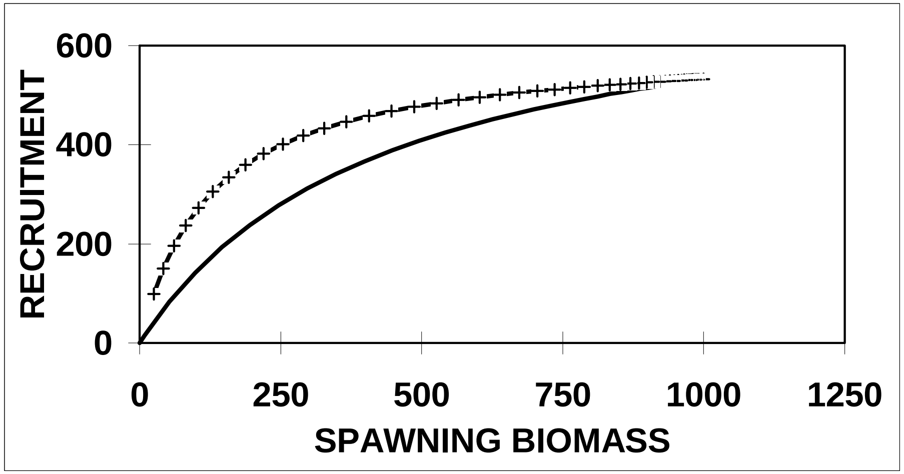
A Review of the Role of Environmental Disturbance and Resource Partitioning as a Source of Population Regulation in Marine Ecosystems

Anne B. Hollowed and Vera N. Agostini

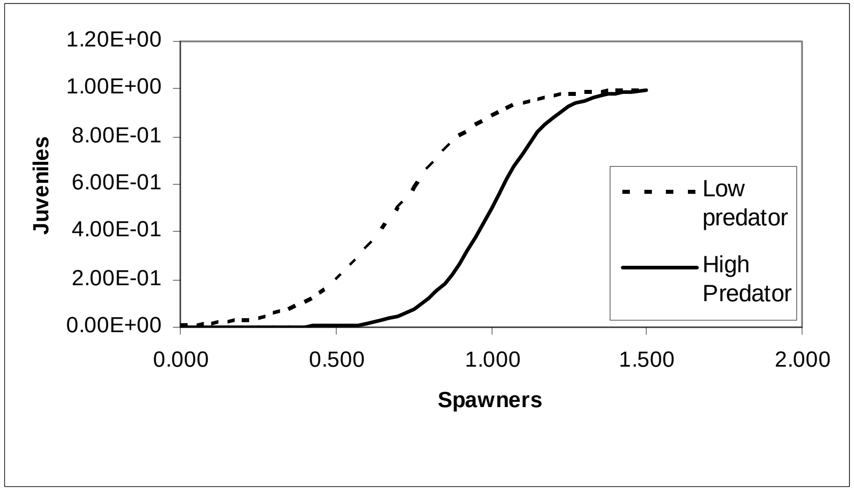
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA 98115

School of Aquatic and Fisheries Science
University of Washington
Seattle, WA 98195

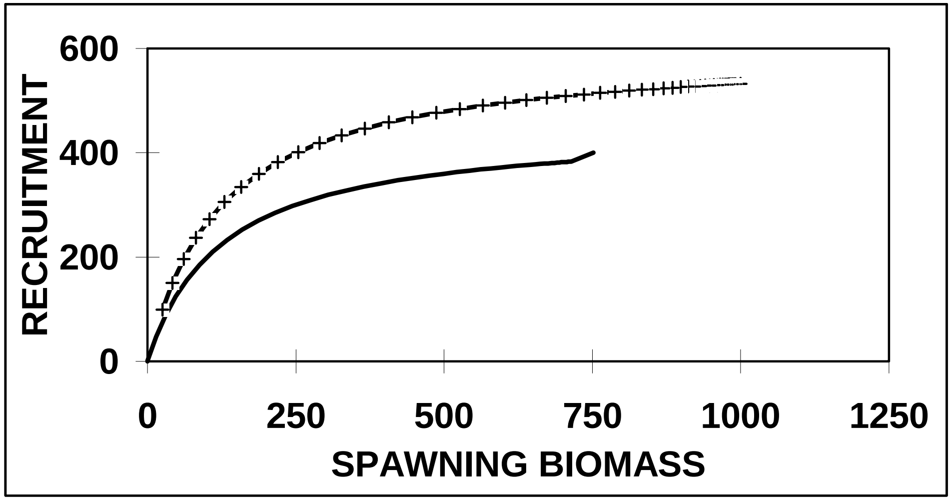
Shift in Productivity



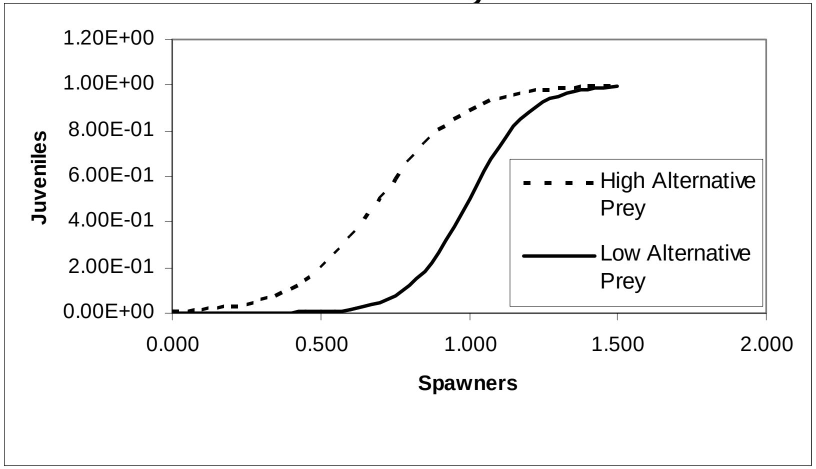
Shift in Predator Threshold



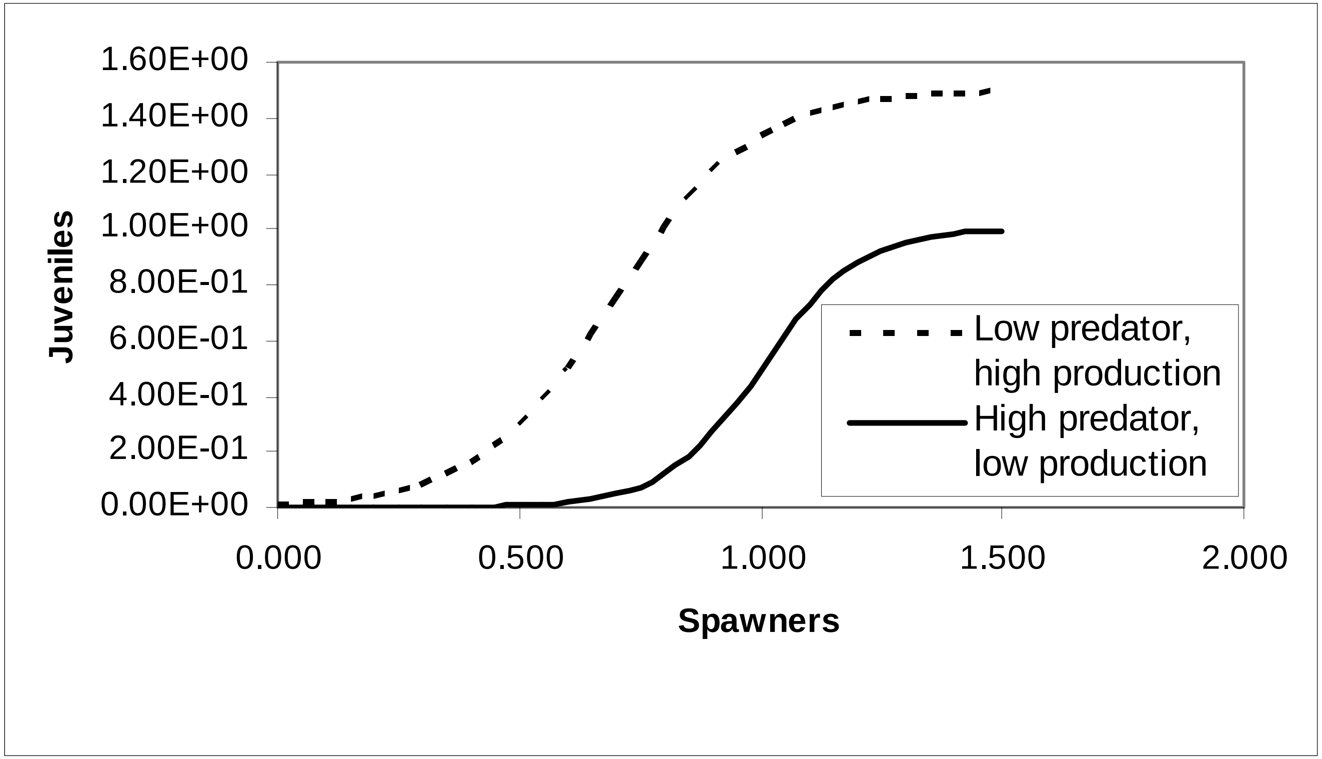
Shift in Capacity



Shift in Alternative Prey



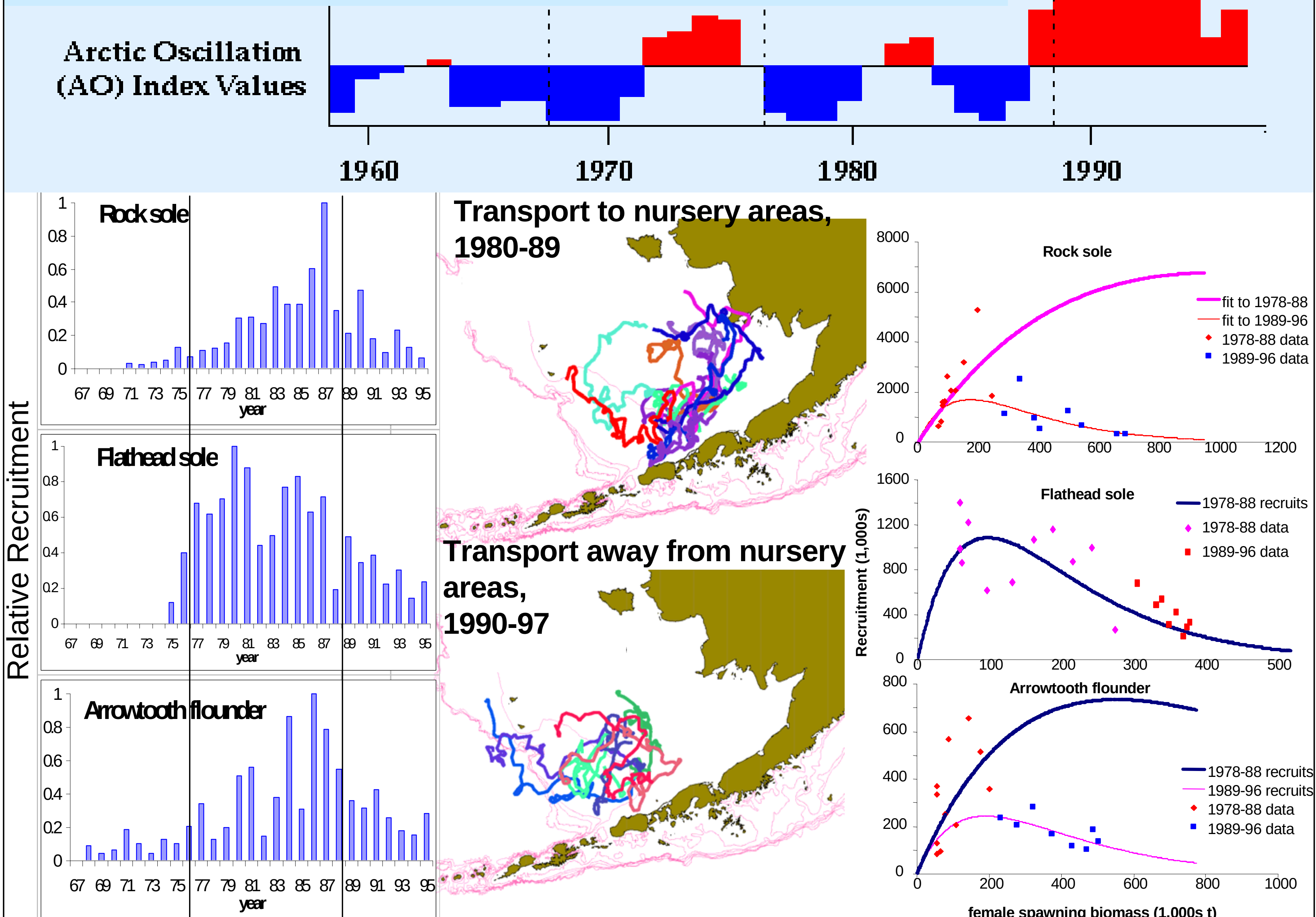
Top down, bottom up



3 Case Studies

- Transport of winter spawning flatfish – environmental mediation
- Predator mediated environmental control - middle out (GOA pollock)
- Environmental control mediated by transport of predator – Pacific hake

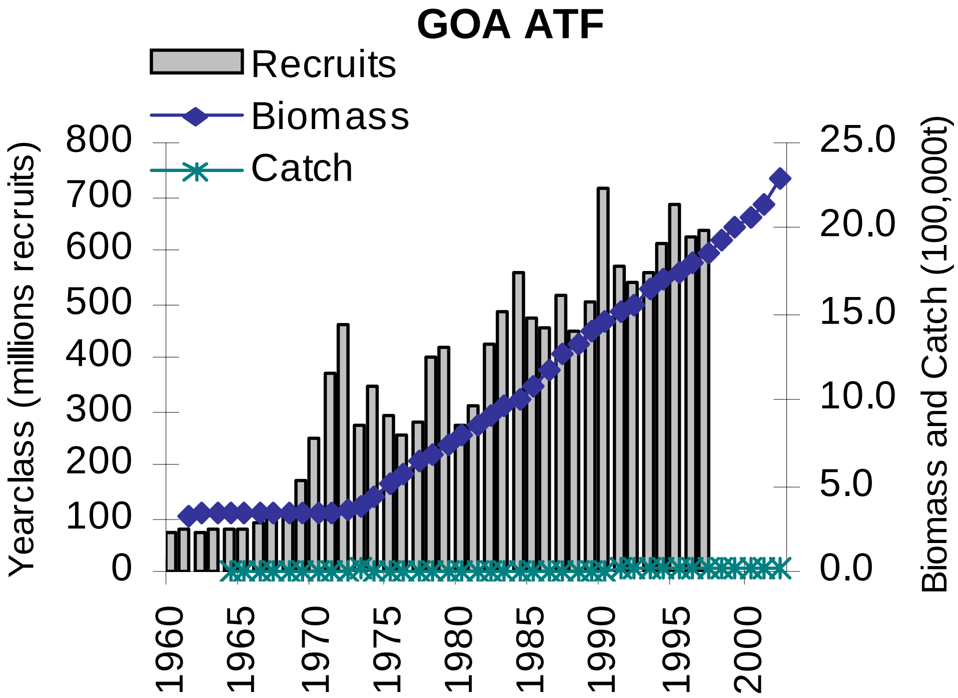
Index of Advection in the E. Bering Sea and effects on winter-spawning flatfish recruitment

