# 2020 ANALYSIS OF LOBSTER RECRUITMENT

Gulf Nova Scotia Fleet Planning Board

Gulf Nova Scotia Fleet Planning Board
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# Table of Contents

# Introduction

The lobster fishery in the Gulf of Nova Scotia provides an international market with healthy, sustainable product while supporting the coastal communities in rural Nova Scotia. The Gulf Nova Scotia Fleet Planning Board has long recognized the value of collecting and archiving the baseline historical data relating to the health and quality of the lobster population. The lobster fishery in the Gulf of Nova Scotia has been undergoing many changes in recent years. Minimum legal carapace size increases have been occurring throughout the region, in an attempt to increase landings and to protect the reproductive potential of the stock. The lobster fishery largely depends on lobsters that have recently moulted to commercial size. Using previously collected data, the relationship between the population of recruit-sized lobsters and the population of commercial lobsters in the near future was examined. The catch per unit effort (CPUE) values of both male/female and berried lobsters were calculated to investigate pulses in the population and landings.

# Data Background

## Background of Recruitment Index Program

The Recruitment Index Program is an annual sampling program that was designed by the DFO. Data from the program is available for the Gulf NS from 1999 up to 2019, with some gaps. There was a total of 55540 traps sampled from 1999 to 2019.

The program uses experimental traps fished by volunteer harvesters during the regular lobster season. The harvesters sample all lobsters in six consecutive traps. Three traps are the regular traps used by the harvester, while the other three traps are modified with blocked-off escape hatches. This allows the traps to retain smaller “recruit” lobsters that would usually escape from a regular trap. The lobsters caught daily in all six traps are measured with gauges labeled with bin sizes 1 to 13. The bin sizes are adjusted to account for the minimum legal carapace size for each sub-zone management area. Bin sizes 1 to 4 are considered “recruit” lobsters, while size 5 and above are commercial sized lobsters. The harvesters record the data in logbooks, which are collected to be analyzed at the end of the season.

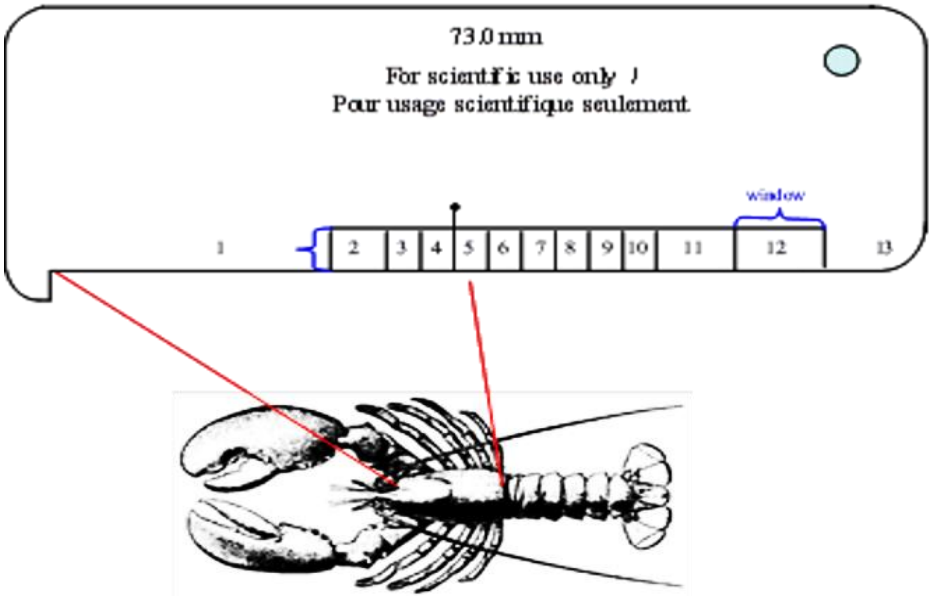



Figure 1. Example of a gauge used for bin size measurements.

## Value of Historical Data

The data collected during the index program is used to identify trends, identify pulses in landings, and monitor the general health of the lobster stocks. The volunteer efforts of harvesters from across the Gulf NS have provided important historical data that can be used to follow pulses over time. The number of recruit sized lobsters can indicate the potential for the stock to grow in future years. The number of berried recruit sized lobsters is an especially good indicator of reproductive potential.

## Sampling Sites

The Gulf NS is broken down into 5 subzones: 26A1, 26A2, 26A3, 26B South, and 26B North. The subzones have varying amounts of data due to differing harvester participation. Each subzone has gap years without any data collected. The site with the most data available from the Index Program is 26B North (14 seasons) and the site with the least available data is 26A1 (6 seasons). The amount of data available for the subzone may affect the ability to accurately identify pulses in certain bin sizes or overall CPUE values.

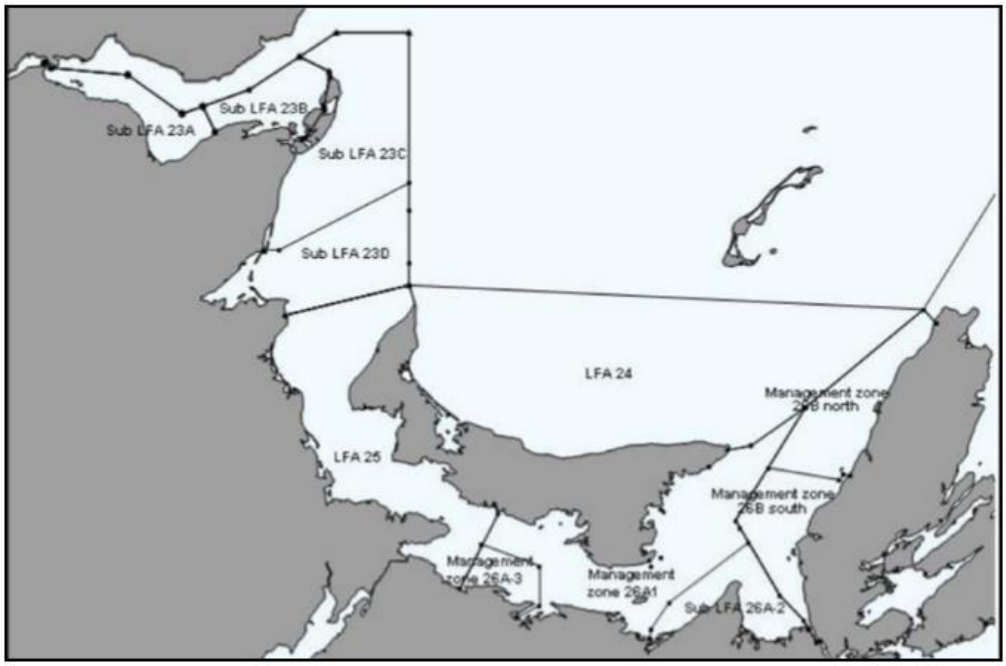



Figure 2. Map of sub-zones used in GNSFPB analysis. 26A1, 26A2, 26A3, 26B South, and 26B North.

As of 2019, the Index Program includes 18 sites, evenly-distributed across the entire Gulf NS region. When possible, the same harvester participants are retained each year to keep the data consistent, but it is common to have 1 to 2 new participants each season. The new harvesters are chosen from the same wharf or sub-zone, but they will not fish in the exact location of the previous participant. This can lead to some variation in the data and can affect annual average values.

