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| **Course(s):** Science 1206, Biology 2201, Environmental Science 3205 |
| **Curriculum Expectations:**   * 331-6 analyse the impact of external factors on an ecosystem (<http://www.ed.gov.nl.ca/edu/k12/curriculum/guides/science/sci1206/unit1.PDF>) * 115-7 explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (<http://www.ed.gov.nl.ca/edu/k12/curriculum/cot_bio2201.pdf>) * 1.07 identify that anthropocentric attitudes have contributed to many of today’s environmental issues * 1.12 define stewardship in relation to sustainability * 1.16 recognize that environmental monitoring is an essential component of sustainability (<http://www.ed.gov.nl.ca/edu/k12/curriculum/guides/science/envsci3205/3205_unit_1_revised_July2010.pdf>) |
| **Overview:** Students will complete a “Jigsaw” activity investigating the conservation measures being attempted to ensure a sustainable American Lobster fishery for the west coast of Newfoundland. |
| **Materials:**  *Teacher*   * Summary Report- “Lobster Sustainability Measures in Newfoundland: Are They Effective?”   \*see CURRA Reference\*  *Students*   * American Lobster Question Sheet * American Lobster Case Study * Jigsaw summaries: Slot Fishery, MPAs, V-notching |
| **CURRA Reference:** Lobster Sustainability Measures in Newfoundland: Are They Effective? – Jennica Seiden, Kate Wilke, and David Schneider (<http://www.curra.ca/documents/LobstersummaryJennicaSeiden.pdf>). For more research on this topic see “Marine wildlife of the Gros Morne national park region” – Joeseph S. Wroblewski or visit [www.curra.ca](http://www.curra.ca). |
| **Lesson Details:**  *Allow for 1-2, one hour periods*   * Students will be separated into “Jigsaw” groups (3 students per group) * Each student will be responsible for filling out the provided question sheet which will in turn become their notes on this lesson * As a group, students will read through the literature provided and answer the first set of questions together * For the “Sustainability Initiative” charts, the students will number themselves off from 1 to 3 and move to new focus groups, either v-notching, slot fisheries, or marine protected areas (MPAs) * Students will become “experts” and complete the chart designated for their specialty * Students will then return to their original groups and teach their group mates about the conservation tool they were assigned * The final two questions can be completed as a group, or individually as a form of assessment |
| **Assessment:**   * Notes can be taken up as a class, or marked as an activity. |
| **Notes:** |

Based on: **Lobster Sustainability Measures in Newfoundland: Are They** Effective- Jennica Seiden, Kate Wilke, and David Schneider (<http://www.curra.ca/documents/LobstersummaryJennicaSeiden.pdf>)

**Why Do We Care?**

The American lobster (*Homarus americanus*) fishery is a locally reliable inshore commercial fishery in North America with an economic value of CAD 550 million/year in Atlantic Canada. In Newfoundland, this provides 30 million/year in landed value and has considerable socio-economic value (2900 license holders) in rural communities throughout the province. The small boat lobster fishery is currently a regular source of income and part of the cultural integrity of coastal communities in Newfoundland.

In recent years concern about the sustainability of this fishery has risen because the percent of harvestable lobsters taken from populations each year is at least 75% in almost all Canadian stocks and in some areas rises to over 95%. The Fisheries Research Conservation Council concluded (FRCC 2007) that in the absence of scientific data on lobster stocks the fate of future stocks is uncertain if lobsters continue to be harvested at recent rates.

Several conservation initiatives were undertaken, with local support, to address these concerns and now form current management practices. These were closed areas [including federally designated marine protected areas (MPAs)], voluntary v-notching, a minimal landing size of 82.5 mm, and the adoption of a maximum size limit in four Lobster Fishing Areas (*i.e*., a slot fishery). The need for better scientific data on the effectiveness of these measures sparked the FFAW and fish harvesters in Newfoundland to collect data, contribute to the assessment of the stock, and propose a collaborative research project with Memorial University scientists in conjunction with CURRA, the Community-University Research for Recovery Alliance (www.curra.ca). With support from NSERC (Natural Science and Engineering Research Council) a 3 year project was undertaken to address questions being asked by harvesters: are these resource sustainability initiatives (v-notching, closed areas, and a slot fishery) effective?; and specifically, do these measures result in increased egg production and increased size/age distribution, which in turn increase egg production? To establish whether these measures have a science basis we used a central concept in population biology called "reproductive value" to evaluate the effectiveness of these measures. Reproductive value considers not only current egg production, it takes into account the expected future value of the individual to the population. Reproductive value allows us to compare the value of an individual as a commodity with its value to its population.

**Reproductive Value Relative to Economic Value**

The first goal of this study was to calculate the reproductive value of lobsters in Newfoundland at each age and size throughout a lobster's life and calculate the ratio of reproductive value to landed value. The ratio of reproductive value relative to dollar value increased onward from reproductive maturity at age 7. The ratio of reproductive value to dollar value increased for large lobsters. For example, the ratio of reproductive value relative to dollar value at age 7 is 78, whereas at age 29 it is 1775. The future reproductive value at age 29 was roughly 120 times more than at age 7 (Xu and Schneider, in press).

