Blue Mussel Monitoring: Understanding Long-Term Impacts of Changing Oceanic Conditions on the Intertidal Zone
Hoonah Indian Association Environmental Program

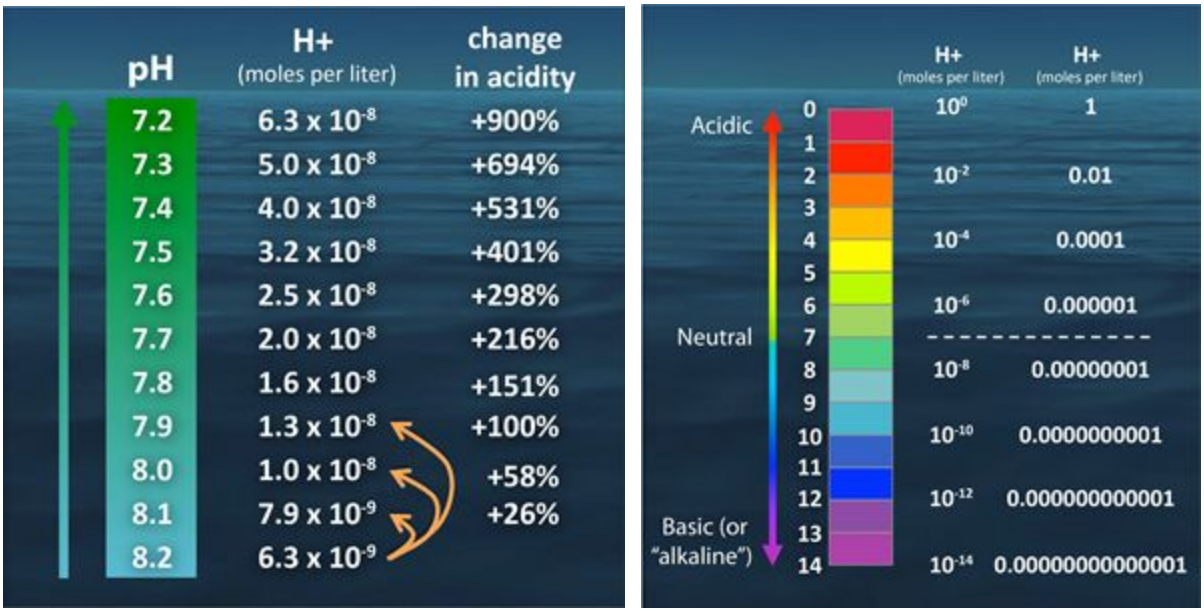
An Introduction to Blue Mussels:
Blue mussels (Yaak, *Mytilus trossulus*) are bivalve mollusk animals that are commonly found on rocky shorelines in temperate ocean environments. Like many mollusks, blue mussels have hard shells and a muscular “foot”, similar to snails, limpets, scallops. Like clams and cockles, blue mussels are a part of a class of mollusks called bivalvia, which features laterally compressed bodies enclosed in a hinged, calcium carbonate shell. Blue mussels form beds or colonies because they are sessile, meaning they are permanently attached to a substrate, and utilize specialized body parts to siphon and filter feed plankton from ocean water.

Blue mussels are important to us for many reasons.They are an important part of coastal food webs by transferring the sun’s energy from primary producers (plankton) to consumers such as starfish, fish, sea ducks, crows and ravens, and many other animals. Blue mussel beds also provide an important habitat for many small organisms such as fish, crabs, snails and algae. Although they are not a common food in SE Alaska due to paralytic shellfish poisoning concerns, many people farm blue mussels commercially and rely on them as a source of food. Blue mussels help create good water quality - a single blue mussel is capable of filtering toxins, contaminants, and plankton from up to 6 gallons of water per day. Finally, blue mussels are a part of natural history and have an intrinsic value regardless of their worth to us as humans.

Using Blue Mussels to look at Oceanic Climate Change:
Scientists use blue mussels as bioindicators of oceanic climate change. A bioindicator is a living organism that can be used to indicate the condition or status of the environment. Blue mussels are used as bioindicators because there is a relatively large body of scientific knowledge available, and because they have a very wide global range. By studying a blue mussel bed in Alaska, you are contributing to our understanding of how climate change will impact the global ocean, and how these

impacts may impact our own futures. Blue mussels are specifically vulnerable to ocean acidification, warming oceanic temperatures, and relative sea level change.

