The impact of environmental variability on the effectiveness of fisheries management strategies

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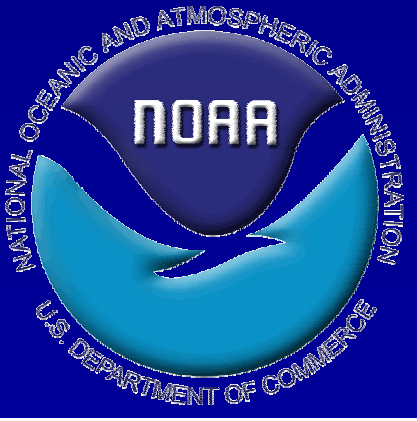

Goals of this presentation

- Alaska groundfish stock assessments that incorporate information on environmental variability
- Management measures given our understanding of how environmental variability affects stocks

Assessments that incorporate information on environmental variability

- Temperature and flatfish catchability
- Transport and pollock recruitment
- Environmentally-based pollock year class forecast

E. Bering Sea and Gulf of Alaska

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Catchability (q)

$$B_s = N \times w \times s_s \times q$$

B_s = survey biomass

N x w = population biomass

s_s = survey catchability (or selectivity)

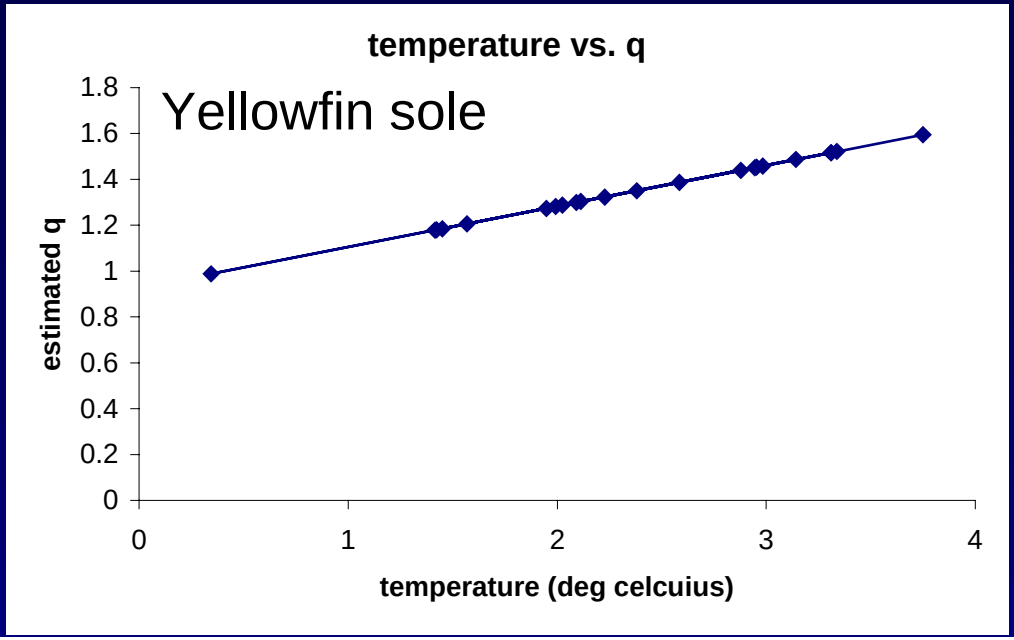
q = catchability (or availability)

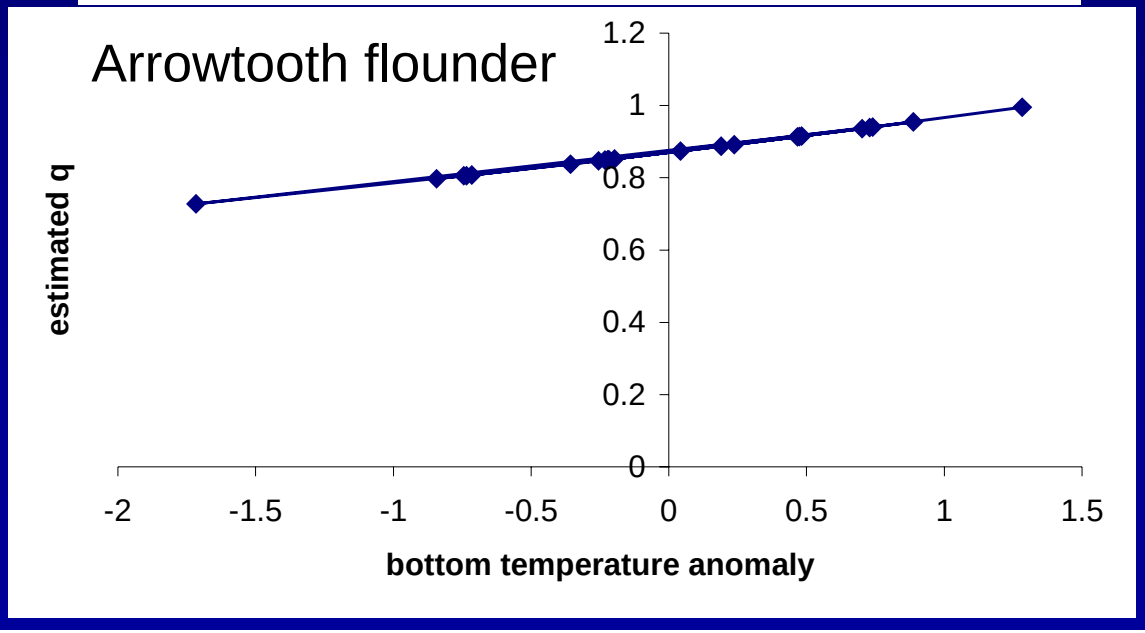
Catchability is related to temperature

Eastern Bering Sea

Mechanism(s):

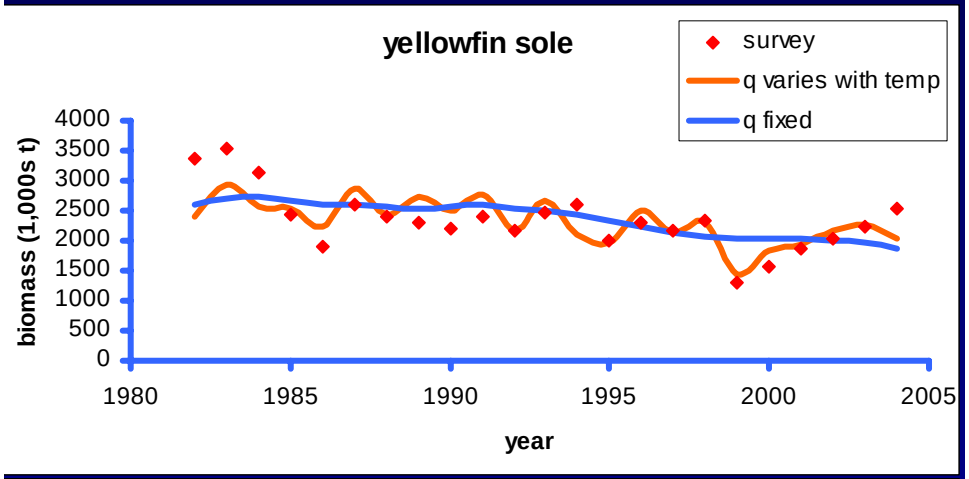
- stock distribution (Spencer)
- activity level of fish

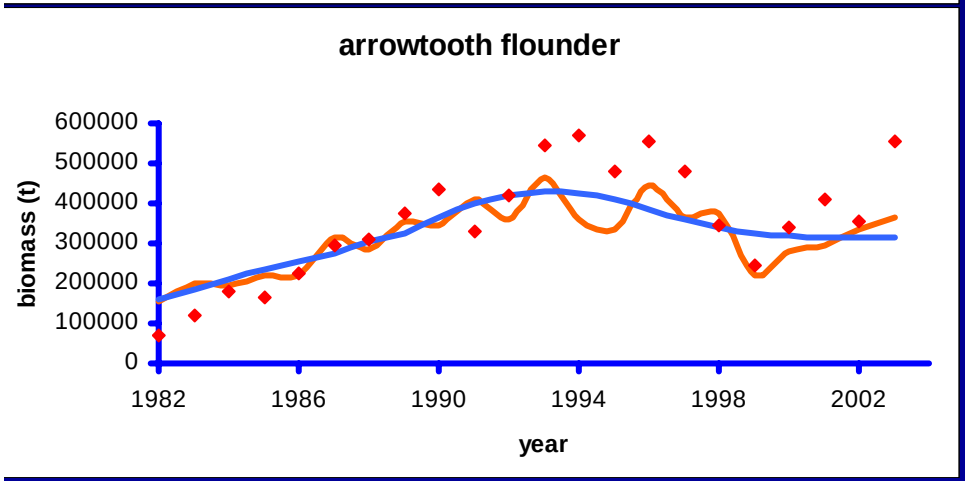


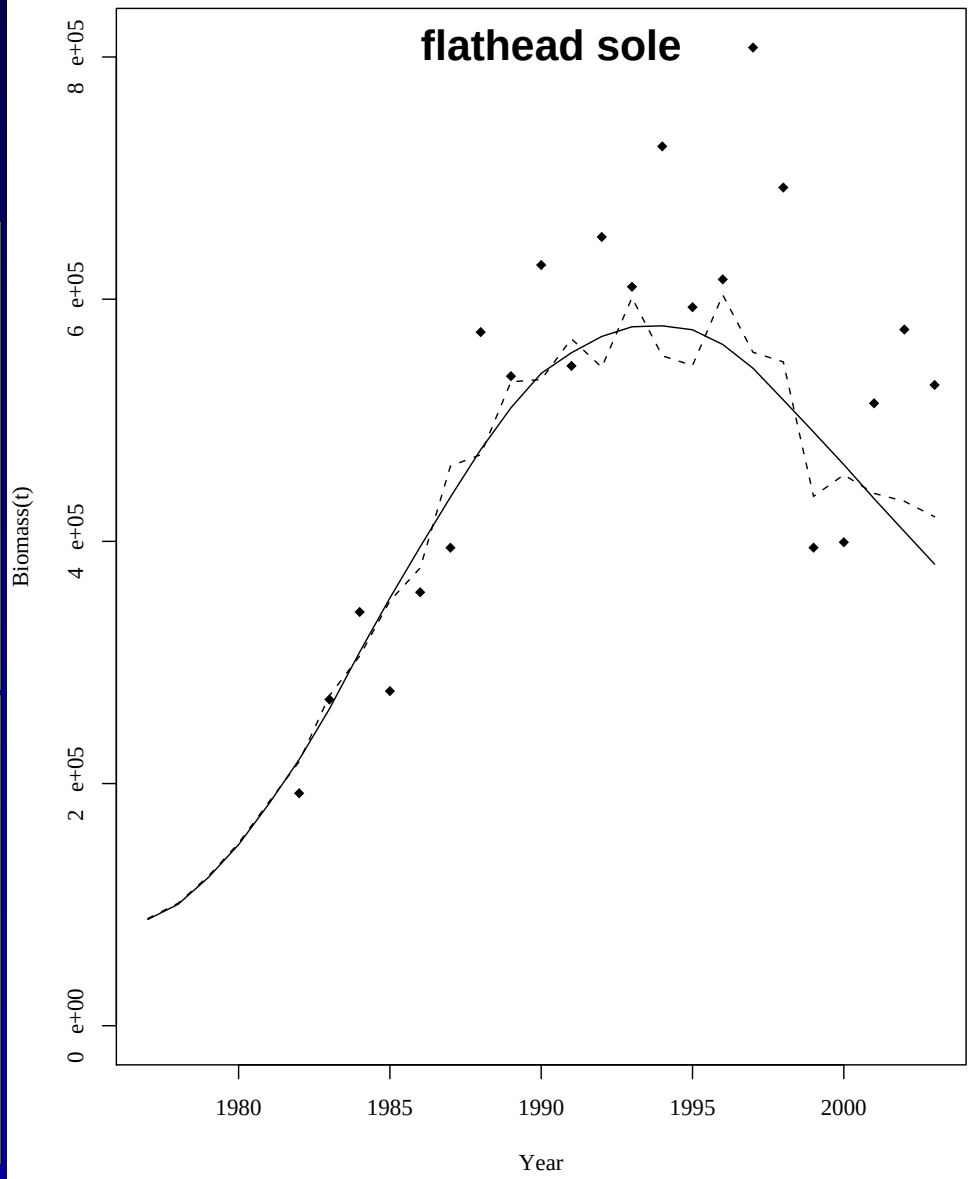


Survey biomass model improved with catchability (q) as a function of temperature

Eastern Bering Sea flatfish
(Wilderbuer and Spencer)







