Warming Ocean Temperatures Affect the American Lobster Population in New England and Eastern Canada

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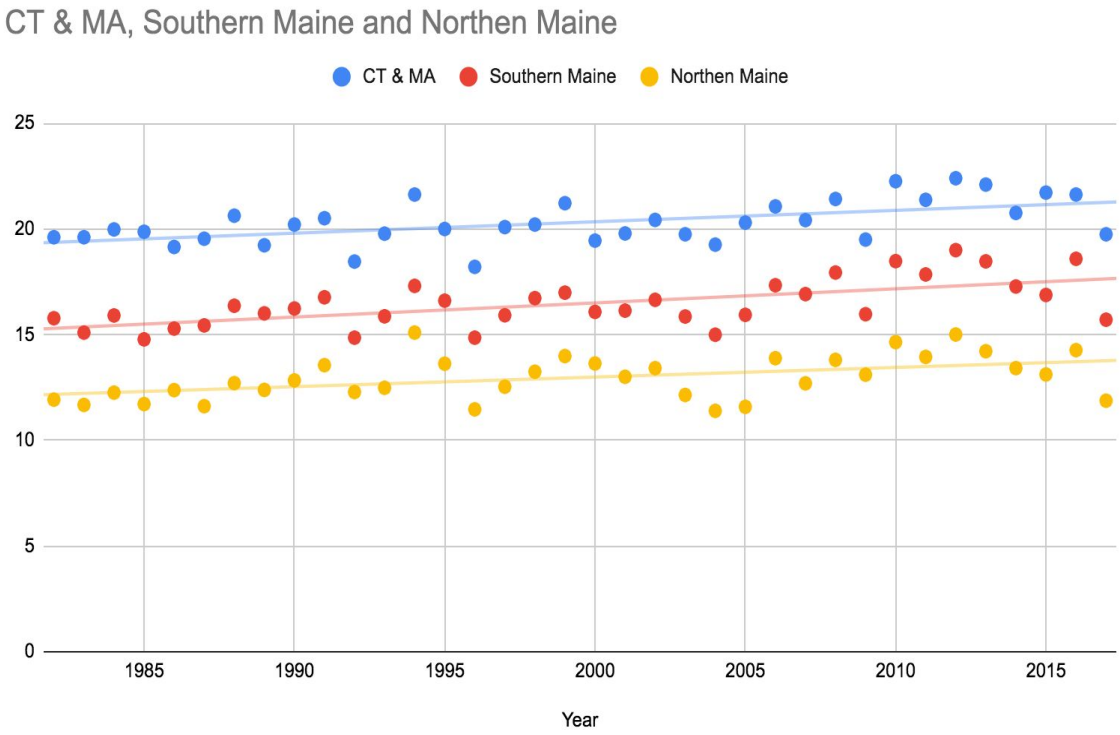
Abstract

Because ocean temperatures are warming, critical habitat for juvenile development and recruitment at the southern range for the American Lobster is becoming too warm. This paper will explore how warming temperatures in the ocean are affecting the American Lobster, and why. Two tables were used for my data, one showing data of young of year data and juvenile data in a variety of areas in New England and Canada. I downloaded these tables into CODAP (Common Online Data Analysis Platform), which is a program that allows you to easily explore and learn from data, represented in a variety of ways. After downloading the tables, it was just four easy steps to create each of my three graphs. Comparing the young of year density and juvenile density, shows us that there are many more juveniles, because not all the lobsters survive until stage four. The sea surface temperature graph is evidence that the reason there is currently a higher amount of American Lobster in New Brunswick, is because it corresponds with the fact that the farther north the state or province, the more young of year or juvenile density there was. I believe that ocean temperatures are warming, which is pushing the American Lobster north, resulting in an increase of population in northern New England and Canada, and a decrease of population in mid and southern New England.

Introduction

Since satellites were invented, sea surface temperatures have generally warmed .03 degrees celsius per year (Rheuban, Kavanaugh, and Doney). Although oceans are warming all over the world, did you know that the northwest Atlantic Ocean has experienced warming rates in the top 1% of oceans globally, (Rheuban, Kavanaugh, and Doney) which is affecting many organisms, including the American Lobster? Because ocean temperatures are warming, critical habitat for juvenile development and recruitment at the southern range for the American Lobster is becoming too warm. (Rheuban, Kavanaugh, and Doney) This means that American lobsters will be unable to live there, resulting in a decline of the amount of lobsters in southern New England over the past several decades. This also means that further north, in northern New England and parts of Canada, the lobster population is growing and growing.