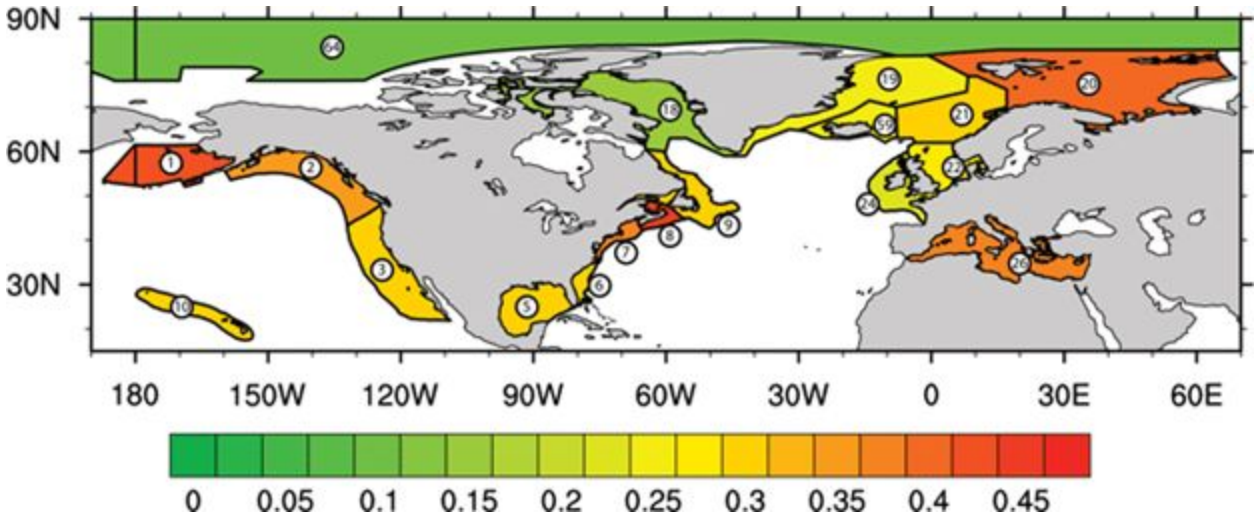
Ocean acidification is a complex chemical reaction that results in a reduction in the pH of the ocean, causing increasingly acidic conditions. Increased carbon dioxide in the atmosphere has been scientifically shown to decrease the pH of the ocean by adding more hydrogen ions. As you can see below, miniscule changes to pH can have a relatively large impact on the percent change in acidity. If current carbon trends continue, the ocean could continue to drop as much as 0.5 more pH units, a change that would make the oceans inhospitable for many marine species (Becker, 2017). Ocean acidification impacts the ability of blue mussels to calcify shells from calcium carbonate, impacting shell density, weight, and length, immune response, and hatching (Parker et al. 2013). These changes make blue mussels less resilient, and more vulnerable to combined stressors such as predation, warming ocean temperatures, and changes in relative sea level.



Above: The pH scale by numbers, and percent change in acidity. A change of one pH unit results in 10x change in hydrogen ion concentration, drastically increasing acidity. (NOAA PMEL 2020)

The ocean retains heat energy longer than the atmosphere because water has a greater specific heat and thermal capacity than air. It takes more energy to heat up a mol of water than air, and water holds on to heat longer. As a result, marine ecosystems are extremely sensitive to even the slightest change in temperature because their

organisms are more adapted to stable conditions. The oceans have absorbed much of the increased heat from human activity, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969 (NASA, 2019). Warmer waters have been shown to reduce their overall growth and physiology of blue mussels by impacting their food (Zippay et al., 2012).



Above: SST trends in Large Marine Ecosystems in the Arctic and around North America and Europe. Colors indicate change in degrees celsius per decade from 1976-2099

As ocean and terrestrial temperatures increase, sea level rise occurs. Hoonah is expected to see a relative sea level decrease, which could potentially impact species such as blue mussels that are sensitive to depth and tidal exposure (Johnson et al. 2019). Blue mussels inhabit a narrow band near the mean low water line - they colonize beneath the mean high tide line, so they can eat plankton, and above mean low tide line in order to avoid starfish. Changes to sea level rise could significantly impact blue mussels and food webs in Southeast Alaska as the mid-tide zone transitions into higher tide zones.

Understanding the distribution and abundance of blue mussels is important for understanding the long-term impacts of ocean acidification, increasing sea surface temperatures, and relative sea level rise. In this activity, we will look at the size and density of blue mussels in order to set a baseline for long term observations of the principal impacts of climate change on the oceans. We will be monitoring the size of the community, its population size distribution, water and air temperature, and relative elevation of the shoreline.

