Ecosystem variability in the Northern California Current

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Cooperative Institute for Marine Resources Studies
Background/Acknowledgements

• Data presented here are a product of several important programs.
  – GLOBEC-NEP
  – NOAA Stock Assessment Improvement Program (SAIP)
  – Bonneville Power Administration Ocean Salmon Survival program (1998 – present)

GOAL: Better understand ocean ecosystem dynamics (variability) and the relationship to salmon survival.
Local Biological Conditions

Basin and local scale forces influence biological process important for salmon

Physical/Hydrographic

Local Conditions
Upwelling & SST
Spring Transition
Coastal currents

Local Biological Conditions

Ecosystem-based approach
Much of the biological and hydrographic information comes from sampling on the NH Line.

Climate indices are from the web.
• Sampled biweekly for 18 years
  – **1996 - present**
  – 7 stations (1 – 25 nm)
• Hydrography
  – CTD
  – Nutrients
  – Dissolved oxygen
• Biology
  – Phytoplankton
  – Zooplankton
  – Ichthyoplankton
• Combine with basin and regional scale indicators
  – Upwelling index
  – PDO, ENSO
Ocean ecosystem indicators of salmon marine survival in the Northern California Current

As many scientists and salmon managers have noted, variations in marine survival of salmon often correspond with periods of alternating cold and warm ocean conditions. For example, cold conditions are generally good for Chinook (Oncorhynchus tshawytscha) and coho (O. kisutch) salmon, whereas warm conditions are not.

These pages are based on our annual report of how physical and biological ocean conditions may affect the growth and survival of juvenile salmon in the northern California Current off Oregon and Washington. We present a number of physical, biological, and ecosystem indicators to specifically define the term “ocean conditions.” More importantly, these metrics can be used to forecast the survival of salmon 1-2 years in advance, as shown in Table 1. This information is presented for the non-specialist; additional detail is provided via links when possible.

BPA Plume Study Target Station Locations

![Map of BPA Plume Study Target Station Locations](image-url)
Array of indicators spanning a range of spatial scales and processes.

<table>
<thead>
<tr>
<th>Large scale physical indicators</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Outlook</th>
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<td>PDO (May – Sept)</td>
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<td>ONI (Jan-Jun)</td>
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<th>Local and regional physical indicators</th>
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<td>Sea surface temperature anomalies</td>
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<td>Coastal upwelling</td>
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<td>Physical spring transition</td>
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<td>Deep water temperature and salinity</td>
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<td>Copepod biodiversity</td>
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<td>Northern copepod anomalies</td>
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<td>Biological spring transition</td>
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<td>Spring Chinook--June</td>
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<td>Coho--September</td>
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Key:
- green: good conditions for salmon
- yellow: intermediate conditions for salmon
- red: poor conditions for salmon
- green dot: good returns expected
- yellow dot: no data
- red dot: poor returns expected
Pacific Decadal Oscillation (PDO)

• Generally multi-decadal
• Short term variability in recent 16 years
  – Coincident with ecosystem monitoring efforts in NCC
  – Interesting opportunity/experiment
Seasonal variation in PDO anomalies

- Winter (Jan-Mar) trending towards more positive PDO values.
- Summer (July-Sept) and Fall have less of a trend and smaller anomalies.
Local temperature signal (50 m NH05) in response to basin scale forcing
Local temperature and salinity signal (50 m NH05) in response to basin scale forcing
Transport

Directly impacts the composition of the lower trophic levels.

Plankton are drifting with water masses.

Transport from the North brings a different copepod community than transport from the South.

Southern copepods – small, lipid poor

Northern copepods – large, lipid rich

Bi et al. 2011
Keister et al. 2011
Two main sources of transport variability forcing copepod communities

Seasonal structure of coastal upwelling

- Spring/summer- Upwelling
  - ‘cold water’ shelf copepods
  - Boreal/Northern spp.

- Winter- Downwelling
  - ‘warm water’ shelf copepods
  - Sub-tropical/Southern spp.
Strong seasonality of Northern and Southern copepods at NH05 - northerns appear more seasonal while southerns have more residuals
Poor relationship between upwelling and the biomass of the copepod community.

**Northern** copepods v. UWI

\[ r = 0.10 \]

**Southern** copepods v. UWI

\[ r = 0.30 \]
Two main sources of transport variability forcing copepod communities

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Basin-scale forcing- Advection
- PDO
- ONI
Inter-annual variability of the Northern and Southern copepod biomass anomalies with PDO and ONI

<table>
<thead>
<tr>
<th>Year</th>
<th>Northern Biomass Anomaly (Log10)</th>
<th>Southern Biomass Anomaly (Log10)</th>
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PDO

ONI

SST Anomaly °C

Inter-annual variability of the Northern and Southern copepod biomass anomalies with PDO and ONI.
Copepod community response to basin-scale forcing

**PDO**
- Northern biomass (Log10): $r = 0.80$

**ONI**
- Northern biomass (Log10): $r = 0.17$

**NPGO**
- Northern biomass (Log10): $r = 0.68$

**SOUTHERNS**
- Northern biomass (Log10): $r = 0.73$
- Southern biomass (Log10): $r = 0.81$
- Southern biomass (Log10): $r = 0.26$
Hypoxia

- Dissolved oxygen < 1.4 ml L\(^{-1}\)
- Seasonal
- Occurs during the upwelling period.
- Most severe in August-September

Peterson et al. 2013
Hypoxia

- Seasonal variation in the position of oxygen isopleths over the shelf.
- Upwelling moves low oxygen water onto the shelf.
- Further oxygen drawdown during productive summer season.
- Low oxygen waters typically in the lower 30m of the water column.
Hypoxia

Most severe, and covered the greatest area (>60%) of the shelf in 2002, 2006-2007

Least severe years were 2003, 2009-10.
Source water oxygen anomaly

Dissolved oxygen (DO)

The DO concentration in upwelled water varies annually.

General trends:

Decreasing DO: 2001 – 2005
Increasing DO: 2006 - 2010
Hypoxia

Intriguing relationship between the amount of oxygen in upwelled water and NPGO PDO

.....though time scales are a bit short (one oscillation) for a robust comparison.
Summary

• NCC has strong seasonal cycles in biology and hydrography.

• Basin-scale processes are driving local hydrography and copepod variability.
  – Northern copepods (PDO, NPGO); Southern (PDO, ONI)
  – Mechanisms and time-lags are less well understood

• Importance of circulation/transport continues to be recognized, but a better understanding is needed
Acknowledgements

W.T. Peterson Group:

Current: Tracy Shaw, Cheryl Morgan

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Captains and Crew of R/V Elakha, F/V Frosti, R/V Wecoma

Bonneville Power Administration