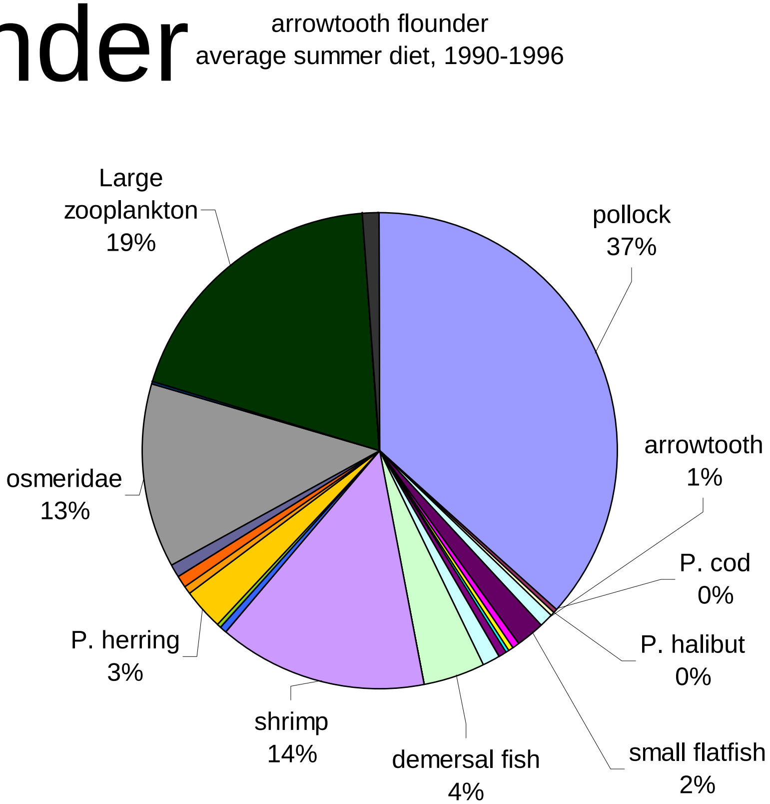


Foraging arenas and shifting control of middle out (Bailey 2001, Walters and Kitchell 2001)

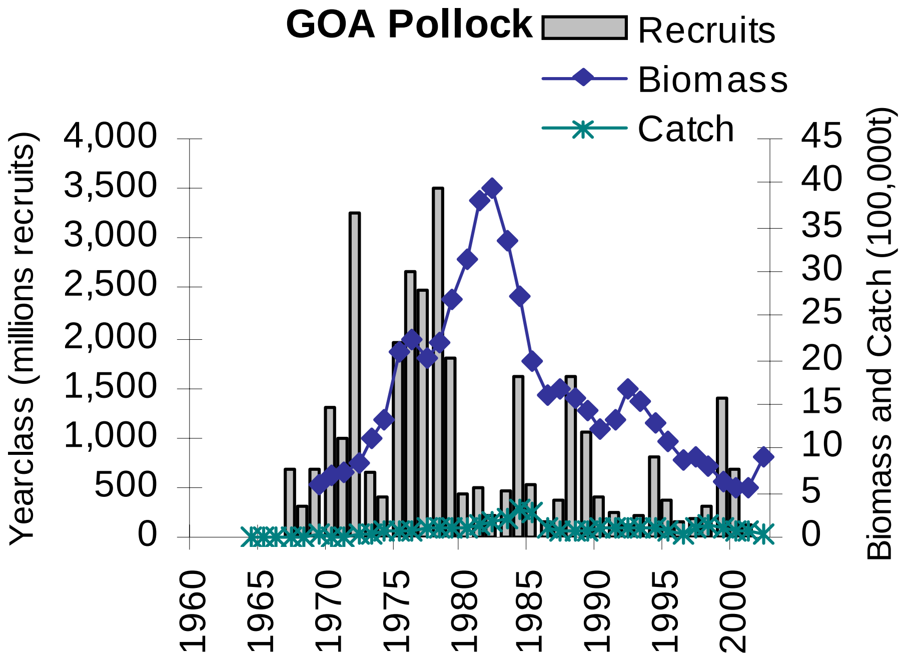
- 1970s – predator abundance low.
- Late 70s and early 1980s - shift in production of Arrowtooth flounder (predator) and pollock.
- Middle 80s arrowtooth flounder achieves dominance
- Juvenile survival declines, and adult pollock biomass declines further
- Capelin and eulachon appear in La Nina period 99 – 02 (climate or competitive release?)