Goals:

1. Develop research skills, use the scientific method, and observe changes in the environment
2. Establish a long-term monitoring site in order to support National Park Service Scientists, USGS, NOAA, Gulf Watch Alaska, and the University of Alaska Fairbanks

Measurable Objectives:

Specifically, the objectives are to assess changes in:

- The size area of selected mussel beds
- The density of mussels within these beds
- The size distribution of mussels, specifically including those greater than 20 mm in length
- Long-term intertidal temperature fluctuations

Materials:

To complete this activity, we will need:

- Calipers (2)
- 2-inch (51mm) diameter PVC Pipe / Core (approx 4 inches long) (2)
- Knife with 20mm marking (2)
- GPS (2)
- 100 m transect tape (1)
- 50 m transect tape (2)
- Data sheets (15)
- String (2)(30m)
- 35 ziploc bags for core sampling (5 extra)
- Epoxy (JB Weld) (1)
- Stainless eyelet markers (2)
- Zip ties (5)
- Camera (1)
- Pencil / pen (4)
- Small ruler / marker 0-100mm (2)
- Measuring stick / tape (2)
- Mortar bit / wireless drill (ensure size compatibility with eyelets) (1)
- HOBO underwater temperature logger & battery (2)

Methods:

Site Establishment

1. Find an eligible sampling site during a negative low tide. An eligible site should be between 50 - 100 meters (165 - 330ft) wide, and are completely or almost completely covered with blue mussels.
    a. Vertical rock walls are not suitable for sampling, and we are looking for boulder & cobble sediments.
    b. Finer sediments may be present but not predominate. Populations should be between 50-100 mussels per square meter).
2. Fill out relevant information on the datasheet (Site ID, Site name, Date, etc.).
3. Stretch the 100m transect tape over your site in the upper margin of the mussel bed, parallel with the shore (see photo below).
    a. Make sure this line is parallel to the shore and as straight as possible.
    b. The 50m transect to the right (shorefacing) is your permanent baseline for sampling.
4. Place your permanent beginning and endpoints for the horizontal transect line. Record GPS positions of horizontal beginning and endpoints on your data sheet.
    a. Drill into the rock at this location and install stainless steel eyelets
    b. Make sure to keep the drill bit wet.
5. Determine the position of placement for 10 vertical transect lines by choosing a random number between between 0.00 and 4.75 meters. Record first vertical transect position on horizontal line on data sheet.
    a. Your first transect line will be on the random number, and each subsequent vertical line will be +5 meters from the previous marker on the horizontal line.

Above: A hypothetical mussel bed including one horizontal 50 m baseline transect (bold) and 10 variable length vertical transect lines that extend from the upper margin, to the lower margin of the bed (or zero tidal elevation if the bed continues below MLLW). The vertical transects are 5 m apart from the first randomly located vertical transect and are variable in length, depending on the width of the mussel bed (Bodkin et al. 2016).

6. On the horizontal transect, place your second vertical transect line 5 meters away from the 1st vertical transect on the horizontal line parallel to the shore. Record all subsequent vertical transect positions on the horizontal line on the data sheet (3.75m, 8.75m, etc).
    a. Repeat until you have 10 vertical transects over 50 meters.
7. Attach a HOBO temperature logger to the beginning and end marker using a zip tie.
8. Determine slope by stretching a string from each marker to the shoreline at 5 evenly spaced random intervals (0, 12.5, 25, 37.5, 50m), making sure the string is flat (0 degrees). Measure the length of the string and the height of the string at the shoreline. Divide rise / run to get your slope. Record slope data sheet.
9. Take pictures of:

   a. 2 pictures of the horizontal transect line, 1 from each endpoint looking towards the start / end point
   b. Take a landscape that captures the whole scene
   c. A half meter quadrat at 10, 20, 30 and 40 meters.
10. Congratulations, the long term monitoring site has been established. Huddle up to begin data collection.