Shell disease is a widespread disease found on lobsters, which they can get when their shell is vulnerable, like during the molting process. This disease, warming temperatures, and the decline of lobster settlement, has affected the American Lobster on a large scale in southern New England, whose population is now only a fraction of what it used to be. This paper will explore how warming temperatures in the ocean are affecting the American Lobster, and why.



My research question is on the relationship between ocean temperature, and the American Lobster. Learning about the American Lobster, and how warming ocean temperatures are affecting populations in different areas of New England and Canada will inform lobsterman, and people who have ever eaten, fished, or wondered about lobster, how much climate change is affecting these creatures, and why it is important to recognize the significance of warming waters. My hypothesis, before I did any research, is that ocean temperatures will continue to increase and lobsters will move north, due to their temperature threshold. This will result in a decline of lobsters in southern New England, and an incline of lobsters in northern New England and Canada. I predicted this because of my previous knowledge of warming waters, and the American Lobster's preferred temperature range. I think this is a reasonable hypothesis, because I know that ocean temperatures are constantly warming, and that is affecting many organisms. The American lobster prefers temperatures from 12-18 degrees Celsius, and as temperatures increase, lobsters are going to be pushed north, where temperatures are colder. Which means less lobsters in southern New England, and more, far north in New England, and in Canada.

Lobsters have a temperature threshold that is crucial to their survival and comfort. The American Lobster is proven to be sensitive to waters greater than 18 degrees C. They "show signs of biological stress when the temperature is greater than 20 degrees." (Rheuban, Kavanaugh, and Doney, 2017) This information shows that lobsters have trouble living where temperatures are greater than 20 degrees. This is why the American lobster have been most commonly found in New England. Until climate change, and oceans began to warm, and now lobsters are moving further north. Summer water temperatures in southern New England have exceeded a long-recognized 20°C physiological threshold with historical frequency. (Wahle, Dellinger, Olszewski, and Jekielek) This is further evidence about why the lobster population is decreasing, and correlates with the fact that lobsters show stress when temperatures are above 20 degrees, resulting in a decrease of population. For example, Rhode Island reached its historical low in recent years, (Wahle, 2012) because of the increase in temperatures and the amount of lobsters that can't survive there. No lobsters have been found in any area with temperatures over 25 degrees celsius, which tells us that if temperatures reach 25 in an area where there are American lobsters, they are forced to migrate north, or killed, because they are

unable to survive. A study in 2013 found that the American Lobster traveled up the Northeast Coast at about 43 miles per decade between 1968 and 2011.

A contrasting study was found almost a century ago. “Despite thriving lobster fisheries, the absence of juvenile lobster in the Bay of Fundy and northeastern Gulf of Maine could be attributed to the colder waters preventing larval development and settlement.” (Huntsman, 1923) Comparing this with now, nearly one hundred years ago, the issue wasn’t the absence of lobsters due to warm waters, it was the absence of lobster due to cold waters.

Referring back to lobsters temperature threshold, knowing that lobsters show stress when ocean temperatures reaches or exceeds 20 degrees celsius, it is also important to know the lowest temperatures lobster can handle. You need to know this, to have their range of preferred temperatures. Here is some information on this subject: “Thermal thresholds act in ways that directly impact species fitness and demographic processes. The 12°C threshold for lobster indicates a point at which colder temperatures induce lethal and sublethal effects. Small temperature changes about this threshold correspond with large changes in survival and settlement which decouples larval supply from settlement patterns (Annis et al., 2013). Thus, the 12°C threshold can act as an ecological barrier to larval transport (Tilburg, McCartney, & Yund, 2012) and survival. Ocean warming, therefore, has the potential to significantly impact the distribution and survival of lobster larvae.”

I chose this topic because I was curious about the amount of lobsters in Maine, and other areas in New England and in Canada. Also because it is important for lobstermen, and people who are used to eating and fishing for lobster, to recognize the importance and impact of warming on this creature, and how it affects the amount of lobster in each area. By researching the American Lobster, and finding data comparing ocean temperature and lobster population, I will have more knowledge about how and why lobster populations are changing in New England and Canada.

