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Recruitment Patterns in Red Sea Urchins: A Population Genetics Approach

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Background

Sea urchins are what are known as "broadcast spawners." Adults release their gametes into seawater, and fertilization occurs if there is a high enough density of gametes to ensure that female and male gametes meet.

What happens after fertilization is something of a mystery. Scientists do not, for instance, know how far, on average, larvae travel during the six-week period it takes for them to develop and settle onto the seafloor. And, they do not know the degree to which ocean waves and currents mix larvae originating from different geographic locales.

There are, though, two possible scenarios at the far ends of a continuum of possibilities. One is that larvae are carried great distances and tossed about along the way by oceanic processes. As a consequence, urchin larvae from different beds (populations) mix and subsequently share many of the same genetic characteristics. The other possibility is that larvae settle down close to where they were formed. Because there is no long-distance mixing of larvae, urchins from different populations may become genetically distinct.

Work conducted by Dr. Ronald Burton, a marine biologist at Scripps Institution of Oceanography, suggests that urchin populations are often genetically distinct.

Although the result may seem largely academic, genetic differentiation has real implications for managing the urchin fishery—the state's number one fishery by volume and value for nearly a decade beginning in the late-80s. In particular, it has significance for establishing scientific criteria for marine reserves and local management of kelp beds.

San Diego-based urchin diver Pete Halmay, president of the California Sea Urchin Harvesters' Association, weighs a half-a-day's catch at a dock in San Diego Bay. Urchins are harvested for their big golden gonads, known as "L.A. uni" in Japan. Photo: Christina S. Johnson, California Sea Grant.

Genetic homogeneity, for instance, suggests that urchin beds are replenished with larvae from a well-mixed "larval pool" in which case managing the fishery is largely about protecting key larval sources, such as places where high urchin density leads to high rates of fertilization.

Genetic heterogeneity, on the other hand, suggests that young urchins are descendents of urchins from nearby beds. In this case, the health of the fishery relies on there being many healthy local urchin beds. Since overharvesting can easily lead to a long-term decline in productivity at any particular locale.

The Method and Findings

For the project, Dr. Burton collected sea urchins from beds between Point Loma in San Diego and Fort Bragg in Mendocino County and then analyzed their genetic signatures at six gene loci, using a technique called protein electrophoresis.

This analysis showed that there was significant genetic differentiation among populations at five of the six gene loci examined. Genetic differences on Nei's scale—a standard scale used to evaluate genetic

variation—ranged from nearly zero to 0.078.

He also showed that the degree of genetic differentiation was unrelated to the location from which the specimen was collected. Neighboring populations often showed greater genetic differentiation than distant ones.

In addition, he showed that there was a high degree of genetic differentiation between different age groups of urchins from the same bed - an observation that is also consistent with genetic heterogeneity. Young urchins, defined as those less than 30 millimeters in diameter, appeared to be more genetically differentiated than adults sampled from the same beds.

Although the genetic patterns are relatively clear, the processes that are generating these patterns are not. There are three possible processes that may be acting alone or in concert. The first is that, through random processes, some adult urchins produce more offspring than others. The second is that some urchin beds produce more offspring than others, due to things like prevailing oceanic conditions. Lastly, some larval genotypes may have significantly higher survival rates than others.

Cooperating Organizations

California Department of Fish and Game
Catalina Offshore Products
San Diego State University
University of California, Davis

Publications

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Trainees and Theses

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