Table 1. Sampling sites and the years with available sampling data for each subzone. The sites in each subzone that were sampled varied by year.

| Subzone | Site | Years Sampled |
|---|---|---|
| **26A1** | Caribou Harbour | 1999 |
| | MacDonald's Cove | 2000 |
| | Pictou Island West | 2016 |
| | River John | 2017 |
| | Toney River | 2018 |
| | | 2019 |
| **26A2** | Arisaig | 1999 |
| | Bailey's Brook | 2000 |
| | Ballantyne's Cove | 2012 |
| | Bayfield | 2013 |
| | Cribbons Point | 2014 |
| | Havre Boucher | 2016 |
| | Lismore | 2017 |
| | Livingstone's Cove | 2018 |
| | Tracadie | 2019 |
| **26A3** | Barrachois | 1999 |

| | | |
|---|---|---|
| | Malagash | 2000 |
| | Pugwash | 2014 |
| | Wallace | 2016 |
| | | 2017 |
| | | 2018 |
| | | 2019 |
| **26B North** | Belle Cote | 1999 |
| | Cheticamp | 2001 |
| | Grand Etang | 2002 |
| | La Pointe | 2003 |
| | Margaree Harbour | 2004 |
| | Pleasant Bay | 2012 |
| | | 2013 |
| | | 2014 |
| | | 2015 |
| | | 2016 |
| | | 2017 |
| | | 2018 |
| | | 2019 |
| **26B South** | Auld's Cove | 1999 |
| | Baxter's Cove | 2000 |
| | Finlay Point | 2014 |
| | Inverness | 2016 |
| | Little Judique Harbour | 2017 |
| | Maryville | 2018 |
| | Murphy's Pond | 2019 |

## Carapace Size Changes

Presently and historically, there are differences in the minimum legal carapace size throughout Gulf NS. Today, 26B North and 26B South have the highest legal size (82.5mm), while 26A1 has the smallest MLS (73mm). Both 26A2 and 26A3 are currently at an MLS of 76mm. Below, table 2 identifies that changes in minimum legal carapace size from 1999-2004, and from 2014-2019.

The bin sizes that are used in this scientific protocol are based on the minimum legal size of each sub-zone, so each sub-zone uses a different gauge for measurement of lobsters sampled in the index program. Since the analysis for our study is done at the subzone level, there is no discrepancy in the measurement of bin-sizes in the statistical analysis.

Table 2. Minimum legal carapace size changes across Gulf NS subzones since 1999. Note the gap between 2004 and 2014.

| | 26A1 | 26A2 | 26A3 | 26B South | 26B North |
|---|---|---|---|---|---|
| **1999** | 65.9 | 65.9 | 65.9 | 70 | 70 |
| **2000** | 66.7 | 66.7 | 66.7 | 70 | 70 |
| **2001** | 67.5 | 67.5 | 67.5 | 70 | 70 |
| **2002** | 67.5 | 67.5 | 67.5 | 70 | 70 |
| **2003** | 68.5 | 68.5 | 68.5 | 72 | 72 |
| **2004** | 69.5 | 69.5 | 69.5 | 73 | 73 |
| **2014** | 72 | 73 | 76 | 79 | 82.5 |
| **2015** | 72 | 75 | 76 | 80 | 82.5 |
| **2016** | 72 | 76 | 76 | 81 | 82.5 |
| **2017** | 72 | 76 | 76 | 81 | 82.5 |
| **2018** | 73 | 76 | 76 | 81.7 | 82.5 |
| **2019** | 73 | 76 | 76 | 82.5 | 82.5 |

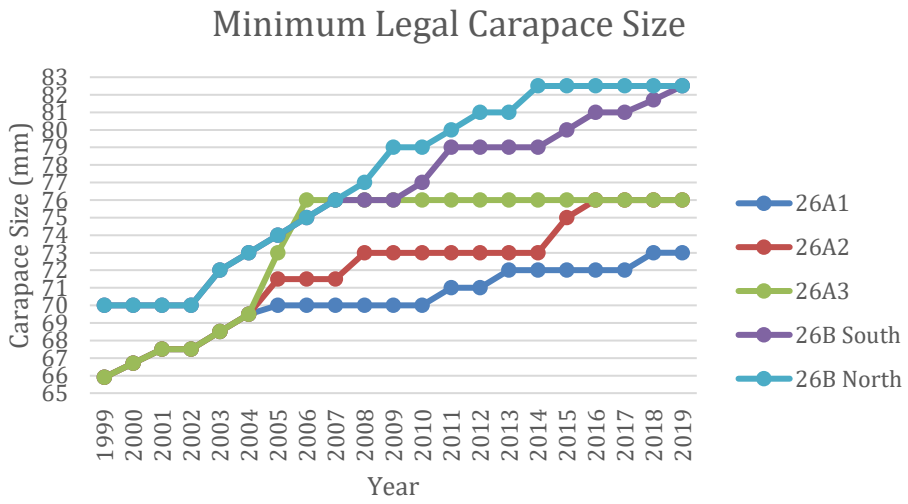



Figure 3. Minimum legal carapace size changes across Gulf NS subzones since 1999.

## Data Processing

This section briefly explains how the raw data was processed for use in the analysis and summaries.

### Regression Analysis

The type I linear regression and data restrictions are based on the assumptions made by Benoit and Bruneau (2012); "it is assumed that, based on growth rate and molting frequency, lobsters in bin-size 4 in a given year, will be in bin-size 5 in the following year". To better emphasize the relationship within one successive molt class, the data was limited to males only and the bin-sizes were restricted to bin-size 4 for recruit lobsters who are just under the legal size, and bin-size 5 for commercial lobsters who have just reached the legal size.

The restricted data was converted to Catch Per Unit Effort, and each subzone was analyzed independently. The annual data for recruit size lobsters was offset by one year, so that the data represented a singular molt from bin-size 4 to bin-size 5 over one year.

### Bin Size Distribution

All data is presented using CPUE values, which were calculated by dividing the number of lobsters caught by the number of traps hauled. CPUE values are used to represent the catchability of lobsters, which can be indicative of the overall population. When computing CPUE values for the bin size distribution graphs, male and female lobsters refer to totals for male lobsters combined with un-berried female lobsters. Berried lobsters refer to female lobsters with eggs.

When determining bin size distribution, lobster CPUE values were calculated separately for modified and regular traps. The values for each type of trap are displayed using different colored bars.

### Evolution of CPUE Values for Recruit and Berried Lobsters

When looking at the CPUE value trends for recruit-sized lobsters, only male and female lobsters caught in modified traps from bin sizes 1-4 were included. When looking at the CPUE value trends for berried lobsters, female lobsters with eggs caught in both trap types from all size categories were included.

# Results

## Regression Analysis

The linear regression used in this report intended to estimate the relationship between the abundance of lobsters who are just under the legal size (recruit size), and the abundance of lobsters (commercial size) who have reached legal size in the following year. Understanding this relationship would then allow us to make short-term predictions of commercial abundance based on current levels of recruit size lobsters.

The regression output identifies a) whether the relationship between the two variables is statistically significant and b) the magnitude of the relationship. The results and interpretation are below.

These regression results should be viewed strictly as preliminary work, as further work is needed to make conclusions about the relationship between successive moult classes and recruitment levels.

Table 3. Summary of linear regression results between dependent variable, male lobsters in bin-size 5, and the independent variable, male lobsters in bin-size 4 one year prior. A result is significant if the Significance-F value is less than 0.05.

| | **26A1** | **26A2** | **26A3** | **26B South** | **26B North** |
|---|---|---|---|---|---|
| **Coefficient** | 0.198 | 0.338 | 0.677 | 0.246 | 0.255 |
| **Significance-F** | 0.452 | 0.075 | 0.041 | 0.019 | 0.13 |
| **Significant?** | No | No | **Yes** | **Yes** | No |