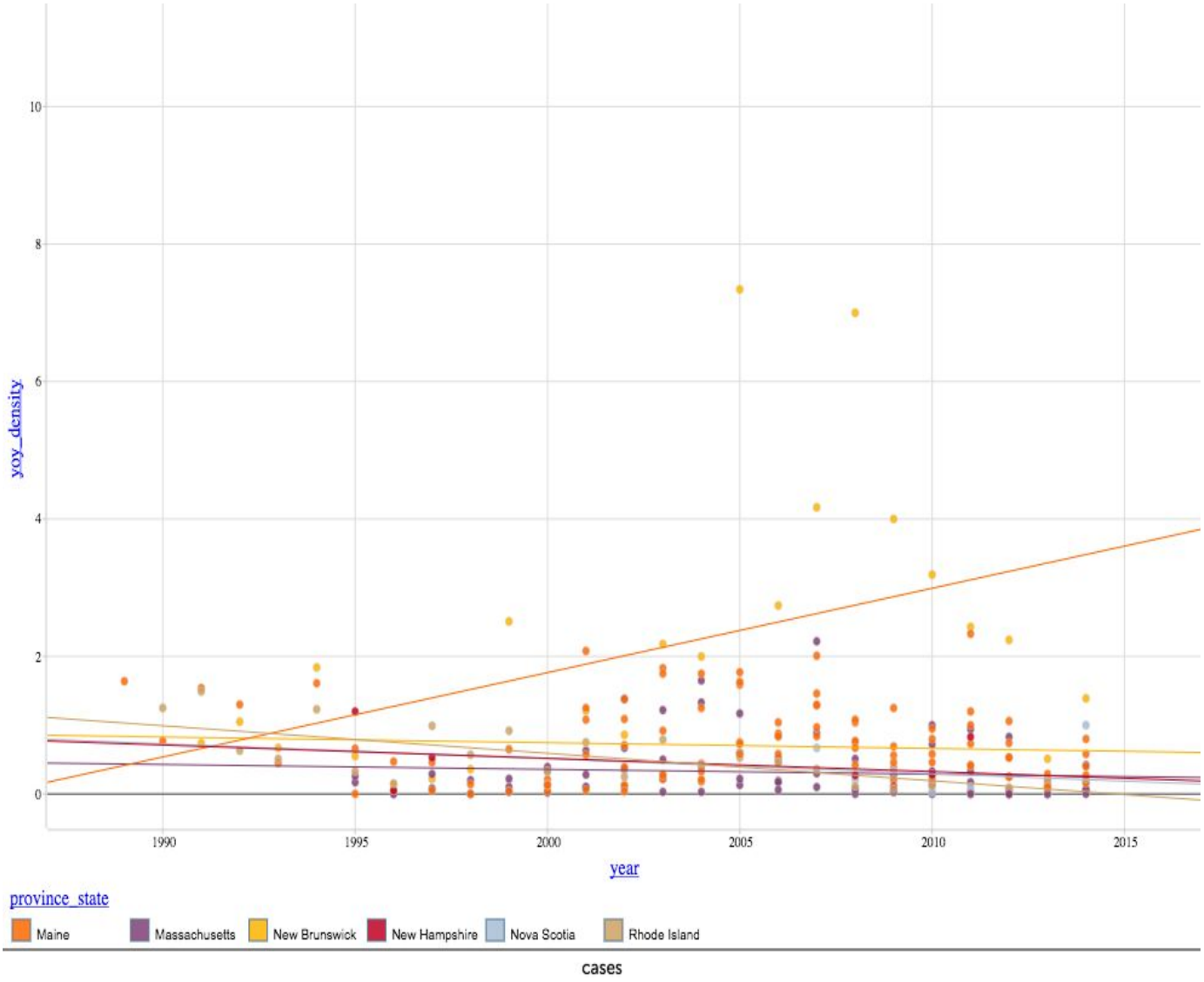
Methods

Two tables were used for my data, one showing data of young of year data and juvenile data in a variety of areas in New England and Canada. This table was from ALSI (the American Lobster Settlement Index) which is a monitoring program that quantifies just settled stage four lobsters in New England and Canada. The second table shows sea surface temperature data for the past forty years. This table was provided by CODAP, which found data from these sites focusing on sea surface temperature: Multi-scale Ultra-high Resolution (MUR) Sea Surface Temperature (SST) Analysis and Optimum Interpolation Sea Surface Temperature (OISST).

