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HOW MIGHT CLIMATE CHANGE AFFECT AMERICAN LOBSTERS?

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Climate change is likely to have a dramatic impact on many animals, including American lobsters (*Homarus americanus*). Lobsters are very sensitive to water temperature, and they will move to avoid water that is too warm or too cold. While this behavior has served them well for 1,000's of years, as the oceans warm up, they might seek new habitats, which might disrupt aspects of their life cycle and lead to a decline in their numbers. In this article, we aim to explain some facts about American lobsters and tell you about several ways that climate change might have an impact on these fascinating and valuable creatures.

THE AMERICAN LOBSTER LIFE CYCLE

Have you ever eaten lobster? Maybe you have enjoyed a lobster roll on a hot summer's day while on vacation or cracked the bright red shell of a cooked lobster to dip the meat in butter—yum! Perhaps you may have even found a small lobster in Maine tide pool. The American lobster is the single most valuable fished species in the United States and, although we capture millions of them each year, we still have much to learn about this iconic species given that they are hard to observe in their natural habitat. Yet, during the last 30 years, we have learned enough to realize that, as the oceans warm due to climate change, lobster populations might decline or become unstable.

ARTHROPODS

Invertebrates that have a shell called an exoskeleton, a segmented body, and numerous paired appendages. This group includes lobsters, insects, and many more.

MOLTING

The process by which arthropods shed their old shells to grow.

To appreciate how climate change might affect lobsters, it is useful to understand the lobster life cycle (Figure 1). Like many **arthropods** that have exoskeletons (external shells), lobsters grow by **molting**. About once a year lobsters "slide" out of their old shells. When they emerge, they are very soft, like gelatin, until their new shells harden—which takes about 2 weeks.

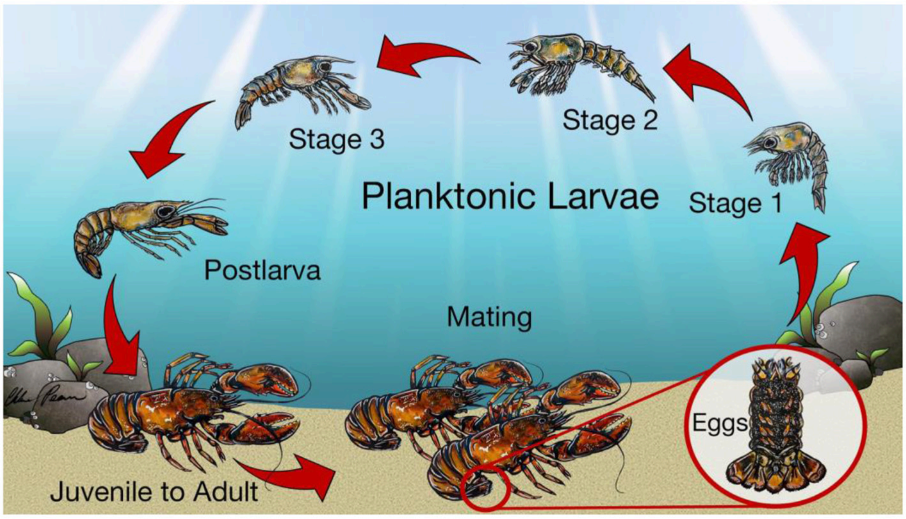

Figure 1

Figure 1

The life cycle of an American lobster. It takes roughly a month for the larvae to develop through all four stages and settle to the ocean bottom. It then takes about 5–7 years for them to reach sexual maturity. As adults, lobsters can live for more than 10 years (Artwork used with permission of Chloe Pearson).

Mature females typically mate just after they molt. Then, after 2–13 months after mating, the female uses her stored sperm to externally fertilize her eggs as she extrudes them, and "cements" them to the underside of her tail. Females carrying eggs this way are called **ovigerous** or "berried" females – the eggs in Figure 2 look like little berries, right?

OVIGEROUS

Bearing eggs. A female lobster carrying eggs on the underside of her abdomen is considered to be ovigerous.

The following year, in the early summer, these eggs finally hatch. The exact timing of hatching depends on the water temperature—warmer water makes the eggs develop more rapidly, like baking cookies at a higher temperature than recommended by the recipe. These hatched baby lobsters, known as larvae, float and swim around near the surface

Figure 2

(A) Eggs cemented to the abdomen of a female lobster. These eggs are almost ready to hatch. **(B)** The dark spot you can see on some of the eggs are the eyes of the larvae (for example, look near the tips of the two arrows).

