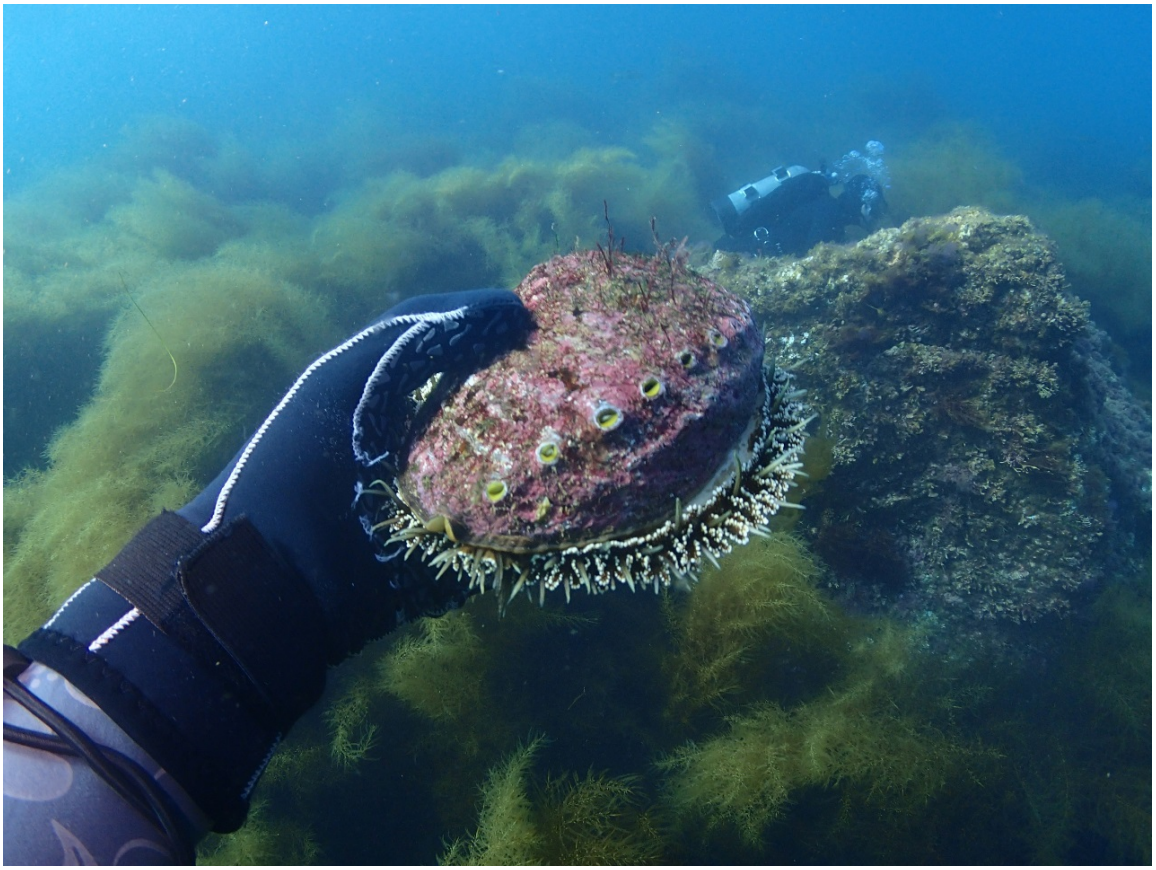
Southern California Green Abalone and Kelp Forest Restoration Project

January 1, 2012 - September 30, 2015



The Bay Foundation and NOAA divers collecting wild green abalone off of Catalina Island, CA

Report Prepared by Ariadne Reynolds, Heather Burdick and Tom Ford

I. Abstract

The Southern California Green Abalone and Kelp Forest Restoration Project aims to restore populations of green abalone (*Haliotis fulgens*), a federal species of concern, to Southern California where they were once plentiful and supported a thriving commercial fishing industry. This pilot project explored methods of spawning, rearing, and outplanting green abalone, investigated the genetic population structure, and assessed disease of green abalone in Southern California. Project results found that the green abalone population in Southern California is panmitic, allowing for translocation and breeding trials to move forward. Disease testing also revealed that RLP, the etiological agent for withering foot syndrome, was present in green abalone from all study sites. Specialized larval and juvenile outplanting equipment was developed and constructed in preparation for outplanting abalone into the wild. Experimental "deck spawning" techniques were tested as an alternative to collecting broodstock and keeping them in captivity. One juvenile outplanting event was conducted in Palos Verdes, CA and monitoring of the outplant site is ongoing. Successful techniques and methods from the project are expected to be transferred to restoration and monitoring efforts for Black (*Haliotis cracherodii*) and White (*Haliotis sorenseni*) which are federally endangered species.

II. Results/Progress to Date

Introduction and Objectives

The Southern California Green Abalone and Kelp Forest Habitat Restoration Project aims to take the first steps in restoring the diminished green abalone (*Haliotis fulgens)* population that – like all other species of abalone in southern California (*Haliotis spp.)* - have experienced massive population declines during the past few decades. Abalone species once supported thriving commercial and recreational fisheries, and are functional components of the giant kelp forest ecosystem of southern California, a productive subtidal habitat that supports over 700 marine species. The project has been conducted in concert with ongoing kelp forest restoration work in Palos Verdes. Mutual benefits of these connected projects include creating quality habitat for abalone and restoring balance between two primary consumers: purple sea urchins (*Strongylocentrotus purpuratus*) and green abalone. The productivity and stability of kelp forests are inextricably linked to the sustainability of many local commercial and recreational fisheries, recreation, tourism, and the local economy.

