



# Where did the seals go? Educator Guide

This educator guide includes NGSS alignment information for middle school and high school, and an educator key to graphs and their interpretation.

## Overview

Long Island Sound is a dynamic, seasonally-driven estuary and is the temporary home of many migratory species. In the colder months of the year, Harbor Seals (*phoca vitulina*) make their way to a Long Island Sound to enjoy the benefits of the milder winter, limited predation and abundant food supply. Several clusters of rocks near the northern shore of Fishers Island make ideal observation locales for scientists. During this program, students will visit these sites virtually, then learn about physical and behavioral adaptations that help seals survive in their environment. Students will dip into our long-term seal dataset to study how seals respond to environmental variables such as temperature and wind. This activity has a strong focus on how physical and biological aspects of an ecosystem interact, and also on data analysis and interpretation. Students will use their scientific skills to make predictions, construct a graph, analyze their results, and construct explanations.

You can allow students to choose their own research focus from the list provided, or assign them to ensure the class as a whole covers all the topics of interest. See the educator key (part II of this document) for information on what they will find.

## I. NGSS Alignment for Middle School and High School

### Science and Engineering Practices

Students will **Develop Models** in the form of graphs that show how seal behavior changes in response to environmental variables. They will **Analyze and Interpret their Data** to **Construct Explanations** for how seals respond to their environments, and then **Engage in Argument from Evidence** as they rely on their data and their graphs to explain and defend the explanations they have constructed.

### Crosscutting Concepts

Students will learn about **Cause and Effect** as they try to explain how seals might be affected by environment, and they will look for **Patterns** in their data using their graphs. Students will also think about what their findings mean for **Stability and Change** in Fishers Island Sound. They will also practice **Communicating Information** to their teachers and classmates as they explain their results.

### Disciplinary Core Ideas

**LS1.A: Structure and Function**

**LS2.A: Interdependent relationships in ecosystems**

**LS2.C: Ecosystem dynamics, functioning, and resilience**



## **Nature of Science**

**Scientific knowledge is based on empirical evidence**

## **Performance Expectations**

*Students will use empirical data about seal populations and seal behavior to build graphical models and construct explanations for how seals interact with their environment. This activity supports progress toward the following performance expectations:*

**MS-LS2-1** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

**MS-LS2-4** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

**MS-LS1-4** Use argument based on evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

**HS-LS4-5** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

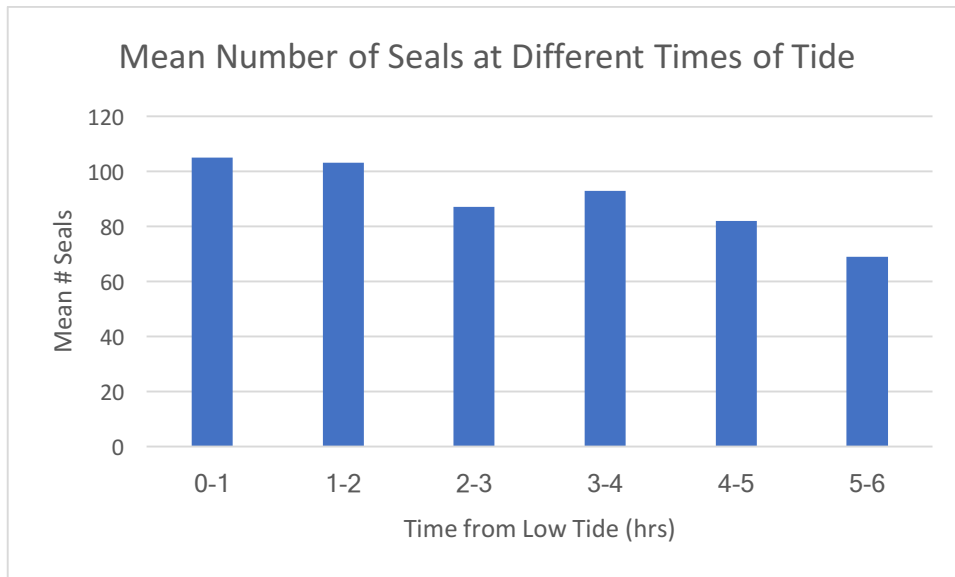
**HS-LS2-2** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.



## II. Educator guide to graphs and their interpretation

There is more than one right way to make graphs; educators are encouraged to give students more detailed guidelines if they are looking for a specific type. Here, we provide simple graphs that show the expected patterns, as well as a discussion of connections that can be made to seal biology and weather.