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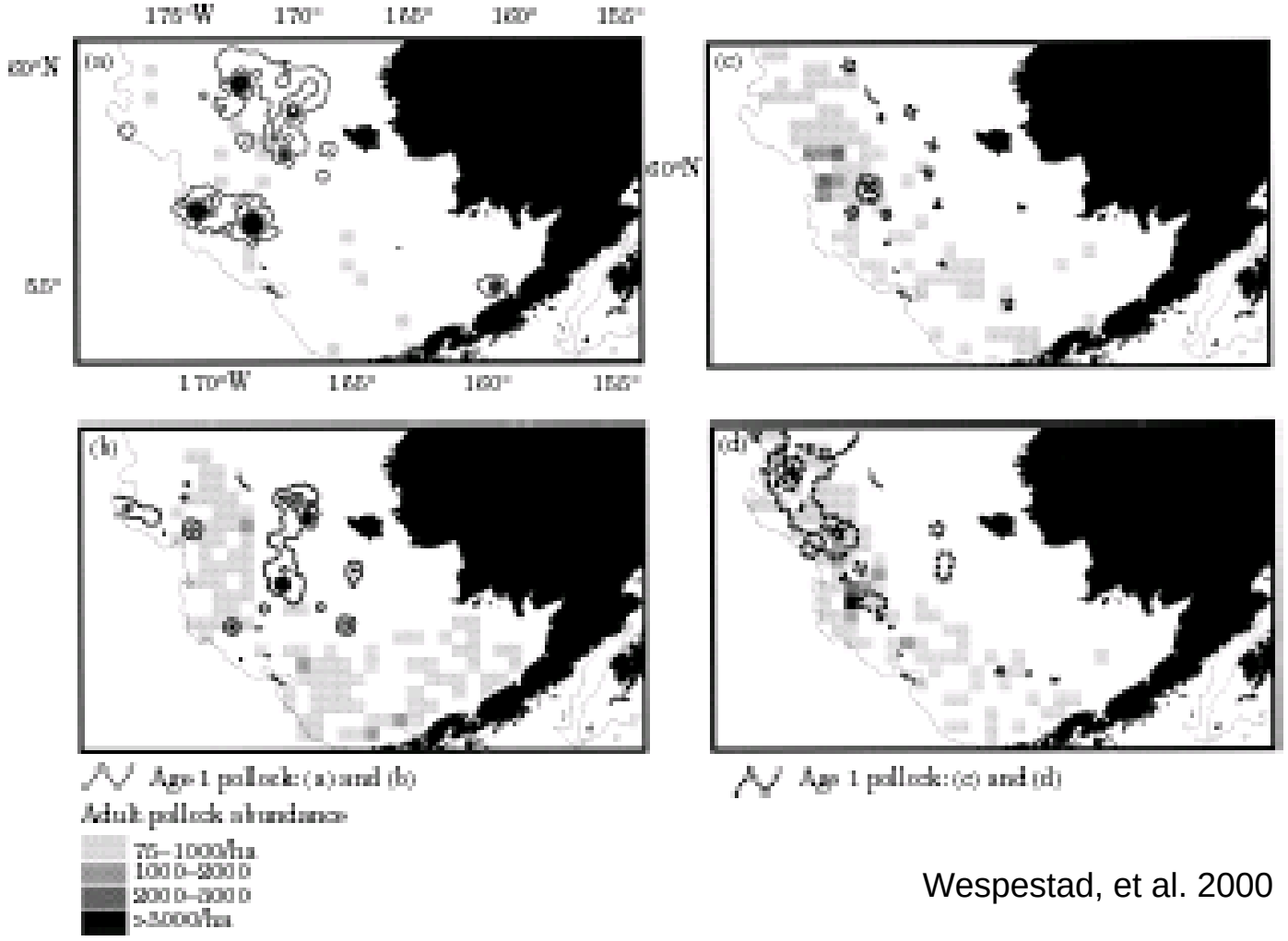
Conceptual model: Transport and cannibalism

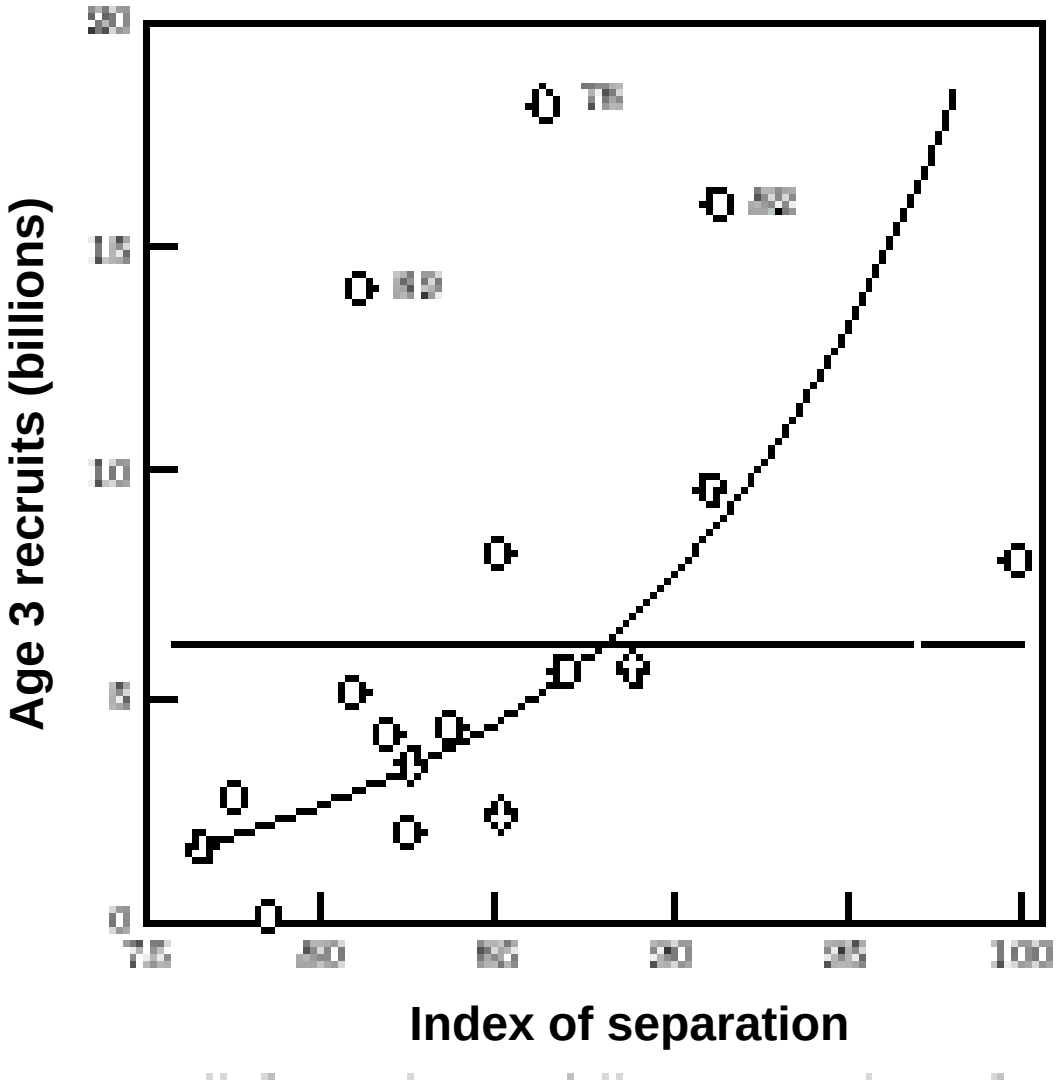
Strong year class

Weak year class



Wespestad, et al. 2000

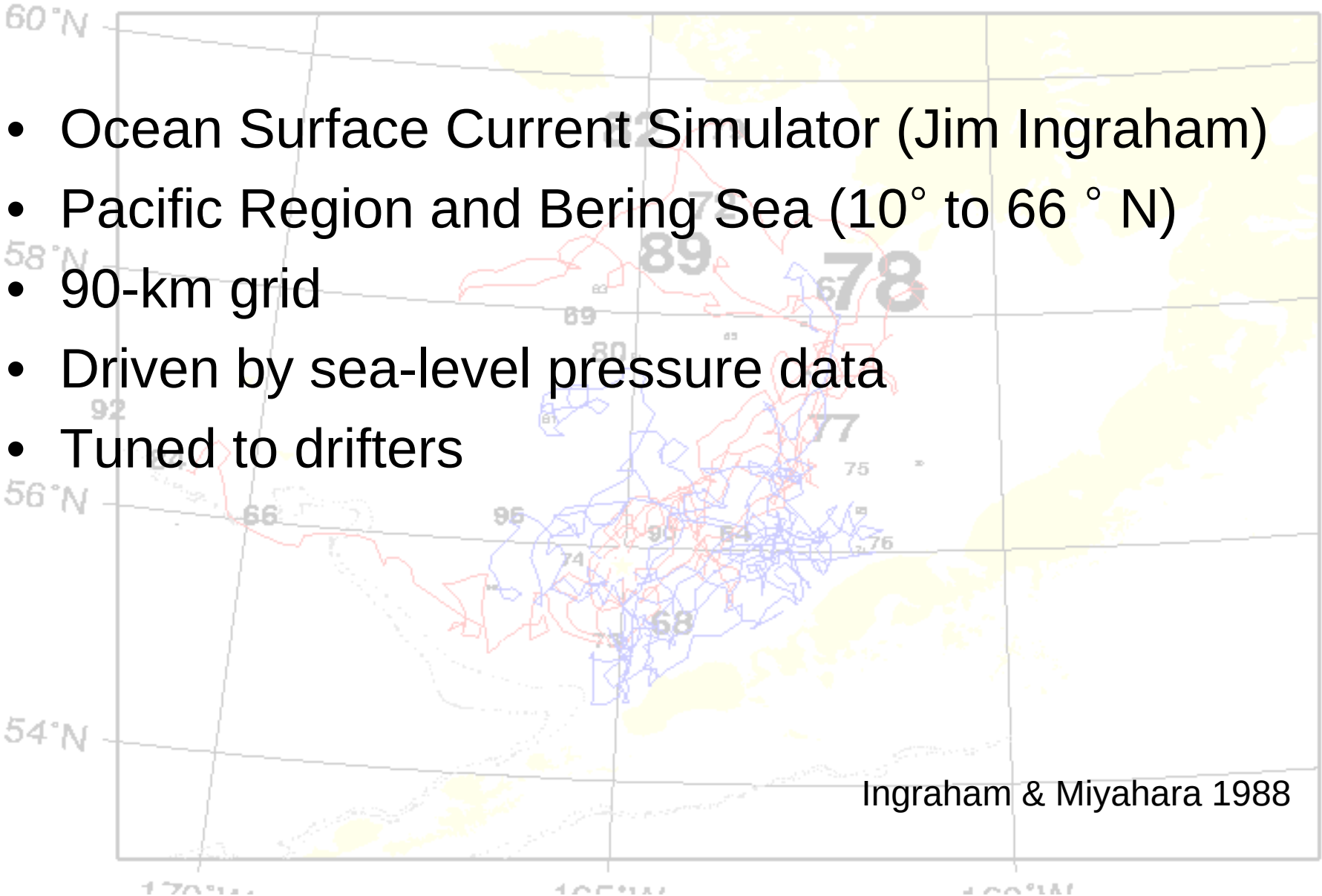
Conceptual model: Transport and cannibalism



