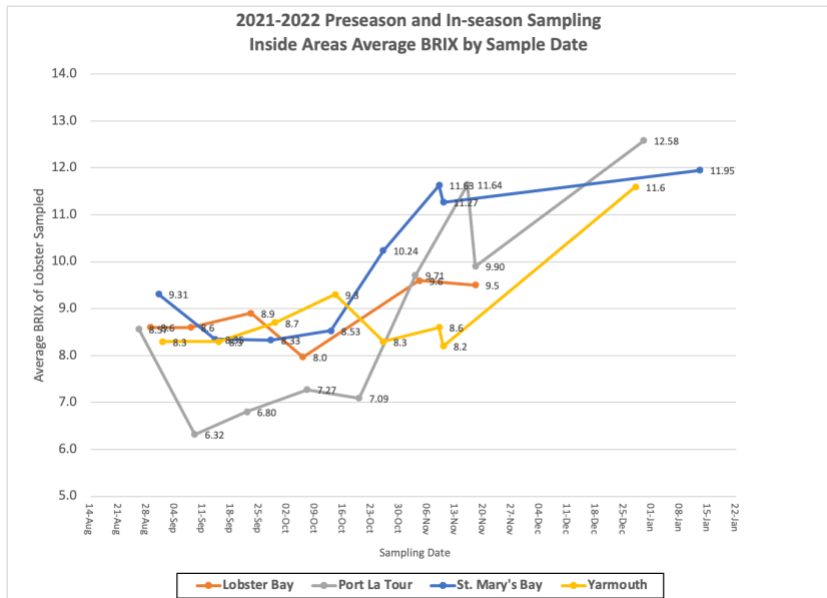


d

(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 Moulting 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 BRUX per sample by location of Inside areas; (d) Bottom right - Average BRUX per sample by location of Outside areas

Appendix B

Berried Females Graphics

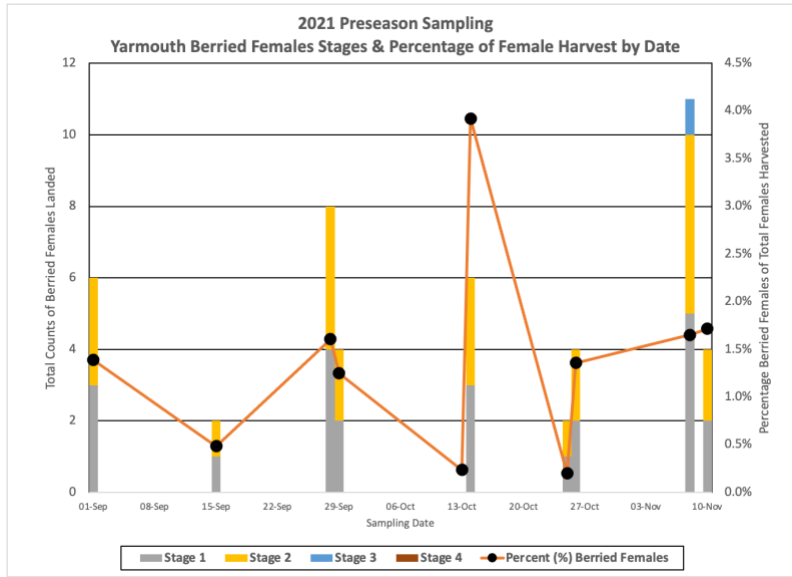
This appendix presents the berried females graphical data summary of the 2021-2022 preseason and in-season sampling surveys for the 4 sample locations that include the inside and outside areas of the locations: (1) Yarmouth; (2) Lobster Bay; (3) Port La Tour; and (4) St. Mary's Bay.

