

GREEN AND PINK ABALONE OUTPLANTING OFF POINT LOMA, CALIFORNIA

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ABSTRACT

Reduced abalone populations in California have prompted more stringent management regulations and have stimulated interest in developing methods for enhancing natural populations. From several large-scale seed plantings of red and green abalone conducted in various coastal sites of southern California, several important facts have emerged. Poor seed survival may be attributed to 1) the vulnerability of small abalone (<30 mm in size) to predation, 2) stressful handling of the seed prior to transplantation, and 3) inappropriate site for the transplantation. Reseeding efforts conducted in Japan showed that the survival of outplanted larger abalone approached 70% (animals > 70 mm in size) (Inoue 1976).

Based on these later studies, our group is currently growing green abalone (*Haliotis fulgens*) to a size of approximately 70-100 mm before attempting to outplant areas off Cabrillo National Monument on Point Loma in San Diego. Pink abalone (*H. corrugata*) will also be spawned in our facility for later outplanting. Both species will be planted in water depths of 4-12 meters. The Department of the Interior, the City of San Diego, Scripps Institution of Oceanography, and SPAWAR Systems Center personnel will conduct preliminary surveys to determine existing populations prior to any outplanting. Survival, growth, and juvenile recruitment within the site will be indicators of success. Lessons learned at this site could be used for other coastal areas.

INTRODUCTION

Long-term trends of the abalone fishery in the state of California show that the fishery flourished between the years 1958 and 1968, with annual landings in excess of 4.5 million pounds (Heiman and Carlisle 1970). Since 1968, however, landings decreased to 1.3 million pounds in 1978 (Cicin-Sain et al. 1977; Tegner et al. 1981). Landings in the state for 1994 totaled only 322,000 pounds. The decline in landings have been attributed to intense harvesting by commercial and sport divers, environmental degradation of habitat, predation by sea otters, and in some cases, competition for space and food from sea urchins (Cicin-Sain et al. 1977; Tegner et al. 1981). Reduced yields for both the commercial and sports fisheries have prompted more stringent management regulations and have stimulated interest in developing methods for enhancing natural populations. Most recently, the commercial and recreational abalone fishery, south of San Francisco to San Diego, was closed in August 1997 so that a fishery management plan could be developed (Tegner 1999).

Previous surveys in the low tidal and subtidal area off Cabrillo National Monument indicate that abalone populations are low (Personal comm. B. Becker). It is the intent of this project, as part of a much larger statewide abalone enhancement program (Personal comm. P. Haaker) to outplant abalone brood (breeding) stock in protected waters off Cabrillo National Monument on Point Loma. Continued outplanting of larger abalone could stabilize declining abalone populations with the addition of spawnable abalone stock (Tegner 1992). Previous studies seem to indicate that the release of larger abalone (>25 mm in size) may substantially increase the chance of maintaining and enlarging the number of brood stock for later recruitment (spawning, larval development, and settlement) (Inoue 1976; Tegner 1992; Kojima 1995). Larger abalones are less cryptic than smaller seed, which will make survival assessment easier. Larger abalones have thicker shells, which offer more protection from predation by crabs, lobster, and octopus. The outplanting of numerous larger sized green and pink abalones in a semi-protected area may increase the number of progeny for long-term recruitment.

With this in mind, our group at SPAWAR Systems Center, San Diego (SSC San Diego), located in Point Loma, is currently growing green abalone to a size of approximately 100 mm before attempting to outplant an area off Cabrillo National Monument. Approximately 1,000 green abalone will be distributed along a series of transects and monitored at regular intervals for survival, growth, and recruitment (Fig. 1).

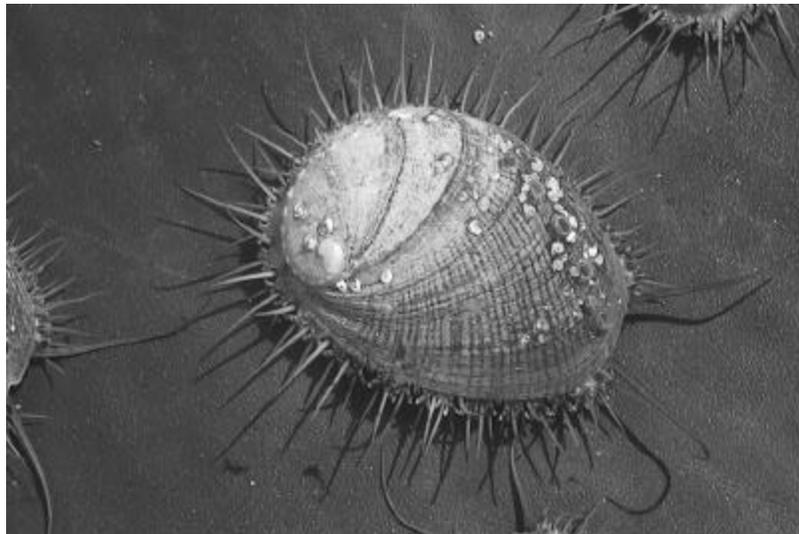


Figure 1. The green abalone *Haliotis fulgens*

(Approx. size 4 cm)

MATERIALS AND METHODS

The project objectives are 1) restore and enhance the survivability of the two abalone species once commonly found within coastal waters off San Diego and develop a system to provide for their continued enhancement; 2) outplant into depleted areas off Cabrillo National Monument with the green abalone (*H. fulgens*) and the pink abalone (*H. corrugata*), and monitor for survival, growth, and recruitment; and 3) establish educational public access designed to increase

public appreciation, awareness, and support for environmental initiatives (brochures, internet information).