Wespestad, et al. 2000

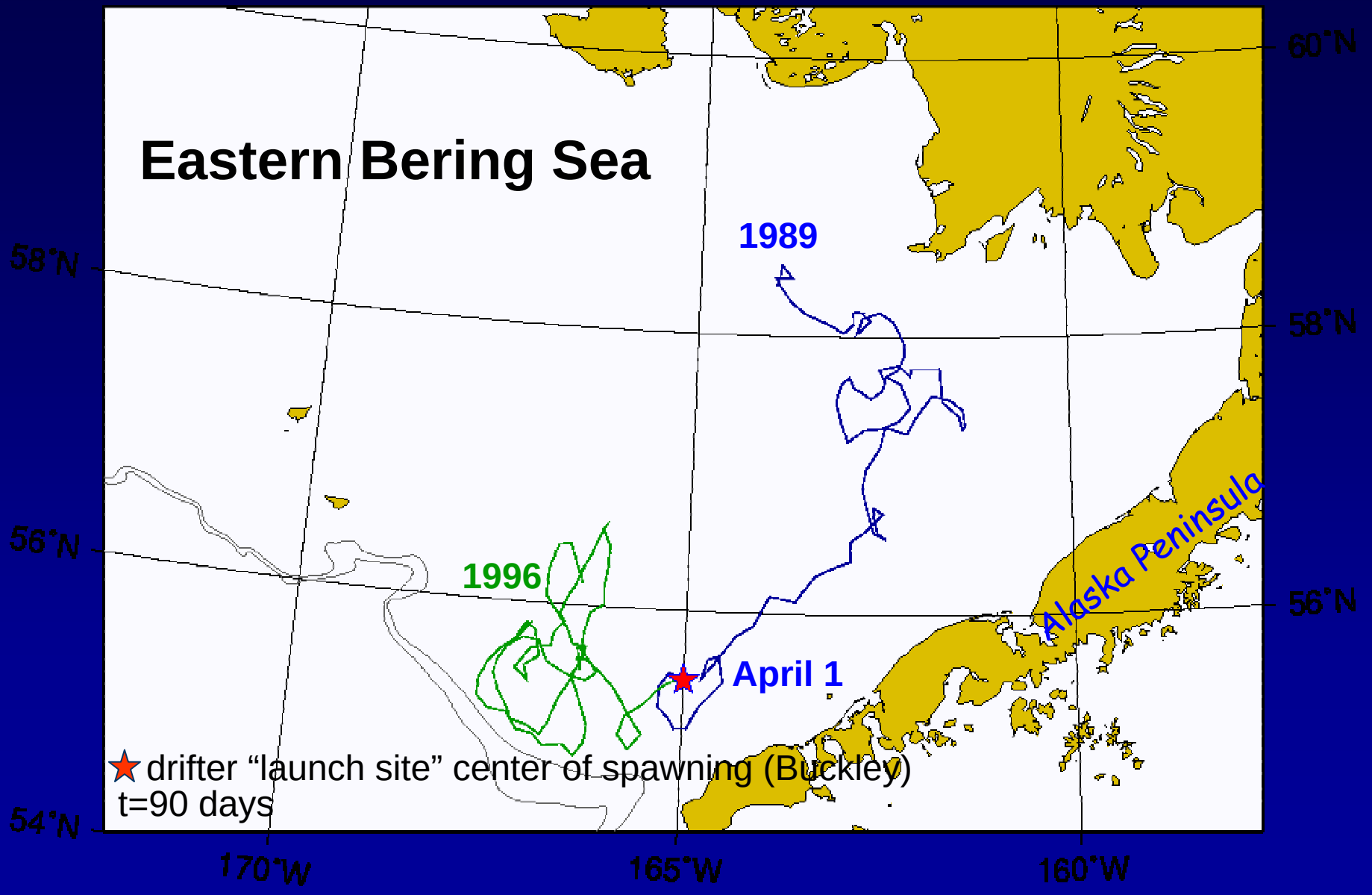
OSCURS

- Ocean Surface Current Simulator (Jim Ingraham)
- Pacific Region and Bering Sea (10° to 66 ° N)
- 90-km grid
- Driven by sea-level pressure data
- Tuned to drifters