### 1. Basic Research Question: How does the tide affect the number of seals observed?

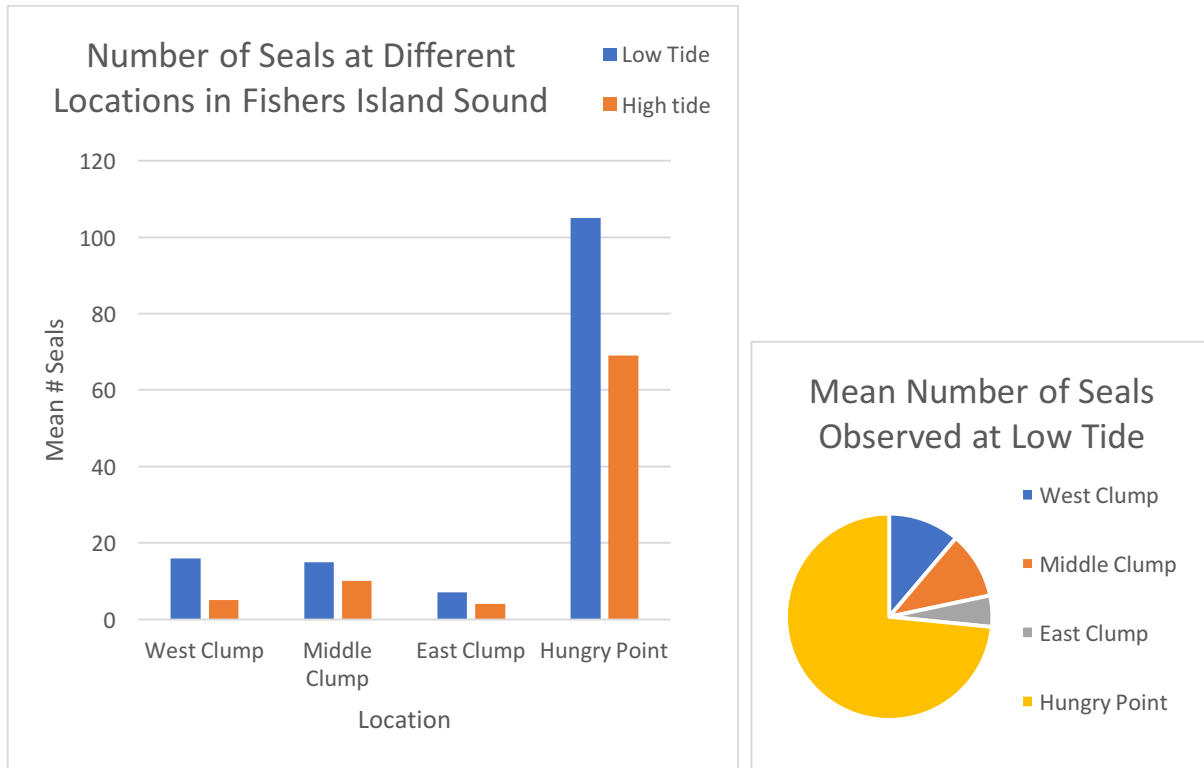


This column graph shows the average number of seals we see at different tides. The times are given in hours from low tide – so 0-1 hours means that it was within an hour of low tide when we went to look for the seals. Because the tide cycle is approximately six hours, 5-6 hours from low means that the trip took place at high tide.

The lower the tide, the more seals we see. When the tide is low, more rocks are exposed and seals have more options for hauling out. Students may be interested to see that even at high tide, we still see lots of seals! This is because some of our locations have good haul-out places even at high tide (they are never totally underwater). For students with some background on tides, it may also be worth pointing out that not all low and high tides are the same. During a spring tide series, there is a very big difference in water level between high tide and low tide, but during a neap tide series, the difference is much less.



## 2. Basic Research Question: How does location affect the number of seals observed?

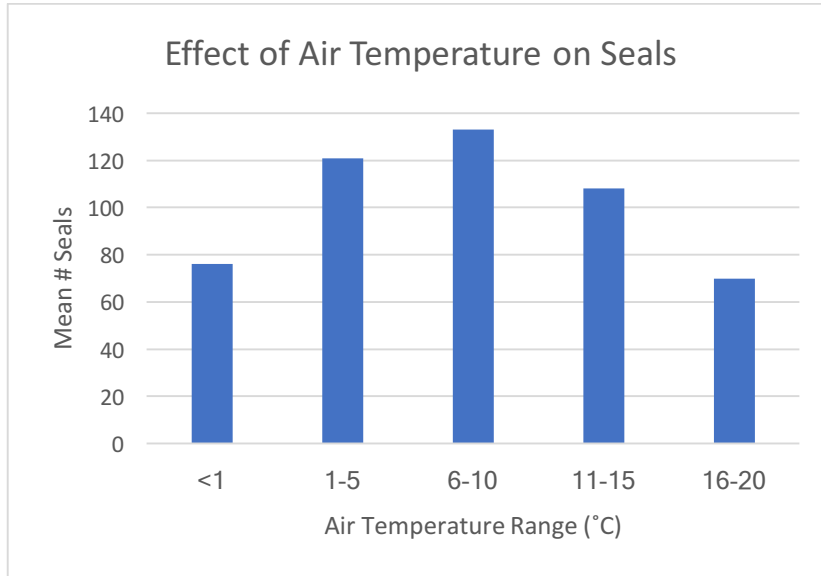


This is one of the few research questions for which a pie chart might be appropriate. A column graph works as well. In the examples above, the column graph shows the comparison at both low and high tide, while the pie chart shows only low tide. If students choose to do a pie chart, they should either ignore the high tide data or make two charts – one for high tide and one for low tide.

We see the most seals at Hungry point, with West Clump and Middle Clump a distant second, and the fewest seals at East Clump. The number of seals is determined by how sheltered the location is and by the amount of available haul-out space. On the virtual tour, students may have noticed that East Clump was a small cluster of rocks, and that many of them were too tall and steep for seals to haul out. In contrast, Hungry Point has large numbers of shallow rocks, and is also more protected.



