Ecology of small neritic fishes in the western Gulf of Alaska: top-down mechanisms can moderate bottom-up forcing

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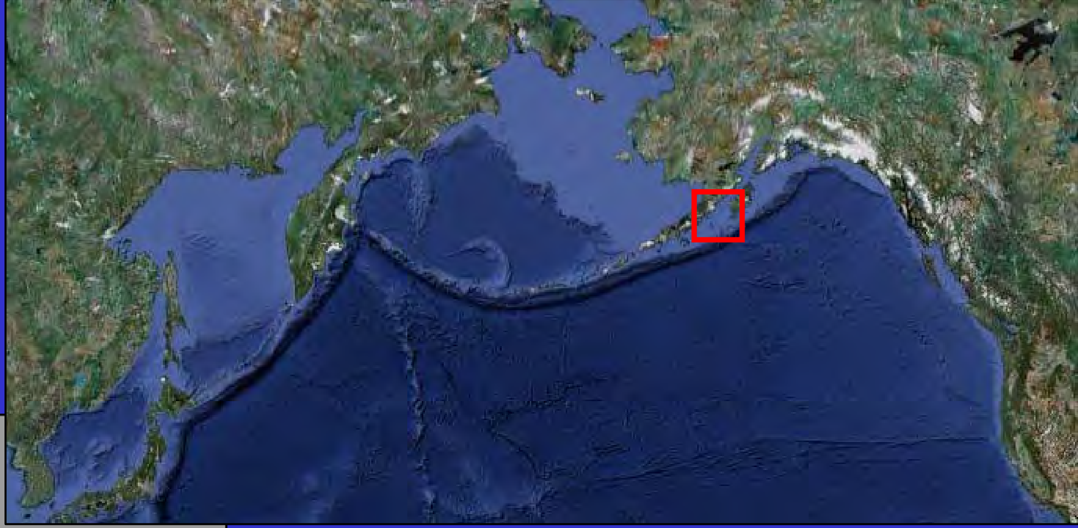
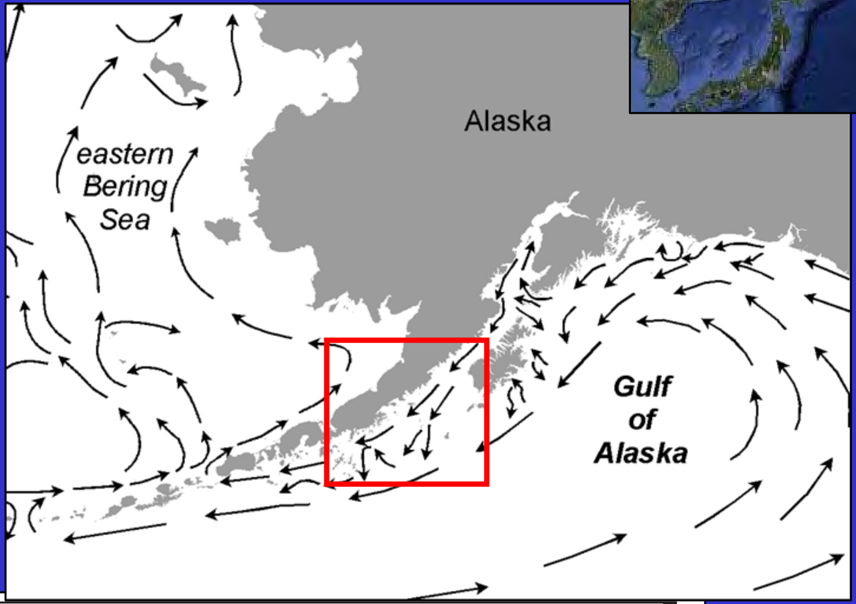
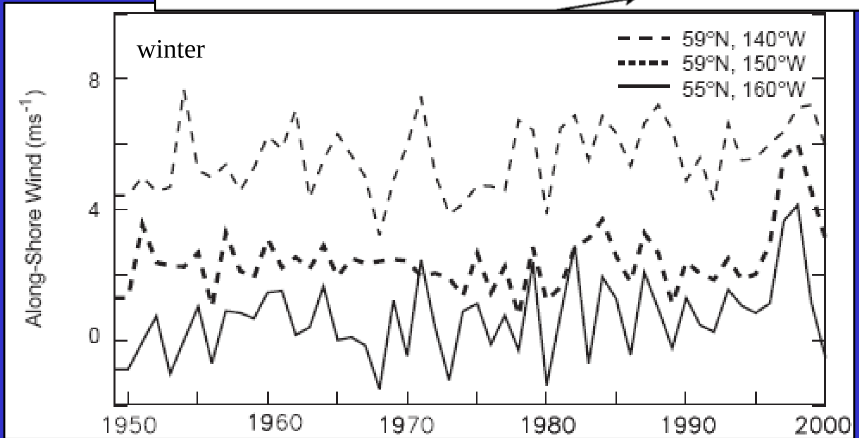


