Pacific halibut larval dispersal in the north Pacific Ocean and Bering Sea

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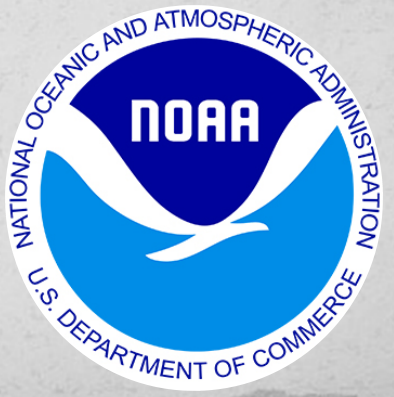


Pacific halibut life history

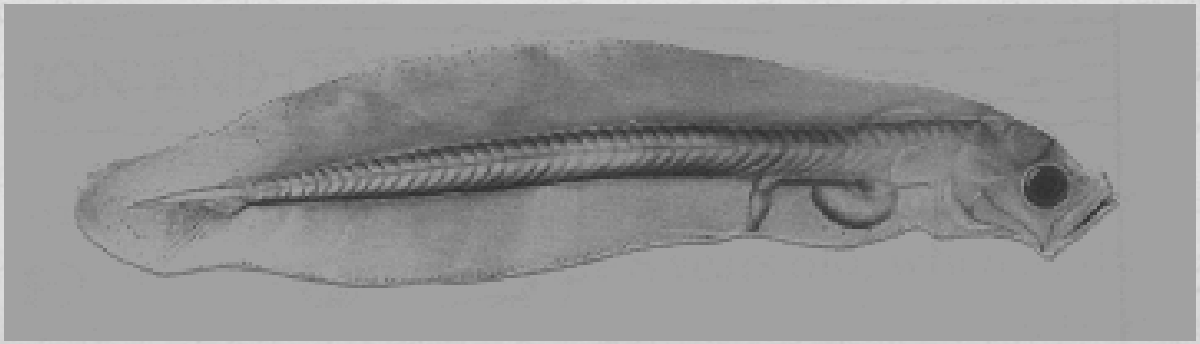
- Long-lived – up to 55 years
- Up to 500 pounds (227 kg) and 2.4 m

Photo credit: Levy Boitor

- Study focus: Larval (pelagic) phase – first 6 months

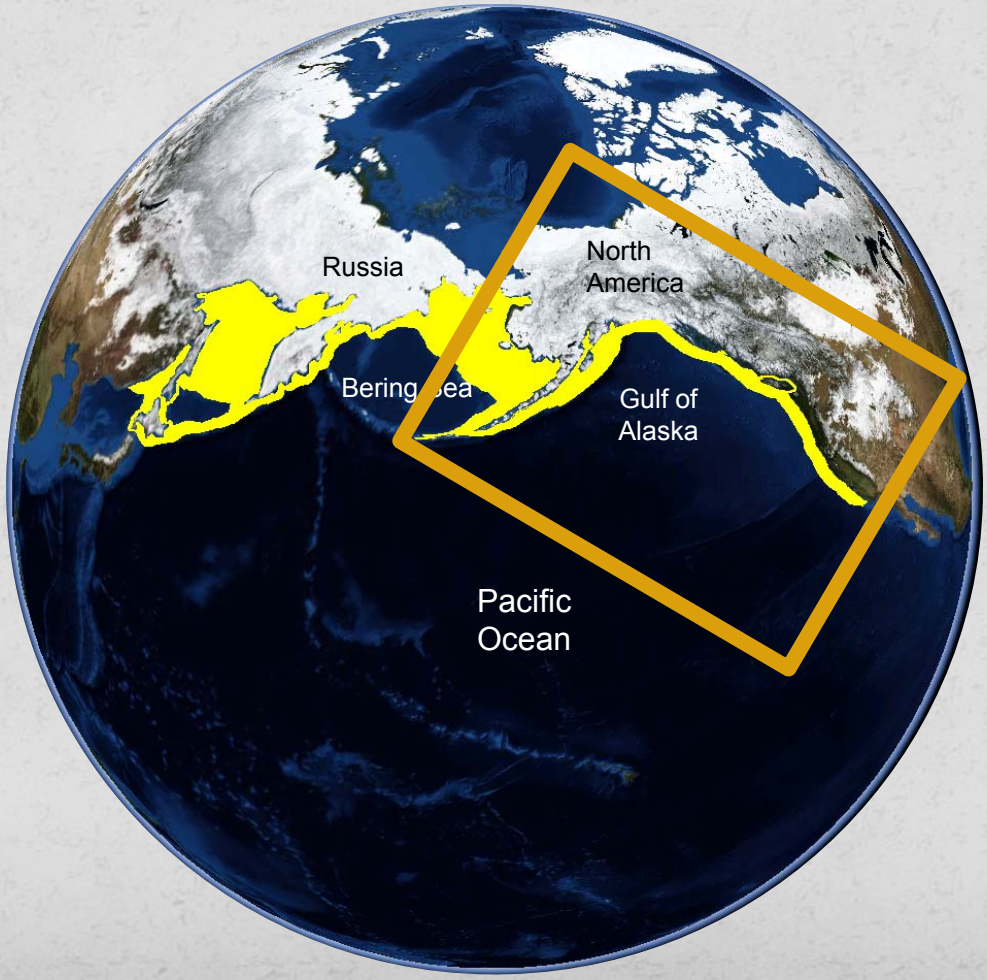
Study objectives

- Redefine larval distribution
- Connectivity between ocean basins
- Influence of environmental factors on:
  - Larval year-class strength
  - Organism size
  - Degree of connectivity
  - Recruitment to demersal stage



