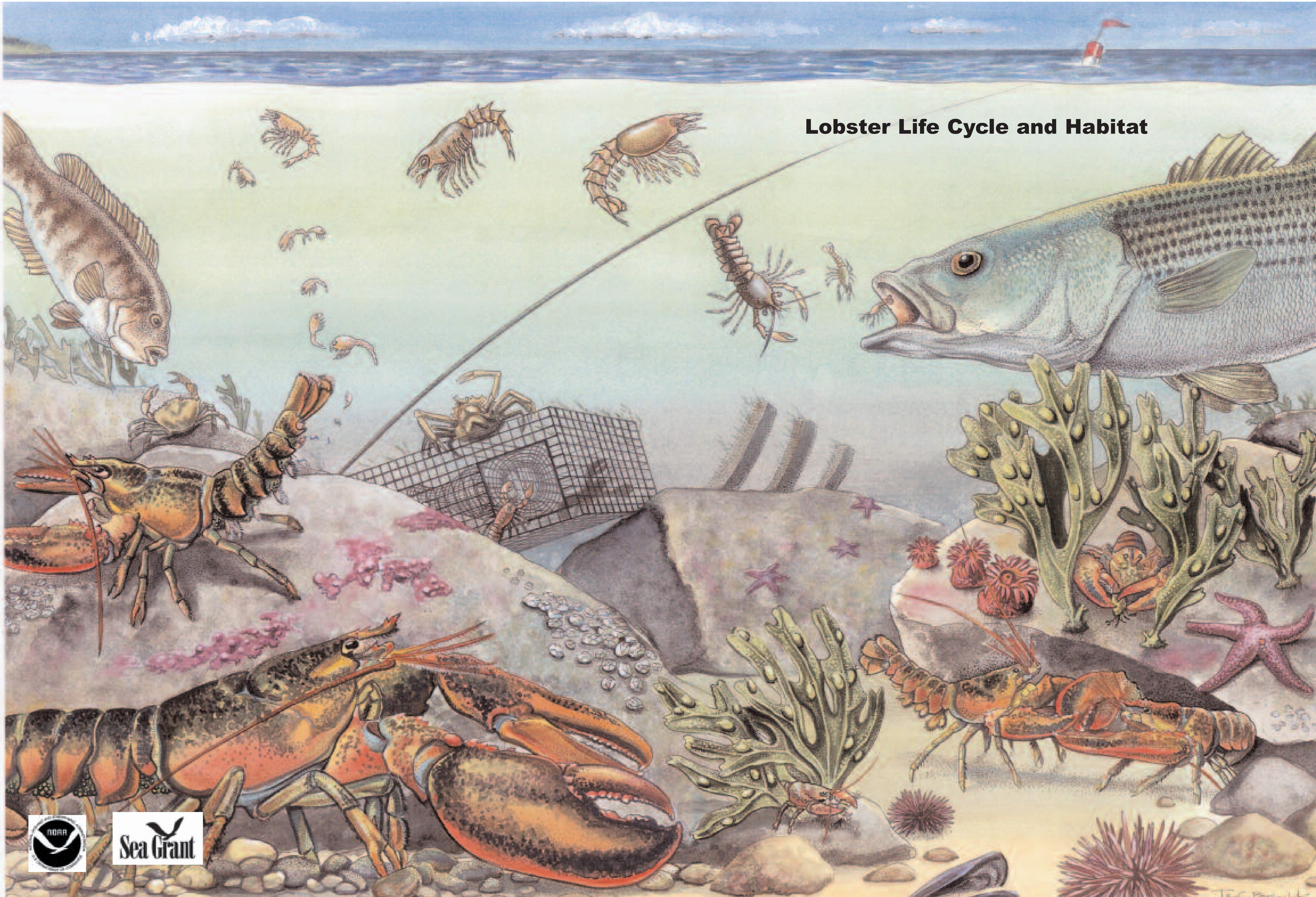
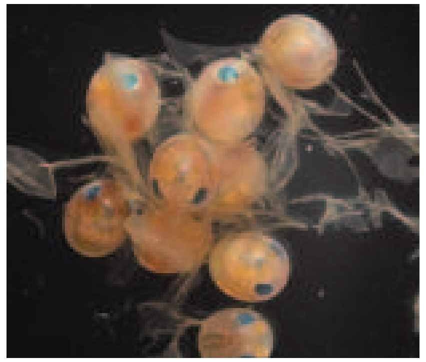
Lobster Life Cycle and Habitat