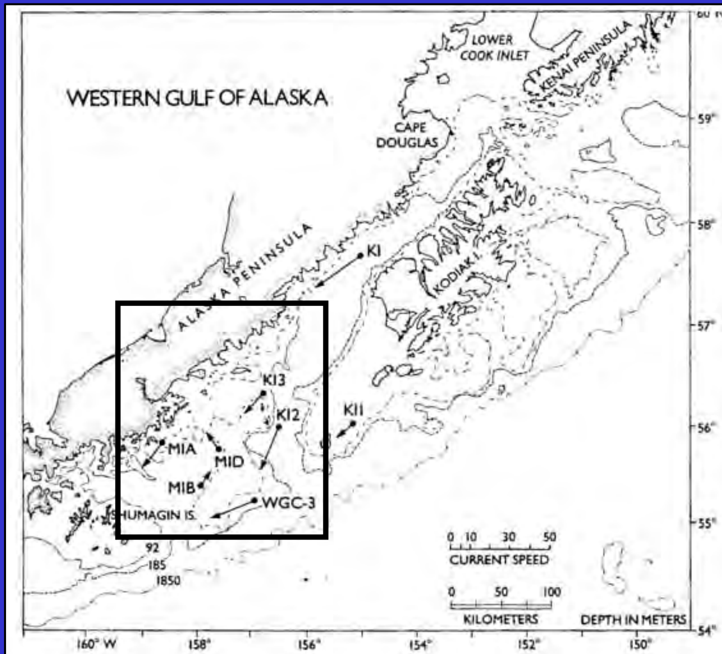
from Reed & Schumacher 1986

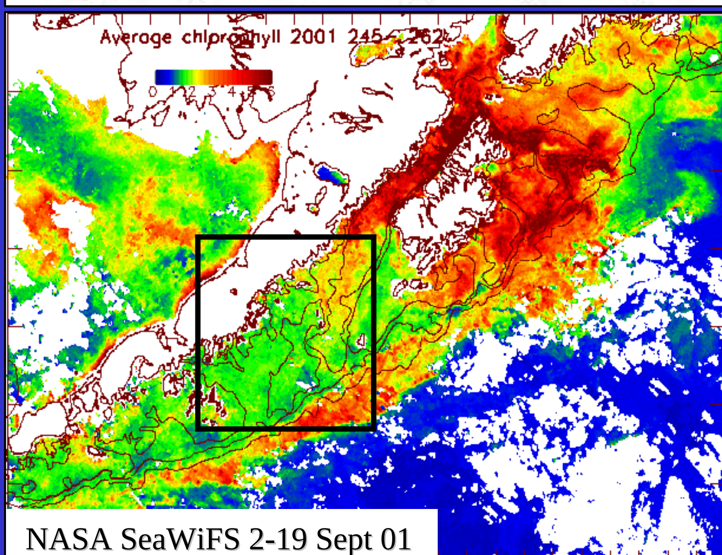


Stabeno et al. 2004



Schumacher & Reed 1986





NASA SeaWiFS 2-19 Sept 01

Cooney (1986)

Meso-scale hydrographic processes contribute to ecosystem productivity by facilitating localized aggregation of zooplankton and zooplanktivores.

Small neritic fishes

1) *Theragra chalcogramma* (walleye pollock)
2) *Mallotus villosus* (capelin smelt)
3) *Thaleichthys pacificus* (eulachon smelt)

Objective

Examine meso-scale geographic variation in fish-zooplankton interaction in relation to net current velocity during late summer when

1) Small neritic fishes are highly abundant,
2) Zooplankton abundance decreases, and
3) Alaska Coastal Current velocity increases.