I downloaded these tables into CODAP (Common Online Data Analysis Platform), which is a program that allows you to easily explore and learn from data, represented in a variety of ways. After downloading the tables, it was just four easy steps to create each of my three graphs. All I had to do was click *graph*, and a blank graph would appear, and I could drag the variables I wanted onto the x and y axis of each graph. It also allows you to drag the regions that each data set focused on into the center of the graph, so that you could see data from each individual region, all on one graph. This was simple to do, and I was then able to compare each region. Then with just three clicks, you can add a least squares regression line to summarize the data. For more information about CODAP go to: https://codap.concord.org/about/.

Results

Young of the Year Density



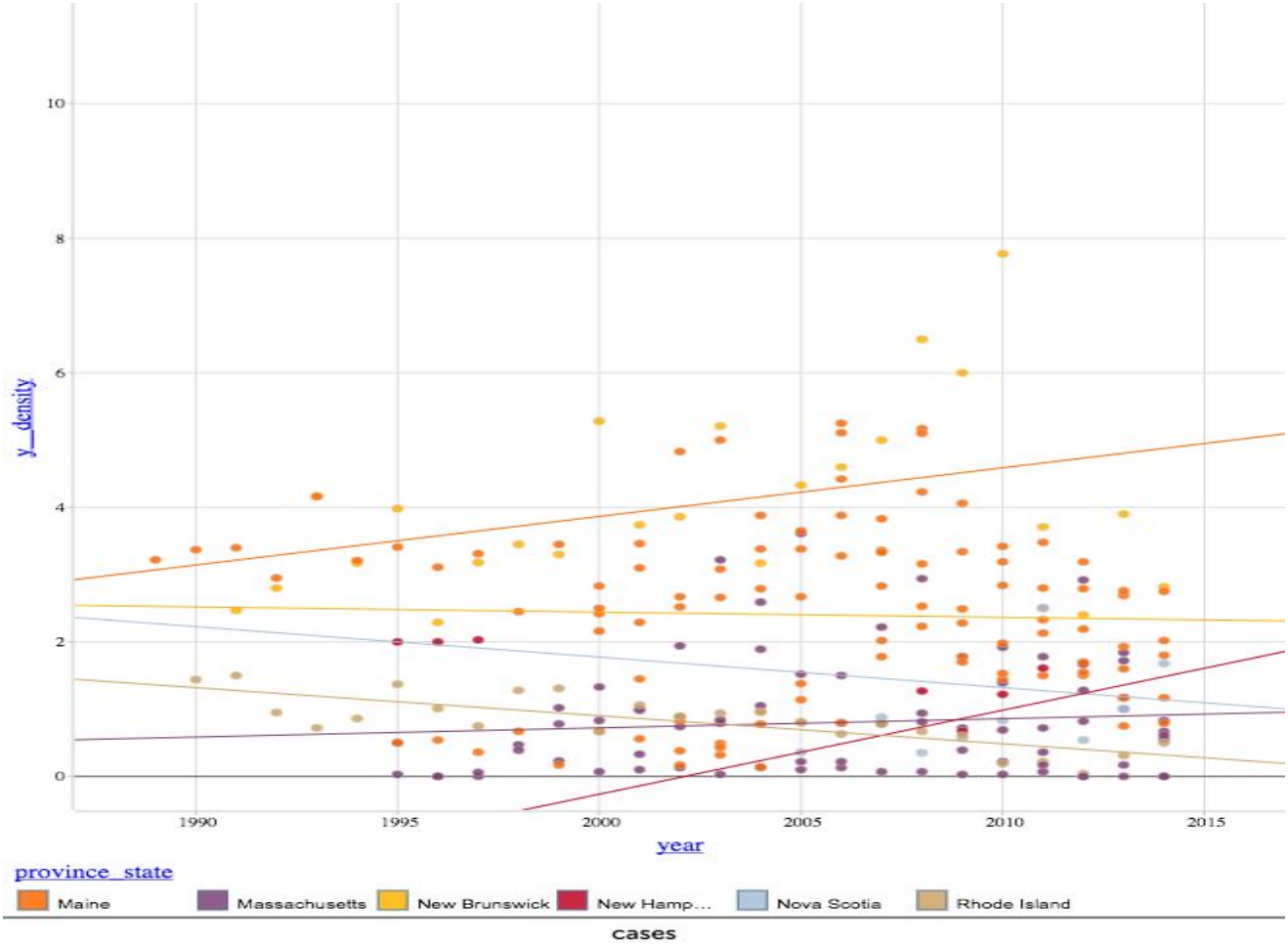
This graph shows the data of the young of year density in different states and provinces from 1990 to 2015. It focuses on Maine, Massachusetts, New Hampshire, Rhode Island, New Brunswick, and Nova Scotia. You can see that out of the six areas, New Brunswick is increasing at a much faster rate compared to the others, it's least squares regression line shows a positive increase over 25 years. The other areas of New England and Canada are decreasing gradually. This shows that since New Brunswick is farther north, it's yoy density is surpassing the other areas farther south, that have warmer ocean temperatures.