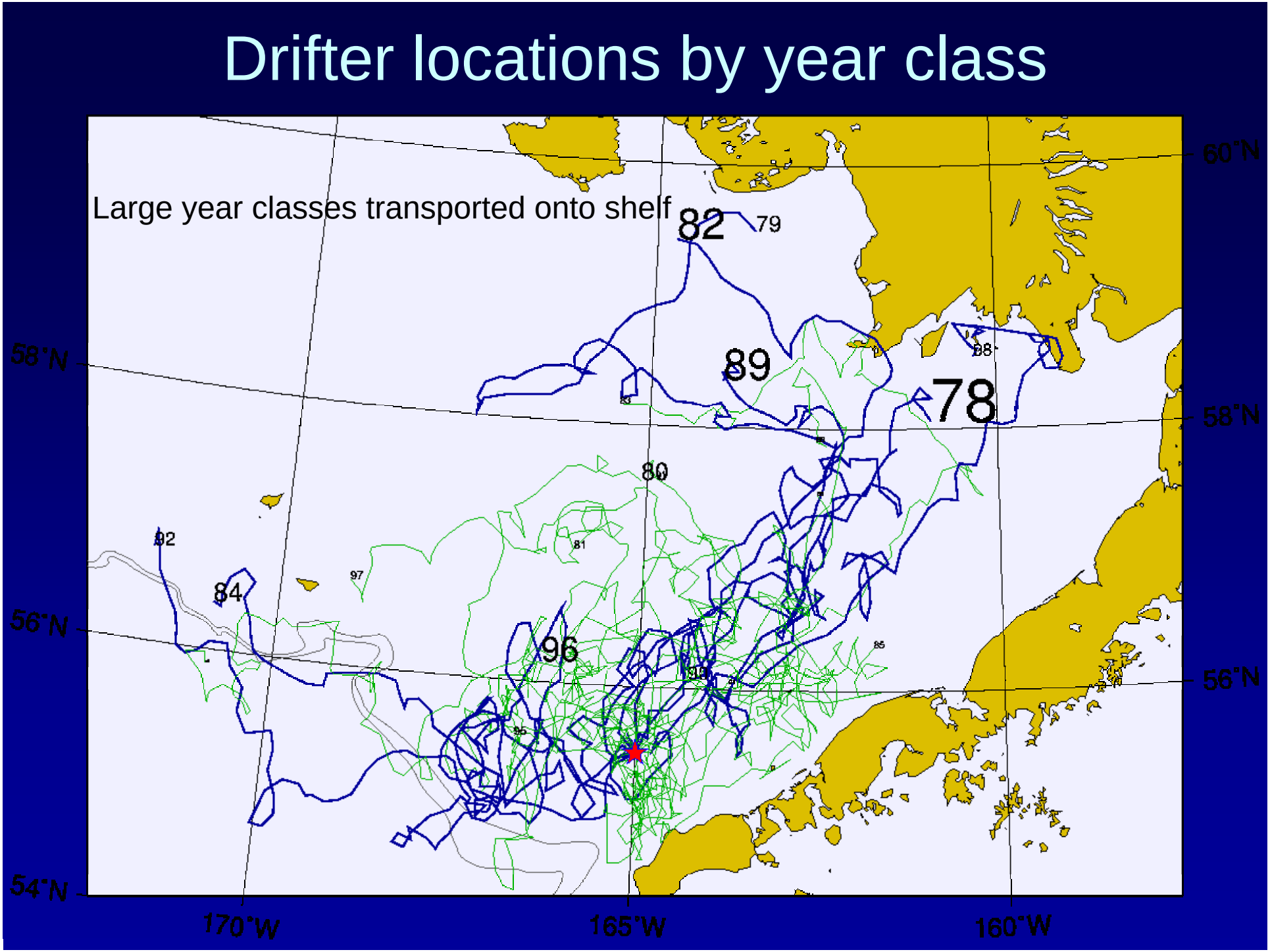


Ingraham & Miyahara 1988

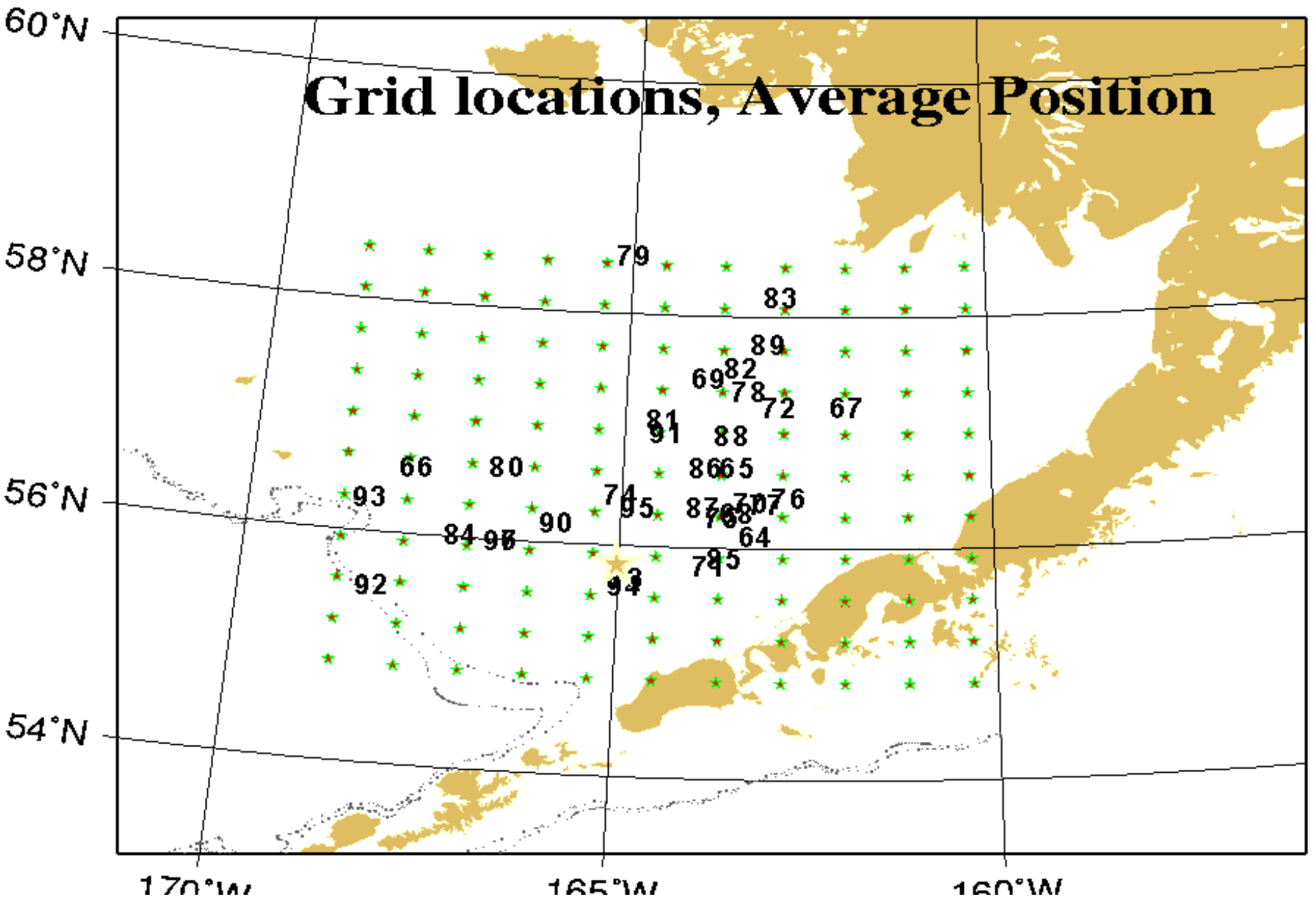
OSCURS – Transport from spawning site



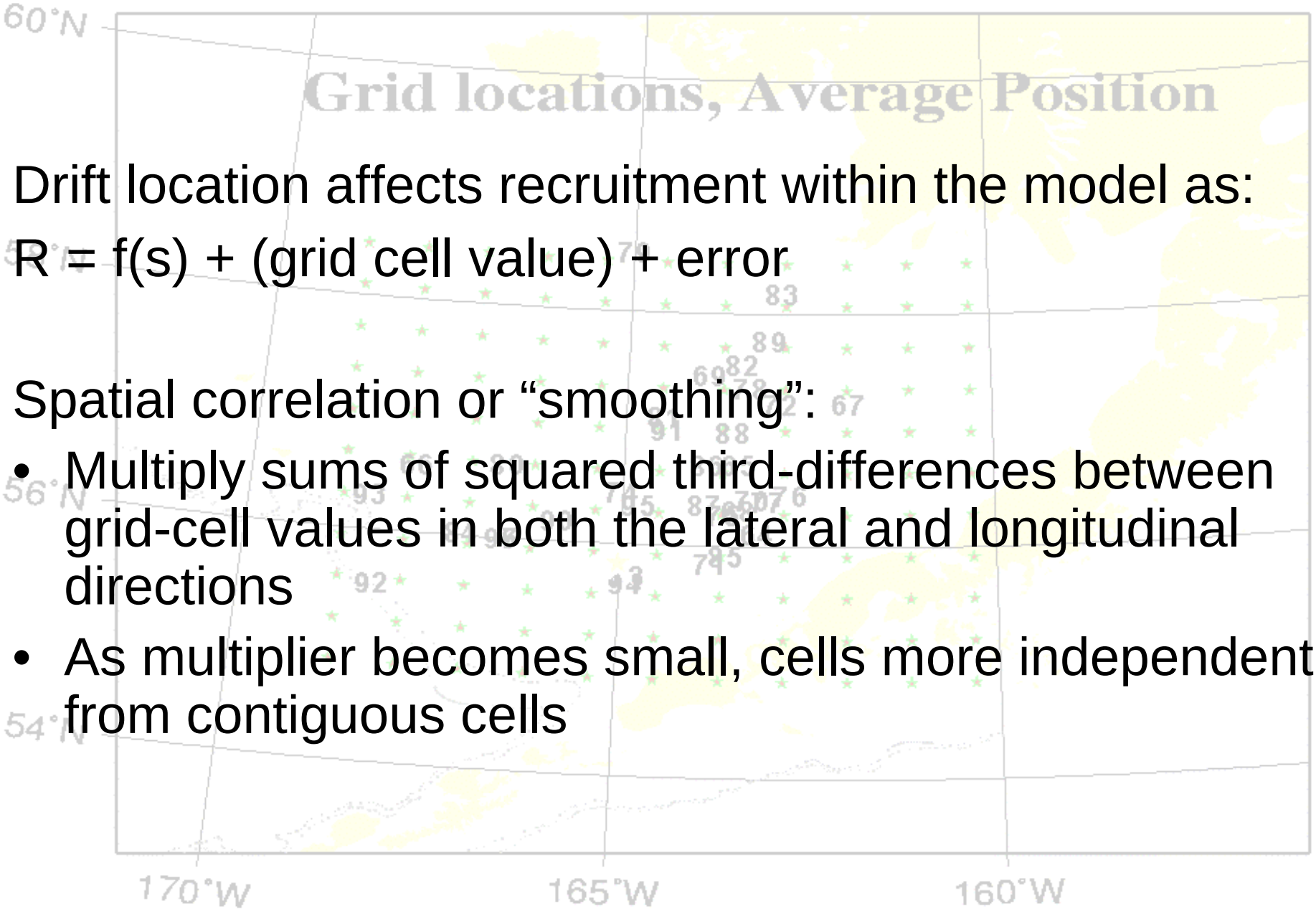
Drifter locations by year class



Grid cell estimation



Grid cell estimation



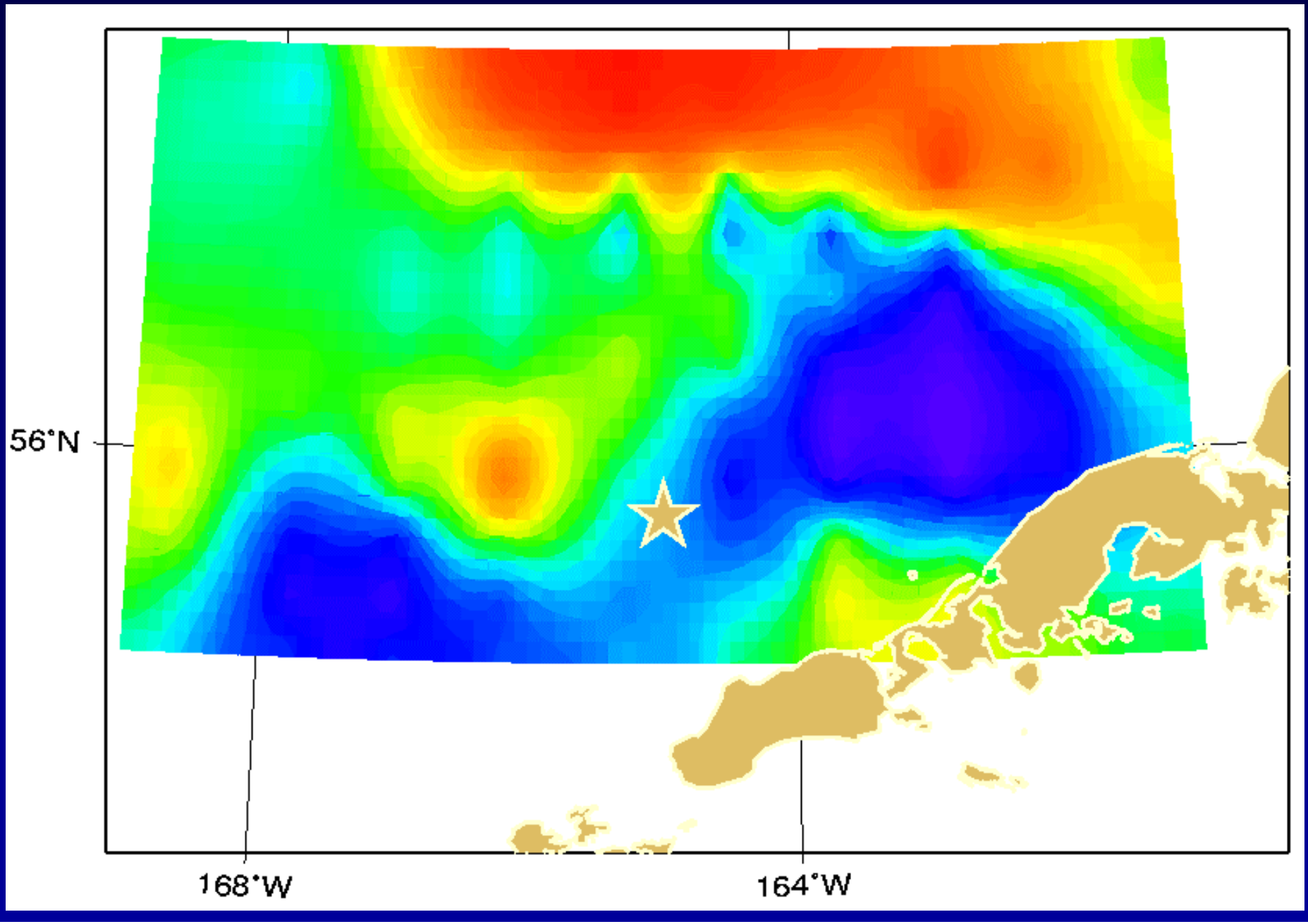
Drift location affects recruitment within the model as:

R = f(s) + (grid cell value) + error

Spatial correlation or “smoothing”:

- Multiply sums of squared third-differences between grid-cell values in both the lateral and longitudinal directions
- As multiplier becomes small, cells more independent from contiguous cells

