Science, Service, Stewardship

A web for all seasons: seasonal and geographic variation in the Bering Sea food web

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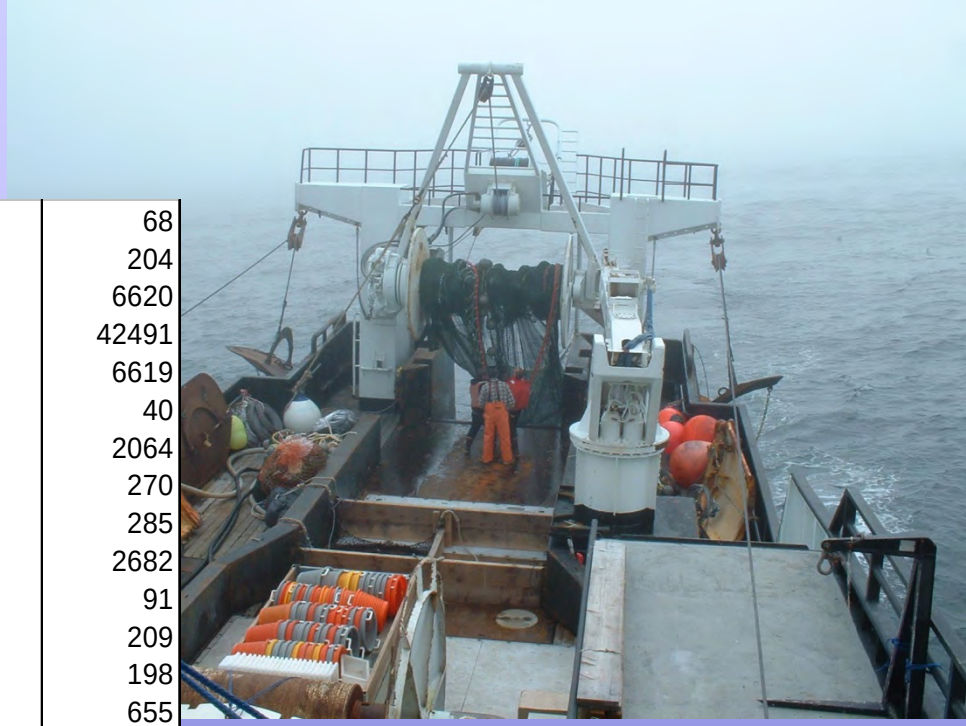
NOAA FISHERIES SERVICE

