At the Base of the Food Web

By Marilyn Barrett

The smallest plants and animals form the base of the marine food web, a labyrinth of interdependent species in an ecosystem. Their lives may be ended because of predators, starvation, or environmental factors. Among the billions of spawned, planktonic eggs, small larvae, and plankton floating freely in a column of sea water, size makes a difference. These organisms are daily banquets for slightly larger larvae and small fishes. Every day, large larvae can consume 50-400 percent of their body weight, increasing their weight by 30-50 percent! Slightly larger fishes in the web are nourished by these small predators and by nutrients from the sea floor and in the water column. Individuals that fail to find sufficient food starve and die. But foraging skill isn't enough.

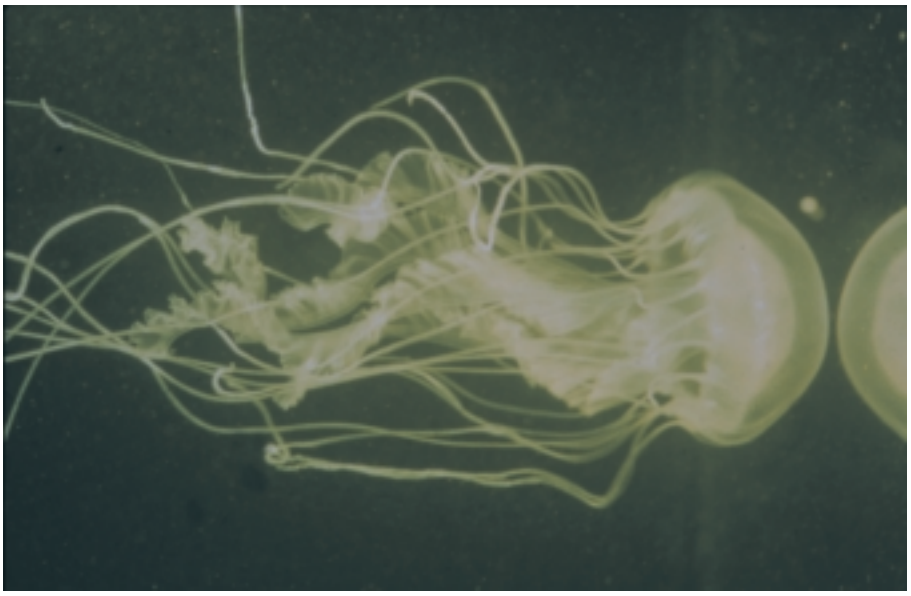
A researcher checks equipment used in a study of microscopic animals and plants in the Gulf of Mexico. Photo courtesy of Dr. J. Cowan.

At early life stages, ichthyoplankton (larval fish) have little control over their own locations. Although they may avoid predators and find enough to eat, they may die from environmental factors such as temperature, currents that separate them from their food sources, and disease. Even so, they contribute nourishment as detritus (decaying matter) to the system.

People think of this trophic labyrinth as a simple hierarchy of big feeding on little, forgetting that every individual (even of the same species) in the food web differs in size, age, and nutritional need, affecting the others in many less apparent ways. People also tend to forget their own participation as predators when harvesting and as protectors when regulating the environment, size or time of harvest, explained Dr. James H. Cowan, Jr., professor at the University of South Alabama and senior marine scientist at Dauphin Island Sea Lab in coastal Alabama. This simplified mental picture can

also be used to predict production — the quantity of adults produced on the basis of the quantity and quality of eggs, and survival rate of larvae. But the mysteries surrounding the dynamic interactions of species, ecological forces, accidental or unique intrusions, climate, and time of year prevent reliable forecasts.

"The most fundamental problem fisheries managers have faced in the last 100 years is predicting the success of a year class," says Cowan. "If fishery managers could predict the size of a year class early in the life of a cohort (the number of individuals of a species born during a particular reproductive cycle), they could more consistently and reliably manage fishing pressure as the cohort matures."



One of the many species living at the base of the food web. Photo courtesy of Dr. J. Cowan.

Cowan has devoted his career to addressing this problem by studying the base of fishery food webs. Along with research partners in Maryland, Alabama, and Texas, he has studied relationships within these food webs from variability among individuals to population-level interactions, and recently combined data and observations with a Louisiana partner to develop models that may eventually lead to more reliable predictions.

"These interactions are dynamic," Cowan added. "Because each young fish is exposed to a different set of environmental conditions every day, and every individual in the food web must secure nutrition regularly, the individuals and interactions are most effectively studied using a multitrophic approach." Cowan looks at the nutritional requirements of each individual in the food web, and relates these requirements to food production and to the potential of each individual as food for larger predators. A six-year study is now underway by Cowan and researchers in Port Aransas, Texas, to learn more about the dynamics of predation. Do some ichthyoplankton survive because they are in the right place at the right time or because they have physiological or behavioral characteristics to escape or avoid predators? Or, as Cowan expressed this question informally: "Are there planktonic 'athletes' and 'nerds' or do they live and die by chance?"

In Mobile Bay, Alabama, Cowan and his partners studied larval fishes in coastal rivers and in the estuary to identify the existence and defining characteristics of potential safe sites, places where environmental conditions routinely enhance biological growth processes. In multitropic fashion, this study examined nutritional contributions from multiple sources, including nutrients in the water, microscopic plants and animals, and several life stages of fishes, as well as overall productivity in the ecosystem. Separate studies have been conducted to gather data about each of the parts of this dynamic system.

For example, predators are drawn to abundant concentrations of their prey, but predation is not the only factor that reduces the numbers of small fishes. Cowan and researchers at the University of Maryland have studied the magnitude of predation at the base of the fish food webs in Chesapeake Bay and Mobile Bay using mesocosms (laboratory models of an ecosystem) large enough to allow both predators and their larval fish prey to exist at densities found in the sea. "As much as 80 percent of all larvae in a food web can be eliminated in a day," Cowan says, "but we found that although a significant proportion is consumed by predators, other sources of mortality not related to predation also are important." He is pursuing the details of predation and the other sources of larval mortality at the base of the food web in ongoing research.

Through these and other studies, Cowan has amassed a great deal of information that describes some portion of the many interactions among species, ecological forces, accidental or unique intrusions, climate, and time, but none yet covers the whole gamut. Cowan and Dr. Kenneth Rose of Louisiana State University have begun to synthesize these studies by combining laboratory and field data with computer modeling. This synthesis is designed to evaluate some of the cumulative effects of individual, size- and density-dependent interactions at the cohort (population) level for some species that represent others typical of North American coastal environments. For each species, the researchers are using field-collected data about spawning, foraging, predation, growth, and mortality to develop computer models of individuals in a population and how they interact in the food web. Through computer simulation, they are hoping to develop some understanding of the processes that lead to variable year class success and the mechanisms that enable populations to cope with man-induced changes in the environment.

In the sea, these simple individuals at the base of the food web are far less threatening than threatened. Yet Cowan and his many professional colleagues believe that in the sea, these almost invisible animals may hold the keys to sustaining the fisheries. "A lot of work remains to be done," Cowan said.