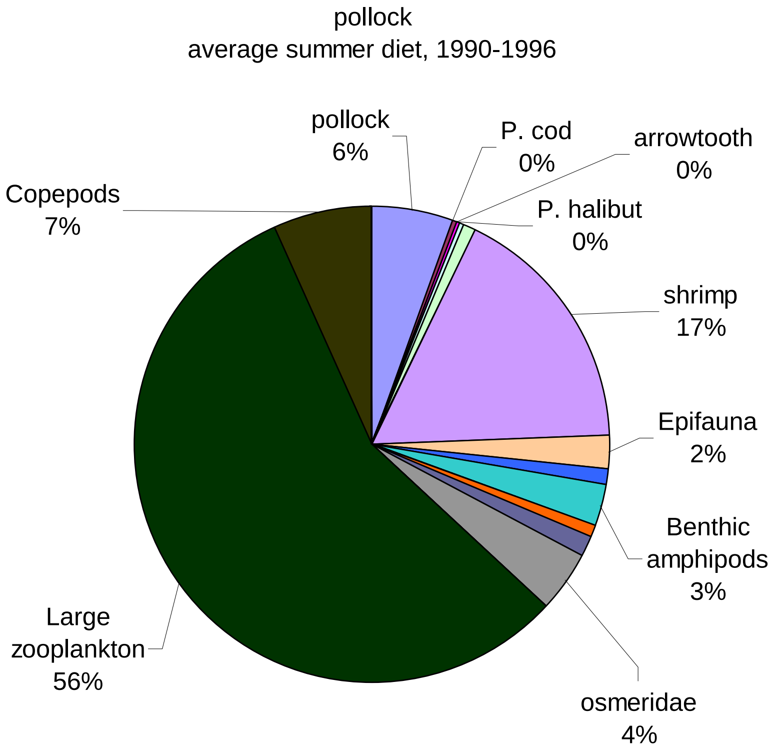
GOA Arrowtooth flounder



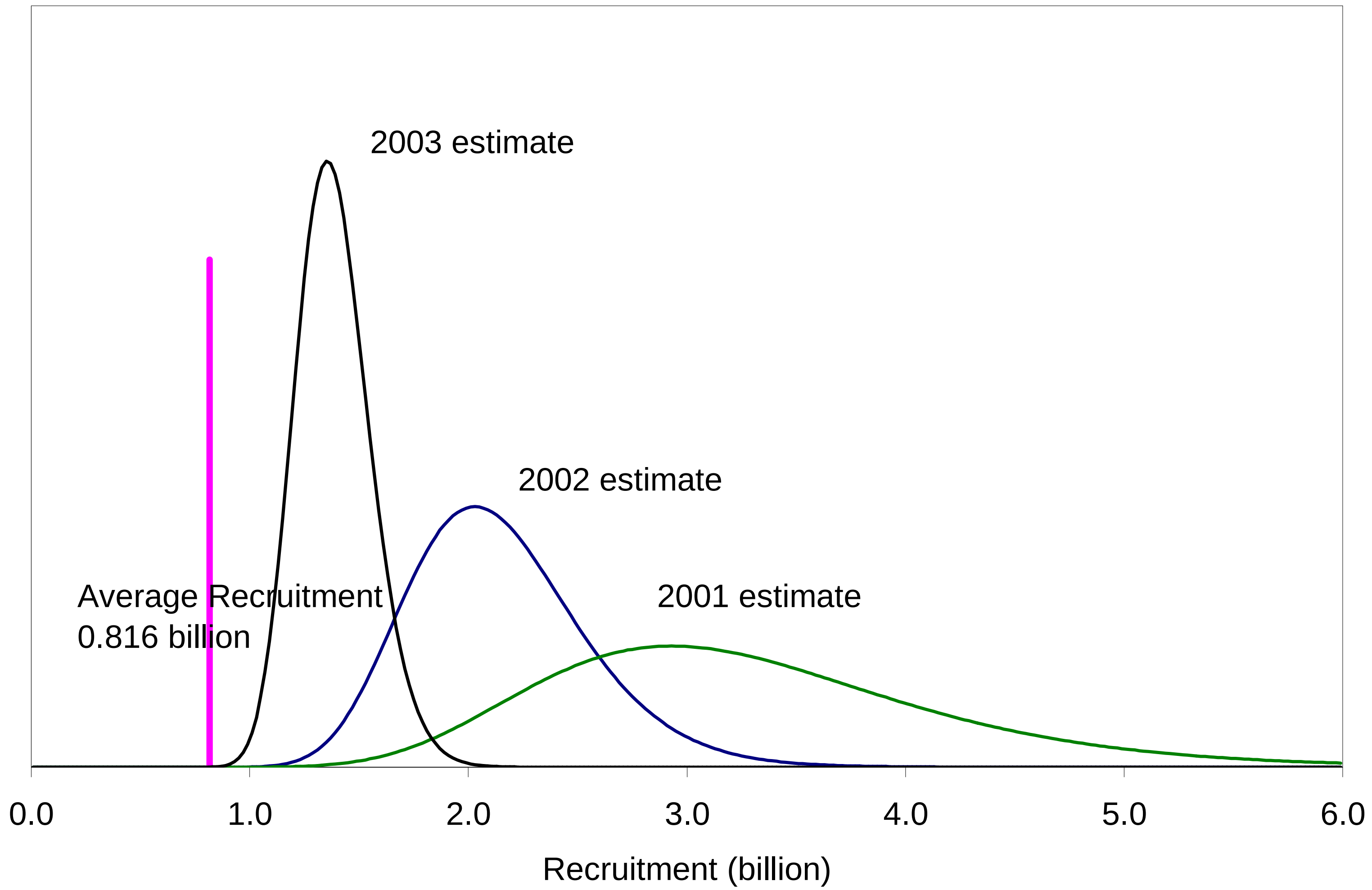


GOA Walleye pollock

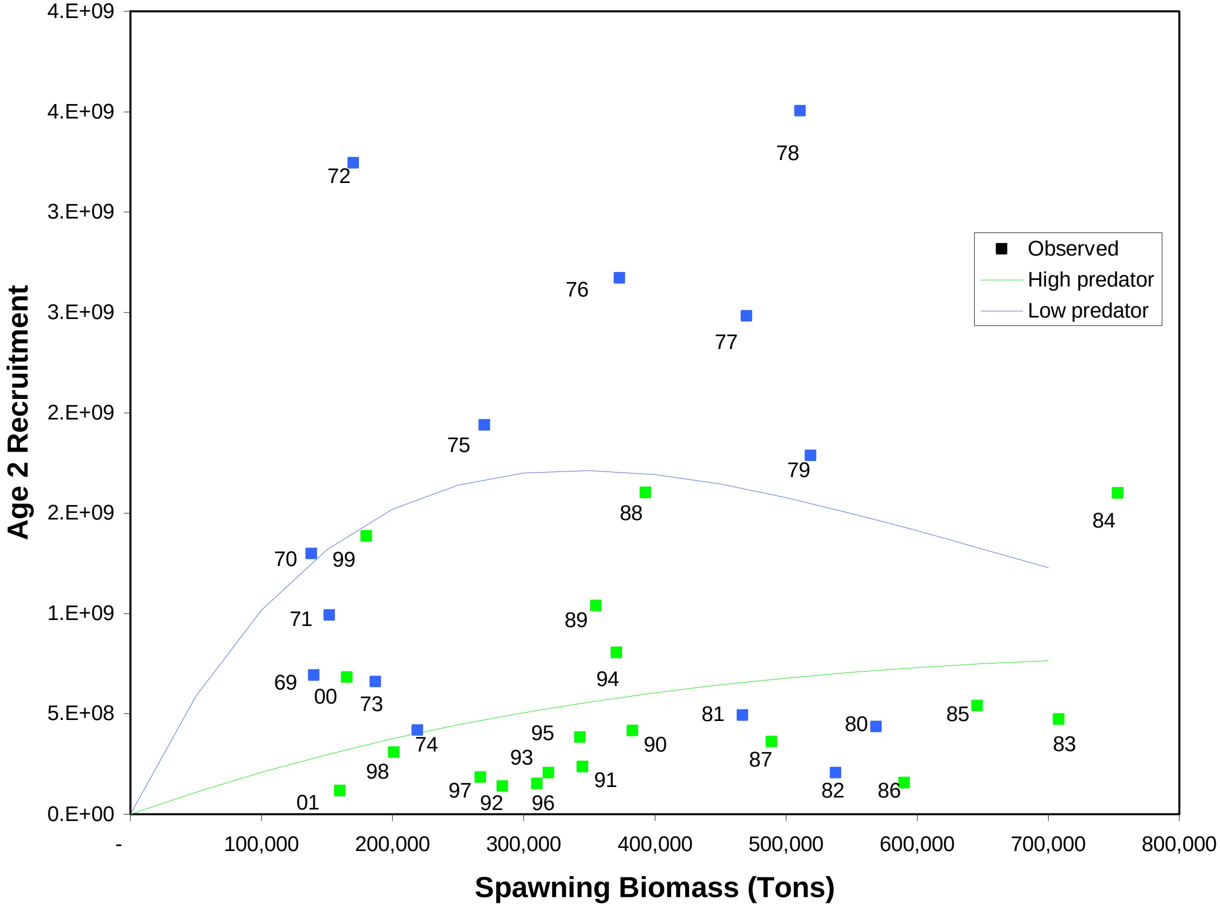




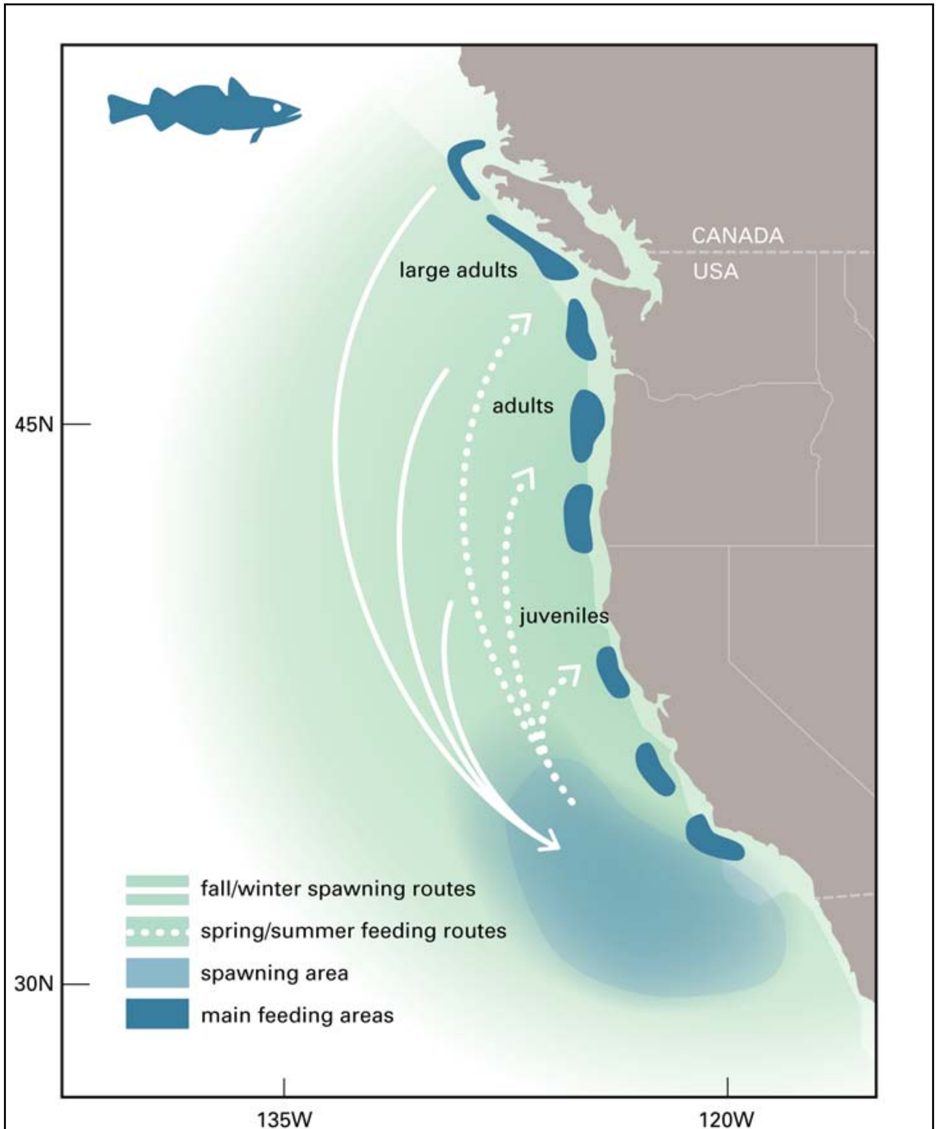
Forecast of 1999 year class of GOA pollock



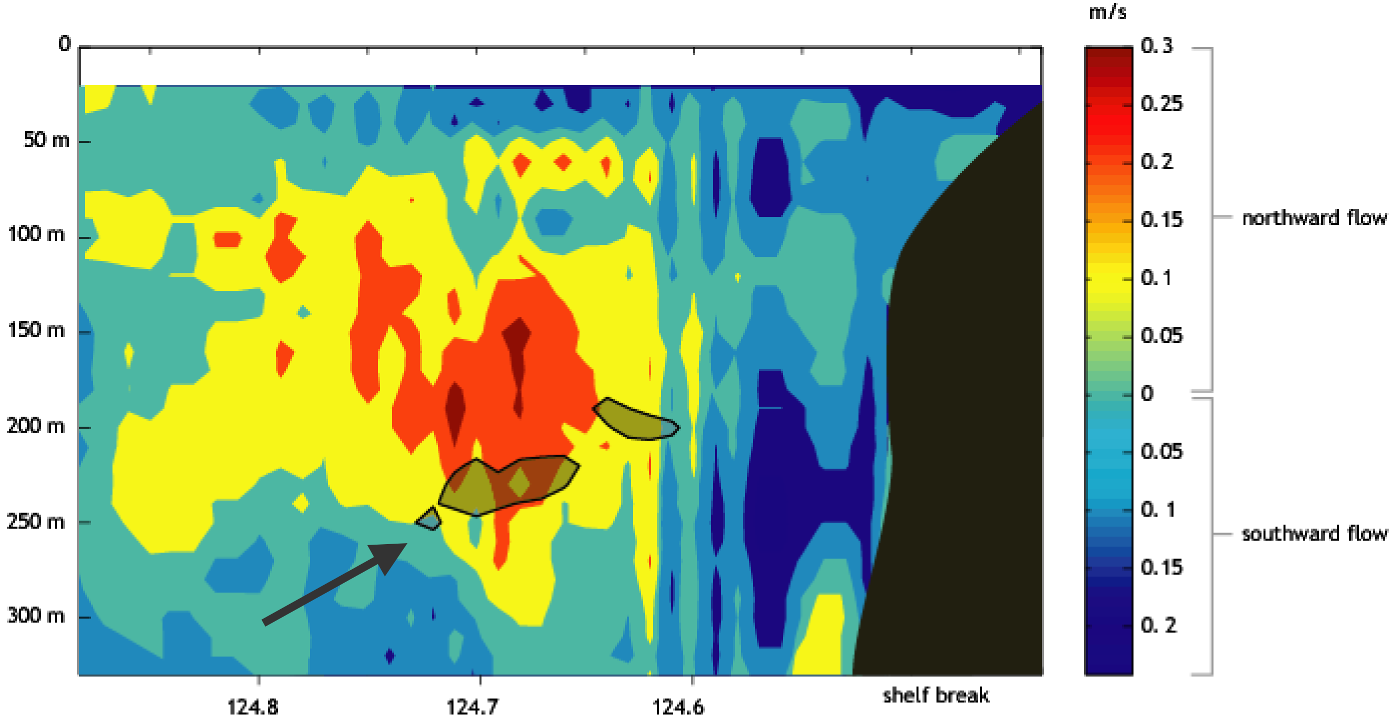
GOA Pollock



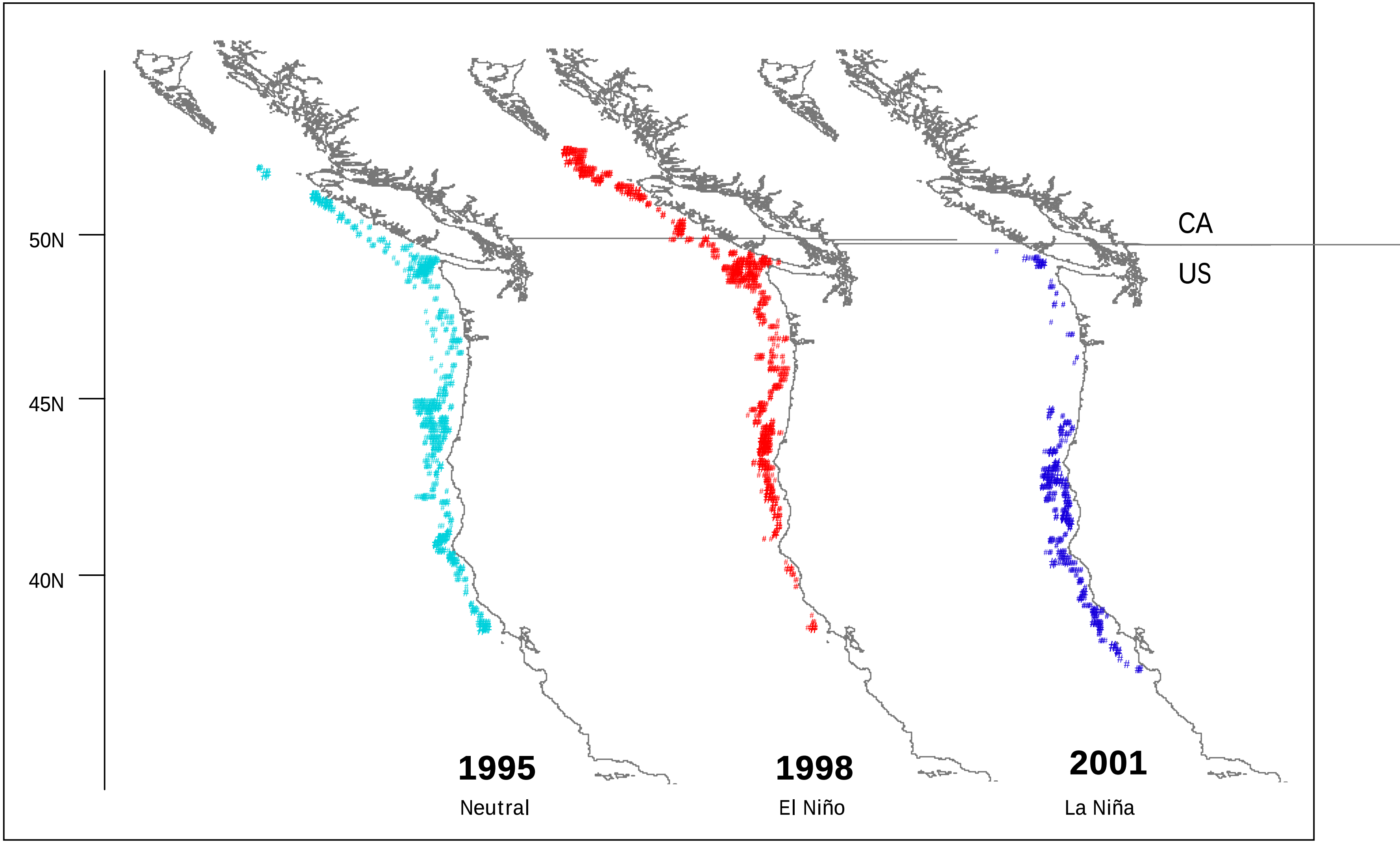
Will change occur without a shift in ATF?



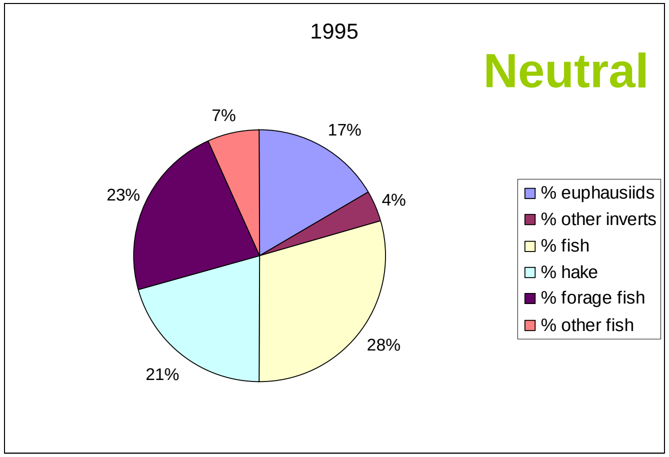
CANADA
USA
large adults
adults
juveniles
45N
30N
135W
120W
fall/winter spawning routes
spring/summer feeding routes
spawning area
main feeding areas

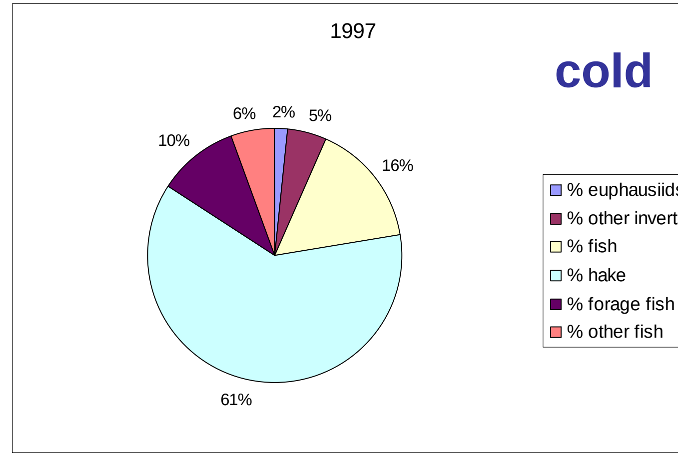


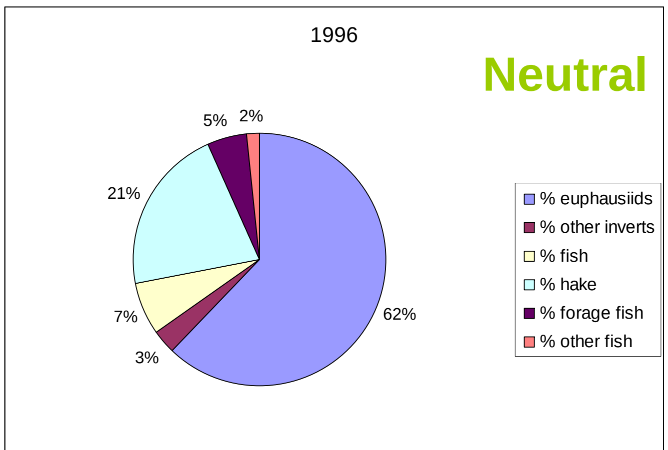
Color: alongshore flow velocity
Black: aggregation of fish (# of fish > 2.83×10^6)

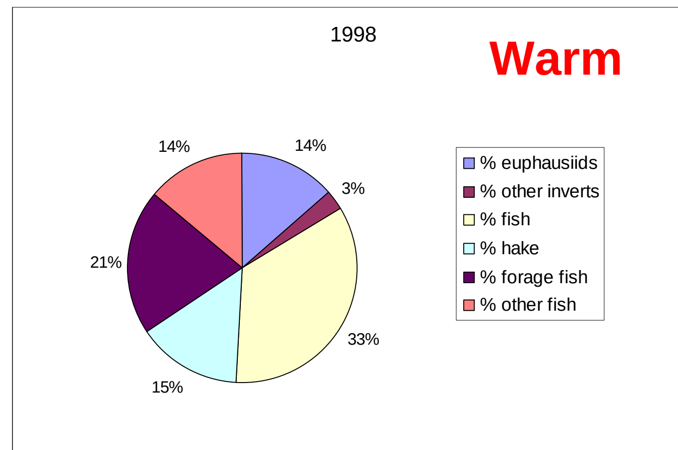


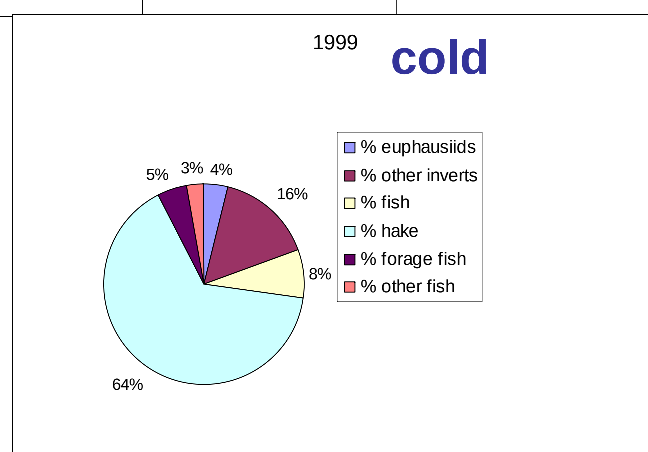
50N
45N
40N
CA
US
1995
Neutral
1998
El Niño
2001
La Niña





