Comparing walleye pollock dynamics across the Bering Sea and adjacent areas

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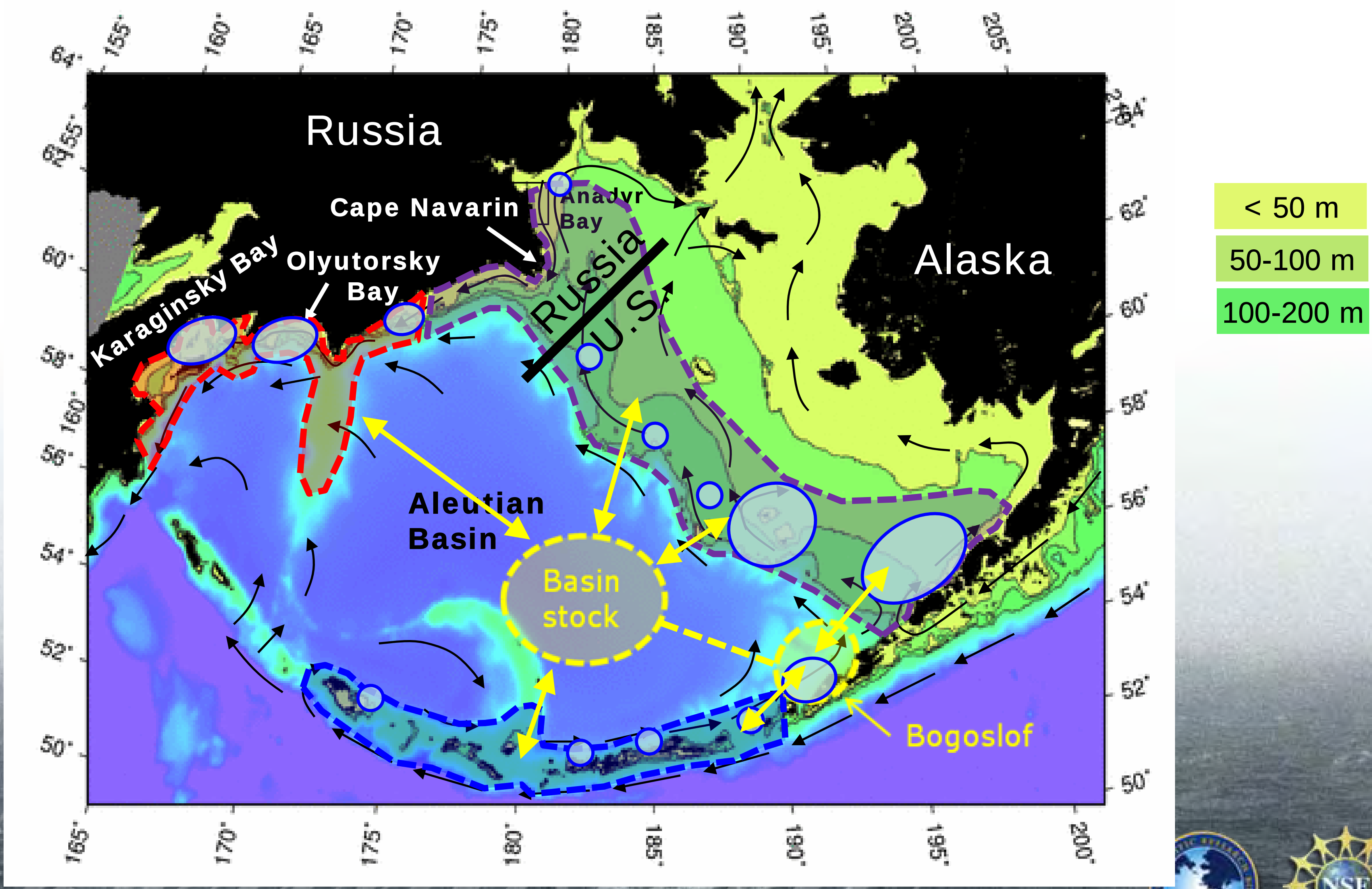
Goal

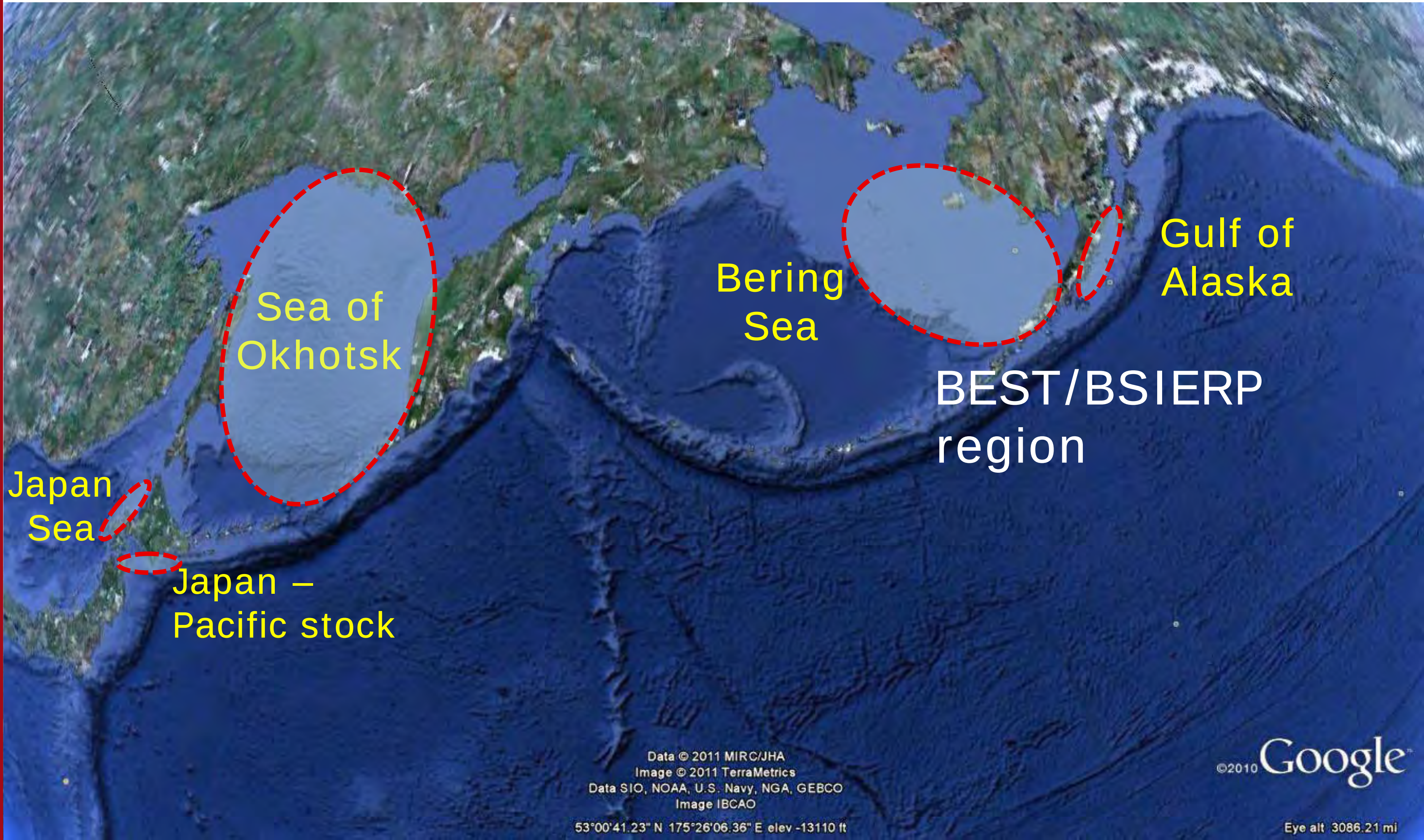
- Review of stock structure and recruitment dynamics of walleye pollock in North Pacific
- Comparisons across systems
  - Major drivers
  - Resilience

The Bering Sea

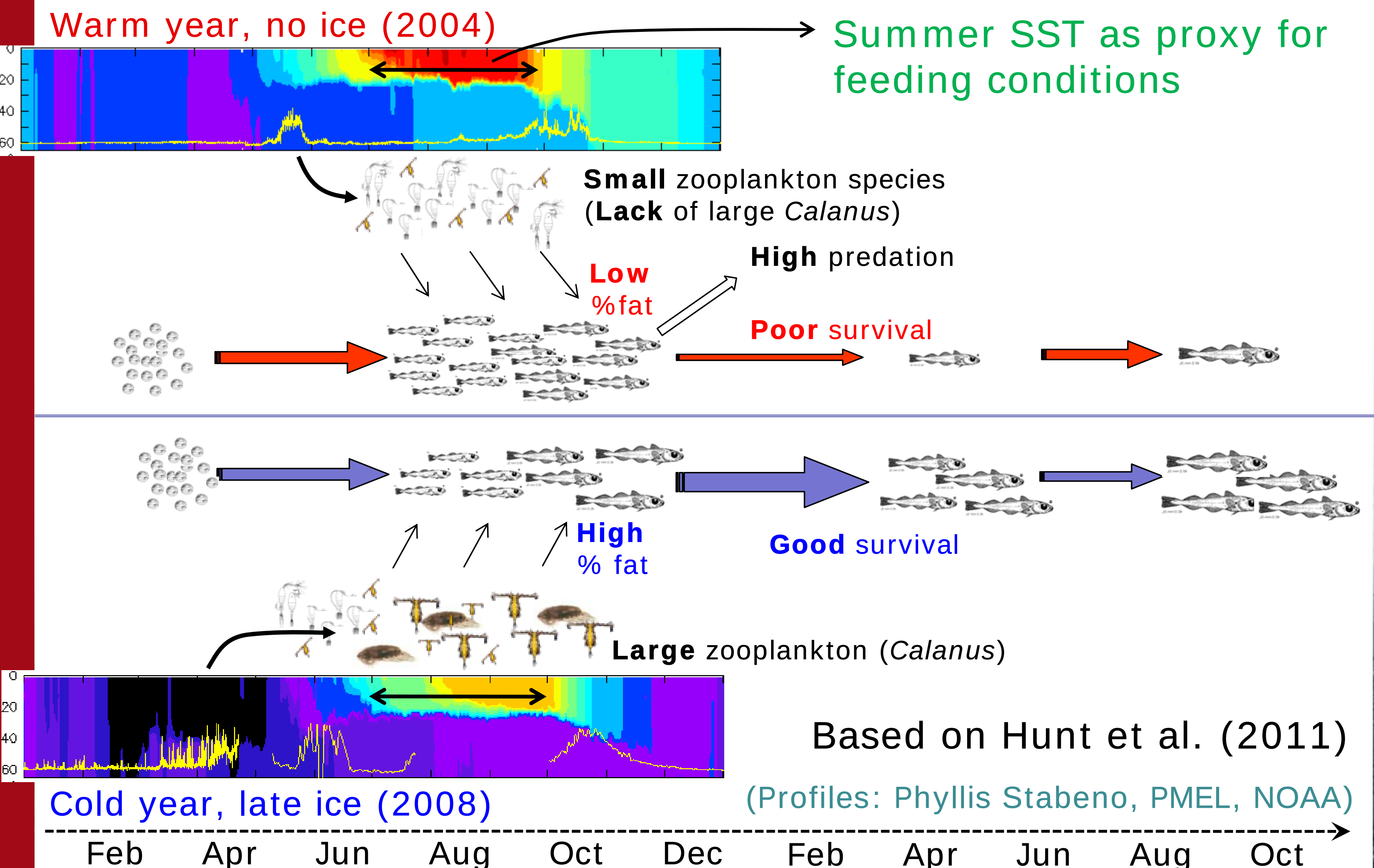


Base map from Aydin et al. (2002)

