

Education Department
Waikīkī Aquarium
University of Hawai‘i-Mānoa



MARINE LIFE PROFILE: CHAMBERED NAUTILUS

Scientific name: *Nautilus* spp.
Distribution: Western Pacific
Size: to 8 inches (20.3 cm) diameter
Diet: crustaceans, small fishes

A "Living Fossil" With An Unusual Lifestyle

The nautilus, whose beautiful shell has inspired poets and puzzled scientists for centuries, is also highly valued as a living key to processes that shaped life in earth's ancient seas. The chambered nautilus is a cephalopod mollusc, most closely related to the cuttlefish, squid, and octopus. Virtually unchanged in the last 500 million years, nautilus are considered by some scientists to be "living fossils." Numerous nautiloid varieties, now extinct, were dominant marine predators before the rise of the fishes. Today, only a handful of nautilus species survive. Paleontologists, ecologists, and physiologists are studying this fascinating mollusc, hoping to gain insight into the marine environment of 500 million years ago and the workings of life forms long extinct.

Living nautilus are now found only in the waters of the tropical Western Pacific, where they live in a poorly-known marine environment - the deep slopes of coral reefs. Capable of migrating from depths of 1500 feet (450 m) to within 300 feet (90 m) or less of the surface, nautilus have a depth range seen in few other marine organisms and seem capable of tolerating dramatic changes in both temperature and pressure.

The Nautilus Shell - Functional Beauty

The external shell of the nautilus is produced by mantle tissue as in their distant relatives, the snails. But, unlike snails, the nautilus shell is divided into compartments (about 4 in newly hatched specimens, 30 in mature individuals), and the animal occupies only the outer-most "living chamber." As the nautilus grows, its body moves forward in the enlarged shell and produces a wall to seal off older chambers. In contrast, snail shells are not usually compartmented and the snail's body extends back to the smallest parts of the spiral shell

The nautilus shell protects and supports the soft body of this mollusc; the animal can withdraw completely into the shell and close the opening with the leathery hood. But the shell's most important function is providing this swimming animal with neutral buoyancy. The older, sealed chambers of the shell contain gas which compensates for the weight of the animal's tissues and shell, keeping the nautilus neutrally buoyant so that it neither sinks nor floats and can move freely in the water.

Nautilus swim in a see-saw motion generated by "jet propulsion." They alternately pull water into the mantle cavity within the shell and blow it out the muscular siphon beneath the tentacles. By directing the jet of water with the flexible siphon, the nautilus can swim forward, backward or sideways. Like many animals that live in open water or above the reef, nautilus show a form of camouflage coloration called countershading. The upper surface of the shell is darkened by irregular stripes that mask its outline when viewed from above, and the light underside of the shell blends with the water surface when viewed from below.

The Nautilus Body and Lifestyle

Nautilus are predators, feeding on shrimp and other crustaceans that they capture with their 38 or more tentacles. The tentacles are all retractable into sleeve-like sheaths when not in use. Instead of the round suckers found in modern cephalopods like squid and octopus, nautilus tentacles are lined with alternating grooves and ridges that allow them to grip objects. Tentacles handle prey and pass food to the mouth (located within the circle of tentacles) where a beak-like jaw tears it into bites. The file-like feeding structure, the radula, further shreds the food before swallowing.

Unlike their relatives, the squid and octopus, nautilus have poorly-developed vision. The simple eyes, located just below the hood, are hollow bulbs on stalks and contain no lens. Nautilus can probably detect light and dark, but it is not known if their eyes can form images. They probably detect prey using chemical cues, as do many deep-water organisms.

Nautilus spend much of their lives on the deep reef slopes at depths of 600 to 1200 feet (180-360 m). Collaborative field research, spearheaded by Waikīkī Aquarium's Bruce Carlson, demonstrated that some species migrate from deep water during the day into shallower waters (300 feet/ 90m) at night, perhaps in search of food organisms that also migrate on a nightly basis.

Nautilus Research at the Waikīkī Aquarium

Nautilus reproduction has remained perhaps the greatest mystery of their biology. Waikīkī Aquarium and University of Hawai'i researchers have found that mating and egg laying can be stimulated in captive nautilus by raising the water temperature slightly. This phenomenon suggests that nautilus migrate into shallower, warmer waters to reproduce. In the natural environment, there are indications that nautilus do enter shallower depths to lay their eggs on hard surfaces like rocks or coral.

Observations of our captive nautilus show that the male holds onto the female's shell with his tentacles during mating, and transfers an elaborate packet of sperm into her mantle cavity with a specially modified arm. The eggs are laid one at a time, packaged in several layers of membranes that form a leathery protective capsule. The female attaches the completed capsule to a hard surface using her arms. The tough, parchment-like capsule has funnel-like openings at the top which allow water circulation. While it is not uncommon for nautilus to lay eggs in captivity, few appear to develop and, until recently, young nautilus had never been hatched in captivity.

The first breakthrough came in 1985, when researchers from the Aquarium and U.H. found the first living nautilus embryos ever observed by scientists, in eggs laid in Aquarium research tanks. The tiny embryo, sitting atop a huge yolk mass, looked something like a limpet with tiny tentacle buds, a developing siphon, and large pigmented eyes. The single embryo was intensively studied while still alive and provided the basis for the first studies ever conducted on the embryology of this "living fossil."

The hatching of the first captive nautilus took place at the Kamoike Aquarium in Japan in 1989. Researchers at that facility reported a development period of 12 months; the hatchling survived just less than 2 months. To promote nautilus embryo development and hatching at the Waikīkī Aquarium, staff researchers set up a special tank for the eggs, separate from the chilled tanks housing the adults. Kept slightly warmer than the adult tanks, this incubation tank was intended to simulate the shallower depths at which the eggs are believed to be laid. This experiment was rewarded on October 27, 1990, when the Waikīkī Aquarium successfully hatched its first young nautilus. Within two weeks, two more hatchlings emerged from their capsules. About the diameter of a quarter (just over an inch, about 3 cm), the young animals are near-perfect miniatures of the adults and are fed a diet of shrimp.

Chambered Nautilus at the Waikīkī Aquarium

In 1976, the Waikīkī Aquarium became the first Aquarium in the United States to display living chambered nautilus. A specially edited version of the video presentation "Nautilus: 500 Million Years Under the Sea," shows continuously in the new Jet Set Gallery. The video, in three short chapters, describes nautilus biology and ecology, and features some of the research efforts in which the Waikīkī Aquarium and other scientists have participated. Other videos are also featured, including a special edit of National Geographic special "Incredible Suckers" about cephalopod molluscs, and a research video of a new species of deep-water octopus discovered in Hawaiian waters).

Adults on display are examples of the Palauan chambered nautilus, *Nautilus belauensis*, the same species as the breeding animals in the research tanks. This species is found only in the islands of Palau (Belau), Micronesia. These specimens were caught in traps baited with fish and set in water 600-1000 feet deep off the reef edge. Eggs of this species are being incubated in the Aquarium's research tanks behind-the-scenes.

Classification:

Kingdom Animalia

Phylum Mollusca

Class Cephalopoda, Subclass Nautiloidea

Order Tetrabranchia

Family Nautiloidea

Genus Nautilus

Species belauensis, pompilius, and others

CHAMBERED NAUTILUS
Nautilus