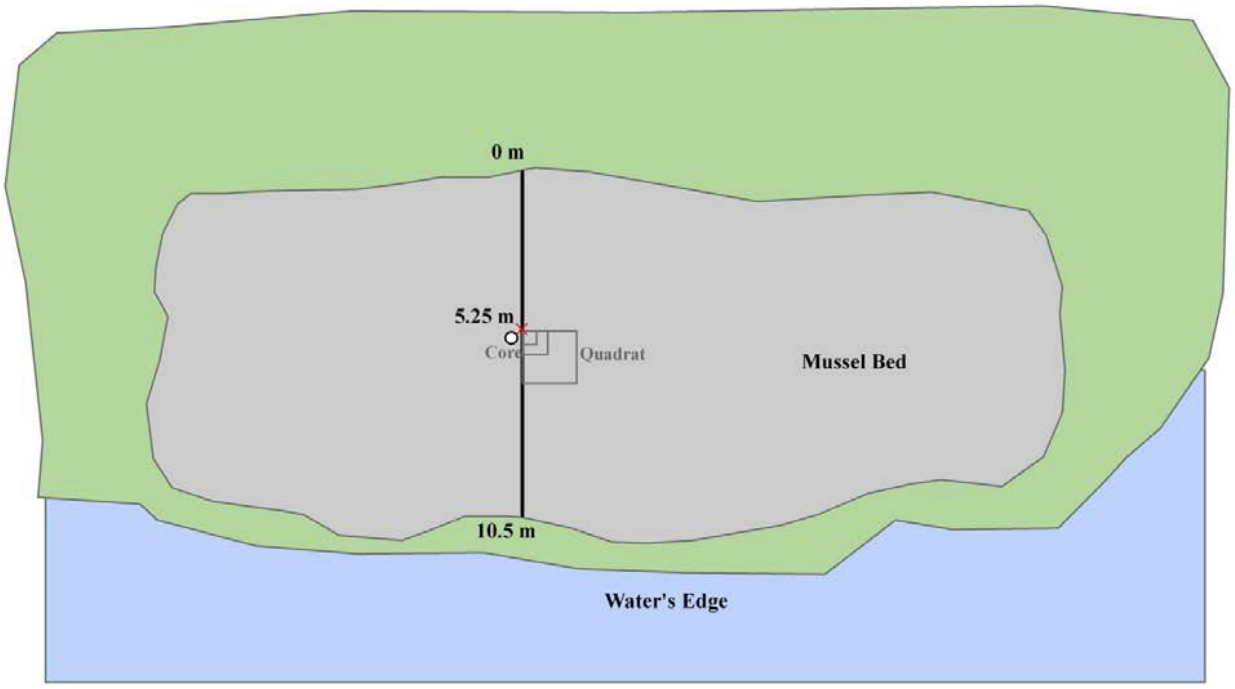
Data collection

Overview: We have established a permanent baseline transect. Each year, we will choose different intervals on the horizontal transect line, and different intervals on the vertical transect line to sample. Vertical transect lines stretch above and beneath the horizontal line. Each vertical transect line (10) will be sampled using 1) a core sample to estimate the density and size distribution of all mussels, and a quadrat of variable size, to estimate the density and size distribution of mussels greater than 20mm in length. We will also take the slope of the shoreline using simple geometry. We will split into two 3-person teams. Arianna and Sean will be team leaders, accompanied by a data recorder and a data gatherer.

Complete the following steps before moving on to the next vertical transect line.

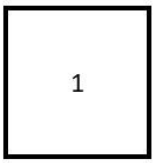
1. Use the right angle of the quadrat to lay a 90 degree vertical transect line in the designated spot on the horizontal transect line. Secure the tape so that it is as straight as possible.
2. Determine the length of the transect line by measuring from the upper end of the bed (above the horizontal transect line) to the lower end of the bed at the mean low water height.
   a. Begin at the uppermost mussels that fall directly beneath the transect tape.
   b. End your vertical transect line when you encounter more than 1m of no blue mussels - even if there are 0 mussels within 1 meter of the horizontal transect tape.
   c. Record if there is a gap of mussels of more than 1 meter but the bed appears to continue after the gap If mussels are contiguous, end your measurement when you get to dark brown kelps, mean low water line, or the mussel bed ends.
3. Record the vertical distance of each vertical transect on your data sheet.
   a. The length will be variable for each vertical transect line.
4. Record the distance between the top of the mussel bed and where it crosses the horizontal line.
   a. Row 5 on the data sheet

5. Record the random independent number & the sampling position (vertical length x multiplier number) in your data sheet.
    a. To determine placement of quadrats, multiply the length of each vertical transect length by a random independent number between 0.00 and 1.00.
    b. The closer you are to 1 the further down the sampling will go, so be mindful of the time and tide cycle you are working under.
6. Sample mussel density and size using the circle core
    a. Place core on the left side of the transect tape, next to the upper left corner of the quadrat
    b. Remove those mussels from the rock and place them into a ziploc bag
    c. Label the ziploc bag with the vertical transect line and **"primary core"** or **"additional core"** and the transect number (Ex. Transect 3.7m)
    d. Gather at least 20 mussels using the core.
    e. Collect all blue mussels from the inside of the core.
    f. Stop after 1 primary core if you collected at least 20 blue mussels that appear to be bigger than 1/10 of an inch
    g. . If necessary, Collect up to 9 additional cores, moving 12.5 cm horizontally to your right (when facing the shore), directly above the quadrat. If you cannot get 20 mussels in the primary core, add all additional mussels from additional cores to the "additional core" bag. Record the number of additional cores if they were necessary.