Grow-Out Activities

The grow-out activities being conducted at SSC San Diego abalone growout facility has a flow-through seawater system and is currently growing 1,000 green abalones for outplanting. At the current rate of growth, the abalone will be approaching 100 mm in size (approximately 4" shell length) prior to outplanting. The facility has been in use since 1991 and is still currently used to conduct an assortment of bioassays used in toxicity testing. The facility contains an indoor and outdoor tank system (30 outdoor tanks), a small cooling system, a filtered seawater line, and basic laboratory instrumentation as well as an abalone larval rearing system (Fig. 2).



Figure 2. SSC San Diego abalone grow-out facility in San Diego Bay

Spawning Activities

Green and pink abalone brood stocks are being spawned at the facility to increase the number of transplantable abalone in the National Monument area. Abalones are conditioned to spawn by elevating water temperatures to 21° C for extended periods of time and feeding to excess with the brown macroalgae *Macrocystis pyrifera*, *Egregia laevigata*, and dried *Laminaria* when fresh kelp is limiting. Abalones are examined for spawning condition on a monthly basis by checking gonad indices (Ebert and Houk 1984; Hahn 1994) and artificially inducing spawning with the addition of hydrogen peroxide (Morse et. al. 1977). Trochophores and veligers (larval stages of the abalone) are reared in a flow-through filtered (5- μ m) seawater system for 3 - 5 days until the veligers display a more settling and benthic existence. The veligers are then siphoned into conditioned settling tanks for final metamorphosis. The tanks are coated with diatoms, which provide the first source of food for the developing abalone (Fig. 3). As they grow and increase in size, abalones are switched to a diet of brown macroalgae (Fig. 4).



Figure 3. Three-month-old juvenile red abalone (*H. rufescens*)

(Approx. size 4 mm)

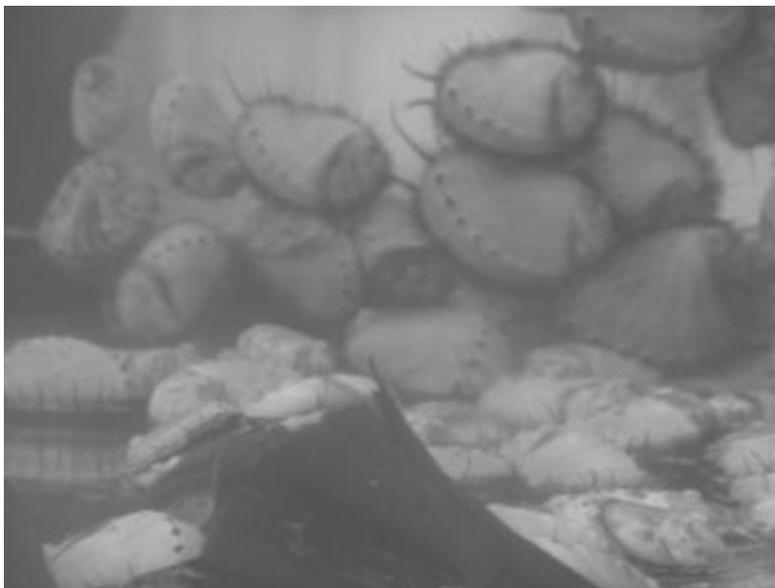


Figure 4. Red-Green hybrid abalone in close quarters

(Abalones are approx. 25 mm and one year old)

Out-planting Activities

Prior to any out-planting, a base-line survey will be conducted to establish current abalone numbers in the study site by personnel of the City of San Diego Ocean Monitoring Program, the Department of the Interior (working out of Cabrillo National Monument), Scripps Institution of Oceanography, the California Department of Fish and Game, and divers from SSC San Diego.

Follow-up surveys will be conducted on a regular basis to determine survival, growth, and recruitment success. Abalones will be transported to the outplant site by moving the abalone in their "abcondos" directly into an anchored position onto the sea floor (Fig. 5).



Figure 5. Green abalones within their abcondos

(Approx. 85 mm)

Each condo is capable of holding up to 25, 100 mm animals. Divers can anchor and insert these condos into the desired ledges of the reefs within a reasonable period of time with little stress to the transplanted abalone.

Project Phases

The project will be conducted in three distinct phases over a 3-year trial period. Phase 1 will focus on the continued grow-out activities of the existing 1000 green abalone. By December 2001, the abalone will be approximately 75 - 100 mm in size and will be prepared for the outplanting. Phase 2 activities will focus on expanding the culture facility in the year 2003. An additional 20-tank system will be installed to maintain the new seed from all laboratory spawnings of green and pink abalone initiated in the laboratory. Phase 3 activities will focus on the grow-out of green and pink abalone from earlier spawnings. Outplantings will continue in Phase 2 and 3. Regular surveys will be conducted during each of these phases to determine the outplant success.

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