The data

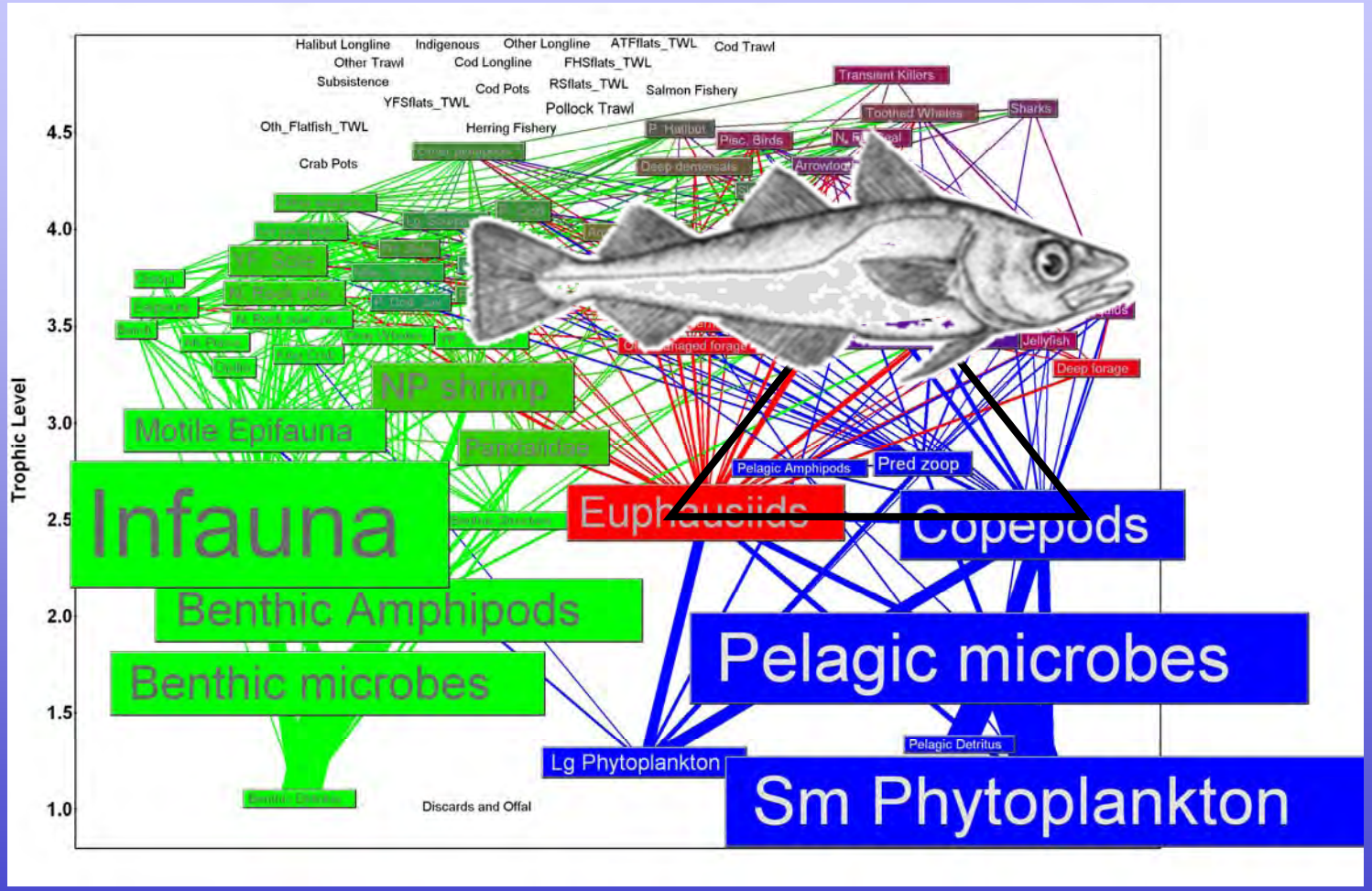


AK Plaice	4695		Mud Skate	68
AK Skate	2043		Myctophidae	204
Aleutian Skate	83		N Rock Sole	6620
Arrowtooth	18657		P. Cod	42491
Atka	2264		P. Halibut	6619
Bathylagidae	61		Pacific Grenadier	40
Bering Skate	44		POP	2064
Big Skate	8		Rex sole	270
Black Skate	4		S Rock Sole	285
Bocaccio	1		Sablefish	2682
Canary Rock	63		Salmon	91
Capelin	1		Sculpin	209
Dogfish	1		Sebastes	198
Dover Sole	905		Sharp North Dusky	655
Eelpout	490		Short Rough Rocks	1054
Eulachon	53		Shortsp Thorny	1255
FH Sole	12421		Sleeper Shark	13
Giant Grenadier	209		Squid	66
Gr. Turbot	3098		Unid Bathyraja	297
Greenlings	24		Unid Rajidae	655
Hake	16504		W. Pollock	82161
Herring	380		WhtBlotch Skate	33
Kamchat fl	1412		Widow Rock	18
Lg Sculpin	3107		Yellowtail Rock	202
Longsp Thorny	328		YF Sole	21525
			Grand Total	236631

Food habits data collected on surveys and by observers 1982-2008

Fisheries observer-collected data is primary source for many critical seasons (e.g. winter).
10cm+ fish (not larval).
Largest sample sizes are for fishery-sized animals.