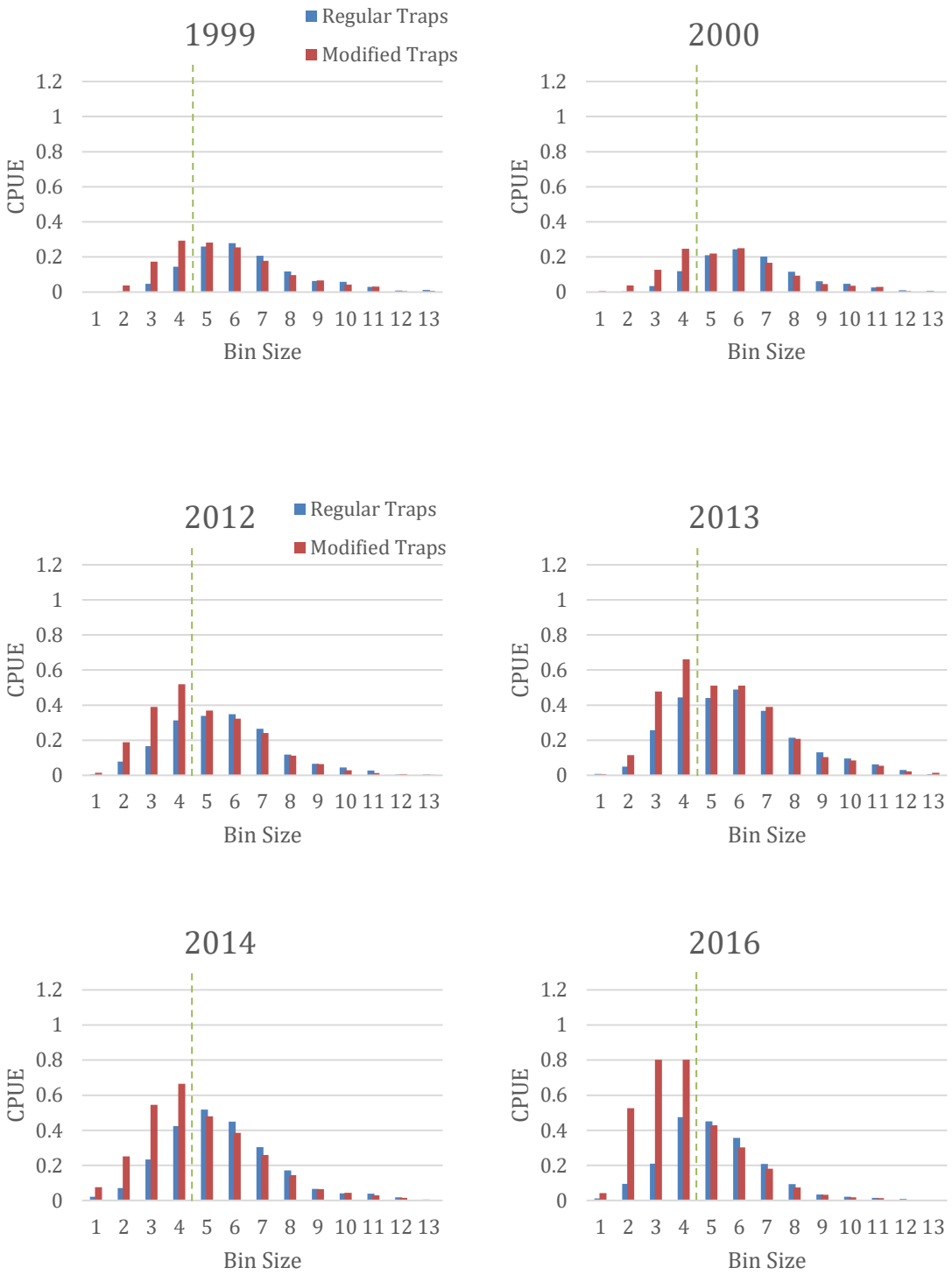
## Bin Size Distribution

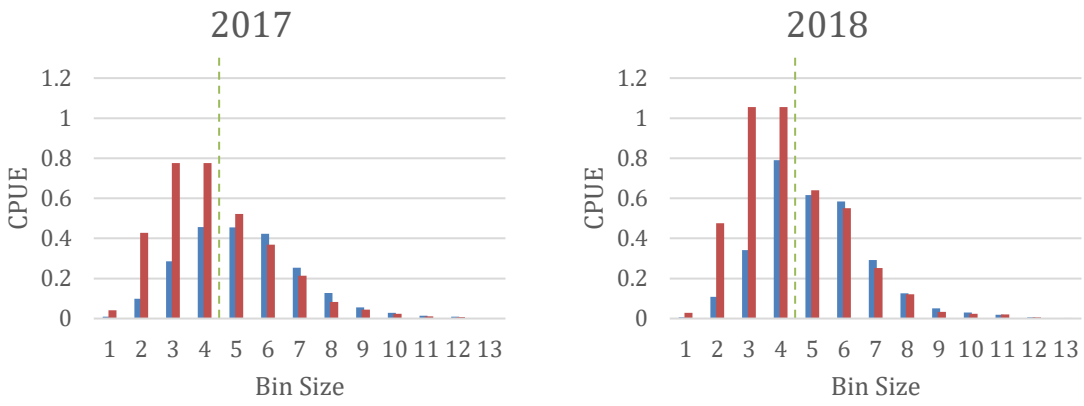
CPUE values for modified and regular traps were calculated separately, in the following figures the red data is for modified and blue data is for regular traps. Note that the dashed line shows the divide between recruit-sized and legal lobsters. The data is displayed by management area; LFA 26A and LFA 26B. Note that the minimum legal carapace size differences are reflected in the bin-sizes.

### Male and Female Lobsters

The following graphs show the bin size distribution of male and female lobsters for all years with available data in 26.

**26A Bin Size Distribution**






**LFA 26A Bin Size Distribution**

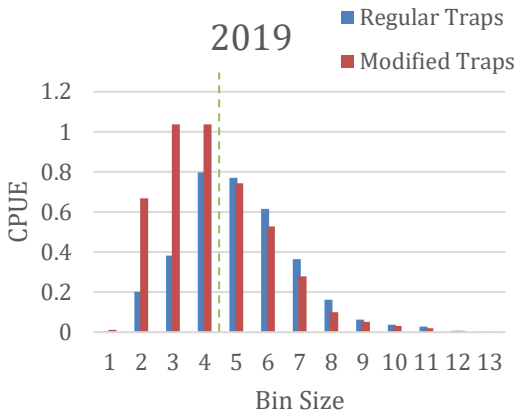
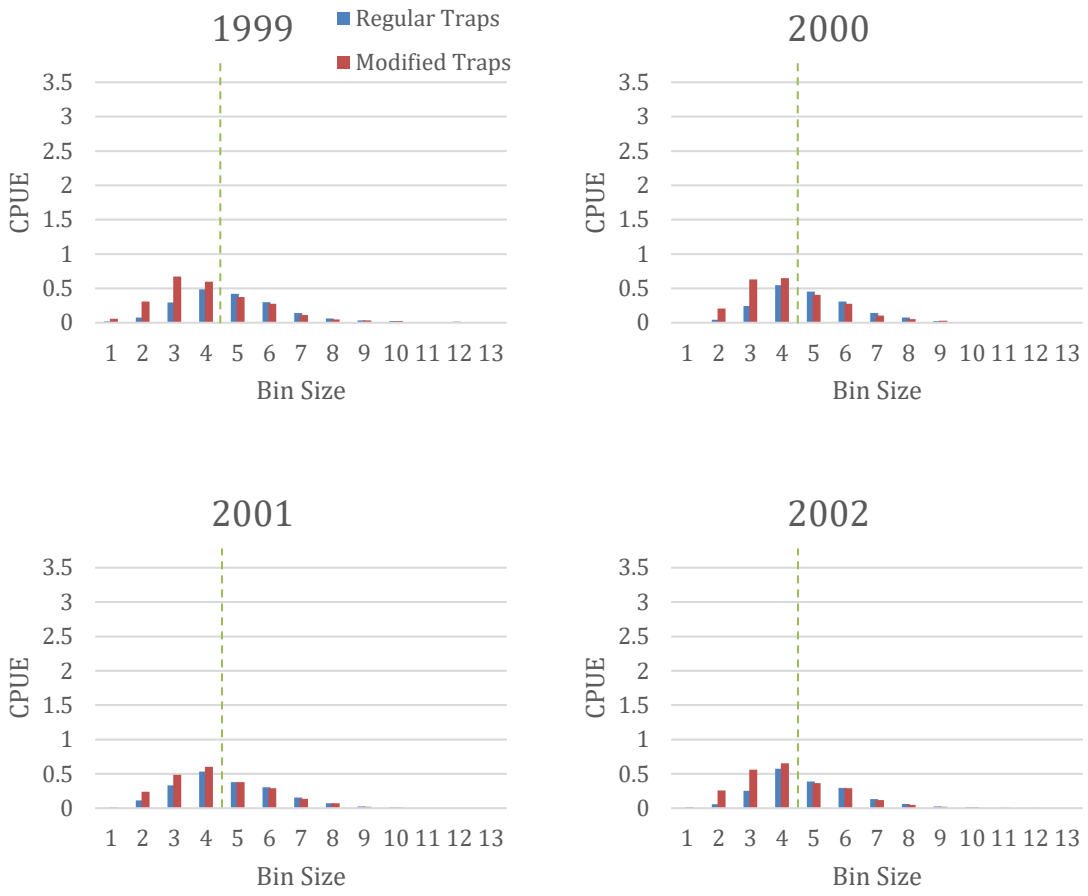


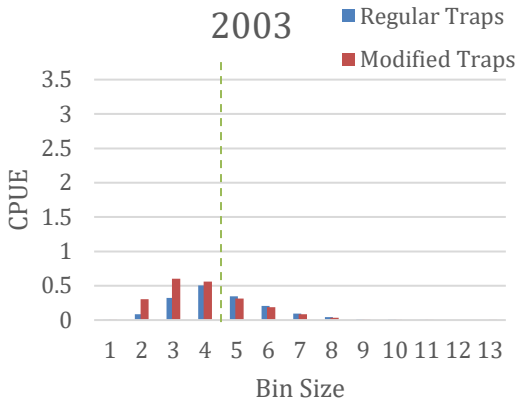

Figure 4. Male/female lobster bin size distribution throughout the years in 26A.