Funds from this grant enabled pilot level projects exploring restoration methods for green abalone populations in Southern California. The Bay Foundation (TBF) partnered with several governmental, non-profit, and educational organizations such as the National Oceanic and Atmospheric Administration (NOAA), Redondo SEA lab, Vantuna Research Group, Cabrillo Marine Aquarium, and California Science Center. The project aimed to address questions identified in the Department of Fish and Wildlife (DFW) Abalone Recovery and Management Plan, and to spawn abalone and outplant resulting offspring off of Palos Verdes Peninsula.

At the close of the project, we have successfully fulfilled many objectives including:

- Assessing the genetic stock structure of green abalone in Palos Verdes
- Identifying sites with optimal abalone habitat for outplanting
- Outplanting one size class of green abalone to develop data on the success of outplanting and tracking methods
- Developing new methods for spawning green abalone in the field
- Monitoring restoration and control areas throughout the project to determine *in situ* survival rates
- Educating the public on the important role of abalone and the need for restoration
- Expanding partnerships with local aquaria and organizations to increase capacity for restoring abalone populations

Abalone restoration is an emerging field, and this project has generated several advances in abalone restoration techniques that will inform future efforts. Throughout the course of this project, partnerships have been forged with several organizations along the west coast of the United States to share knowledge and techniques for spawning, rearing, and outplanting native abalone species. Due to the sensitive and complex nature of abalone reproductive behavior and the many variables involved in rearing abalone in captivity, the experimental design and project timeline changed significantly over the course of the project. However, many of the goals set for the project have been accomplished and the project has received new funding to continue beyond the scope of this award. Objectives, results, challenges, and lessons learned throughout the project are outlined below for each individual project task.

Green Abalone Genetics Study

In preparation for translocation, captive breeding, and wild outplanting activities, The Bay Foundation (TBF), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), and other project partners conducted a study to better understand the genetic stock structure of the wild green abalone (*Haliotis fulgens*) population in Southern California. The study used the next-generation sequencing technique restriction site associated DNA sequencing (RADSeq) to inform the process. RADSeq enabled the isolation and genotyping of 1,209 single nucleotide polymorphism (SNP) loci theoretically spread randomly throughout the genome in *H. fulgens*. The results from the analyses suggested that the *H. fulgens* population in the Southern California Bight appeared to be panmictic (randomly mating) within our sampling area, with an overall effective population size of ~1,150 to 1,550. These results informed constraints that would have limited collection and translocation due to concerns for maintenance of population structure. Once it was determined that the green abalone from northern San Diego County, Orange County, southern Los Angeles County and Santa Catalina island were members of the same population collection and translocation throughout the region was permitted to enable Broodstock collection for captive breeding. The study also informed

other projects involved in translocation and breeding activities in the region. The study is titled "Development and application of genomic tools to the restoration of green abalone in southern California", and was published in *Conservation Genetics* in August 2013. A link to the research article is available on TBF's website, www.santamonicabay.org.

RLP Detection & Prevalence in the Wild

Project partners completed a comprehensive study to determine the presence of Rickettsiales-Like Prokaryote (RLP; the etiological agent for withering syndrome) in wild populations of green abalone. Green abalone tissue samples were collected from four regions in Southern California (Palos Verdes Shelf, Orange County, San Diego County, and Catalina Island) and tested for RLP. The study found RLP present in all of the populations sampled, meaning that the abalone restoration sites were already exposed to RLP. The presence of RLP on Palos Verdes in particular was an important determination for obtaining a private stocking permit, as CDFW will not permit any activity that may introduce RLP to an area that was not already exposed. The study provided valuable insights into the population of green abalone in Southern California, informing other restoration efforts in the area.

Captive Spawning

A total of forty wild broodstock were collected for spawning under a project partners' broodstock collection permit, which was approved following the above mentioned studies. Of the forty broodstock, eight were collected from Palos Verdes, eight each from three different sites on Catalina Island, and eight total from Orange County and San Diego County. Unfortunately these broodstock did not prove to be a reliable spawning source. The broodstock spawned spontaneously once when transferred to the lab, but did not spawn thereafter when induced. Most of the wild broodstock began to exhibit symptoms of withering syndrome, and the disease led to mortality in all but 4 individuals. Fortunately, the original spontaneous spawning yielded fifty F1 generation offspring which are being reared at the SEA lab for future spawning trials once they reach maturity. Other captive-bred broodstock already being held at SEA Lab were used in captive spawning events to produce larvae and juveniles for outplanting. This lead to an amendment of the project's Scientific Collection Permit to allow for destructive sampling of the abalone outplanting sites.

Over the course of the project, 5 captive spawning events were held at SEA lab on November 10, 2014, December 15, 2015, January 26, 2015, March 6, 2015 and August 24, 2015. See Figure 1 for the number of individuals induced, sex and number spawned, and resulting fertilized eggs.

Date	Number Individuals Induced	Number Females Spawned	Number Males Spawned	Number Fertilized Eggs
11/10/2014	16	2	3	113,349
12/15/2014	17	3	4	661,000
1/26/2015	19	2	5	458,000
3/6/2015	16	0	2	0
8/24/2015	25	0	2	0

Figure 1. Results of five captive spawning events performed at Redondo SEA Lab

For each successful spawn we transferred the fertilized eggs to a partner aquarium facility - either Redondo SEA Lab, California Science Center, or Cabrillo Marine Aquarium. Facilities were selected based on the availability of tank space and staff resources at the time. Unfortunately, in all cases the eggs did not survive longer than one week at any of the partner facilities. We are now working on comparing methods between aquaria and isolating variables that could lead to more success with larval rearing in the future.

The last two captive spawning events on March 6th and August 24th respectively did not yield any fertilized eggs. In both events two males spawned, while no female spawning took place. After the first unsuccessful trial on March 6, 2015, the broodstock abalone were allowed a several month recovery period. Additionally, SEA Lab staff attempted to condition the abalone by varying the light cycle and controlling temperature in the holding tanks to simulate natural spawning conditions. For the August 24th attempt 6 additional abalone were included than in the previous trial. However, despite these updates in protocol, our second spawning attempt was still unsuccessful.