Recruitment success



Assessments that incorporate information on environmental variability

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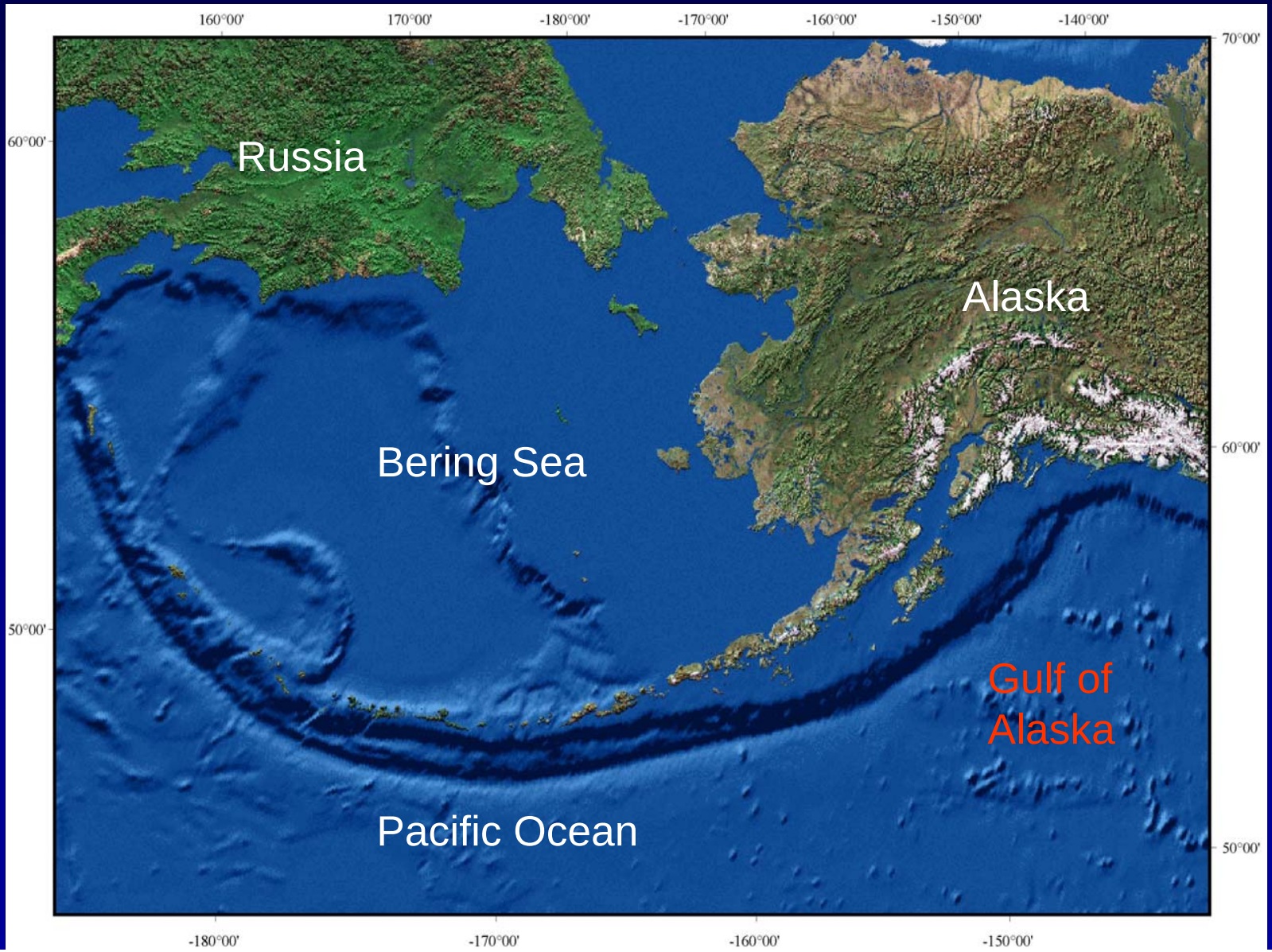
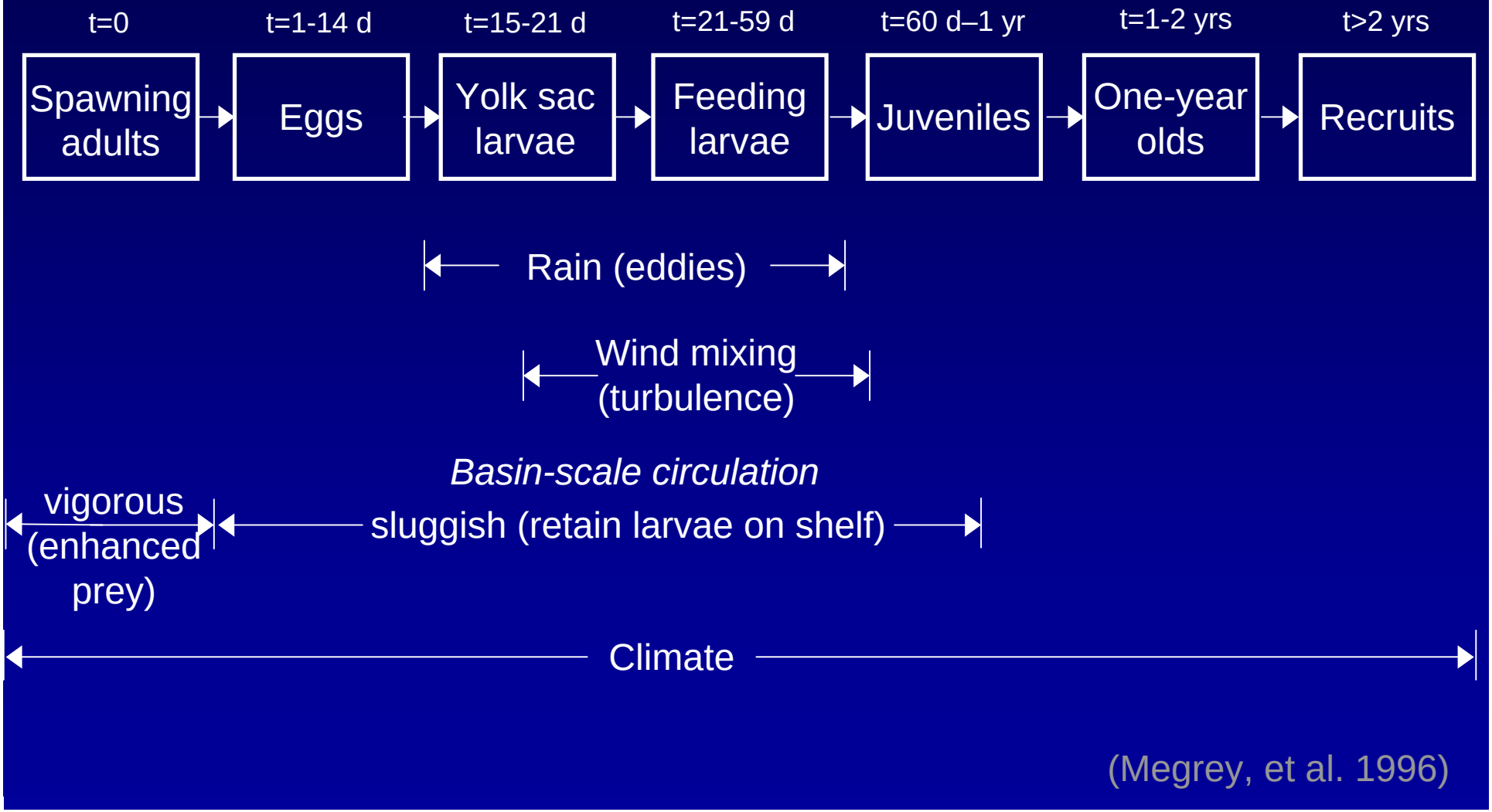
E. Bering Sea and Gulf of Alaska



FOCI year class prediction
Gulf of Alaska pollock



(Megrey, et al. 1996)

Data

1. Monthly precipitation
2. Wind-mixing energy (sea-level pressure)
3. Advection (drifters)
4. Pollock larvae counts (survey)
5. Age-2 pollock abundance (assessment)

2003 year class prediction
Scores: 1(weak) – 3(strong)

Element	*Score*
Precipitation	2.24
Wind-mixing	2.15
Advection	2.00
Larval index	2.33
Age-2 abundance	2.34
Mean	**2.21**

Prediction accuracy (1992-2002)

Year	Forecast	Observed
1992	S	W
1993	A	W
1994	A	A-S
1995	A-S	W-A
1996	A	W
1997	A	W
1998	A	W-A
1999	A	S
2000	A	A-S
2001	A-S	W
2002	W-A	W
2003	A	Available 2005

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Management measures

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- Automatic re-building
- Thresholds for predator-prey interactions
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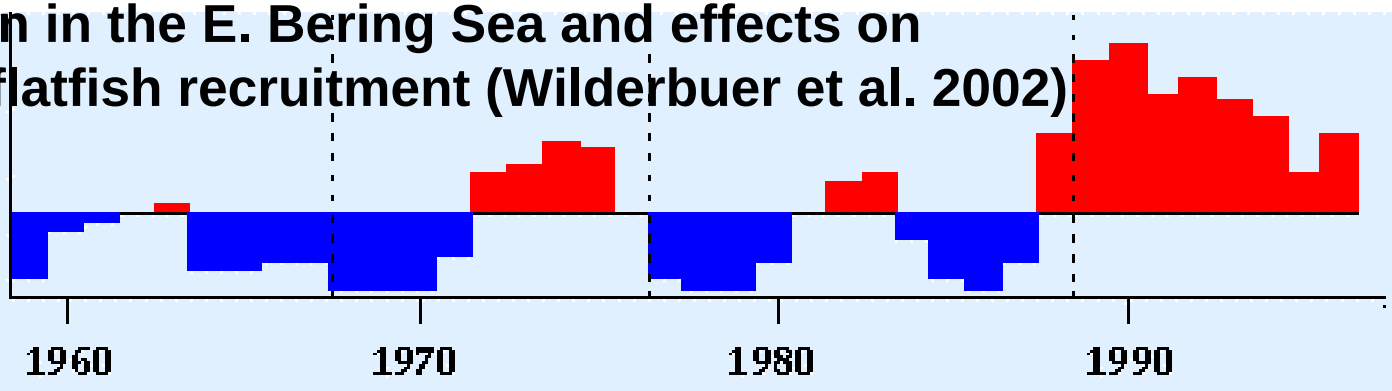
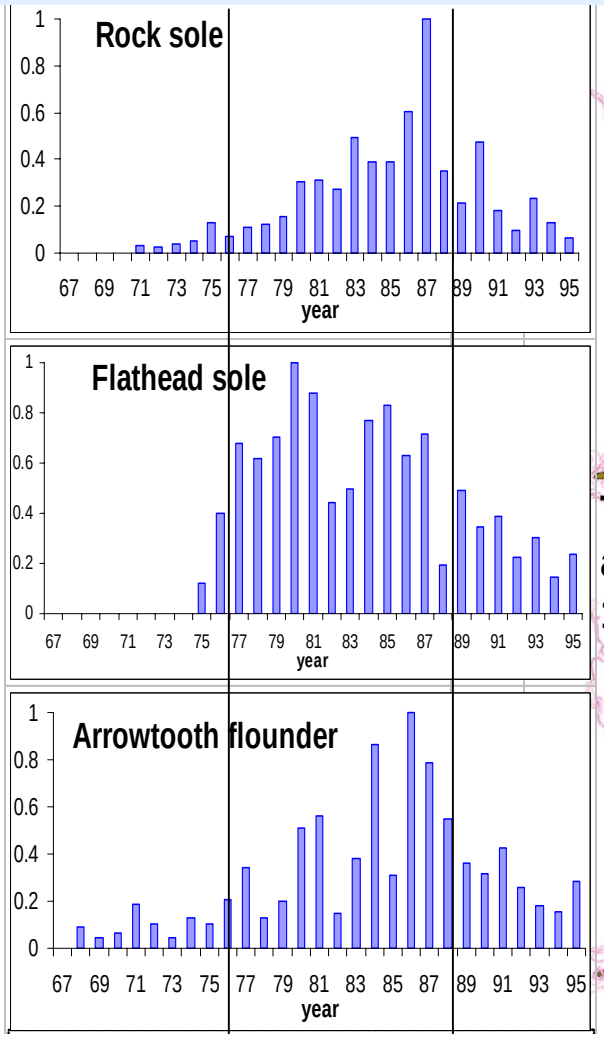
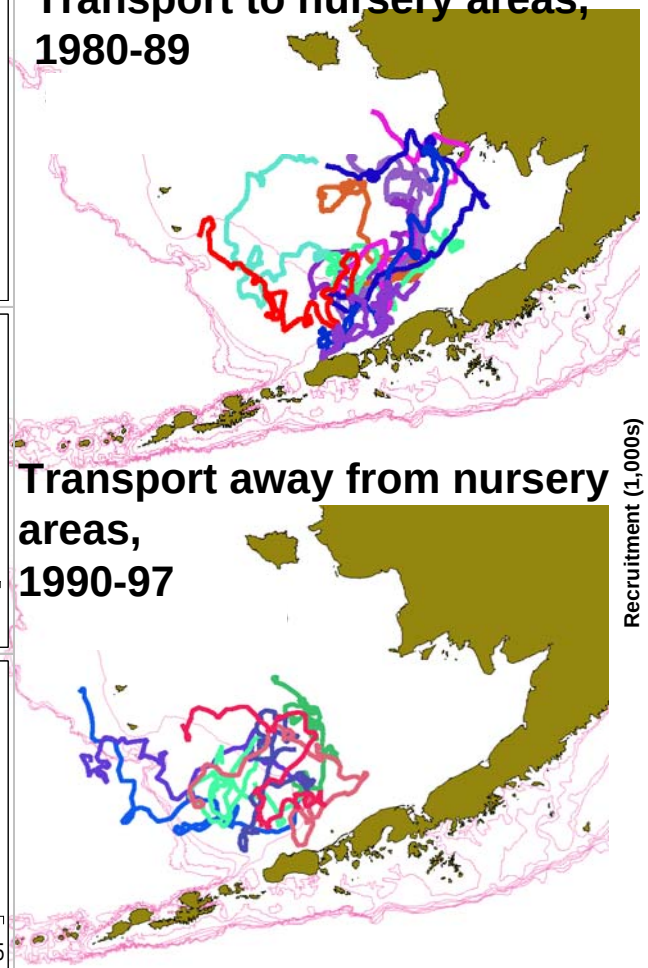
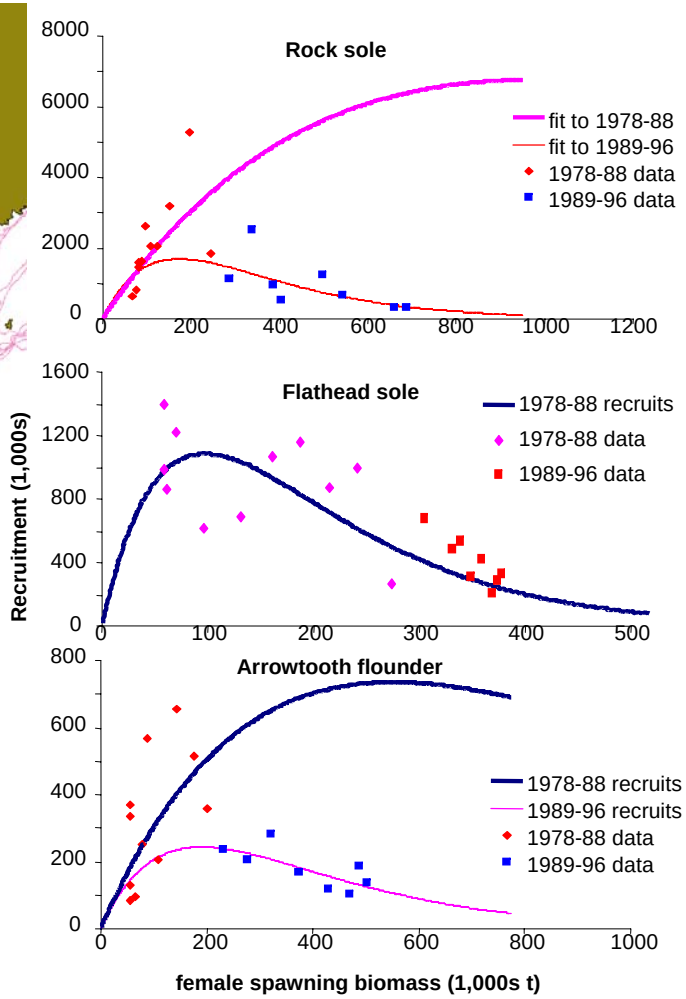
Index of Advection in the E. Bering Sea and effects on winter-spawning flatfish recruitment (Wilderbuer et al. 2002)