YOY Density Means

Massachusetts	0.32
Nova Scotia	0.33
New Hampshire	0.41
Rhode Island	0.51
Maine	0.7
New Brunswick	2.07

This table shows the means of each area from least to greatest. They show that for almost every area, the farther north, the higher the density. This corresponds with the graph, because for both sets of data, you can see that for every area (with the exception of Nova Scotia and Rhode Island) there are more young of year lobster farther north.

Juvenile Density



This graph has the same states and provinces as the yoy graph, but this is showing data of *juvenile* density from 1990 to 2015. You can see that it has similar patterns compared to the yoy density data. This is for the same reason: for all of the areas (excluding Nova Scotia and Rhode Island) the farther north the higher the density. This graph shows data points that are higher than the first graph, for each corresponding state or province. It is easy to see that New Brunswick (yellow) is increasing, and so is Nova Scotia (blue) and although Maine's (orange) least squares regression line is negative, this state's y density has been fairly similar to New

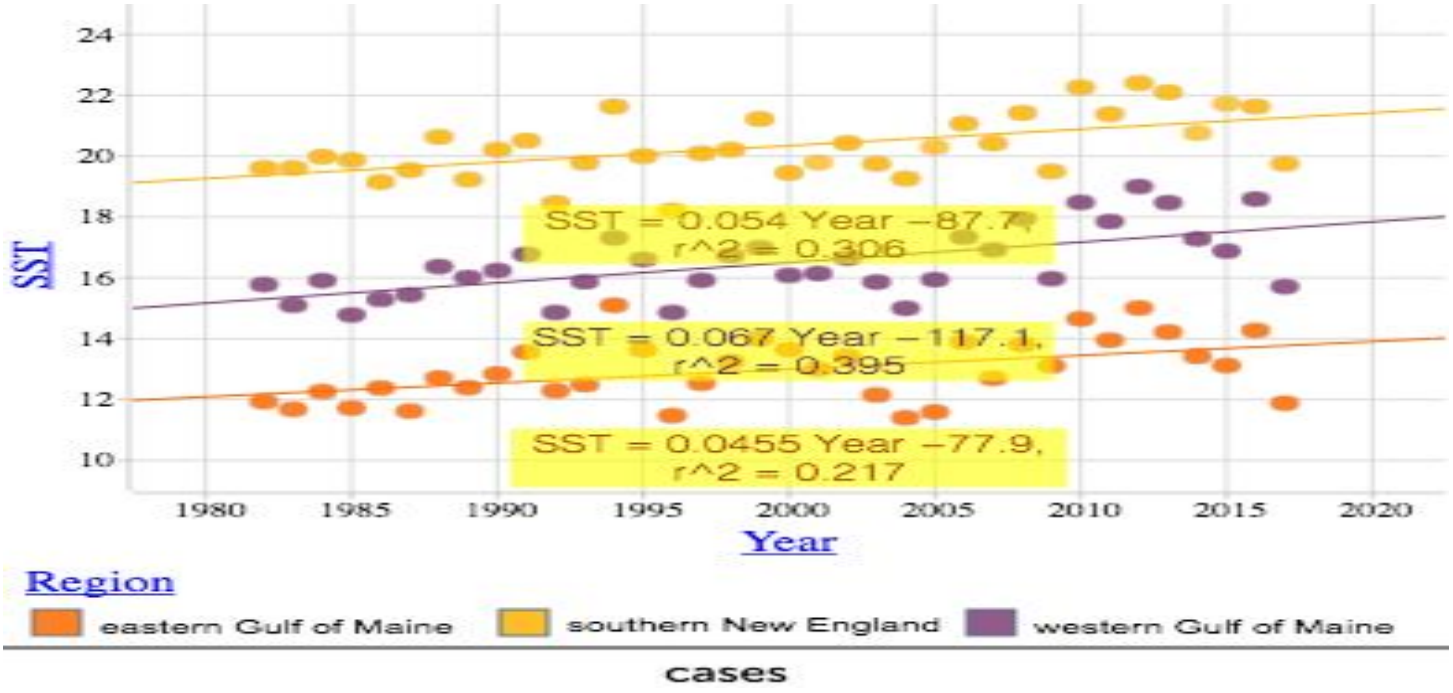
Brunswick's, with the actual coordinates around the same time. For example, you can see that in maybe 2006, Maine and New Brunswick's y density were both, at one point about 4.5.