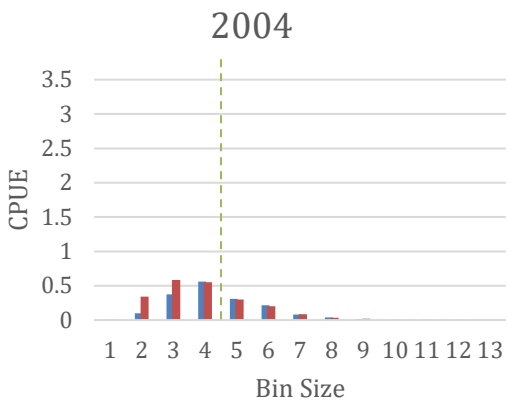
The following graphs show the bin size distribution of male and female lobsters for all years with available data in 26B:

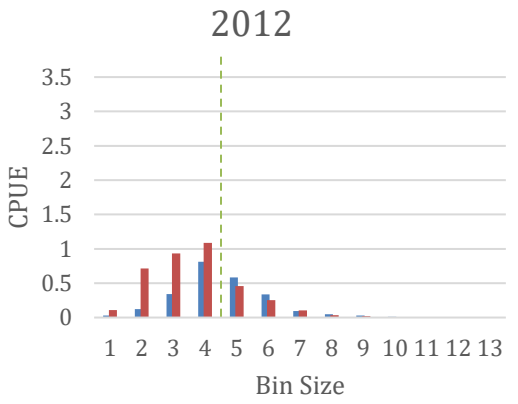
**LFA 26B Bin Size Distribution**

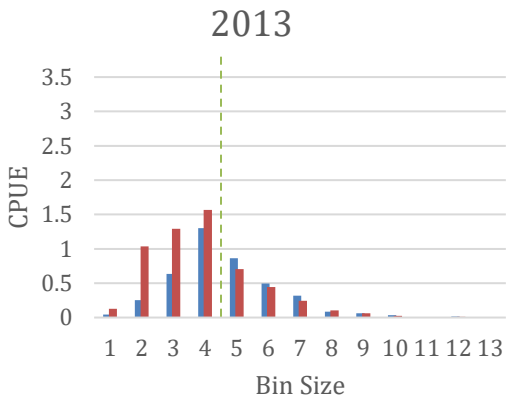


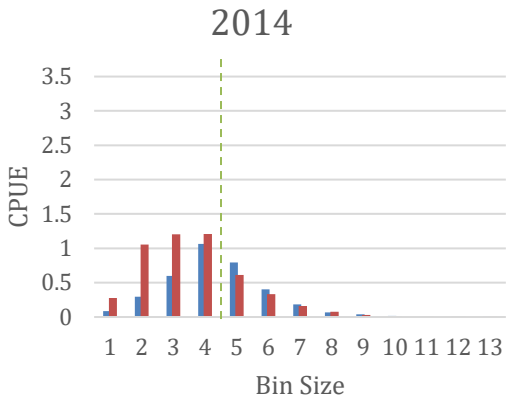
**LFA 26B Bin Size Distribution**

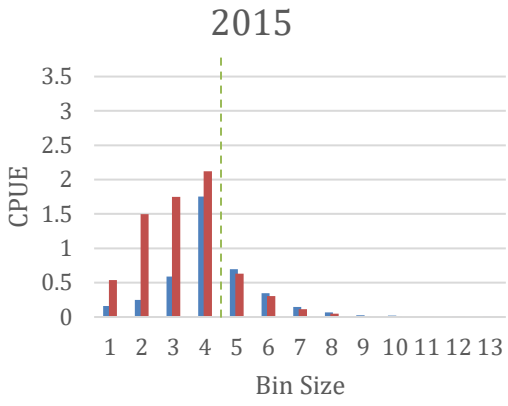


**LFA 26B Bin Size Distribution**

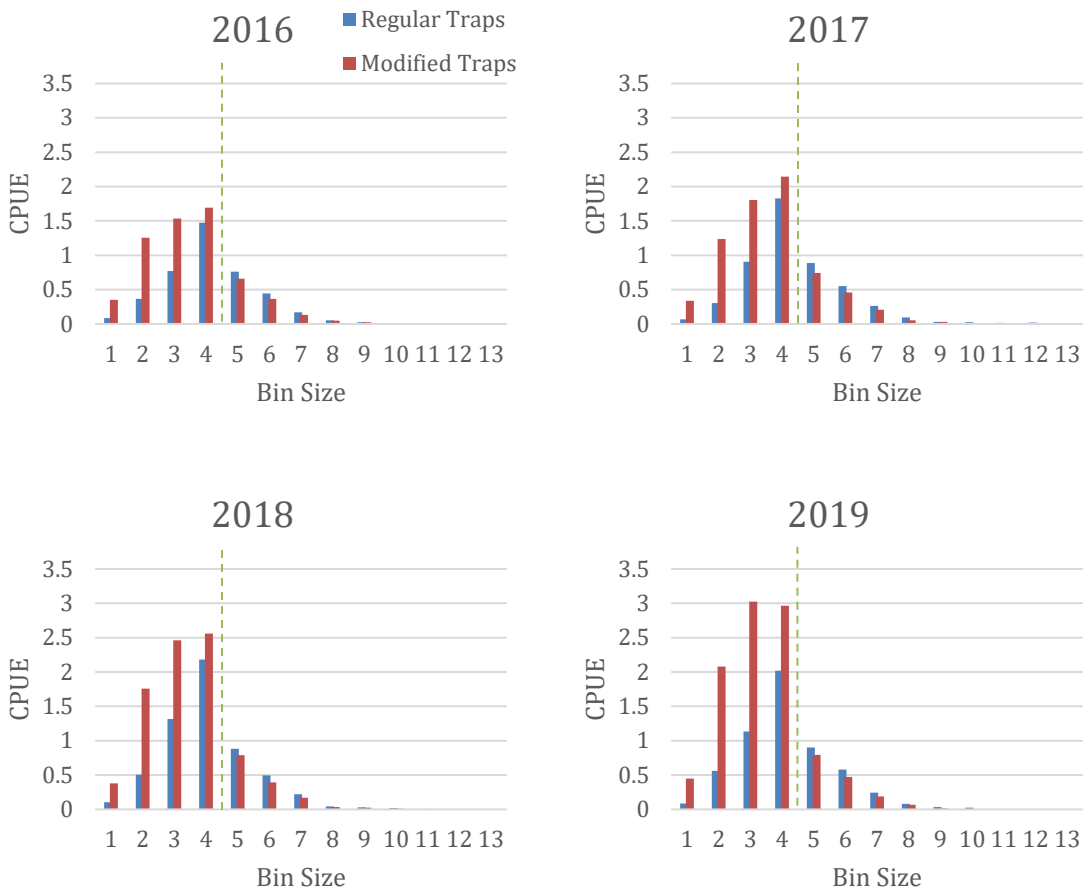
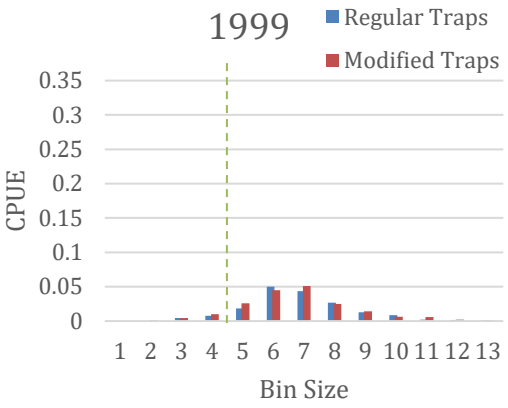


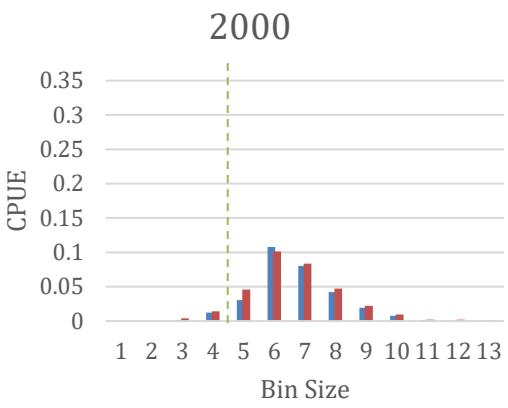

Figure 5. Male/female lobster bin size distribution throughout the years in 26B.