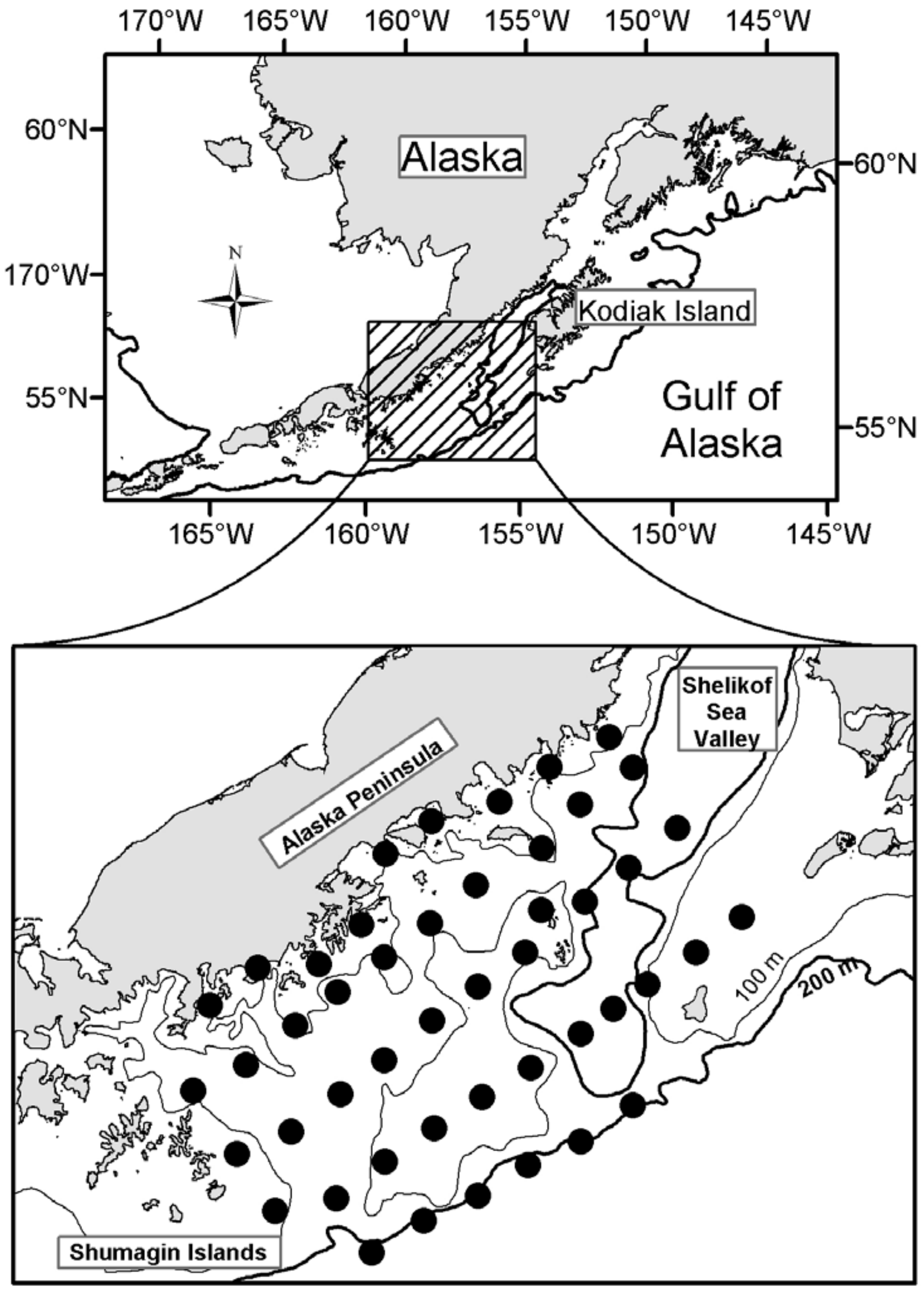
METHODS

September 2000, 2001, & 2003

NOAA ship Miller Freeman

Day and night sampling

Depth-integrated 0-200 m



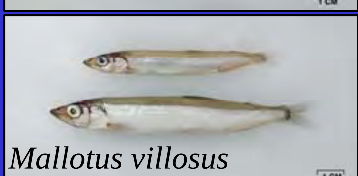
Data Sources

Sampling

fishes

zooplankton

Theragra chalcogramma



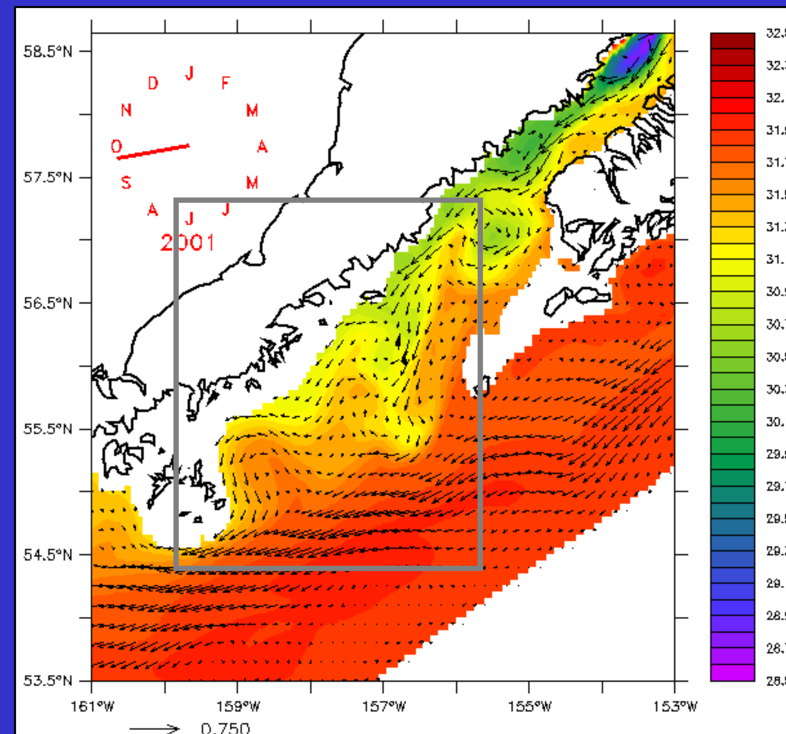
Mallotus villosus

Thaleichthys pacificus

Model output

net current velocity

Hermann & Stabeno 1996



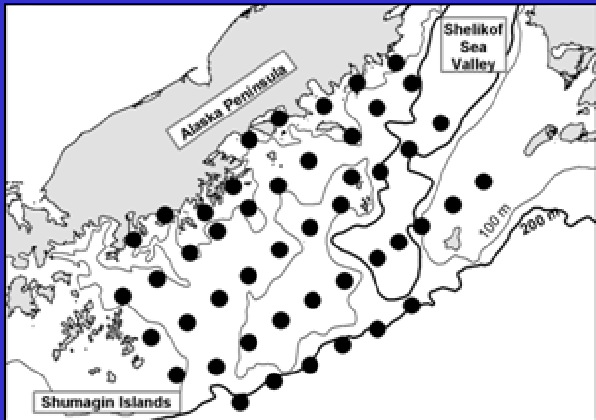
http://nctr-people.pmel.noaa.gov/spillane/shelikof.html

RESULTS

Geographic correlation in population density between fish and zooplankton groups.

