Just going with the flow?

How Nearshore Currents affect Larval Dispersal and Genetic Connectivity of China Rockfish (*Sebastes nebulosus*) Along Oregon and Washington Coasts

Alexandra M. Avila, PhD

Fisheries Science from Oregon State University 2023

Western Groundfish Conference 2023

Juneau, AK

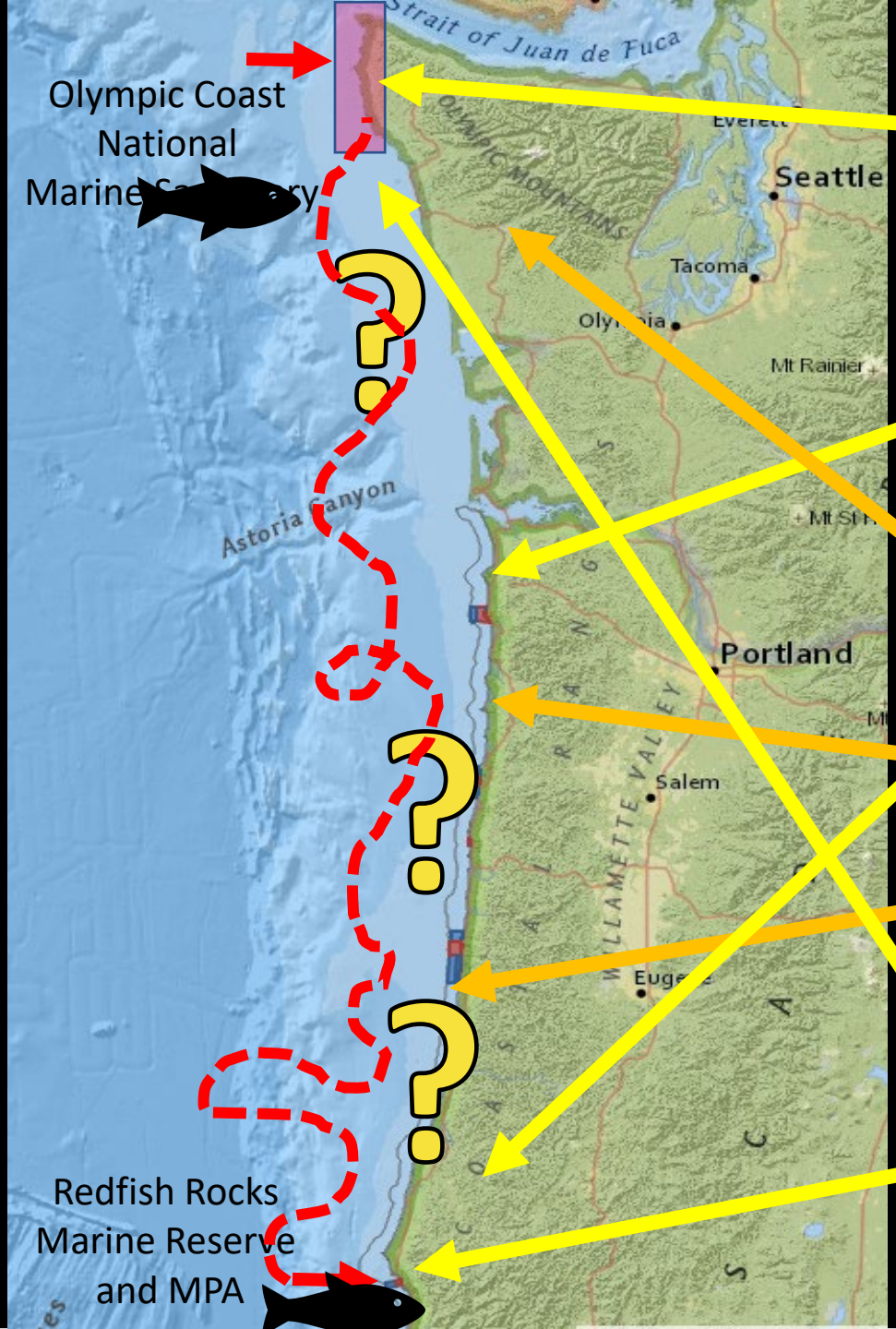
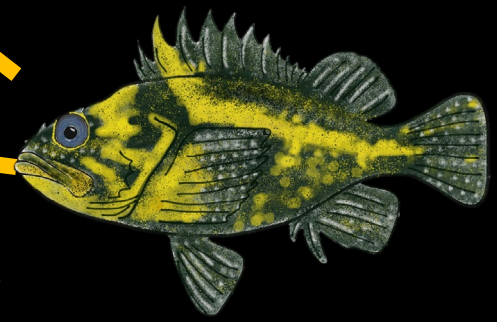


Illustration credit: Alex Avila



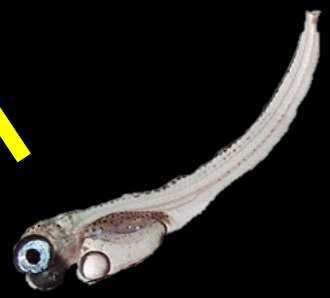


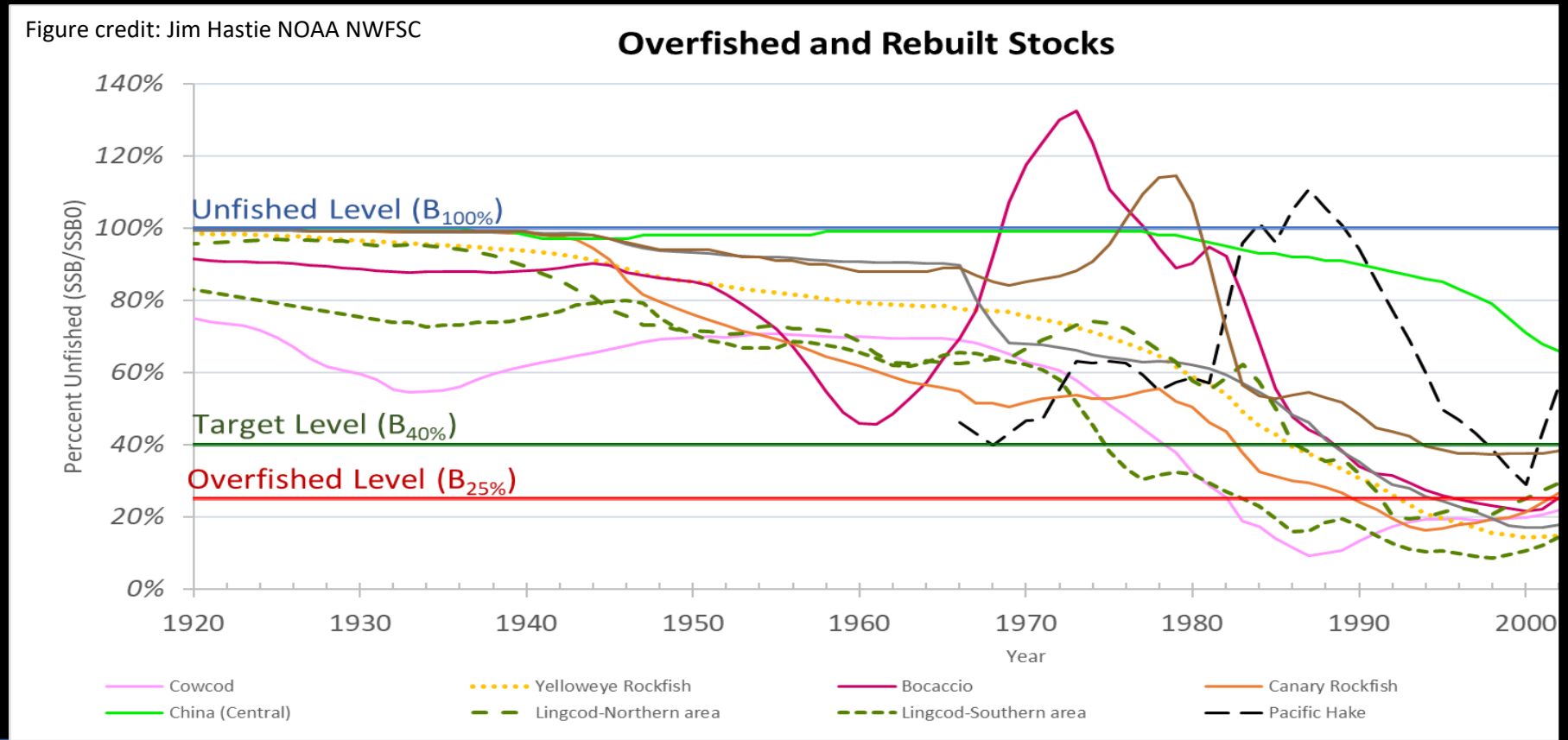
Photo credit: NOAA

Are China Rockfish populations in Oregon and Washington connected?

Why Rockfish?

- Commercially important ($140 million USD/yr)
  (Caselle et al 2010)
- Previously overfished in 2000s (NMFS 2009)

Figure credit: Jim Hastie NOAA NWFSC



Why Rockfish?

- Commercially important ($140 million USD/yr)
  (Caselle et al 2010)
- Previously overfished in 2000s (NMFS 2009)

Certified sustainable fishery by MSC

Catch shares implemented

Establishment of RCA

Declared overfished

Figure credit: Jim Hastie NOAA NWFSC

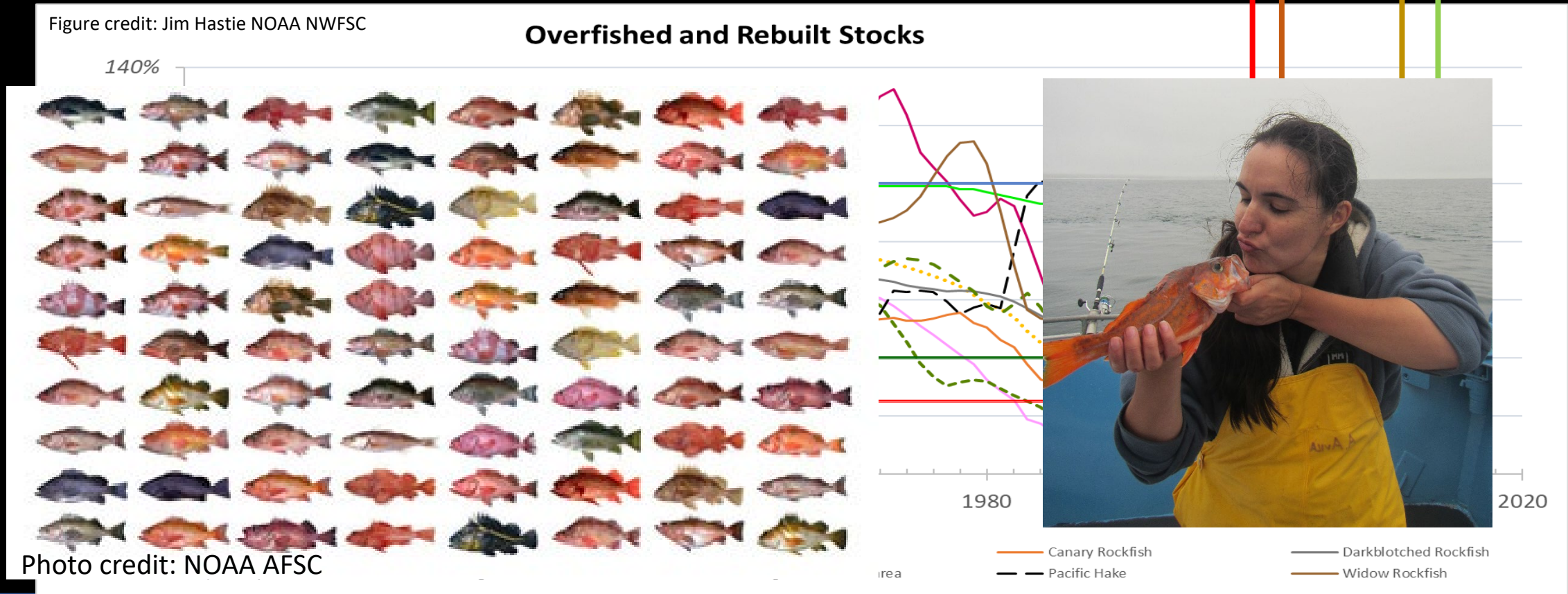


Photo credit: NOAA AFSC

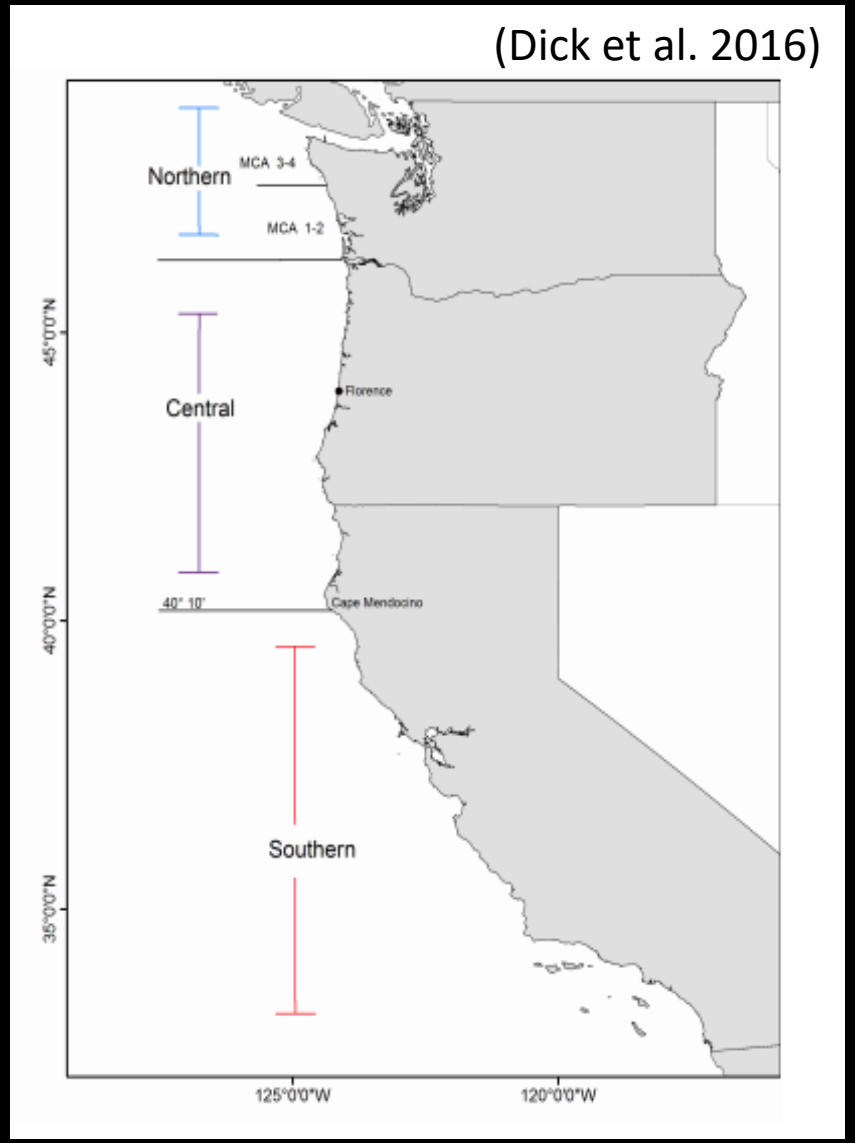
Why care about rockfish, ocean currents and spatial management?

