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Publication Date

2005-07-01

Conservation Genetics of California Abalone: Developing Tools for Management

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Background

The history of California's abalone fisheries has become an object lesson in the potential for traditional fisheries management to fail in protecting species from over-harvesting and even the threat of extinction. Over the course of four decades, five species of abalone (red, green, pink, white and black) were sequentially exploited in California. Despite management efforts, based on minimum-size limits, landings of each species sequentially crashed. In 1997, after years of debate among fishing interests, managers and biologists on the severity, meaning and cure for the declines, the California Department of Fish and Game (CDFG) closed all commercial abalone fishing and relegated sport diving to the cold, rough waters of Northern California, where inaccessibility of the shoreline and prohibitions on using SCUBA gear have created *defacto* refugia for sexually mature abalones. On top of this, the only abalone species that can be recreationally harvested is the relatively abundant red abalone.

The regulations, however, came too late to prevent the white abalone from being listed on the endangered species list in 2001, making it the first marine invertebrate to be granted protection under the Endangered Species Act. Some biologists now say that the black abalone is a candidate for "threatened" or even "endangered" status.

With the broad goal of rebuilding abalone stocks to healthy levels, CDFG recently developed an abalone recovery and management plan, expected to be accepted by the state's Fish and Game Commission

in August 2005. Among the plan's recommendations is a request for more basic biological information on abalones. It is hoped that this information will greatly enhance management strategies, since the tasty gastropod's basic biology—and the lack of information on it—has played so large in its decline.

Abalone don't move around much. Hunting for them was once pretty much as easy as picking apples off a tree. Their reproductive biology also makes them vulnerable to over-exploitation. Abalone are broadcast spawners, meaning that males and females release millions of gametes directly into water. Reproductive success hinges on there being sufficient numbers of adults in sufficient proximity to each other to ensure fertilization. When divers remove many large adults from an area, they are likely to reduce the critical mass of abalone needed to ensure fertilization.

Now that abalone stocks have been so reduced, the goal is to identify aspects of their biology that can help in crafting recovery and management plans. One such topic is understanding the degree of "reproductive connectivity" between remaining abalone populations (i.e., the degree to which existing beds of sexually mature abalone can reseed depleted areas).

Project

California Sea Grant funded marine biology professor Ronald Burton of Scripps Institution of Oceanography and Sea Grant Trainee Kristen Marie Gruenthal to develop and use genetic techniques to examine the reproductive connectivity of red and black abalones. Their studies are



Marine biologist Ron Burton in his lab at Scripps Institution of Oceanography. Photo: ©Fred Greaves

based on DNA extracted from tissue samples from 473 wild red abalone and 588 wild black abalone. (These tissue samples were taken without injuring or otherwise harming the animals.)

While the details of these genetic analyses are beyond the scope of this publication, the main point is that the scientists were successful in developing a set of microsatellite loci for evaluating the population genetic structure of each species (i.e., the degree of genetic variation between specimens from one location versus another). From this information, scientists are able to infer the spatial scales at which larvae are dispersed. This information, in turn, sheds light on the potential for existing abalone beds to replenish nearby or distant depleted areas.

Findings

The genetic signature of red abalones was shown to be uniform across the animal's range. "We could not find any genetic differences between northern and southern red abalone populations," said Burton, who is a member of the advisory panel for the state's abalone recovery and management plan. "This suggests the populations are highly connected. Larvae are moving between places and sometimes great distances. It could be that Southern California red abalone populations exist only because they constantly are being re-seeded with larvae from the north."

While red abalone were genetically very similar, black abalone were not. "Genetics tell us that there are differences among black abalone populations," he said. "This suggests populations are not connected. There is not as much larval dispersal."

Red and black abalone have very similar life histories so why the differences in larval dispersal? Burton's leading explanation is it reflects differences in their breeding seasons. Red abalone spawn year-round; black abalone only in summer when coastal currents are weaker. Surf, winds, currents—the physical oceanographic conditions that are more intense in winter—transport red abalone larvae relatively great distances.

The scientists would have liked to have been able to conduct genetic analyses for wild white abalone. However, because the animals are so rare, it is now impossible to conduct true field studies of their natural history. As a best alternative, they instead collected tissue samples from captive-bred white abalone and from these were able to develop a set of genetic markers. These markers make it possible for biologists to positively identify white abalone

from closely related species such as pinto, red and flat abalones. They also evaluated the genetic variability in offspring of white abalone brood adults and found that there is some genetic diversity in offspring—an important discovery given long-term plans to one day "out plant" cultured white abalone into the wild and a somewhat surprising discovery given that only six brood adults contributed to these offspring.

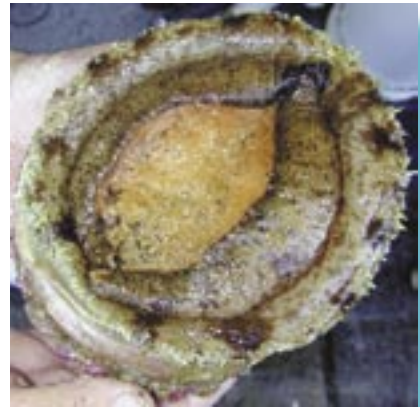
Implications for Management

"The degree of connectivity between populations has significant implications for how you want to manage abalone," said Pete Haaker, a senior marine biologist with CDFG who is involved in the state's abalone recovery plan. The high degree of connectivity of red abalone means that what you do in one area can affect surrounding areas, he said. If you don't have many abalone, areas that do have large adults become very important to recovery efforts.

"You could remove a lot of the reproductive potential by removing large adults from just one area," he said. Marine reserves may be a good way of protecting abalone, because they ensure there will be areas where there are large numbers of abalone close enough to reproduce. "If there are not enough of these areas, which is what happened in Southern California, the resource will go belly up," he said.

Because red abalone larvae can travel great distances, it is possible that a few well-placed reserves could go a long way toward rebuilding stocks. The same is not true for black abalone. Because black abalone populations are not well connected, many smaller reserves would be a better strategy for replenishing depleted areas.

The research also has management implications for the white abalone because the genetic markers can be used to maximize genetic diversity in the brood stock's offspring. Genetic fingerprinting will also make it possible to track the success of outplanting efforts. "We are also able to make sure that new brood stock are of the correct species," Sea Grant Trainee Gruenthal said. "This is crucial to restoring white abalone as a pure species."



White abalone. Photo: K. Lafferty, USGS

Collaborations

California Department of Fish and Game
Channel Islands Marine Resource Institute
National Park Service (Channel Islands)

Awards

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Trainee

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July 2005

This work is sponsored in part by a grant from the National Sea Grant College Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant number NA04OAR4170038, Project number A/P-1. The views expressed herein are those of the author and do not necessarily reflect the views of NOAA or any of its subagencies. The U.S. Government is authorized to reproduce and distribute for governmental purposes.

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