### 3. Basic Research Question: How does air temperature affect the number of seals observed?

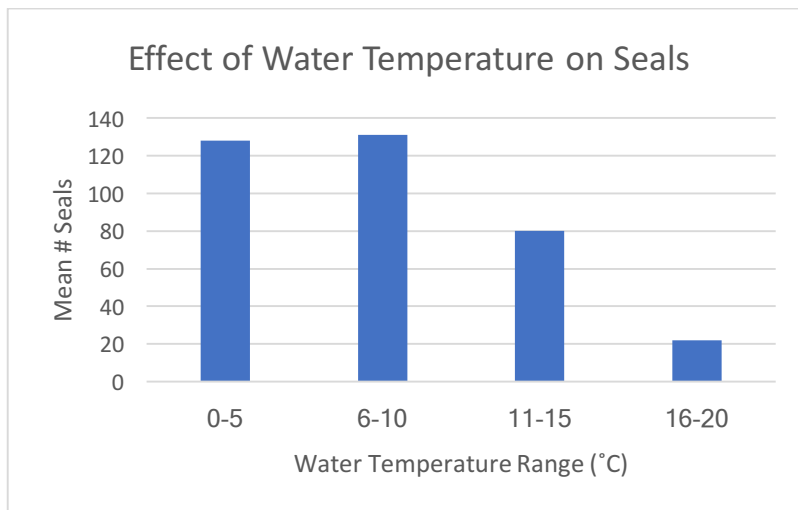


The number of seals observed increases as air temperature increases until about 10°C. This is likely because one of the main reasons seals haul out is to get warm, so the warmer the air, the more thermal benefit they get.

At air temperatures higher than 10°C, the number of seals declines again. On warm days, seals can actually get too hot out on the rocks! They may be staying in the water to avoid overheating.

There could also be a seasonal effect. The warmest air temperatures in our dataset occur in October and May, when fewer seals are present.

### 4. Basic Research Question: How does water temperature affect the number of seals observed?

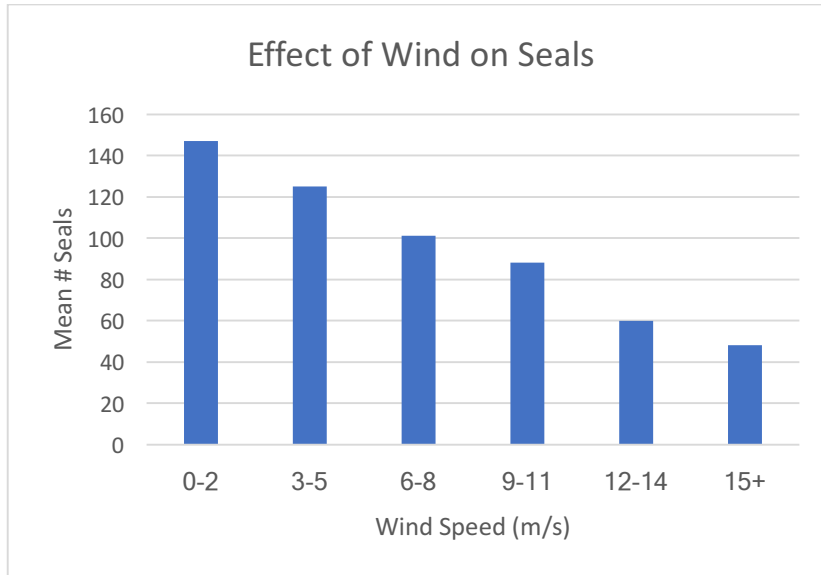


The number of seals observed declines with increased water temperature. There are two big reasons for this: First, seals haul out to rest and warm up. If the water is warm, then they won't lose as much heat in the water and they won't need to warm up as much. Under those circumstances, we're a lot less likely to see them on the rocks!

Second, there is a clear seasonal effect: the warmest water temperatures in our dataset occur in October, when fewer seals are present because most are still migrating from Maine and Canada.

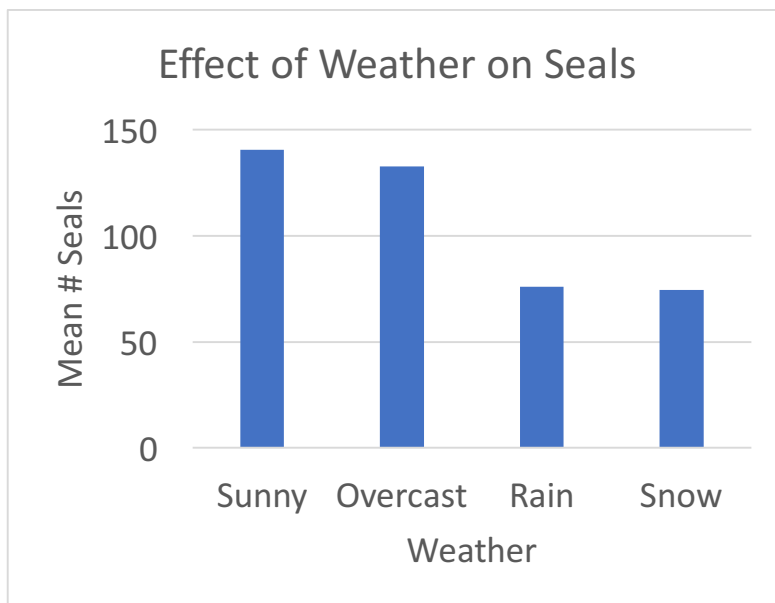


**5. Basic Research Question: How does wind speed affect the number of seals observed?**



The number of seals observed declines with increasing wind speed. There are several reasons for this. On windy days, wind chill and wave splash can decrease the effective air temperature, and seals do not gain as much thermal benefit from hauling out. There could also be an observer bias: it's harder to see and count seals from our boat in windy conditions!