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

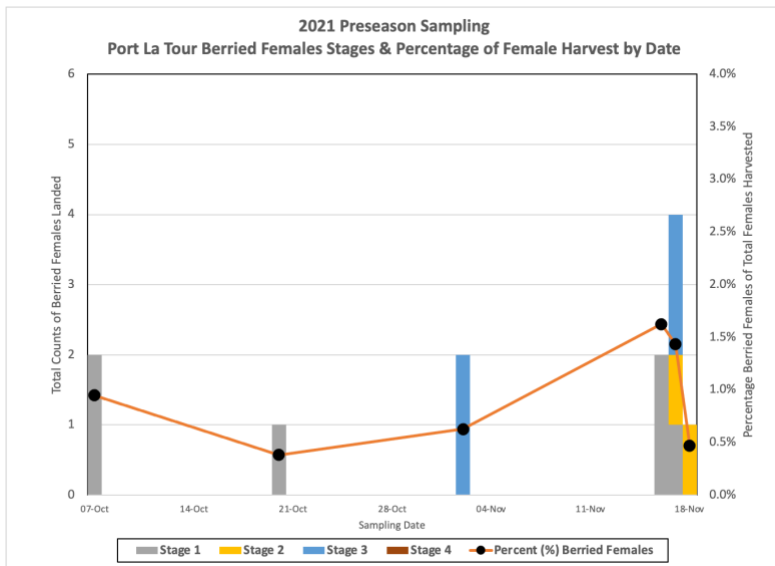
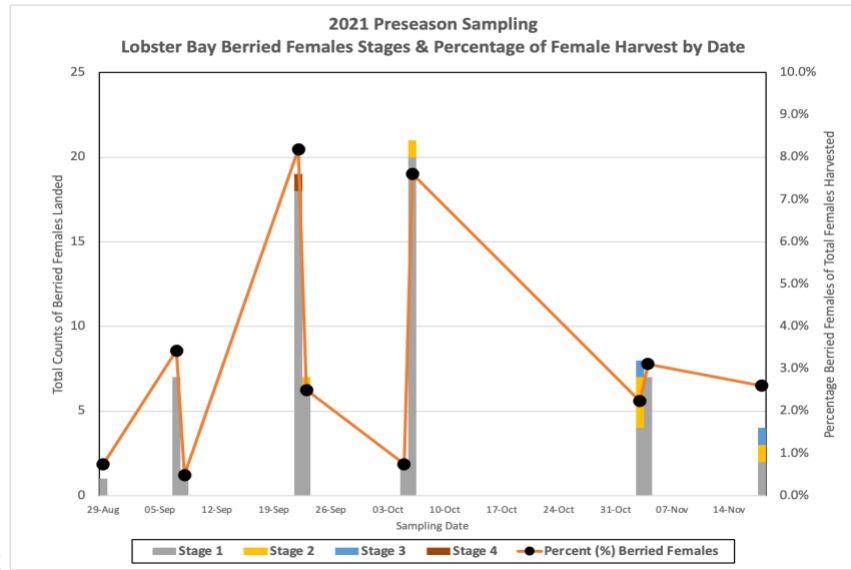
- 1) Berried females sampled and percent of harvest for Yarmouth Inside & Outside areas
- 2) Berried females sampled and percent of harvest for Lobster Bay Inside & Outside areas
- 3) Berried females sampled and percent of harvest for Port La Tour Inside & Outside areas
- 4) Berried females sampled and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

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

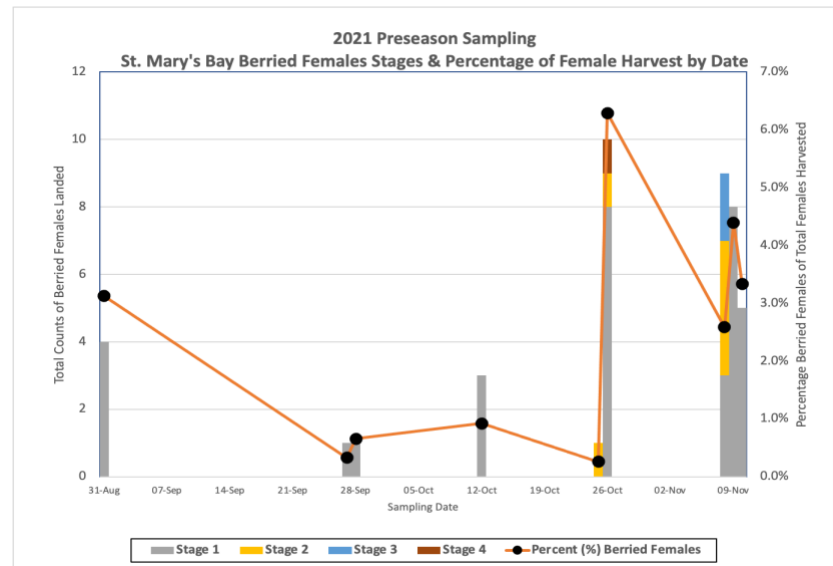
- a) Berried females Stage 1 counts for Inside areas
- b) Berried females Stage 1 counts for Outside areas
- c) Berried females Stage 2 counts for Inside areas
- d) Berried females Stage 2 counts for Outside areas
- e) Berried females Stages 3 & 4 counts for Inside areas
- f) Berried females Stages 3 & 4 counts for Outside areas