**Results:** As lobsters grow larger, their value in terms of current and future egg production increases to a greater extent compared with their increase in dollar value. This is because egg production increases more rapidly than dollar value, measured at market prices of dollars per pound. Although harvesters lose the landed value of releasing large lobsters in the short term, this trade-off is beneficial in the long term because large lobsters make a far greater contribution to egg production than to landed value. Because reproductive value takes into account both the current and future value of a lobster it allows the value of an individual to its population to be compared with its value as a commodity.

**Variation in Egg Production and Growth Rates**

Quantifying reproductive value requires estimates of growth rates and egg production in relation to size. The second goal of this study was to identify whether differences exist in lobster growth and fecundity (egg production) at any given size and whether the relation of fecundity to size varies in any systematic way across the species range.

**Egg Production**

Egg number depended on female size; larger females produce more eggs. Traditional techniques to estimate eggs per lobster rely on removing all of the eggs from a lobster, an activity that requires special pleading (to remove eggs from only a “small” number of lobsters). Published estimates of eggs per lobster number in the tens of thousands through the range of the species, leading us to use this information to estimate egg/female throughout the range. We expected that the relation of egg number to female number would depend on water temperature and hence on latitude.

**Results:** Lobsters in more northern latitudes (Newfoundland) carry fewer eggs than lobsters further south (New England). A formula was developed to estimate the number of eggs per lobster throughout its entire geographic range (Currie and Schneider 2011) given its size. Lobsters in northerly latitudes (Newfoundland) carry fewer eggs than lobsters in more southern regions (southern New England).

**Growth Rates**

Growth in lobsters varies geographically and likely depends on several environmental factors, notably water temperature. To examine growth throughout the range, historical tagging data from over 15 studies were combined with current data from the west coast of Newfoundland.

**Results:** Growth rates, based on a commonly used formula, the von Bertalanffy growth curve, were found to decrease with increasing latitude and depend on temperature.

What is the importance of the American Lobster to Newfoundland and its residents?

Why is it important to implement sustainability initiatives in this fishery?

How does geographical variation affect the egg production and growth rates of American Lobsters in the Bonne Bay area?

What conservation measures were researched in this study?

**Sustainability Initiative:**

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What is the goal of these sustainability initiatives?

Why is an increased reproductive value important for the American Lobster fishery?

**Closed Areas (MPAs)**

Based on: **Lobster Sustainability Measures in Newfoundland: Are They** Effective- Jennica Seiden, Kate Wilke, and David Schneider (<http://www.curra.ca/documents/LobstersummaryJennicaSeiden.pdf>).

In addition to management regulations to control fishing effort (seasons, trap limits, minimum size limits), local groups have initiated several lobster closed areas, where fishing is prohibited, as a measure to increase stock sustainability. The goal is to protect lobsters from harvest in a small area, allowing them to grow bigger and reproduce, thus seeding nearby fished areas with larvae and increasing catches by adult spillover into adjacent areas.

In a Master’s thesis (2010) associated with this project, Roanne Collins found that in two closed areas (Duck Island and Round Island at Eastport in Bonavista Bay), over a 12-year period, female numbers, size, and hence eggs per female inside both closures consistently exceeded that in adjacent areas. For male lobsters, the difference in size was even greater than that of female lobsters. Over time there was an increase in the mean size of lobsters in the areas adjacent to the closures, which could be due to a spillover effect from the closure (Collins 2010).

**Value of result:** Closing an area does not guarantee an increase in lobster size. Factors such as location and size of closed area, suitable habitat (affecting survival and growth), and lobster movement (affecting recruitment) may be responsible for inconsistent effects among locations.

Closing an area to fishing increases reproductive value by reducing mortality and so increasing size and egg production. The calculated increase in reproductive value, 65%, was greater than the other conservation measures; however, this increase is restricted to small areas, in contrast to v-notching and slot fishing, which apply to entire lobster fishing areas.

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**Slot Fishery**

Based on: **Lobster Sustainability Measures in Newfoundland: Are They** Effective- Jennica Seiden, Kate Wilke, and David Schneider (<http://www.curra.ca/documents/LobstersummaryJennicaSeiden.pdf>).

A slot fishery protects large lobsters as well as immature lobsters. A minimum legal size (82.5 mm carapace length in Newfoundland) allows lobsters to reproduce at least once. The upper limit on landing size of 127 mm in Newfoundland protects large lobsters, which are capable of producing far more eggs than small lobsters. The purpose of a slot fishery is to increase the number of lobsters that reach reproductive maturity (through a minimum landing size) and increase the number of large lobsters in a population (through a maximum landing size); both restrictions aim to increase the egg production in a population and so increase overall lobster stock biomass and harvest.

**Results:** The slot fishery on the west coast of Newfoundland (minimum landing size 82.5 mm and maximum landing size 127 mm) increased reproductive value by 16.8% compared with a minimum size restriction only. Taking lobsters greater than 127 mm reduces the percent increase in reproductive value. Modified slot fishing (protection below 82.5 mm and in a window, between 100 and 129 mm) was less effective resulting in an average increase of 8.7% in current and future egg production. Narrower windows (between 115 and 129 mm and between 125 and 139 mm) were still less effective in increasing reproductive value (Xu and Schneider, in press).

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**V-Notching**

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