Other walleye pollock stocks



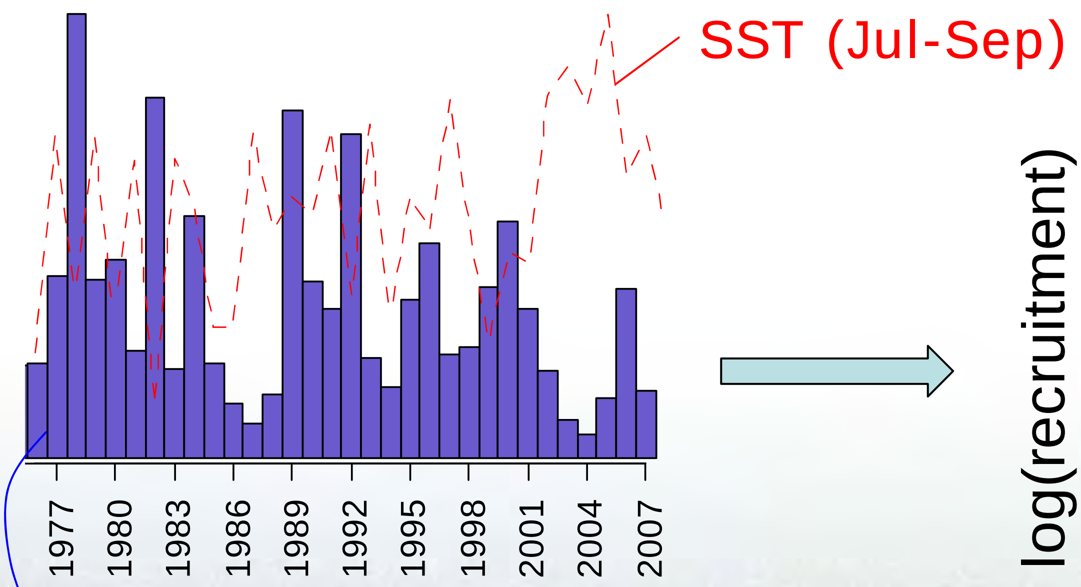
EBS pollock recruitment dynamics



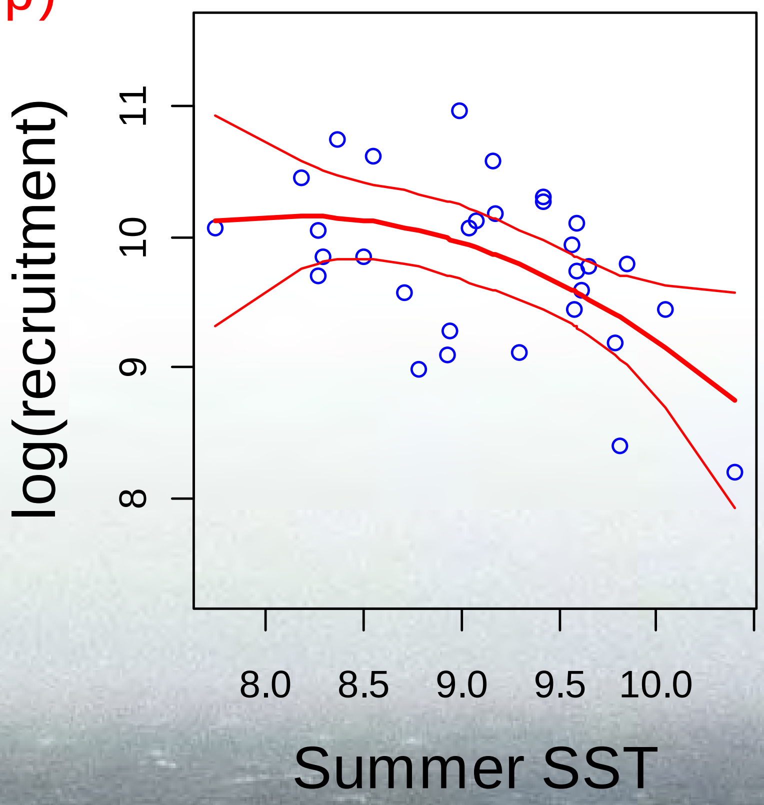
Based on Hunt et al. (2011)

(Profiles: Phyllis Stabeno, PMEL, NOAA)

Recruitment & late summer SST

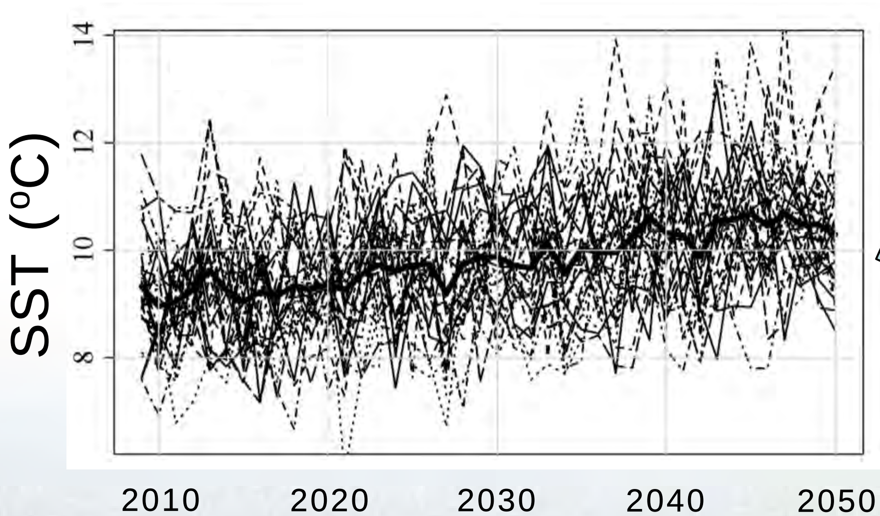


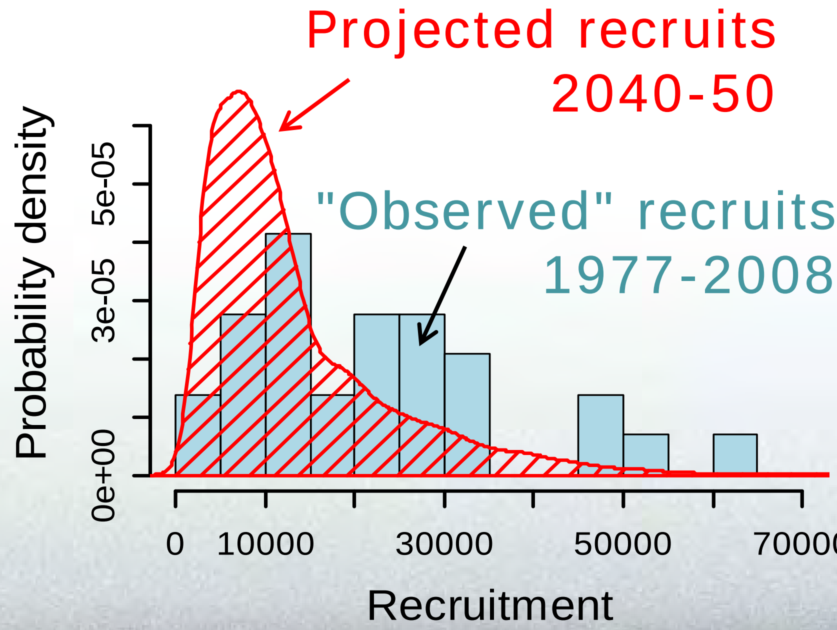
Recruitment estimates
From Ianelli et al (2009)