**6. Basic Research Question: How does weather affect the number of seals observed?**



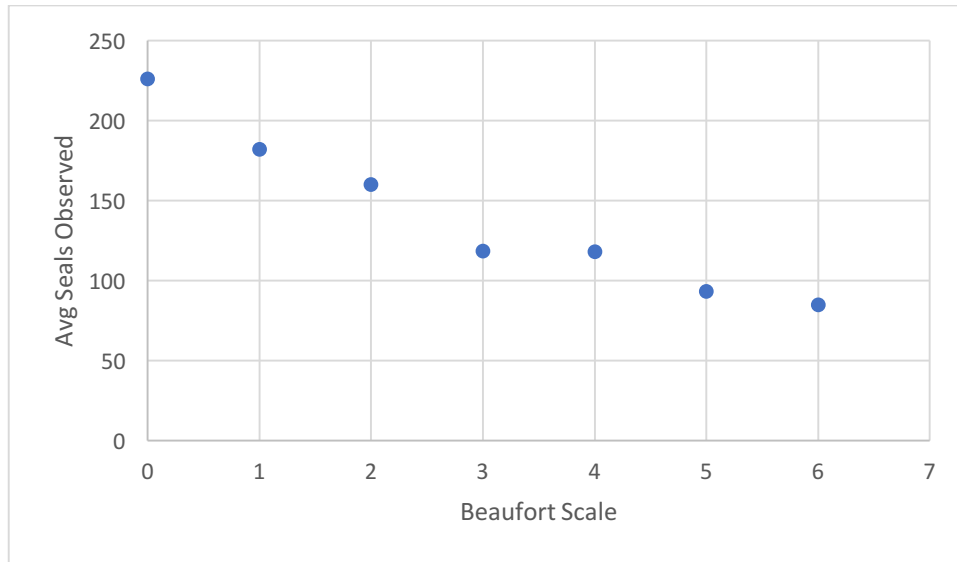
We see fewer seals when it is raining or snowing. This is because seals can't get dry when they haul out under those conditions, so they don't get as much of a thermal benefit from being on the rocks.

Interestingly, we do not see a big difference in the number hauled out in sunny vs. overcast conditions. If there is an advantage to hauling out in the sun, it's tiny compared to the advantage of being able to get dry.

This dataset may be challenging for students who don't know what to do with the list of numbers for each weather condition. You may choose to suggest calculating an average and/or provide the formula to do so, or just let them flounder a little and try to figure out the best way to show the data.



## 7. Basic Research Question: How does Beaufort Scale affect the number of seals observed?



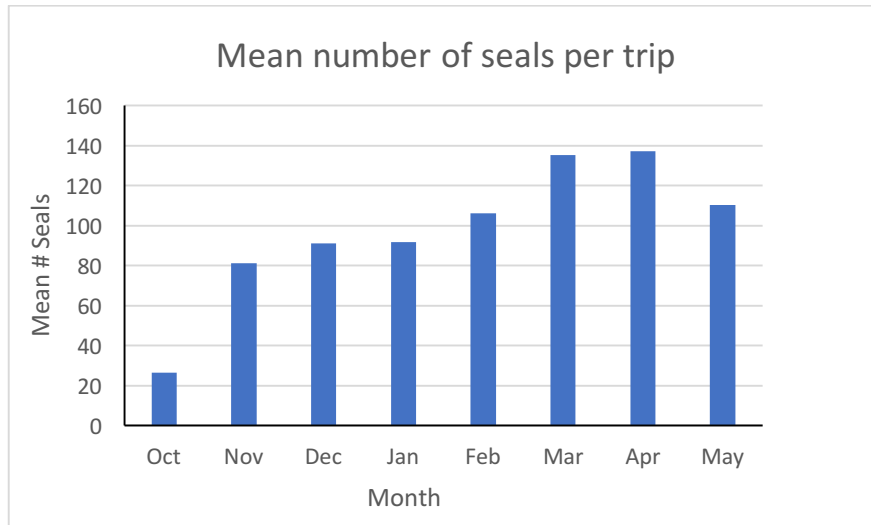
Beaufort scale is a measure of how rough the seas are. It is strongly correlated with wind speed, although it is also affected by other factors such as local geography, ocean currents and waves, etc. It may be helpful to think of the Beaufort Scale as a measurement of how the wind affects the sea surface. Students may notice that the dataset only goes up to six – that is because Project Oceanology does not go out in rougher weather!