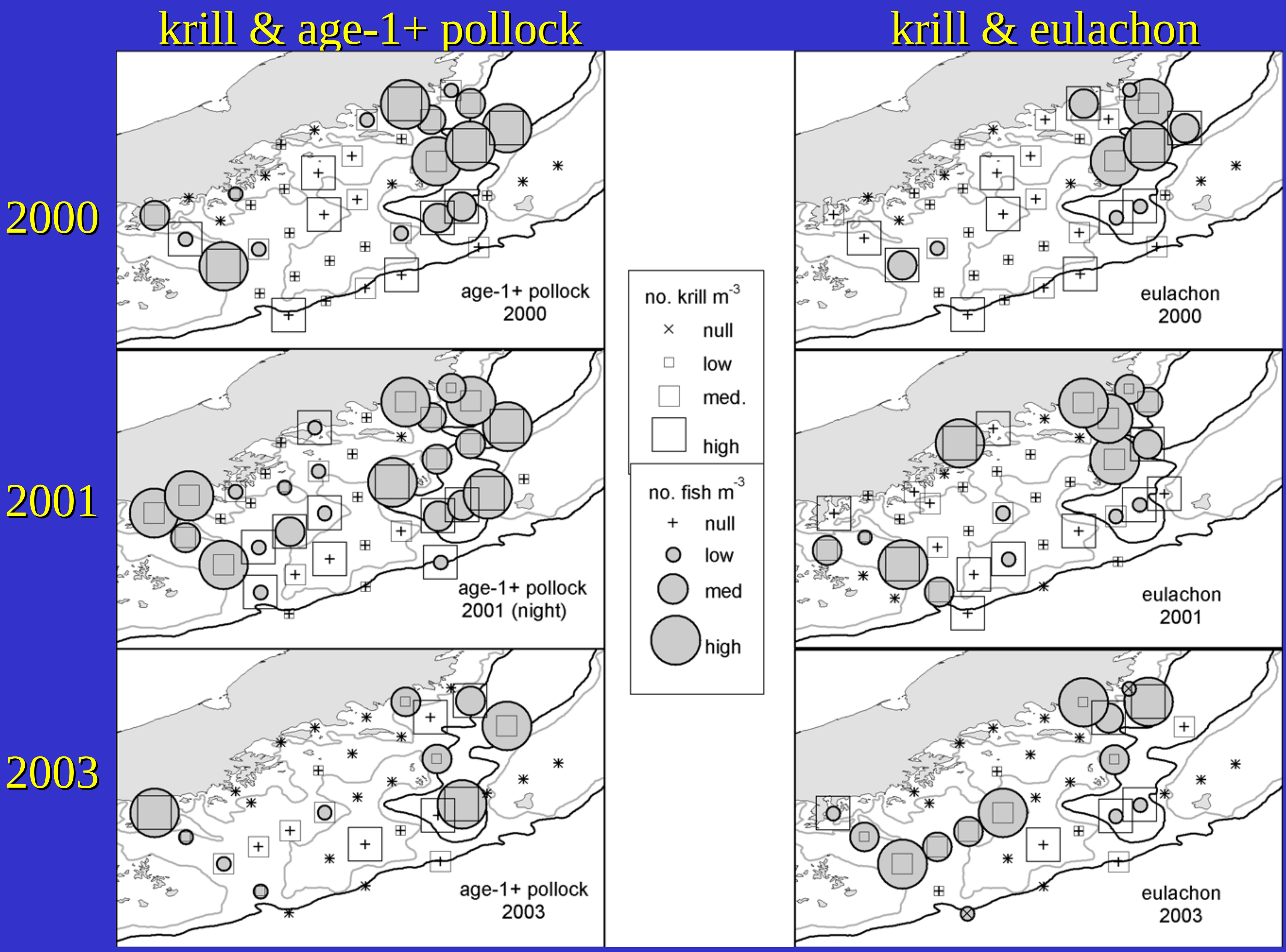
Predator stomach content response to fluctuation in the abundance of krill in the zooplankton.