1 2

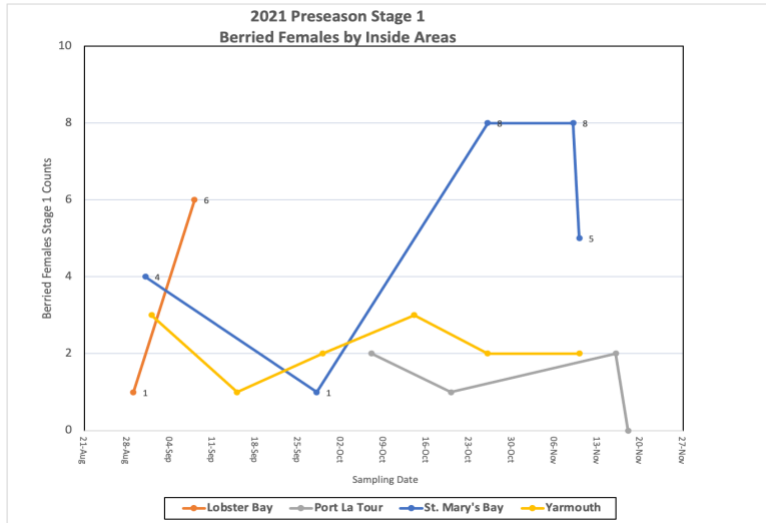


3 4

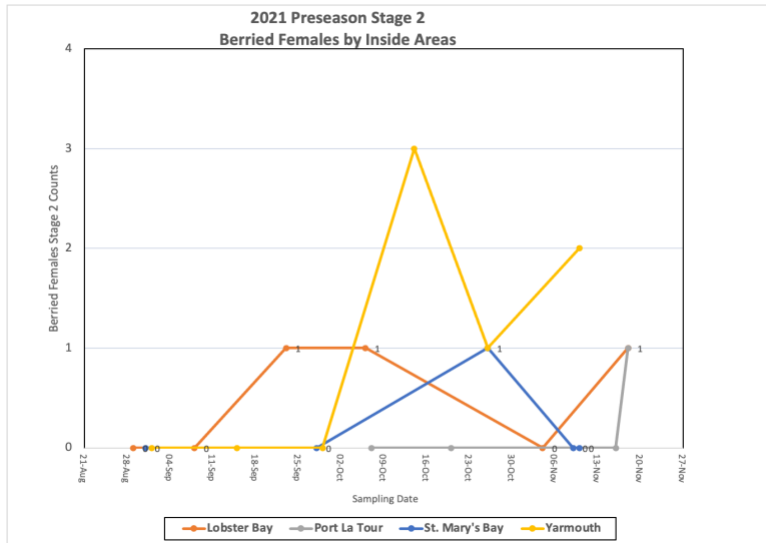
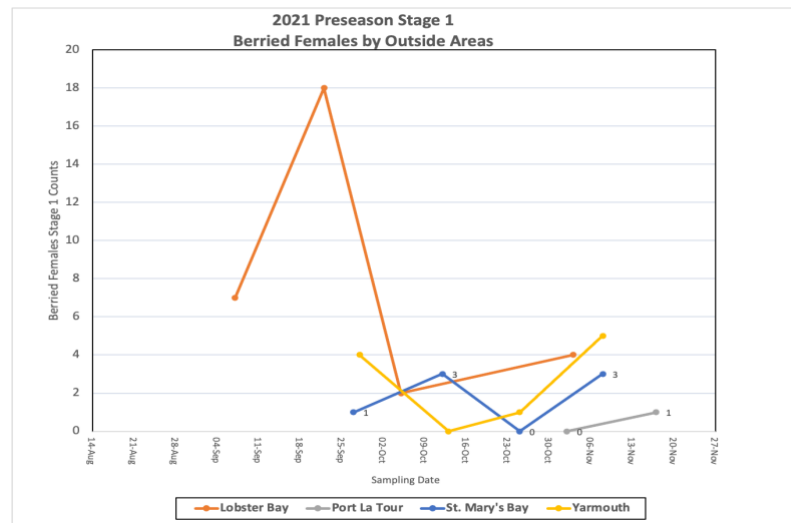