Projecting pollock dynamics

1. SST projections, downscaled to Eastern Bering Sea, 2010-2050

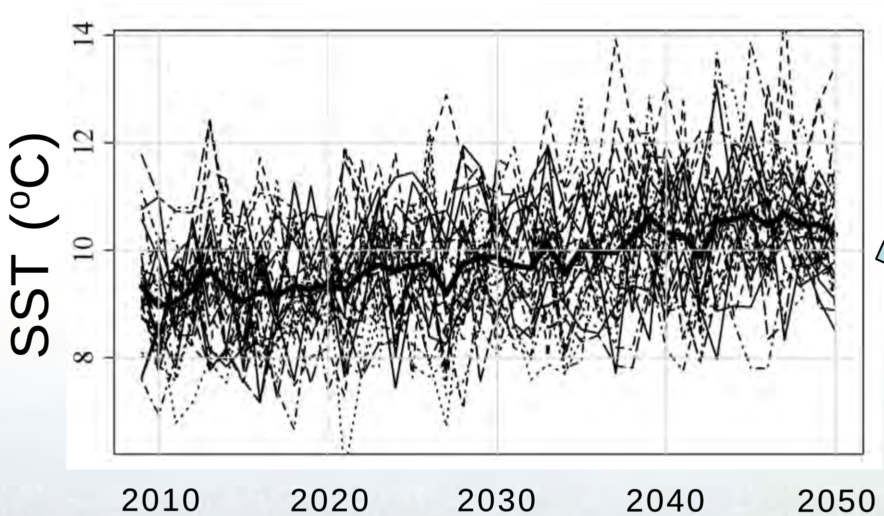


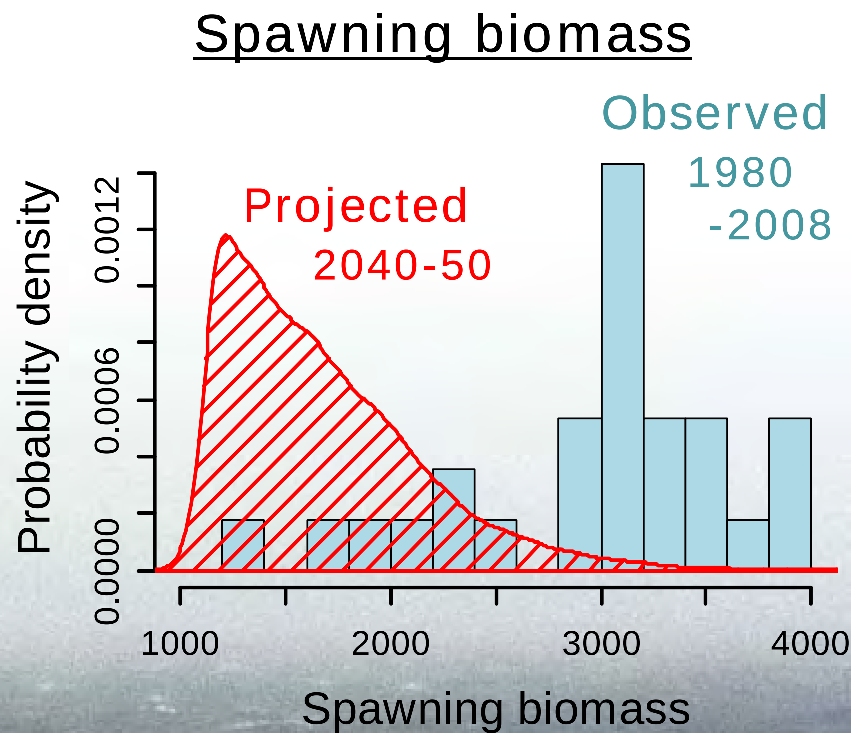


2. Cannibalism / Predation

Projecting pollock dynamics

1. SST projections, downscaled to Eastern Bering Sea, 2010-2050



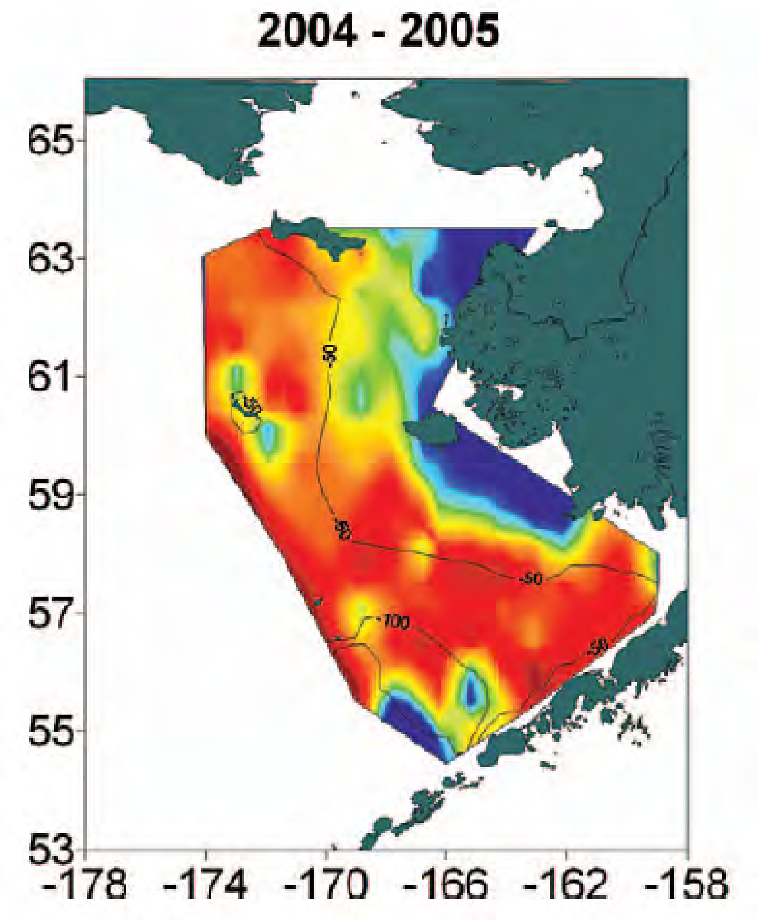


2. Cannibalism / Predation

Cautions

- Proposed mechanism reflects processes in middle domain of southeastern shelf
  - Recently, observations of large concentrations of age-0 pollock in deeper slope waters during cold years, rather than over the shelf (see Parker-Stetter et al. presentation)
    - Change in spawning distribution or transport?
  - Large concentrations of age-0 larvae & juveniles on northwestern Bering Sea shelf during warm years
    - Possible losses due to emigration into northern Bering Sea

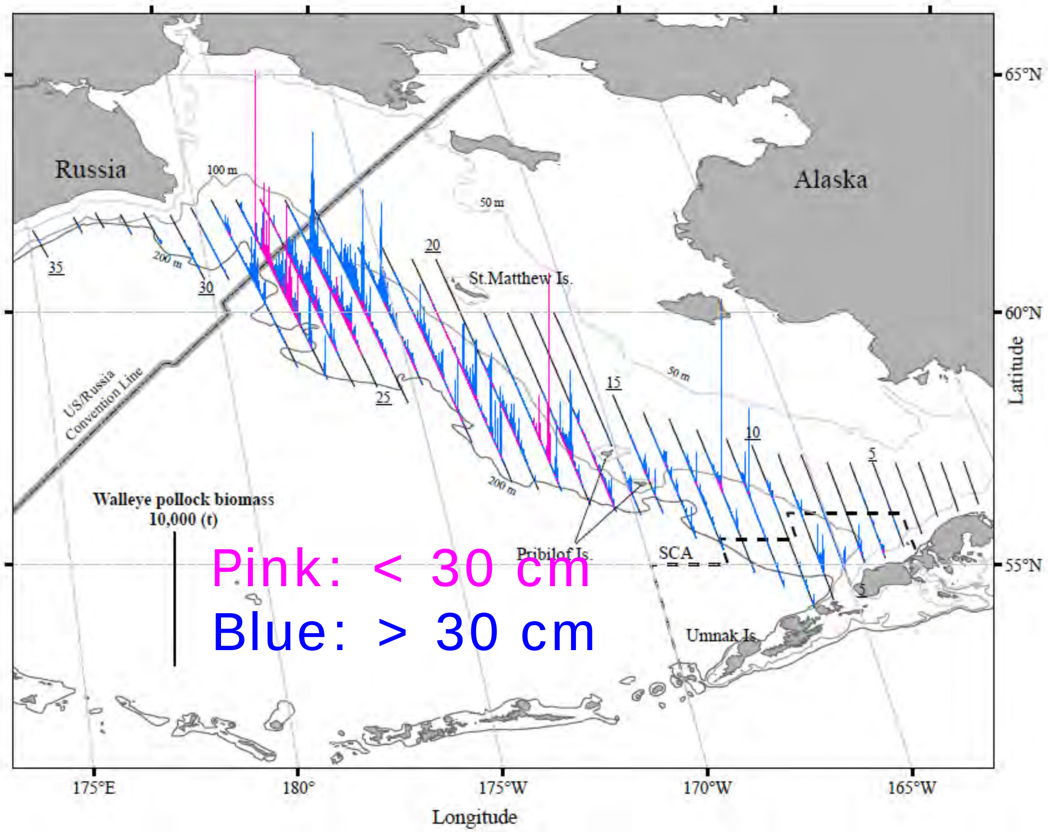
Distribution of age-0 pollock in late summer, 2004/2005



Moss et al. 2009

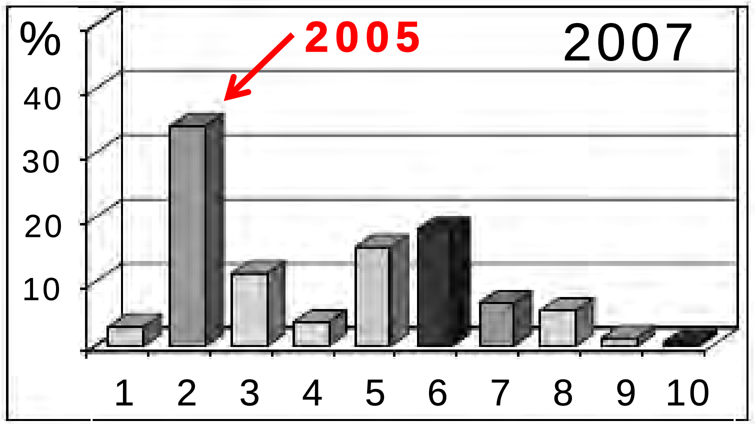
2004/2005 year classes

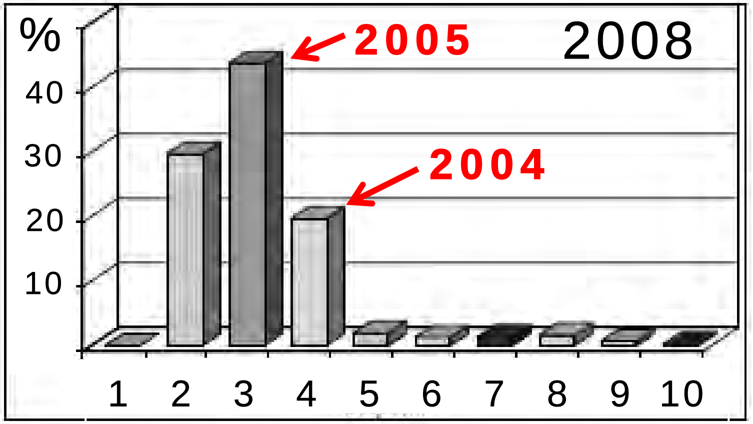
2007 estimated biomass from Echo-integration trawl survey



From Honkalehto et al (2008)