Relative Recruitment







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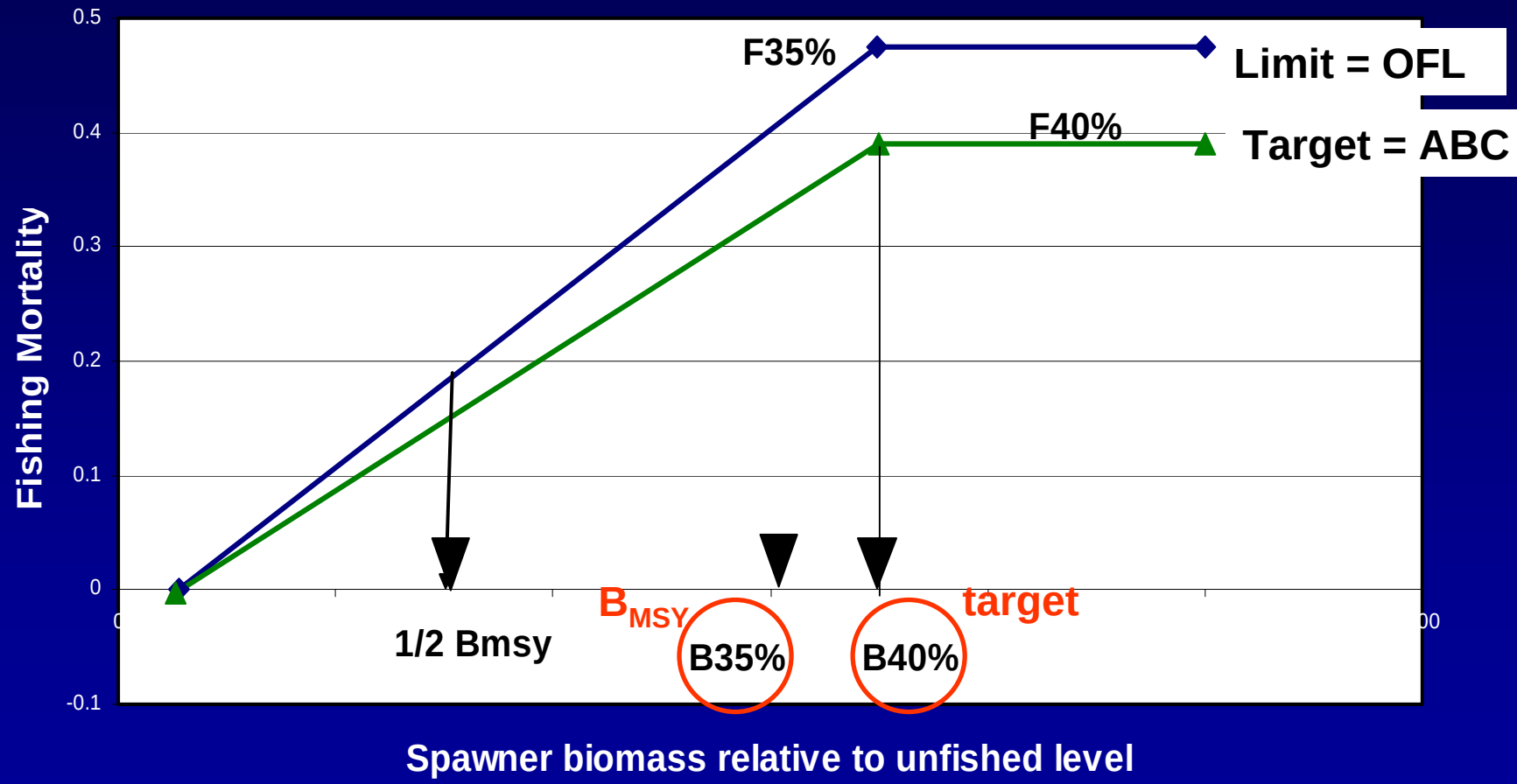
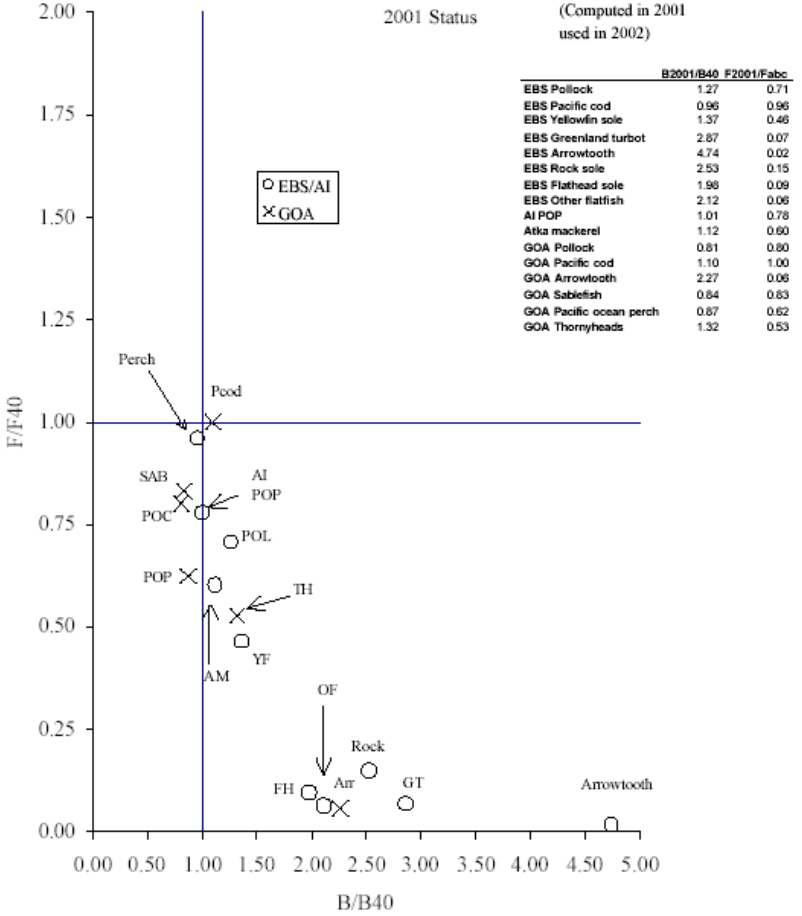
Automatic re-building

Alaskan Groundfish Harvest Control Rules





	B2001/B40	F2001/Fabc
EBS Pollock	1.27	0.71
EBS Pacific cod	0.96	0.96
EBS Yellowfin sole	1.37	0.46
EBS Greenland turbot	2.87	0.07
EBS Arrowtooth	4.74	0.02
EBS Rock sole	2.53	0.15
EBS Flathead sole	1.98	0.09
EBS Other flatfish	2.12	0.06
AI POP	1.01	0.78
Atka mackerel	1.12	0.60
GOA Pollock	0.81	0.80
GOA Pacific cod	1.10	1.00
GOA Arrowtooth	2.27	0.06
GOA Sablefish	0.84	0.83
GOA Pacific ocean perch	0.87	0.62
GOA Thornyheads	1.32	0.53

Figure 3.3. $F/F_{40\%}$ versus $B/B_{40\%}$ for species in the GOA and BSAI in 2001. Values in the lower right quadrant are considered ideal (population above the target, fishing mortality below the target).

Management Strategy Evaluation

- J. Ianelli, et al.
- Are current management strategies robust to environmental change?