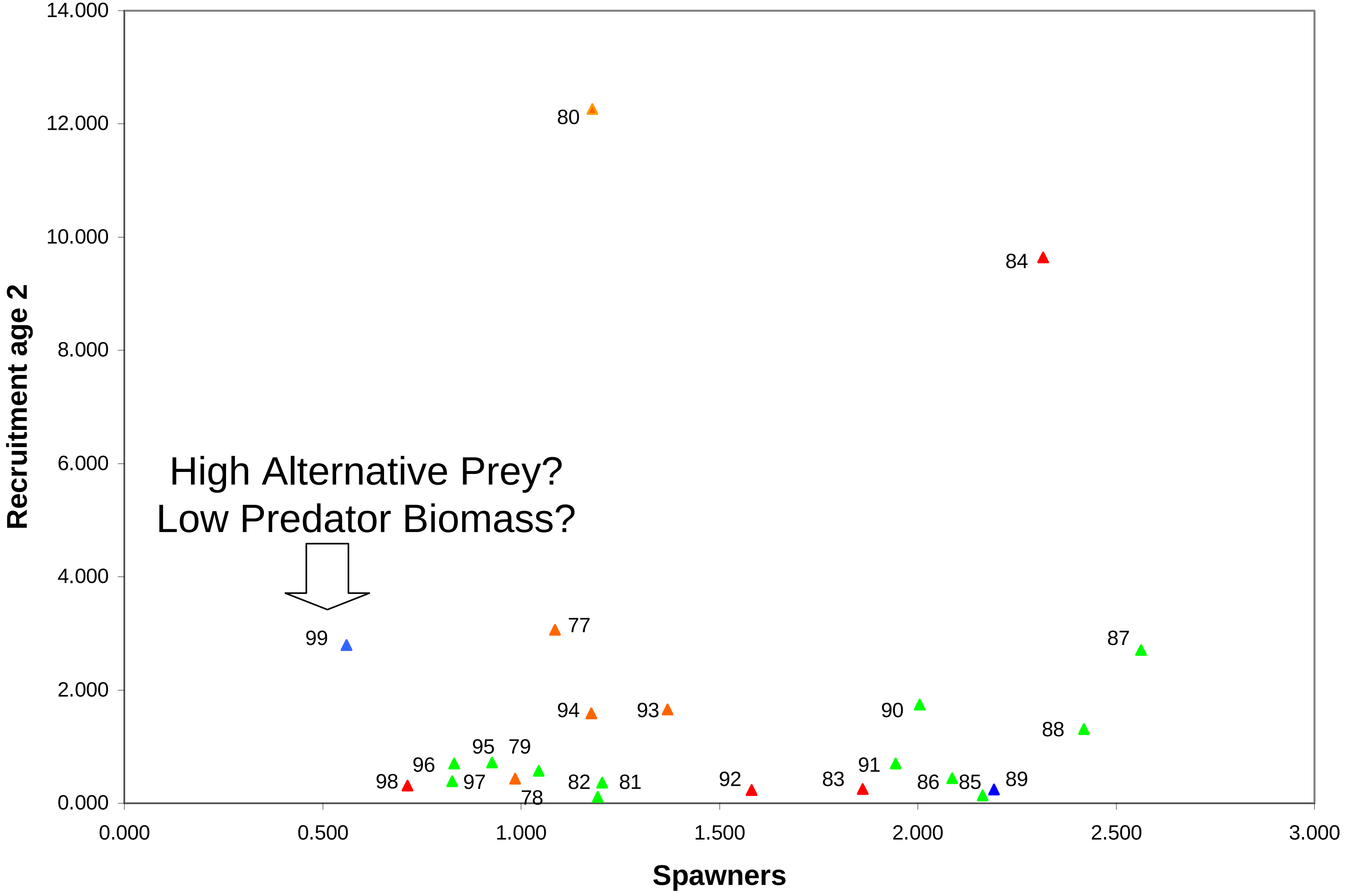






Pacific hake diet composition – AFSC

Pacific Hake

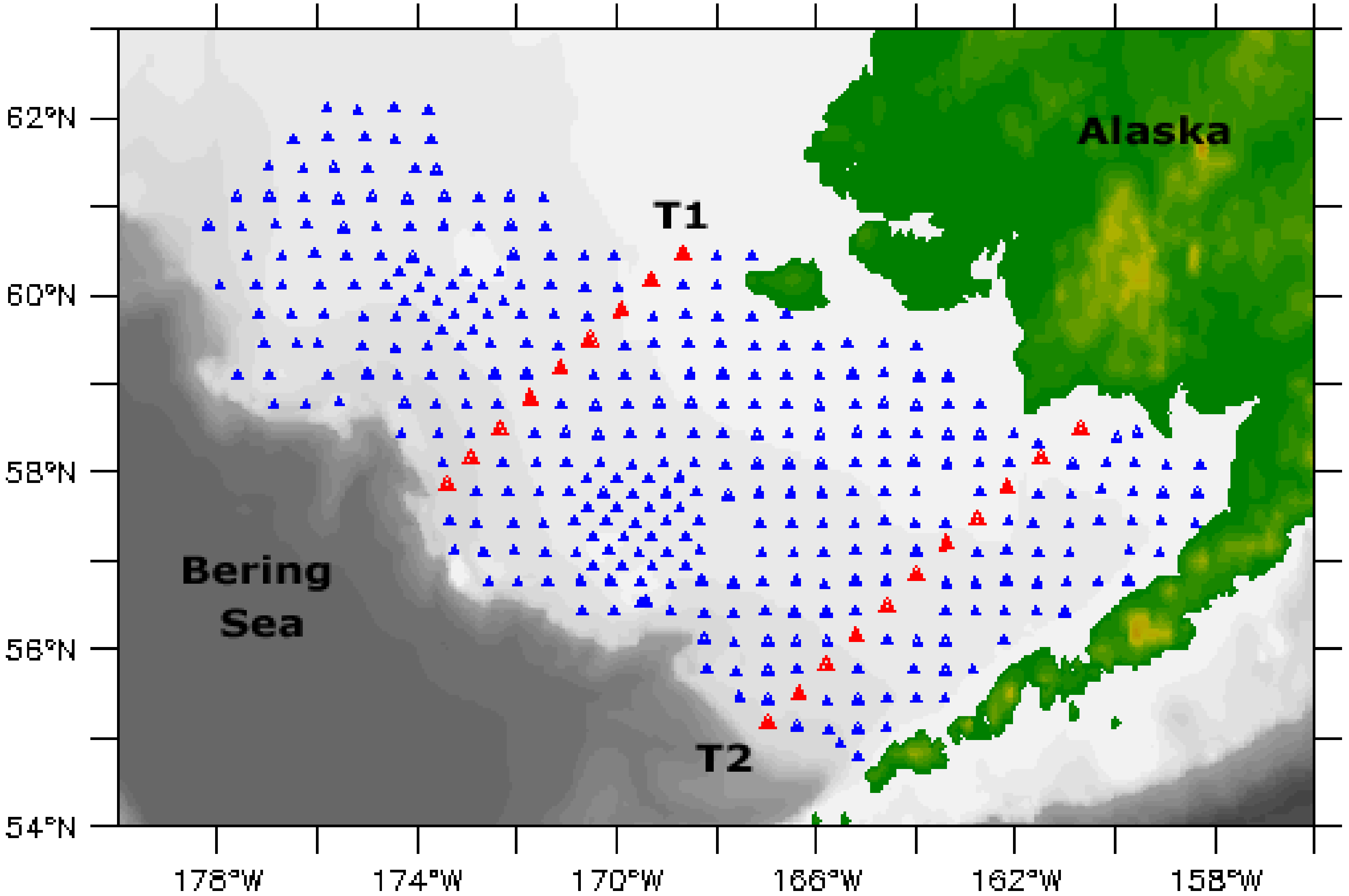


Conclusion – response differs between species

- High interannual variability indicative of multiple factors controlling production
- Low interannual variability indicative of single primary control
- Shifts in larval transport modulated by density dependence in nursery areas (flatfish)
- Shifts in control due to environment threshold effects modulated by predation (middle out - GOA pollock)
- Annually varying distribution of predators a function of pelagic ocean habitats (Pacific hake)

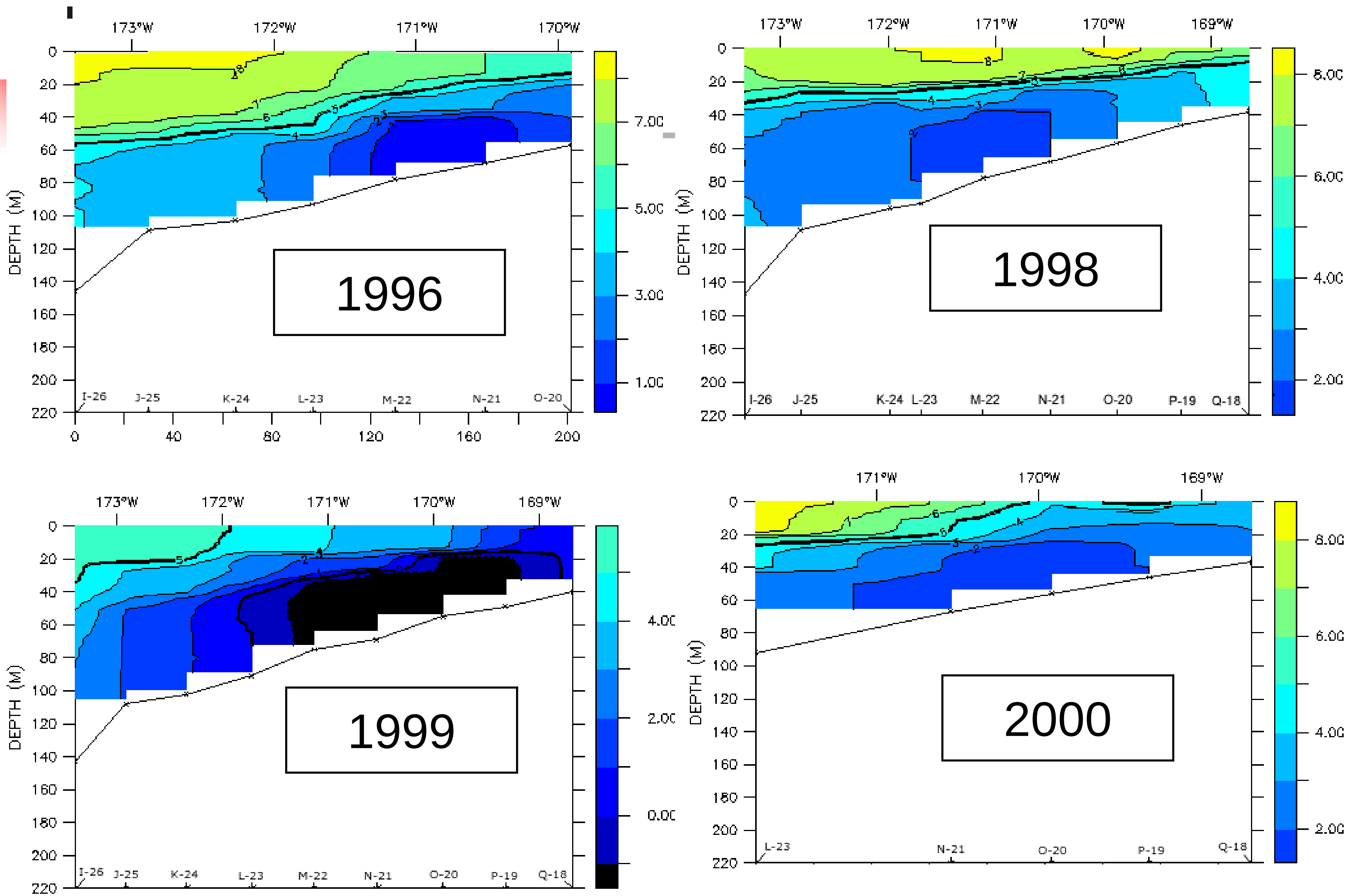
Questions

- Is it that simple? No single hypothesis adequate
- Are these hypotheses testable? YES if research focuses on controls at specific life stages
- Will they lead us to a predictive capability? Maybe, if we incorporate climate and predation influences in stock assessments and verify parameters with seasonal foraging studies