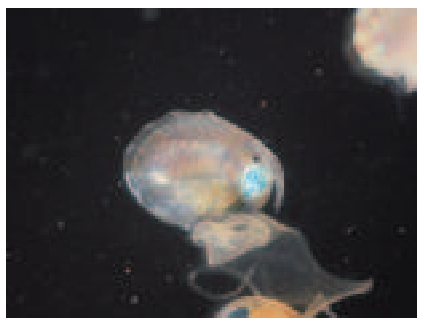


Life as a Lobster in Long Island Sound: Biology and Life Cycle

Jan Robert Factor and Antoinette Clemetson



Ready-to-hatch eggs containing pre-larvae; some eggs have already hatched, leaving behind empty egg membranes.



Newly hatched larva (prezoea), which will molt into Stage I larva.

Stage I larva, the first of three larval stages that live in the plankton, near the surface.

Intact molted shell of an American lobster.

American lobsters are the only clawed lobster found in the northwestern Atlantic Ocean, from Newfoundland and Labrador throughout New England, and into the mid-Atlantic states. While a few have been found in deep offshore waters as far south as Cape Hatteras, North Carolina, the lobsters of Long Island Sound are close to the limit of their inshore range and form the southernmost major fishery for this species. The pronounced olive green or greenish brown colors are a result of diet, heredity, and exposure to light; however, they may be red, albino, or even blue. This nocturnal creature spends most of the day hiding with its head and antennae protruding from nooks. Although lobsters select their dens from the naturally occurring terrain, they can actively carve out burrows in muddy substrate when there is no shelter available. They feed at night and can cover considerable distance. These territorial animals aggressively defend their shelters. The *cheliped* (enlarged claw) is used for fighting and crushing shellfish to eat, while the tail serves as a powerful thruster to push the animal backwards as it escapes to a safe place when threatened.

Temperature has a pronounced effect on lobster growth and biology. For example, cooler temperatures slow growth and delay sexual maturity. Observations from laboratory studies further support this temperature-size relationship. Juvenile lobsters have been shown to mature at approximately the same size when reared at a common temperature, even if they come from paternal stocks with widely differing maturity sizes. Growth and maturation are slow processes, taking four to seven years. In Long Island Sound, females take one year to complete a reproductive cycle. Typically, females molt and mate in early summer. After the females mate, the sperm is held in a special pouch until they lay their eggs. Females carry fertilized eggs on the underside of the tail for about 9-10 months. They must care for them until the eggs hatch, to reduce fouling from microorganisms and parasites, and provide sufficient aeration by fanning the swimmerets. Egg-bearing females usually carry their tails tucked underneath, and they contract and relax the tail in a rhythmic motion to release the larvae. The cycle is repeated approximately one to three months after the eggs hatch.

Lobster larvae are planktonic and free swimming and head up to the surface waters after they hatch. A single brood can produce 8,000-10,000 larvae; however, young lobsters suffer heavy predation. The three larval stages feed on microscopic and small planktonic organisms for about one month before undergoing the transformation that makes them resemble miniature adults, about $^{3}/_{4}$ inch in length. After metamorphosis, they move to the bottom and begin the life of a true benthic dweller. Many people believe that lobsters prefer decaying matter and are cannibalistic; however, that isn't quite correct. As bottom dwellers, they feed on a wide variety of organisms including fish, crabs, snails, mussels, clams, worms, and marine plant material. While cannibalistic behavior has been observed among lobsters held in captivity, scientists believe that such activity is a result of crowded conditions and have found no cannibalism in wild habitat. Scientists estimate that for every thousand larvae released, about one will survive to minimum legal size. Survival is dependent upon finding sufficient food and avoiding predators. Extreme winters also take a heavy toll on early life stages, so they need to find waters with favorable temperature.

The shell is made up of a flexible material called *chitin,* as in insects, but in lobsters calcium salt deposits make it harden. Because the shell is inelastic, lobsters must shed it to grow, a process controlled by hormones that is known as molting or *ecdysis.* The new shell is soft and flexible, and expands quickly to allow growth. Once it hardens, it remains that size until the next molt. Lobsters molt frequently, especially in the first year, but eventually settle down to molt once every six months to two years. It is impossible to accurately estimate the age of a lobster from its size; however, lobsters held in captivity have lived for decades. Some of the largest lobsters taken in offshore fisheries have weighed in excess of 25 pounds (~11 kg). The largest lobster measured by the State of Connecticut from Long Island Sound had a carapace length of 5.3 inches (135 millimeters).