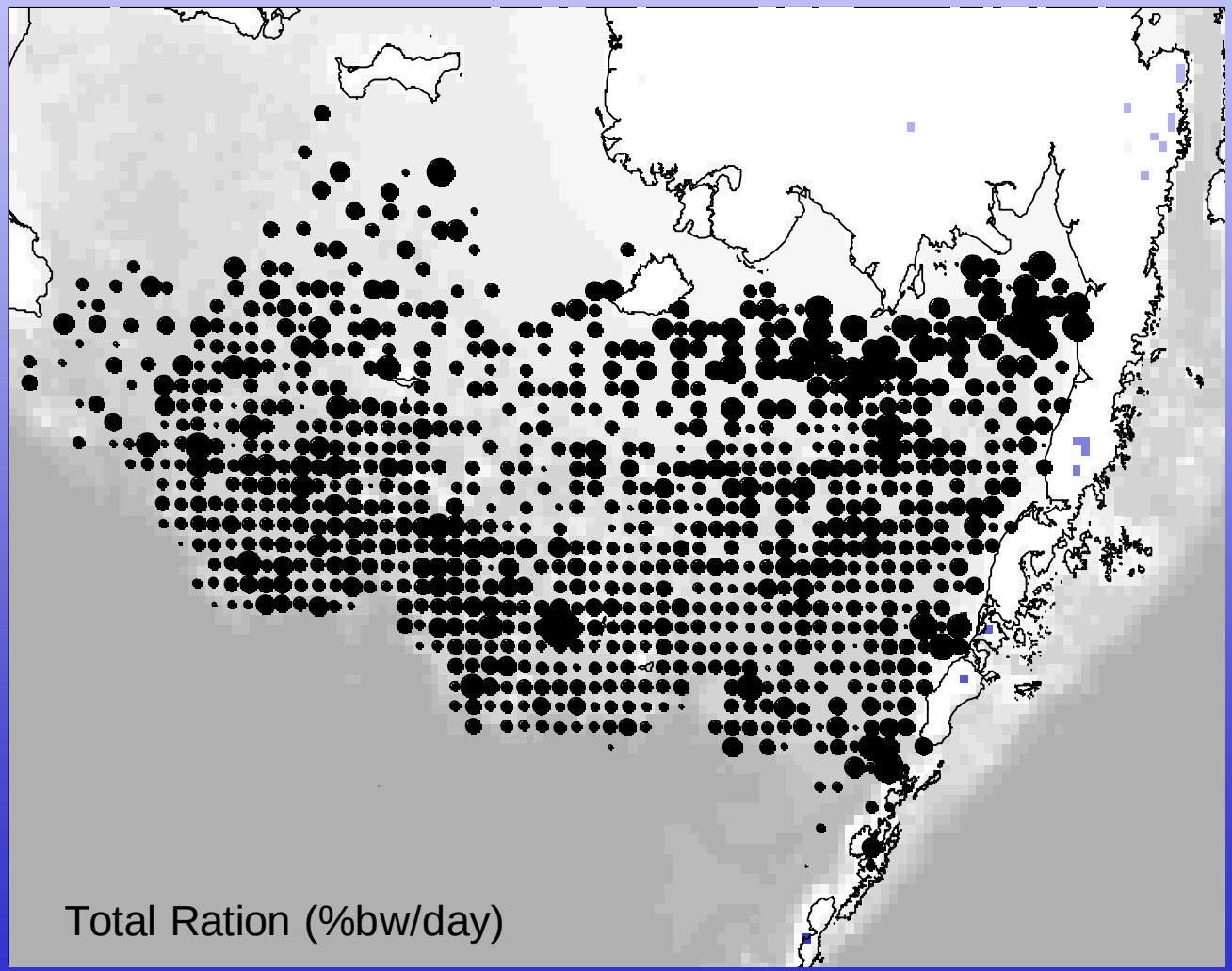
A critical triangle

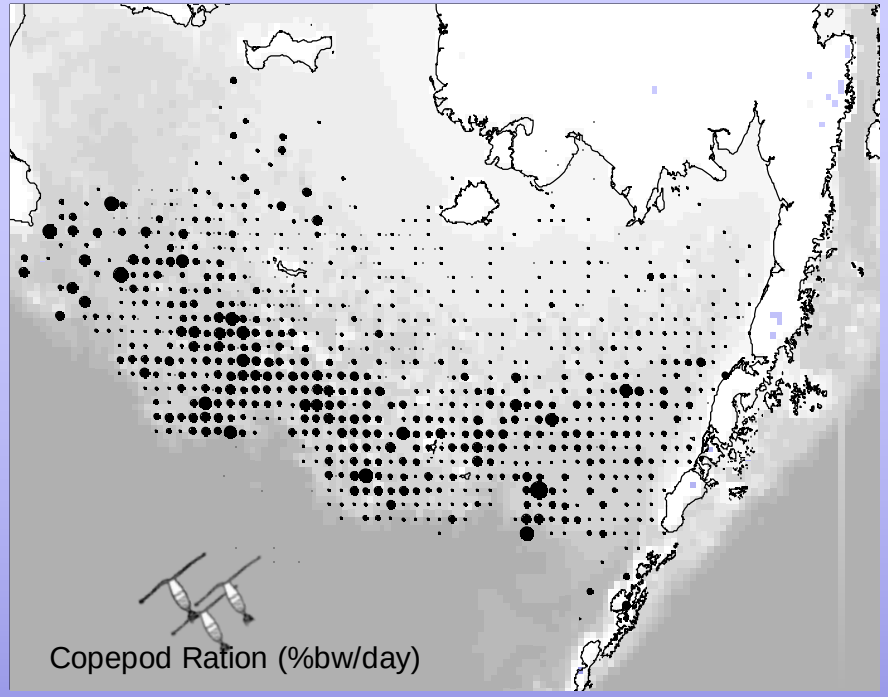


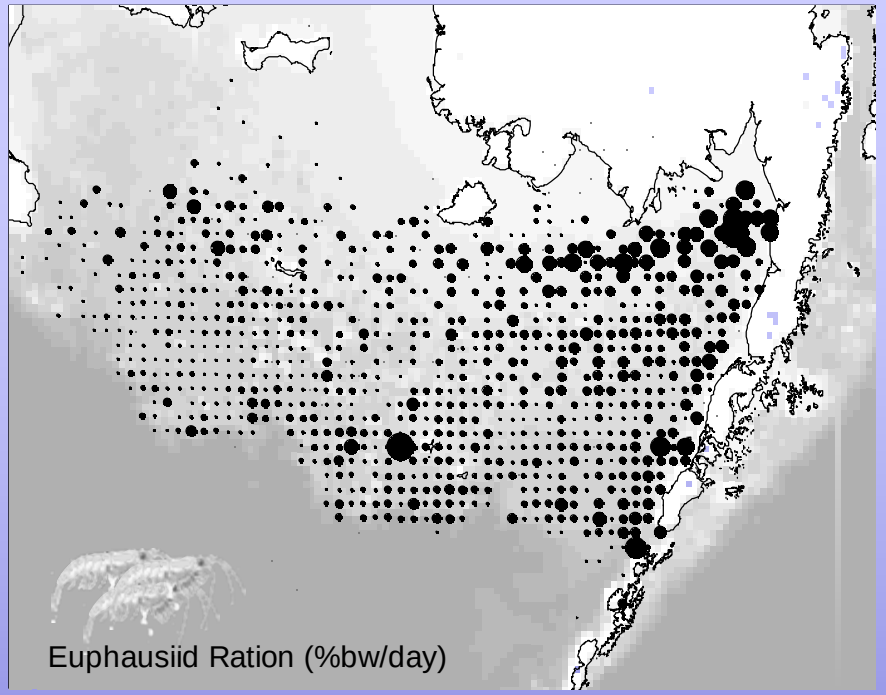
- >60% of trophic level 3 consumption is by pollock
- >70% of that is consumption of copepods and euphausiids