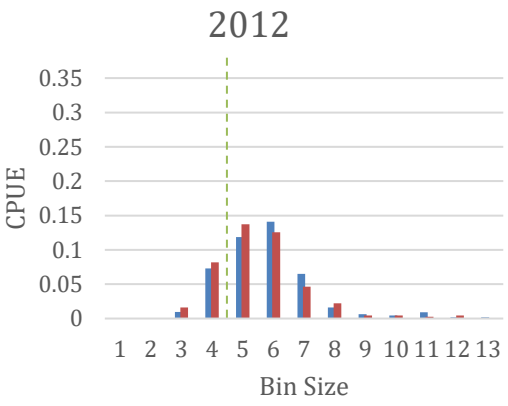
## Berried

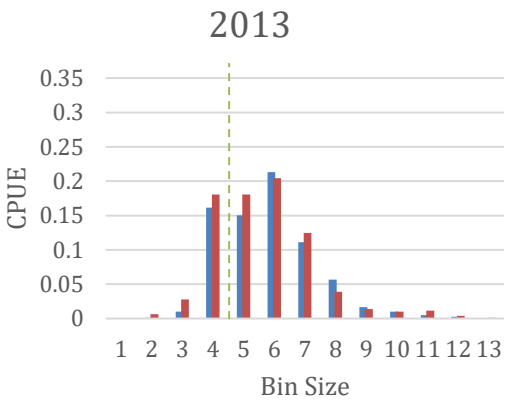
The following graphs show the bin size distribution of berried lobsters for all years with available data in 26A

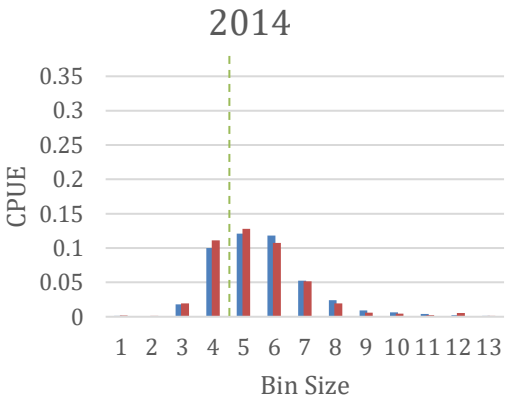
**LFA 26A Berried Bin Size Distribution**

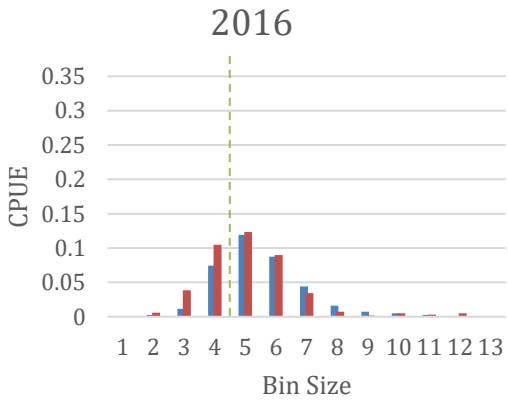


**LFA 26A Berried Bin Size Distribution**

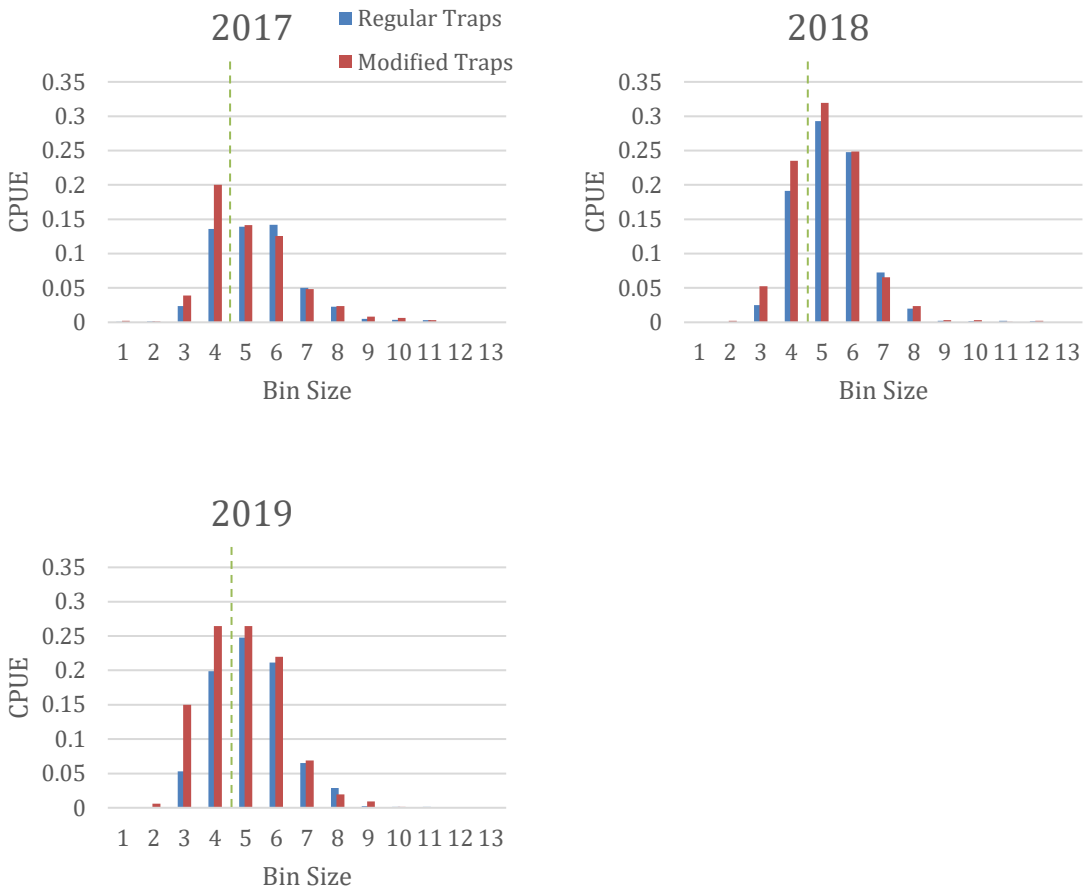
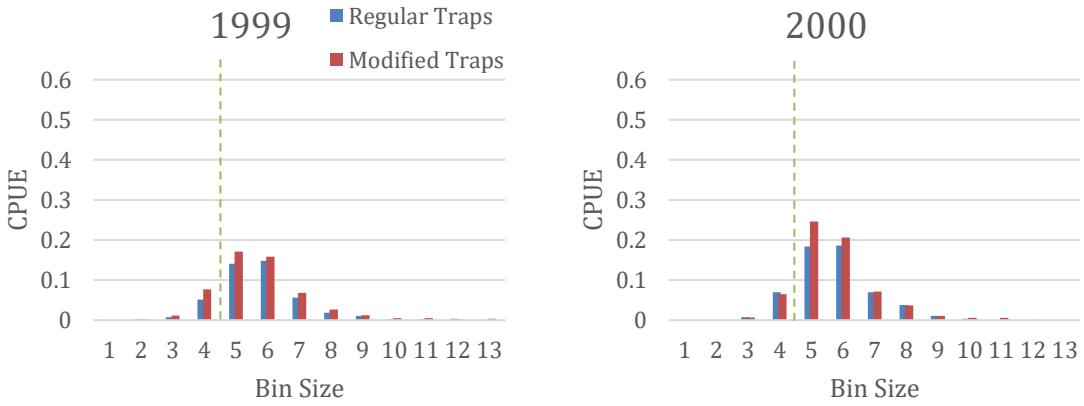


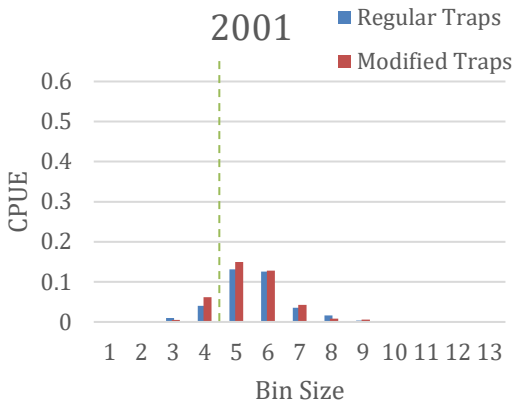

Figure 6. Berried female lobster bin size distribution throughout the years in 26A.