Locations

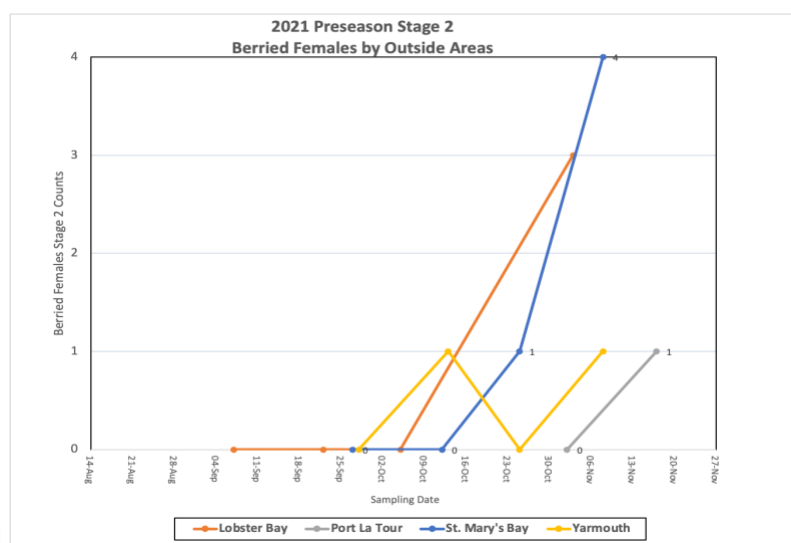
Graphics: (1) Top left–Yarmouth Berried Females Stages Count & Percent Females; (2) Top right–Lobster Bay Berried Females Stages Count & Percent Females; (3) Bottom left–Port La Tour Berried Females Stages Count & Percent Females; (4) Bottom right–St. Mary's Bay Berried Females Stages Count & Percent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