Communications with other abalone facilities including commercial farms have revealed that spawning and larval rearing have been difficult in the past year with much lower yields than normal. There are several theories for this, including abnormally warm water during spawning season which may be altering environmental spawning cues, and changes in water chemistry that may be preventing normal development of the shell. Figure 2 shows the trends of captive spawning success for 5 events from November 2014 to August 2105. While spawning seasons usually occur in the spring and late summer / early fall, our trials were most successful in winter 2014. We will continue spawning efforts to reveal more of a trend into the next year.

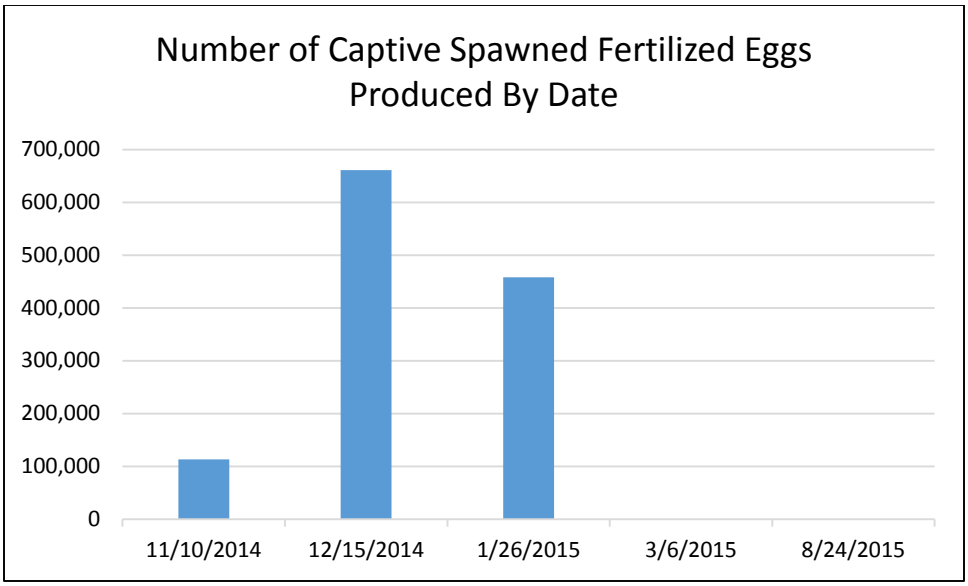


Figure 2. Number of captive spawned fertilized eggs produced by date

The process of rearing extremely sensitive larvae at different aquarium facilities with varying levels of staff expertise, different rearing systems and water sources, and limited resources to dedicate to the project has led us to pursue funding to create our own dedicated abalone spawning and rearing facility. Through the various trials of spawning and rearing abalone in captive environments, we have learned how important close observation and diligent recording of water quality parameters can be to the success of abalone spawning efforts. We have secured funding for the beginning stages of constructing an abalone rearing facility at the Southern California Marine Institute (SCMI). This location is ideal because our research vessel is berthed here, it is close to our restoration and outplanting sites, there is easy access to macroalgal food sources, and SCMI already has much of the equipment necessary to supply a recirculating aquarium system. The system has not housed abalone in over 15 years, so it is sabellid free and will undergo the sabellid certification process as soon as the system is constructed.

Deck Spawning Experiments

Obtaining larvae and juveniles from captive broodstock sources remained a significant bottleneck throughout the life of the project. To navigate around this issue, project partners devised an alternative option in the last year of the project, referred to as “deck spawning”. In this spawning method, staff collect abalone from the wild, induce them to spawn using chemical and physical methods, and cross any resulting gametes on the deck of a research vessel. Non-lethal tissue samples are taken from the adult abalone for genetic analysis, and then the adult abalone are returned to the wild. This work was led by NOAA and The Bay Foundation staff and performed under the authority of NOAA’s Scientific Collection Permit and Memorandum of Understanding with the California Department of Fish and Wildlife.

Project partners performed five deck spawning field trials over the course of the project. The only event that resulted in fertilized eggs was on October 10, 2014. On this day, one female and one male each spawned and we were able to mix their gametes. The female that spawned was not a prolific spawner, resulting in a only a small number of fertilized eggs. These fertilized eggs were held for 2 weeks in the California Science Center facility, but none survived beyond that time period. Length and weight information was recorded for the adult wild abalone during each deck spawning attempt, and genetic samples were collected on three occasions to help build understanding of the green abalone population off of Catalina Island. One explanation for the lack of spawning could be the abnormally warm water temperatures this year, an average of 2 degrees Celsius warmer than any year in the past 10 years. The regular spawning season for green abalone has also been based on anecdotal evidence, so we hope to perform deck spawning experiments throughout the year in the future to more accurately capture and categorize the prime spawning season.

Although we have not consistently produced fertilized eggs from the deck spawning methods, these experiments have provided valuable information about the current population of green abalone off of Catalina Island. Figure 3 shows the size frequency of green abalone that were collected for deck spawning experiments. Abalone were selected randomly and size was not a factor for selection, yet on each collection date the majority of the abalone collected ranged between 150 and 180 mm. Although abalone growth rates fluctuate based on diet and environmental conditions, individuals of this size are likely between 8 and 20 years old. This corresponds with the closure of commercial and recreational abalone fishery in Southern California in 1996.