Pacific halibut resource range

North Pacific continental shelf

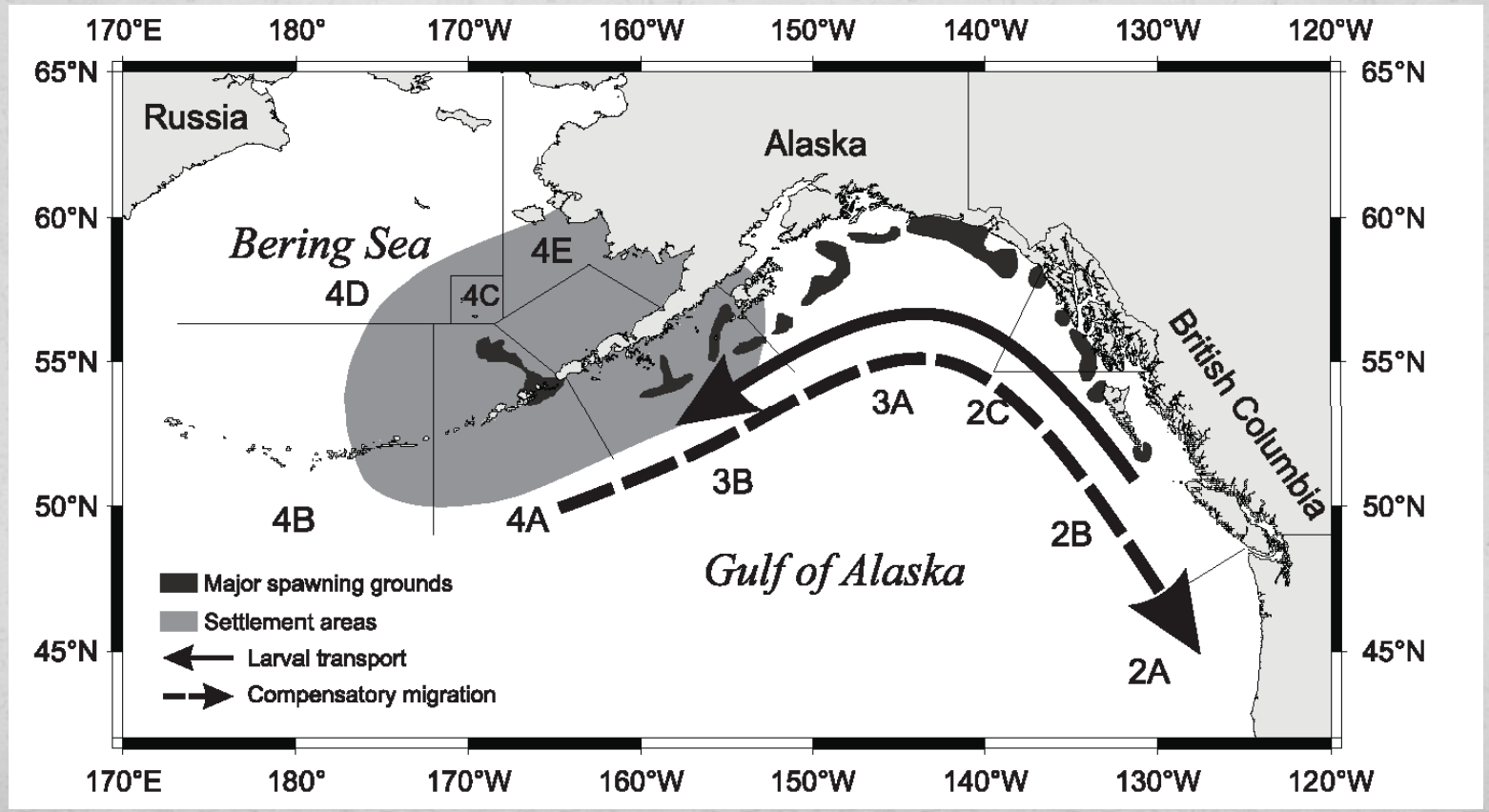


International Pacific Halibut Commission (IPHC) management area

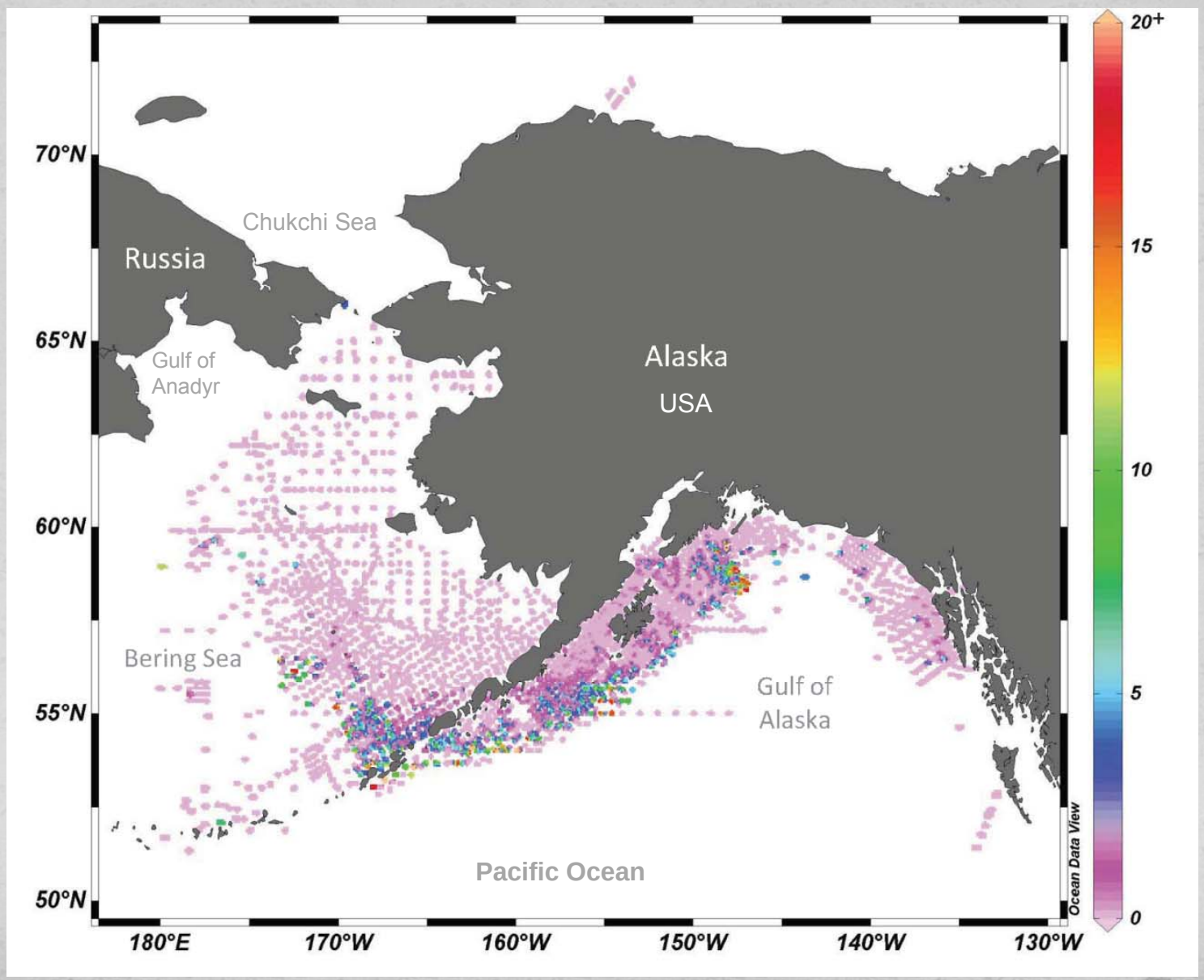
Source: Wikipedia. Background image from NASA World Wind