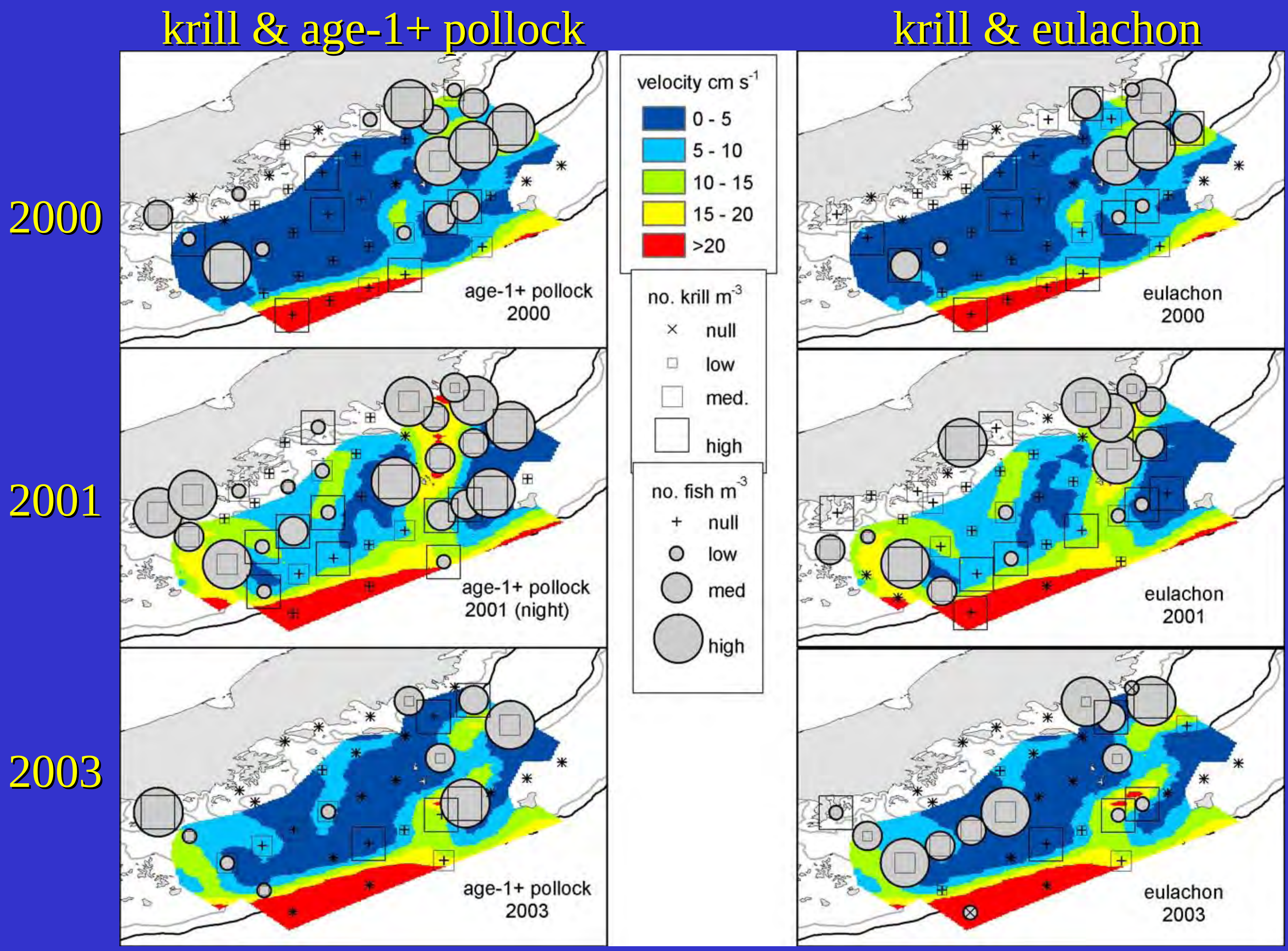
Population density



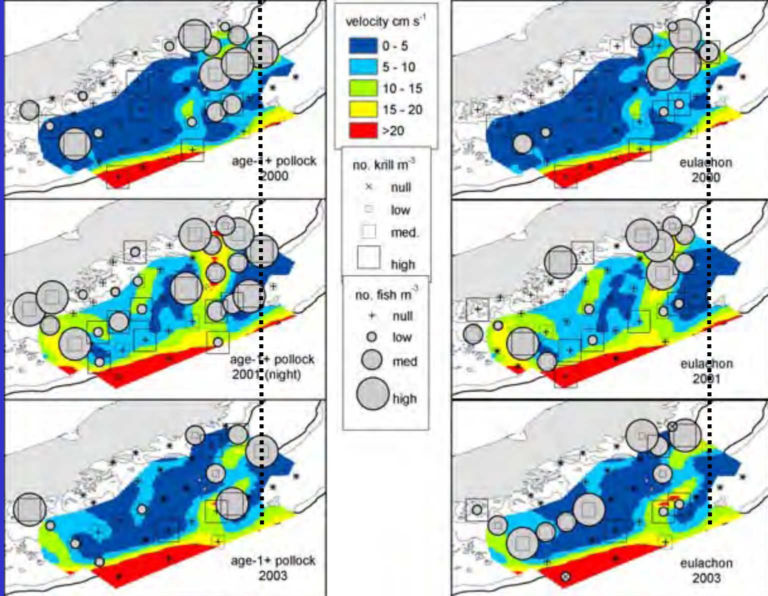
krill (euphausiids)

