GREEN ABALONE (*HALIOTIS FULGENS*) AQUACULTURE METHOD DEVELOPMENT AND TECHNOLOGY TRANSFER

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BACKGROUND

Abalone (*Haliotis spp*.) were once abundant in California. However, due to commercial and recreational harvesting, Withering Syndrome, and habitat loss, wild populations have been vastly depleted. Five of the seven native abalone species in California (red, green, pink, black, and white) once supported recreational and commercial fisheries. Although fishery landings were high throughout the 1950s, wild populations began dramatically declining in 1969, resulting in fishery closures [1]. By 1997, the abalone fishery for all species in California had been closed, aside from the recreational red abalone fishery north of San Francisco. Populations of white and black abalone declined to the extent that they were both placed on the Endangered Species List in 2001 and 2008, respectively. Since the closure of the wild fisheries, supply of domestic abalone for food now relies solely on the aquaculture of red abalone (*Haliotis rufescens*) [1, 2, 3].

Figure 1. Red abalone releasing sperm during captive spawning attempt. We are currently refining spawning methods for green abalone using reds.

Figure 2. 40 green abalone were collected on SCUBA from Arrow Point, Catalina Island and transported to SCMI in January 2018.

PROJECT OVERVIEW

Red abalone require colder water temperatures than other species and it is of major concern that climate change and el Niño patterns will negatively affect growing conditions on California flow-through farms [4, 5]. We are investigating the application of existing culture methods of red abalone (Fig. 1) on green abalone (*Haliotis fulgens*) (Fig. 2). Green abalone are a southern species suited to warmer waters, making them a potential candidate for the changing aquaculture industry in California. To implement our project, we acquired the permits necessary to collect wild green abalone broodstock for our aquaculture lab located at Southern California Marine Institute (SCMI) (Fig. 2). These broodstock abalone were conditioned to be used to refine green abalone aquaculture methods and used in spawning experiments. Another project objective was to develop a "deck-spawning" method designed to collect wild abalone larvae in the field (Fig. 5-6). The ultimate goal of the project is to make abalone aquaculture more resilient through diversification of cultured species, while also restoring wild populations in southern California.

OBJECTIVES

<u>Objective 1</u> (NOAA funds): Develop a deck spawning method aimed at securing a viable source of wild abalone gametes. Investigate seasonal patterns in green abalone reproduction.

<u>Objective 2</u> (ARI funds): Develop and apply red abalone culture methods to green abalone. Assess the effects of water temperature on green abalone broodstock maturation and captive spawning.

<u>Objective 3</u> (NOAA funds): Examine survival rates of outplanted larval and juvenile green abalone on Palos Verdes and Catalina Island to begin to develop methods for wild abalone restoration.

LABORATORY AQUACULTURE METHODS

- CA Department of Fish and Wildlife permits were acquired in January 2017, allowing the immediate collection of 10 wild adult green abalone from Catalina Island. Following a 6-month waiting period, the permit allowed collection of 30 additional green abalone at which point we began conditioning for spawning experiments.
- In preparation for green abalone method development, we refined our lab culture methods using red abalone acquired from a commercial abalone farm in southern California.
- Abalone were regularly measured, weighed, sexed, and scored using a Gonad Index scoring system on a scale of 0 to 3 (Fig. 4) [6].
- Abalone are induced to spawn using a hydrogen peroxide spawning induction method [4], and spawns are recorded and compared to the gonad index score.
- Sperm and eggs are then combined, and larval development and health are closely monitored for the next 7 days (Fig. 3).
- Resulting settled larvae are then transferred to the settlement tank seeded with *Navicula* (diatom), where they will spend the next several months, with development and survival assessed weekly.

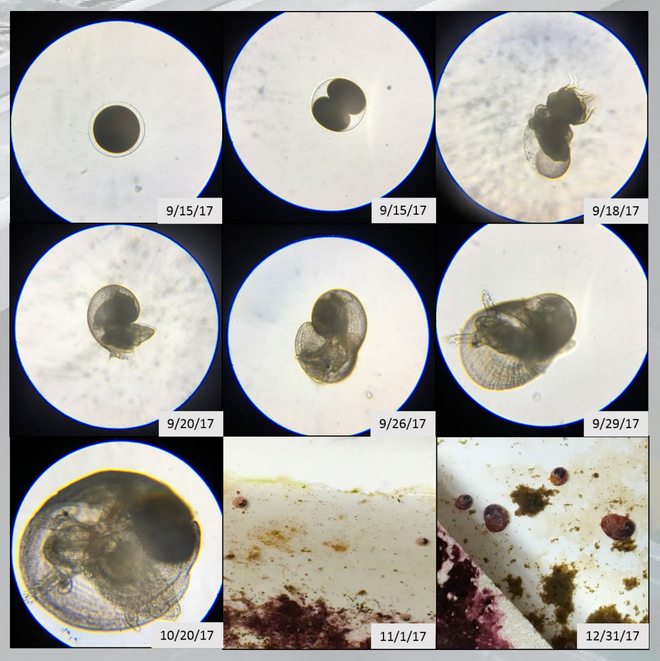

Figure 3. Day 1: Abalone eggs are fertilized. Day 2: The ciliated girdle becomes visible. Day 3: Larvae begin developing their shells. Day 4: The shells continue to grow and the retractor muscle develops. Day 5: The operculum, digestive gland, and mantle develop. Day 6: Abalone are ready to settle from pelagic to benthic stage when the eyespots, foot, and cephalic tentacles are present.

Figure 4. Top: Ben Grime (CPP grad student) monitors abalone placed in spawning-inducing chemicals. Bottom: Interns Austin Pyles (CPP undergrad and grad student) and Anna Thomasdotter assist with abalone data collection prior to spawning event.

DECK SPAWNING

- Conducted 7 deck spawning trials at Catalina Island in an attempt to provide an alternate source of abalone gametes to be used for culture or outplanting (Fig 5-6).
- Coincided with El Niño and other warm water events that virtually eliminated the main algal food sources

Figure 5. TBF crew organizing abalone for spawning induction.

Figure 6. The abalone are collected via scuba and induced to spawn "on deck."

Results / Conclusions

- Conducted 15 red abalone spawning trials producing 1.1 million fertilized eggs. Resulting juvenile abalone being maintained in lab for future wild population restoration.
- 2,000 veliger larvae outplanted to Palos Verdes to restore wild populations
- Green abalone broodstock acquired "Hot foot syndrome" and Withering Syndrome inhibiting experimental procedures (Fig. 7-8)

Figure 7. Abalone exhibiting "hot-foot syndrome" behavior.

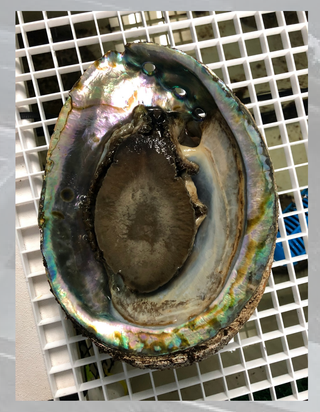

Figure 68 Abalone showing signs of Withering Syndrome.

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