Study area

- Pelagic drift to the west
- Counter-migration to the east

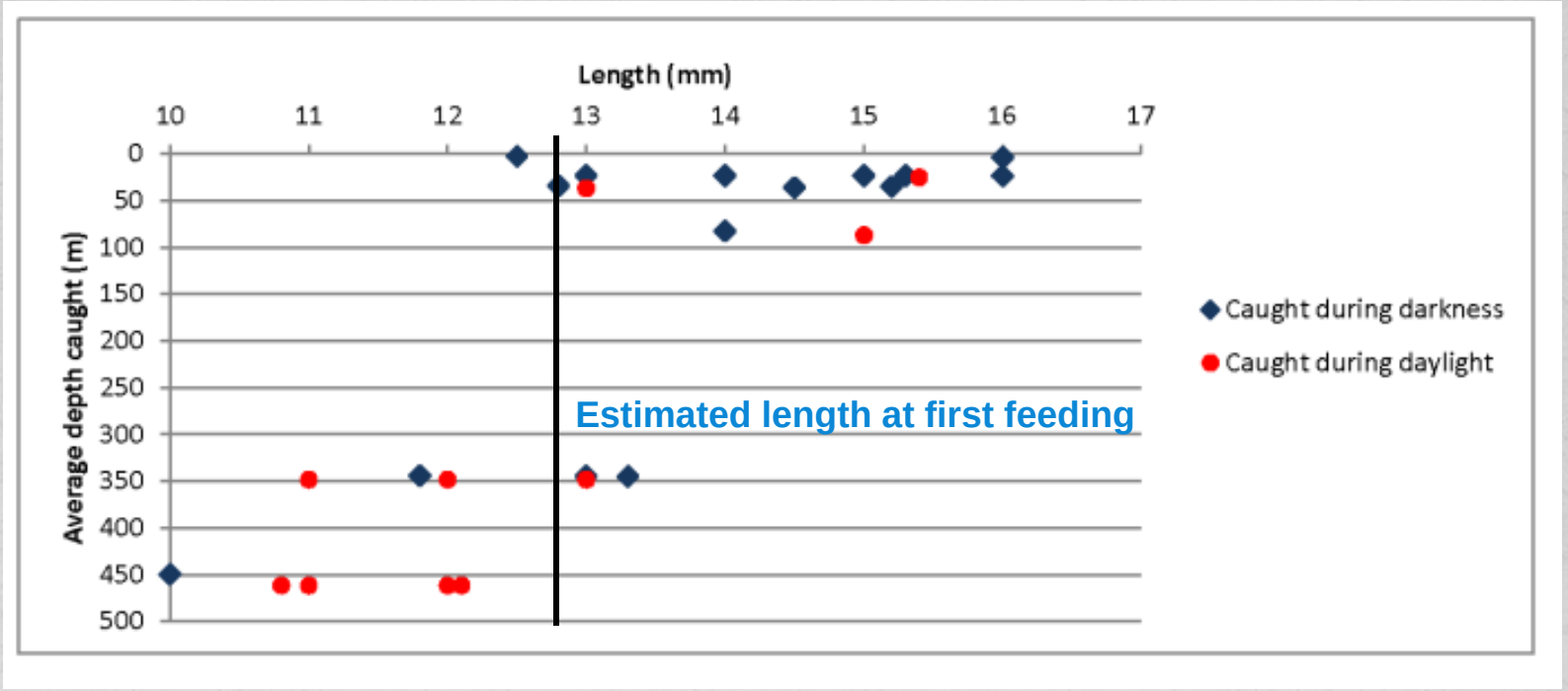


Horizontal distribution



Pacific halibut larvae caught during NOAA icthyoplankton surveys 1972-2015.

