Evaluation of *Candidatus* Xenohaliotis californiensis (*CXc*) and its associated phage (*pCXc*) in black abalone of Baja California

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Black abalone

- *Haliotis cracherodii*, Leach 1814
- Point Arena, CA – Bahía Tortugas, BCS
- Intertidal 3 – 6 m
- T°C, salinity, humidity, waves
- 20 – 30 years

Historical and current distribution of black abalone (*H. cracherodii*) throughout the Northwest Pacific (modified from Neumann et al. 2010)

(Cox 1962, Butler et al. 2009, Neumann et al. 2010)
Black abalone fisheries in Mexico

1860: Start of commercial fisheries
1922: Sporadic catch reports
1940: Establishment of the 1st cooperative
1950: Beginning of the commercialization of the species
1970: Peak point of commercialization
1996: Agreement to stop the capture of the species
1980s: Report of high mortalities
2006: Reported as the 0.2% of total fishery

Decline in black abalone populations

Wild populations decline

- Climate change
- Pollution
- Habitat degradation
- Overfishing
- Diseases

(Hamm & Burton 2000, Cáceres-Martínez 2002)
Withering syndrome

- **1985** in CA (USA) and **1994** in BC (MX)
- Chronic and lethal disease
- *Candidatus* Xenohaliotis californiensis
- Rickettsia-like (vacuole)
- Digestive epithelia
- Abnormalities within digestive gland
- Depletion of glycogen reserves
- Weakness, foot atrophy, anorexia and death

Healthy black abalone (top) and with signs of WS (bottom)
Candidatus Xenohaliotis californiensis

- Mortality rates varies between species
- Female are more resilient
- Presence do NOT guarantee the disease
- Warmer water temperatures benefit CXc
- Black abalone (100%)
- Unknown reason

Cultured red abalone posterior esophagus tissue:
(A) Healthy (left) &
(B) Infected with CXc (right)

(Ben-Horin et al. 2013, Friedman et al. 2014, Brokordt et al. 2017)
Bacteriophage (pCXc)

- Red and black abalone from CA
- Red, green and pink abalone from BC

- Both bacteria and phage are well established in the area
- Alteration in the disease development
- Reduces pathogenicity of CXc

No official records of the health state nor the organisms density in the area (BC)

Recent monitoring

Abalone populations present signs of recovery without signs of the disease

Previous research and present overview

• 10 studies
• Prevalence of CXc infected by pCXc
• CA and BC species (wild and cultured)
• Detection of CXc in black abalone of BC, but not of the phage (Valles-Ríos, 2000)

Techniques

- Histology
- PCR - 16S
- qPCR
- In situ Hybridization


(Ibarra-Macías et al. 2019, Cepeda-Ochoa, 2019)
Area of study and sampling

- 14 sites – 6 zones
- 1/3 of total habitat
- Low tide
- 236 random fecal samples
- Semi invasive / Non-lethal
- Shell length (cm) measurement
Methodology

**Histology**
- Gastrointestinal tissue of an infected organism of ITS

**DNA extraction**
- Commercial extraction Kit QIAGen (Cruz-Flores, 2017)
- Extraction quality review (Friedman et al. 2014; Friedman et al. 2012)

**PCR amplification**
- CXc 16S
  - 426 bp (Cicala et al. 2017)
- pCXc
  - 412 bp (Cruz-Flores et al. 2018)

Reference or Positive control
- (Valles-Ríos, 2000)

(Valles-Ríos, 2000)
Prevalence of CXc and pCXc per zone

- 236 total / 199 individuals (84.3%)
- 6% for CXc
- 34% for pCXc
- 38% for CXc infected with pCXc
- 22% no prevalence for both CXc and pCXc
- Fluctuation throughout the area
- No geographic pattern
Correlation between prevalence of CXc and pCXc with:

1. Abalone length
   - Certain correlation but no significant
   - CXc and pCXc present in all lengths

2. Abalone location
   - No correlation
   - Does not mean it doesn’t exist

3. Abalone density
Summary

• First study that detects the presence of pCXc infecting CXc in black abalone from Baja California

• Both bacteria and phage are widely distributed in the study zone and across the different abalone lengths

• Aparent correlation between prevalences of the bacteria and phage with the abalone lengths...
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Questions?

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