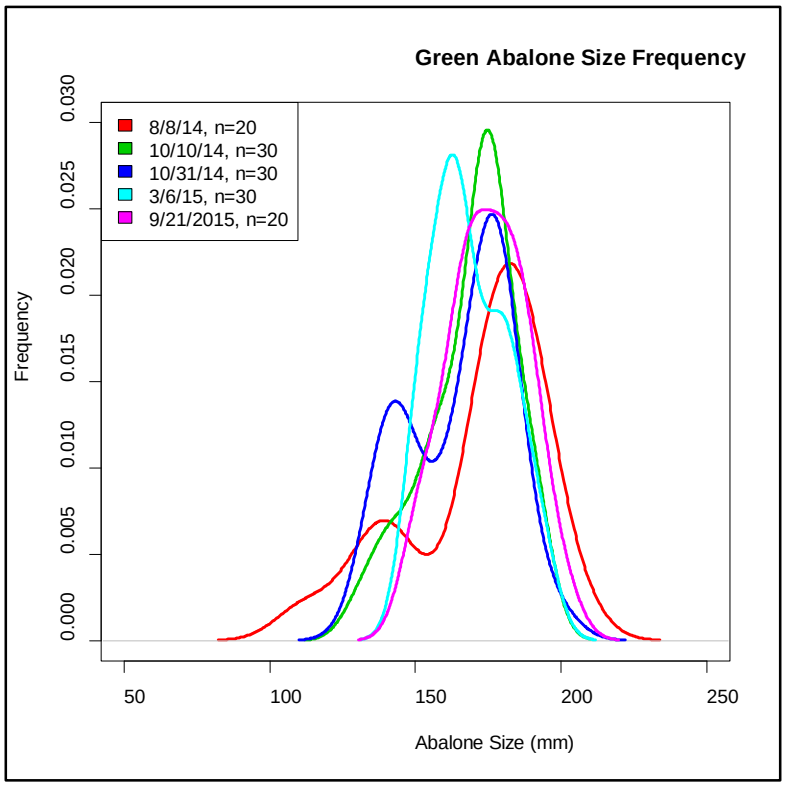


Figure 3: Size Frequency of Adult Green Abalone found off of Catalina Island

Through conversations with other organizations engaged in spawning experiments, we believe this method still holds promise and we hope to develop and adjust our methods in the coming year. One suggestion for the future is to allow more time for the abalone to spawn after inducing with hydrogen peroxide, since research has shown that abalone can spawn up to 8 hours after induction. This would involve some logistical challenges, but we are working on alternatives for the next round of deck spawning experiments.

Outplanting Equipment Research and Development

During the course of the project, TBF and partners developed and tested specialized equipment for abalone outplanting. We plan to employ a "pump and tent" combination for larval outplanting when sufficient numbers of larvae are produced. The design of a larval holding tent was based off of previous research (*Heasman et al. 2004*) and modified using available materials. Project partners designed and constructed a pump that plunges larvae into the holding tents which are placed on desirable settlement substrate. The pump was constructed from PVC piping, fittings, hose clamps, and rubber flexible coupling. It holds 6 liters of water and was designed so that it could be sealed water-tight before and after deployment to measure the efficacy of the pump and assess any damage to larvae.

The combination of the tent and new pump was tested at the California Science Center on November 14, 2014 in an 800,000 gallon kelp forest tank. In the trial, 50,000 larvae were plunged from the pump under the weighted skirt of the holding tent which was placed at the bottom of the tank at a depth of approximately 20 feet by teams of divers. The surge machine was then activated to simulate ocean conditions, and the tent stayed in place. The pump was sealed after deployment, brought to the surface, and rinsed to evaluate the effectiveness of the pump. In this first trial, 77% of the larvae were deployed. The larvae that remained in the pump were intact and not damaged. This suggests that a second filling of the pump and redeployment could be performed to ensure that all of the larvae are deployed in the field.

Juvenile abalone were outplanted in modules consisting of 18'' sections of 6'' diameter PVC tubing with netting enclosing both sides. These modules were based off of previous research (*personal correspondence with Josh Bouma, Puget Sound Restoration Fund*) and modified using available materials.

Outplanting

On June 17, 2015, TBF and NOAA divers outplanted 863 juvenile green abalone into a kelp forest restoration site off of Palos Verdes, CA. One month prior to outplanting, 934 juvenile abalone were tagged using honeybee tags and cyanoacrylic glue, and measured to determine size distribution. Between the date of tagging and outplanting, 71 mortalities were found in tanks at SEA lab. It is unknown whether this was due to the tagging process, however this tagging method has been employed in other juvenile outplanting experiments successfully. The remaining abalone were placed into outplanting modules 24 hours before outplanting.

8 outplanting modules containing approximately 107 juvenile abalone each were outplanted in a 100 square meter restoration site off of Palos Verdes. The site was selected for suitable boulder and cobble habitat, the presence of crustose coralline algae which acts as a settlement cue as well as a food source for juvenile abalone, and a favorable depth profile ranging from 3 meters to 9 meters. The site had been previously restored from a purple urchin barren to a healthy kelp forest with presence of various micro and macro algal species. Outplanting modules were held in place to the substrate at a 45 degree angle using small boulders, and the netting was removed from the bottom side of the tube to allow the abalone to crawl out of the tubes into the desired location. The outplanting modules were left underwater for 24 hours, retrieved the following day. Though most of the abalone readily crawled out of the outplanting modules, some remained in the tubes and were placed onto substrate during the module collection. See section VIII. Monitoring and Maintenance Activities for monitoring results and discussion. Also see Supporting Materials for video footage of the outplanting process.

Kelp Restoration

Kelp Restoration activities are moving forward successfully. Full scale kelp restoration work in the project area began in July, 2013. Work is being conducted in 900 m^2 blocks. This enables complete surveys of the entire 900 m^2 area immediately before and after restoration to assess pre and post urchin density. To date, restoration work has been completed in 34 acres spanning five coves and eight restoration sites along the Palos Verdes Peninsula (Underwater Arch Cove, Honeymoon Cove, Marguerite Cove, Hawthorne Cove, and Point Fermin). In these areas, restoration activities have reduced the average purple urchin density from 40 m^2 to 2 m^2, per our scientific collection permit. Warmer water temperatures associated with El Nino are affecting kelp growth in some restoration sites. TBF staff and partners are conducting monitoring to track ecosystem responses during the expected strong El Nino season of 2015-2016.