Vertical distribution

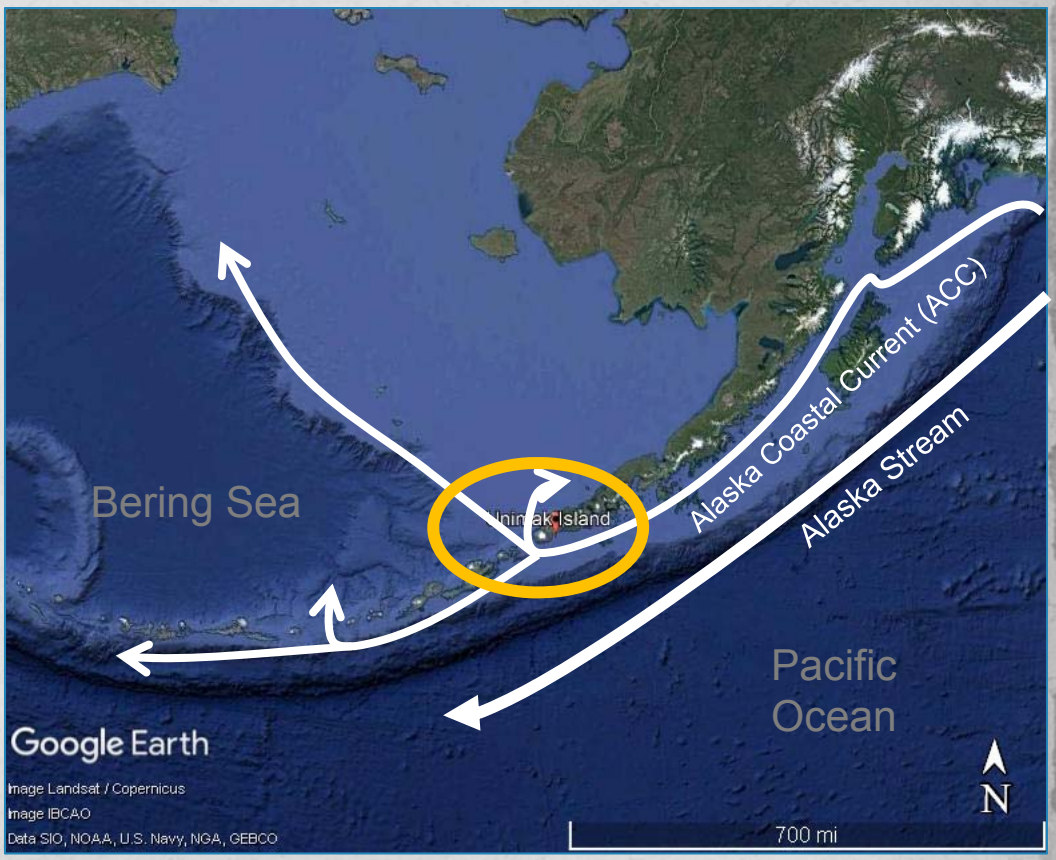


- Yolk-sac phase[1] >300 m depth
- Near-surface distribution consistent with yolk sac absorption at ~12.75 mm length[1]
- At first feeding, top 100 m

[1]Larval staging by length based on laboratory studies by McFarlane et al. (1991) and Liu et al. (1993)

Ocean basin connectivity

- Westward flowing Alaska Coastal Current through Aleutian Passes[1,2]
- Unimak Pass – shallow, shelf connector[1]
- Past assumption: spawning in each basin determined recruitment there[3]



[1]Stabeno et al. (2002)
[2]Bailey et al. (2008)
[3]Thompson and VanCleve (1936)

Predicting larval catch and recruitment

- Linear regression models used to find predictors

- Variables:
  - Gulf of Alaska (GOA) larval catch
  - Bering Sea larval catch
  - Abundance of 2-year olds in the Bering Sea
  - Catch weighted mean length by month
  - January SST in the GOA and Bering Sea
  - May SST in the Bering Sea
  - Summer bottom temperature in the Bering Sea
  - Extent of sea ice cover
  - North Pacific Index (NPI)[1] – Alaska Coastal Current
  - Pacific Decadal Oscillation (PDO)[2] – temperature driven

Catch

Environment

[1] NPI defined by Trenberth and Hurrell (1994)
[2] PDO defined by Mantua et al. (1997)

Regression results

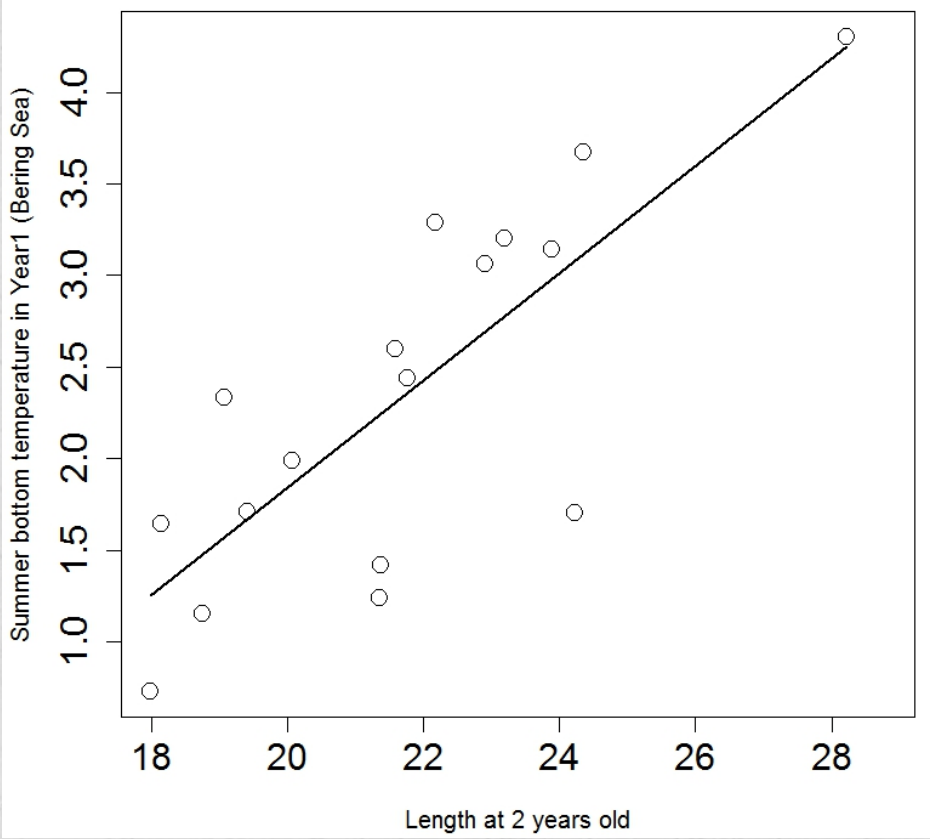
- Bering Sea larval catch ~ GOA larval catch + NPI
  - (Adj R^2= 0.20, p-value=0.031)