Spatial Management

Rockfish
Larval dispersal
Genetic connectivity

Oceanography

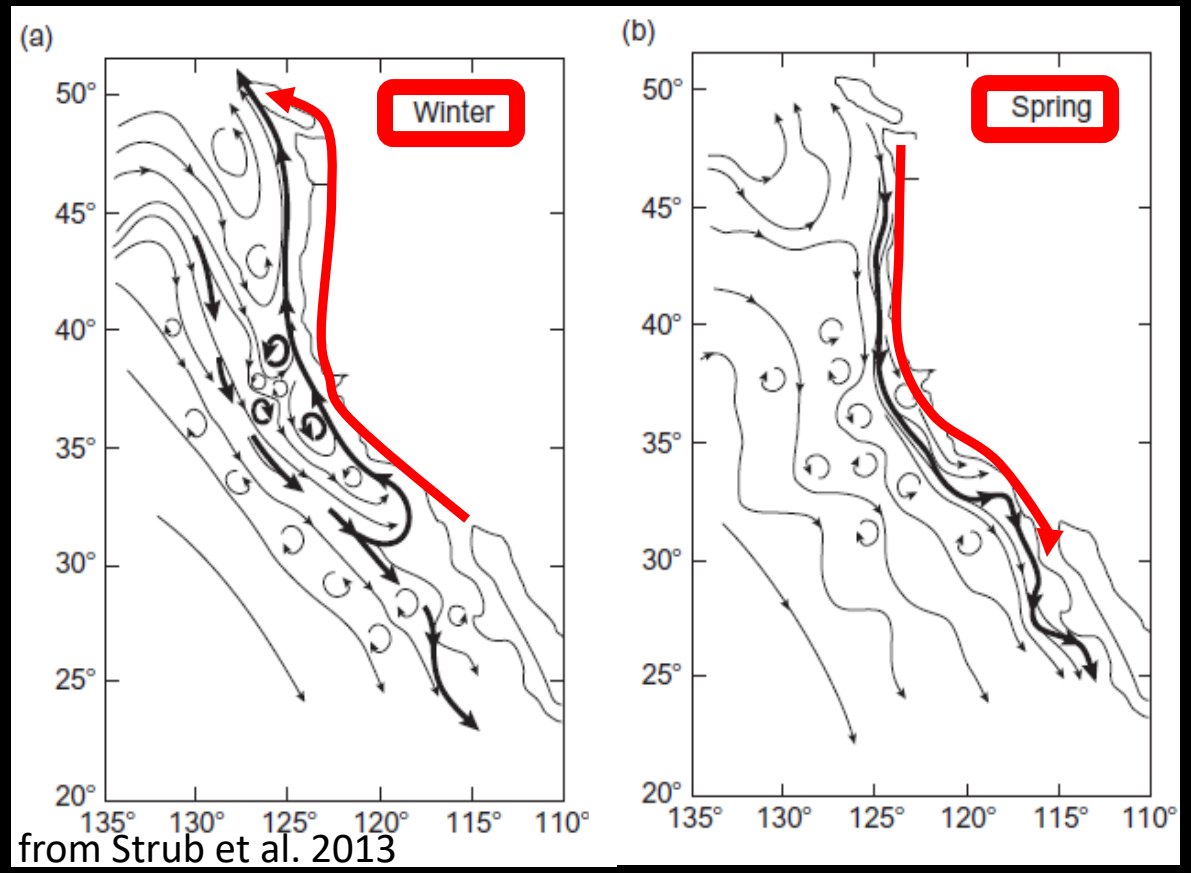
(Dick et al. 2016)



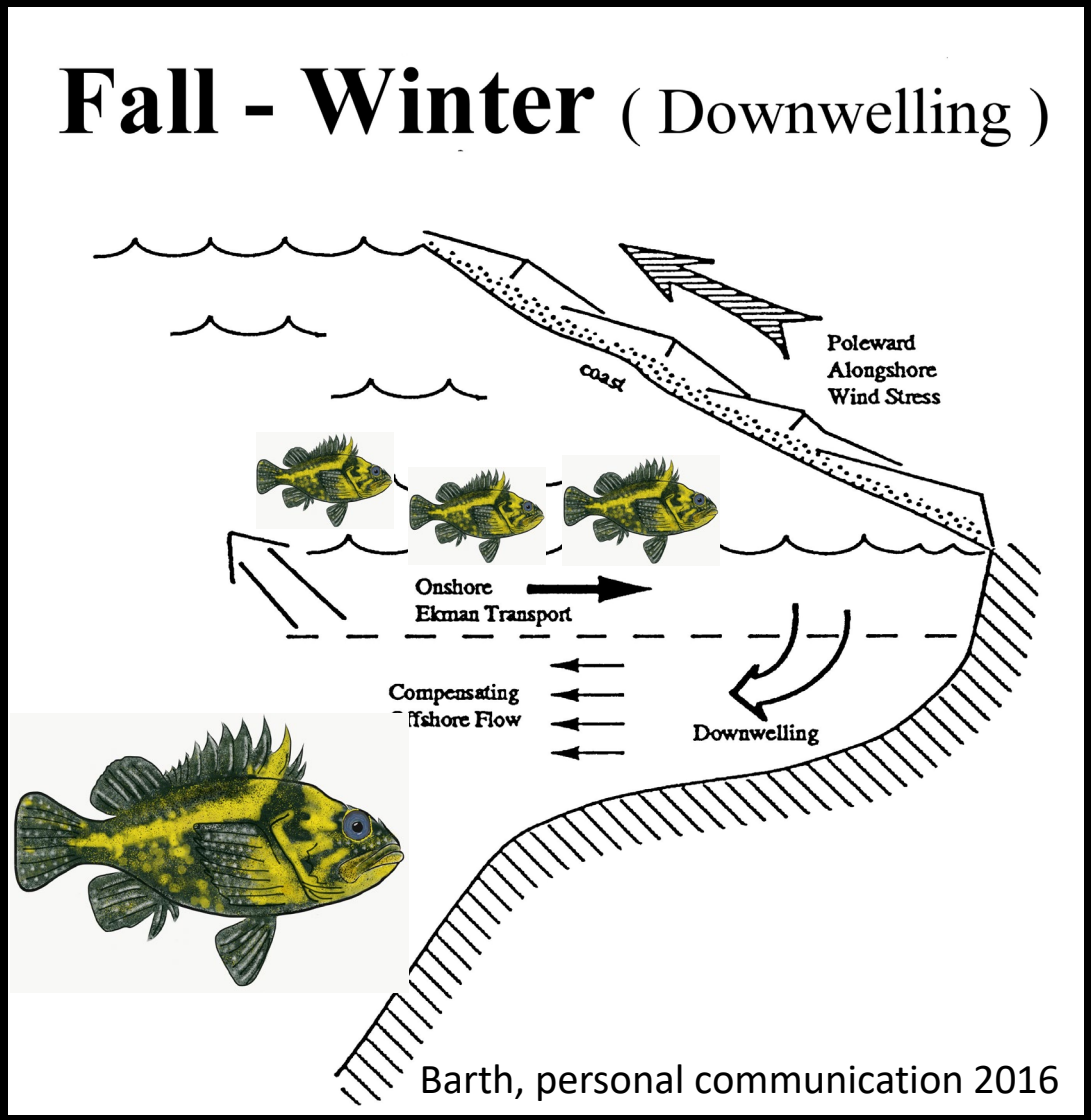
Oceanography and Rockfish Larval Dispersal

- Recent increase in oceanographic data collected
  - Spatial and temporal scales
- Biological data collection, that is useful to managers, is still costly
  - inter-annual and geographic patterns of larval and pelagic juvenile replenishment

Oceanography and Rockfish in PNW

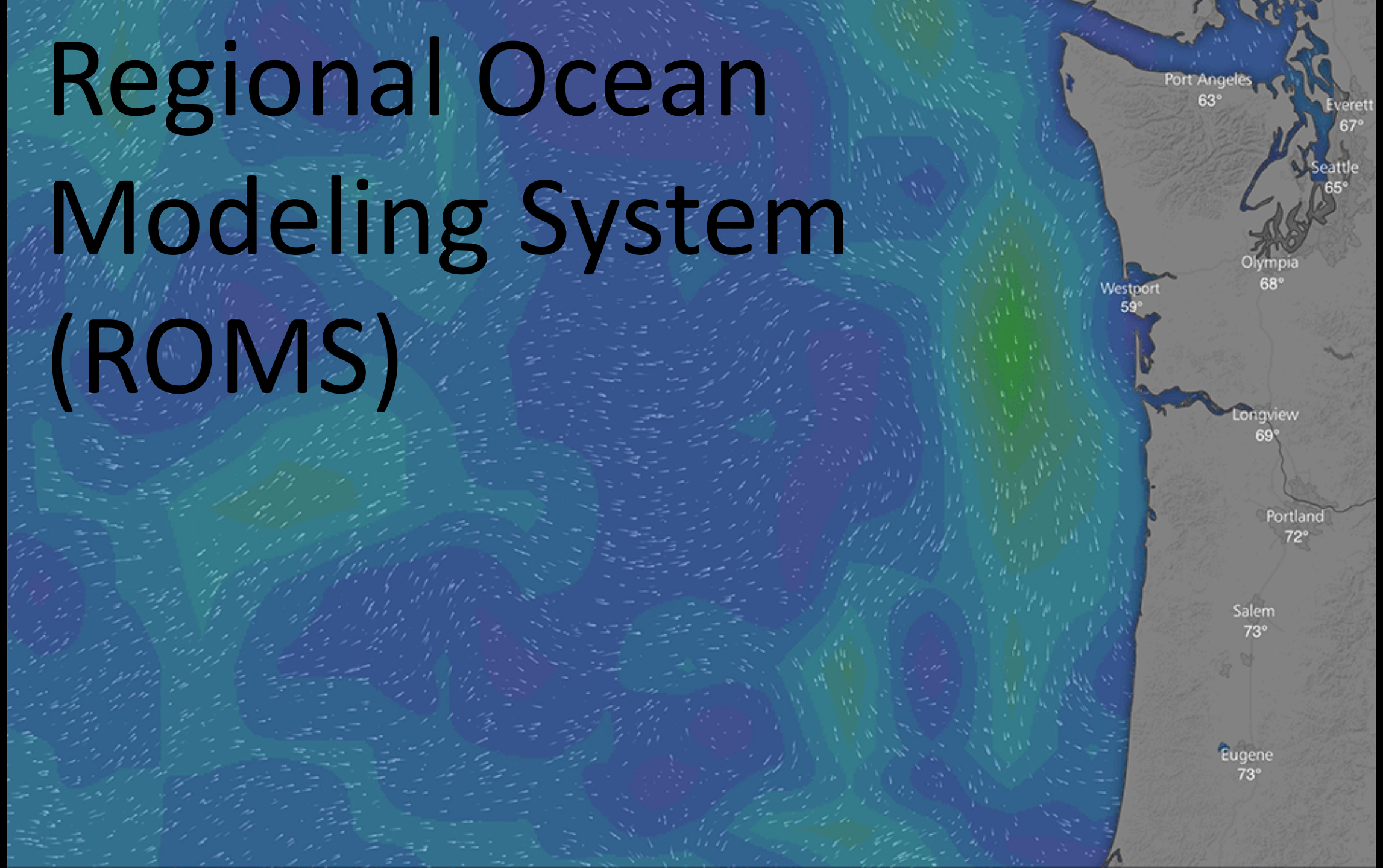


from Strub et al. 2013



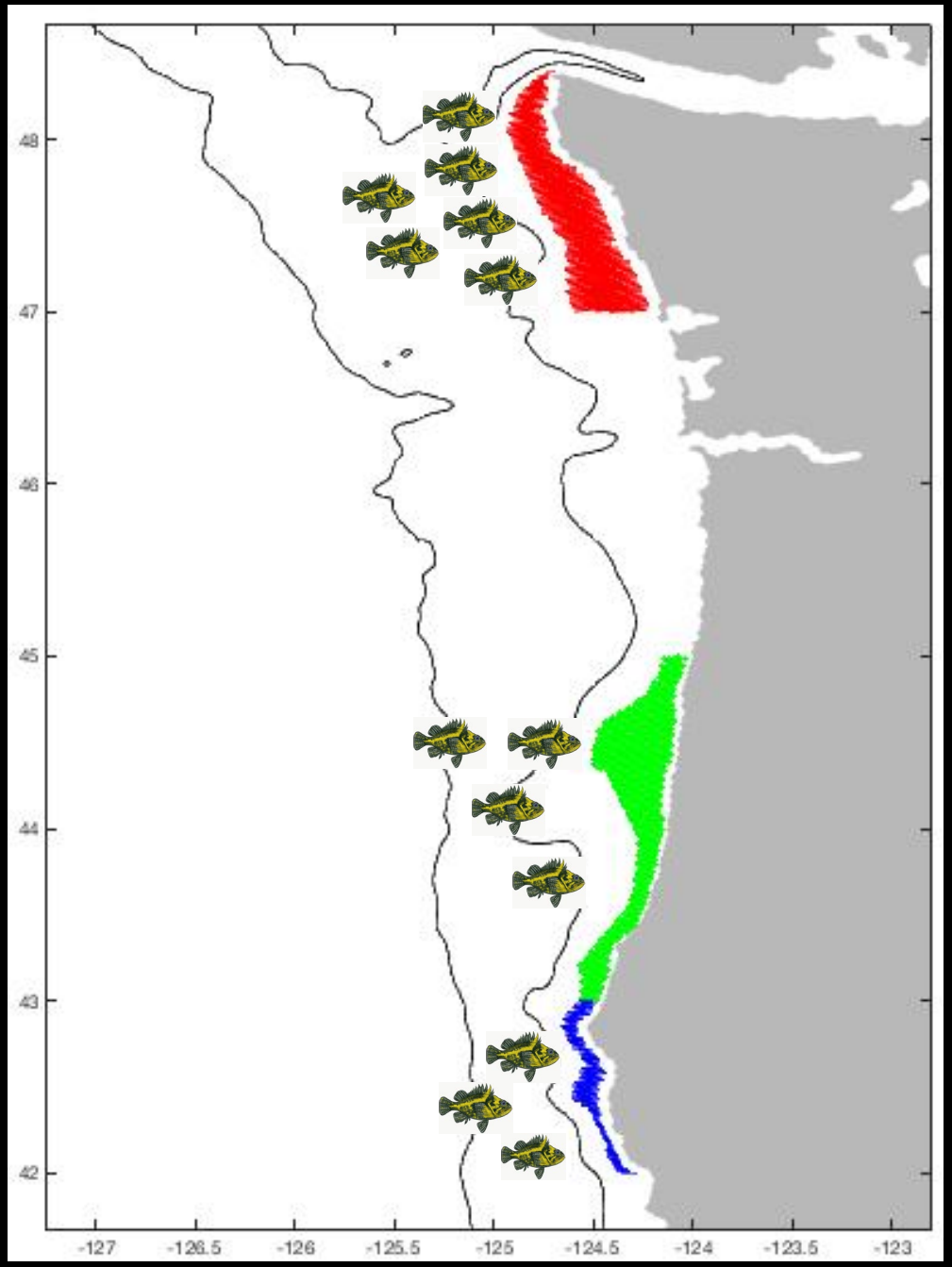
Barth, personal communication 2016

Regional Ocean Modeling System (ROMS)

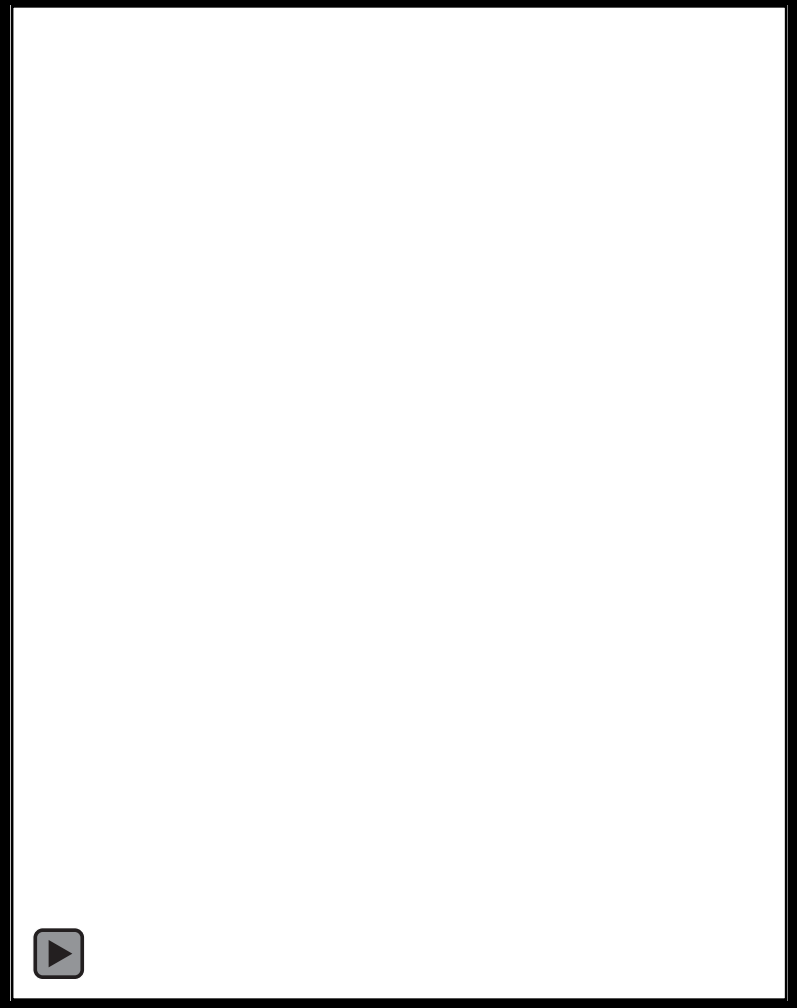


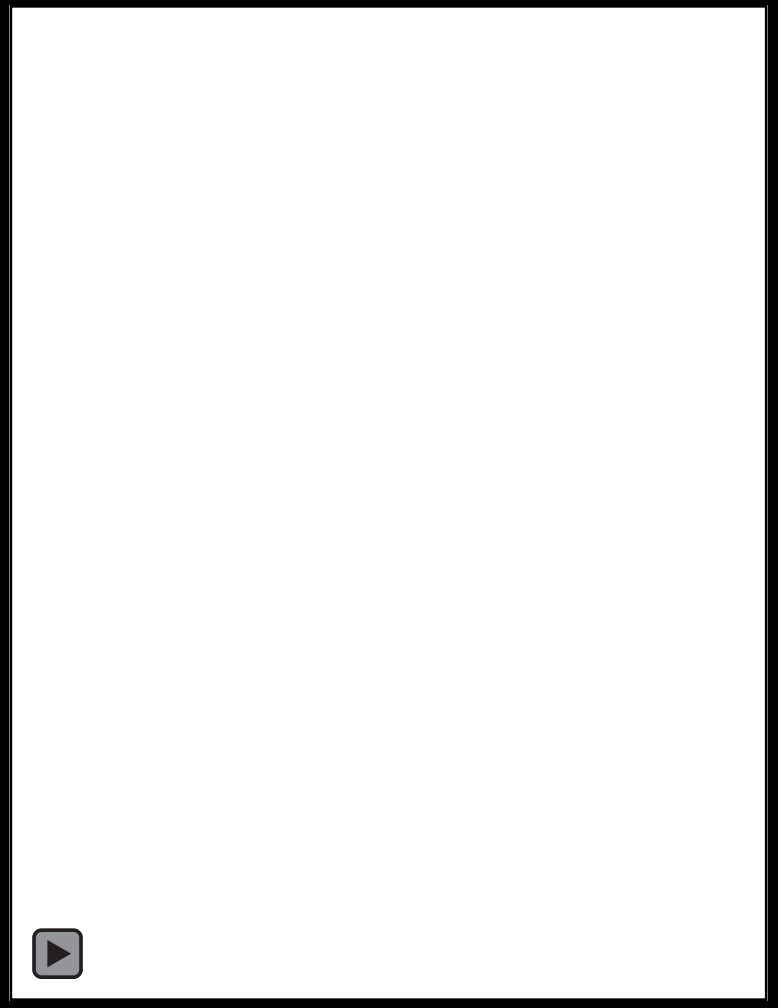
Oceanography Methods:

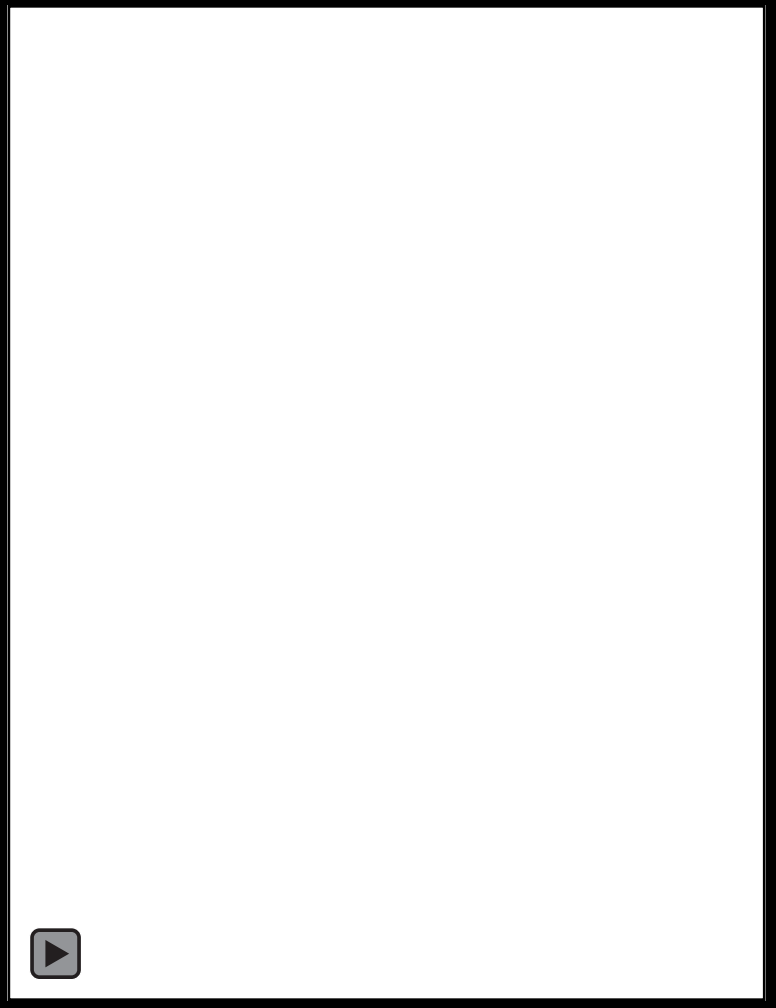
- ROMS models modified by Alexander Kurapov
  - West Coast Operational Forecast System (WCOFS)
- Overlay a Lagrangian particles simulation
  - Passive particle tracking



Oceanography Methods:

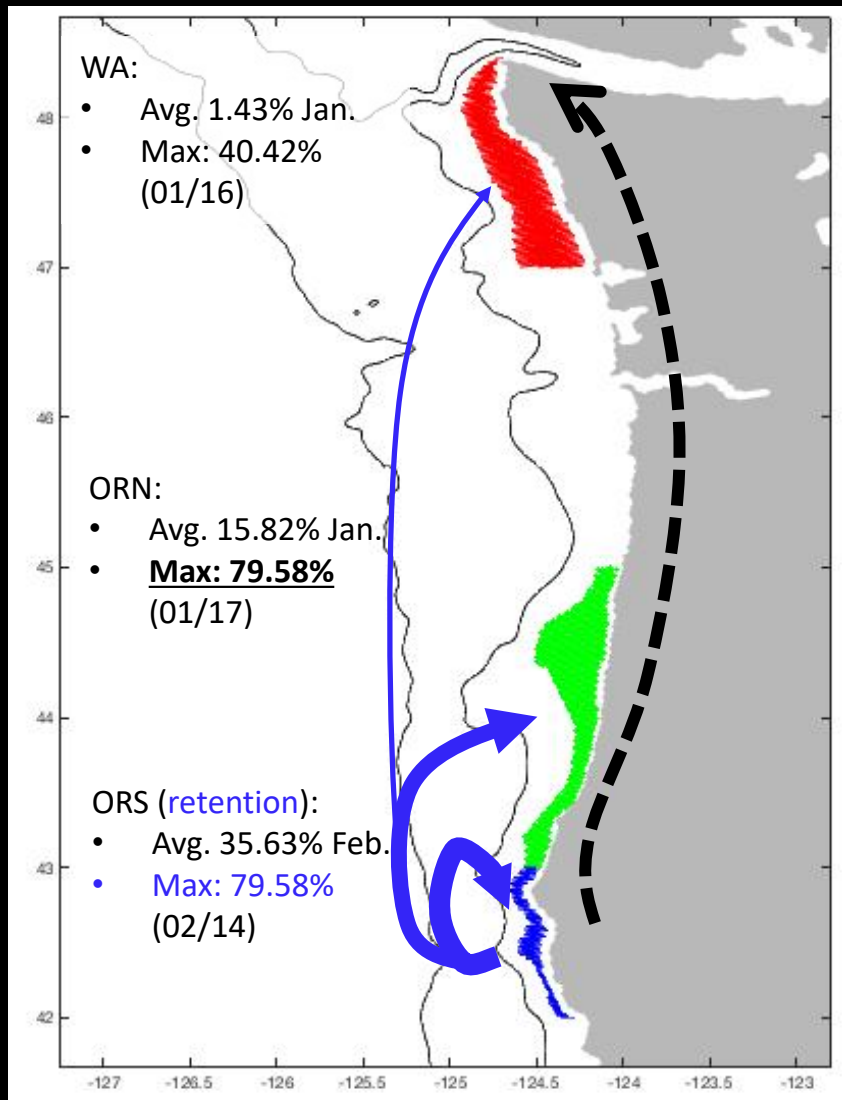




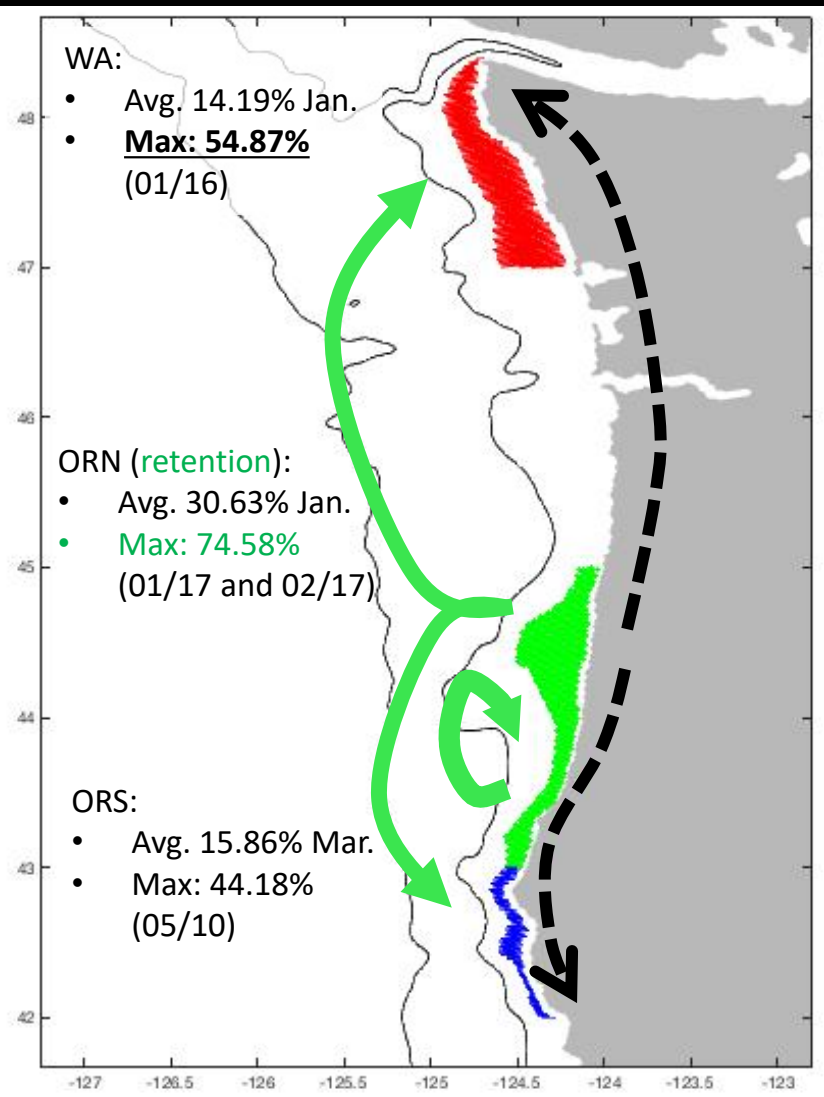


Oceanography Results:

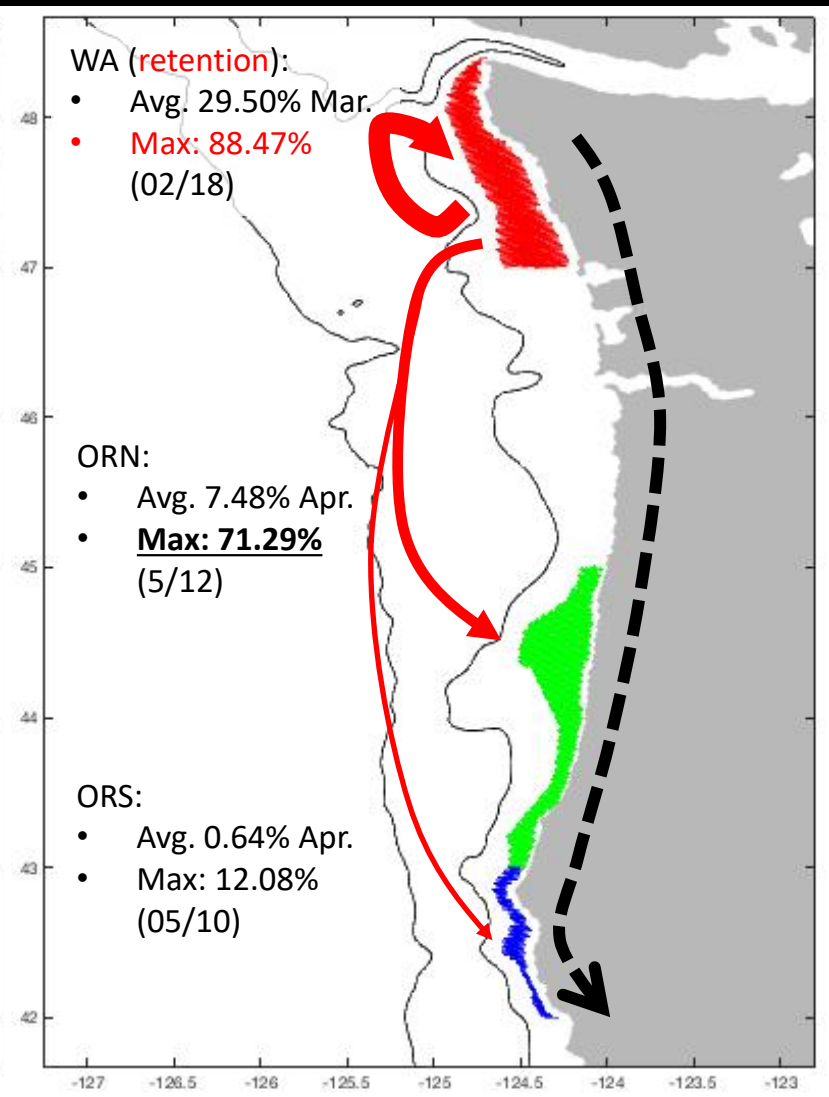
Connectivity from ORS



Connectivity from ORN



Connectivity from WA

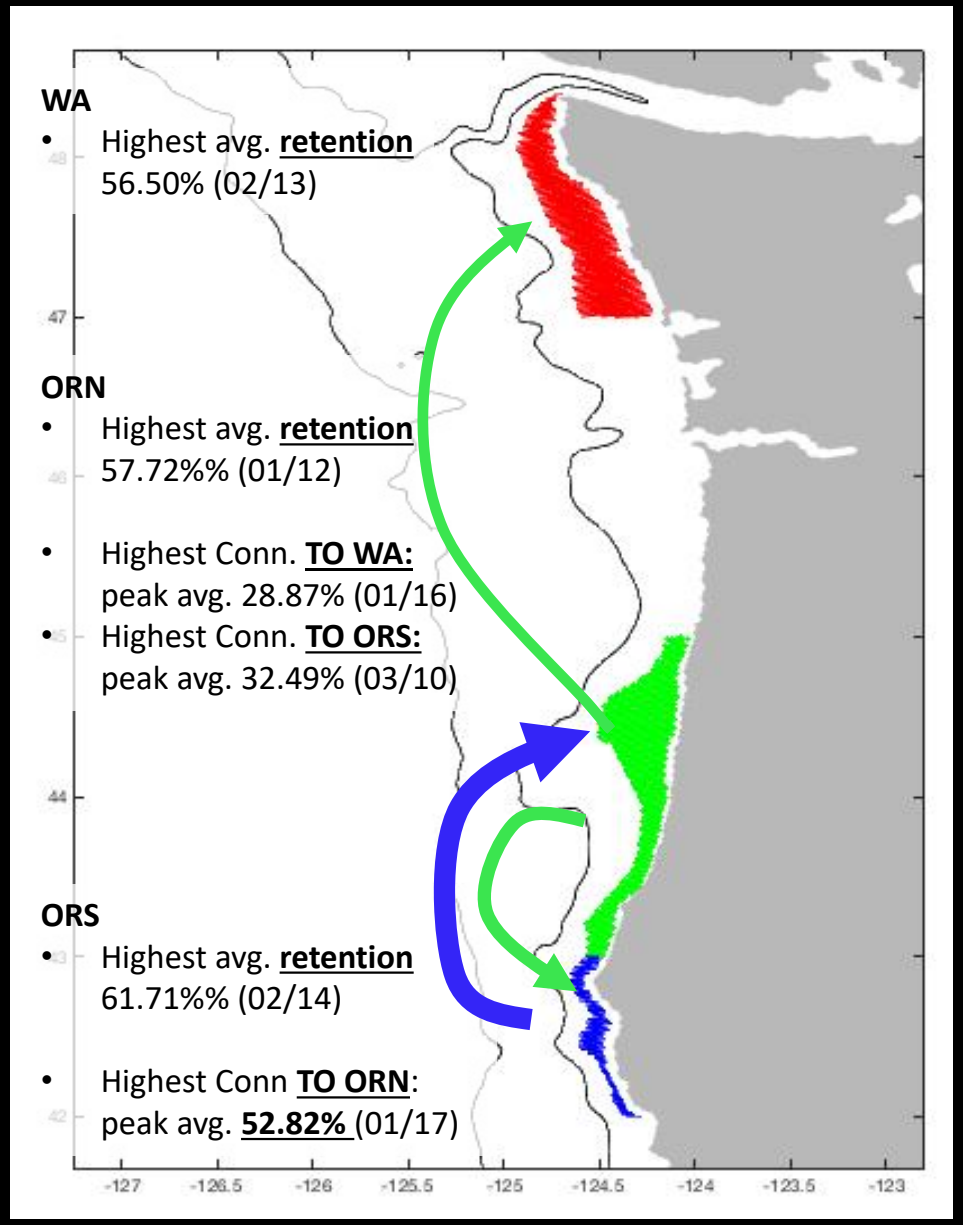


Oceanography Results:

Connectivity TO:

- Washington came from Oregon North
- Oregon North came from Oregon South
- Oregon South came from Oregon North