III. Restoration Targets and Progress

Habitat Type:	Acres/miles/metric tons accomplished to-date (cumulative):	Acres/miles/metric tons projected to be completed at end of award:
Kelp Forest	34 acres	35 acres
Minimum Viable Abalone Population	0.024 acres	7 acres

Figure 4. Restoration Progress Table

Kelp forest restoration has reached over 34 acres and is on target with the projected restoration goals. The accomplished minimum viable abalone population was determined based on the spatial area of our juvenile abalone outplanting site. The original projection of 7 acres of minimum viable abalone population assumed that obtaining juvenile and larval abalone would not be a limiting factor to the project. Because of the limited supply of abalone, the projected viable abalone population has not yet been achieved.

IV. Permit Status

Broodstock Collection Permit (Obtained)
Private Stocking Permit (Obtained)
Scientific Collecting Permit (Obtained)

V. Species Benefitting

The overarching kelp forest restoration project will benefit the 716 plus species that comprise Southern California kelp forest ecosystems. Surveys in the project restored sites have already shown an increase in biodiversity of species, total biomass, and density of individuals of indicator species like kelp bass (*P. clathratus)* and California sheephead (*S. pulcher)*. Green abalone, the target species of much of this award and a major benefitting species, is a federal species of concern. Many of the methods tested under the scope of this project may be transferred to the restoration and management of White Abalone (*H. sorenseni*) and Black Abalone (*H. cracherodii*), both federal endangered species.

VI. Project Partners

National Oceanic and Atmospheric Administration (NOAA) - Project funder and research associates. Deck spawning activities were conducted with NOAA staff under their scientific

collection permit and memorandum of understanding with the Department of Fish and Wildlife. NOAA staff contributed to experimental design planning and fieldwork including deck spawning, outplanting, and monitoring activities.

Redondo SEA Lab (A program of the LA Conservation Corps) - Project contractor and research associate. Captive spawning activities were conducted at SEA Lab and captive broodstock were reared at the SEA Lab facility. SEA Lab staff time and supplies were contracted using project funds.

Department of Fish and Wildlife (DFW) - Regulatory agency for the project. DFW reviewed permit requests and provided permits for broodstock collection, private stocking, and scientific collection. Staff assisted with collection efforts in San Diego County

California Science Center (CSC) - Project contractor, partner, and research associate. CSC volunteered staff time and equipment to raise larvae and contributed divers, a videographer, and use of the kelp forest ecosystem tank for outplant equipment testing. CSC was provided with project funds for supplies to rear larvae for the project.

Vantuna Research Group (VRG) - Project contractor and research associate. Staff from VRG conducted SCUBA site surveys and collection, captained the vessel for several deck spawning attempts, and contributed to data analysis.

Cabrillo Marine Aquarium (CMA) - Research associate. CMA reared larvae for 2 weeks following a deck spawning experiment.

VII. Project Timeline

The following tables show the timeline for the duration of the project. In years 2012-2013, the project was focused on the genetics and RLP prevalence studies and obtaining permits before any spawning or outplanting could occur. In late 2014 and 2015, the project focused on constructing and testing new equipment, finding suitable sites for outplanting, and finally spawning and outplanting activities.

Tasks and Milestones	2012	2013	2014											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Method Experimentation														
Genetic Population Testing														
RLP Detection														
Deck Spawning														
Captive Spawning														
Raise juveniles														
Site Assessments														
Outplant Veligers														
Outplant Juveniles														
Monitor Outplant Sites														

Tasks and Milestones	2015								
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Method Experimentation									
Deck Spawning									
Captive Spawning									
Raise juveniles									
Site Assessments									
Outplant Veligers									
Outplant Juveniles									
Monitor Outplant Sites									

Figure 5. Project Timeline

VIII. Monitoring and Maintenance Activities

Juvenile Outplant Site Monitoring

The juvenile abalone outplanting site has been monitored daily for three days, weekly for four weeks, and monthly for three months following outplanting. Some planned monitoring days were not possible due to adverse weather conditions, but monitoring was rescheduled and closely followed the estimated monitoring timetable. Figures 6 and 7 show the number of live abalone and the number of shells found in our restoration site during each monitoring event.

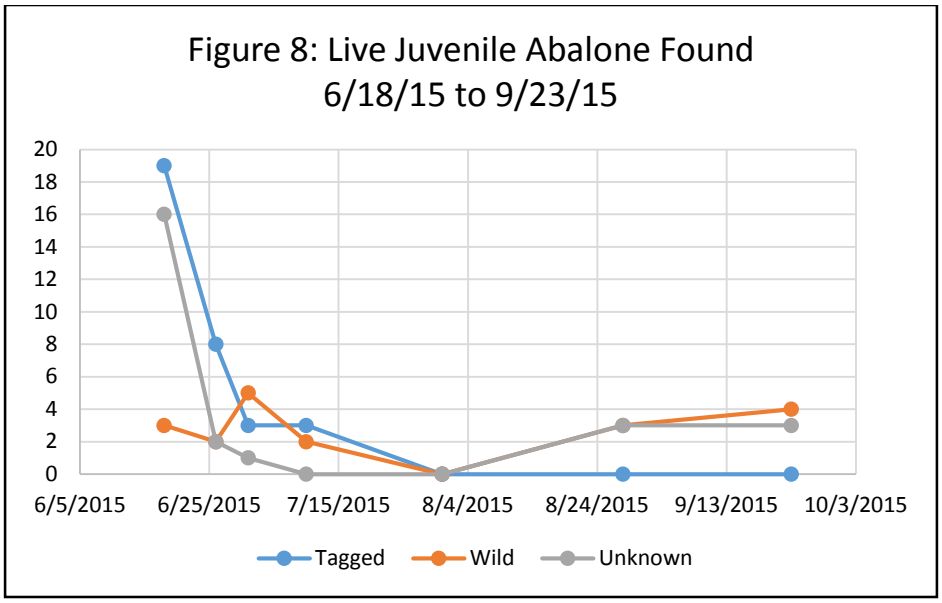
Figure 6. Live Juvenile Abalone Found 6/18/15 to 9/23/15

