

Correlation between female size and egg energy content in American lobsters

(Homarus americanus)

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INTRODUCTION: The American lobster (*Homarus americanus*) is a substantially important organism in the economy of the Northeast seaboard, but little is definitively known about the organism itself (Lobster Institute 2004). Larval development is well documented but aspects of the lobster's biology are poorly understood (Helluy and Beltz 1991). The lobster fisheries' large input into the North American economy, \$2.4-4 billion in 2002 (Lobster Institute 2004), and the trend to increase landings each successive year has made it important to research American lobsters in regard to fishery management (Idoine 2006). The northeast US and eastern Canada experienced the results of poor management with the collapse of the cod fishery in the 1950's. Without sufficient management, overfishing could cause a similar situation in the lobster fishery (Comeau and Savoie 2002).

American lobsters primarily exhibit two year reproductive cycles and it can be difficult to determine maturity morphometrically as a result (Conan et al. 2001). Before mating in July-August, a female travels to a male's shelter and undergoes molting. During mating, a male deposits his spermatophore, a gelatinous spermatozoa cluster, into a female's seminal receptacle (Gosselin et al. 2003). A female carries the male's spermatophore for an entire year internally, along with eggs developing in the ovaries over the same period. The following July-August, female lobsters extrude their eggs and fertilize the egg mass externally (Aiken et al. 2004). Fertilized eggs are carried externally, attached to the female's pleopods (Figure 1) for another year until hatching the following May-June (Helluy and Beltz 1991). Throughout the industry, "berried" females, ones that extruded their eggs, cannot be landed and must be returned to the

ocean immediately. Another step in the attempt to maintain broodstock involves V-notching “berried” females on their right endopodite (Figure 1) so they can be identified and released in years without “berries”. Typically, the notch is believed to last through two molts, protecting that female from harvest for 1-4 years and allowing another opportunity to reproduce prior to being harvested (McKiernan 2007).

In the United States, V-notching is mandated by law in some states and voluntary in others (Maine Department of Marine Resources 2002). However, in Canada, V-notching is voluntary and this disparity between the fisheries diminishes V-notching’s effectiveness (Acheson and Knight 2000). Also, V-notching is performed at sea during landings and therefore is difficult to enforce. Management practices hinge on finding the size of female lobster that produces eggs of the highest quality with the highest fecundity (Comeau and Savoie 2002). The lobster fishery currently uses size to limit landings because size is easy to determine during landings. Size restrictions vary throughout the industry and protect juvenile lobsters along with large females thought to produce many eggs. However, eggs with the highest energy content are thought to produce eggs of the highest quality and this study seeks to find a correlation between female size and egg quality (Attard and Hudon 1987).

Historically, the assumption has been that larger lobsters produce more energy dense eggs and have higher egg volumes. This assumption is the result of studies where “large” lobsters were defined as one with 110mm carapace length (Attard and Hudon 1987). Conversely, the Bay of Fundy is a habitat in which lobsters greater than 110mm in carapace length are frequently observed (Figure 2), questioning the validity of the assumption of larger lobsters producing more energy dense eggs (Campbell 1983), as the egg quality in these lobsters has not been evaluated.

If exceptionally large lobsters are producing eggs of high quality then the current assumption will stand. However, if these extra large lobsters are producing eggs of poor quality, than it may indicate that reproductive senescence is occurring. Reproductive senescence is a natural reduction in reproductive success as the animal ages (Berube et al. 1999). Menopause in female humans is an example (Ward et. al 2009). If reproductive senescence is occurring in larger lobsters it would be one of the few documented cases in invertebrates (Moya-Laraño 2002). One difficulty with studying reproductive output as lobsters age, is there is no reliable way to age these animals yet. Lobsters shed their exoskeleton with each molt thus eliminating any opportunity to age them via exoskeletal characteristics. Large lobsters can be assumed to be older because large size is produced through molt cycles that require many years (Campbell 1983). Aging lobsters will continue to be of interest in order to determine if reproductive senescence is occurring.

OBJECTIVE AND JUSTIFICATION: In this study, the following questions will be addressed:

Is there a relationship between female size and egg quality? I hypothesize that the energy content of a female lobster's eggs will be positively correlated with female size (carapace length). If this hypothesis is true, then: Do the largest lobsters (those with CL > 160mm) continue to produce eggs with high energy content? I hypothesize that the largest lobsters will show a negative relationship between the energy content of female lobster's eggs and female size (carapace length).