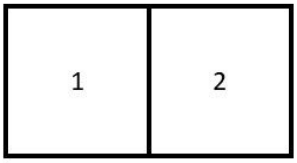
Above: A hypothetical single vertical transect, 10.5 m in length, sampled at 5.25 m, based on a random number between 0 and 1 of .50. The 51 mm diameter core pipe is centered along the left margin of the tape at the 5.25 m mark. The smallest quadrat that will yield approximately 20 mussels ≥20 mm in length, is placed at the right margin of the 5.25 m mark on the same vertical transect.

7. Sample mussel density and size using quadrat
    a. The goal of the quadrat sample is to collect 20 large mussels (greater than 20mm) per site. We use a variable size quadrat because mussel density can be highly variable.
    b. A variable quadrat frame is used to achieve this goal. There are 3 different quadrats to choose from. Choose the quadrat that incorporates at least 20 big mussels (greater than 20mm) by looking at the sampling location. If large mussels greater than 20mm are abundant, use a small quadrat (6.25cm x 6.25cm). Record your quadrat size on the data sheet. Collect all mussels greater than 20mm from the quadrat.
    c. Remove all mussels larger than 20mm from the quadrat and put them into a ziploc bag labeled with the vertical transect number.

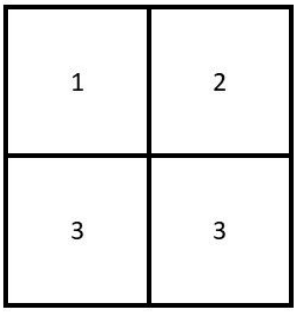


6.25cm x 6.25 cm **OR** 12.5cm x 12.5cm **OR** 25cm x 25cm **OR** 50cm x 50cm

Quadrat Dimensions (cm)	Quadrat Dimensions (fraction of m)	Quadrat Area (cm^2)	Quadrat Area (m^2)
6.25* 6.25	1/16 x 1/16 m	39.0625	0.003906
6.25 * 12.5	1/16 x 1/8 m	78.125	0.007813
12.5* 12.5	1/8 x 1/8 m	156.25	0.015625
12.5* 25	1/8 x 1/4 m	312.5	0.03125
25 * 25	1/4x 1/4m	625	0.0625
25 * 50	1/4 x 1/2 m	1250	0.125
50 * 50	1/2 x 1/2 m	2500	0.25
50 * 100	1/2 x 1.0 m	5000	0.5
100*100	1.0 x 1.0 m	10000	1



6.25cm x 12.5 cm **OR** 12.5 x 25cm **OR** 25cm x 50 **cm OR** 50 x 100 cm



12.5 cm x 12.5 cm using 4 rotations of 6.25cm (if you do this do all 4 squares)

You have several quadrats to choose from. Pick the one that will probably give you approximately 20 mussels larger than 20mm. If you pick it too small, you can flip the quadrat using this method. Be sure to record the quadrat lengths on your data sheet!

8. **Repeat process for each vertical transect line**
9. Remove all materials except for permanent transect line markers and ensure you have left no traces

Post Collection Data Processing

1. Review data sheets and edit as necessary to improve legibility and resolve discrepancies
2. Count and record the number of mussels from each core sampled that day and enter into the core spreadsheet. Measure and record the sizes of the mussels from the core sample (those greater than or equal to 1.5 mm)
3. Count and record the number of mussels from each quadrat sampled that day and enter into the core spreadsheet. Measure and record the sizes of th mussels from the core sample (those greater than 19.5mm)
4. Release all samples
5. Record any suggestions for improvement or flaws
6. Prepare next days equipment and sheets

Results

•Plot out the mussel bed dimensions and calculate area of mussel bed in m2
•Calculate densities of mussels by dividing the number of mussels by the area
•Calculate densities of mussels ≥20 mm from each quadrat and calculate mean and se of large mussel density
•Catalog site photos

This methodology was prepared for the HIA Coastal Program and Training Rural Alaskan Youth Leaders (TRAYLS) Program. Adapted from the National Park Service, Natural Resource Stewardship and Science, Mussel Bed Sampling SOP v. 1.2, Southwest Alaska Inventory and Monitoring Network (2016)

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