Date	Tagged	Wild	Unknown	Total
6/18/2015	19	3	16	38
6/26/2015	8	2	2	12
7/1/2015	3	5	1	9
7/10/2015	3	2	0	5
7/31/2015	0	0	0	0
8/28/2015	0	3	3	6
9/23/2015	0	4	3	7
TOTAL	33	19	25	77

Figure 7. Juvenile Abalone Shells Found 6/18/15 to 9/23/15

Date	Tagged	Wild	Unknown	Total
6/18/2015	7	0	0	7
6/26/2015	17	0	0	17
7/1/2015	10	1	2	13
7/10/2015	6	2	0	8
7/31/2015	13	4	1	18
8/28/2015	5	3	3	11
9/23/2015	0	1	0	1
TOTAL	58	11	6	75

While the number of shells found at the restoration site did not seem to follow a predictable pattern, the number of tagged live abalone observed decreased steadily in the first 4 weeks and remained at zero thereafter (See Figure 8). Overall, a small fraction of the outplanted abalone have been observed. Our monitoring has been non-invasive, meaning that divers have not moved or disturbed rocks to search for abalone. Therefore many abalone may be in areas that are not visible to divers during searches. An invasive sampling event will occur at 6 months post outplant.



The Bay Foundation staff plans to continue monitoring the juvenile outplanting site after the conclusion of this project funding, concluding with a destructive sampling event in which all tagged abalone will be collected. This will help determine the survival of the outplanted abalone population, the amount of growth that has occurred, and dispersal.

IX. Community Involvement

	To-date (cumulative):	Projected for completed award:
Volunteer Numbers:	104	N/A
Volunteer Hours:	2591	N/A

Figure 9. Volunteer Participation Table

The above volunteer hours consist mainly of scientific divers assisting with kelp forest restoration, and volunteers assisting with sea urchin dissection at Loyola Marymount University. A small portion of the hours (2 volunteers and 16 hours) were volunteers assisting with juvenile abalone tagging. Volunteers were not used for abalone outplanting and spawning activities due to the specialized nature of the work. There was no original projection for volunteer hours specific to this grant and project timeline since we did not anticipate using volunteers for the abalone restoration portion of the project.

X. Outreach Activities

- March 12, 2014 – Socio-Economic Analyses of Coastal Ecosystem Resilience Conference, Los Angeles, CA. Presented about abalone restoration and its relationship to kelp forest ecosystem restoration at Loyola Marymount University.

- March 22, 2014- Aquarium of the Pacific, Long Beach, Ca. Presented an overview of the Southern California Abalone and Kelp Forest Restoration Program to the public at Divers Day at the Aquarium of the Pacific. Over 50 people attended the presentation.

- November 14, 2014- California Science Center, Los Angeles, CA. Engaged with the public during outplanting equipment testing trial. Educated visitors about abalone restoration work. CSC staff also created a video for project outreach.

- January 27, 2015- Loyola Marymount University, Los Angeles CA. Presentation to Seaver College of Science and Engineering students.

- February 24, 2015- NOAA Headquarters, Silver Springs MD. Presentation on the Kelp Forest and Abalone Restoration Project at a NOAA brown bag lunch.

- March 24, 2015- National Shellfish Association Conference, Monterey CA. Presentation on Green Abalone Spawning and Outplanting Techniques.

- May 6, 2015 – The project was featured on the NOAA Montrose settlements restoration program webpage in an article called "Restored kelp forests provide a home for recovering abalone species" focusing on the nexus between kelp restoration and abalone efforts. URL: http://www.montroserestoration.noaa.gov/2015/05/05/restored-kelp-forests-provide-a-home-for-recovering-abalone species/?utm_source=May+2015+Newsletter&utm_campaign=Spring+Newsletter+2015&utm_medium=email

- May 14, 2015- The project was featured on SoCalWild, a blog about southern California wildlife news in an article titled "Greening the ocean with abalone" focusing on the projects abalone tagging and outplanting effort. URL: http://www.socalwild.com/2015/05/greening-the-ocean-with-abalone/1598/

- July 13, 2015 – The project was featured on NOAA's Response and Restoration Blog in an article focused on the project including a video of the juvenile outplanting event. URL: https://usresponserestoration.wordpress.com/2015/07/13/to-bring-back-healthy-california-ocean-ecosystems-noaa-and-partners-are-planting-long-lost-abalone-in-the-sea/

- July 29, 2015- NOAA's National Ocean Service published a video documenting the juvenile outplanting event on their YouTube channel. This video shows the equipment

project partners developed and constructed in use. URL: https://youtu.be/zNTKMWyGcAQ

- October 19, 2015- Loyola Marymount University, Los Angeles, CA. Presentation to undergraduate Environmental Studies class students.

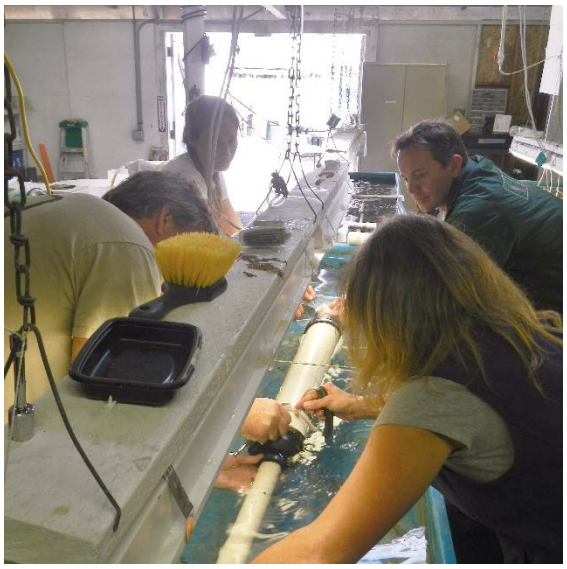
- Staff regularly posts social media (Twitter, Facebook, and Instagram) updates on project activities.