Many of the graphs in this educator guide could be scatterplots instead of column graphs, and we have formatted this one as a scatterplot to demonstrate. You can leave the graph type up to your students, or give them some guidance if you have a preferred format – it's up to you.

As the Beaufort scale increases, the number of seals observed decreases. In rough seas, seals do not gain much thermal benefit from hauling out because they are constantly splashed by waves and buffeted by wind (wind chill is also a factor). There may also be observer bias: it is more difficult to count seals in rough seas!



**8. Basic Research Question: How does the seal population in Fishers Island Sound change over the course of a year?**



Seals arrive in our waters in October, and depart in May. We see the most seals on trips in March and April. Students may be surprised to find that the peak number of seals is in spring, rather than in the middle of winter! It's possible that seals slowly arrive throughout the winter, so that the number keeps increasing. The interplay of air and water temperatures may also play a significant role.

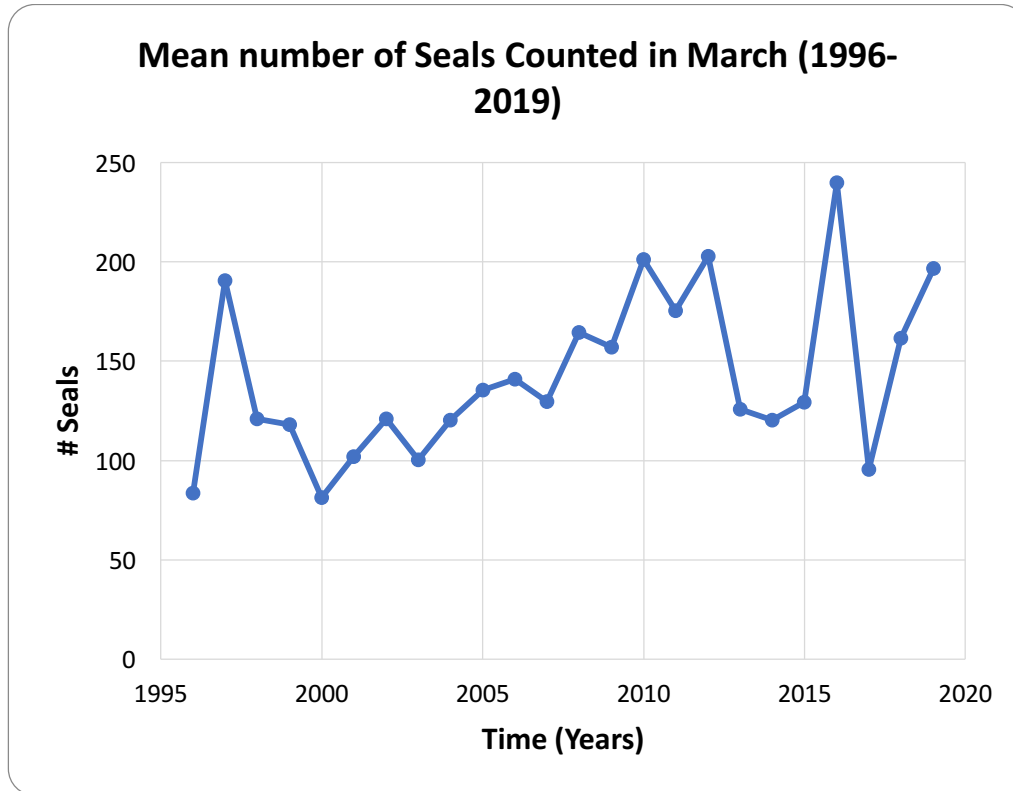
Seals haul out to rest and warm up, and the thermal benefit of hauling out is greatest when the air is warmer than the water. In October-February, conditions are the opposite (water temperature is warmer than air), but beginning in March, air temperatures are frequently warmer. Thus, we are more likely to see them hauled out for longer periods in the spring months.



## PROJECT OCEANOLOGY



9. Basic Research Question: How has the seal population in Fishers Island Sound changed over time?



Our time series data are from March, a month when we see large numbers of seals and have historically run the most seal watch trips. The mean number of seals seen per trip fluctuates but has increased overall between 1996 and 2019. This is consistent with data from NOAA and other sources: seal populations in our region have increased over the past several decades.