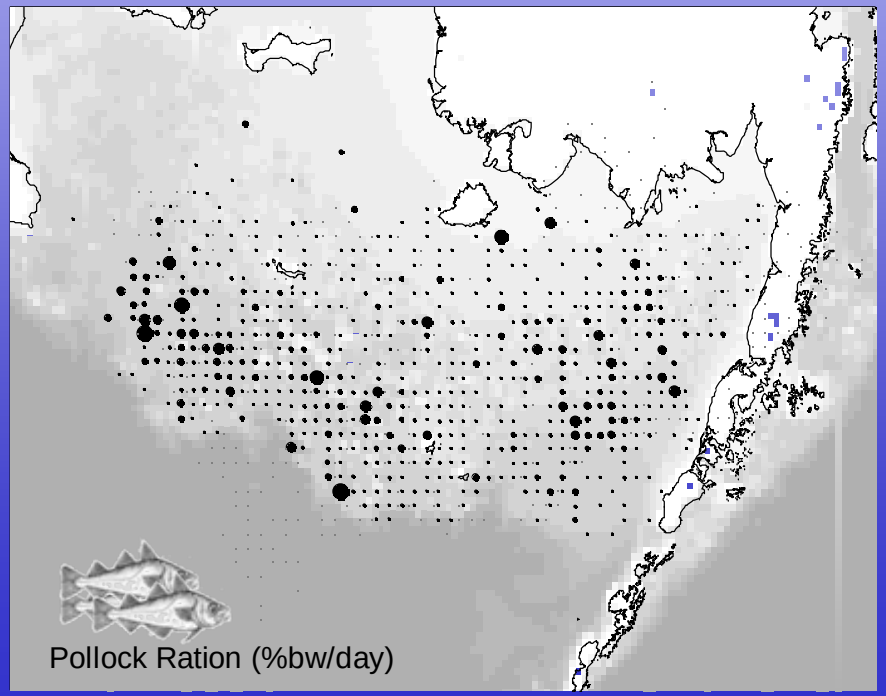
Direct estimates of pollock consumpton

- Pooled 1982-2008, all size classes >5cm
- This figure shows May-September data
- Ration estimate from mean stomach weight, times digestion rate (%body weight/day)
- Largest circle in figure is ~5% body weight/day