XI. Supporting Materials

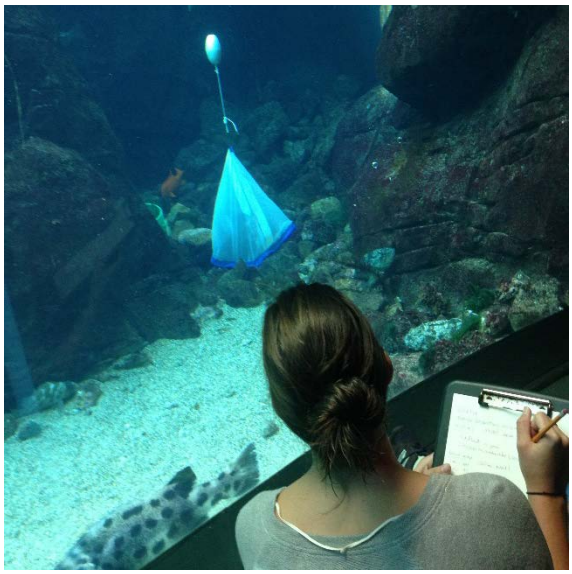
This section contains restoration project pictures that refer to previous sections.

Photos:

Outplant Equipment Testing

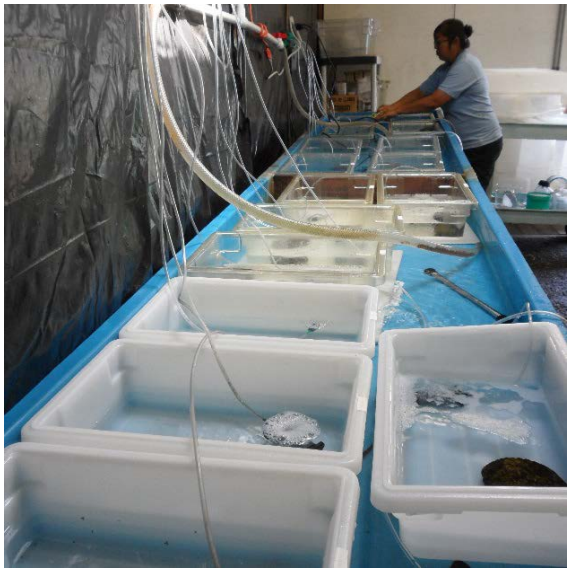


Testing larval pump in SEA Lab Tank



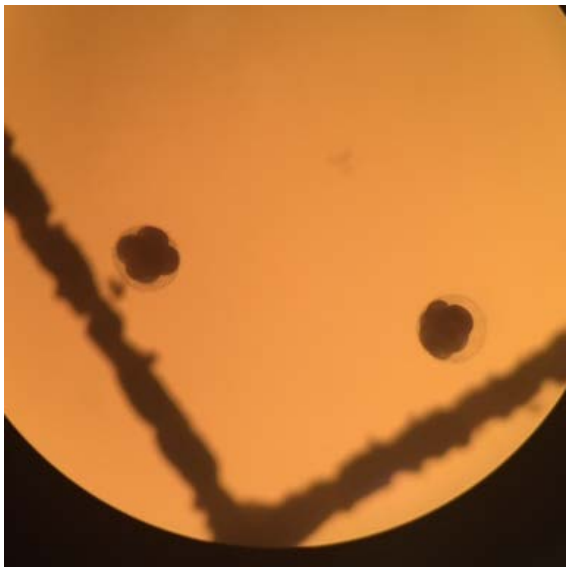
Testing larval tent at the California Science Center