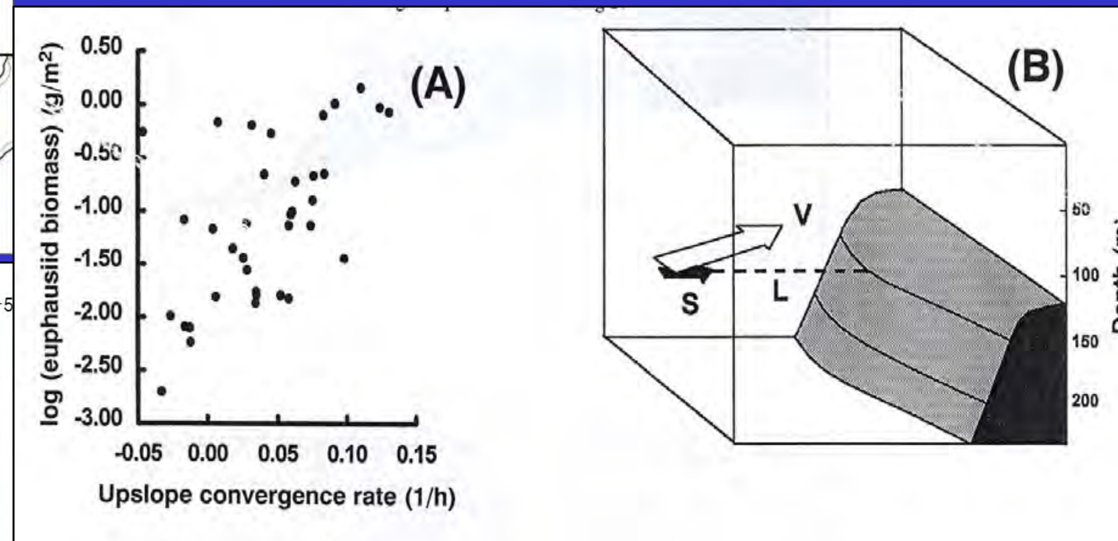
fish	zooplankton	year	diel	Spearman correlation rho	Spearman correlation p	no. samples	no. non-null pairs
pollock, age-0	Copepoda, large	2003	day	0.46	0.006	34	21
pollock, age-1+	Amphipoda	2001	day	0.57	<0.001	40	7
	Chaetognatha	2000	day	0.42	0.006	42	16
	Copepoda, large	2000	day	0.47	0.002	42	16
	Copepoda, large	2000	night	0.45	0.003	43	18
	krill	2000	day	0.63	<0.001	42	16
		2001	night	0.51	0.001	39	24
		2003	day	0.54	0.001	34	10
		2003	night	0.52	0.003	31	15
	Mysidacea	2000	day	0.44	0.003	42	3
		2001	day	0.46	0.003	40	6
		2003	night	0.59	0.001	31	7
capelin	krill	2003	day	0.58	<0.001	34	14
	Larvacea	2003	day	-0.47	0.005	34	12
eulachon	Amphipoda	2001	day	0.54	<0.001	40	7
	Chaetognatha	2000	day	0.48	0.001	42	10
	Copepoda, large	2000	day	0.54	<0.001	42	10
	krill	2000	day	0.58	<0.001	42	10
		2001	day	0.41	0.008	40	15
		2003	day	0.61	<0.001	34	12
		2003	night	0.49	0.006	31	16
	Larvacea	2000	night	-0.45	0.003	40	5
		2003	day	-0.49	0.003	34	11
	Mysidacea	2000	day	0.52	<0.001	42	3
		2003	night	0.55	0.001	31	7


krill & age-1+ pollock
krill & eulachon
2000
2001
2003
age-1+ pollock
2000
eulachon
2000
age-1+ pollock
2001 (night)
eulachon
2001
age-1+ pollock
2003
eulachon
2003
no. krill m-3
null
low
med.
high
no. fish m-3
null
low
med
high

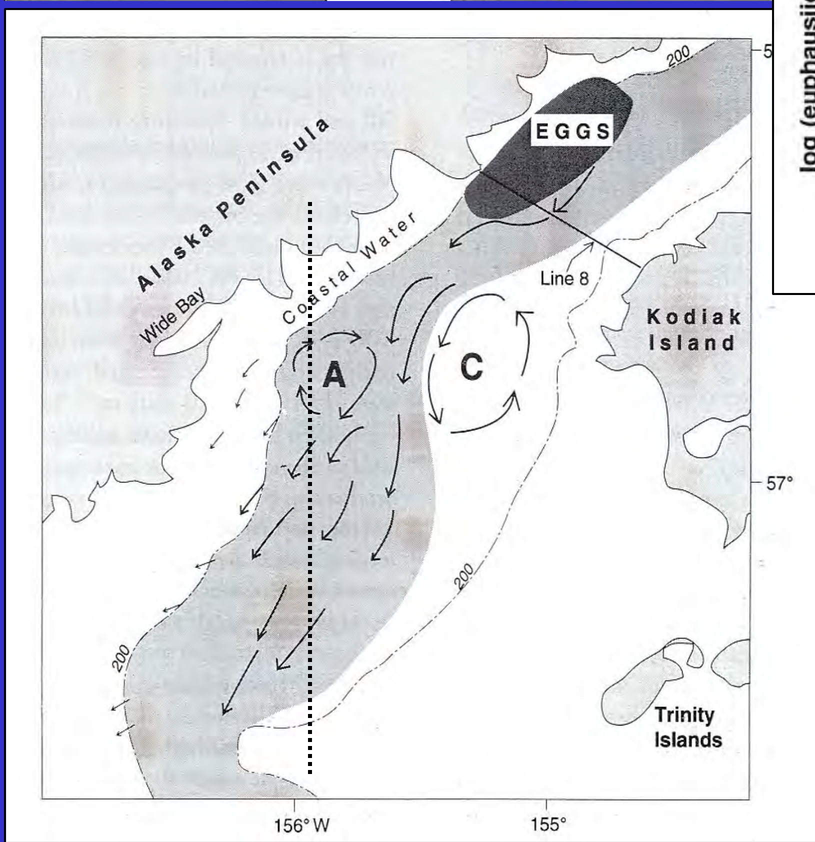

krill & age-1+ pollock
krill & eulachon
2000
2001
2003
velocity cm s-1
0 - 5
5 - 10
10 - 15
15 - 20
>20
no. krill m-3
null
low
med.
high
no. fish m-3
null
low
med
high
age-1+ pollock 2000
age-1+ pollock 2001 (night)
age-1+ pollock 2003
eulachon 2000
eulachon 2001
eulachon 2003