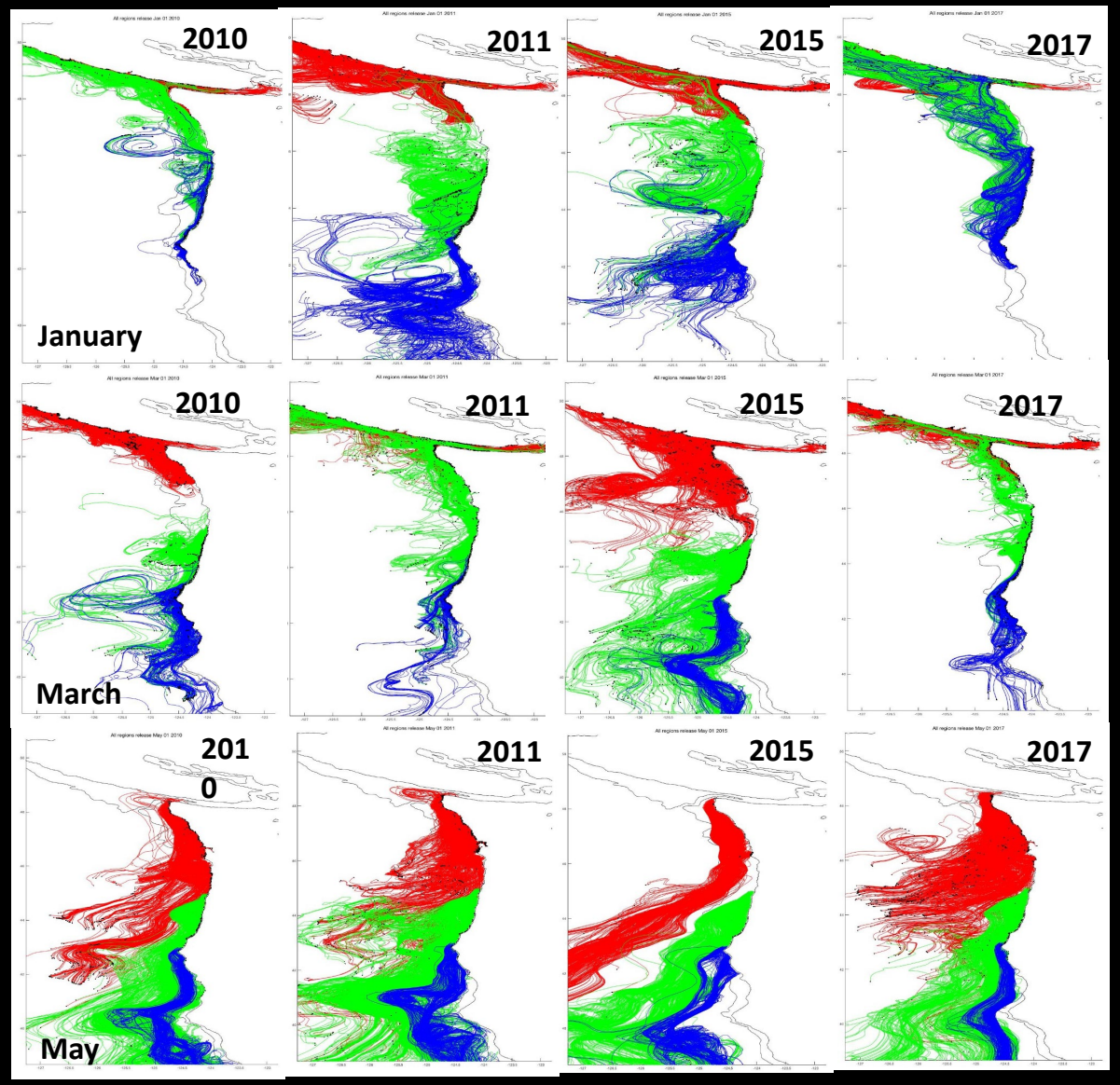
Nearshore currents max connectivity to all sites



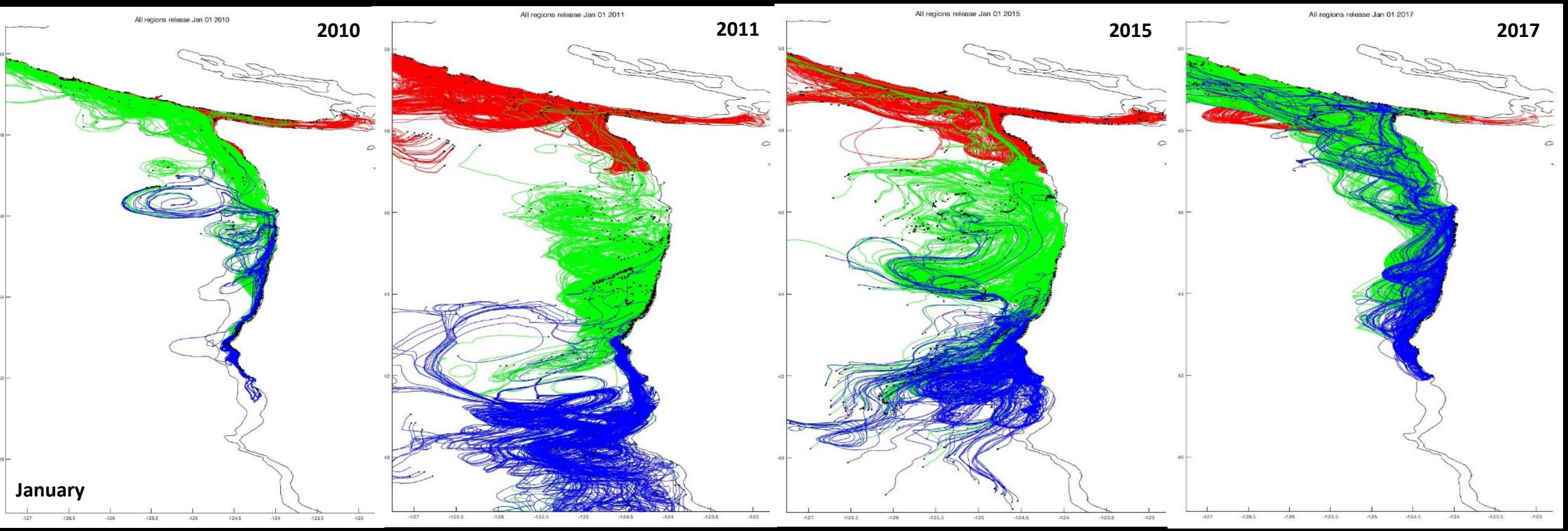
Oceanography Discussion:

Oceanography Discussion:

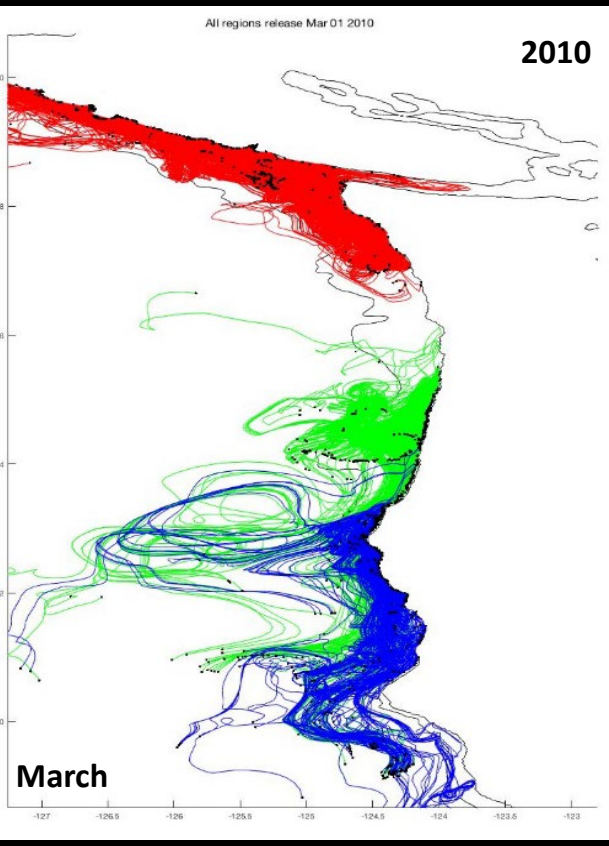
- Inter-annual variability

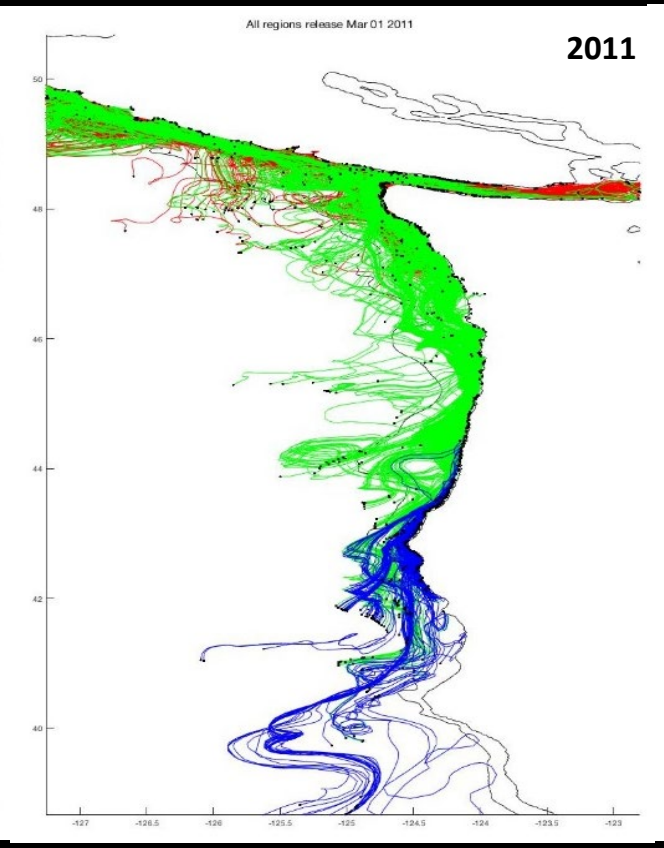


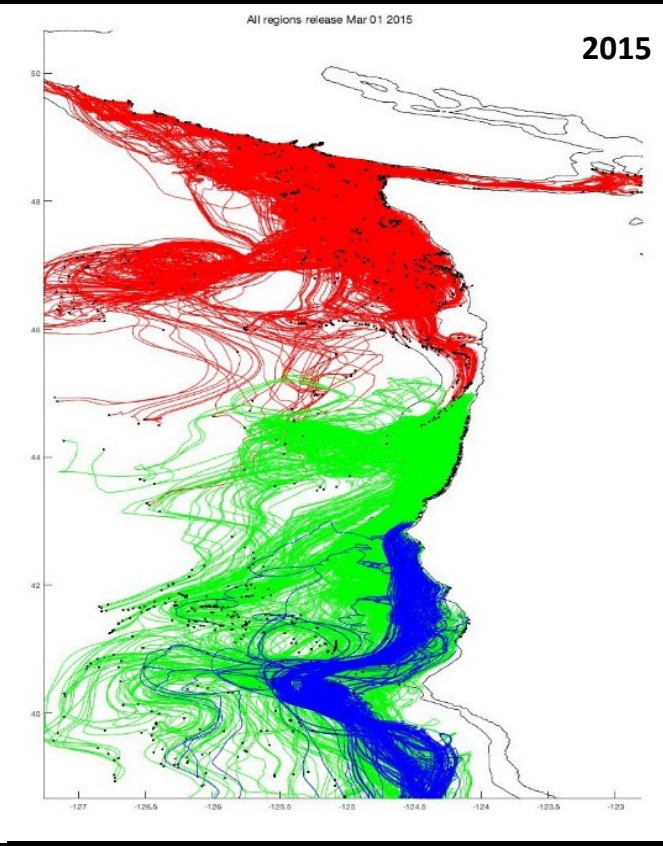
Oceanography Discussion:

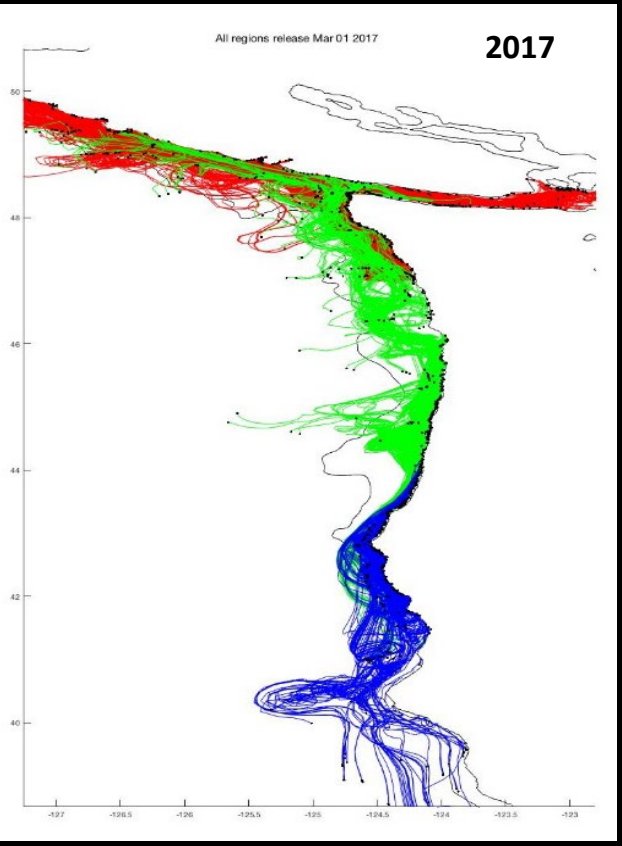


Oceanography Discussion:

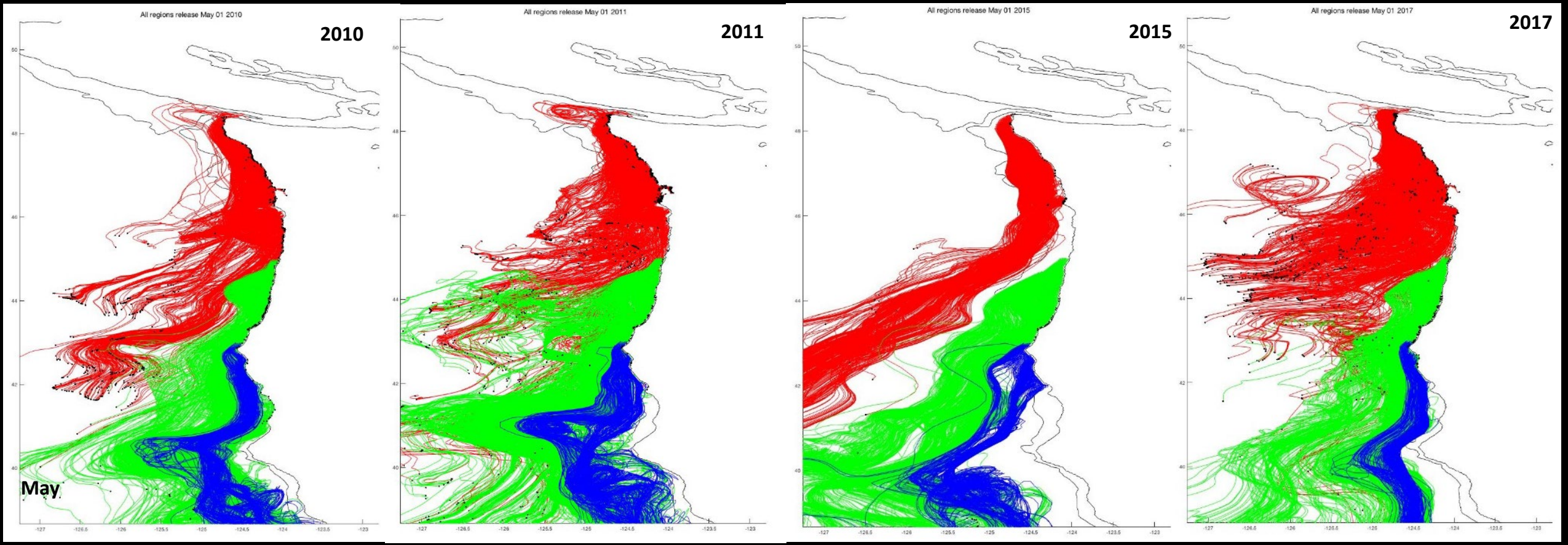






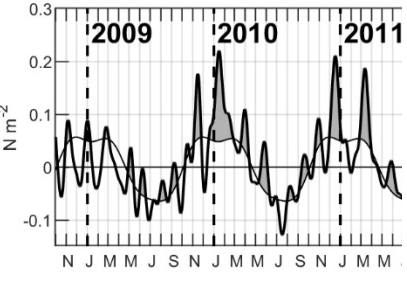


Oceanography Discussion:



Ocea

(Kurapov et al. 2022)



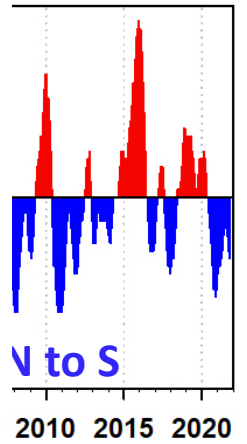
NEWS

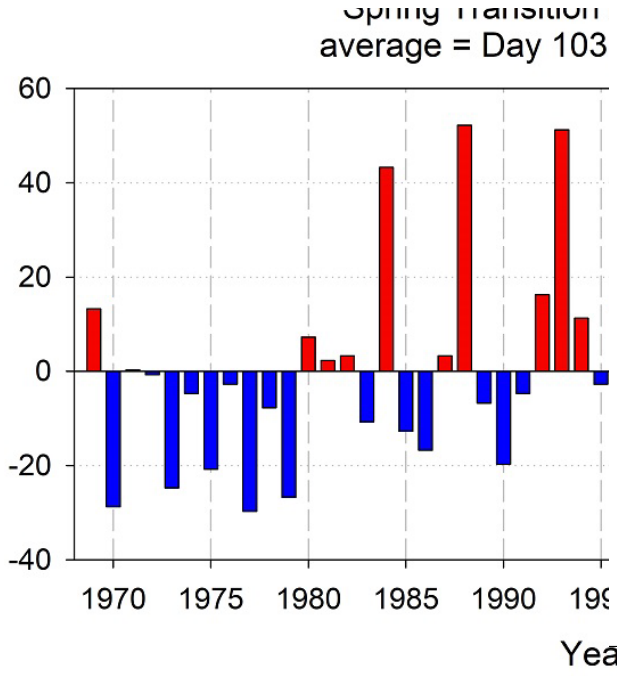
New Marine Heatwave Emerges off West Coast, Resembles "the Blob"

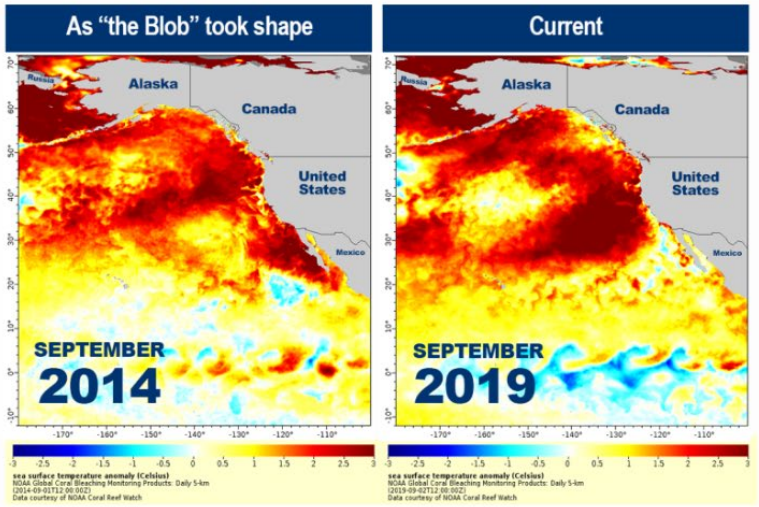
September 05, 2019

Researchers are monitoring a new marine heatwave off the West Coast for effects on the marine ecosystem.