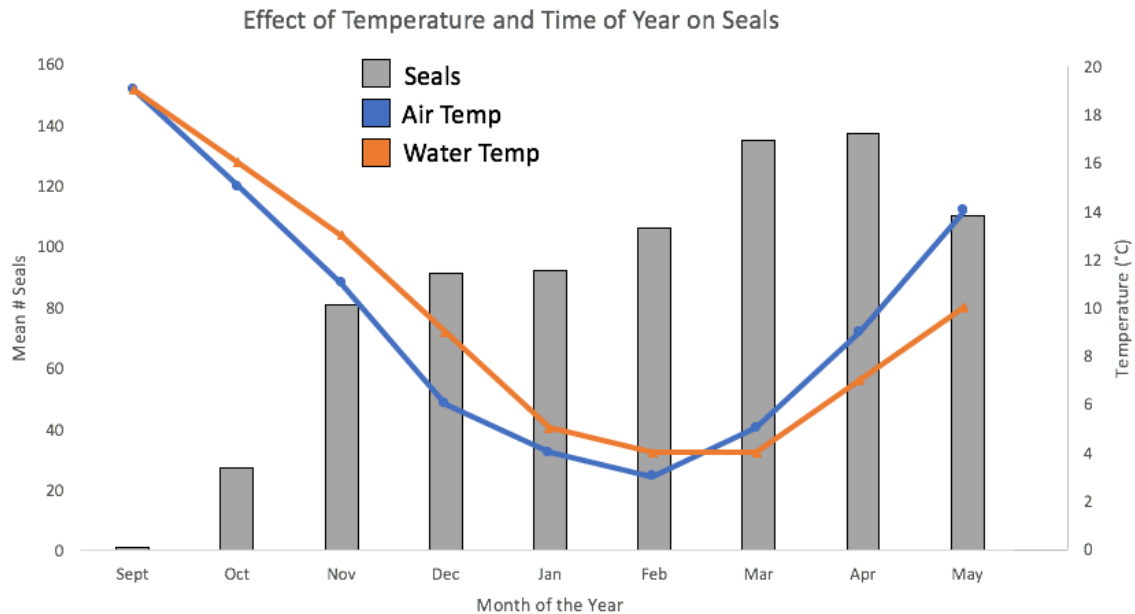
Students may notice that the increase is steady until 2012, then fluctuates much more widely. We do not know why this is the case.



## PROJECT OCEANOLOGY



### 10. Advanced Research Question: How do air and water temperatures affect the seal counts in Fishers Island Sound over the course of a year?



Seals arrive in our waters in October, and depart in May. We see the most seals on trips in March and April. Students may be surprised to find that the peak number of seals is in spring, rather than in the middle of winter! It's possible that seals slowly arrive throughout the winter, so that there really are more seals in March and April than in December and January. It is more likely, however, that they are there the whole time but we are more likely to see them in March and April.

Seals haul out to rest and warm up, and the thermal benefit of hauling out is greatest when the air is warmer than the water. In October-February, conditions are the opposite (water temperature is warmer than air), but beginning in March, air temperatures are frequently warmer. Thus, we are more likely to see them hauled out for longer periods in the spring months.

The primary challenge with this dataset is figuring out how to graph it – in fact, one suggested use for this deep dive is as a science communication challenge. An advanced student may think to have two y-axes (as we have done above) so they can overlay the datasets on one another. However, it is more likely that students will either make several graphs and line them up next to one another for comparative purposes. They may also graph the seal data and add the temperature data on in some other way (for example, by writing the numbers in or next to each column). You may want to consider having your students use this information to make an infographic or some other science communication tool that goes a little beyond graphing.



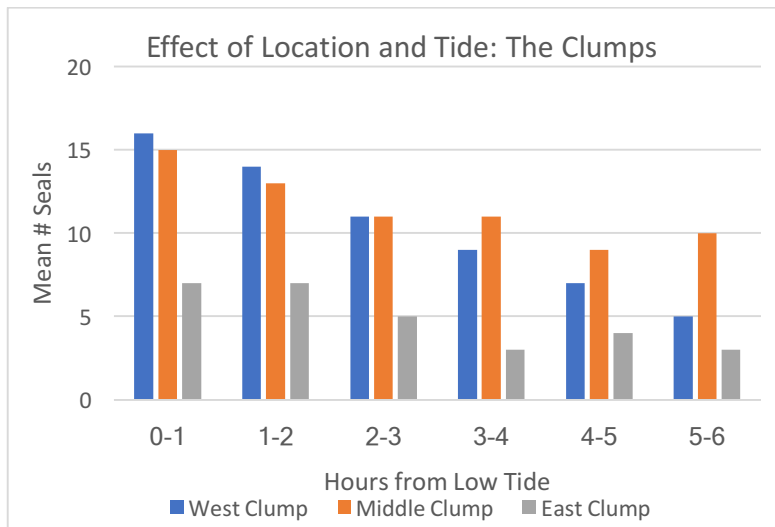
# PROJECT OCEANOLOGY



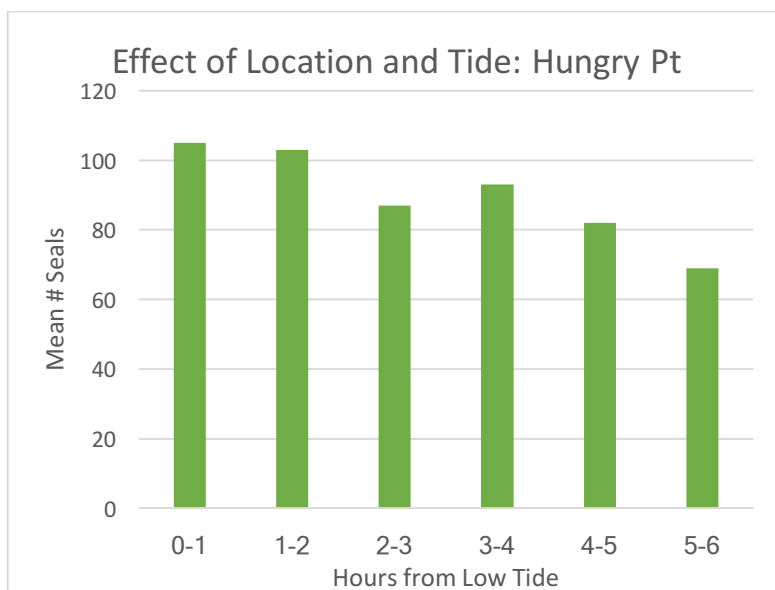
## 11. Advanced Research Question: How do time of tide and location affect the number of seals observed?