Flow-related aggregation mechanism





Mackas et al. 1997



Napp et al. 1996

Predator - prey interaction

Stomach content data from all 3 species
(age-0 & age-1+ pollock, capelin, eulachon)

Focus on krill due to major prey status
(>50% of total stomach contents)

Estimate daily rates of consumption

Daily rates of consumption

Per capita

$$PC_{jky} = PW_{jky} \times DR_j \times KP_{jky} \div KW_{jky}$$

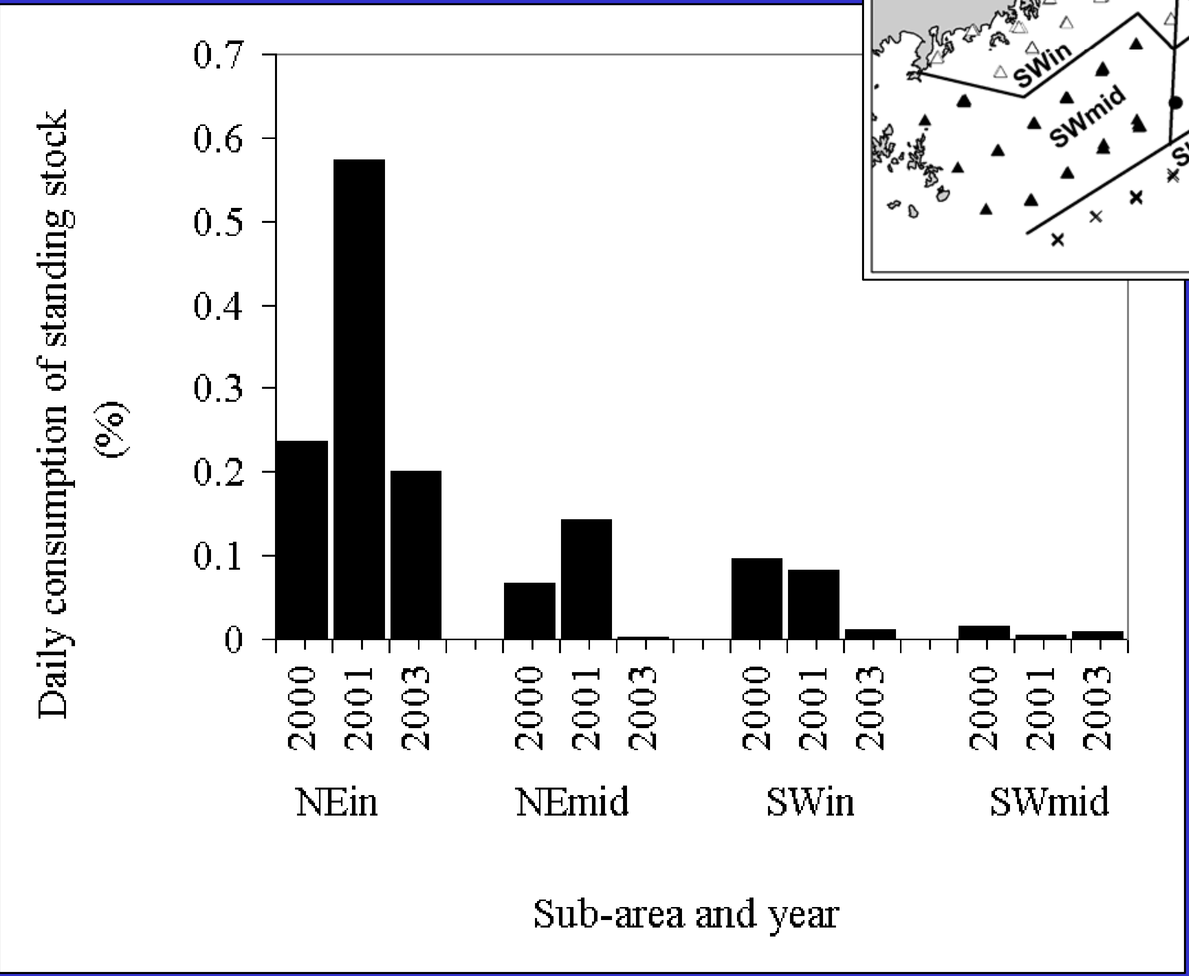
Population

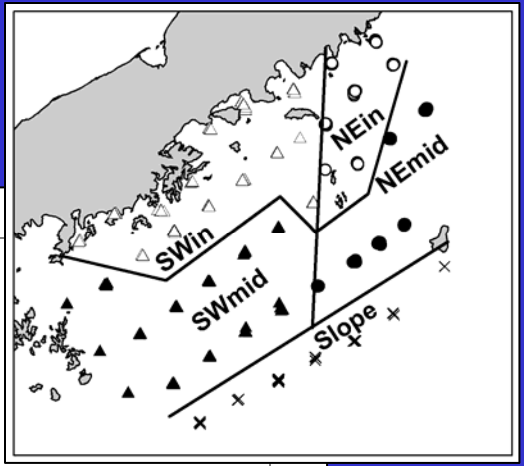
$$DC_{ky} = \sum_{j=1}^{4} (PA_{jky} \times PC_{jky})$$