- 2YO Bering Sea abundance ~ GOA larval catch
  - (Adj R^2=0.11, p-value=0.039)

- No variables or combination of variables significant in predicting GOA larval catch

Size and temperature

- 2-year old length (BS) ~ summer bottom temp at age-1
  - (Adj R^2=0.595, p-value=0.0002)

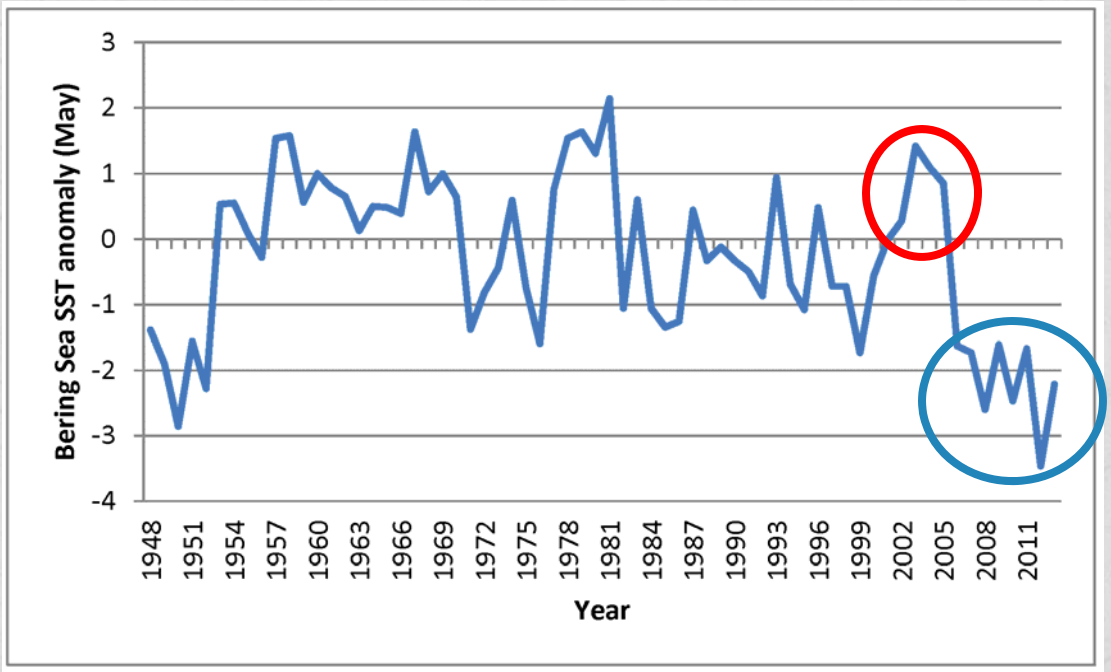


Data included: 1996 forward

- Neither larval length nor temperature in year 0 was significant

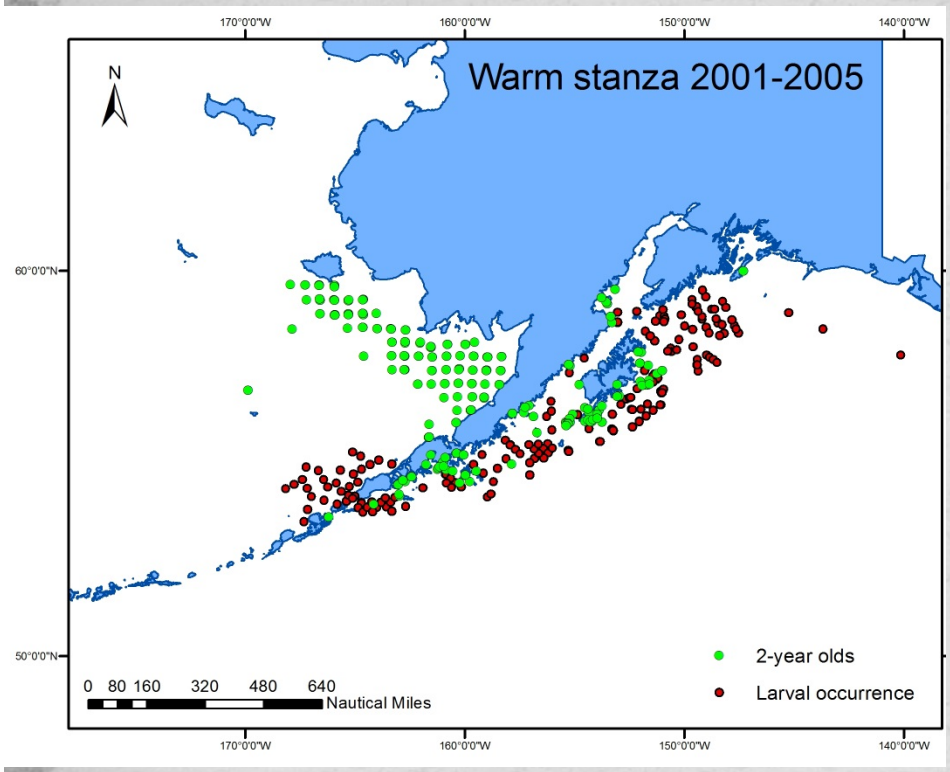
Bering Sea temperature