Management Strategy Evaluation Allowable Biological Catch (ABC)

1. Develop hypotheses about population dynamics relative to environmental changes (a.k.a. “operating model”)
2. Simulate typical “assessment data” from the operating model each year (with stochasticity)
3. Apply the current “management strategy” using a typical assessment to produce ABC recommendations for each year
4. Using “actual catch” from step 3., increment operating model one year
5. Repeat 2. – 4. until 60 years are simulated

Operating model

Two production regimes alternate every 15 years

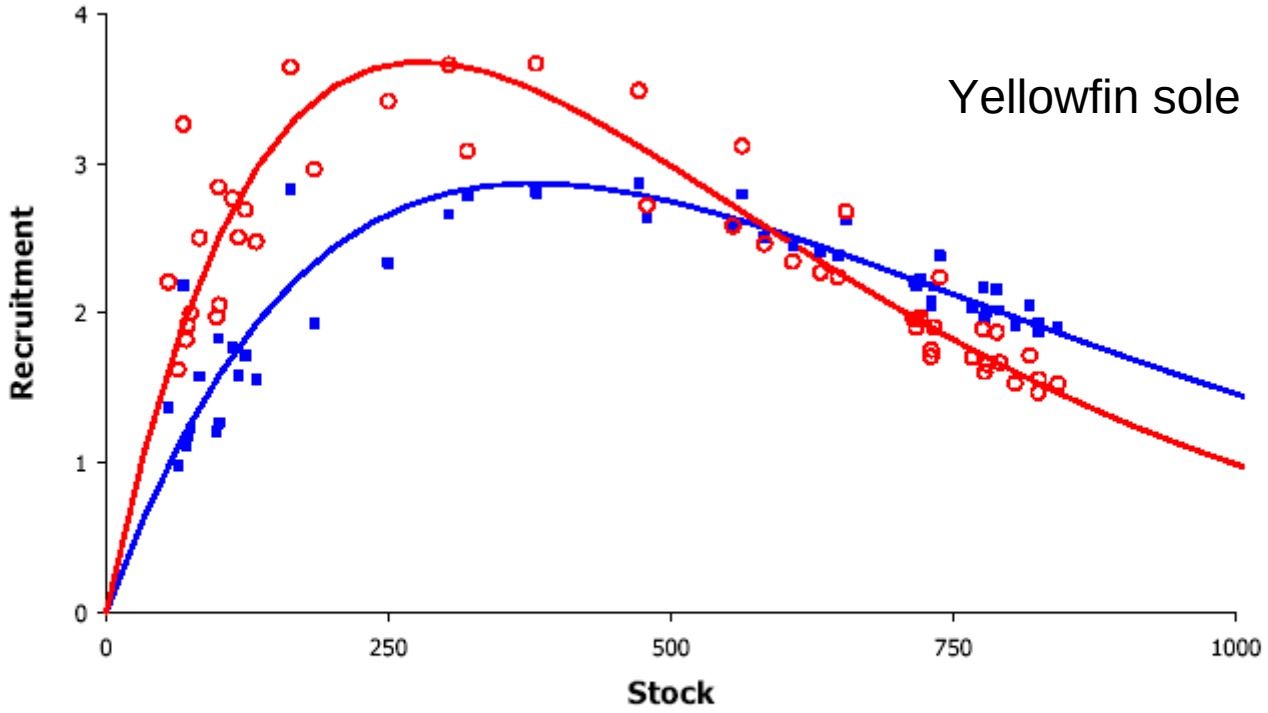


Figure 12. Estimates of two "regimes" of productivity as estimated from a species of flatfish in the EBS. These estimates provided the foundation for initial simulation trials for underlying "true" operational model.

Dorn, et al. 2004 (ICES CM 2004)

Preliminary results

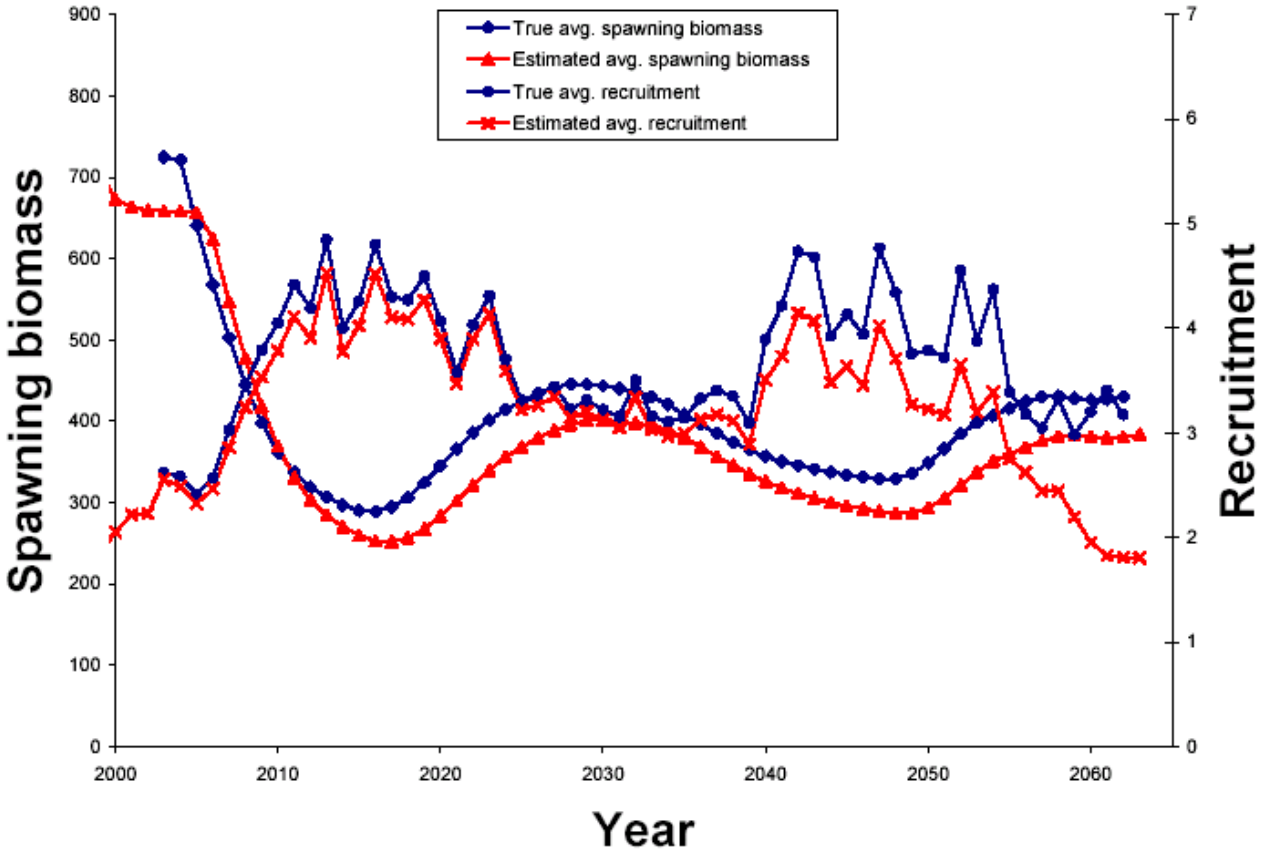


Figure 13. Performance results from simulations comparing average estimated population characteristics (assuming no environmental change) to the "true" average underlying characteristics (which included environmental regime changes).

"…current harvest strategy where environmental change is not explicitly modeled is robust to underlying changes in stock productivity" (Dorn, et al. 2004 ICES CM 2004)

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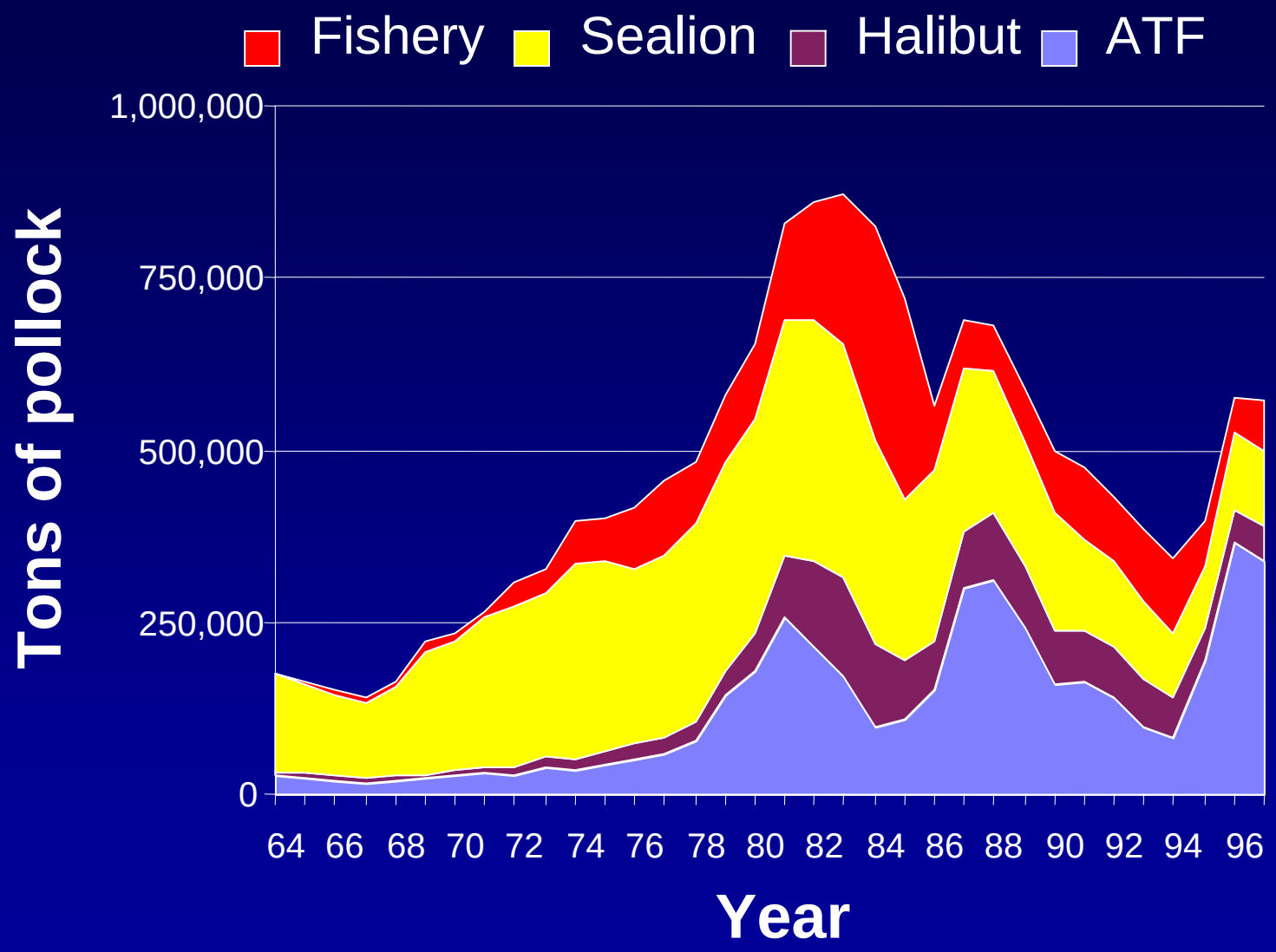
Predation mortality