This research question is advanced because it asks students to wrestle with two variables: time of tide and location. The patterns are clear: we see the most seals at Hungry Point, with West Clump and Middle Clump a distant second, and the fewest seals at East Clump. The number of seals is determined by how sheltered the location is and by the amount of available haul-out space. On the virtual tour, students may have noticed that East Clump was a small cluster of rocks, and that many of them were too tall and steep for seals to haul out. In contrast, Hungry Point has large numbers of shallow rocks, and is also more protected.

The lower the tide, the more seals we see. When the tide is low, more rocks are exposed and seals have more options for hauling out. However, the effect of tide is different at different locations.



The graph to the left shows seal populations at the three ‘clumps’ as a function of time from tide. Within a few hours of low tide (the left side of the x-axis), we see similar numbers of seals at West Clump and Middle Clump, but fewer at East Clump. At high tide, however, Middle Clump has by far the most seals. This happens because West Clump is the lowest-lying site, and is frequently completely underwater at high tide.



We have chosen to graph Hungry Point separately, because the seal numbers are so much higher than at the other locations. If students put them all on the same graph, then the difference between Hungry Point and the clumps will be obvious, but the comparisons between the clumps (see above) will be hard to see. Just like the clumps, the number of seals at Hungry Point is lower at high tide – but the effect is not as drastic as for West Clump because there are always plenty of places to haul out at Hungry Point, even at high tide.

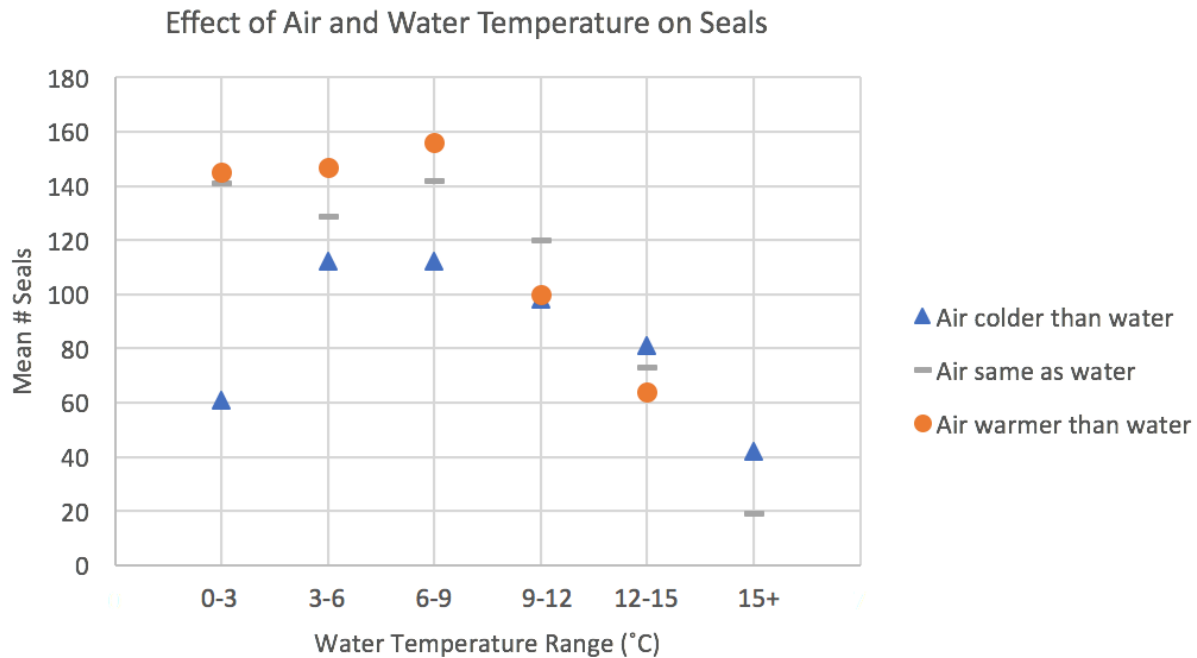


# PROJECT OCEANOLOGY



## 12: Advanced Research Question: How do air temperature and water temperature interact to affect the number of seals observed?

This advanced question is similar to #10 above, but instead of focusing on patterns over the course of a year, this one gets more directly at the question of how air and water temperature might interact to affect seal behavior. It would be a good follow-up to question #10, or to #4 (the basic research question on seals and water temperature) but can also stand alone.



A scatterplot is probably the best way to show this relationship – a column graph is much more confusing. Another option is to make three separate graphs (one for air colder, one for air same, one for air warmer) and line them up for comparison – in that case it would be acceptable to use column graphs. This might be easier for students to do, although the comparison is then not quite as direct.

When the water temperatures are warm, we don't see as many seals and the air temperature does not seem to matter. When water temperatures are colder, however, air temperature DOES appear to matter! At colder water temperatures, we see the most seals when the air temperature is the same as or warmer than the water.