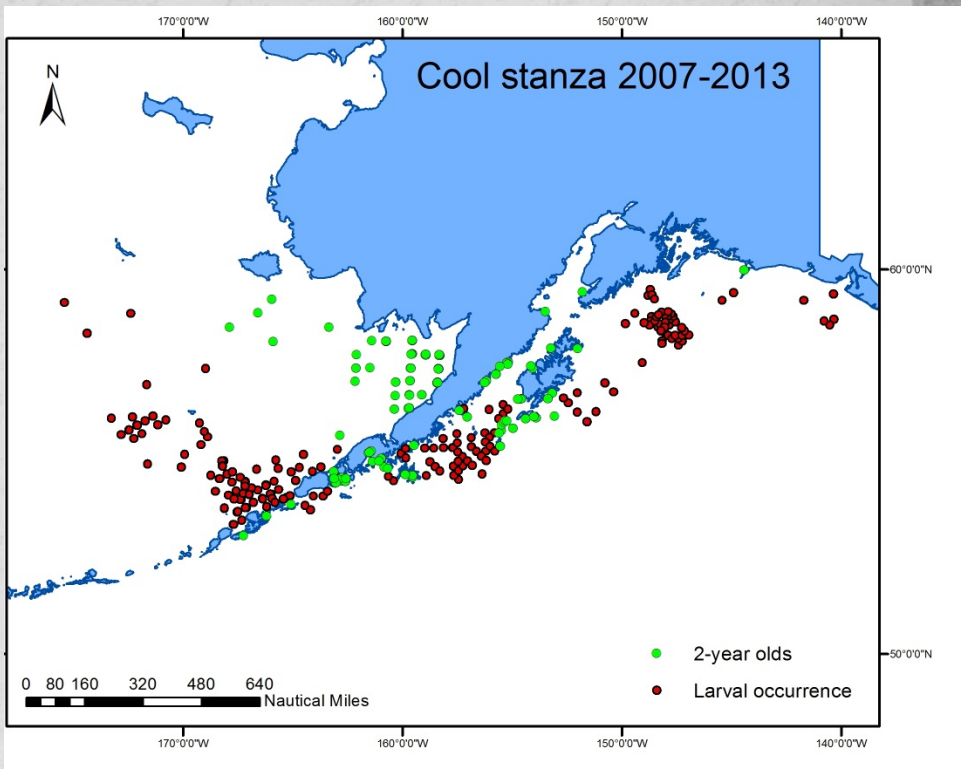
- Warm stanza 2001-2005
- Cool stanza 2007-2013



Data source: http://www.beringclimate.noaa.gov/data/BCresult.php

Comparing warm and cold years





Warm

- Larvae in the east in Bering Sea
- 2YO widely distributed

Cold

- Larvae dispersed along 200 m edge
- 2YO concentrated in E Bristol Bay

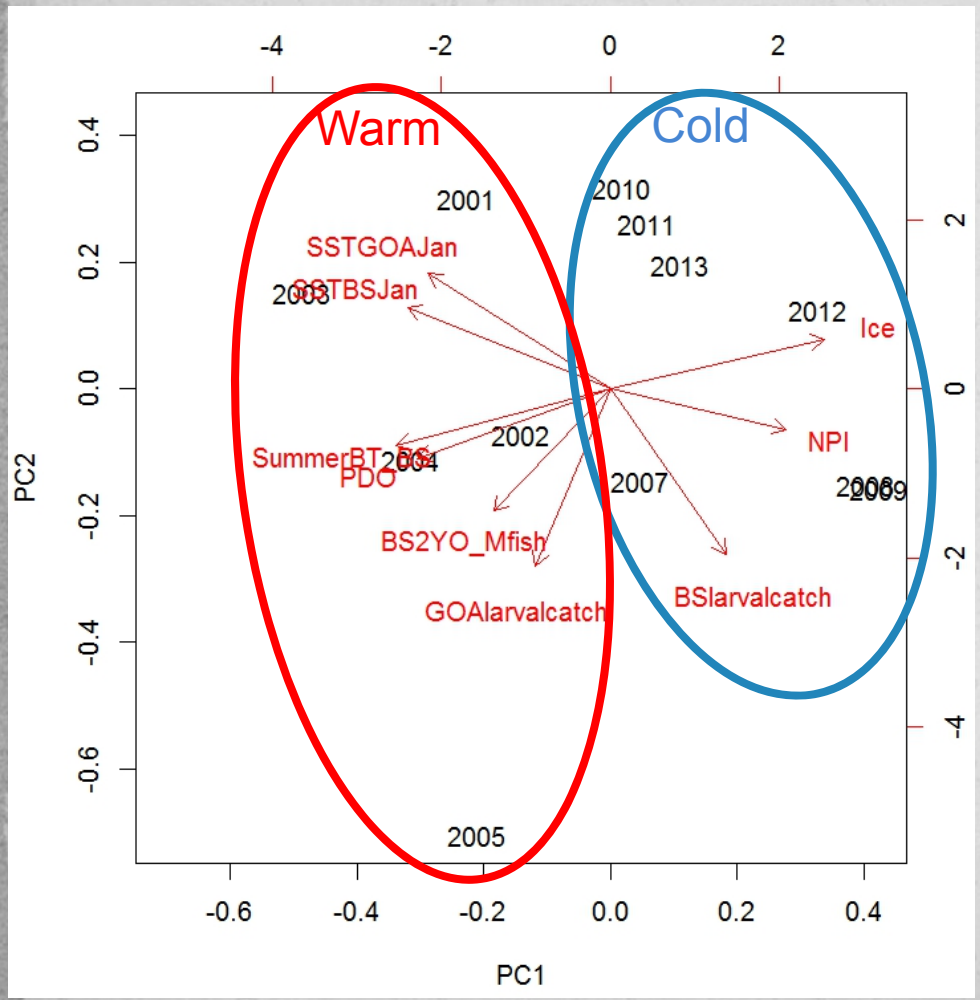
Differences between stanzas

- t-test for means (sqrt trans)
- F-test for variance (sqrt trans)