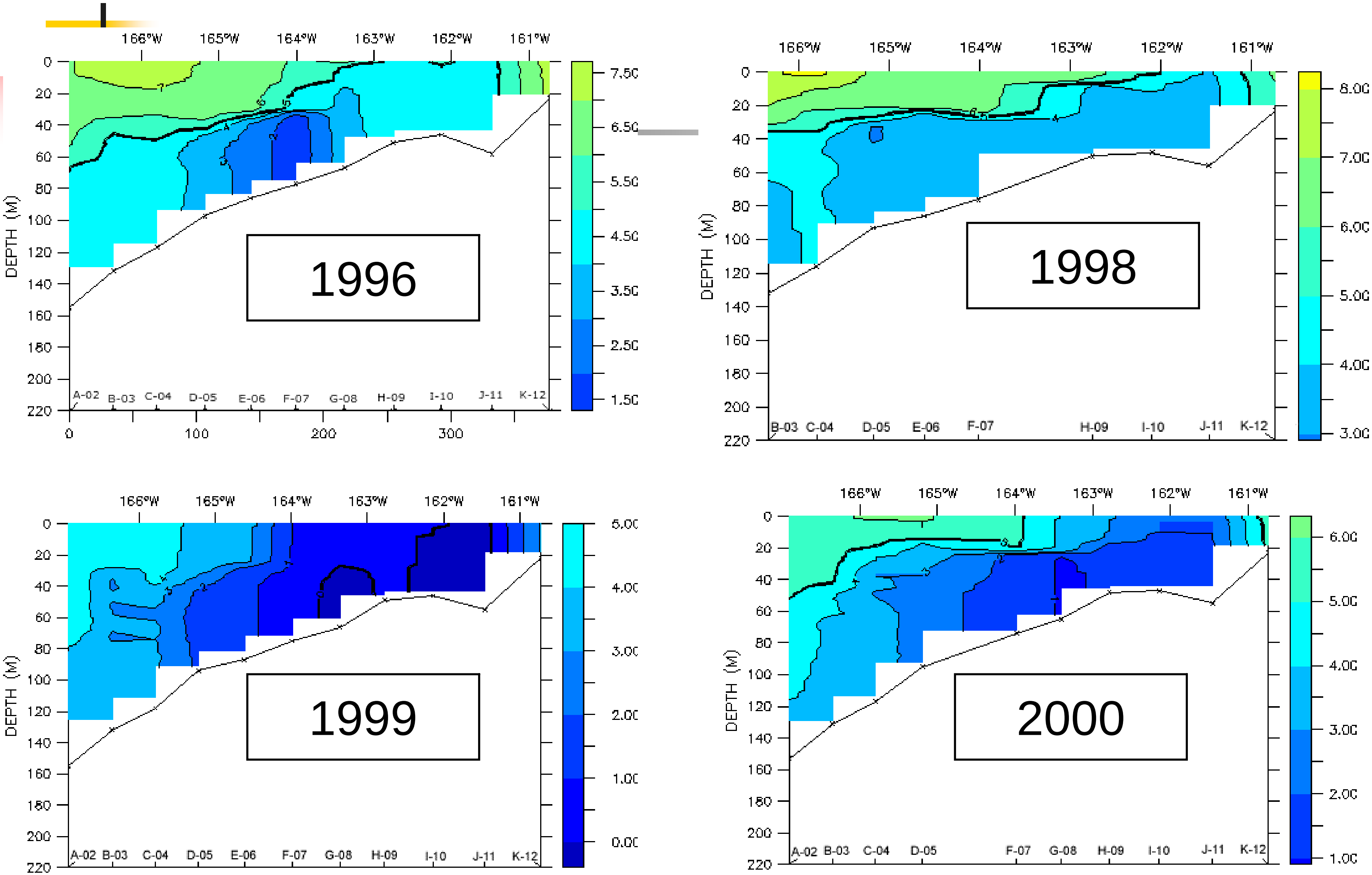


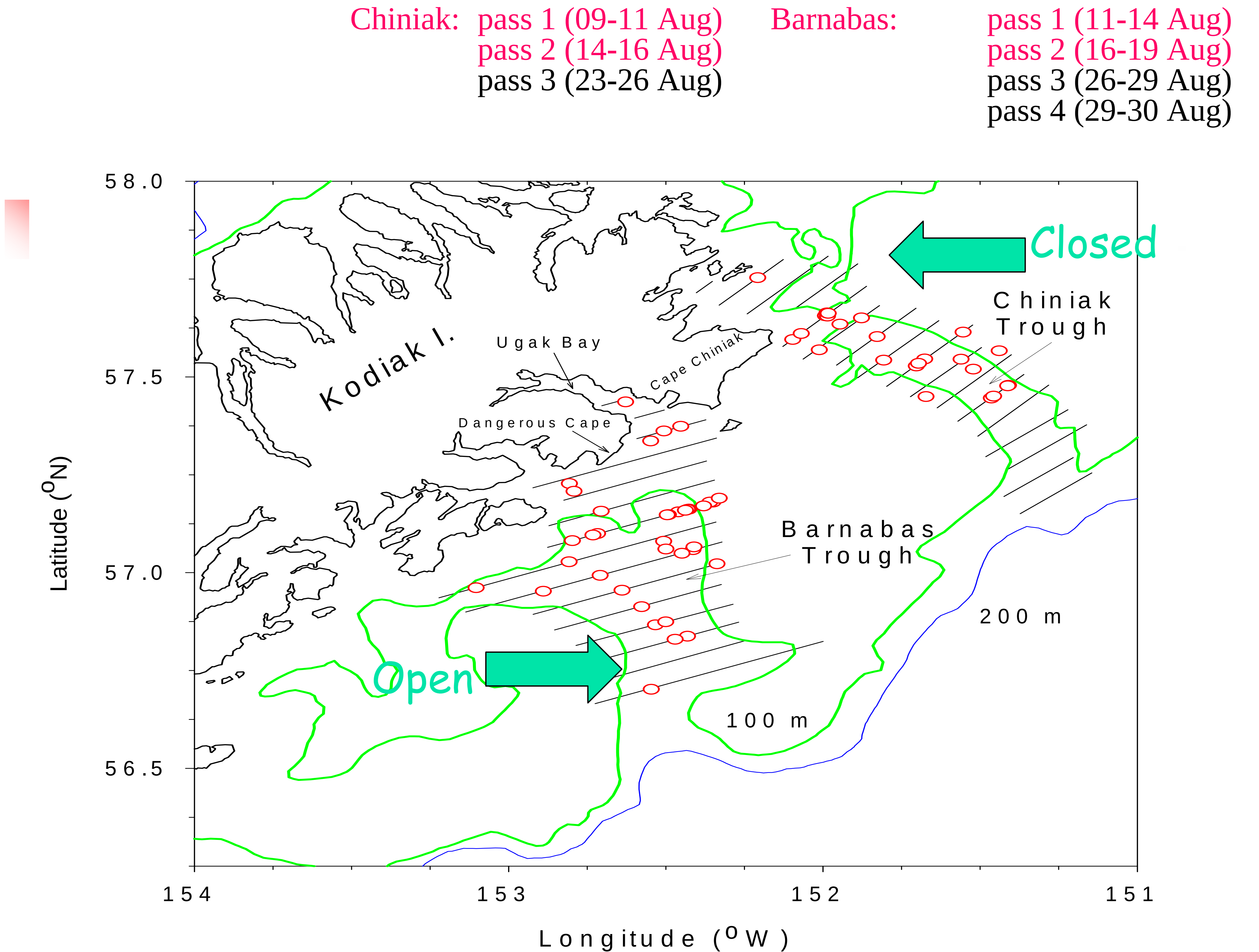
Alaska
T1
Bering
Sea
T2
62°N
60°N
58°N
56°N
54°N
178°W
174°W
170°W
166°W
162°W
158°W

Transect 1 - Jun - Jul



Transect 2 - Jun - Jul

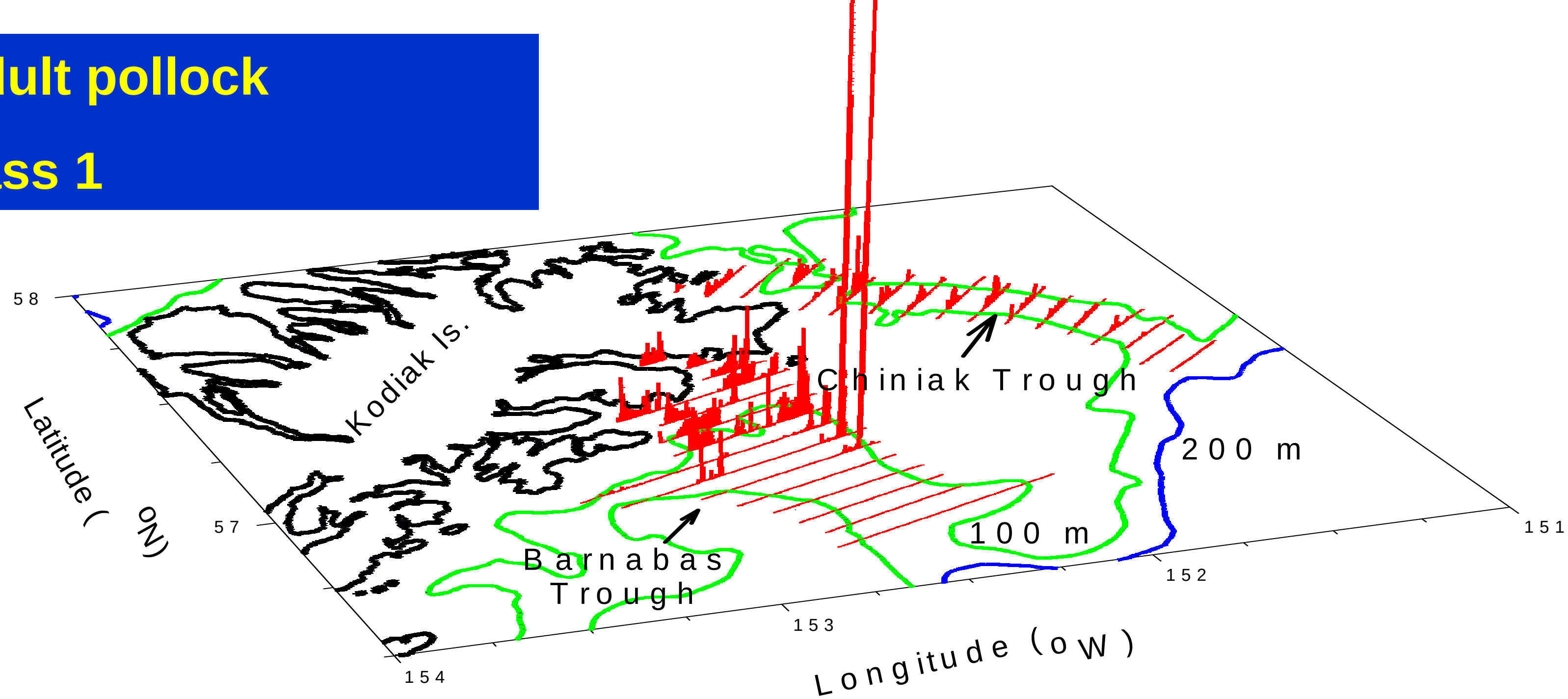




Chiniak: pass 1 (09-11 Aug)
pass 2 (14-16 Aug)
pass 3 (23-26 Aug)
Barnabas: pass 1 (11-14 Aug)
pass 2 (16-19 Aug)
pass 3 (26-29 Aug)
pass 4 (29-30 Aug)
Closed
Open
Chiniak Trough
Barnabas Trough
Kodiak I.
Ugak Bay
Cape Chiniak
Dangerous Cape
100 m
200 m
58.0
57.5
57.0
56.5
Latitude (oN)
154
153
152
151
Longitude (oW)