This result makes a lot of sense because seals haul out to rest and warm up. When the water temperatures are warm, they don't get very cold and thus do not need to haul out as frequently or for as long. When water temperatures are cold, they get the most thermal benefit from hauling out when the air temperatures are warmer.



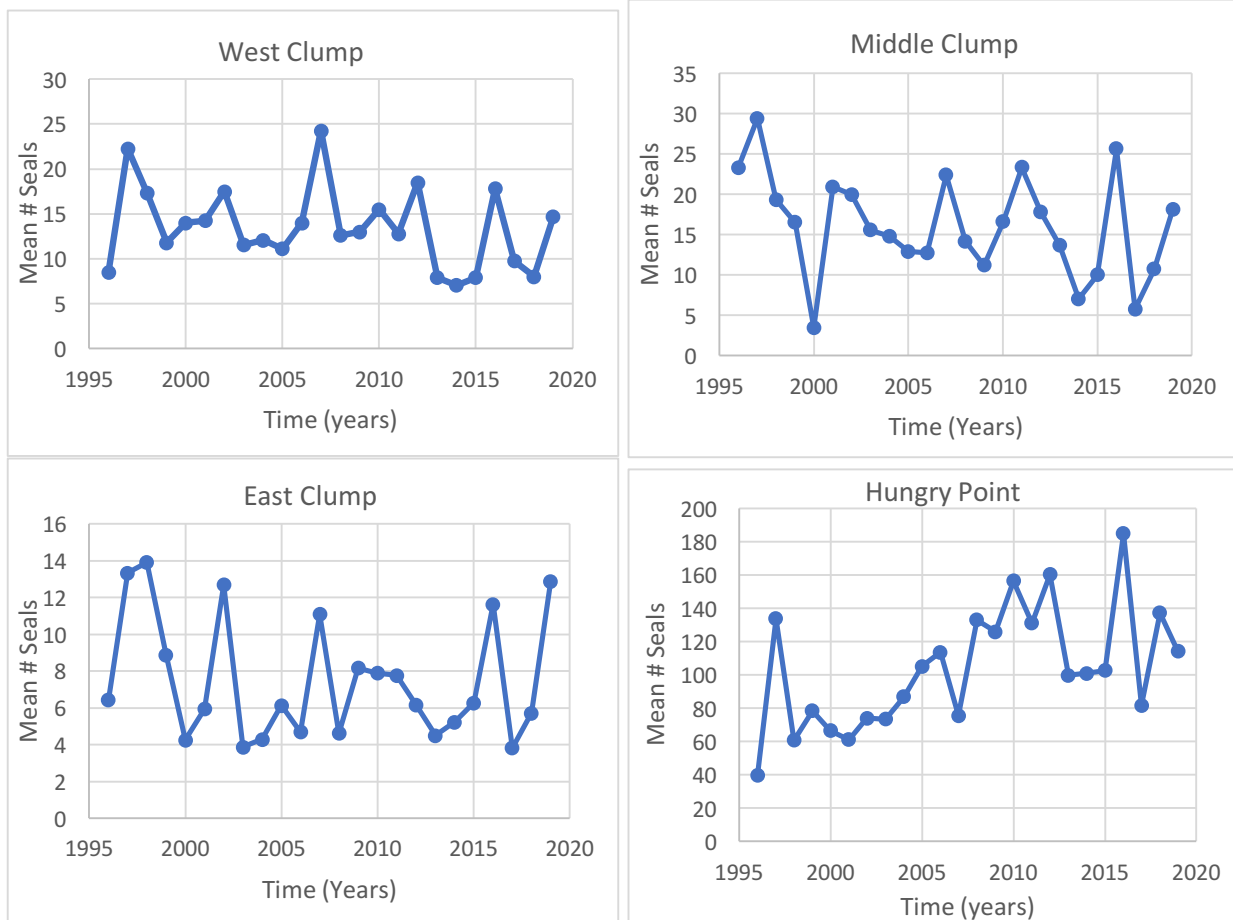
# PROJECT OCEANOLOGY



## 13. Advanced Research Question: How have seal populations changed over the years at different locations?

Our time series data are from March, a month when we see large numbers of seals and have historically run the most seal watch trips. The mean number of seals seen per trip fluctuates but has increased overall (when all locations are lumped together) between 1996 and 2019. This is consistent with data from NOAA and other sources: seal populations in our region have increased over the past several decades.

When we break out our data by location, we see that this overall trend of an increasing population is driven by an increase in the number of seals using Hungry Point to haul out. Seal populations at the other locations have been flat or even declined slightly. The most likely explanation for this is capacity. The Clumps are much smaller than Hungry Point, and it's likely that these haul-out sites simply cannot accommodate more seals, even if there are more around. Hungry Point, on the other hand, has a much larger capacity. You may want to point out to the students that if each of them looked at only one site, they would likely draw very different conclusions about what the seal population in Fishers Island sound is doing over time!





# PROJECT OCEANOLOGY



The most effective way to show these data is probably to plot them as scatterplots and show them side by side (above). It's also possible to put them all on the same graph (below) and see the same trends, although the population change patterns at the clumps are harder to see because they end up so compressed.