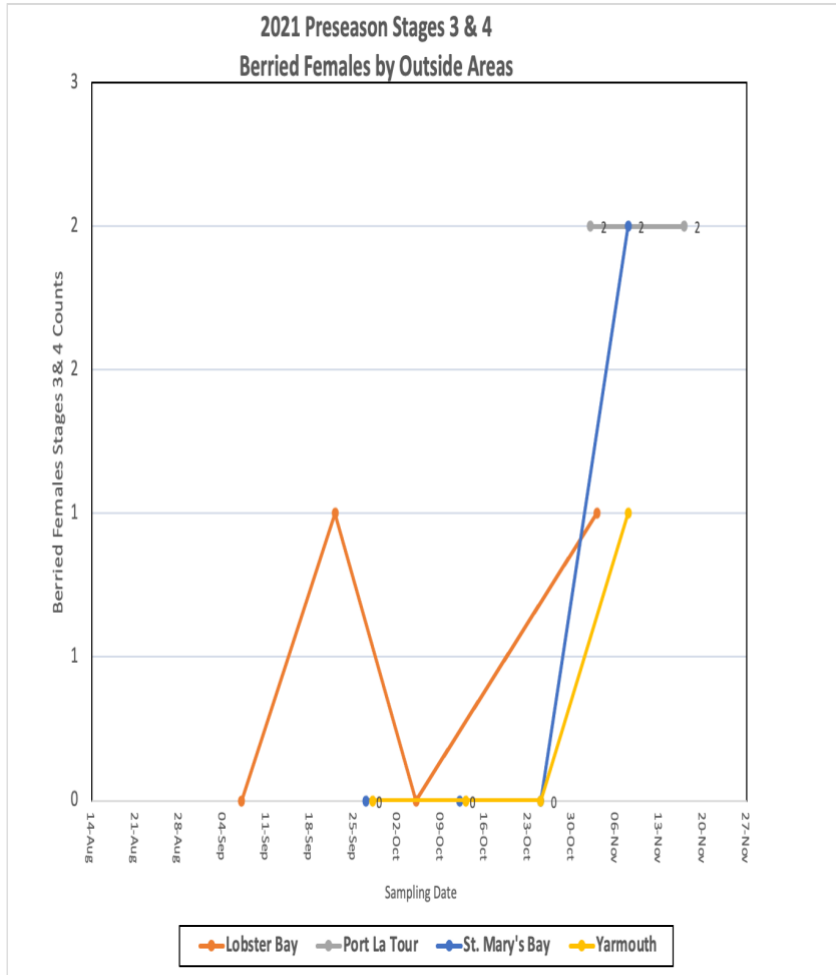
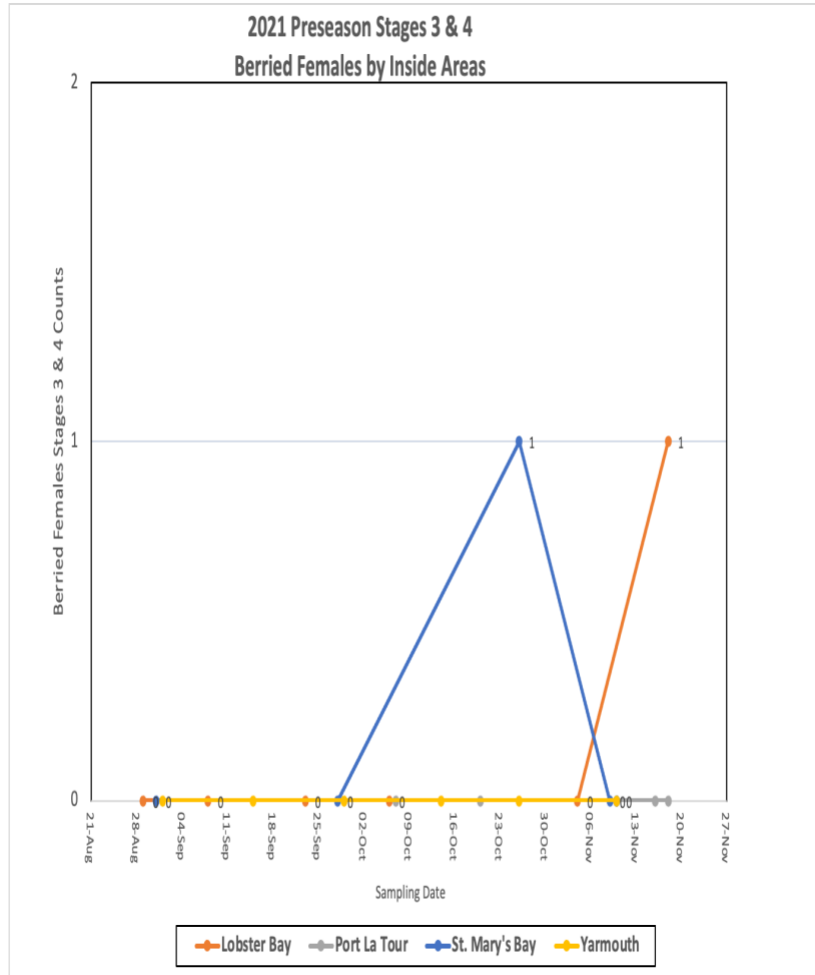
a b



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 2021a) released on November 24, 2021 prior to the beginning of the 2021-2022 commercial lobster season in LFA 33 and 34.

The following table summarizes the predictions by sampling location as provided in text from below. Highlight text below indicates 2021 Quality Prediction.

Sampling Location	Area	2021-22 Overall Quality Prediction	Comparable Preseason Year(s) to 2021	Remarks on 2021 Sampling
Yarmouth	1. Inside	MODERATE-LOW (ML)	2014	ML class includes all low quality regime years
	2. Outside	MODERATE-LOW (ML)	2014, 2015	ML class includes all low quality regime years
Lobster Bay	3. Inside	LOW (L)	2013, 2017	November samples rebound to improve to MH
	4. Outside	MODERATE-LOW (ML)	2015	November samples improve to M
Port La Tour	5. Inside	MODERATE (M)	2016	Improving BRIX from L to MH over sampling period
	6. Outside	MODERATE (M) to MODERATE-LOW (ML)	2014, 2017	Gradual improvement in BRIX over sampling period
St. Mary's Bay	7. Inside	MODERATE (M)	2020	Improvement in BRIX over sampling period to H
	8. Outside	MODERATE (M) to MODERATE-LOW (ML)	2017	Near constant M BRIX levels over sampling period