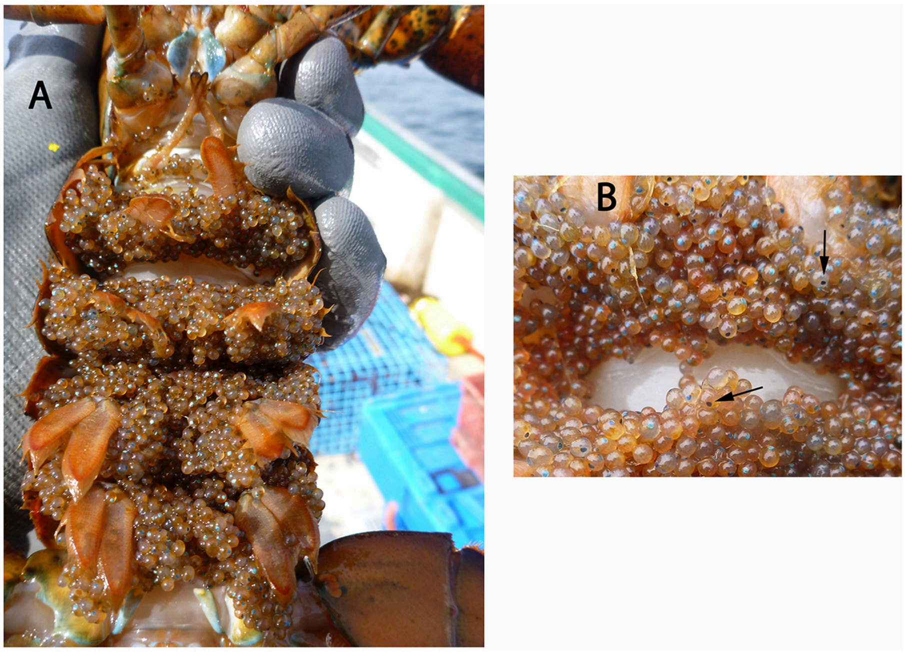

Figure 2

ZOOPLANKTON

Tiny animals that are transported in the ocean by the currents. The name is derived from "planktos," the Greek word for "drifting."

of the ocean, where they feed on **zooplankton** for about 20–30 days. During this time, lobster larvae pass through four larval stages, molting and growing a bit each time, and then they settle to the bottom (Figure 1). Eventually, after 5–7 more years of molting and growing, they become adults. Keep in mind that temperature has a big impact on all aspects of the lobster life cycle.

HOW MIGHT WARMER WATER IMPACT LOBSTERS?

About 20 years ago, we discovered that lobsters can sense very small changes in water temperature (1°C, which is 1.8°F) [1] and that they try to avoid water that is either too cold (<5°C or 41°F) or too warm (>23°C or 73°F) for their liking [2]. In general, lobsters prefer a water temperature of 16°C (61°F).

As a result of their temperature preferences, and the fact that they can walk more than 2 km per day, the seasonal movements of lobsters are fairly predictable. Many lobsters move away from the coast in the late fall and winter, because waters nearshore become too cold. In the spring, they often move back to nearshore waters, where the waters along the coast warm up faster than the deeper, offshore waters [3]. Interestingly, female lobsters prefer water that is slightly colder than males, and so cooler areas tend to have more females and warmer areas, like estuaries and some bays, tend to have more male lobsters [4]. We still do not know why males and females have evolved this difference in sensitivity to water temperature.

WHY ARE LOBSTERS PICKY ABOUT WATER TEMPERATURE?

Lobsters, like fish, are **ectotherms** (cold-blooded). This means that, unlike humans and other mammals, they are not very good at regulating their body temperature, so their internal temperature changes along with the temperature of their surrounding environment. The only way lobsters can control their body temperature is by moving to warmer or colder areas, kind of like how you might move indoors if you get too cold outside. This is called **behavioral thermoregulation**.

ECTOTHERMS

Cold-blooded animals whose body temperatures change along with the temperature of their environments.

BEHAVIORAL THERMOREGULATION

Behaviors that ectotherms exhibit to have some control over their body temperatures. This can include moving to areas that are warmer or colder.

Why do they do this? Because as a lobster's body temperature increases, so does its **metabolic rate** (heart rate, breathing rate, use of energy, etc.). If lobsters are too cold they cannot move as fast, so they might become easy prey or be unable to catch *their* prey. Or, if a lobster is too warm and its metabolic rate is too high, it will burn a lot of energy and will thus need to find more food—kind of like a kid right after playing a whole soccer game. Unfortunately, lobsters cannot just open the refrigerator; they need to consume more food, which costs them even *more* energy. So, you can see why lobsters try hard to stay in the right temperature zone.

METABOLIC RATE

A measure of how fast an animal uses its energy reserves. This can be measured by the rate of oxygen use or heat production.

IF LOBSTERS CAN MOVE, WHAT IS THE PROBLEM?

In some colder areas of the world, like along the coast of Maine, USA, ocean warming might not have much impact in your lifetime. But in warmer areas, like south of Cape Cod, Massachusetts, USA, climate change is already causing problems. Due to a combination of warmer water and the diseases that spread more easily in warm waters, the lobster populations in those regions have declined a great deal.