Age composition of catch in Russian fall fishery

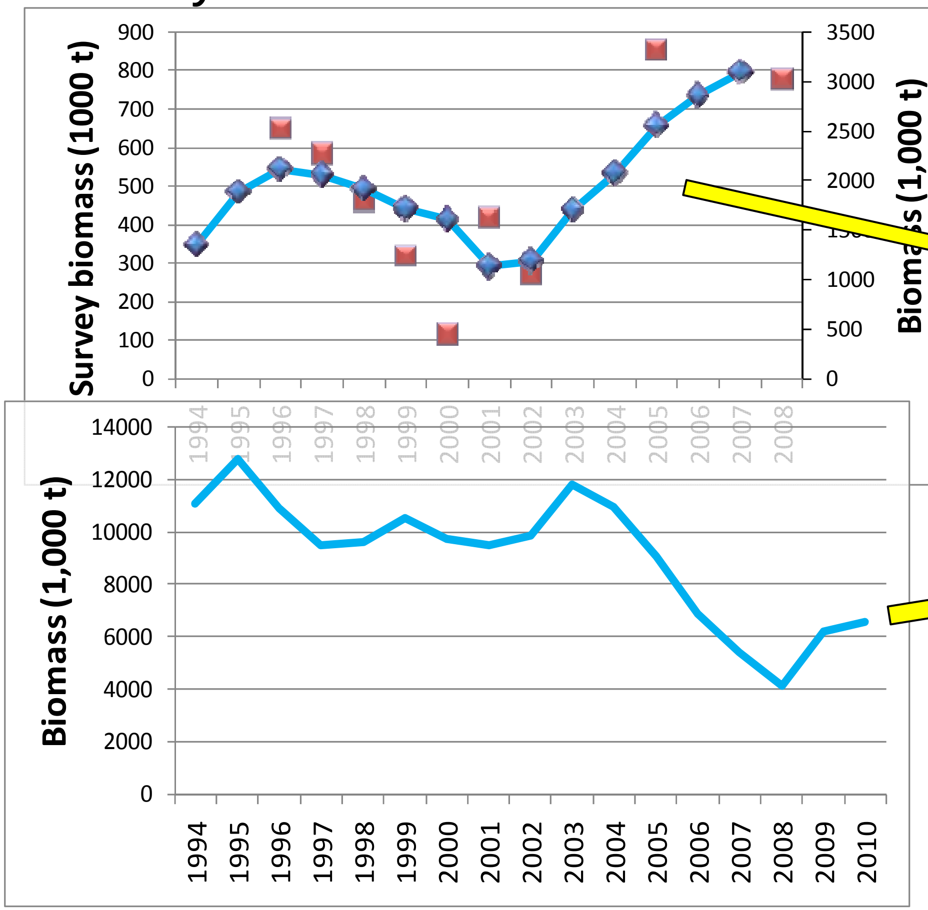




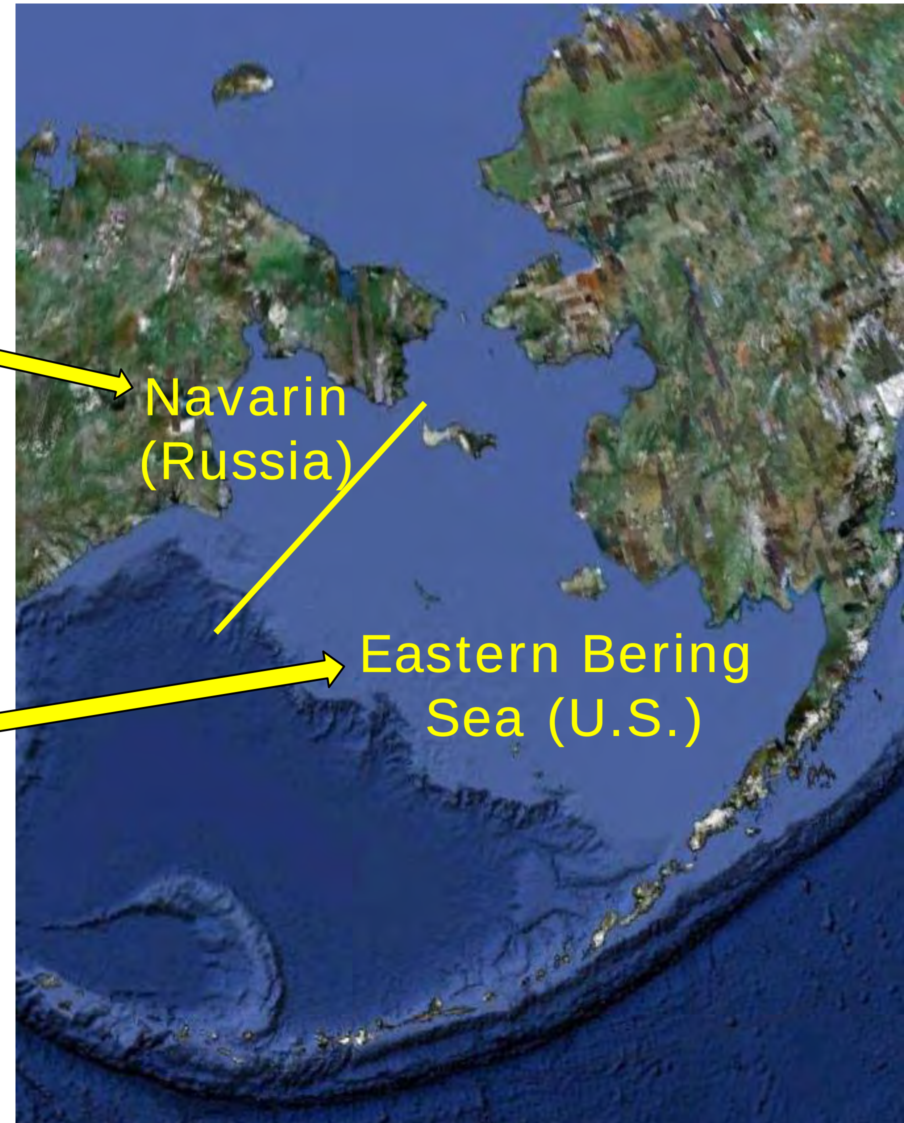
Total catch ~ 590,000 t in both 2007 & 2008

Navarin region vs. EBS

Navarin region
Survey biomass & VPA model fit



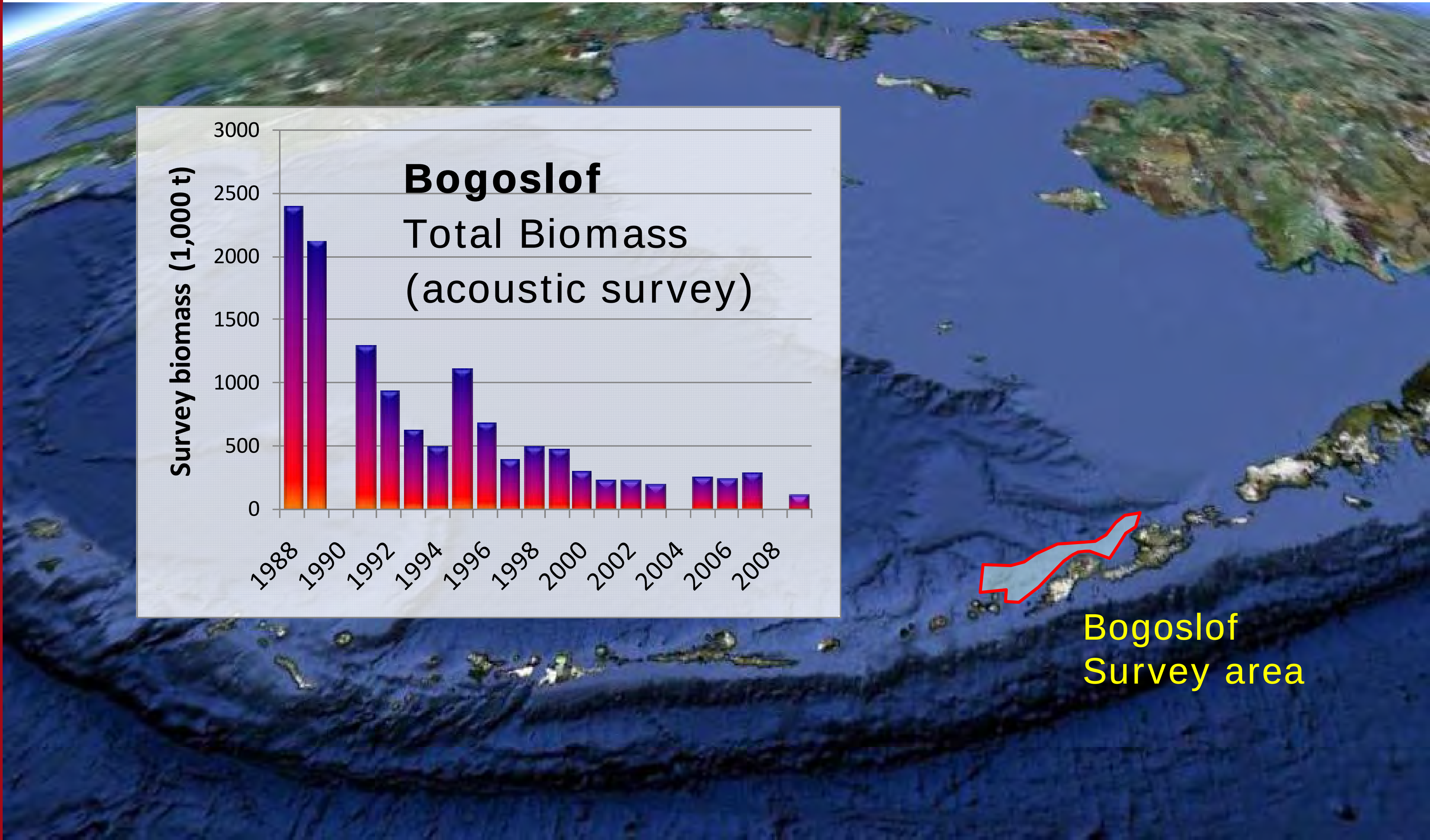
Eastern Bering Sea
Model estimates (Ianelli et al. 2010)



Other Bering Sea stocks

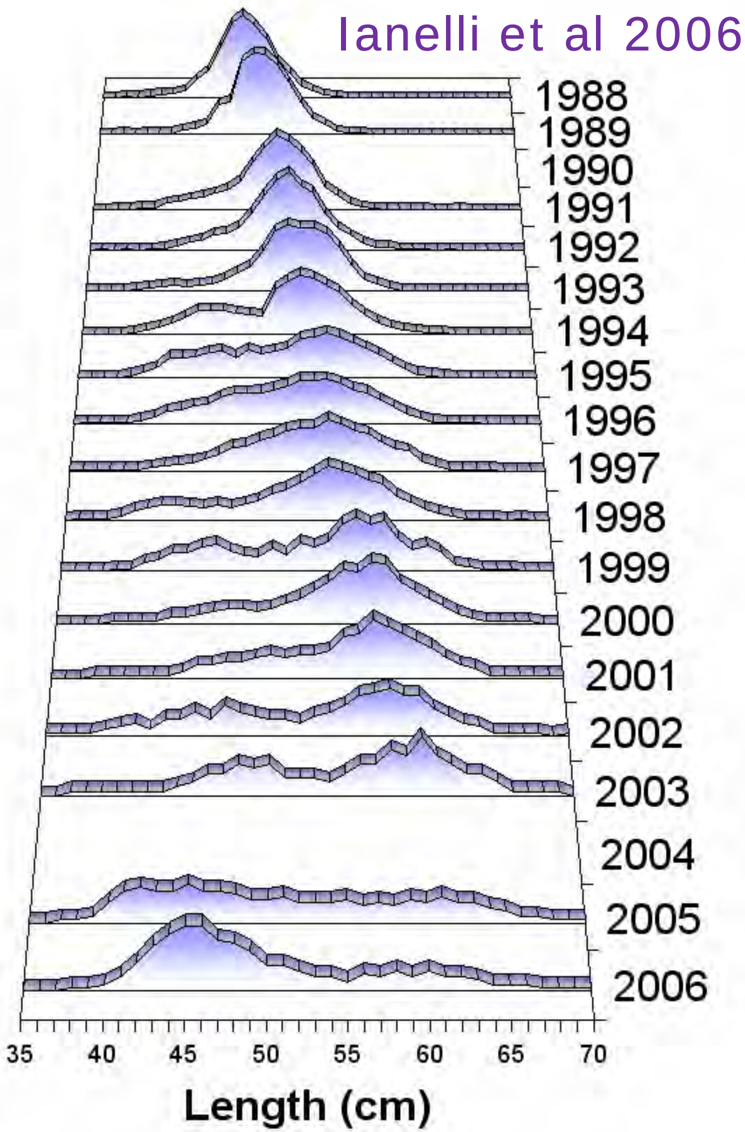
- Bogoslof / Aleutian Basin
- Aleutian Islands
- Western Bering Sea

Bogoslof



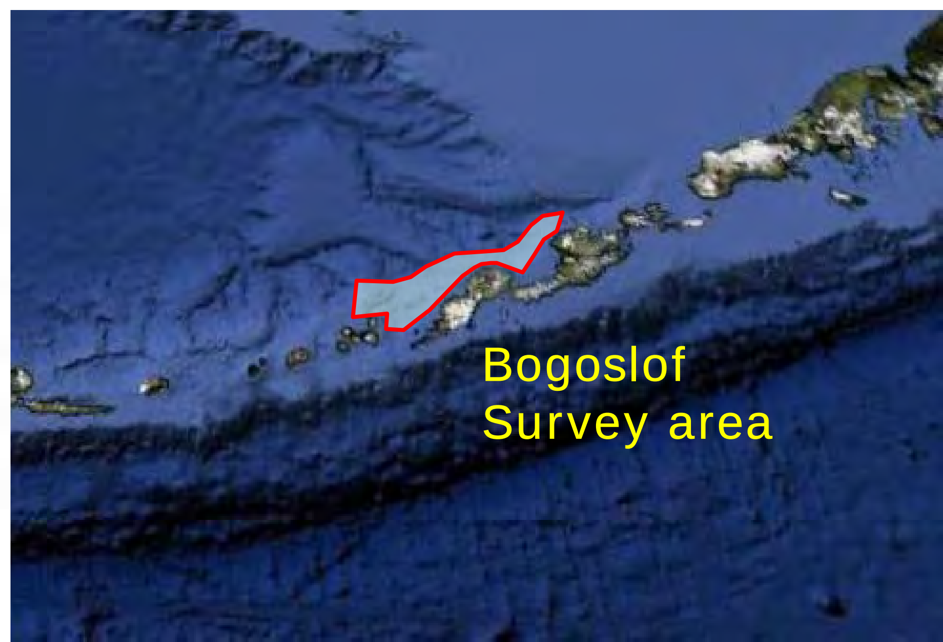
Bogoslof
Total Biomass
(acoustic survey)
Survey biomass (1,000 t)
3000
2500
2000
1500
1000
500
0
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Bogoslof
Survey area