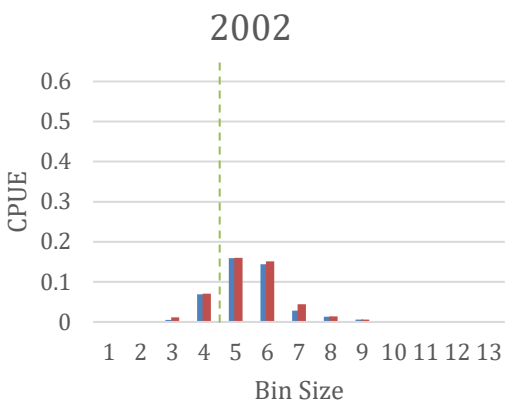
The following graphs show the bin size distribution of berried lobsters for all years with available data in 26B

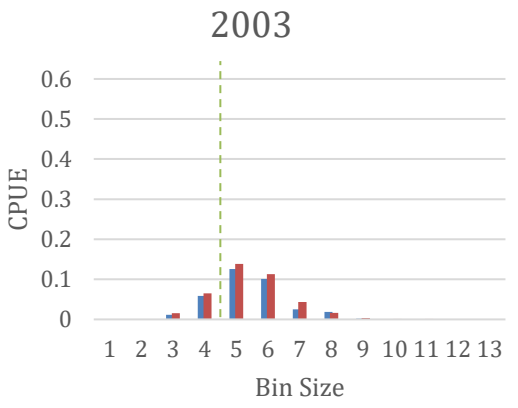
**LFA 26B Berried Bin Size Distribution**

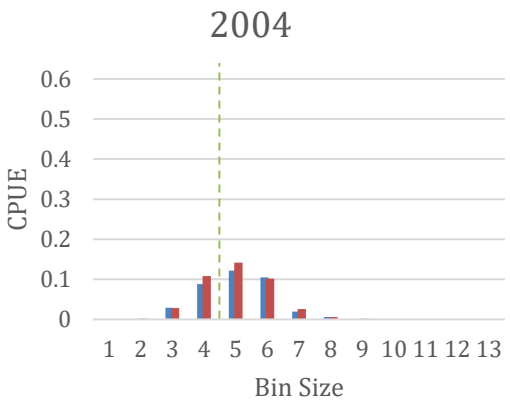


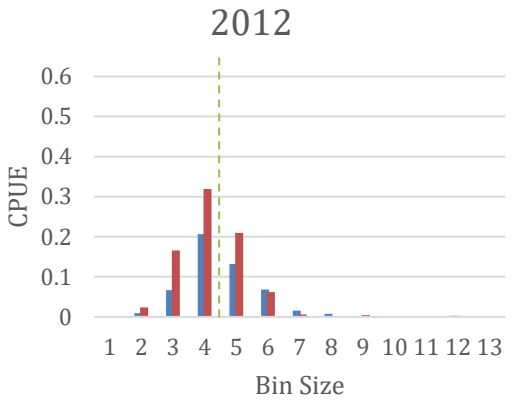
**LFA 26B Berried Bin Size Distribution**

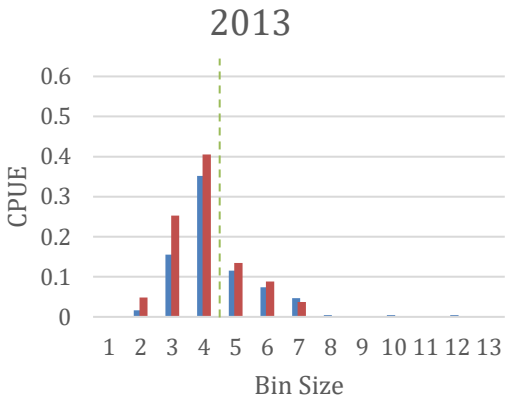


**LFA 26B Berried Bin Size Distribution**

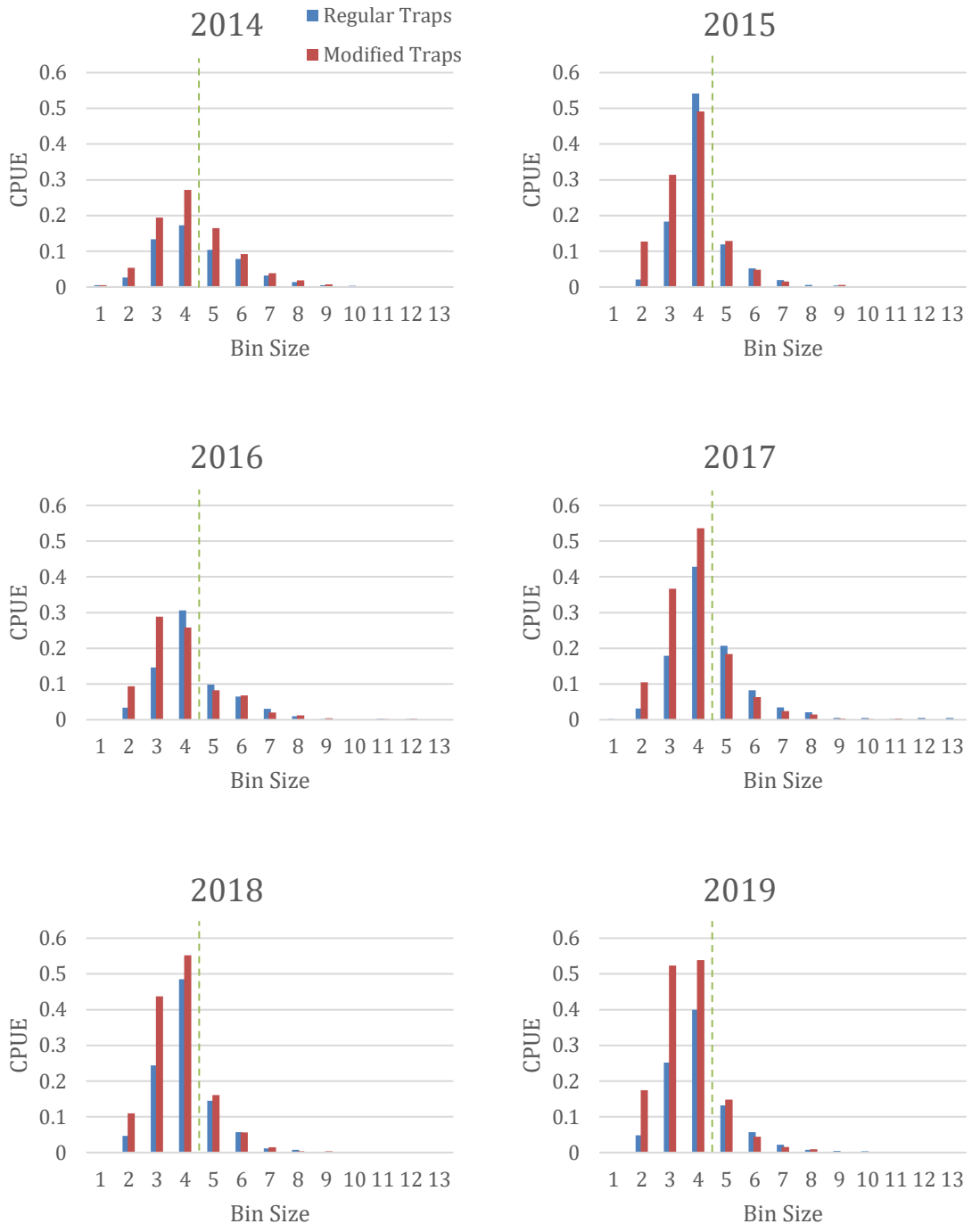



Figure 7. Berried female lobster bin size distribution throughout the years in 26B.