Feature Story | West Coast







Sea surface temperature anomaly maps show temperatures above normal in orange and red. Courtesy of NOAA Coral Reef Watch.

More Information

- California Current IEA Marine Heatwave Tracking
- Marine Heatwaves in a Changing Climate
- Predicting the Evolution of the 2014–2016 California Current System Marine Heat...

Recent News

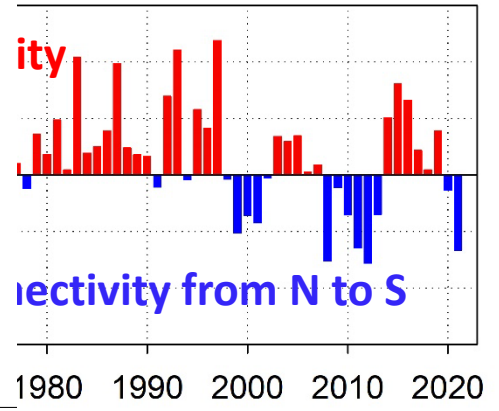
STORY MAP

Storymap: The Past, Present and Future of Restoration in Washington's Commencement Bay

West Coast, National

FEATURE STORY

Partnership to Improve Conservation of Nearshore Habitat



Oceanography Discu

'Tu Stultus Es'

the ONION

WEATHER Page B11

Sunny—still one day closer to death, though.
LOW 38
HIGH 56

• VOL. 56 ISSUE 44

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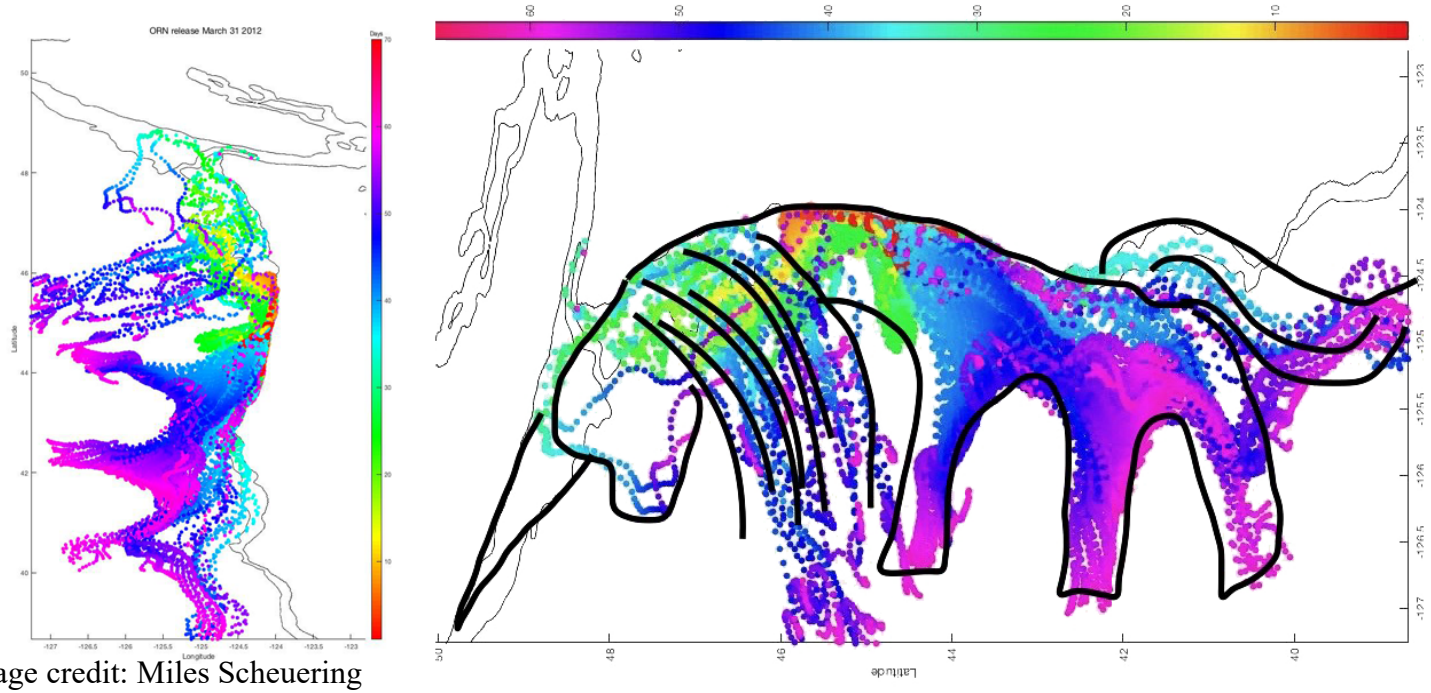


Image credit: Miles Scheuering

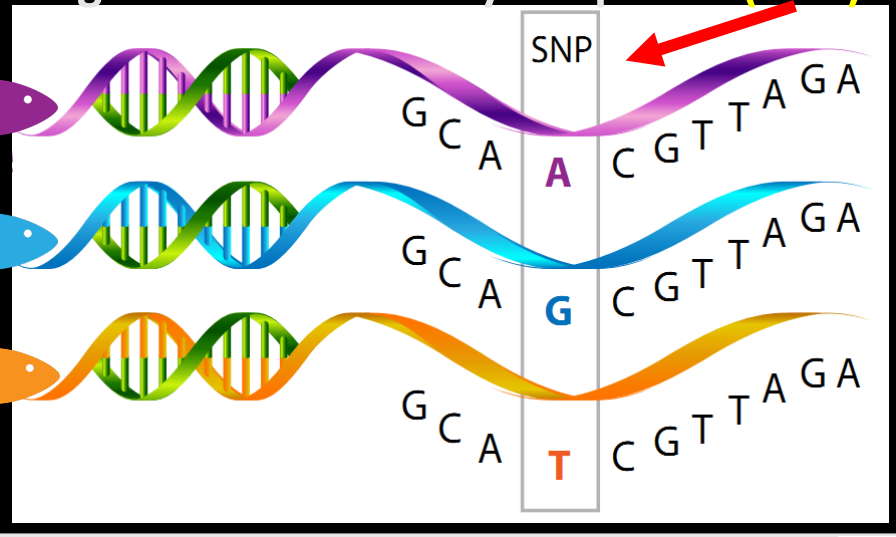
'GROUND BREAKING DISCOVERY' as marine unicorn discovered off Oregon and Washington coast

An OSU researcher has stunned the scientific community this week with the first documentation of a marine unicorn. This finding provides a huge boost of credibility to the MEIUP (Mythical Equines In Unexpected Places) hypothesis, which was previously derided as 'ridiculous.' While the cupboard pegasus and other species remain undiscovered

Population Genetics

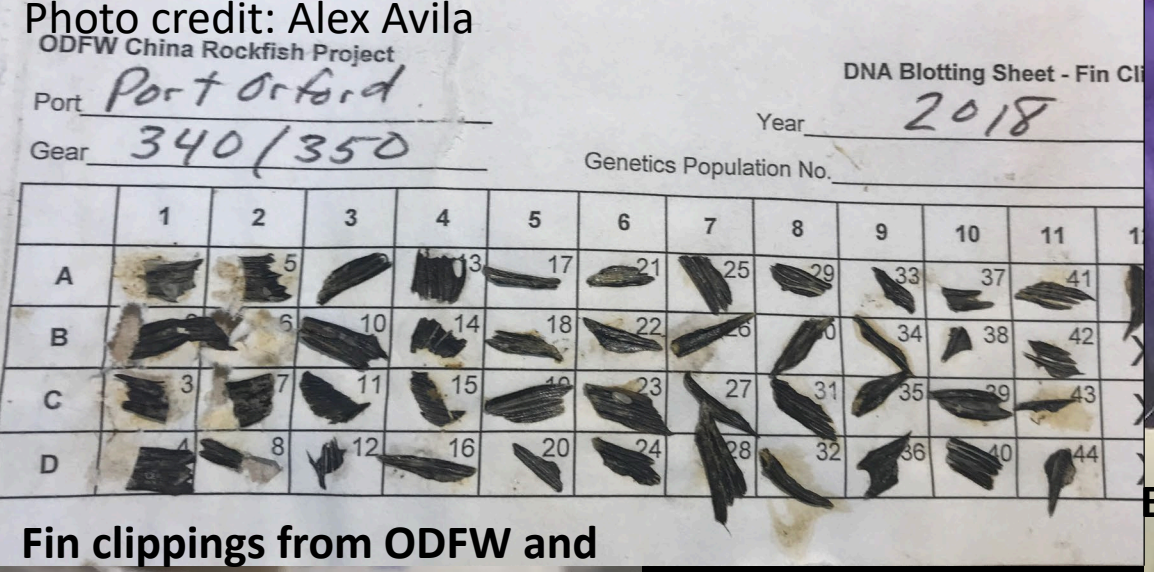
Population Genetics is the study of genetic differences or variation within populations, and changes in frequencies of genes/alleles over space and time

Single Nucleotide Polymorphism (SNP)

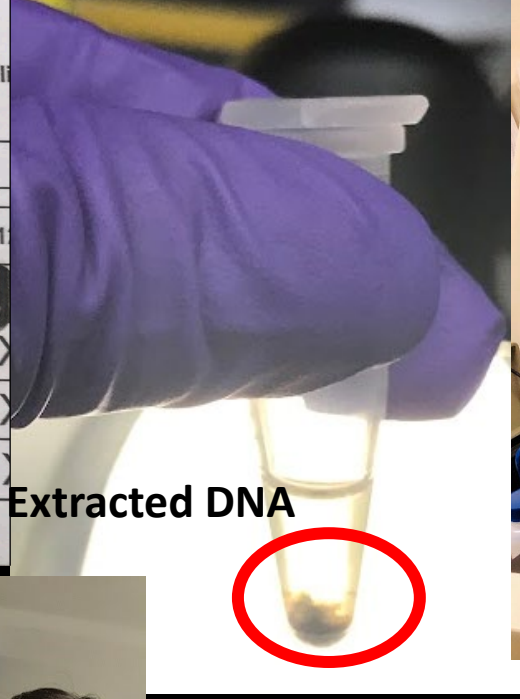


Population Genetics Methods:

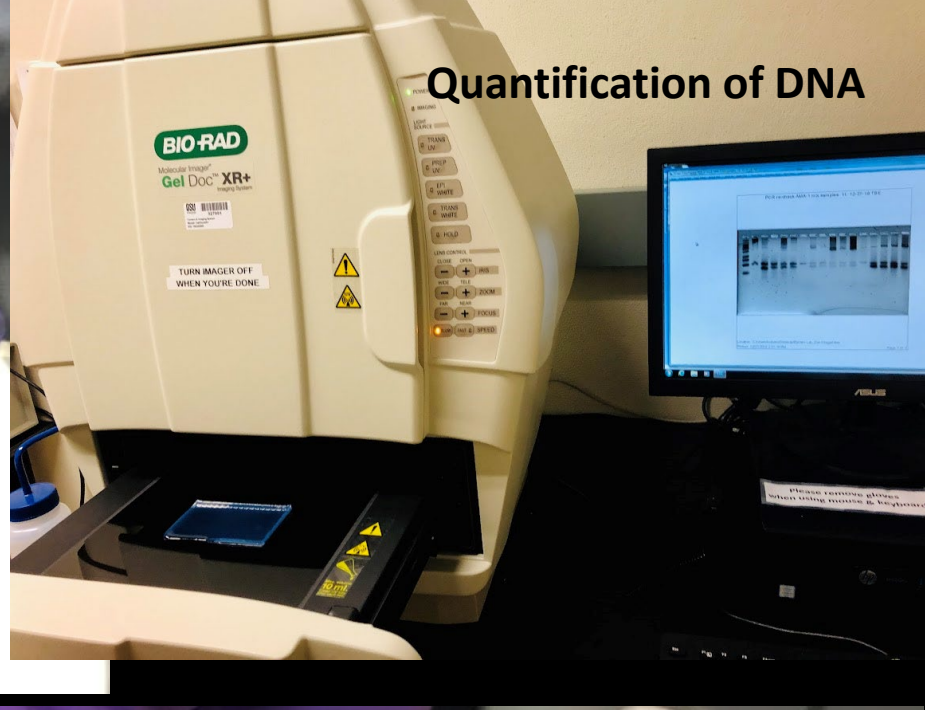
Photo credit: Alex Avila



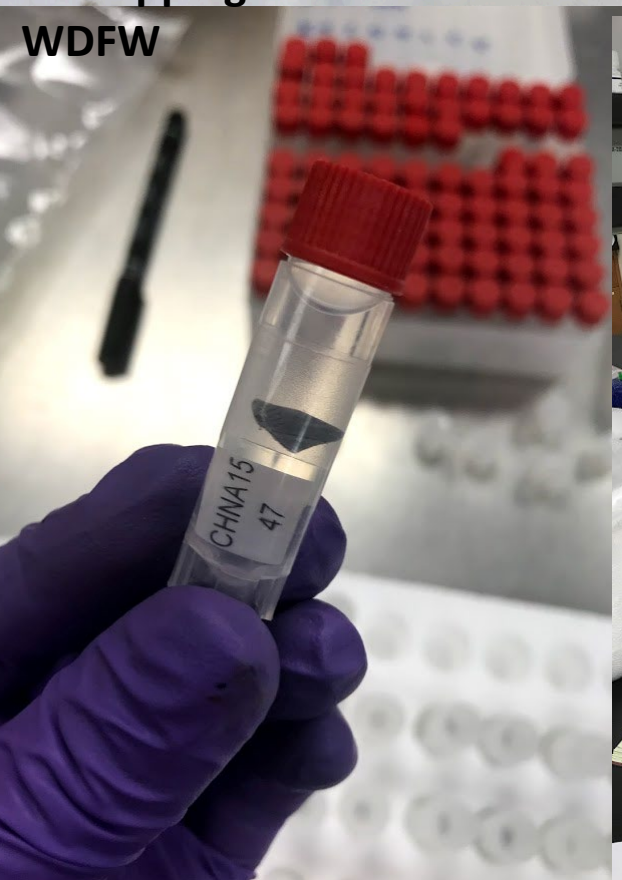
Fin clippings from ODFW and WDFW



Extracted DNA



Quantification of DNA

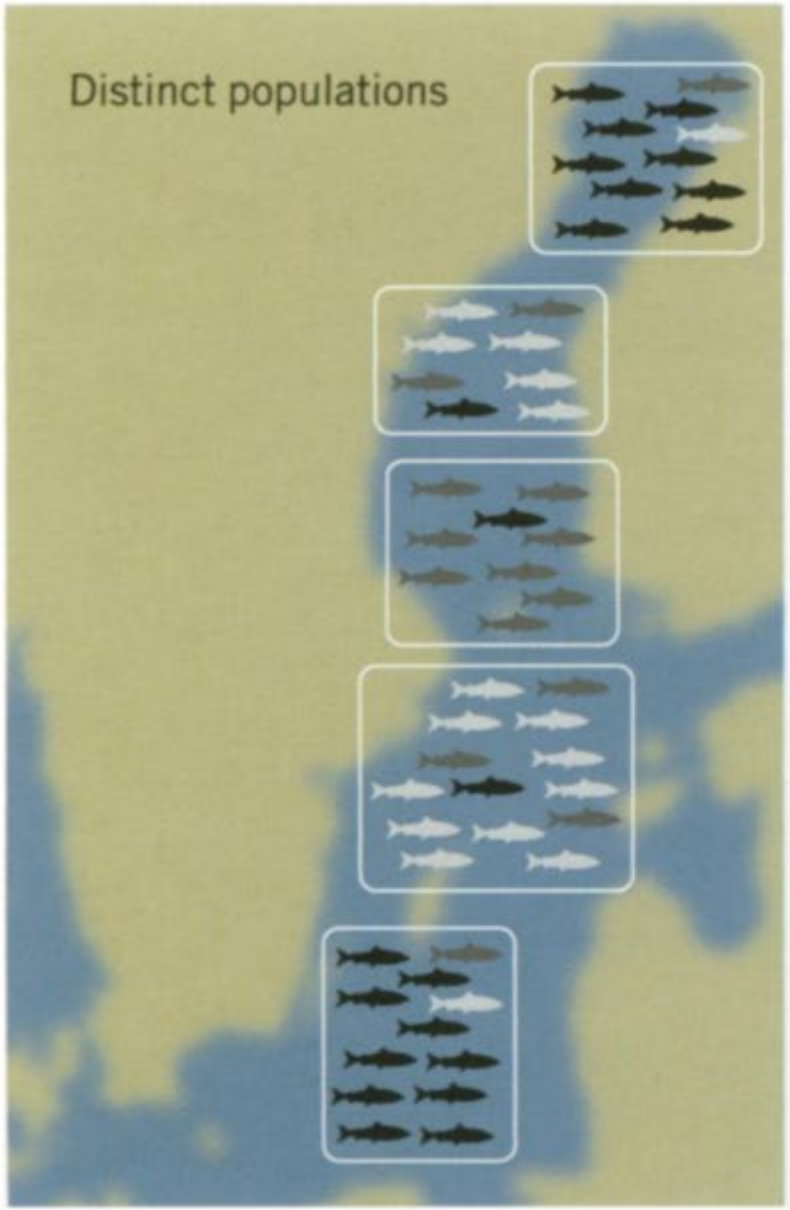


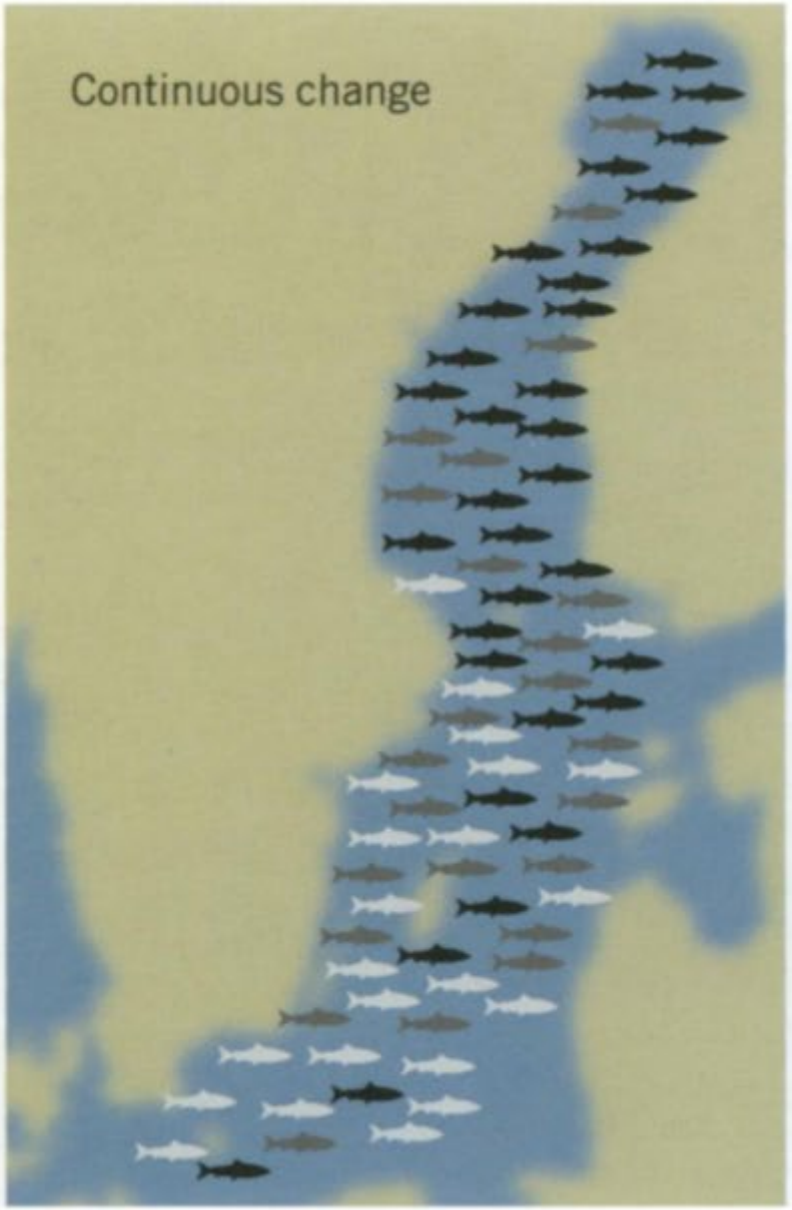
Extracting DNA

Digestion/Ligation/Library-Prep

2bRad method at OSU CQLS

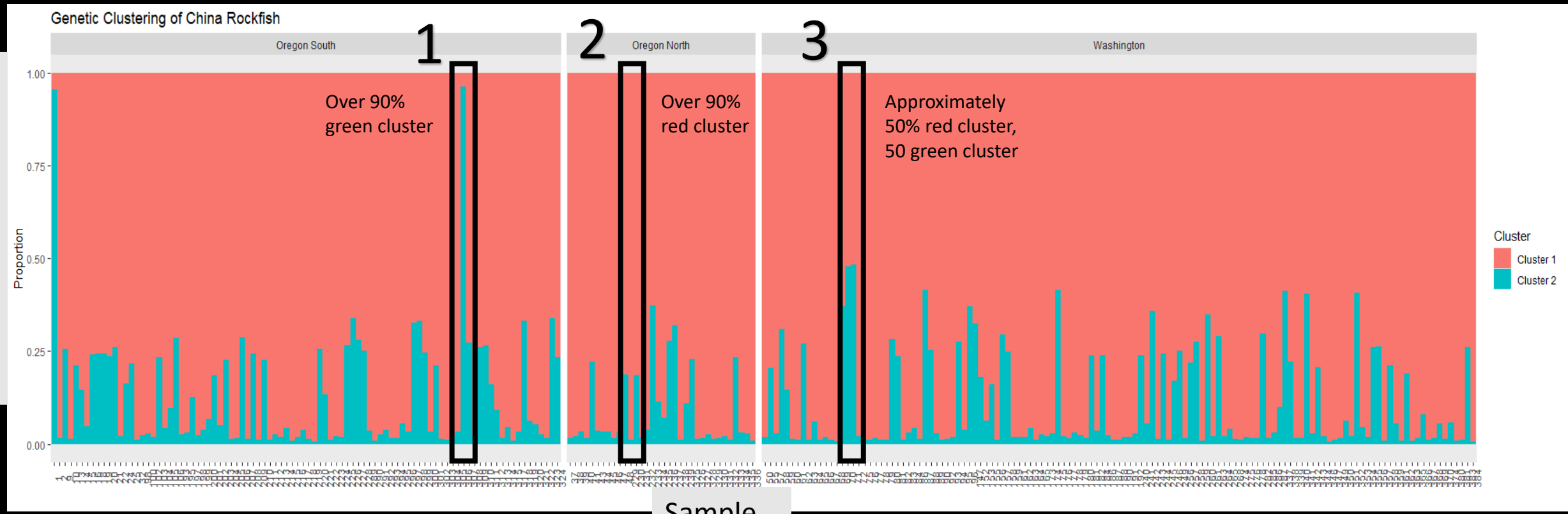
Population Genetics Results:


Distinct populations


Continuous change

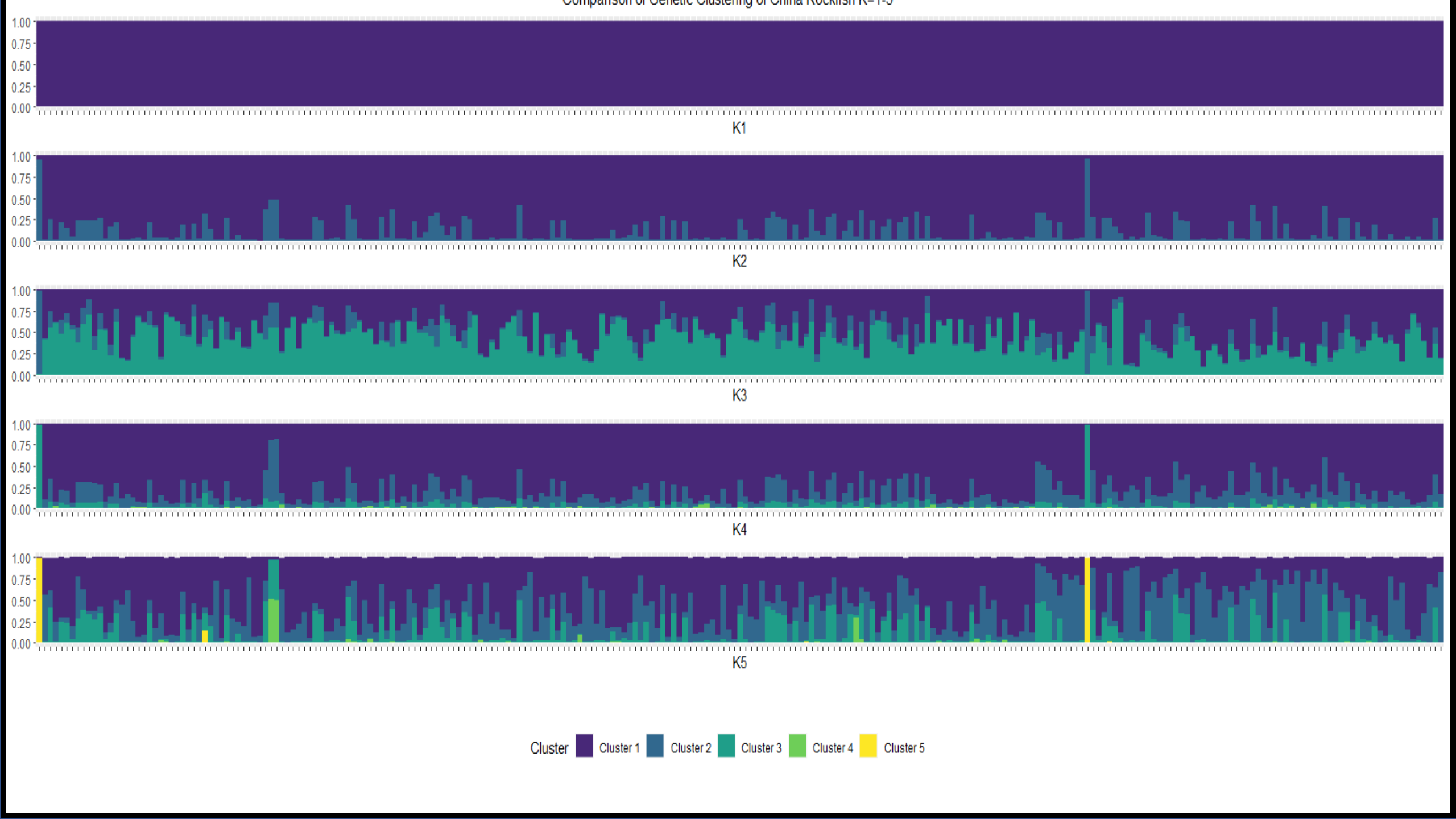

No differentiation

Population Genetics Results: Population Structure



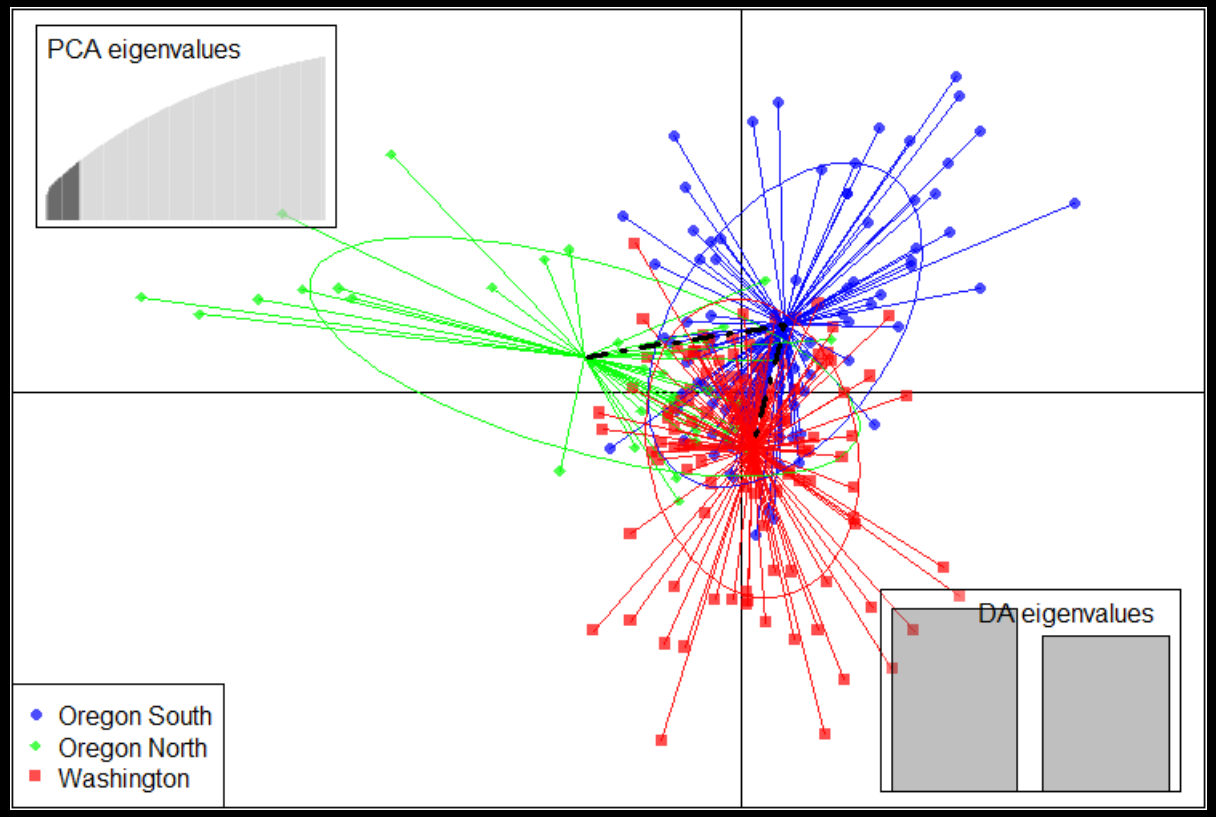
After filtering 3x based on SNPs loading

SNPs 2,199 loci 255 samples

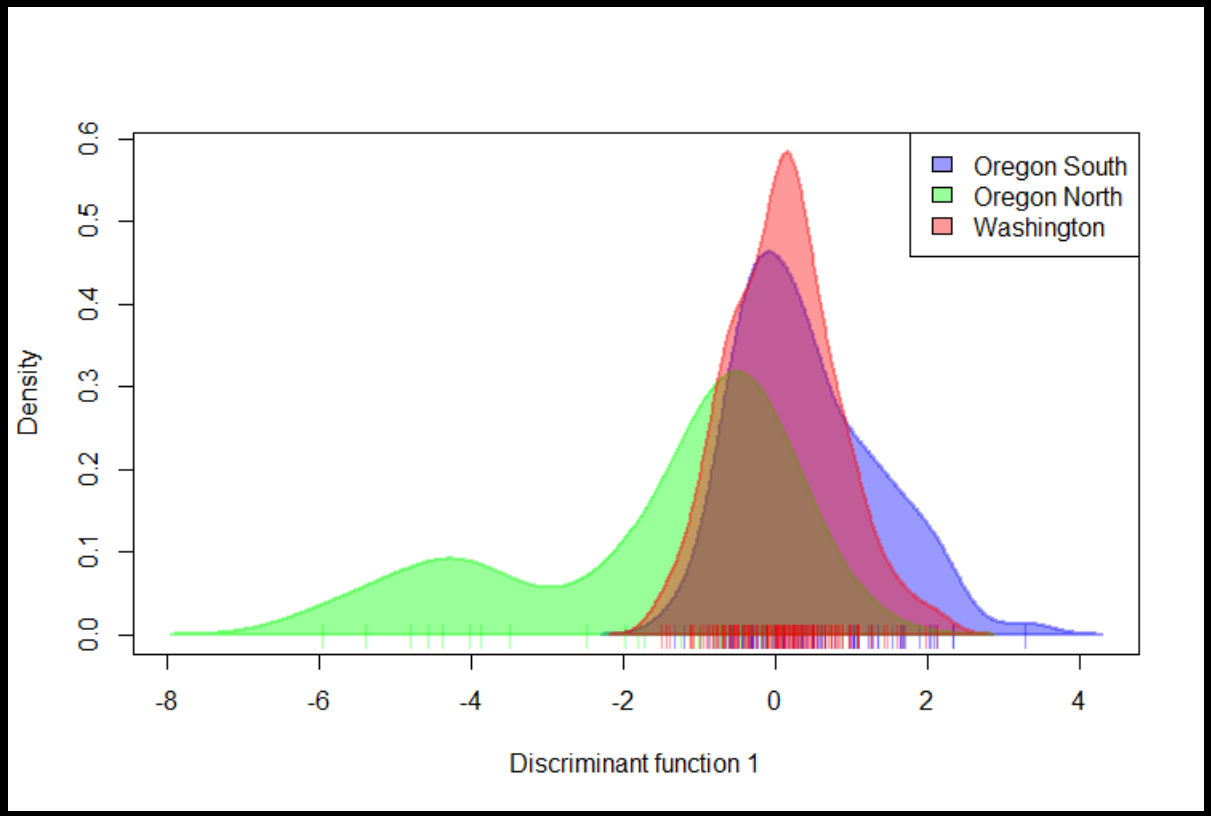

Comparison of Genetic Clustering of China Rockfish K=1-5
1.00
0.75
0.50
0.25
0.00
K1
K2
K3
K4
K5
Cluster
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5

Population Genetics Results: Population Structure

Discriminant Analysis of Principal Components (DAPC)



One Discriminant Function



Results: Population Structure

Summary of Analysis of MOlecular VAriance (AMOVA)

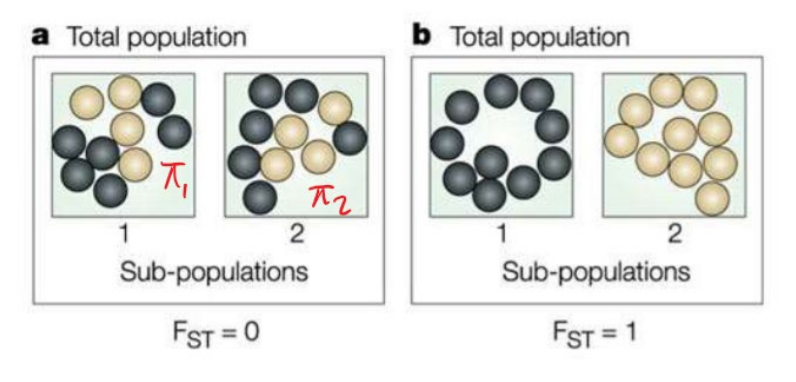
Summary AMOVA Table					
Source	DF	SS	MS	Est. Var.	% Var.
Among Pops	2	764.665	382.333	0.06	0%
Among Indiv.	252	93762.260	372.072	5.11	1%
Within Indiv.	255	92268.500	361.837	361.83	99%
Total	509	186795.425		367.02	100%

- Highest variation came from within individuals (99%)

F-Statistics

F-Statistics	Value	P(rand >= data)
Fst	0.000	0.319
Fis	0.014	0.127
Fit	0.014	0.123

- F_{ST} (within subpopulations relative to the total)
- F_{IS} (within individuals relative to the subpopulation)
- F_{IT} (within individuals relative to the total)



Hartl and Clark (1997) had some classes for FST.