Growth in length is achieved by complete replacement of the hard parts during the molt. Between molts, the muscles become more densely packed and the lobster grows into the expanded space. Eventually, the lobster stops eating to prepare for the next molt. Calcium from the old shell is reabsorbed and reconstituted in the soft tissue. The new soft and flexible shell is laid down underneath the old shell. This new shell is complete with all the details, including spines, hairs, and bristles, as well as the internal structures. The old shell splits and once the lobster leaves the old shell, it drinks water and uses a kind of hydraulic fluid system to inflate its soft tissues to fill the new shell. This new growth can be as much as 20 percent weight increase, and although it takes about 15 minutes for the lobster to climb out of its old shell, the process takes a lot of energy out of the lobster. The old shell, rich in calcium and other minerals, is eaten by the lobster to recycle the minerals and quickly harden the new shell.

The molting process also gives lobsters the amazing ability to regenerate their limbs. They can voluntarily release (or *autotomize*) a limb if injured, a strategic move when the animal finds itself held by an adversary, or at a disadvantage, or injured in a fight. Lost limbs grow back as the animals molt. Regeneration time is relatively short in juveniles; however, it takes several years to regenerate a full-size cheliped in adults. Molting is a stressful but important biological process that every healthy lobster must endure from time to time, and hormones produced by the endocrine system help to regulate various aspects of the life cycle. Many of these biological processes are entwined in *Homarus americanus*, such as molting and reproduction, and consequently, so are these respective hormone systems. Several hormones, including *ecdysteroids* and crustacean hyperglycemic hormone (CHH), are produced to regulate molting. Timing is critical in the molt process, and molting must be avoided once the eggs are extruded to avoid loss of the attached eggs with the cast shell. Yet, it is advantageous for female lobsters to molt (and mate) as soon as their eggs hatch.

Lobsters considered "pre-legal-size" to the LIS commercial fishery (~2-3 inches or 50-80 mm) carapace length) molt on average twice a year. Mature, legal-size lobsters in the Sound molt at least annually. As in many species, larger females put more energy into producing eggs than for growth (i.e., they have higher *fecundity*), and consequently, they molt less frequently.

In addition to this, environmental factors work together to trigger the release of certain hormones that causes the animals to molt. An important chemical is *methyl farnesoate*, which is secreted by an organ that is located at the base of the eyestalk. This hormone acts as a kind of juvenile hormone (JH) that triggers the transformation stages in the larvae.

The circulatory system distributes nutrients, respiratory gases, metabolic wastes, and hormones throughout the body. Lobster blood (or *hemolymph*) is a colorless fluid that contains proteins and circulatory cells (or *hemocytes*). The system design is simple, consisting of a heart, and an extensive set of vessels that lead from the heart to other parts of the body. These vessels eventually terminate and hemolymph flows into blood sinuses (open spaces) and perfuses the tissues directly; meaning lobsters have an *open* circulatory system, and mostly lack capillaries. Blood flows from the heart to the body, then to the gills, and back to the heart. Three categories of blood vessels have been identified: arteries, arterioles, and capillaries.

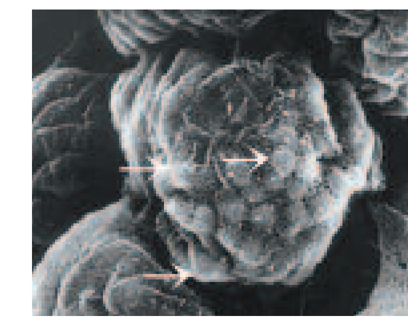
Blood contains several proteins, some of which carry oxygen; others help the blood to clot (coagulants), and others aid in immunity. There are several categories of hemocytes serving multiple functions including clotting, hardening the exoskeleton, and clearing foreign materials (immune defense). A good immune system to fight disease is key to animal survival, and must act quickly to detect and remove foreign particles. In addition to blood cells, special cells called *fixed phagocytes* are attached to the arteriole walls in the digestive gland (or liver). These cells fight infection and remove foreign disease-causing agents from the blood.