## Evolution of CPUE Values for Recruit and Berried Lobsters

### LFA 26A Subzones

The following graphs show the change in the CPUE values through time within LFA26A.

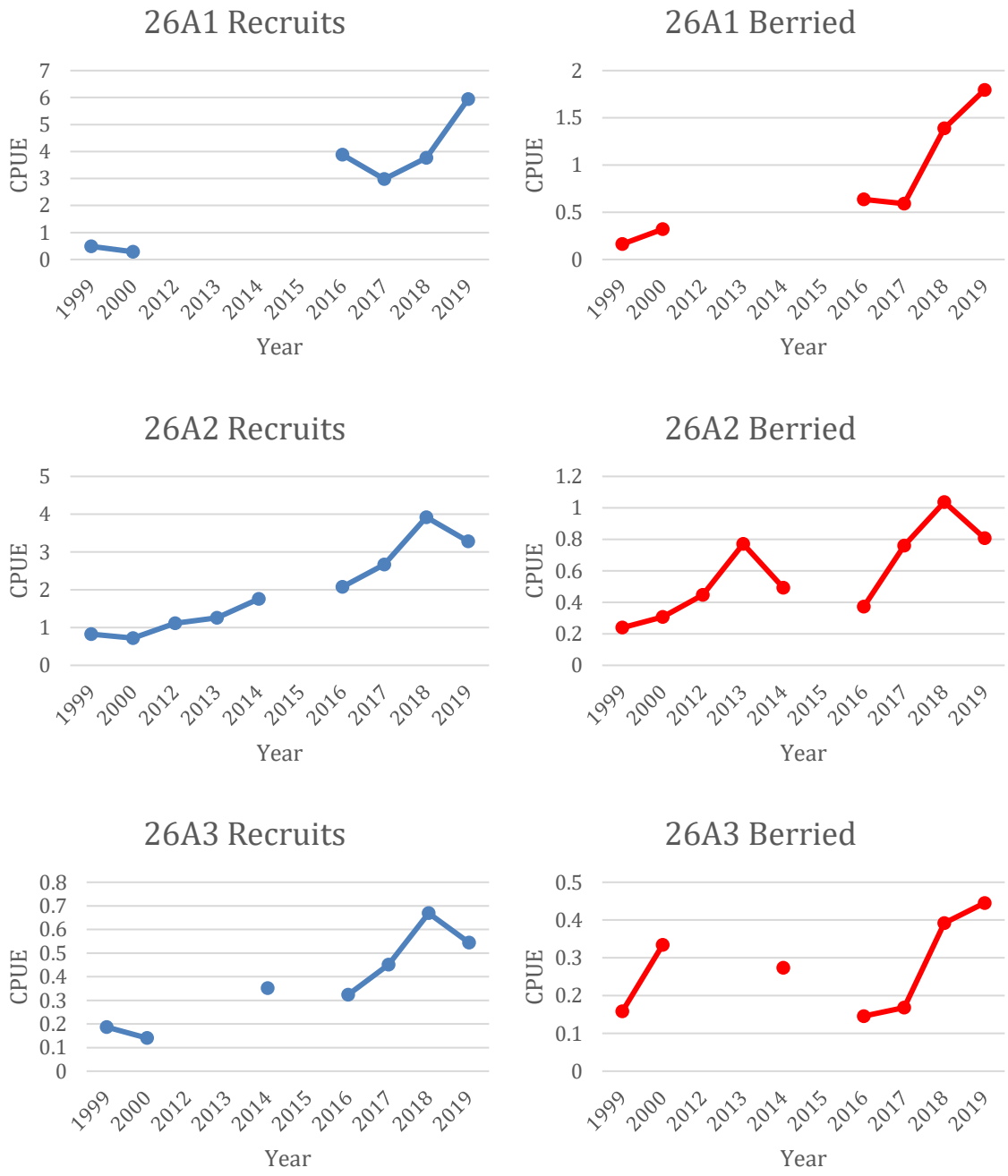



Figure 8. CPUE value trends for recruit-sized (bin sizes 1-4, male and female lobsters caught in modified traps) and berried (all bin sizes caught in modified and regular traps) lobsters across all subzones. Note the gaps in years along the x-axis and differences in y-axis scale values.

### LFA26B Subzones

The following graphs show the change in the CPUE values for recruit and berried lobsters through time in the subzones within LFA26B.

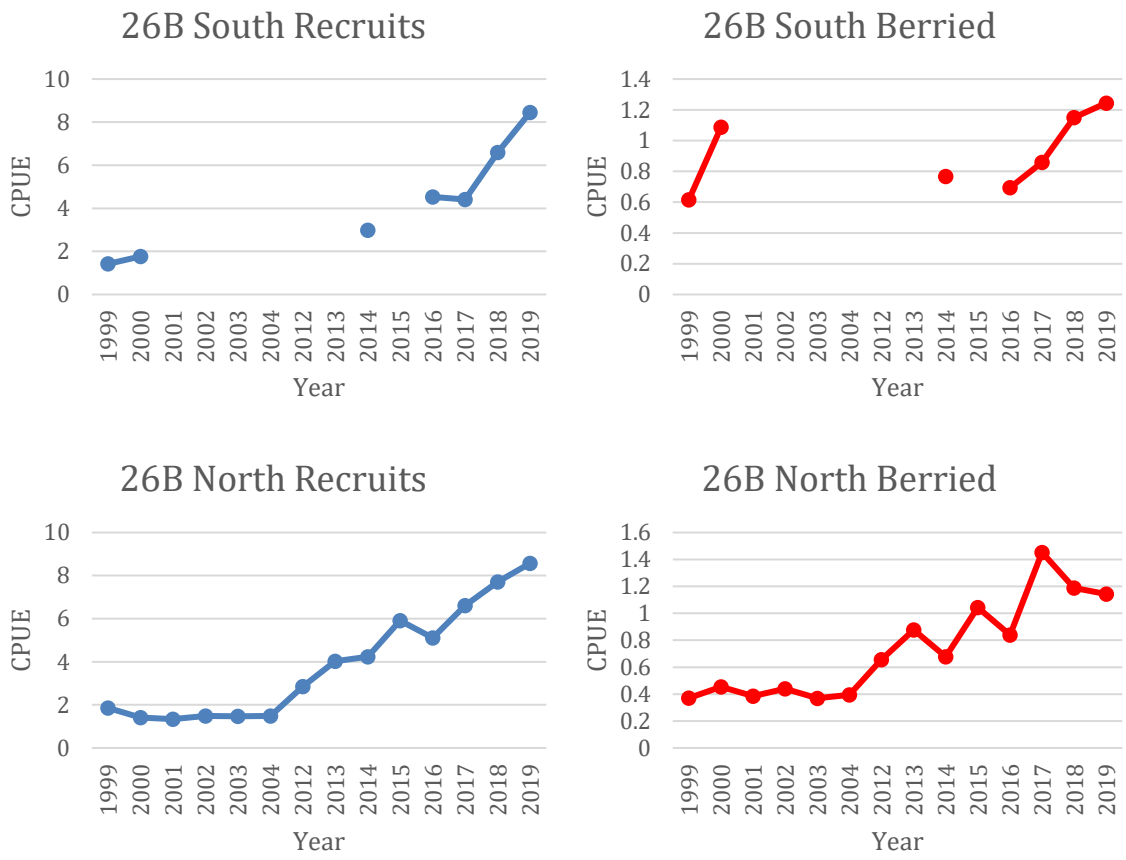



Figure 9. CPUE value trends for recruit-sized (bin sizes 1-4, male and female lobsters caught in modified traps) and berried (all bin sizes caught in modified and regular traps) lobsters across all subzones. Note the gaps in years along the x-axis and differences in y-axis scale values.