In some areas, temperature preferences might cause lobsters to move at different times than they usually do, or to different places. For example, females seeking cooler water might end up in areas with very few males (remember, males tend to prefer warmer water than females). This is already the case in places like Buzzards Bay, Massachusetts, and in estuaries like the Great Bay Estuary in New Hampshire [3]. If female and male lobsters end up in separate areas because of their temperature preferences, some females that are ready to mate might fail to find partners, and this could lead to fewer offspring.

Warming oceans might also negatively impact lobsters by changing where female lobsters are when their eggs hatch (remember, they hold onto their eggs throughout their development cycle). For example, along the coast of New Hampshire and southern Maine, many female lobsters carrying eggs spend the winter near a group of islands located about 7 km from the coastline [3]. When their eggs hatch in the spring, larvae are carried by the ocean currents toward Massachusetts (Figure 3). Eventually, after about 20–30 days, these larvae are ready to settle to the bottom along the coast of Massachusetts, where there are good places to hide from predators and plenty of food. However, if females move further offshore to incubate their eggs because nearshore waters are too warm, their eggs may hatch in a different location, and the ocean currents might transport them to a completely different location—possibly one where it is more difficult for them to survive (Figure 3).

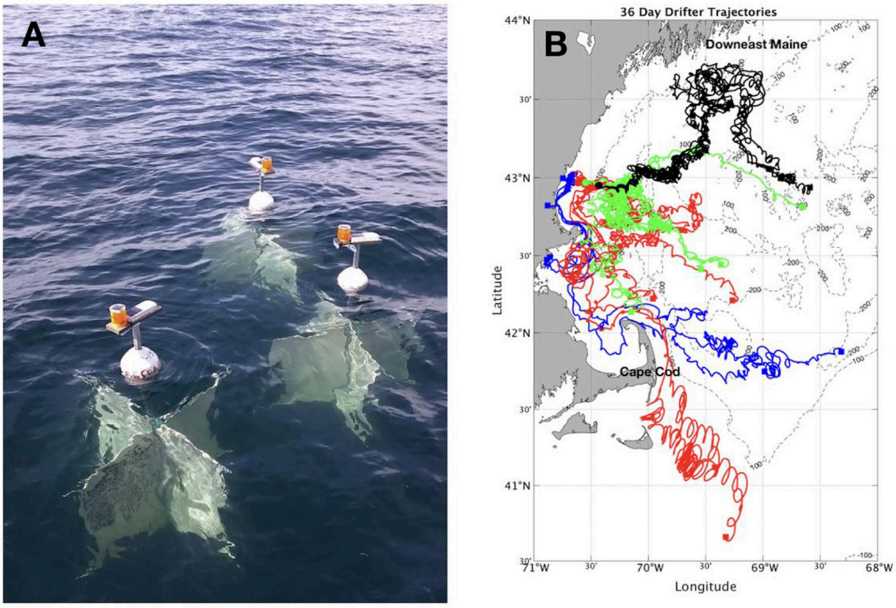

Figure 3

Figure 3

(A) Ocean "drifters" equipped with GPS units were used to determine how larvae that hatch at various distances from the coastline are transported in ocean currents. **(B)** Colored tracks (each color represents a different drifter) show how larvae might end up in very different areas, depending on their initial location. For example, compare where the blue drifter, released closest to shore, ended up compared with the black drifter, released furthest from shore. These data suggest that if female lobsters move further offshore to seek cooler water, their larvae might end up too far from the coast when they settle.

Even if female lobsters stay in their normal locations, their eggs might hatch sooner in the warmer water. This could be a problem because there might not be as many zooplankton in the water for the larvae to eat when they hatch [5]. And, if the water is warmer, larvae might grow and molt faster, so they will be ready to settle to the bottom sooner than usual and could end up in a habitat that is not optimal for their survival. Recently, scientists have found that, while there are plenty of females with eggs and lots of newly hatched larvae, there are fewer late-stage larvae and newly settled lobsters in the waters around New Hampshire and Maine, suggesting that fewer larvae are surviving—probably because they cannot find enough to eat [5].

SUMMARY

American lobsters are extraordinarily valuable and an important species to coastal ecosystems. However, like many other species, their numbers, movement paths, and locations may be changing as a result of climate change. Lobsters are very sensitive to water temperature, and there are many aspects of their life cycle that could be affected by changing ocean conditions, including warming water temperatures. Some of these factors could cause a severe decline in the number of new lobsters produced each year, particularly in regions of New England and Canada. This is important because the American lobster fishery is the most valuable single species fishery in the United States and, as a result, it is vital to the social and economic stability of many New England coastal communities.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

JOSEPHINE, AGE: 11
My name is Josephine. I love to read and write stories. My favorite animals are pigs because they are really cute. Pink is my favorite color. Science is one of my favorite subjects, and I like to complete projects every year for the science fair.

MARTIN, AGE: 13
I love to play games with my family and go on walks or bike rides. I like to go to the bike park near my home, or any parks with my family. I love to play video games. Some of my favorite video games are Krunker.io, Clash Royale, Minecraft, and Bloons TD 6.

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