Y Density Means

Massachusetts	0.82
Rhode Island	0.82
Nova Scotia	0.97
New Hampshire	1.56
Maine	2.4
New Brunswick	4.05

The averages of this data show that the amount of juvenile lobsters is nearly double those of the young of year lobsters for each corresponding area. This means there are more Juvenile lobsters in every area than there are young of year, which means that many don't survive before they become stage four.

Sea Surface Temperature
(degrees celsius)



This graph shows data from 1980 to 2015, using least squares regression to predict into 2020 and further into the future. It includes three areas of New England: Southern New England, the western Gulf of Maine, and the eastern Gulf of Maine, and shows the sea surface temperature for each one. Ocean temperatures are warmer farther south, and colder in places farther north, and this graph obviously shows that. You can easily tell that the southern Gulf of Maine has always had the highest temperatures. The western Gulf

of Maine has the second warmest SST's and the eastern Gulf of Maine has the lowest. Each of these areas have increasing sea surface temperatures, and they are all increasing and estimated to continue increasing at almost identical slopes.

SST Means

Eastern Gulf of Maine	12.97
Western Gulf of Maine	16.47
Southern New England	20.31

The averages of this data just show again, that the southern Gulf of Maine had the warmest SST's, its mean being 20.31. The Eastern Gulf of Maine has an average of 12.97, and the western Gulf of Maine almost exactly in between, with an average of 16.47.

Comparing the young of year density and juvenile density, shows us that there are many more juveniles, because not all the lobsters survive until stage four. The sea surface temperature graph is evidence that the reason there is currently a higher amount of American Lobster in New Brunswick, is because it corresponds with the fact that the farther north the state or province, the more young of year or juvenile density there was.

Finding the averages for each graph was useful so that you are able to look at a few specific numbers, and easily find a pattern in the data.

Conclusions & Discussion

Analyzing the graphs showing data of young of year density, juvenile density, and sea surface temperatures over time, confirms my hypothesis, and answers my essential question. My claim, and my hypothesis are the same. I believe that ocean temperatures are warming, which is pushing the American Lobster north, resulting in an increase of population in northern New England and Canada, and a decrease of population in mid and southern New England.

The young of year graph shows that New Brunswick's lobster population is increasing at a high rate, compared to the other areas that are slowly declining. This is because New Brunswick is furthest north, where the water is colder. New Brunswick is predicted to continue to increase in the future, and the rest of the areas' least squares regression show that they are predicted to continue to decrease. The juvenile density graph is also evidence of this, showing that New Brunswick and Nova Scotia are increasing, while the rest of the regions are decreasing quickly. The sea surface temperature graph shows that as time goes on, temperatures in all three regions continue to increase, with the southernmost area having the warmest temperatures, and the northernmost area having the coolest. This makes sense, because it proves that ocean temperatures are warming, which is what is causing American Lobster to move north.

The only evidence against this is that Nova Scotia's yoy density is only greater than the state of Massachusetts, which is interesting because it's in Canada, so based on my claim it should have a higher density than all the states south of it. The other opposing piece of information is that Rhode Island had a greater young of year density than New Hampshire, Nova Scotia, and Massachusetts, even though it is farther

south, therefore based on my claim, should have warmer ocean temperatures, and a lower young of year density because of this.

I am confident in my final analisis, because almost all evidence shows that as time goes on, oceans are continuing to warm, the American Lobster is continuing to move north, and areas like New Brunswick, have more and more lobster every year. What I found in my research will be important for lobstermen, people who eat lobster, and people who care about the environment and organisms, that climate change is impacting this creature. So, in conclusion, lobster populations are changing in New England and Canada because of temperatures warming in the Atlantic ocean, which is affecting lobsters because of their thermal threshold of temperatures from 12 to 18 degrees celsius.

References

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