Summary : (1) YARMOUTH INSIDE –

- 1) **2021 samples exhibit relatively constant BRIX behaviour over the preseason sampling period at moderate to low quality levels; the 2021 sample is most comparable to 2014 preseason sample 3-4 weeks before the start of the commercial season**
 - 2) **Lobster quality category for 2021 samples are classified as “Moderate-Low” (ML) with estimated 70% likelihood of occurrence**
 - 3) **Past years with ML classification include 2014, 2015, 2017, 2019 and 2020 – all years at the post-2013 lower quality regime**
-

Summary : (2) YARMOUTH OUTSIDE –

- 1) **2021 samples exhibit constant BRIX behaviour over the preseason sampling period at moderate to low quality levels, most comparable to the 2014 or 2015 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 50%**
 - 3) **Past representative years with ML classification include 2014, 2015, 2017, 2018– years of the post-2013 lower quality regime**
-

Summary : (3) LOBSTER BAY INSIDE–

- 1) **2021 samples exhibit stable BRIX behaviour with some improvement in BRIX from the early sample periods to the end of the preseason sample period**
 - 2) **2021 samples are most comparable to the 2013 or 2017 preseason samples 3-4 weeks before the start of the commercial season**
 - 2) **Lobster quality category for samples classified as L as the beginning of the 2021 preseason sampling period have estimated likelihood of 50%**
 - 3) **2021 November samples suggest improvement in Lobster Quality category to MH, estimated at 60% for the last sample date (November 18).**
-

Summary : (4) LOBSTER BAY OUTSIDE–

- 1) 2021 samples have relatively constant BRIX over the 4 preseason sampling dates at low to moderate quality levels for this location
 - 2) 2021 preseason sample 3-4 weeks before the start of the commercial season continues the improving trend from low BRIX results to higher BRIX since the lower results of the 2016 preseason sample
 - 3) Overall Lobster Quality category for the 2021 samples average to ML; however, maximum likelihood is estimated at 30% for each of the L and M categories; likelihood of M or less is 80%
 - 4) Last sample date (November 4) suggests some improvement in Lobster Quality category to M, estimated maximum likelihood category at 38%, and highest sample date mean BRIX of 8.3.
-

Summary : (5) PORT LA TOUR INSIDE–

- 1) 2021 samples exhibit variable but improving BRIX behaviour over the 8 preseason sampling dates from low and moderate-low quality to moderate-high BRIX levels for this location
 - 2) 2021 preseason sample 3-4 weeks before the start of the commercial season has mean BRIX value (9.6) among the highest in the time series
 - 3) Overall Lobster Quality category for the 2021 samples average to above ML; however, maximum likelihood is estimated at 55% for M or greater in the last 3 sample dates before the start of the commercial season with high average BRIX values at 10
-

Summary : (6) PORT LA TOUR OUTSIDE–

- 1) 2021 samples exhibit gradual improvement in BRIX behaviour over the last 4 preseason sampling dates from mean BRIX levels below 7 to 7.8
 - 2) 2021 preseason sample 3-4 weeks before the start of the commercial season is comparable to BRIX distributions in 2014 and 2017
 - 3) Overall Lobster Quality category for the 2021 samples average between M and ML; estimated likelihood that Port La Tour Outside Lobster Quality category is M or lower (ML or L) is 70%
-

Summary : (7) ST. MARY'S BAY INSIDE–

- 1) 2021 samples exhibit gradual improvement in BRIX distribution with moderate mean BRIX levels of 8.5 moving to a high mean BRIX of 10 by the end of the sample period
 - 2) 2021 and 2020 preseason samples 3-4 weeks before the start of the commercial season demonstrate a shift in BRIX to higher levels
 - 3) Overall Lobster Quality category for the 2021 samples approaches M levels; estimated likelihood that St. Mary's Bay Inside Lobster Quality category is MH is over 50% based on the last 3 samples in 2021
-

Summary : (8) ST. MARY'S BAY OUTSIDE–

- 1) 2021 samples exhibit a near constant series of BRIX distribution and mean values; moderate mean BRIX values range from 8.3 to 8.6 with overall mean of 8.4
 - 2) 2021 preseason sample 3-4 weeks before the start of the commercial season is comparable in BRIX mean and distribution to 2017
 - 3) Overall Lobster Quality category for the 2021 samples is between M and ML levels; estimated likelihood that St. Mary's Bay Inside Lobster Quality category is either M or ML is over 90% based on the last 5 samples in 2021
-