Preliminary analyses [fecundity, lipid profiles of eggs] from the Koopman lab have led to the suggestion that reproductive senescence may occur in large female lobsters (those with CL > 160 mm). Confirmation or rejection of historical assumptions about the American lobster's reproductive biology may be possible following this study. Either way, this study could provoke

further research into the management and conservation of this economically important organism. Additionally, finding the female size that correlates to the highest egg quality could help establish updated size restrictions for lobster fisheries. This research has implications for not only our understanding of lobster biology but also for ways to manage and conserve other economically important crustaceans.

METHODS: American lobsters were collected 10-17 nautical miles off Grand Manan Island in the Bay of Fundy, Canada from “berried” lobsters (Figure 3). Lobsters were collected in June 2008, December 2008, June 2009, and December 2009. The commercial lobster fishery vessel Kadie Mae II, captained by Neil Morse, was used to collect lobsters offshore, 100-200m in average depth, using trawls of 24-30 traps. Lobstermen pull the traps onto the boat’s deck to land the lobsters. As “berried” females are pulled from the trap, Dr. Heather Koopman measured and sampled the lobsters before they were released. Each lobster’s carapace length, in millimeters, and egg volume, in cubic centimeters, was measured. Approximately 10 cm³ of eggs were removed and a portion of the eggs were preserved in 65:35 ethanol/glycerin for developmental index and size. The rest was frozen in seawater for lipid and energy content analysis.

The collected egg’s energy content will be determined in Dr. Heather Koopman’s laboratory in Friday Hall 2037 by an IKA-C2000 basic bomb calorimeter. A bomb calorimeter is, in essence, a water bath surrounding a stainless steel canister, a bomb, with an attached computation unit (IKA Werke 2007). Two repetitions of the lobster egg sample are weighed out in a metal crucible and desiccated in an Isotemp oven at 60°C for five days prior to being combusted. The samples are weighed midway through drying to ensure desiccation and an average dry weight between 0.2-0.3 grams. Bomb calorimeters determine energy content through

the energy released during the sample's combustion. Oxygen is injected in the bomb and ignited by a cotton thread tied to an electrical conduct and covered by the sample. A thermometer measures the temperature change in the water bath following combustion and this change is converted to joules per gram, the SI unit for energy content and useful to compare samples. Calibration is done using benzoic acid tablet standards to keep accuracy constant.

Data interpretation will compare energy content to lobster carapace length. I expect to find a positive relationship between the two except with exceptionally large lobsters, where I expect to find a negative relationship. Each collection group, summer versus winter and yearly, will be compared to see differences in energy content. To better understand the results and to have any implications for the lobster fishery, the data from this study will be combined with two other studies conducted in the Koopman lab looking at the eggs' developmental index and the lipid content. Since the current study and the two adjoining studies use the same lobster samples, a complete profile of egg quality can be assembled based on carapace length.

PRODUCT: Results from this study will be combined with data obtained from the same samples, including egg size, egg developmental index [carried out by Emily Probst, Honors project in the Koopman lab] and data on lipid content and fatty acid profile [carried out by Dr. Koopman] into a manuscript for publication in a peer-reviewed scientific journal. As well, the results of this research will be detailed by a scientific report to the funding agencies.

SUPPORT: The collection of lobsters could not have been done without the help of Captain Neil Morse and the crew of the Kadie Mae II. The lobster collection also received help from Grand Manan Whale and Seabird Research Station and support from both Maine and North Carolina Sea Grant and UNCW.