Bogoslof

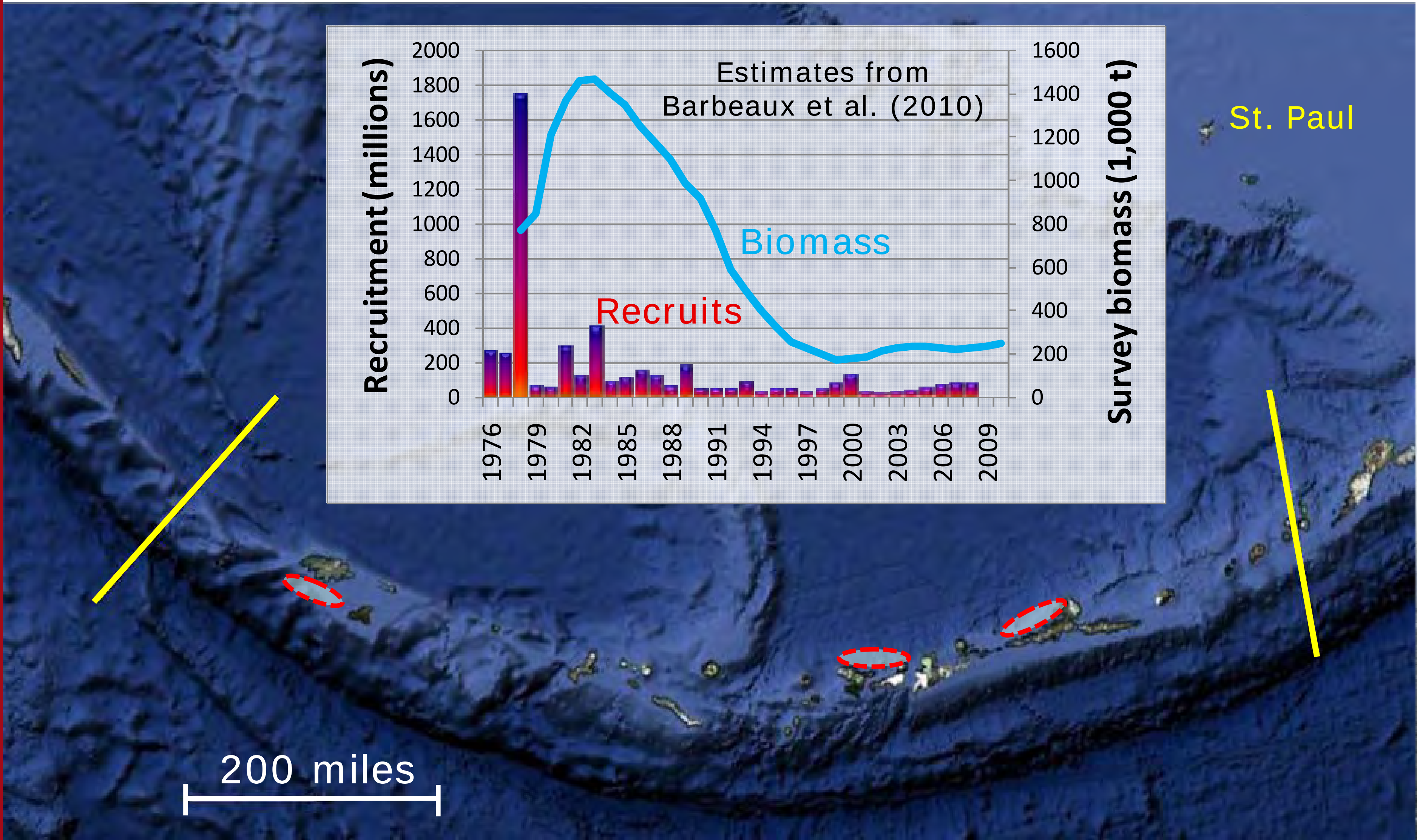


Recruitment dynamics

- Sustained by large year classes originating in late 1970s / early 1980s
- Incoming year classes coincide with large year classes in EBS
  - Strong connection to EBS stock



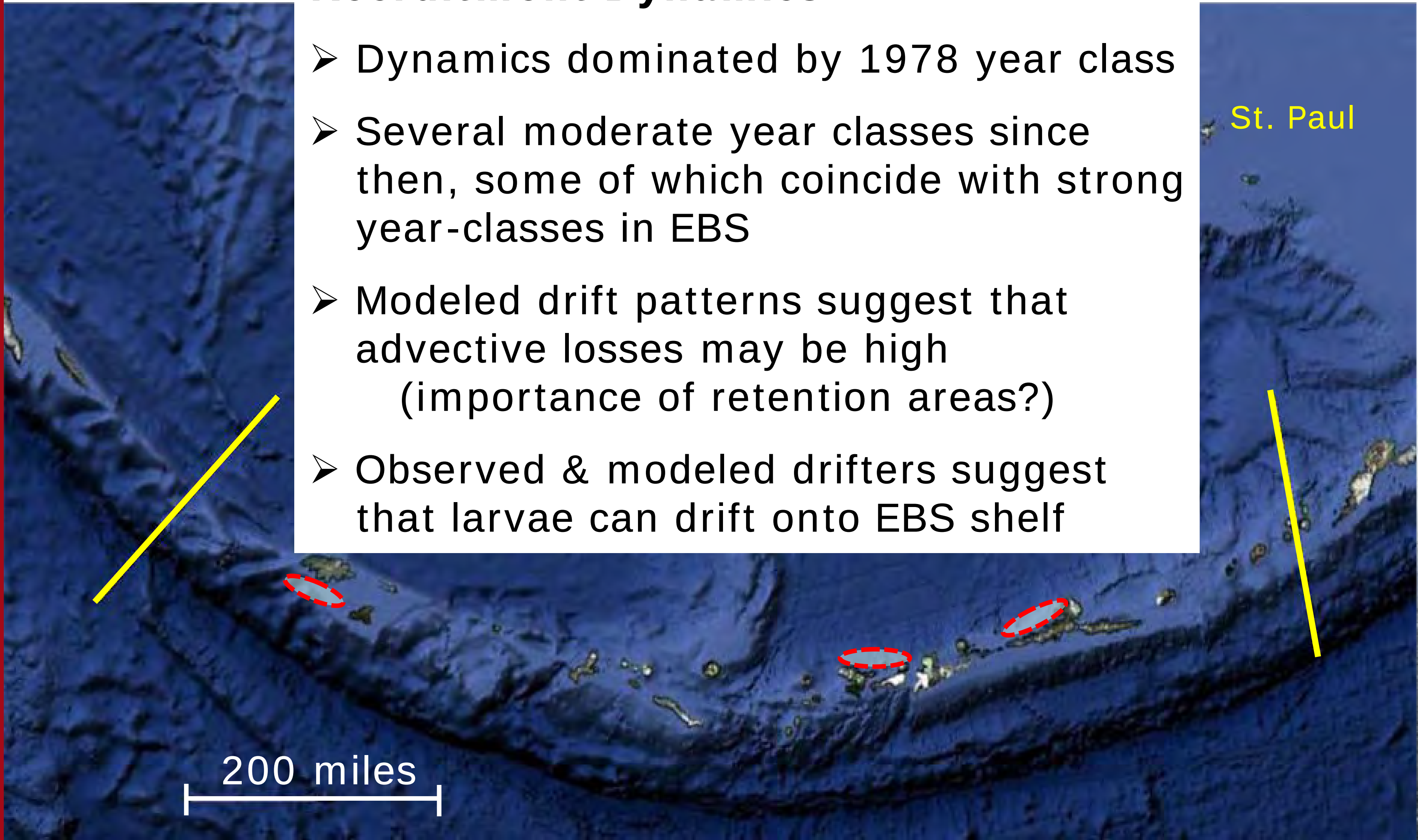
Aleutian Islands



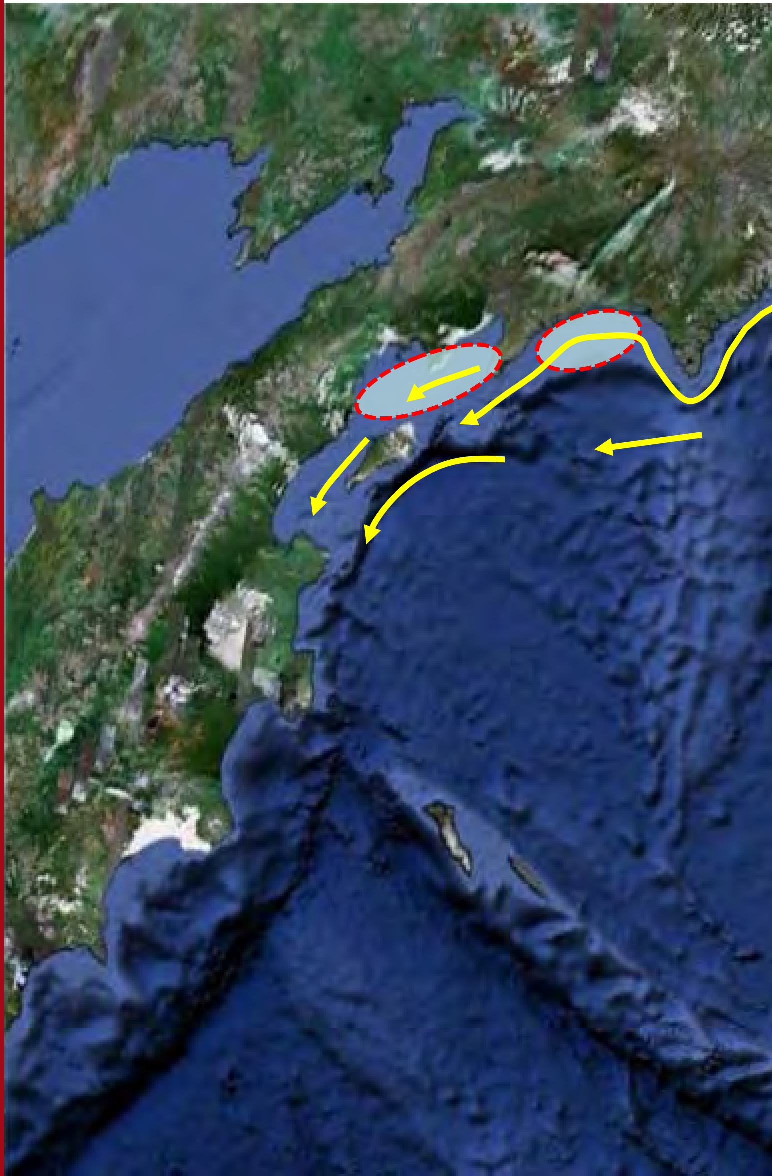
Aleutian Islands

Recruitment Dynamics

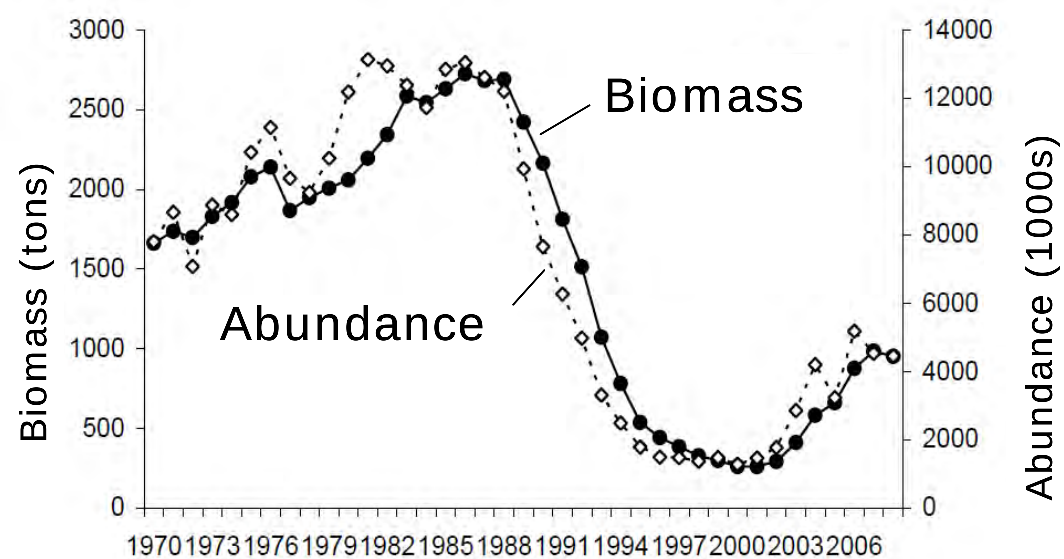
- Dynamics dominated by 1978 year class
- Several moderate year classes since then, some of which coincide with strong year-classes in EBS
- Modeled drift patterns suggest that advective losses may be high
  (importance of retention areas?)
- Observed & modeled drifters suggest that larvae can drift onto EBS shelf