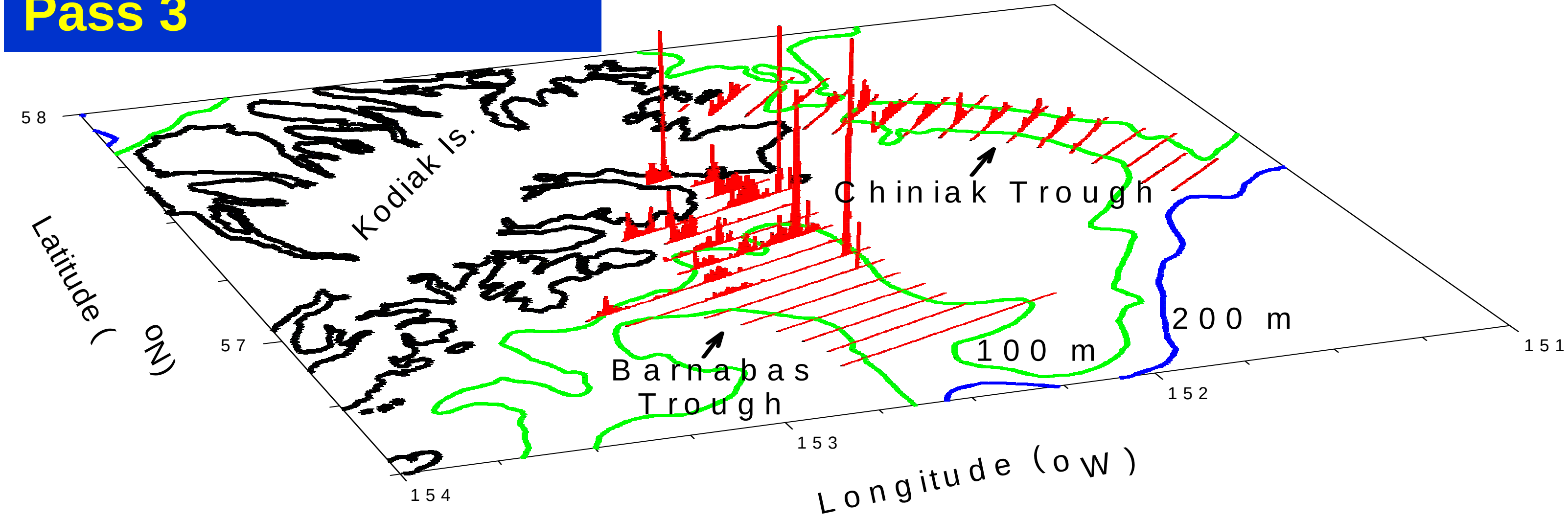
Adult pollock

Pass 1

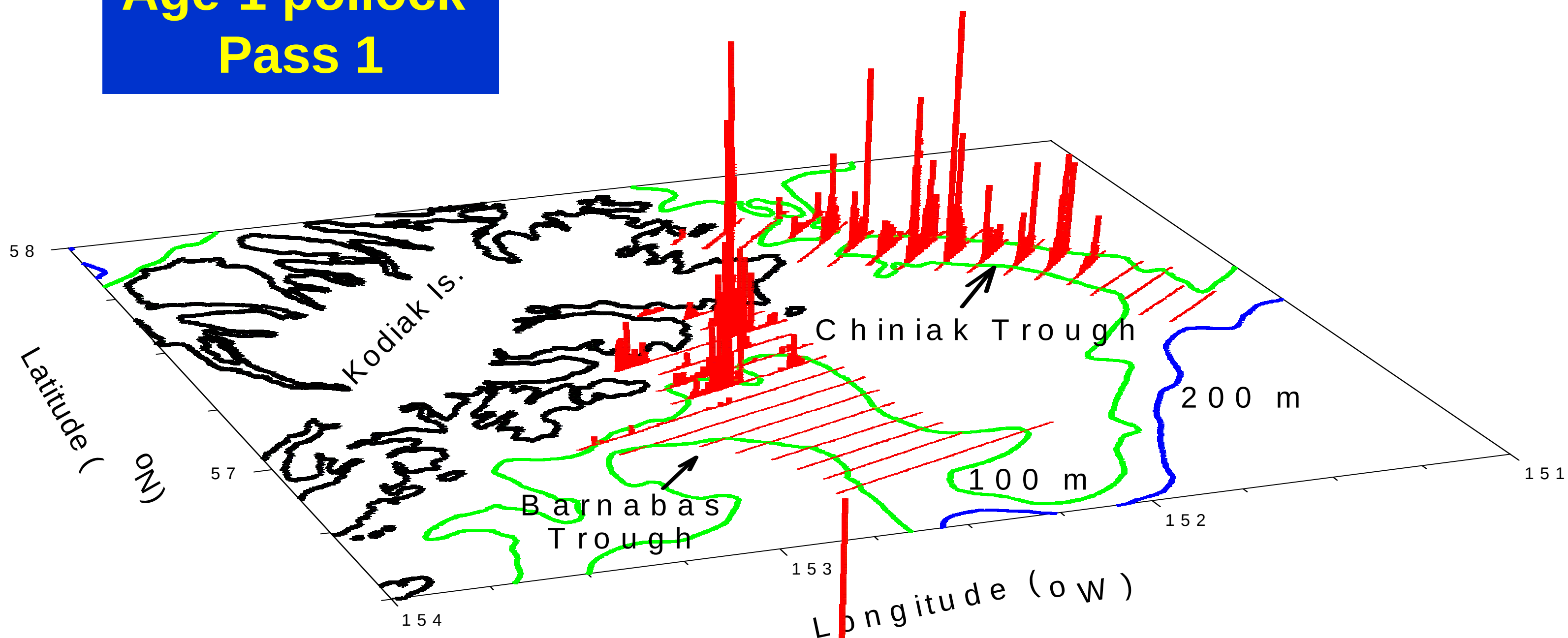


Adult pollock

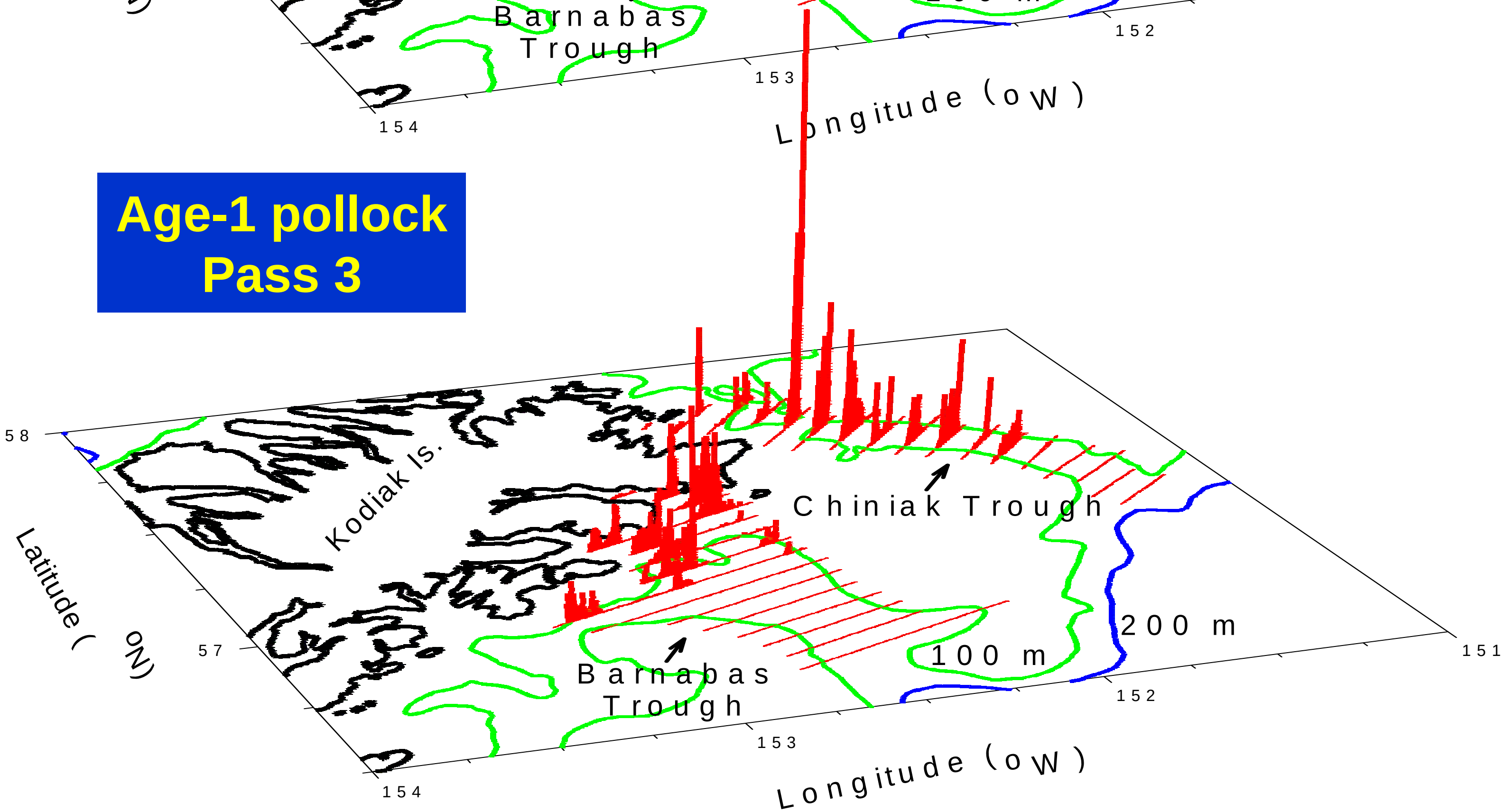
Pass 3



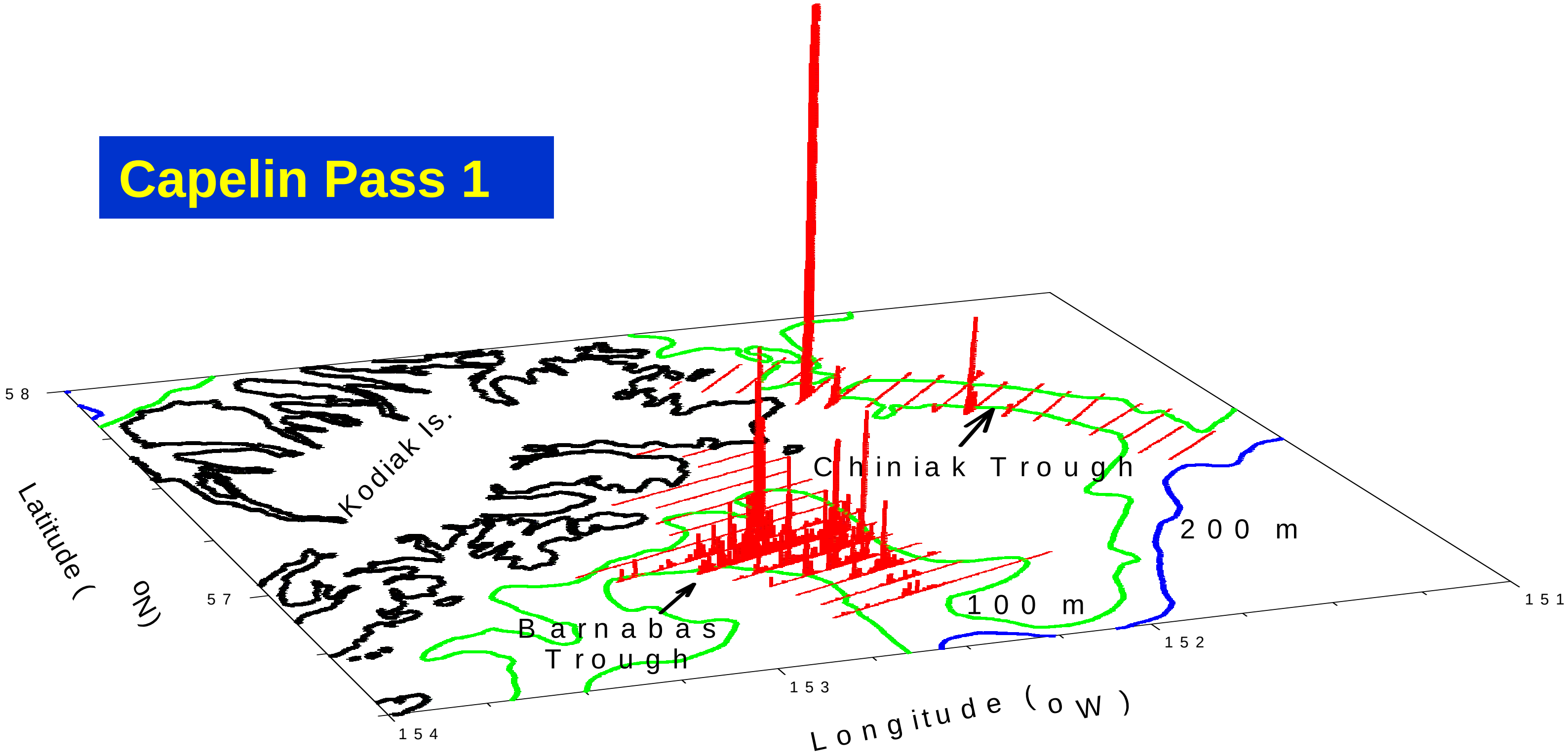
Age-1 pollock
Pass 1



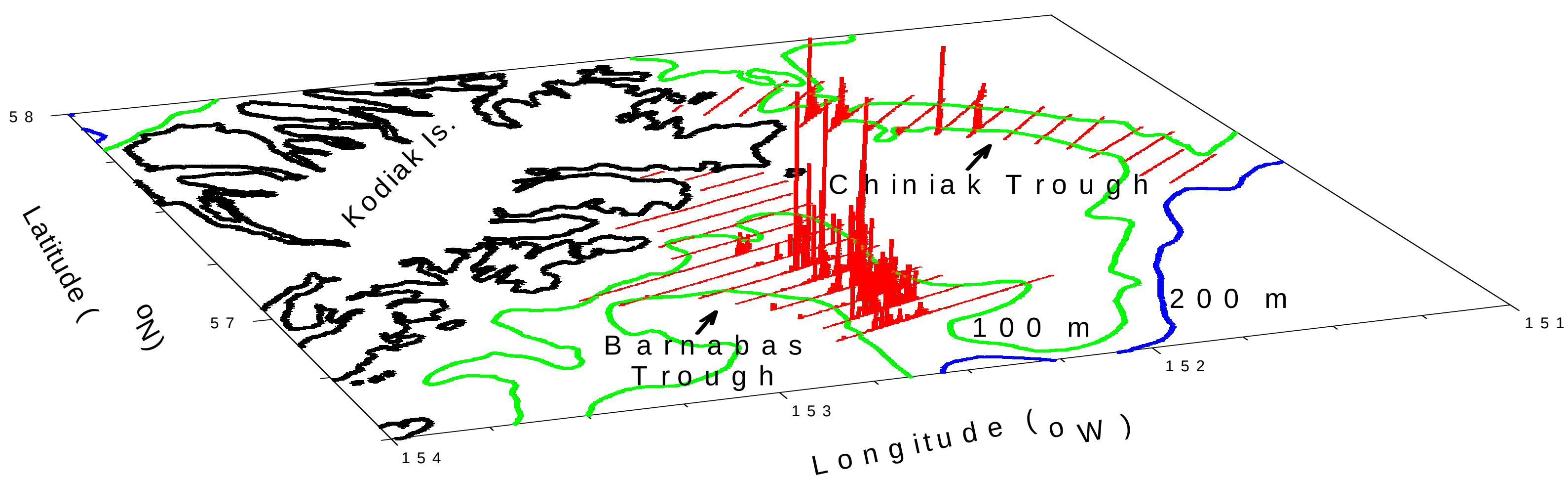
Age-1 pollock
Pass 3



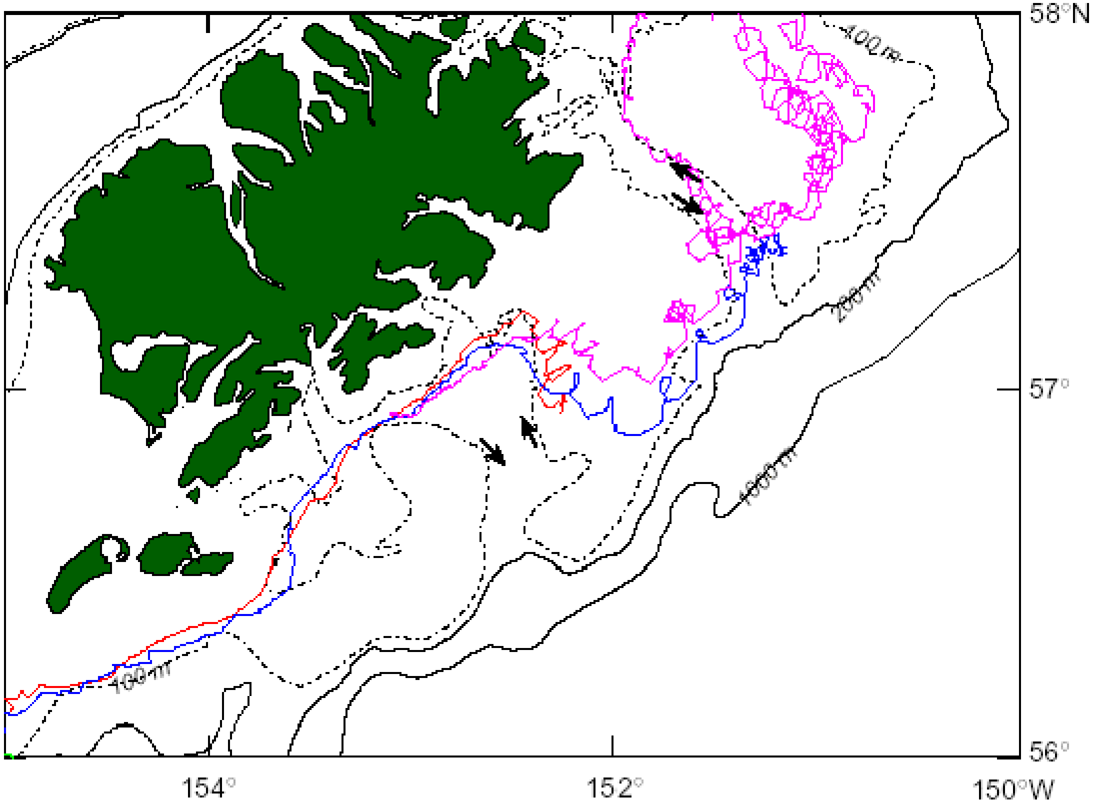
Capelin Pass 1



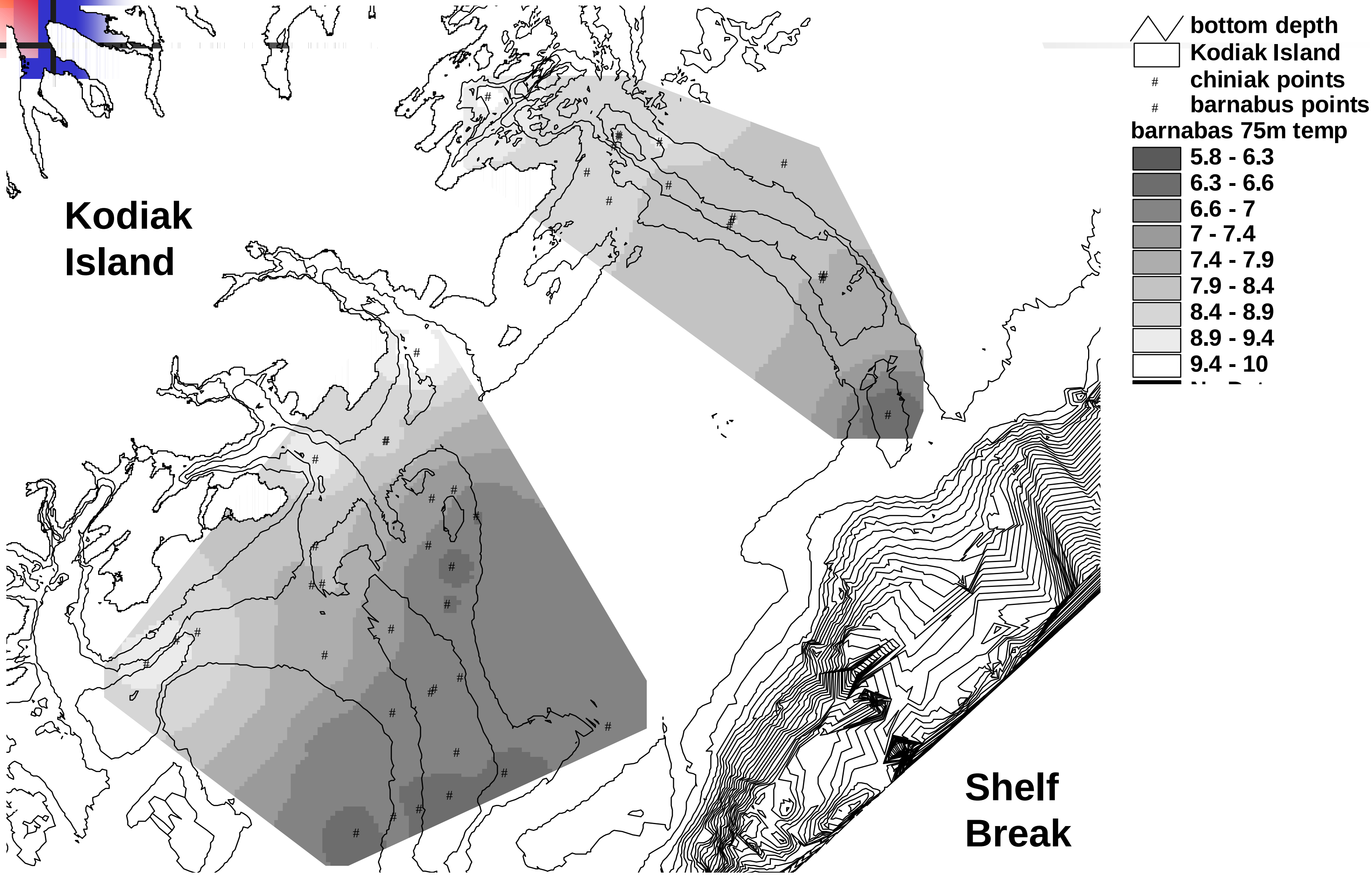