DIAGRAMS:

Figure 1-Diagram of American lobster anatomy (reproduced from Jones 2004)

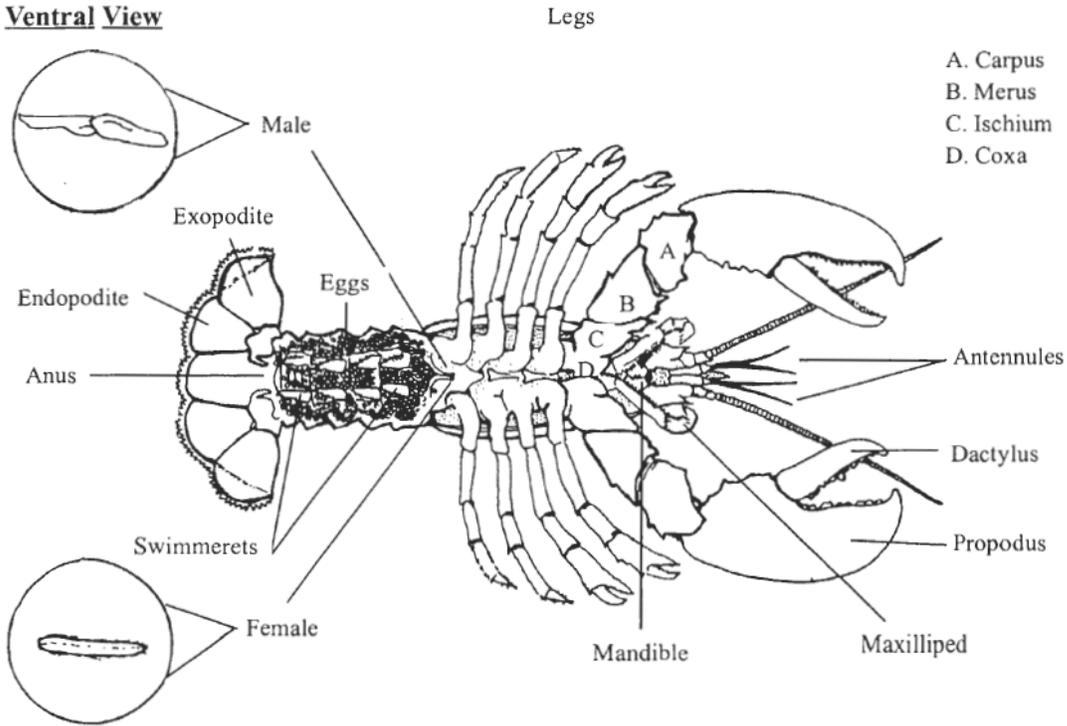
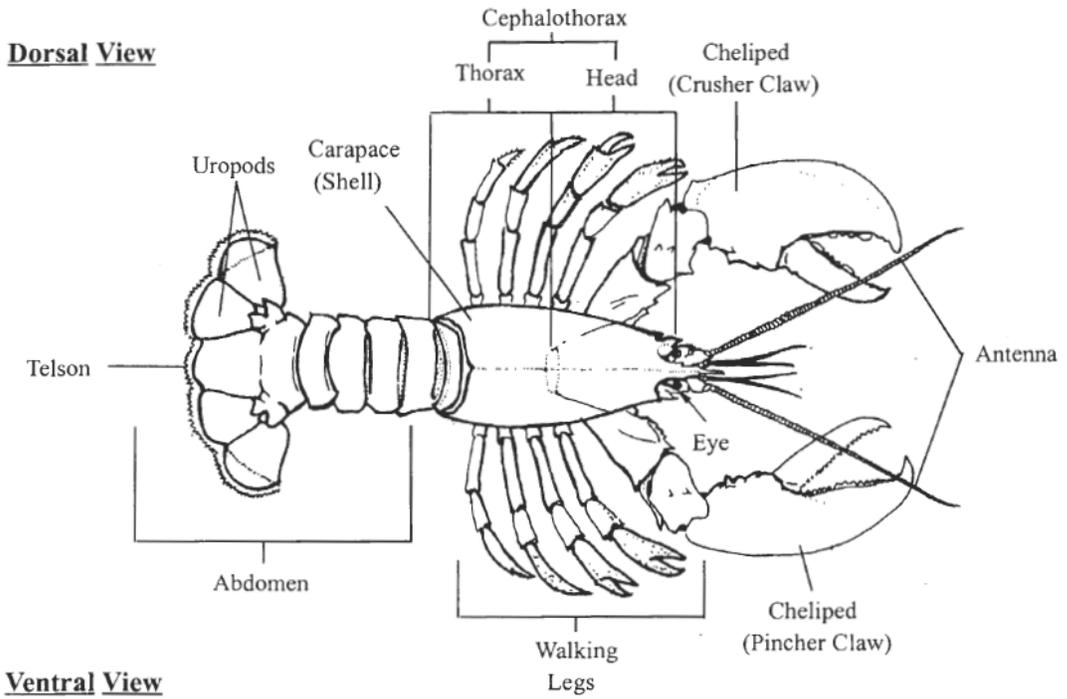
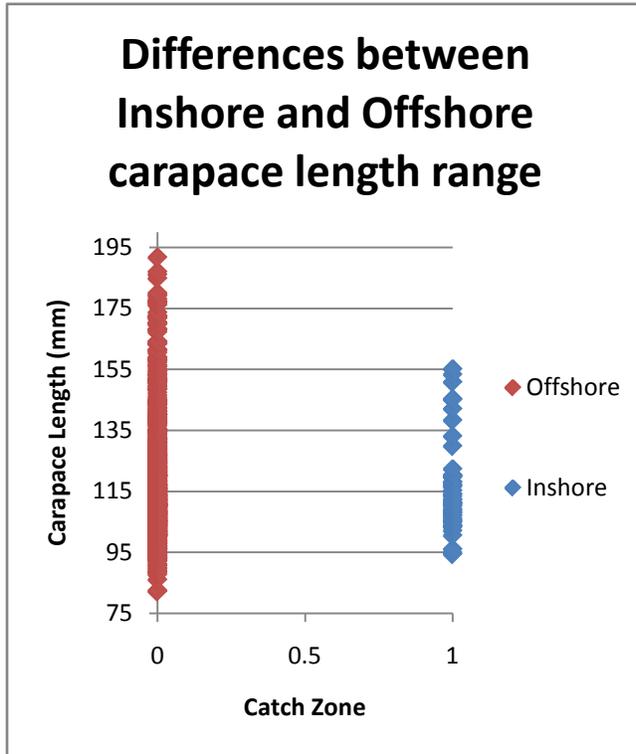