		Warm	Cool	p-value	Significant
Bering Sea larval catch	Mean	7.1	10.7	0.215	
	Variance	57.6	40	0.066	
GOA larval catch	Mean	30.6	7.6	0.093	
	Variance	1570.4	17.3	0.002	**
2YO abundance	Mean	22.7	2.7	0.034	**
	Variance	436.4	4.9	0.013	**

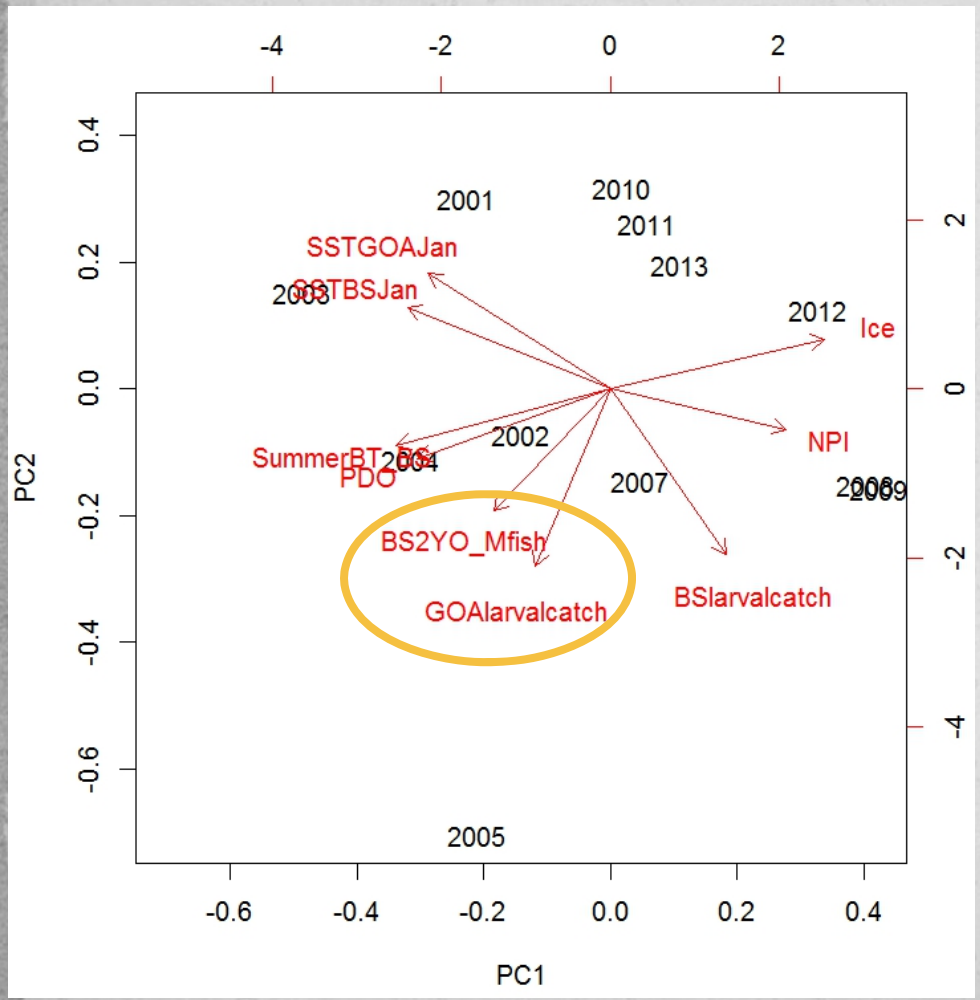
- Larval catch not significantly different
- 2YO abundance higher in warm years
- Variability greater in warm years (GOA)

Principle component analysis



- **First 2 PCs significant**
- **PC1 temp driven**
- PC2 catch driven
- GOA larval catch and 2YO in same quadrant
- Bering Sea larval catch and cooler temps