Capelin Pass 3



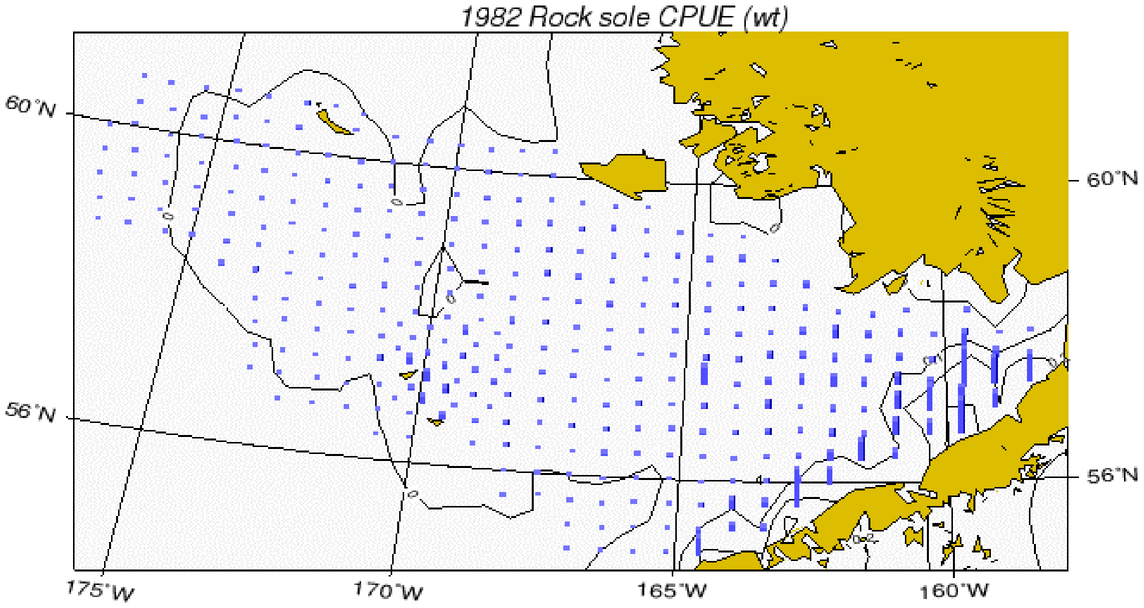
Drifter Track



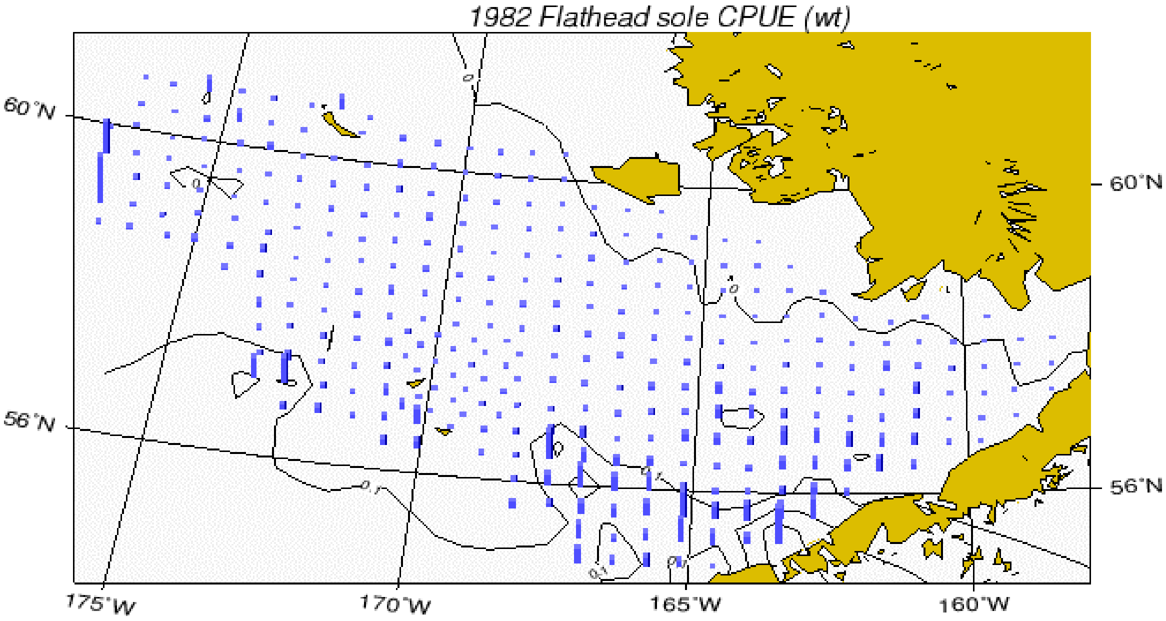
Chiniak and Barnabus Troughs at 75m for pass 3



Rock sole



Flathead sole



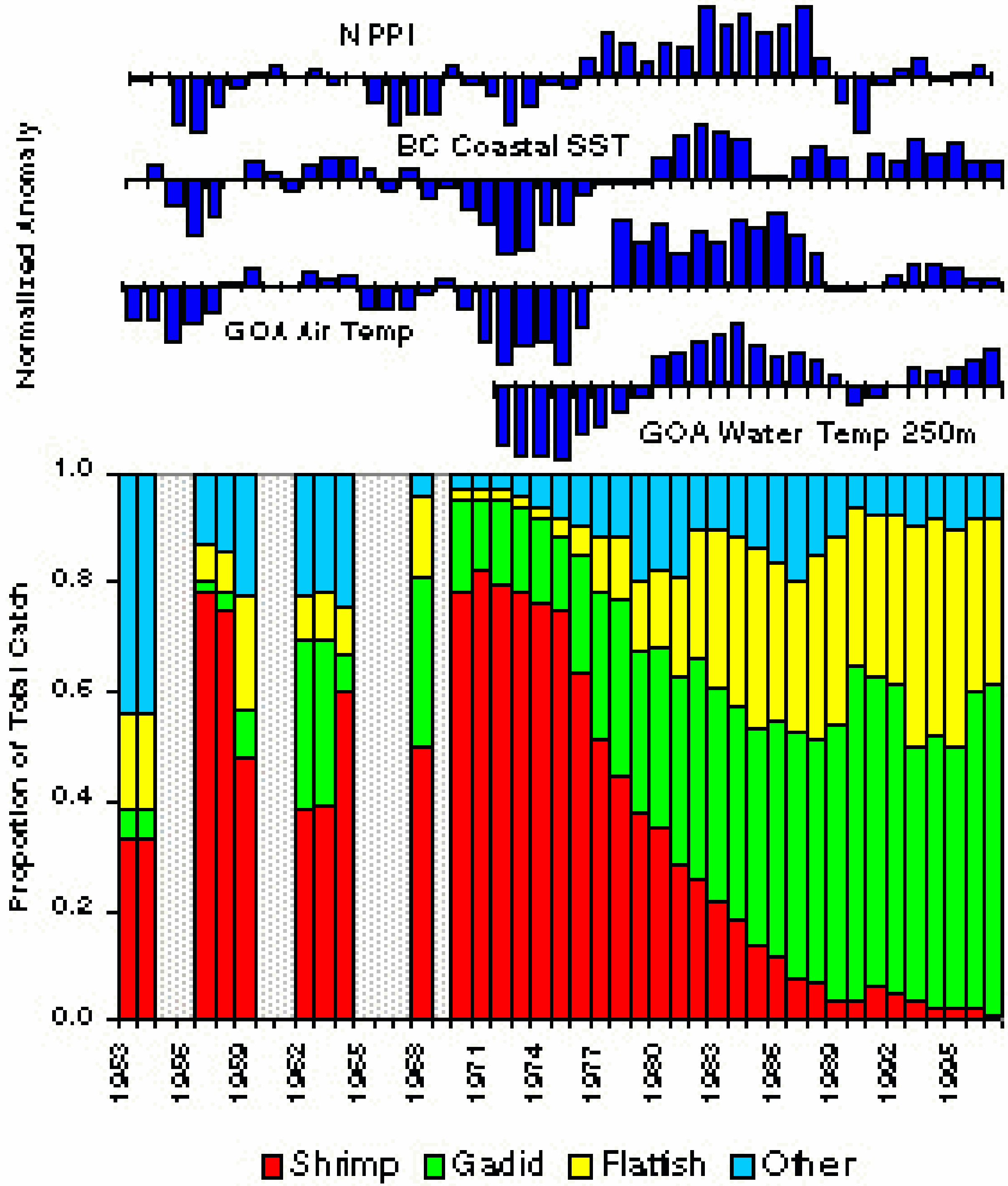
Gulf of Alaska

Climate Indices

and

Shrimp-Trawl Catches

(Biomass)



(Anderson and Piatt, 1999)

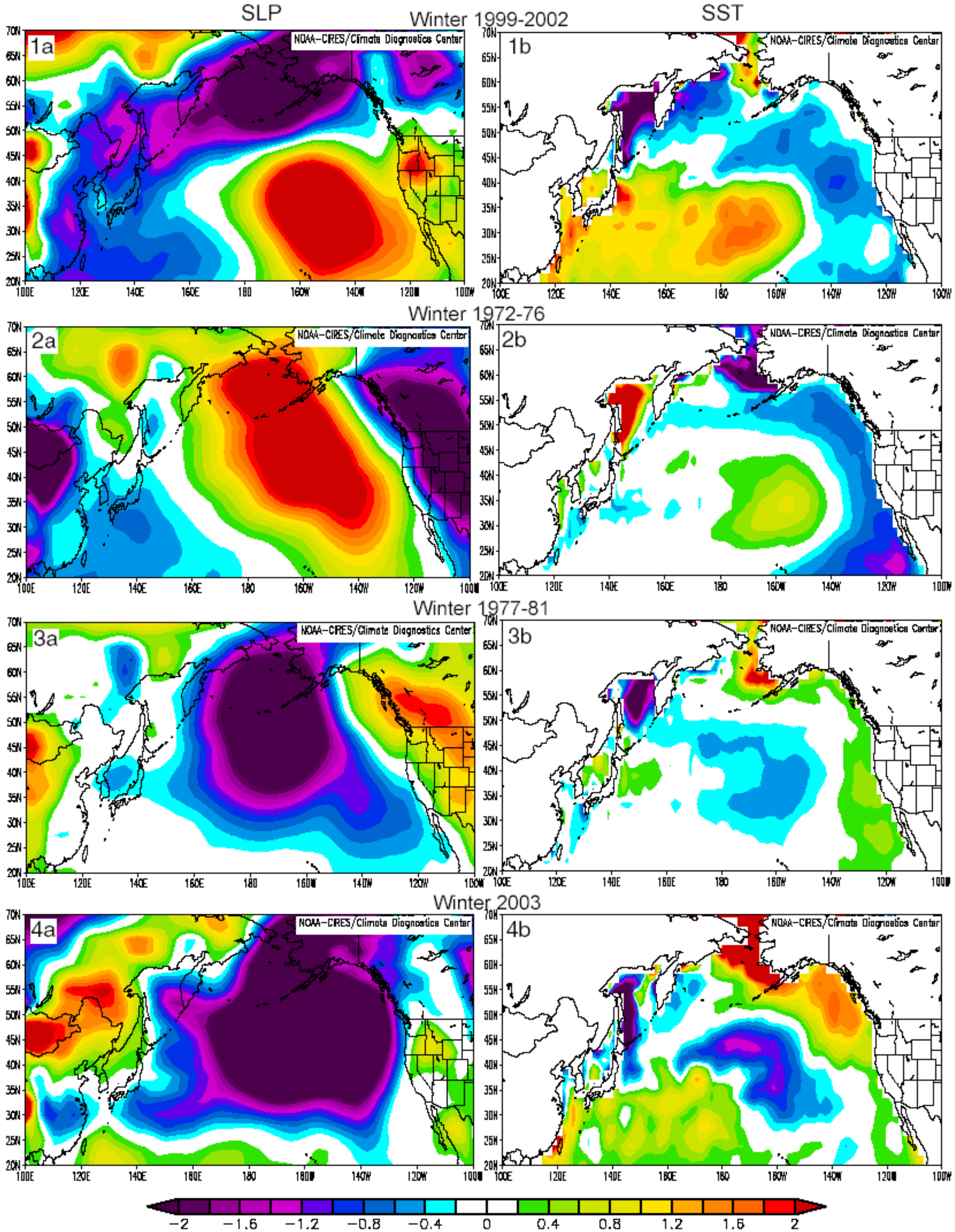
N. Bond et al. (PMEL/NOAA)