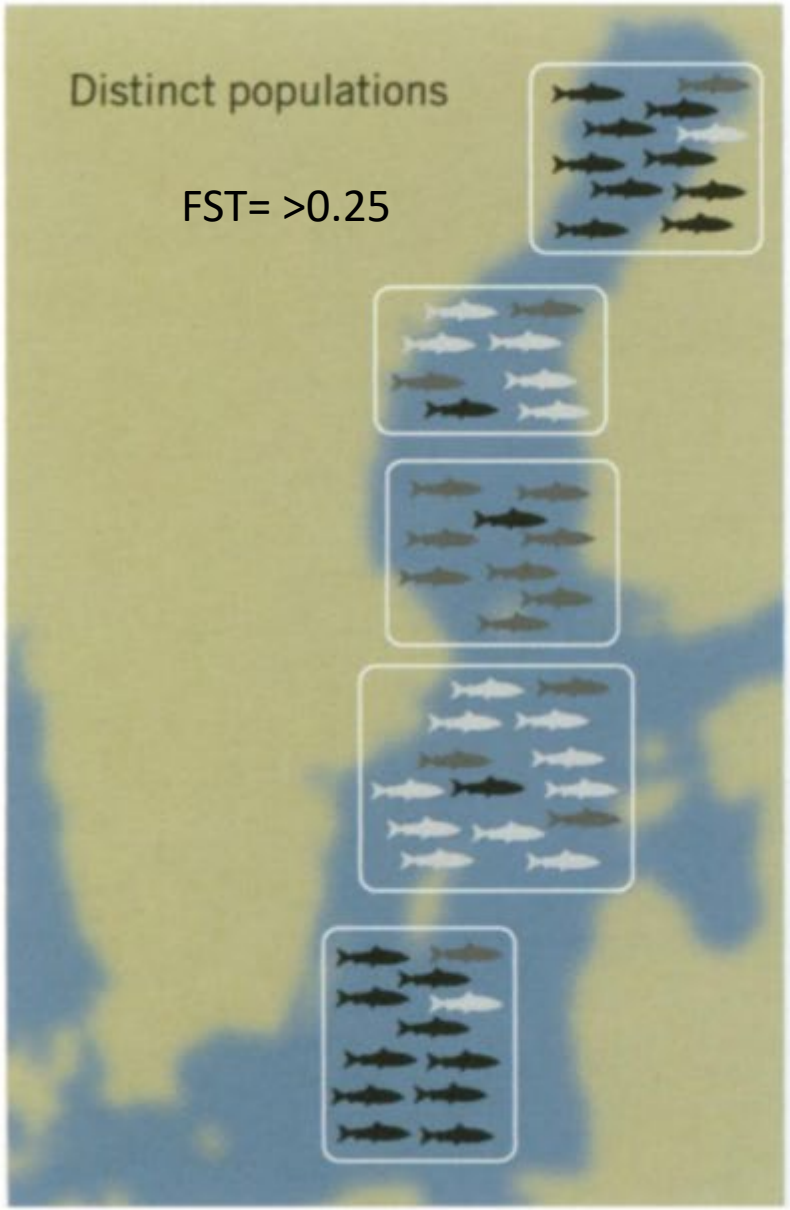
<0.05 = **little** genetic diff.

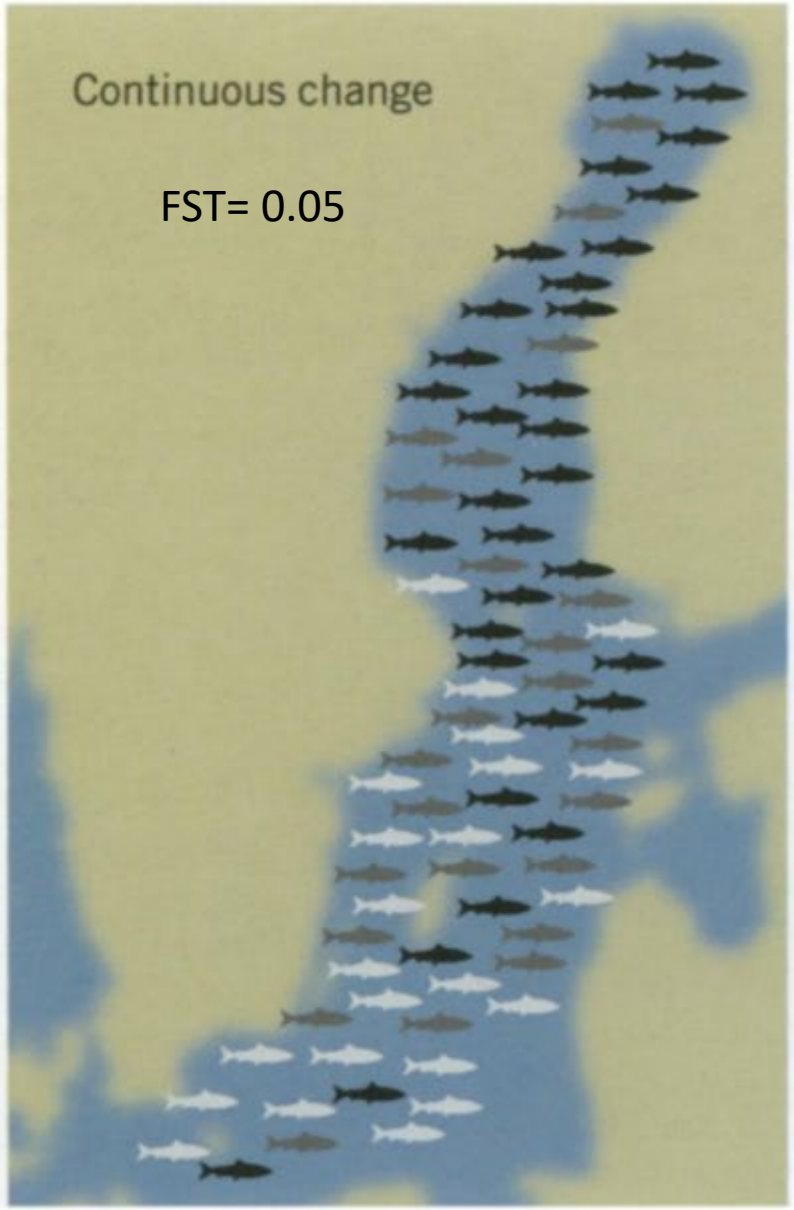
0.05-0.15 = **moderate** genetic diff.

0.15-0.25 = **great** genetic diff.

>0.25 = **very great** genetic diff.

Frankham et al. (2002; 2010) had FST>0.15 = **significant** differentiation

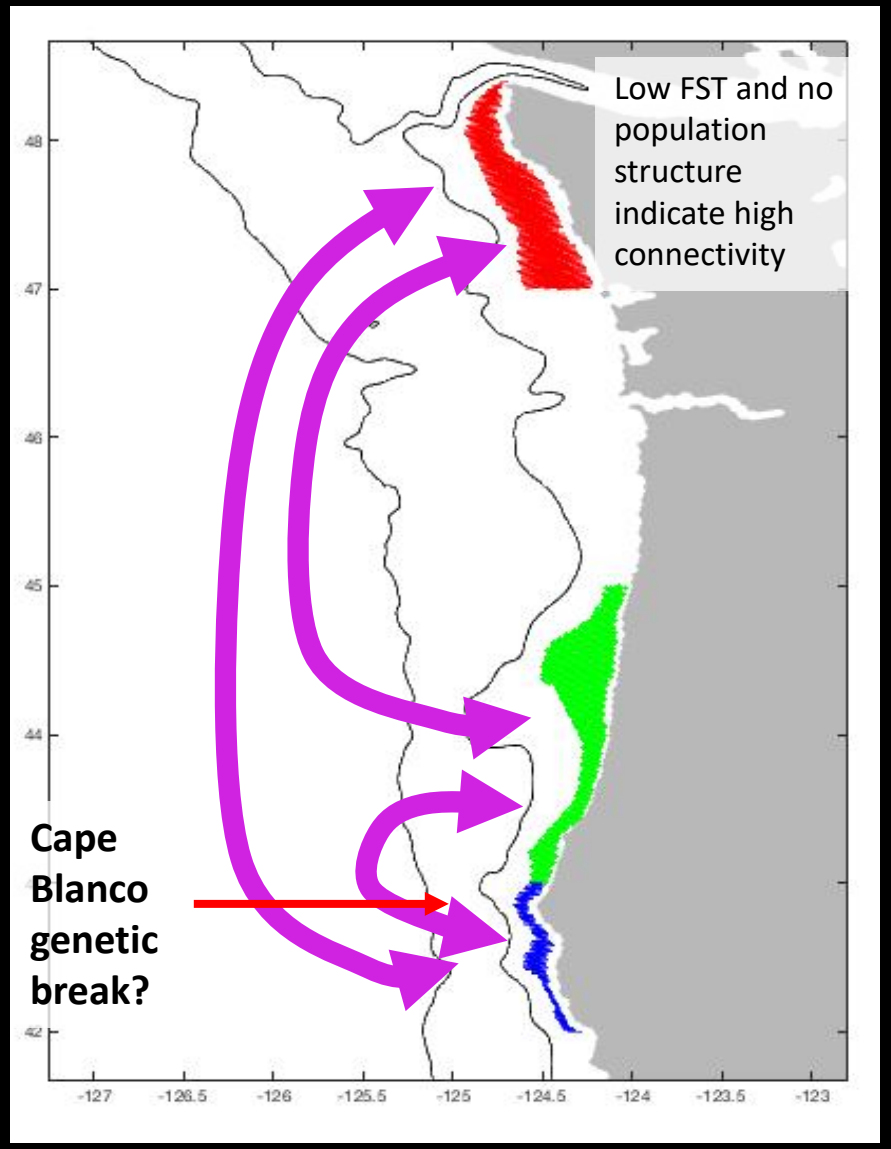

Distinct populations
FST= >0.25


Continuous change
FST= 0.05


No differentiation
FST= <0.05
FST= 0.002

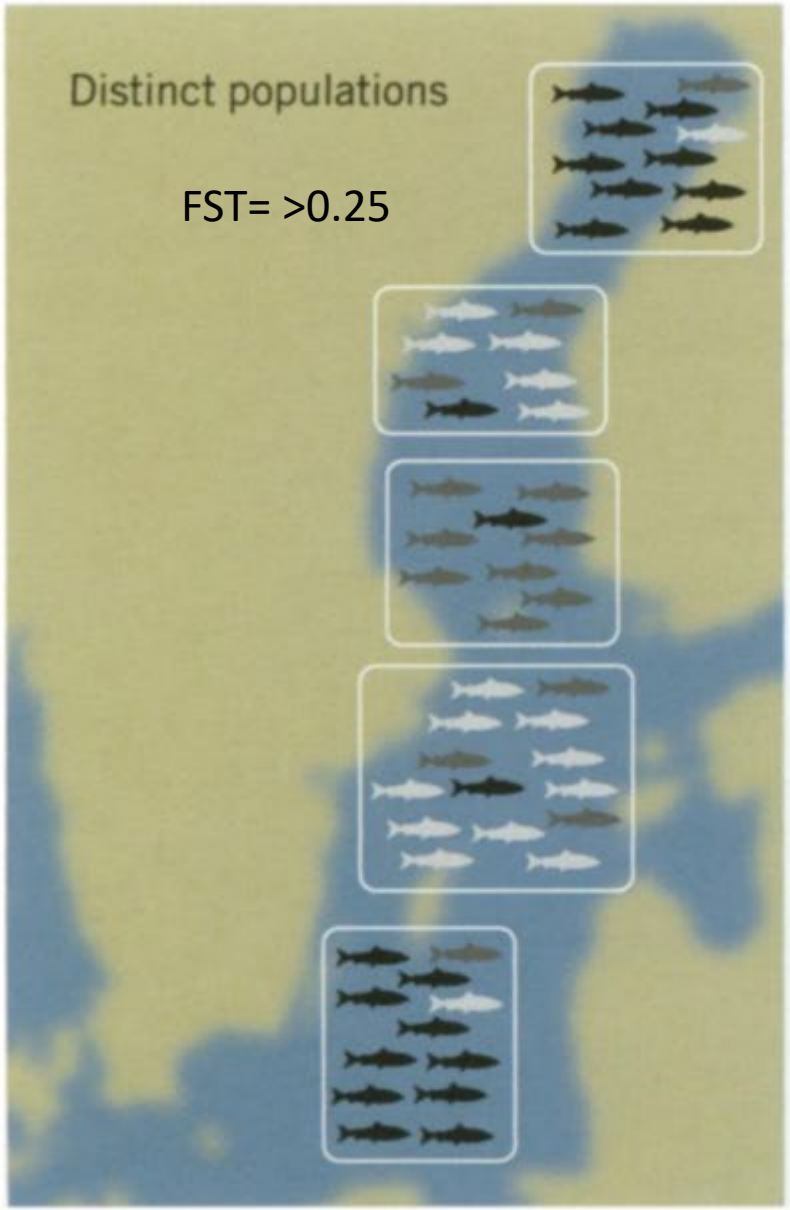
Population Genetics Discussion:

- Identified two distinct genetic clusters and high connectivity
  - Verified by :
    - FST
    - No population structure
- Other studies Rockfishes population genetics
  - Vermillion Rockfish (Hyde and Vetter 2009)
  - Canary Rockfish (Wishard et al. 1980)
  - Blue Rockfish (Berntson and Moran 2009, Hyde and Vetter 2009)



Population Genetics Discussion:

- Recommend population genetic study along the entire West Coast (including Alaska and Canada)


Distinct populations
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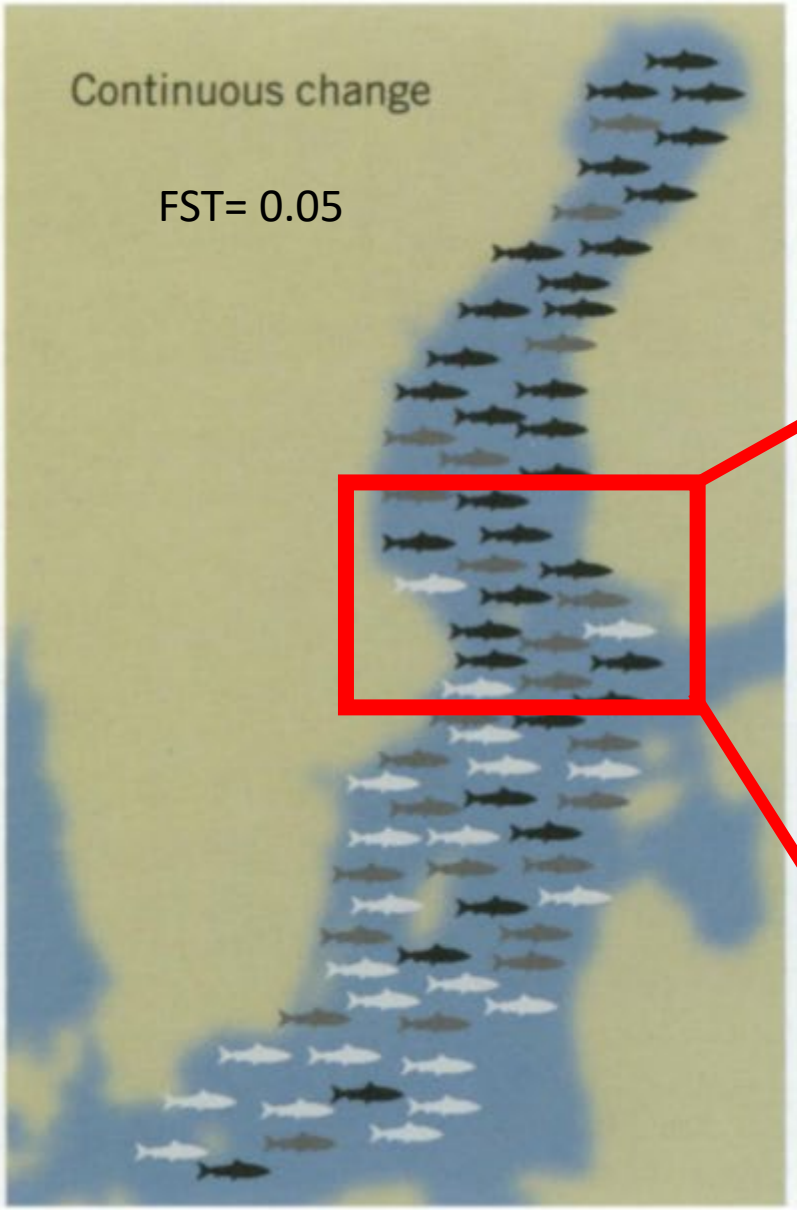
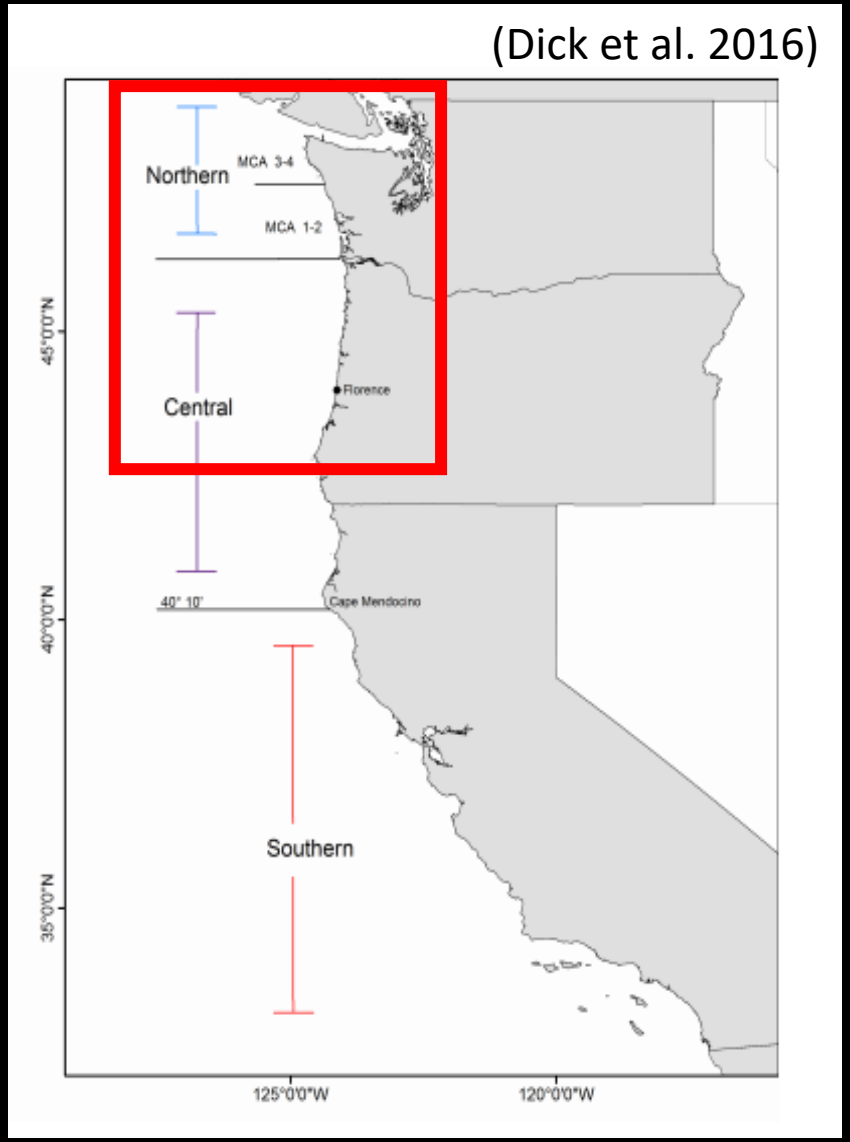