Figure 2-Carapace length ranges of this study from June 2008, December 2008, April-June 2009 and December 2009



Offshore Carapace Length Range: 82.1-191.6mm
 Inshore Carapace Length Range: 94.3-155mm

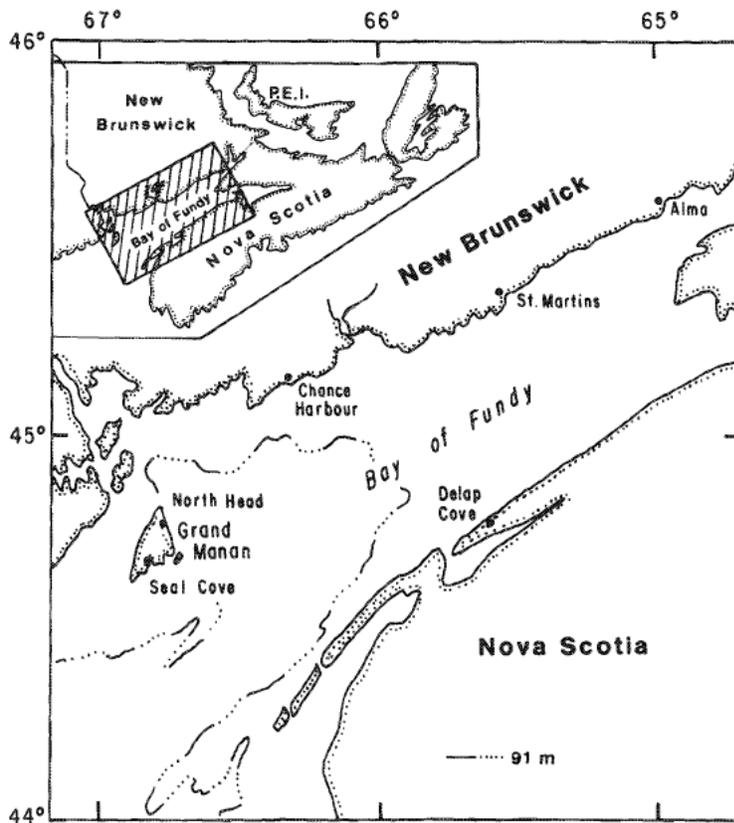


Figure 3-Map of Bay of Fundy where the lobsters were collected (reproduced from Attard and Hudon 1987)

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