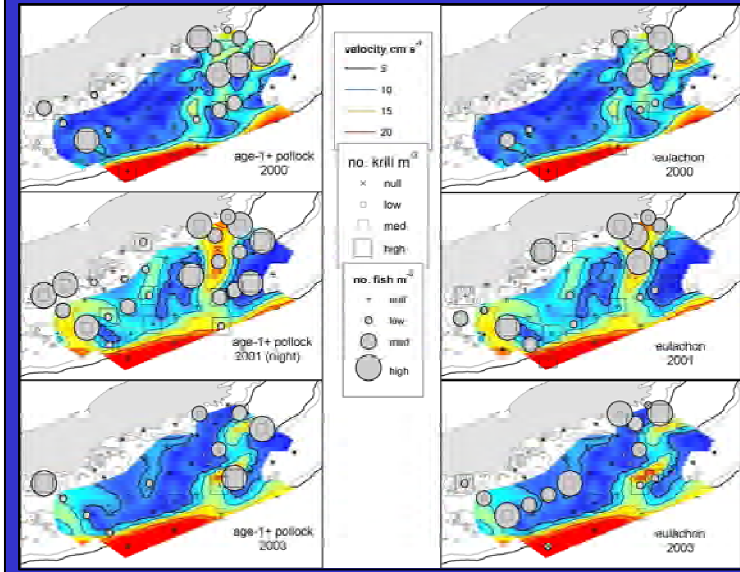
Per-capita consumption

Year	Per-capita consumption (krill fish^{-1})	Krill abundance (no m^{-2})	Krill body wt (mg ind^{-1})	Est. net current vel. (cm s^{-1})
2000	3.1	158	21.5	5
2001	**13.6** *	**586** *	**15.7** *	**9**
2003	1.9	65	32.8	6

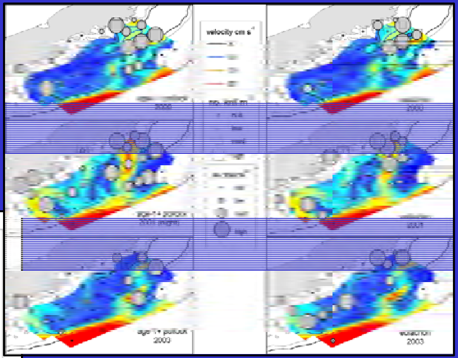
Population consumption
(Percent of krill standing stock)

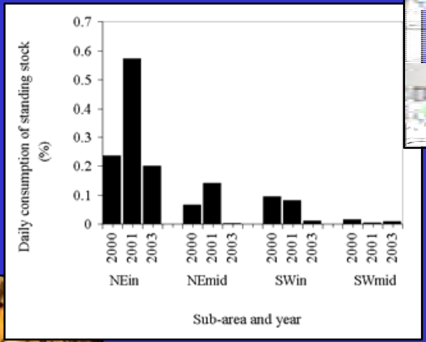






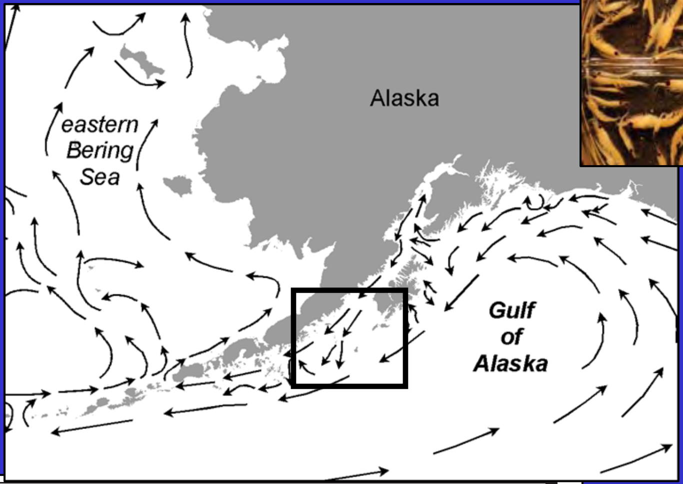
DISCUSSION



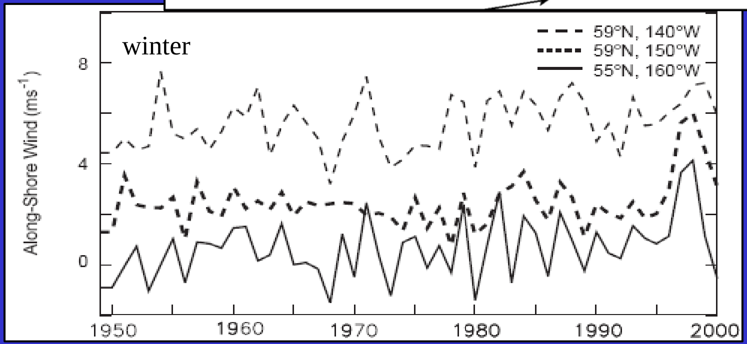


Trophic compensation

from Reed & Schumacher 1986



Climate forcing



Stabeno et al. 2004

CONCLUSIONS

Net current velocity and bathymetry associated with fish-krill aggregation.

Increased net current velocity had a positive effect on krill population density and a negative effect on krill body size.

More small krill caused predators to increase per capita consumption of krill.

The population response was compensatory, but geographically confined.

Results support Cooney’s (1986) hypothesis that hydrographic effects cause local aggregation of zooplankton and zooplanktivores in the Gulf of Alaska.

Predator-prey relationships may oppose climate forcing of ecosystems.

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