Western Bering Sea

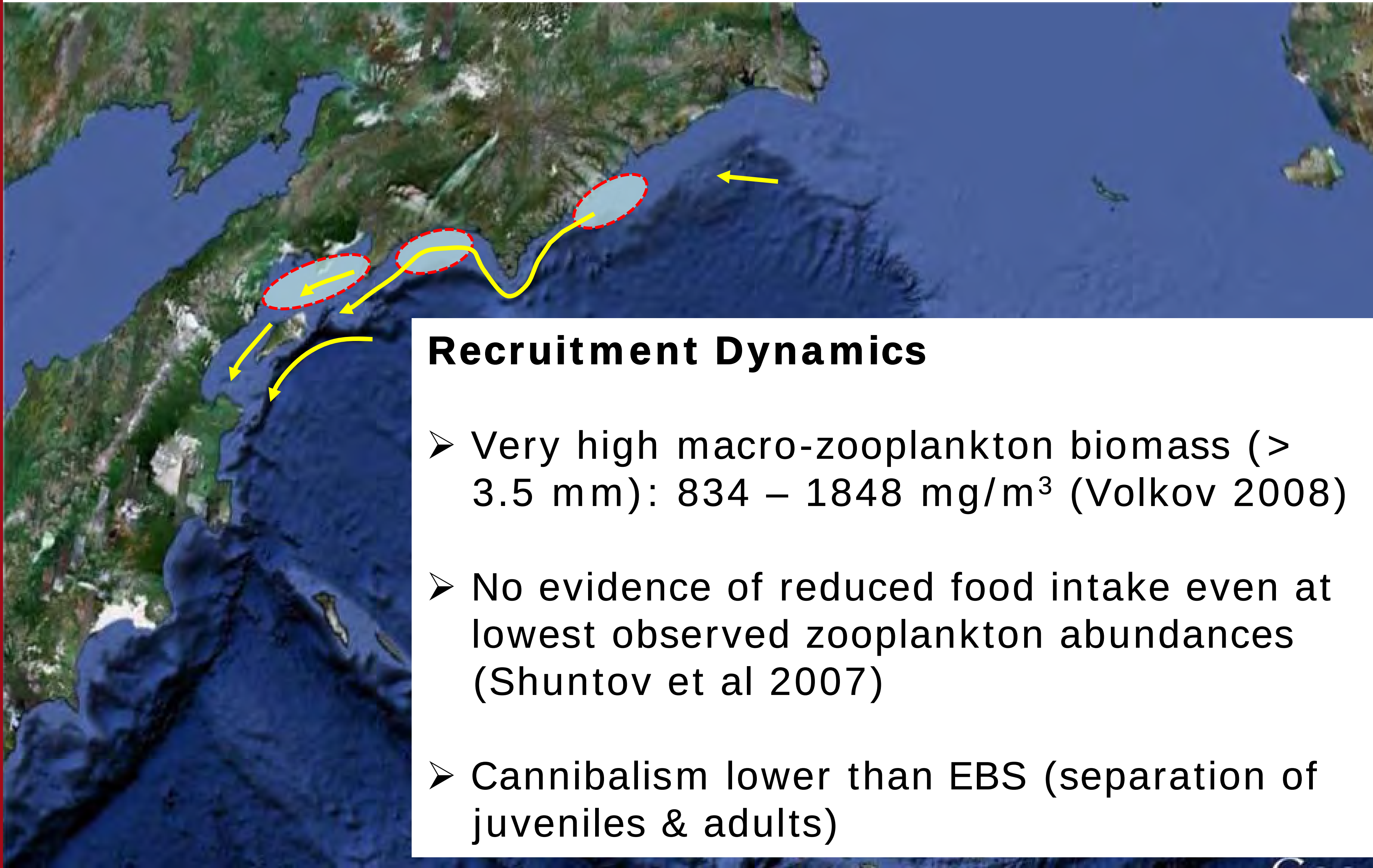


VPA model estimates



- Heavy fishing led to drastic decline in early 1990s
- Fishery closed 2002-06
- Rapid response in biomass

Western Bering Sea



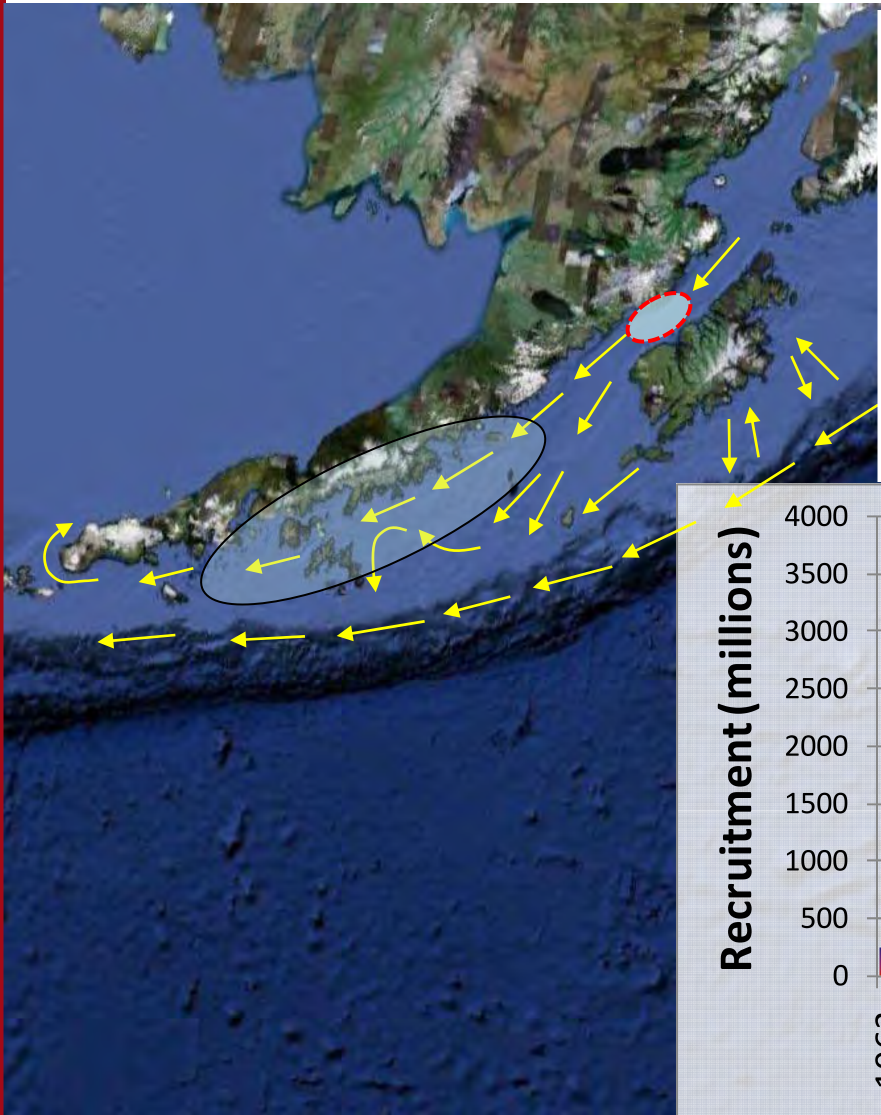
Recruitment Dynamics

- Very high macro-zooplankton biomass (> 3.5 mm): 834 – 1848 mg/m^3 (Volkov 2008)
- No evidence of reduced food intake even at lowest observed zooplankton abundances (Shuntov et al 2007)
- Cannibalism lower than EBS (separation of juveniles & adults)

Other regions

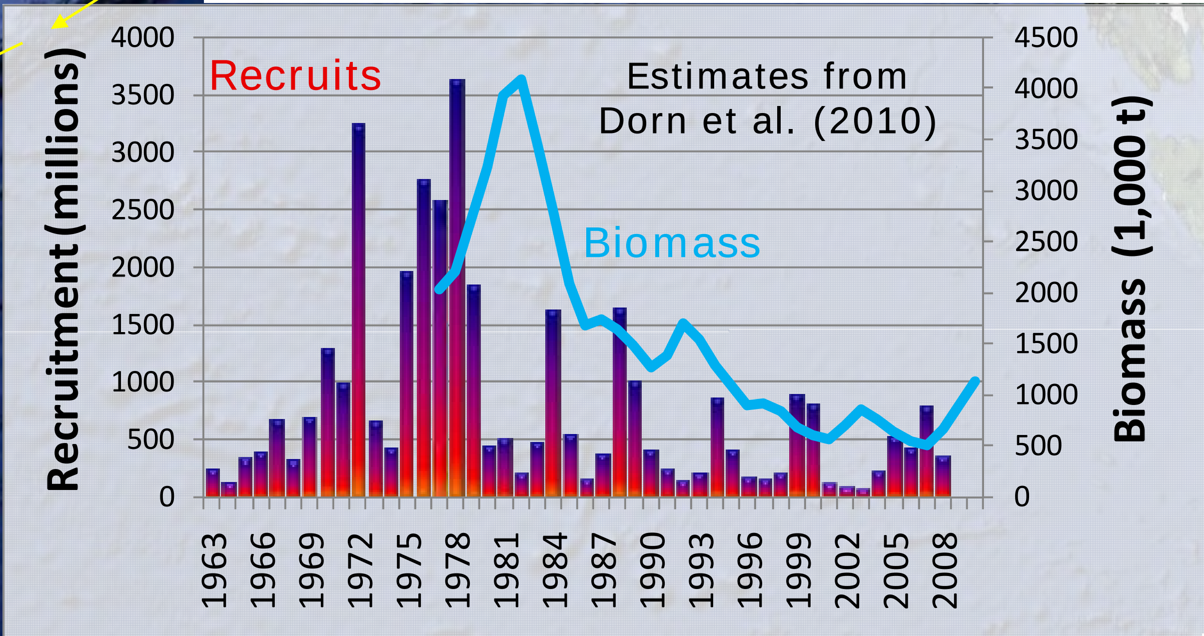
- Gulf of Alaska
- Sea of Okhotsk
- Northern Japan Sea
- Pacific Coast of Japan

Gulf of Alaska



Recruitment Dynamics

- Important role of advection to suitable nursery areas
- Switch from bottom-up control to top-down control (arrowtooth fl.)
- Some strong year classes shared with adjacent regions



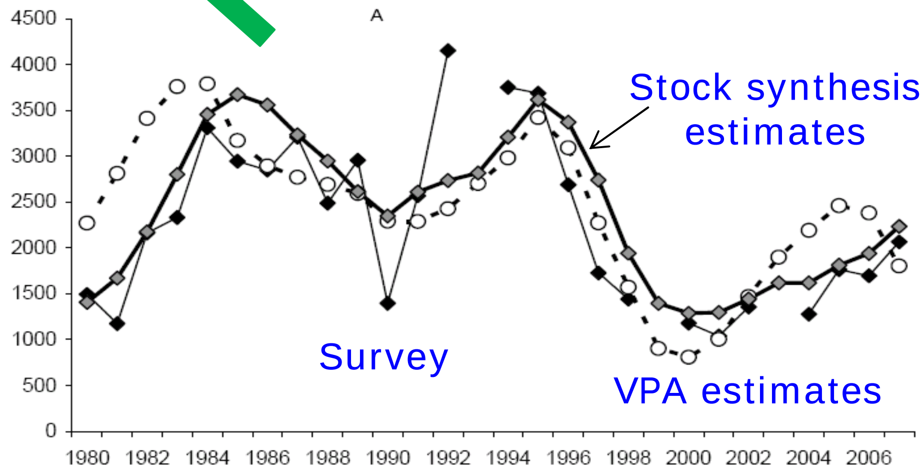
Sea of Okhotsk

Spawning locations

Spawning biomass (W. Kamchatka)