1999-02

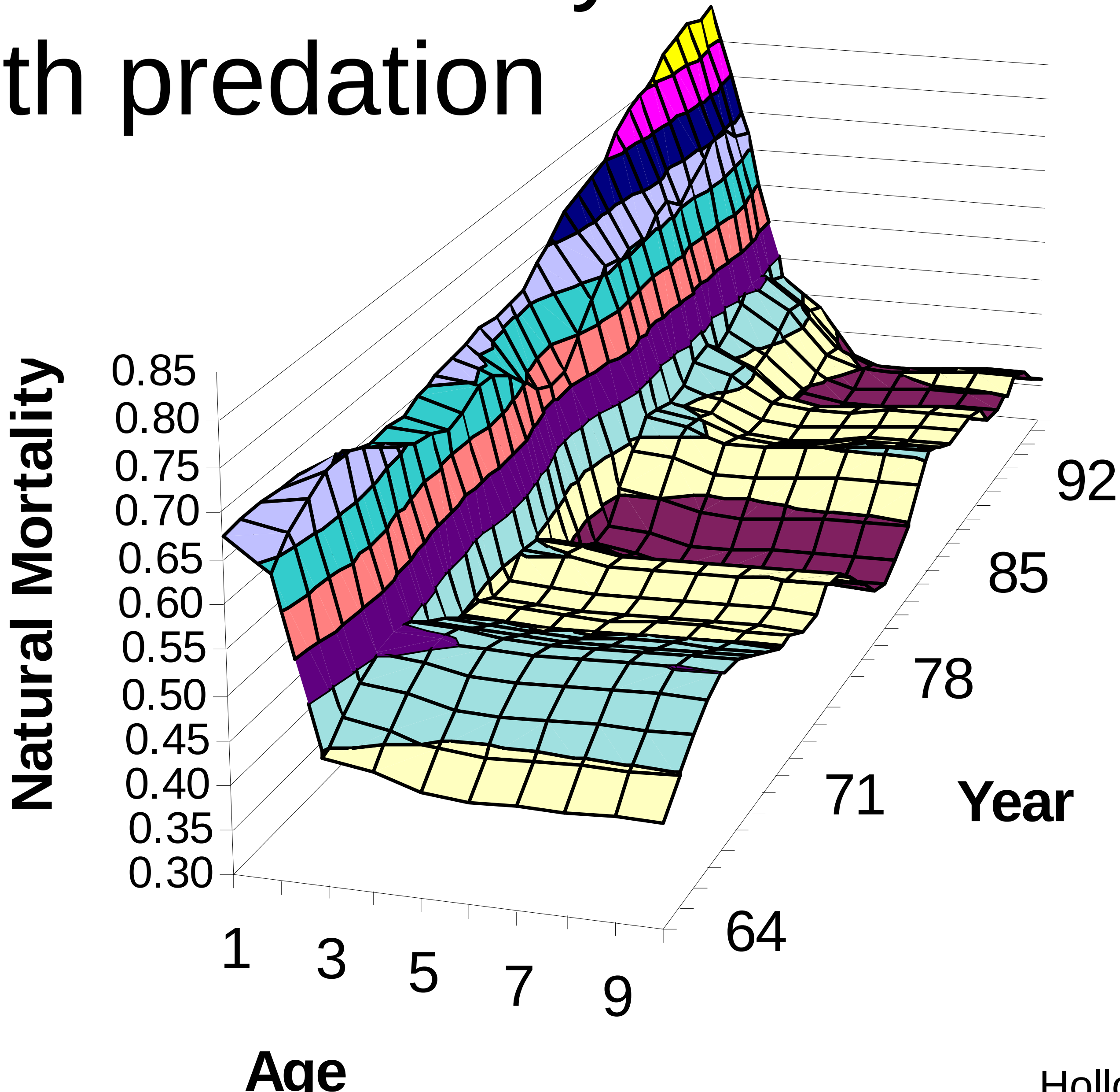
1972-76

1977-81

2003

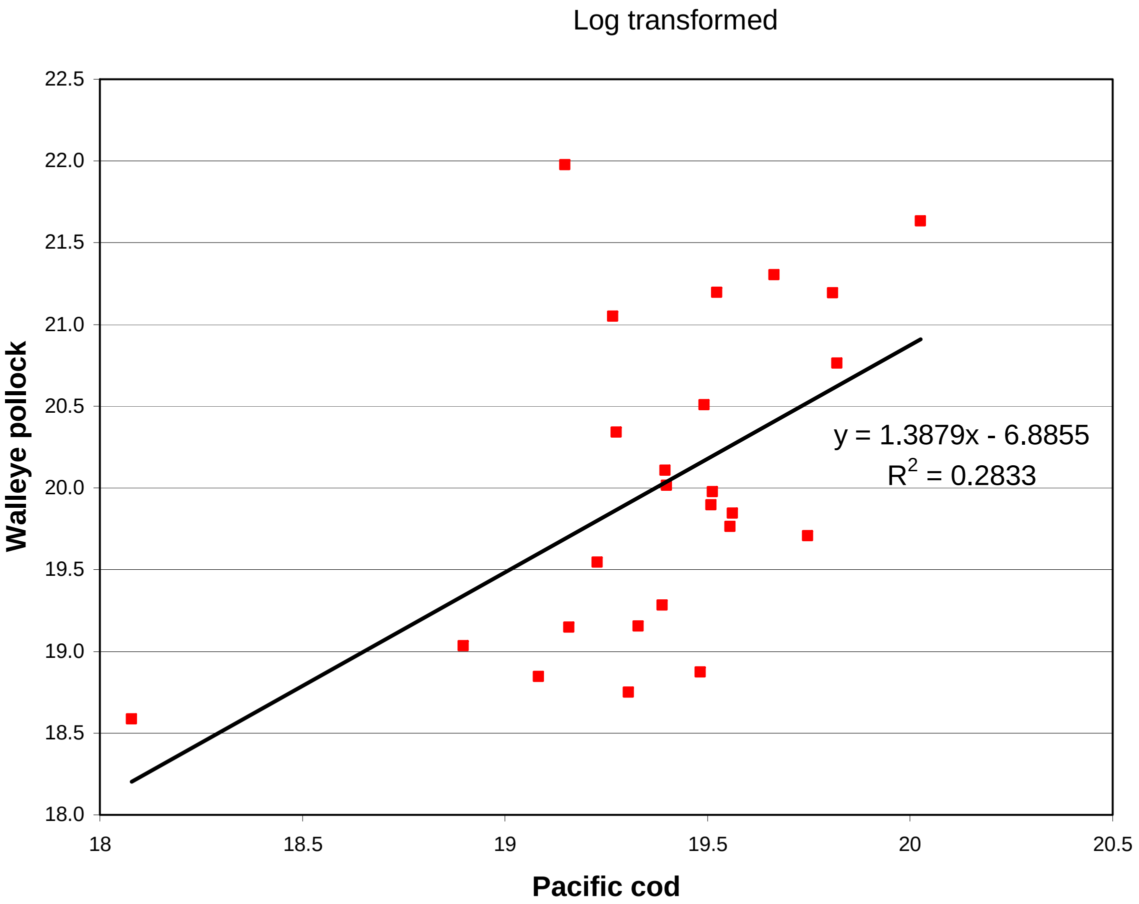


Natural Mortality -with predation



Hollowed et al. 2001

Synchrony

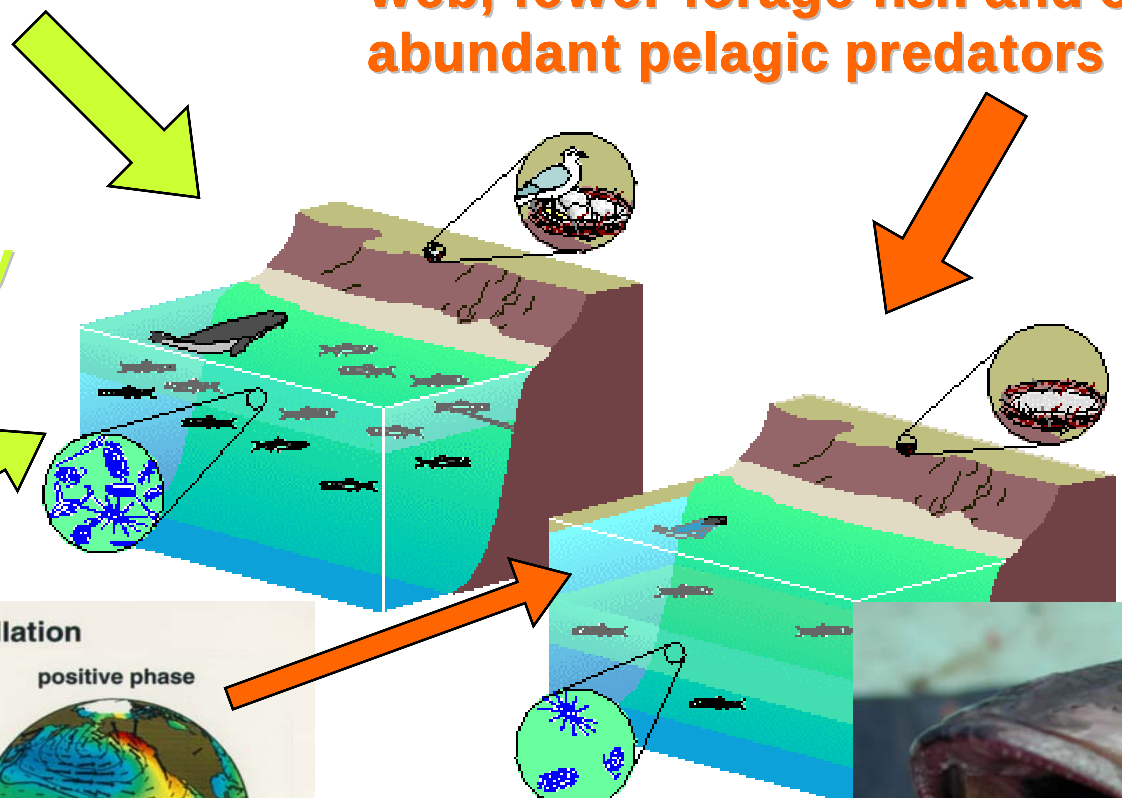


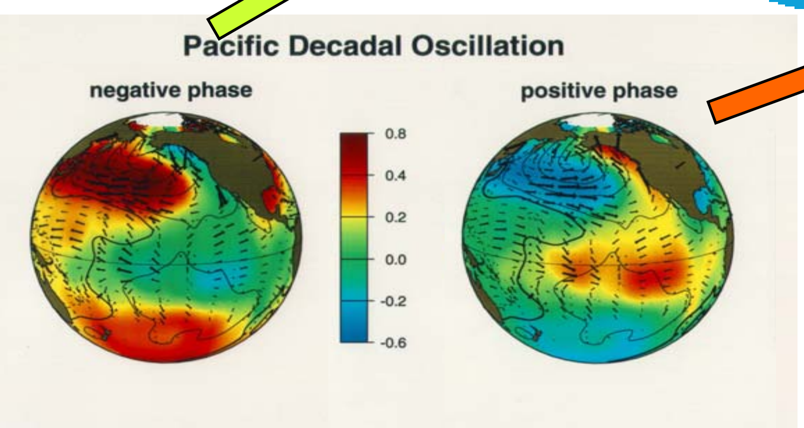
Log transformed
22.5
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
Walleye pollock
y = 1.3879x - 6.8855
R2 = 0.2833
18
18.5
19
19.5
20
20.5
Pacific cod

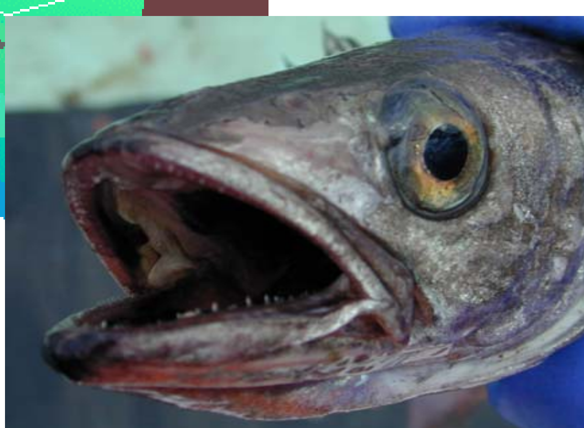
Climate Variability

Cool water, weak stratification high nutrients, a "subarctic" food web with abundant forage fish and relatively fewer warm water predators

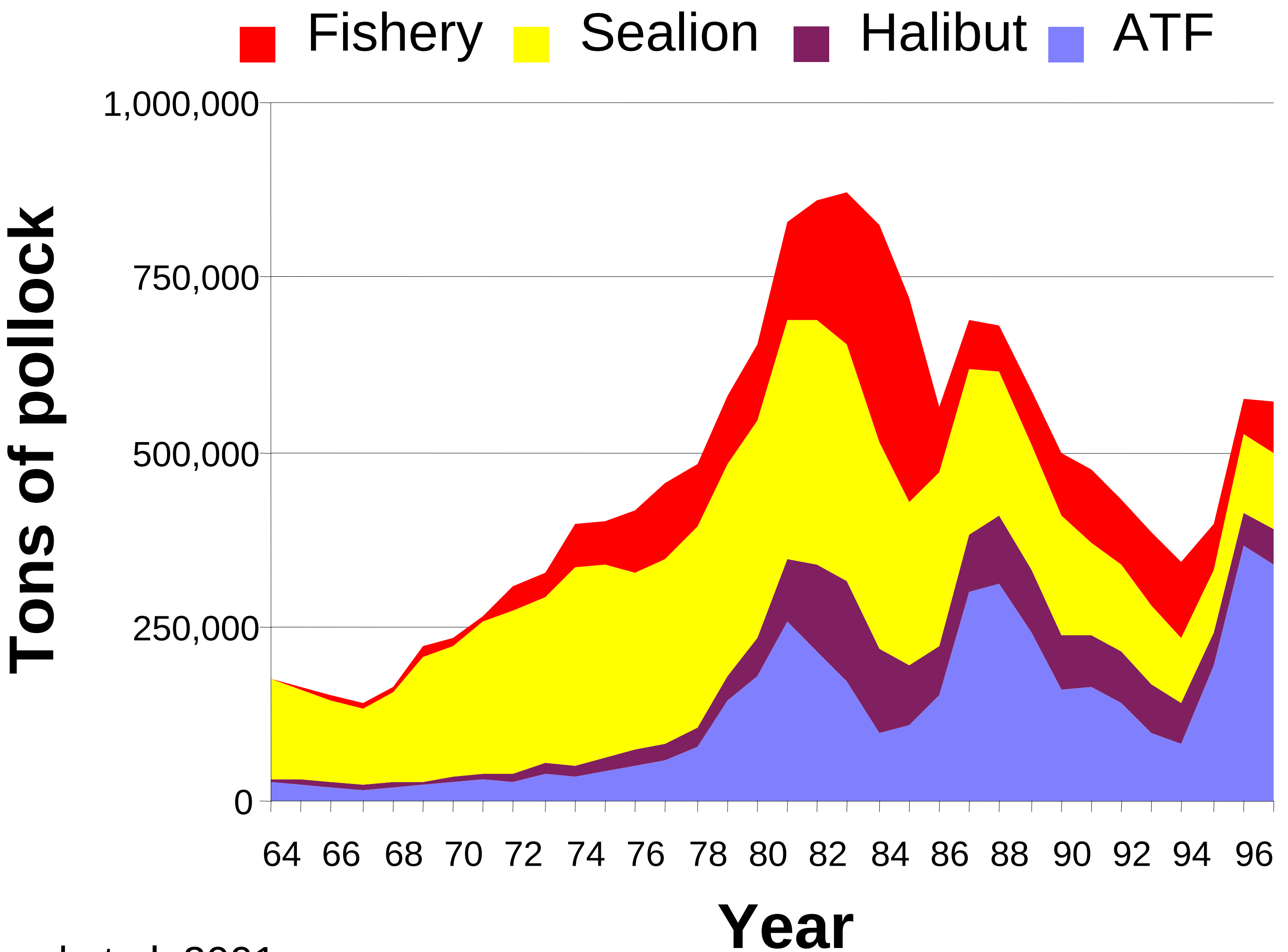
Warm stratified ocean, few nutrients, low productivity "subtropical" food web, fewer forage fish and often abundant pelagic predators







Who’s eaten how much…



Hollowed et al. 2001