Maintaining the Health of Endangered White Abalone (*Haliotis sorenseni*) in a Captive Breeding Program

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Overview

• White Abalone History

• Endangered Status and the White Abalone Recovery Plan

• Monitoring for Infectious Disease and Pests

• Treatment of Infected and Infested Captive Abalone
Abalone Species Found on the Pacific Coast of North America

Red Abalone *(Haliotis rufescens)*

Pink Abalone *(Haliotis corrugata)*

Green Abalone *(Haliotis fulgens)*

Black Abalone* *(Haliotis cracherodii)*

White Abalone* *(Haliotis sorenseni)*

Flat Abalone *(Haliotis walallensis)*

Pinto Abalone *(Haliotis kamtschatkana)*

Threaded Abalone *(Haliotis kamtschatkana assimilis)*

*Endangered
White Abalone (*Haliotis sorenseni*)

- First described in 1940
- Estimated life span is 35-40 years
- Deepest occurring abalone species in California (most abundant between 25-65m)
- Broadcast Spawners

Adult White Abalone are usually between 5 to 8 inches long.
White Abalone (*Haliotis sorenseni*)

Photo: Carolina Rivera Alvarez
Distribution

- Range: Point Conception, California to Punta Abreojos, Baja California

- Population in California has been reduced to 1% of its historic size

- Population in Mexico is being studied, but remains largely unknown
Commercial Fishery Landings
(In Pounds)

Year

White abalone
Commercial Fishery Begins
Commercial Fishery Collapses

All abalone

Commercial Fishery Begins
Commercial Fishery Collapses
Endangered Status and Recovery Plan

1999
Center for Biological Diversity and Marine Conservation Institute both petition for ESA listing

May 29, 2001
White abalone becomes first marine invertebrate to be listed as an endangered species

2001
Captive breeding produces more than 100,000 juvenile white abalone

2002
95% of these offspring die from disease

2008
NMFS published the White Abalone Recovery Plan
Withering Syndrome

- First discovered off the channel islands in 1985
- Can affect all species of abalone

- Signs of disease:
  - Shrinkage of foot muscle
  - Lethargy
  - Decreased food consumption
Candidatus Xenohaliotis californiensis (CXc)

- *Rickettsiales* prokaryote
- Obligate intracellular bacterium
  - Infects the mucosal epithelium of the gastrointestinal tract
  - Replicates within intracytoplasmic, membrane-bound vacuoles
- Not cultivatable on fish media or fish cell lines

Friedman et al. 2000
Candidatus Xenohaliotis californiensis (CXc) Detection

Necropsy

Histology
Post-esophagus tissue

Healthy
Infected

Feces Samples (Non-Lethal)

In Situ Hybridization

qPCR (Friedman et al. 2014)
Testing White Abalone for CXc

• Transmitted through untreated seawater

• Routine qPCR testing at Bodega Marine Laboratory and five other partner facilities
  – Feces samples collected on monthly, quarterly, or biannual basis
  – DNA Extracted using a QIAamp Fast Stool Mini Kit

• Detect emerging infections before signs occur
  – Antibiotic Treatment
Antibiotic Treatment

• Antibiotic: Oxytetracycline (OTC)
  – Informed by previous treatments on fish
  – Effective treatment of infections caused by Rickettsiales species

• Methods to administer OTC:
  – Intra-muscular injections (Friedman)
  – Incorporate into artificial diet
  – Bath (Moore et al.)
Advantages:
• Consistent dosage of drug
  – Uptake of the drug is independent of behavior
• Treat multiple animals at once—no handling required
• Negligible mortality

Disadvantages:
• Expensive
• Wastewater

Eight (8) 500ppm OTC baths, each bath lasts 24 hours
Antibiotic Kinetics in Abalone Tissue

The baths were administered on days noted by pink triangles.

OTC Treated Abalone

Eliminates Infection, May Prevent Reinfection
Shell-Boring Organisms

Sponges
(\textit{Cliona celata californiana})

Bivalves
(\textit{Clam: Panitella conradi})

Polychaetes
(\textit{Polydora spp})
Shell Lesions

White Abalone with Shell Lesion
Waxing Treatment to Eliminate Shell Boring Organisms

Beeswax (66%) and Coconut Oil (34%), ~70°C
Waxing Treatment to Eliminate Shell Boring Organisms

- Initial application, followed by subsequent applications on a routine basis
- Eliminates sponges, bivalves, and polychaetes
- 100% abalone survival

Wild-origin White Abalone Broodstock

Aug. 2009

Oct. 2010
Summary

• Routine monitoring ensures that infected abalone are treated promptly
  – No mortalities solely attributed to infection with CXc in captive white abalone since program’s inception
  – Program on track for outplanting due to health maintenance

• Decline in mortalities due to shell boring organisms and opportunistic microbes
  – Successfully eliminated Polydora worm using the waxing treatment
Health Maintenance and Disease Management has played, and is continuing to play, an integral part in the recovery project!
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Websites
CDFW Shellfish Health Lab:
https://www.wildlife.ca.gov/Conservation/Laboratories/Shellfish-Health

White Abalone Recovery Project at Bodega Marine Lab:
http://bml.ucdavis.edu/research/research-programs/saving-white-abalone/