Captive Spawning

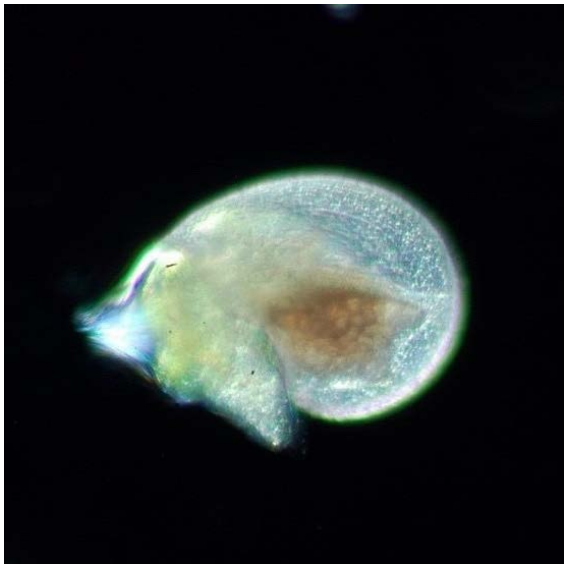


Spawning trays at SEA Lab

Male Green Abalone Spawning

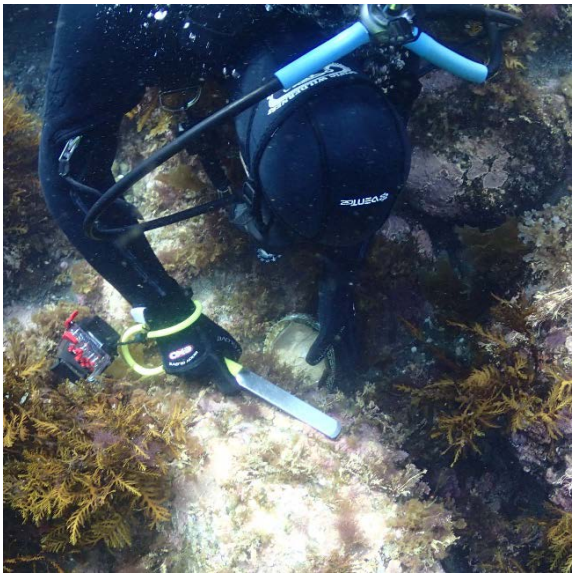


Green Abalone Egg Cleavage under microscope

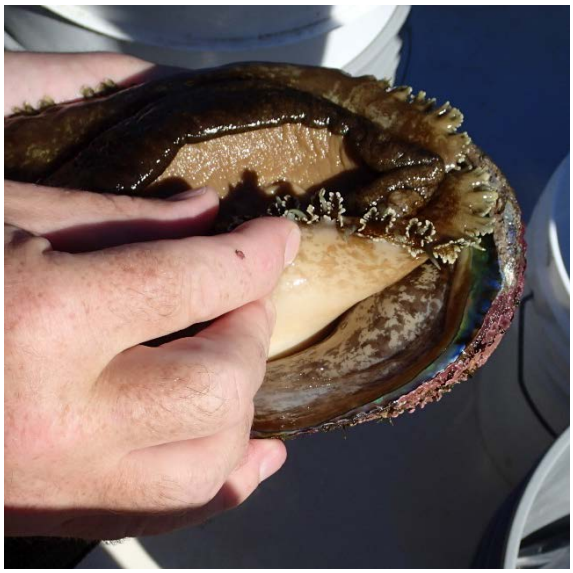


Green Abalone Veliger under Microscope

Deck Spawning



Diver collecting adult abalone for spawning

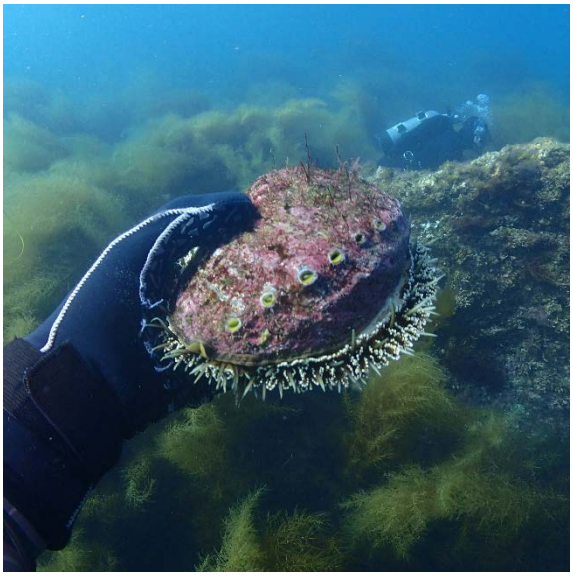


Checking abalone gonad for ripeness

Collecting an epipodial sample for genetics

Adding hydrogen peroxide to induce spawning

Waiting for abalone to spawn in buckets



Returning abalone to the wild

Juvenile Outplanting

Tagged juveniles in outplanting module

Abalone modules in coolers on research vessel

Divers ready to deploy modules

Diver and module at outplanting site

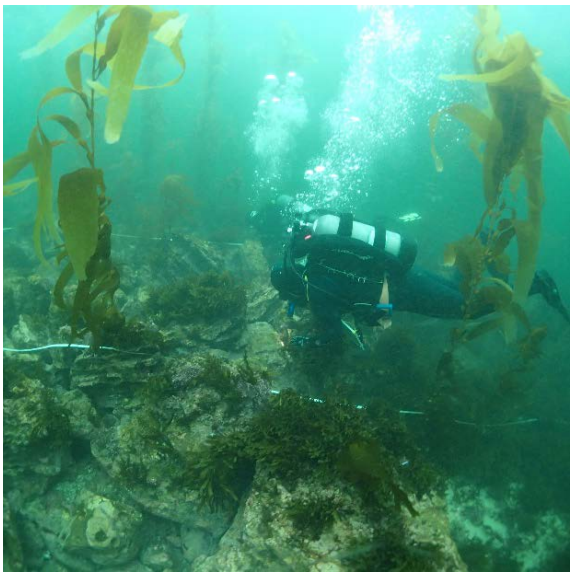
Divers installing modules in cobble

Juvenile Module Installed in Cobble

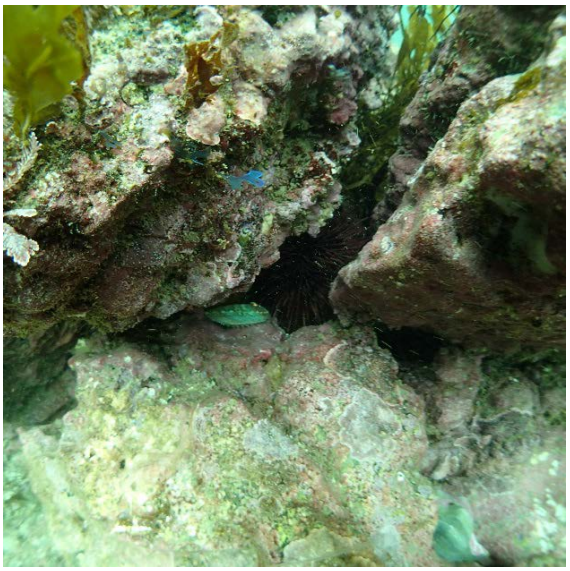
Juvenile Abalone crawling out of module

Juvenile Abalone settling on rocks

Juvenile Outplant Monitoring



Divers searching for outplanted abalone along transect tapes



Live tagged abalone in crevice

Octopus with abalone shell