Continuous change
FST= 0.05


No differentiation
FST= <0.05
FST= 0.002

Population Genetics Discussion:

- Recommend population genetic study along the entire West Coast (including Alaska and Canada)
- 2 genetics clusters
  - Population structure might become apparent if larger sampling area
- Defining stock boundaries for PFMC
  - More near shore/shallow water trawl surveys
  - Coordination between states
- OR and WA could be managed as one population

(Dick et al. 2016)



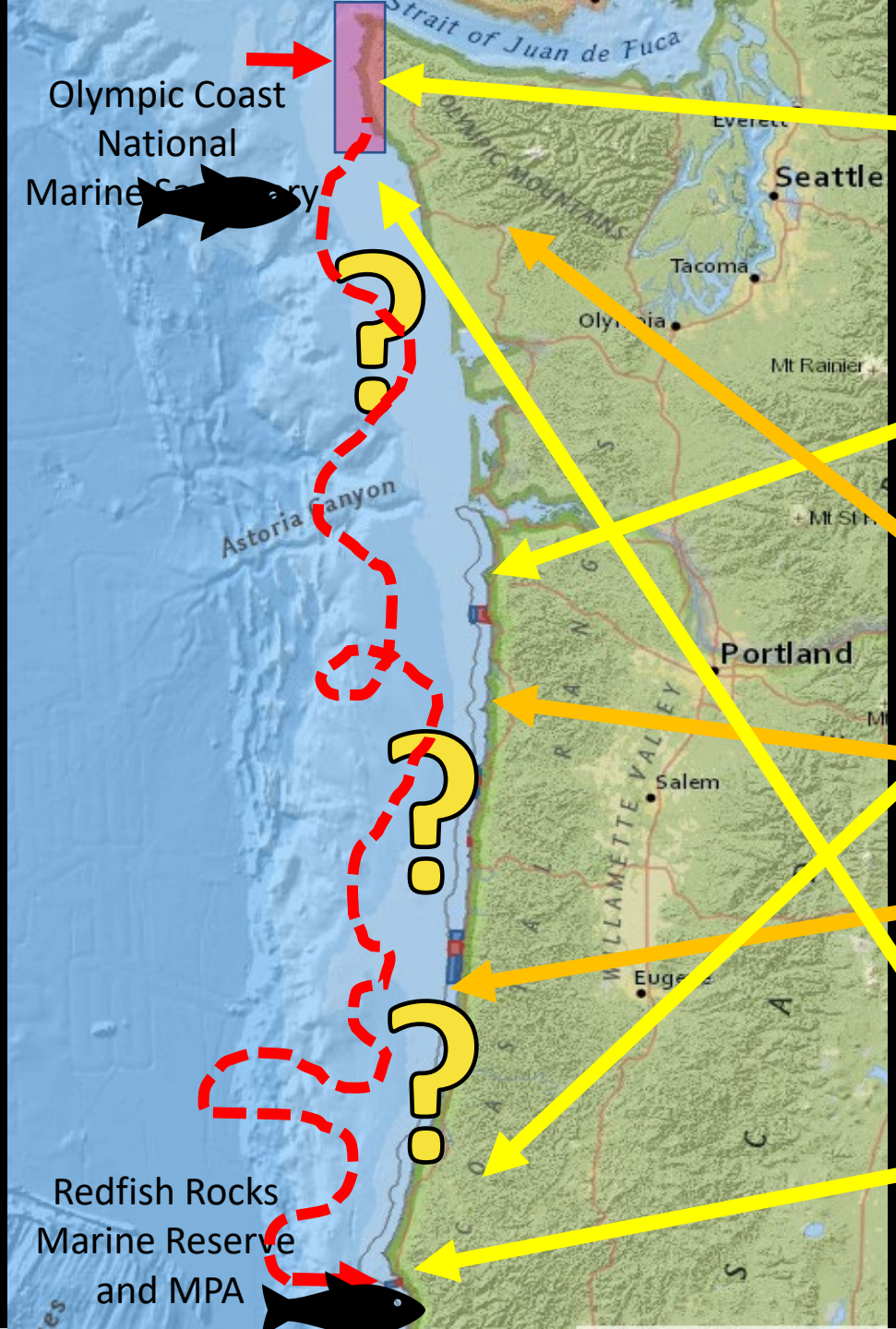
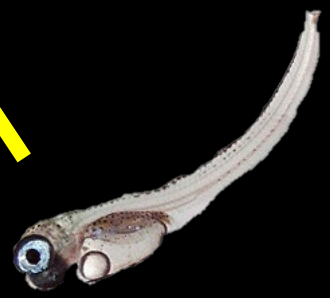


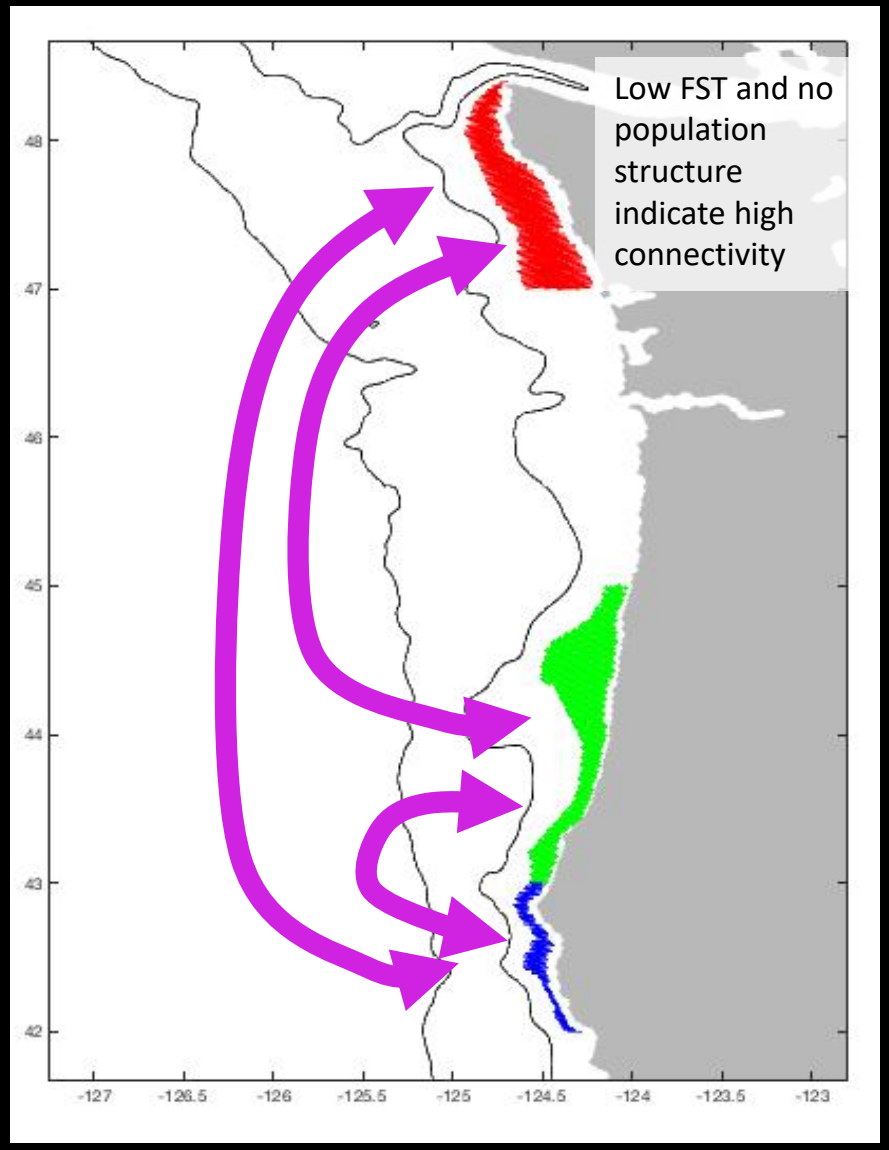
Illustration credit: Alex Avila

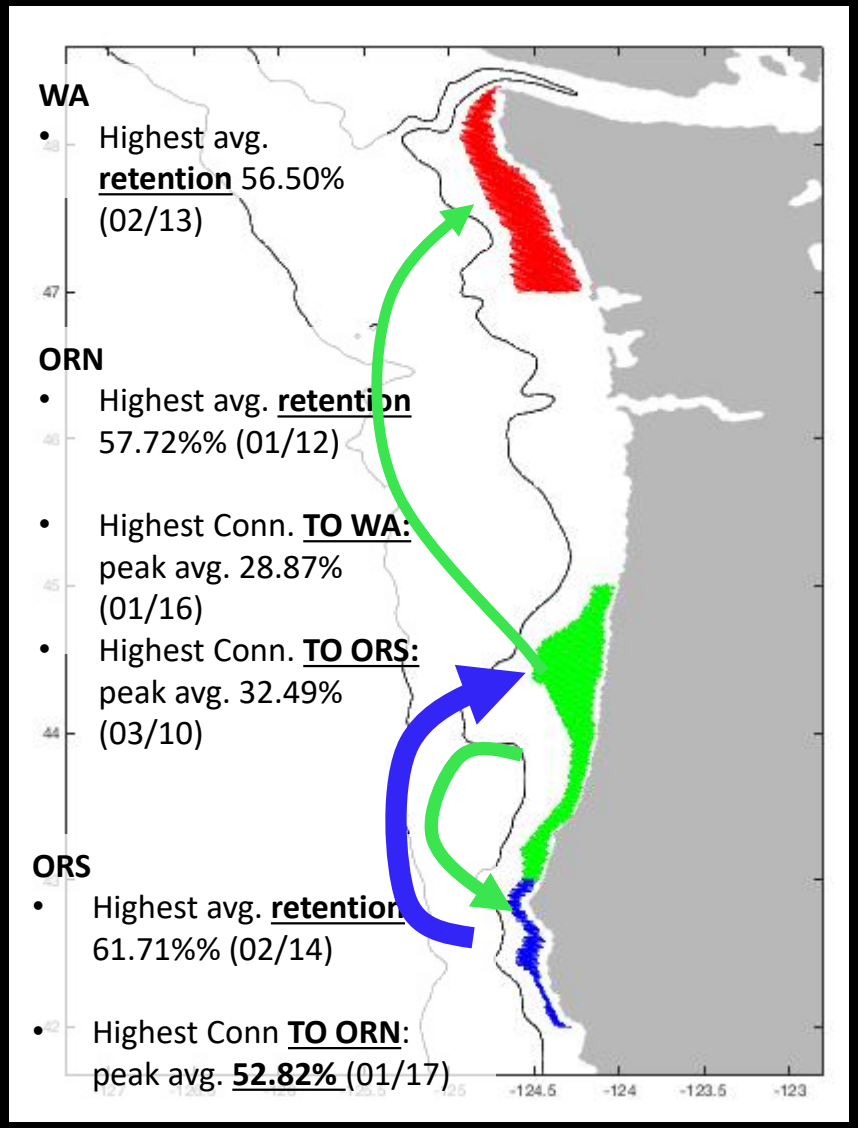


- Highly connected both genetically and oceanographically

Photo credit: NOAA

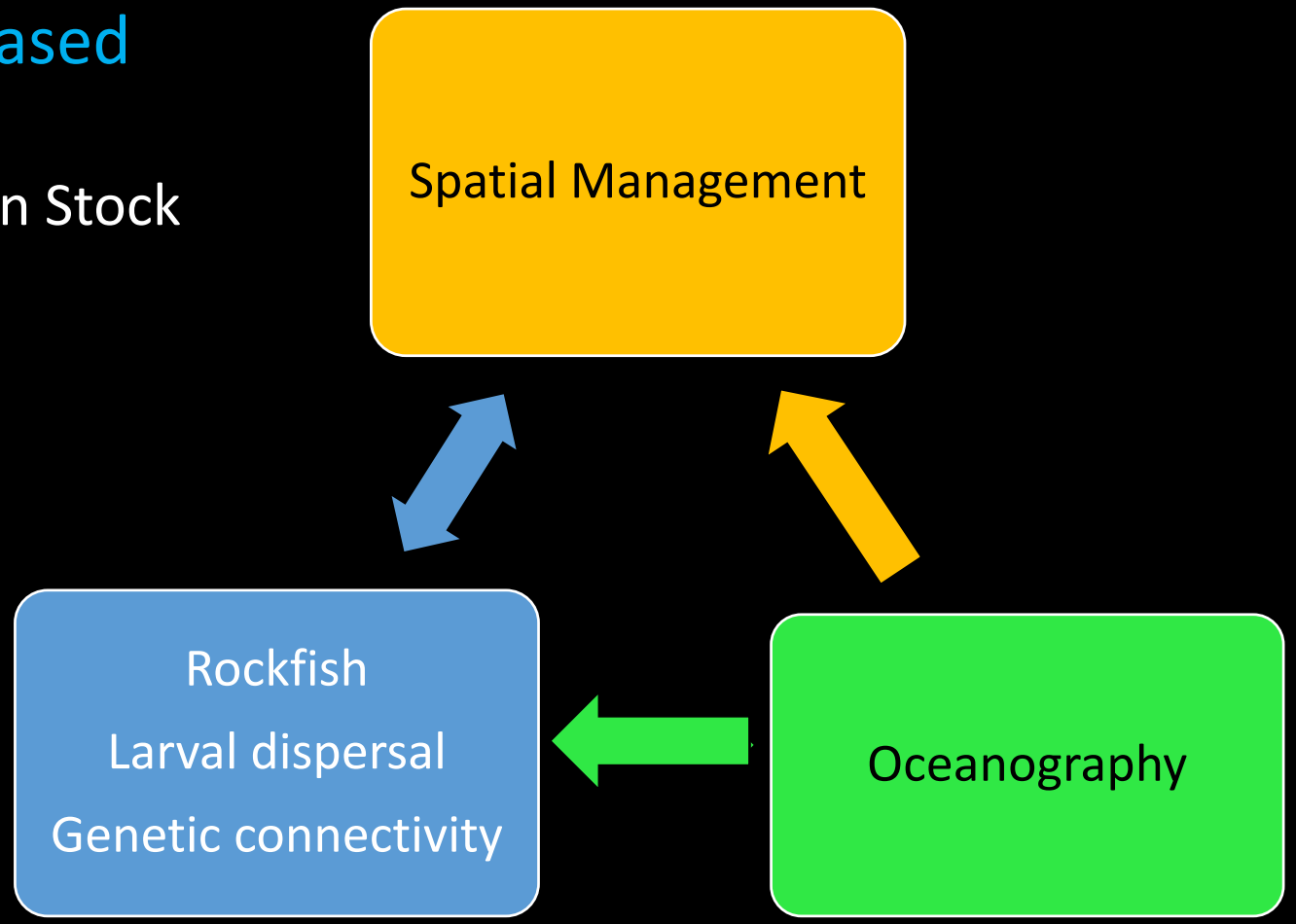
Population Genetics vs Oceanography





Broader Impacts

- Help improve future management plans in moving towards Ecosystem Based Fishery Management (EBFM)
  - Include environmental variables in Stock assessments
  - Spacing/size of RCAs or MPAs



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Thank You!
FIN

Questions?

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