Can larval dispersal explain differences in population structure of ESA-listed rockfish in Puget Sound?

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CAN LARVAL DISPERSAL EXPLAIN GENETIC DIFFERENCES OF ESA-LISTED ROCKFISH IN PUGET SOUND?

Kelly Andrews, Chris Harvey, Dan Tonnes, Mary Bhuthimethee, Parker MacCready & Bradley Bartos
3 ROCKFISH SPECIES IN PUGET SOUND LISTED UNDER THE ESA

Yelloweye rockfish

Canary rockfish

Threatened

Bocaccio

Endangered
PUGET SOUND/GEORGIA BASIN DPS

3 species of Puget Sound rockfish listed for protection
CANARY ROCKFISH IN PUGET SOUND ARE NOT GENETICALLY DISTINCT FROM OUTER COAST

No genetic structure observed.

3 other analyses support this same conclusion.

Andrews et al 2018
CANARY ROCKFISH WERE DELISTED ON MARCH 24, 2017
YELLOWEYE ROCKFISH IN PUGET SOUND ARE GENETICALLY DISTINCT FROM OUTER COAST

Three distinct clusters of genetic variation:

1) CA, OR & WA coast, Strait of Juan de Fuca and Canadian outside waters.
2) San Juan Islands, Central Puget Sound and Canadian inside waters.
3) Hood Canal isolated.

Six fish (of 151) defy the inside/outside pattern.

3 other analyses support this same conclusion

Andrews et al 2018
YELLOWEYE ROCKFISH DPS IS SUPPORTED, BUT…
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WHAT MECHANISM(S) ARE RESPONSIBLE FOR THESE DIFFERENCES?

• Adult movement?
  • Canary rockfish show large movements;
  • Yelloweye rockfish are very site-attached (Hannah & Rankin 2011)
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• Larval dispersal?
  • 3-4 month pelagic duration
  • Differences in timing of parturition between species
MODELING LARVAL DISPERSAL

- MoSSEA (Modeling the Salish Sea) 2006 conditions
  - Numerical model based on ROMS simulating hourly 3-D fields of temperature, salinity and three components of velocity
LARVAL RELEASE SITES

- 15 – 18 sites across 6 regions inside and outside DPS
  - Outer coast
  - Strait of Juan de Fuca
  - Strait of Georgia
  - San Juan Islands
  - Central Puget Sound
  - Hood Canal
  - South Puget Sound
LARVAL RELEASE & TRACKING

- At each site...
  - Released
    - 10,000 larvae as passive particles
  - Over 60 days with this lunar distribution
  - Canary release in January
  - Yelloweye release in May
- Settlement
  - Monitor regional location between 90 – 120 days post-release

Parturition frequency (%)

1998 n= 150
1999 n= 253

Sebastes inermis; Plaza Pasten 2003
VERTICAL DISTRIBUTION OF LARVAE

Sebastes sp.

Day
Night

Noelle Bowlin dissertation
LARVAL TRACKS RELEASED FROM OUTER COAST

Canary rockfish: Outer coast

Yelloweye rockfish: Outer coast
LARVAL TRACKS RELEASED FROM CENTRAL PUGET SOUND

Canary rockfish: Central Puget Sound

Yelloweye rockfish: Central Puget Sound
LARVAL TRACKS RELEASED FROM HOOD CANAL

Canary rockfish: Hood Canal

Yelloweye rockfish: Hood Canal
3 BASIC QUESTIONS

1. What proportion of larvae released at sites inside (outside) the DPS settle inside or outside the DPS?

2. Does release timing matter?

3. Does larval duration matter?
EXPECTEDATIONS IF LARVAL DISPERSAL IS MECHANISM FOR DIFFERENCES

Possible expectations based on genetics:
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1. Canary would show large amounts of settlement across DPS boundaries across regions.
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Possible expectations based on genetics:

1. Canary would show large amounts of settlement across DPS boundaries across regions

2. Yelloweye would show very little to no settlement across DPS boundaries
SIMILAR SETTLEMENT PATTERNS AMONG ESA ROCKFISH

**Pearsons Chi-squared test:**
X-squared = 4.9241, df = 5, p-value = 0.4252
SIMILAR SETTLEMENT PATTERNS AMONG ESA ROCKFISH

1. Released outside DPS – settle outside DPS

Pearson's Chi-squared test:
X-squared = 4.9241, df = 5, p-value = 0.4252
SIMILAR SETTLEMENT PATTERNS AMONG ESA ROCKFISH

1. Released outside DPS – settle outside DPS

2. Released in Puget Sound or Strait of Georgia – settle inside DPS

Pearson's Chi-squared test:
$X^2 = 4.9241$, $df = 5$, $p$-value $= 0.4252$
SIMILAR SETTLEMENT PATTERNS AMONG ESA ROCKFISH

1. Released outside DPS – settle outside DPS

2. Released in Puget Sound or Strait of Georgia – settle inside DPS

3. Released in San Juans – settlement is nearly equal between inside and outside

Pearson's Chi-squared test:
X-squared = 4.9241, df = 5, p-value = 0.4252

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<thead>
<tr>
<th>Settlement region</th>
<th>Inside DPS</th>
<th>Outside DPS</th>
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Mean proportion of larvae

Release basin

- canary
- yelloweye
NO OVERALL PATTERNS WITH
RELEASE TIMING
NO PATTERNS WITH LARVAL DURATION
CONCLUSIONS

• No definitive differences in dispersal spatial patterns between the species

• High proportion of larvae moving across DPS boundaries for both species

• Release date and larval duration don’t appear to show any distinct patterns of influence on dispersal

• All together, suggests that larval dispersal, modeled as mostly passive particles, is NOT a likely mechanism for genetic isolation of yelloweye rockfish
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Outer coast = DPS
CAUTIONS: 2006 WAS NOT “NORMAL”

Low surface flow
CAUTIONS: 2006 WAS NOT "NORMAL"

Low surface flow +

High deepwater intrusion =

Greatest upwelling in 36 years!

Mean + SD from 1985-2008
CAUTIONS: 2006 WAS NOT “NORMAL”

• Based on 2006 oceanographic conditions:
  • Estimates of dispersal were likely:
    • < average from the Puget Sound DPS to outer coast
    • > average from the outer coast into the Puget Sound DPS
  • This shouldn’t affect our main conclusion as this likely means more dispersal of YE from the San Juans and Strait of Georgia to outer coast in more ‘average’ years.
NEXT STEPS...MAYBE?

• LIVE OCEAN
  • new model that will allow us to measure rates of dispersal across multiple years with different conditions

• Introduce more larval behavior?
  • Mostly a black box
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Kashef et al. 2014
ANY QUESTIONS?

NO DATA!