Hollowed et al. 2001

Steller sea lion Harvest Control Rule

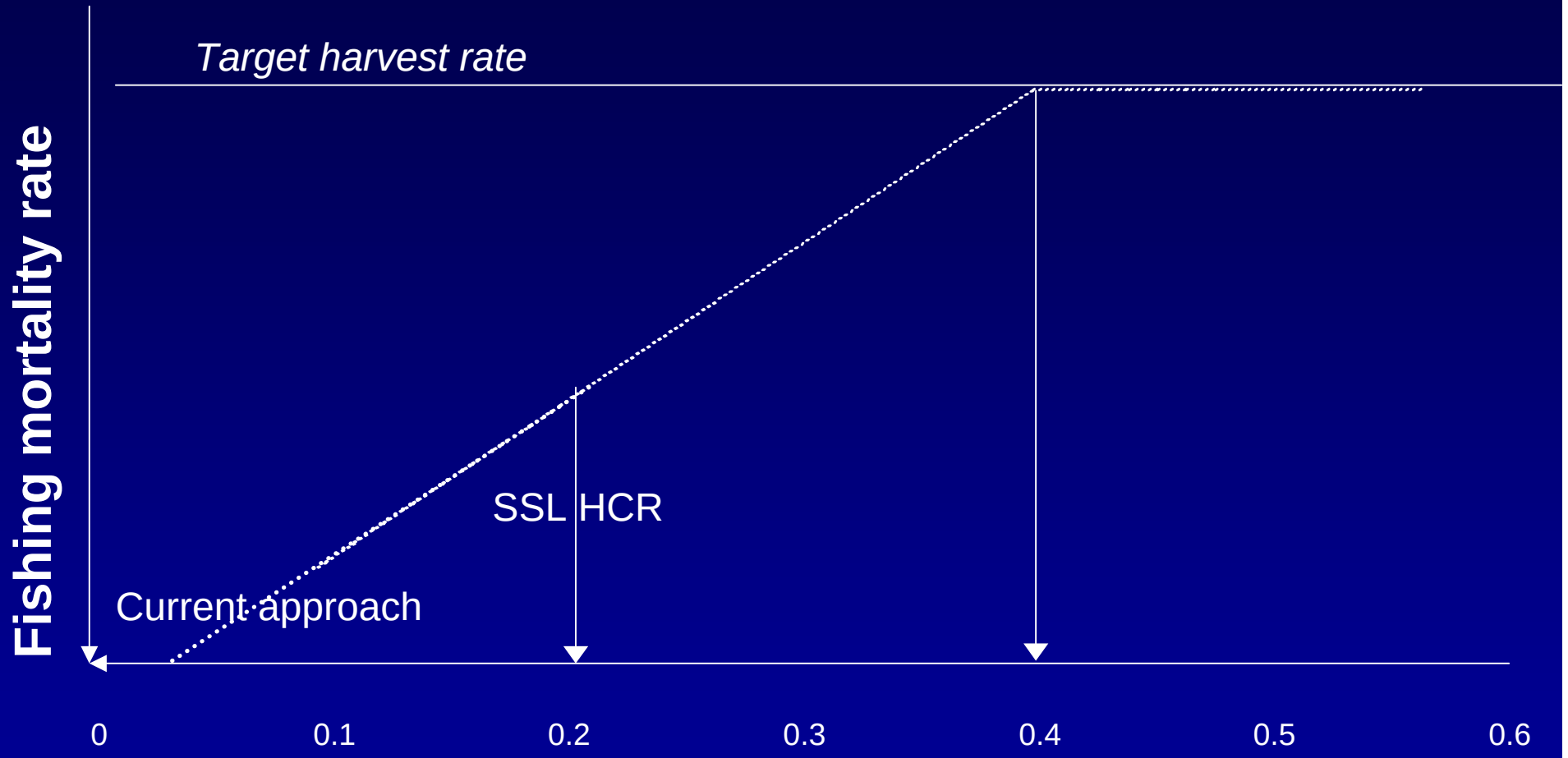


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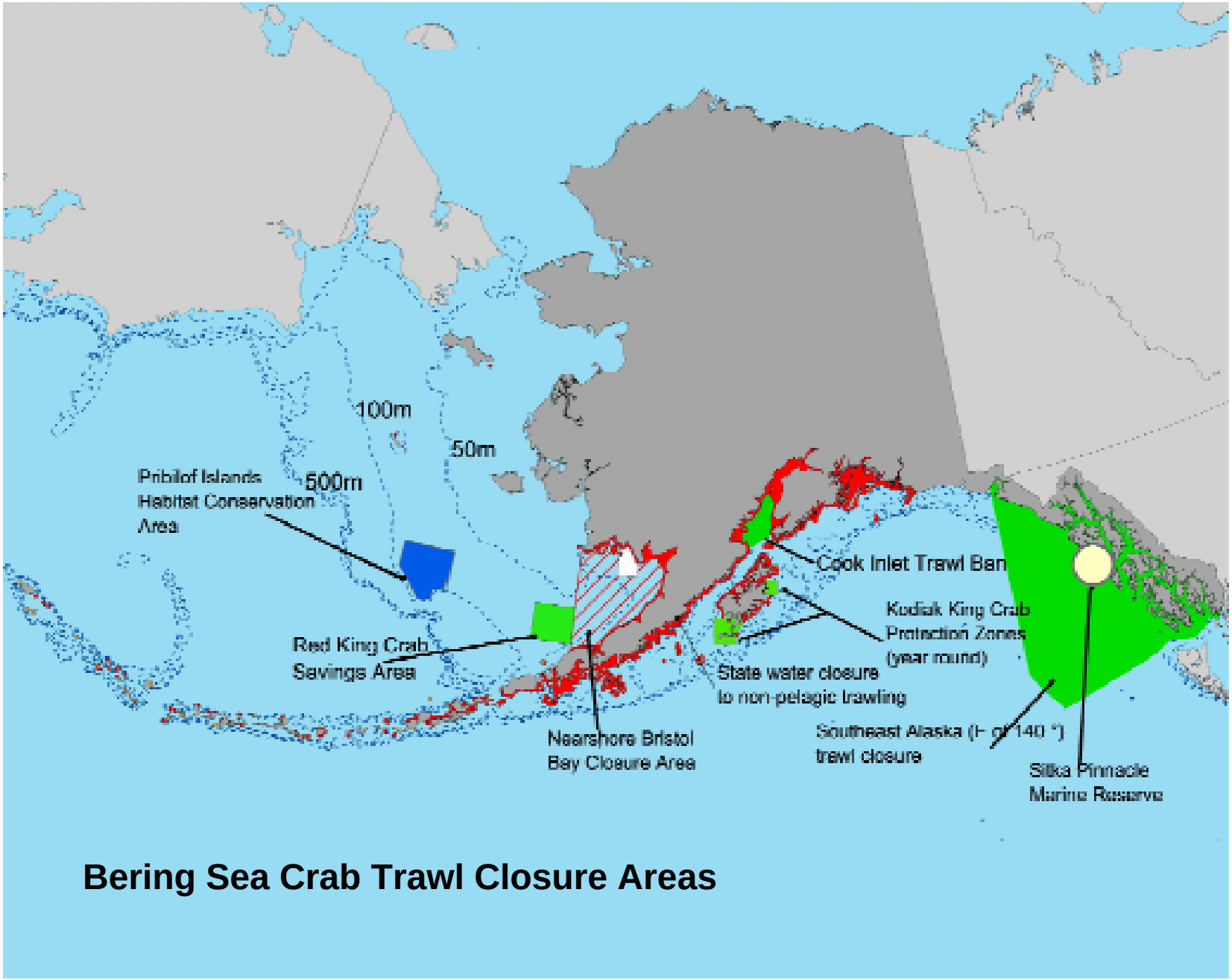
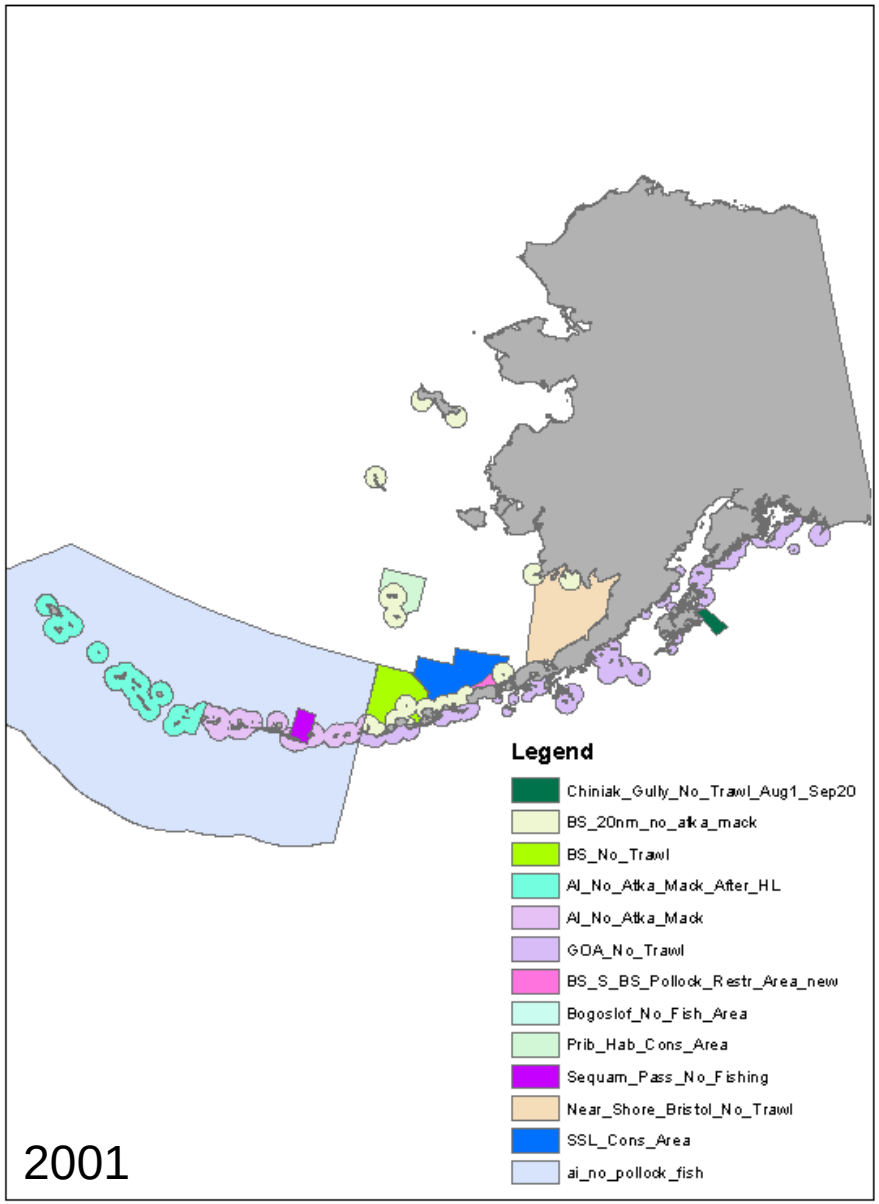
Figure 2-1. Areas Closed Year-round to Bottom Trawling



Steller sea lion protection measures



Summary

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Discussion topics

- What types of management measures should we take, given our understanding of environmentally-driven variability in stock production?
- Will an understanding of environmental factors that affect stocks improve predictions?
  - Is the environment itself too unpredictable?
  - Do surveys and population models provide more reliable predictions than environmentally-driven models?
  - Are current harvest guidelines sufficiently robust to environmental variation?