The American lobster may not be considered to be the most graceful creature, with its oversized claw and heavy armor. Many people will agree that it looks as if it was taken from a character in a science fiction movie. Despite their apparently primitive nature, lobsters are highly evolved animals that are well equipped to overcome the many challenges of life on the bottom.

Jan Factor, Purchase College, SUNY, is currently developing an assay for phagocytic activity in the immune system of American lobsters. He is the editor of *Biology of the Lobster Homarus americanus*. (Academic Press, 1995, 528 pp.)
Antoinette Clemetson is a Fisheries Specialist with New York Sea Grant.

New claw being regenerated in American lobster (arrow).

Scanning electron micrograph of terminal hepatic arteriole from the hepatopancreas, the major digestive organ, showing fixed phagocytes covering the outer surface (x 410).



Close-up of fixed phagocyte after lobster was injected with tracer particles (arrows). Tracer particles, like natural bacteria, are removed from the blood by the phagocytes, protecting the lobster from disease (x 6100).

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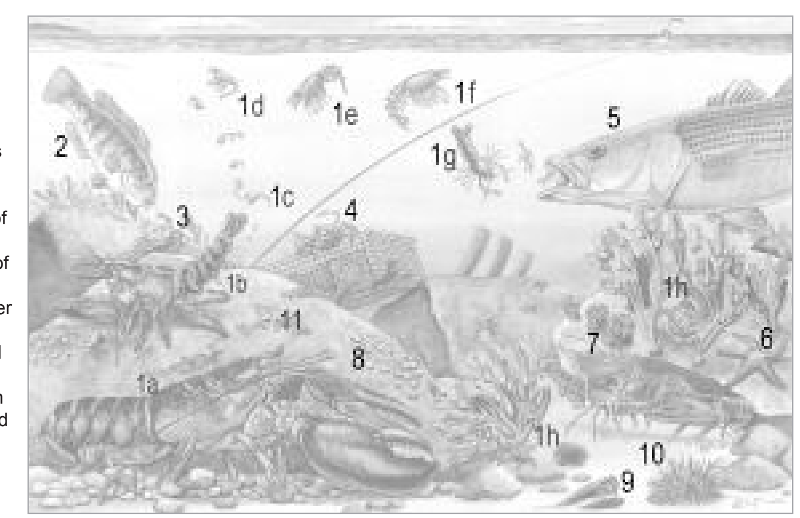

About the artist:

Jan C. Porinchak is a Long Island artist whose detailed works in a variety of media illustrate the exquisite intricacy of natural history subjects. An art teacher who comes from a family of artists and art educators, Jan has an appreciation for the outdoors and a keen sense for capturing minute details.

Lobster Life-cycle and Habitat Key

Each egg sac releases a tiny larva that floats towards the surface. It takes between 15 to 30 days for the planktonic larvae to complete a series of metamorphisms (Stages I-III). They spend a little more time in the plankton as post larvae, searching for a suitable habitat to settle.

1. American Lobster — *Homarus americanus*
    a. Egg-bearing female adult
    b. Female releasing mature eggs
    c. Prezoea (newly hatched larva)
    d. Stage I
    e. Stage II
    f. Stage III
    g. Stage IV (Post Larva)
    h. Juvenile feeding in shelter
2. Blackfish — *Tautoga onitis*
3. Green crab — *Carcinus maenas*
4. Portly spider crab — *Libinia emarginata*
5. Striped bass — *Morone saxatilis*
6. Northern sea star — *Asterias vulgaris*
7. Northern red anemone — *Tealia crassicornis*
8. Rock barnacle — *Balanus balanoides*
9. Blue mussel — *Mytilus edulis*
10. Purple sea urchin — *Arbacia punctulata*
11. Purple Sponge – *Haliclona permollis*

The Long Island Sound Lobster Research Initiative supports a large multi-state investigation to determine the cause(s) of the 1999 Long Island Sound lobster mortalities. It is a collaboration of the National Oceanic and Atmospheric Administration (NOAA), the National Marine Fisheries Service, the NOAA Sea Grant programs of Connecticut and New York, the Connecticut Department of Environmental Protection, New York Department of Environmental Conservation, and the U.S. Environmental Protection Agency Long Island Sound Office, administered by the Atlantic States Marine Fisheries Commission.