Recruitment trends

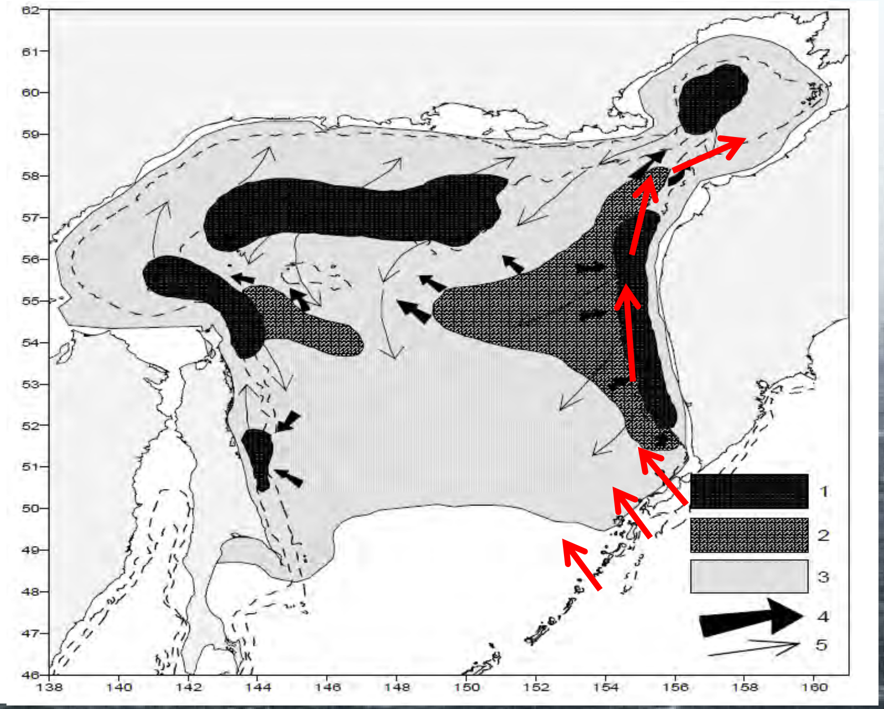
- Strong <u>1978/79</u> year classes
- Strong recruitment in 80s, low in 90s
- Moderately strong: 2000, '02, '04, '05



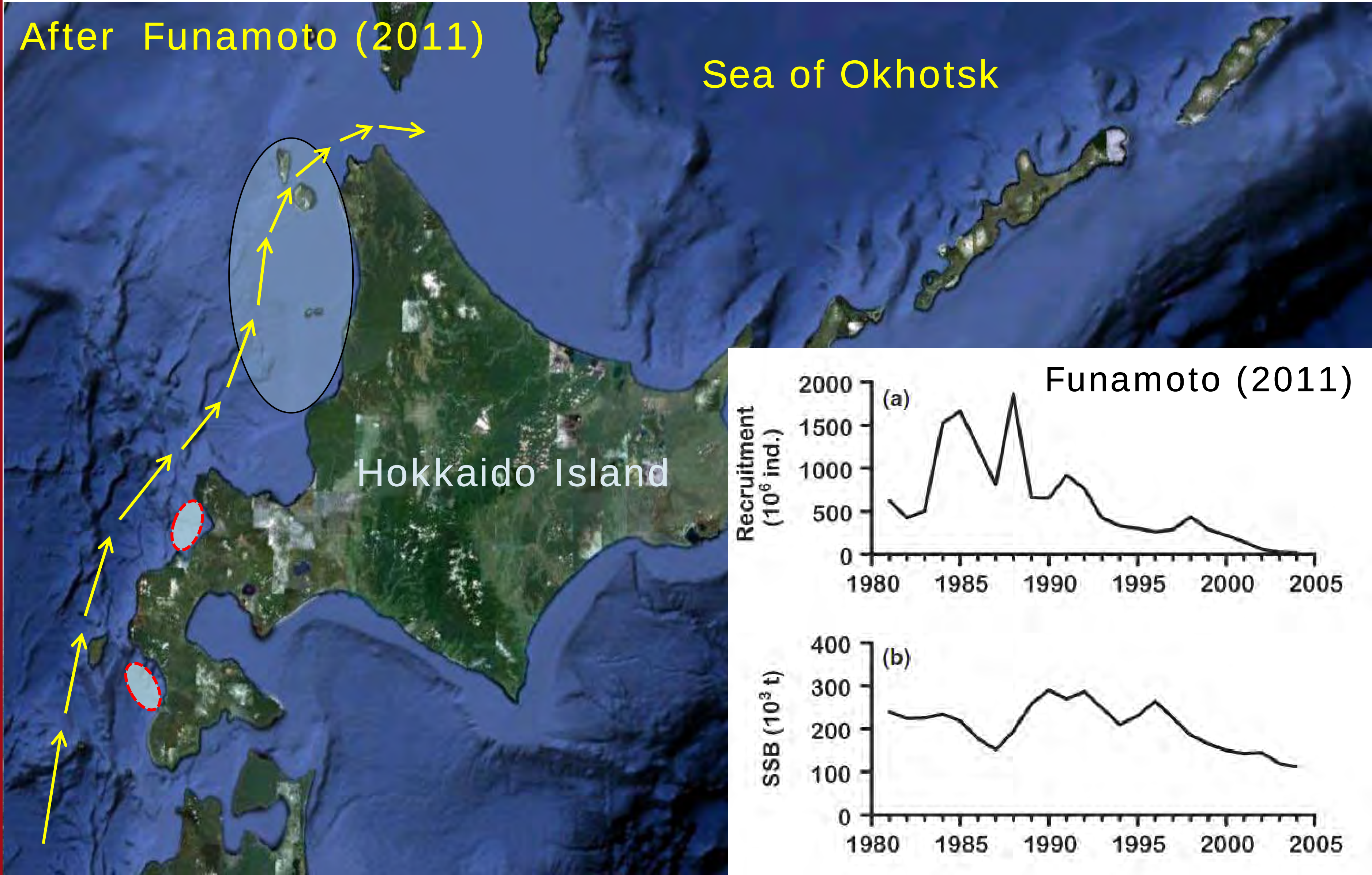
Sea of Okhotsk

Recruitment Dynamics

- Highest juvenile survival in years with:
  - High abundance of zooplankton (especially copepods)
  - Strong northward advection of (warm) Pacific waters
- Strong year classes during both warm and cold years!



Northern Japan Sea



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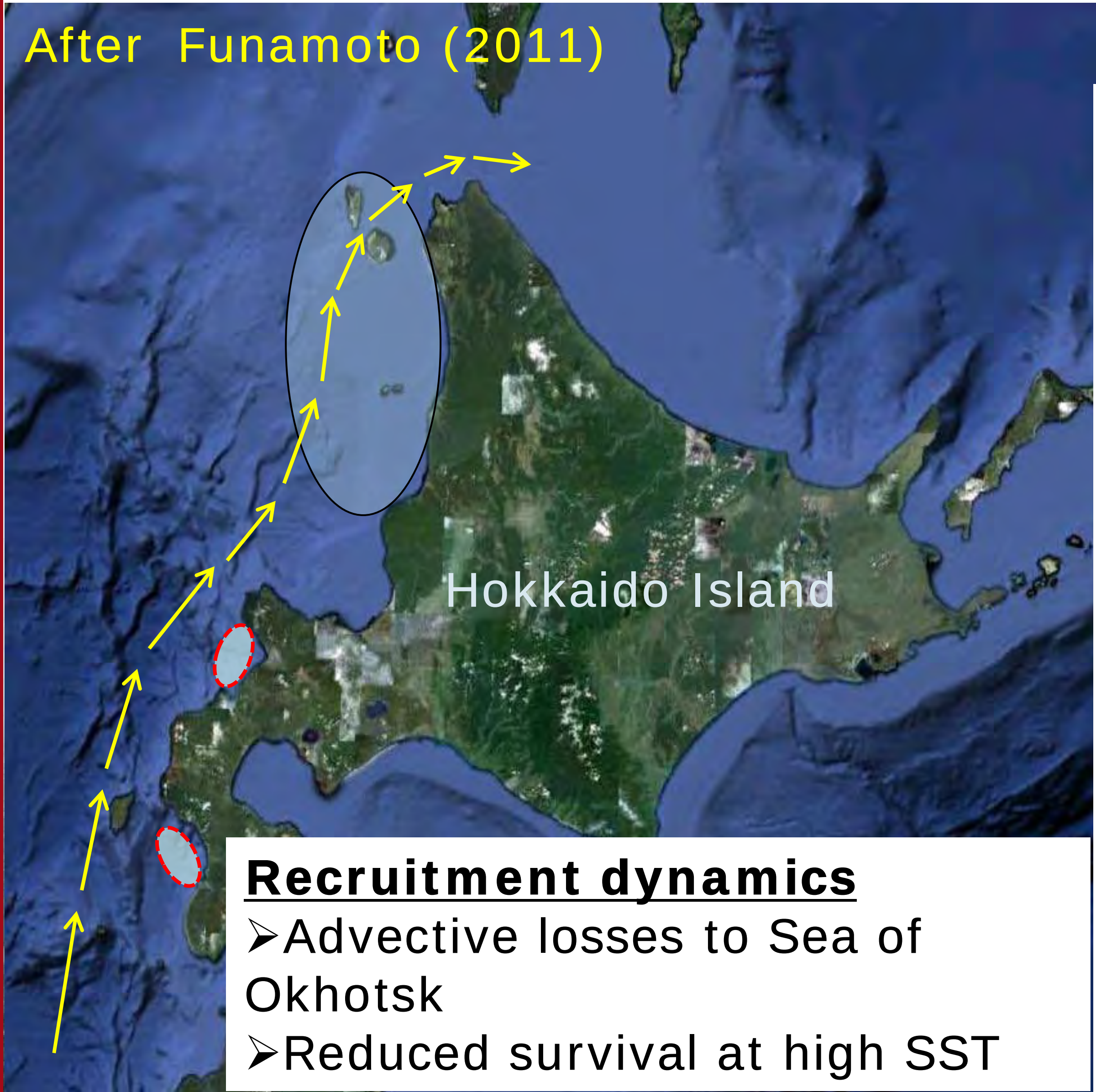
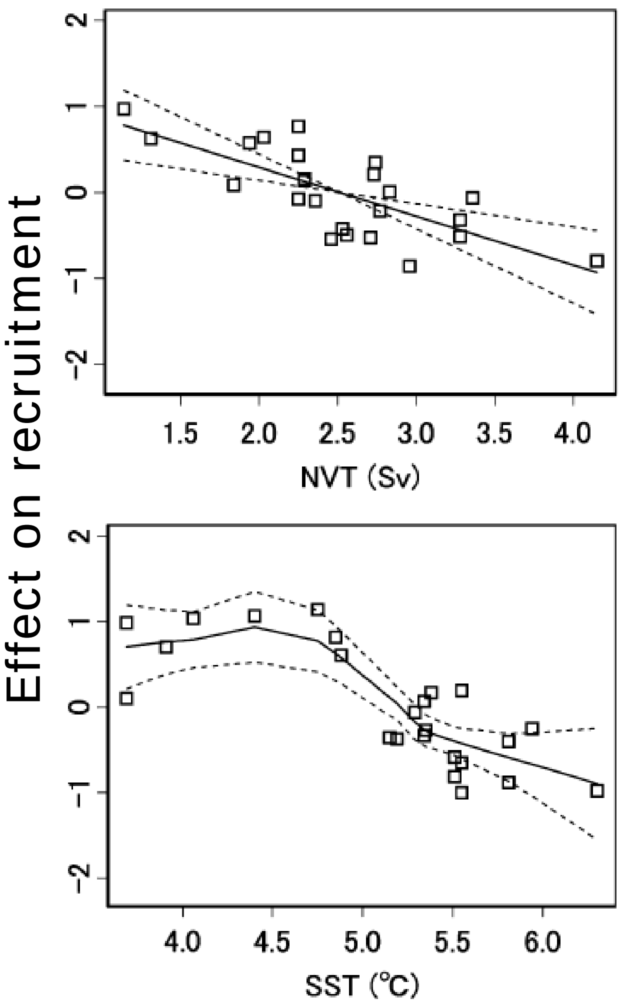
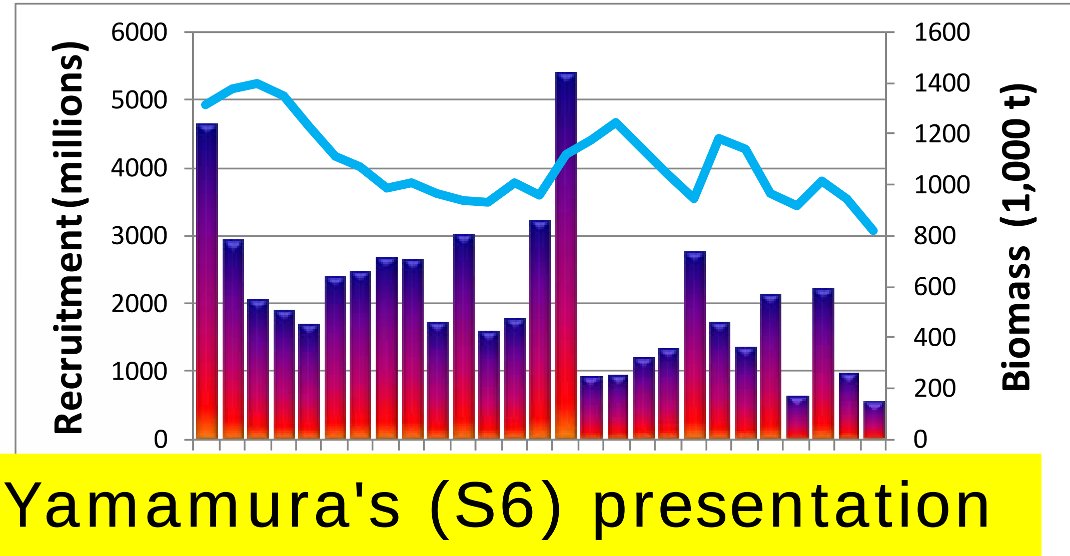