## Discussion

### Regression Analysis

The results were significant for two of the five sub-zones; 26A3 and 26B North. The other three sub-zones had significance-f and p-values greater than 0.05, meaning that that there was insufficient data to make a conclusion. The coefficients for 26A3 and 26B North were both positive and significant.

The regression results indicate that further research is needed before we can develop a tool for short-term predictions of commercial lobsters based on recruitment levels. The

insignificant results simply indicate that there is not enough data to detect a statistically significant response from that variable.

There are several reasons why the relationship was weak or inconclusive for 3 of the 5 sub-zones. First, the model selected was a simple 1 variable analysis. It is known that factors such as weather (wind, temperature) and moulting period affect landings. It would be worthwhile to include additional variables to capture the ecological and behavioural factors that are present in the data. Secondly, the data was not adjusted to account for the seasonal changes in size-distribution as a result of fishing effort. For instance, the number of legal-size lobsters diminishes over the length of the fishing season relative to the proportion of sub-legal lobsters. A third factor may be a result of the data processing protocol. The commercial variable is only looking at lobsters in bin-size 5. We recognize that regular trap escape mechanisms do not retain 100% of new recruit size lobsters (bin-size 5), and that the growth rates may vary slightly in some areas so lobsters may not spend as long in bin-size 5.

## Bin Size Distribution

26B generally had higher CPUE values than 26A for recruit and berried lobsters. Both zones and categories of lobster have seen CPUE increases since the program was launched in 1999.

### Recruits

Subzone 26B South and 26B North appears to have undergone the greatest increase in the number of recruit lobsters. In 26B South in 1999, 1769 recruit lobsters were caught during the program in 1498 trap hauls (1.2 CPUE). In 2019, 6805 recruits were caught in only 900 trap hauls (8.5 CPUE). In 26B North in 1999, 2155 recruit lobsters were caught in 1452 traps (1.5 CPUE). In 2019, 6499 recruits were caught in 912 trap hauls (8.6 CPUE).

Subzone 26A3 appears to have undergone the least increase in the number of recruit lobsters, but an increase had still taken place. In 26A3 in 1999, 154 recruit lobsters were caught during the program in 1068 trap hauls. In 2019, 335 recruits were caught in 786 trap hauls.

In 26B, the bin sizes 3 and 4 have been around the same level in recent years. This is especially evident in modified traps, which makes sense because more size 3 lobsters may escape regular traps. This may be indicative of growing populations in the smaller age classes in 26B, which is promising for the future. In 26A, the number of lobsters from bin size 4 is often higher than size 3 values, except in recent years.

26B CPUE values for all bin sizes remained relatively stable from 1999 to 2004, but increased in recent years. Catches in 2014 and 2016 seemed to remain fairly constant compared to 2013 and 2015, respectively, but the trends were generally increasing from 2012 to 2019.

26A CPUE values for all bin sizes remained relatively stable from 1999 to 2000. There is a large gap in the data until 2012. From 2012 to 2019, the CPUE values have generally been increasing.

The difference between modified and regular trap CPUE values is higher for recruit sized lobsters than for larger lobsters. The highest CPUE values for bin sizes 1-4 were generally found in modified traps, while CPUE values for sizes 5-13 were generally higher in regular traps. The CPUE values rapidly drop after size 4 in 26B, while the CPUE values for 26A show a more gradual decline.

#### Berried

Berried CPUE values were lower than values for males and un-berried females combined, which was expected. 26A CPUE values for berried lobsters shifted from a bin size 6/7 peak to a bin size 4/5/6 peak throughout the years. There are very few berried lobsters under size 3 in 26A. In 26B, the amount of 2 and 3 bin-sized berried lobsters has dramatically increased in recent years. Most berried females are now around bin size 3/4 in 26B, but around bin size 4/5/6 for 26A.

### Evolution of CPUE Values for Recruit and Berried Lobsters

26B subzones generally had higher recruit and berried lobster CPUE values. In general, CPUE values seemed to increase in recent years in all subzones, with some peaks. Within subzones, the CPUE values for berried and recruit lobsters seemed to follow the same general pattern.

#### LFA 26A Subzones

Trends in CPUE values were difficult to identify due to the gaps in the data. 26A1 saw a decrease in berried and recruit lobster CPUE values in 2017. There were no changes to minimum legal carapace size in that subzone for 4 seasons before 2017. 26A2 recruit CPUE data showed a fairly steady increase, but the values peaked in 2018. 26A2 CPUE values for berried lobsters peaked in 2013 and 2018. 26A3 had the least amount of data available, so trends are not very clear. 26A3 also saw a peak in recruit lobster CPUE in 2018.

#### LFA 26B Subzones

Trends in CPUE values were difficult to identify due to the gaps in the data. 26B South did not have much data available, so trends were not very clear. In recent years, the CPUE values for both berried and recruit lobsters have generally been increasing. 26B North berried lobster CPUE values show peaks every second year between 2012 and 2018. The 26B North berried lobster CPUE values have been slightly decreasing since 2017 but are still very strong.

## Conclusion

This report intended to provide insight into the baseline historical lobster recruitment data, and to work towards developing a predictive tool for short-term pulses of commercial landings. Despite the results of the regression analysis being weak and inconclusive; the summary statistics (Evolution of recruits, berried and bin-size distributions) provide a valuable look in to the distribution and evolution of growth in age classes of lobster throughout the Gulf NS.

Primarily, the summary statistics show us the immense value of having continuous annual sampling with no time gaps. 26B North had the longest consecutive data collection, allowing us to follow the changes in abundance and bin-size distribution throughout the years. It is recommended that the annual lobster sampling remains a priority for the GNSFPB and its members in future years. The archive of historical data can act as a baseline of natural levels, so that in the future if there are any stock or environmental challenges, scientists can determine the normal 'healthy' levels based on this data.

Both 26A and 26B have seen gradual annual increases in abundance of recruit sized and berried lobsters since sampling began in 1999. Generally, 26B had higher CPUE values than 26A for both recruit sized (male and female) and berried lobsters. At the sub-zone level, 26B North and South had the greatest increase in abundance (measured in CPUE) of recruit size lobsters, from 1.9 lobsters per trap to 8.6 lobsters per trap and 1.4 lobsters per trap to 8.5 lobsters per trap respectively. These two sub-zones have also had the highest minimum legal carapace size throughout the entire project. This suggests that the increases in MLS have successfully protected the reproductive potential of the stock; allowing lobsters to reach 100% sexual maturity as defined by DFO, and reproduce at least once before capture.

The bin-size distribution summaries were relatively consistent throughout the two zones, 26A and 26B. In 2018 and 2019, the abundance for bin-sizes 3 and 4 were relatively close. This suggests that there are strong age classes coming in the next 1-2 years. In previous years and in 26A, there is a greater discrepancy between bin-sizes 3 and 4.
The recruitment trends in 26A1, 26A2 and 26A3 followed similar trends but at varying magnitudes. Subzone 26A3 has historically had the lowest recruitment levels; from 0.2 CPUE in 1999 to 0.7 CPUE in 2018 or 0.55 CPUE in 2019. The abundance of berried lobsters in 26A3 is also low, however there has been a positive increase from around 0.15 CPUE to 0.45 CPUE. 26A3 is the subzone with the least amount of sampling, so perhaps increased and more continuous data will help to identify trends.

The abundance of berried lobsters through time displays a cyclical pattern in several sub-zones; 26B North, 26A2 and 26A3. For example in 26B North (Figure 9), we can see the annual up and down fluctuation of about 0.2-0.6 lobsters per trap every year from 2013-2018. One factor that may cause this phenomenon is that studies have shown that a portion of mature females, and first-time spawning females, can moult and spawn in the same year in the Gulf of St. Lawrence (Comeau & Savoie, 2004).

This is the first step in working towards a model that is able to make short-term predictions in future commercial landings based on current levels of recruitment. For future work, a statistical model will need to be developed that can account for some of the more complicated factors and nuances contained in the existing data. It is recommended that the GNSFPB conduct this work with an academic researcher such as a PhD student. This report shows the value of consistent annual data collection; and emphasizes that a stop and go approach is not recommended.

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