Principle component analysis



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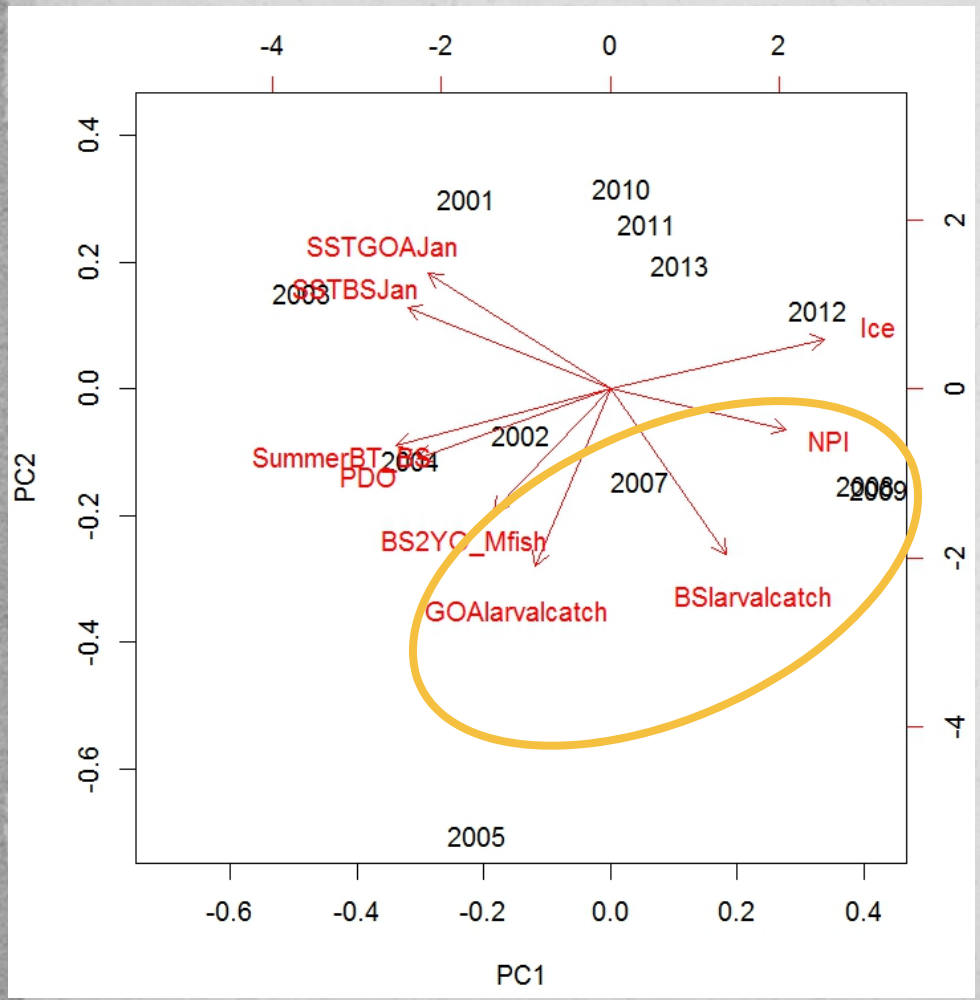

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General Conclusions

1. GOA larvae a contributor to eastern Bering Sea recruitment
2. Variability in the Alaska Coastal Current affects larval transport and therefore recruitment in the eastern Bering Sea
3. Bering Sea-spawned larvae may not be a significant contributor to recruitment in the eastern Bering Sea.

General Conclusions

4. Temperature not a major factor in larval occurrence.
5. Temperature is a factor in growth of post settlement juveniles.
6. Temperature is related to larval distribution differences in the Bering Sea, possibly reflecting differences in currents.
7. Ultimately, management decisions that affect the GOA spawning population could have implications to recruitment of Pacific halibut in the Bering Sea.

Next steps

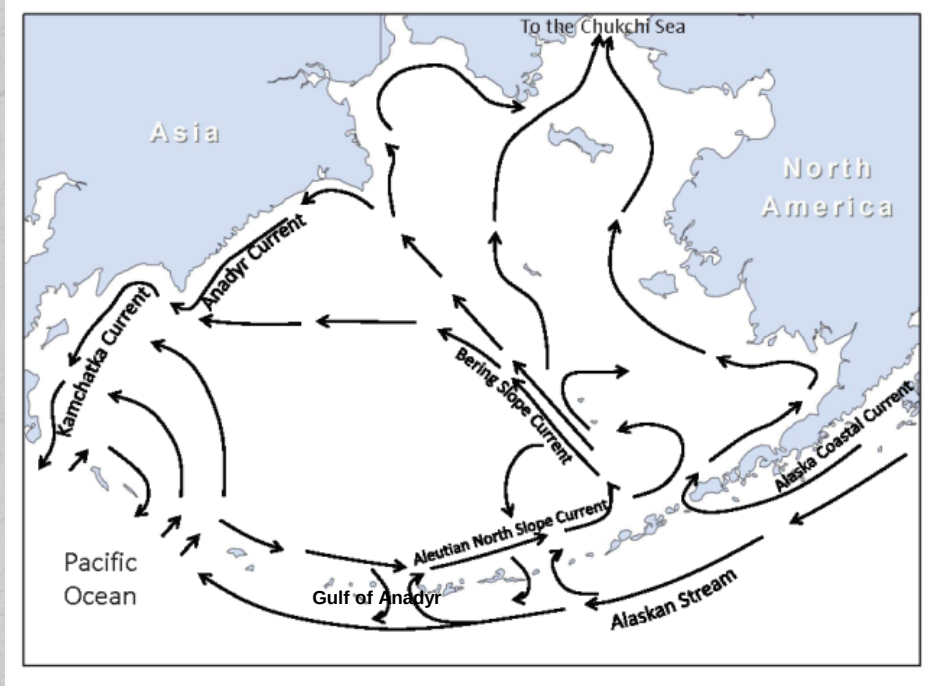


Figure reproduced from Sadorus et al. 2016.

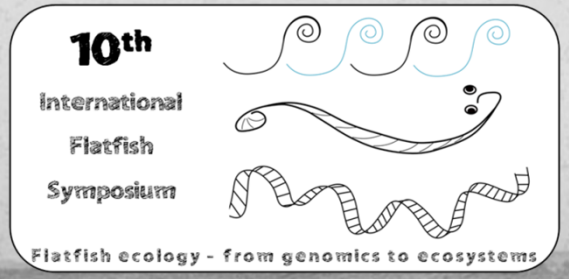
- Defining volume of transport through Unimak Pass
- Transport variability under different environmental conditions
- Spawn location – where were Unimak Pass larvae spawned?
- Larval transport paths in the Bering Sea

Acknowledgements


Photo credit: Sam Parker

Wikipedia

- NOAA and IPHC biologists who tirelessly collected Pacific halibut data for all life stages throughout the years.
- Marine vessels and their crews who have bravely traversed the Gulf of Alaska and Bering Sea to collect the data.
- NOAA and IPHC technology staff for expertly handling thousands of catch records.



Thank you!