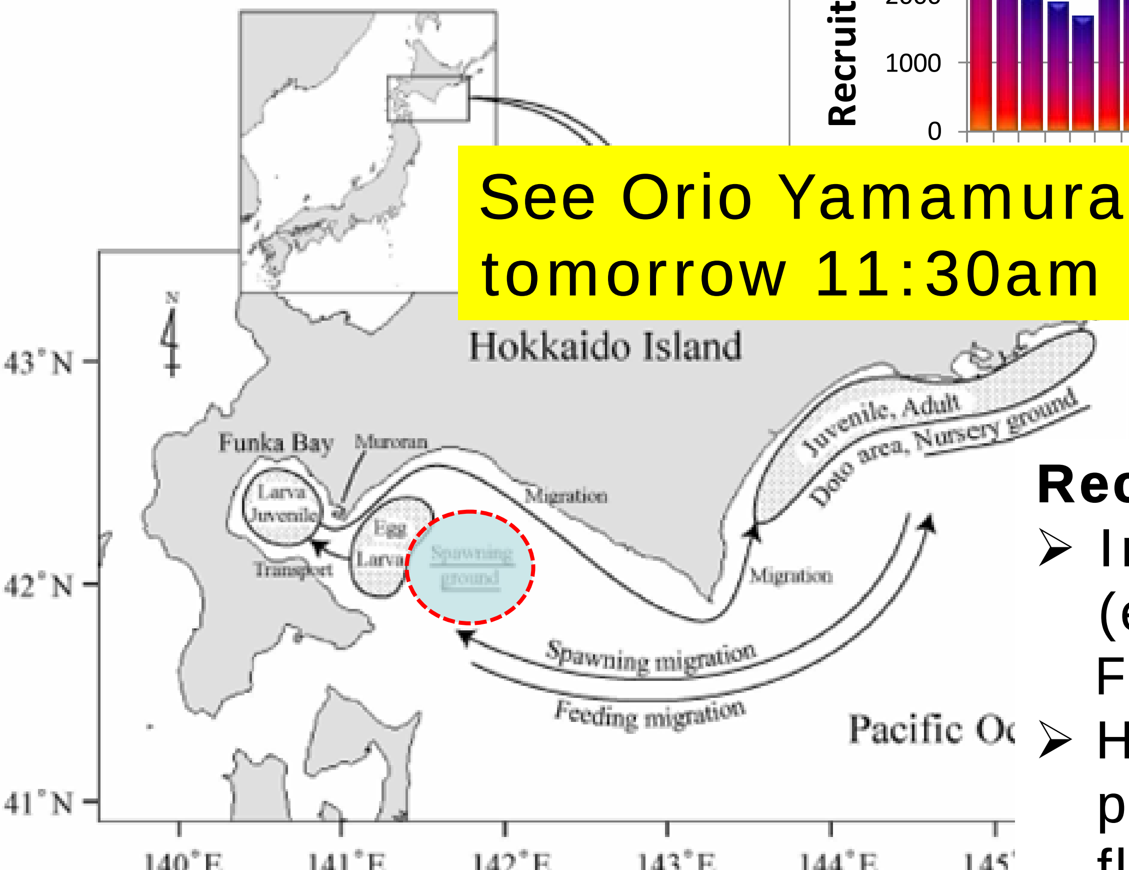
Recruitment dynamics

- ➢Advective losses to Sea of Okhotsk
- ➢Reduced survival at high SST

Japan – Pacific stock



See Orio Yamamura's (S6) presentation tomorrow 11:30am



Recruitment Dynamics

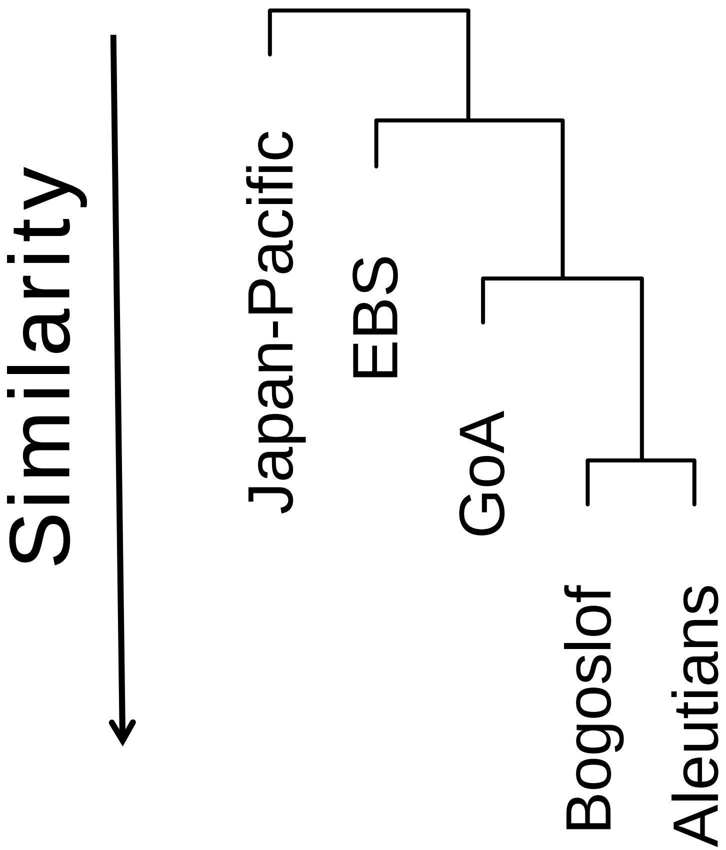
- Important role of advection (egg/larval transport into Funka Bay)
- Heavy cannibalism & predation by Kamchatka flounder & Pacific cod

Recruitment series
Spearman rank correlations

	EBS	Bogoslof	Aleutian Islands	Gulf of Alaska	Japan - Pacific
EBS					
Bogoslof	**0.480**				
AI	0.310	**0.680**			
GoA	0.240	**0.490**	**0.540**		
Japan - Pacific	-0.010	0.210	0.350	0.270	

P < 0.05

Recruitment-based clustering



Summary

Stock	Bottom-up controls	Top-down controls	Resilience	Outlook (short / long)
Eastern Bering Sea	Temp.-mediated prey availability	Predation strong in warm years	Moderate	↑ ↓
Bogoslof / Basin	? (immigration)	?	Low	↓ ↓
Aleutian Islands	(retention?)	?	Moderate	↔ ?
Western Bering Sea	?	Strong	High	↑ ?
Gulf of Alaska	Advection	Strong	Moderate	↑ ?
Sea of Okhotsk	**Advection Prey availability**	**Weak**	**High**	**↑ ↑**
N. Japan Sea	Advection SST	Weak	Low	↓ ↓
Japan – Pacific	Advection	Strong (Cannib + predation)	Moderate	? ?

Summary

Stock	Bottom-up controls	Top-down controls	Resilience	Outlook (short / long)
Eastern Bering Sea	Temp.-mediated prey availability	Predation strong in warm years	Moderate	↑ / ↓
Bogoslof / Basin	? (immigration)	?	Low	↓ / ↓
Aleutian Islands	(retention?)	?	Moderate	↔ / ?
Western Bering Sea	?	Strong	High	↑ / ?
Gulf of Alaska	Advection	Strong	Moderate	↑ / ?
Sea of Okhotsk	Advection Prey availability	Weak	High	↑ / ↑
N. Japan Sea	Advection SST	Weak	Low	↓ / ↓
Japan – Pacific	Advection	Strong (Cannib + predation)	Moderate	? / ?

Conclusions

- Walleye pollock in the North Pacific form a number of loosely connected meta-populations (e.g. Bailey et al 1989)
- Strong year classes typically every 4-6 years
- Synchronous strong recruitment through much of North Pacific in the late 1970s (1978)
  - Little evidence of basin-wide synchrony since then
  - Moderate to strong synchrony within NE Pacific
  - Pattern of declining strength of large year classes
- Largest populations in areas with broad shelf and moderate currents
  - Eastern Bering Sea & Sea of Okhotsk

Conclusions (cont'd)

- Advective processes critical to recruitment success in most regions
  - Retention / Transport to suitable nursery areas
- Evidence of prey limitation (low copepod abundances) in some years
  - Eastern Bering Sea & Sea of Okhotsk
- Strong potential for top-down limitation
  - e.g. Gulf of Alaska, Japan and possibly others
- Recent warming associated with reduced recruitment in several regions
  - Japan Sea, Eastern Bering Sea

Proposed hypothesis

- **Major perturbation of the 1976/77 regime shift allowed an "outburst" of walleye pollock throughout the North Pacific following one or several "super-abundant" year classes**
- **As communities adapted to the new regime, pollock have been subjected to more efficient predation and the magnitude of subsequent recruitment peaks has diminished over time and may continue to diminish in some systems**

Bering Sea

Acknowlegements

- Funding: North Pacific Research Board
- BEST/BSIERP investigators