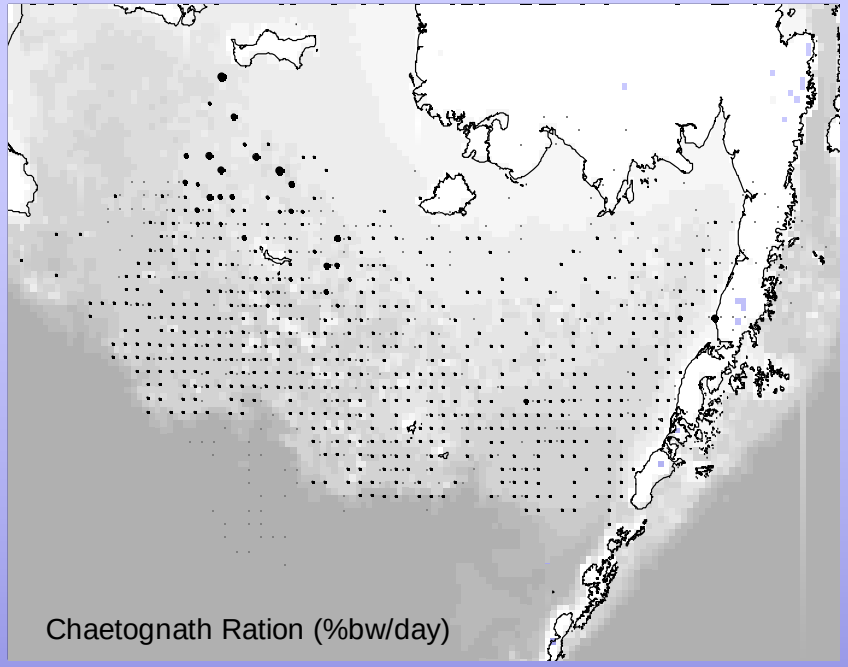


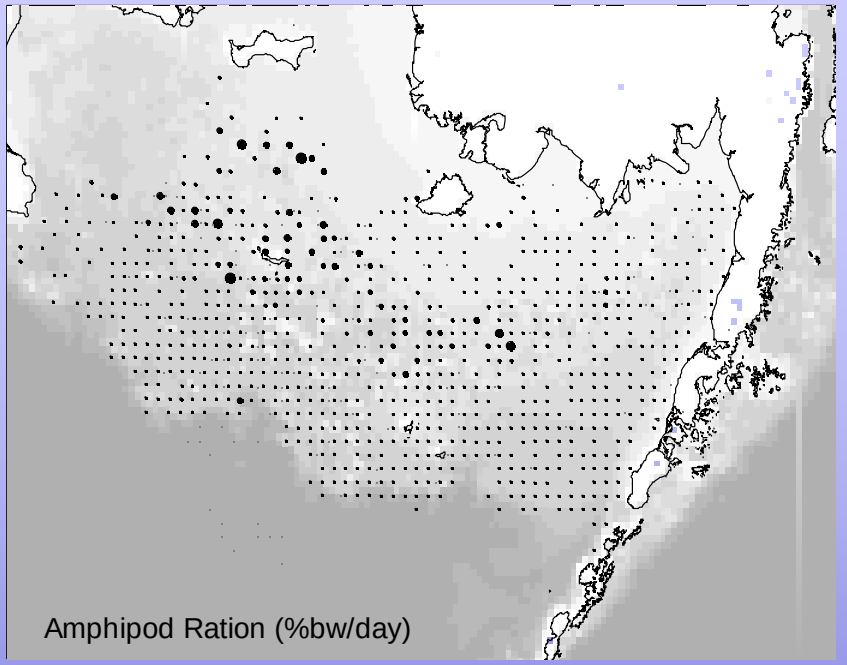


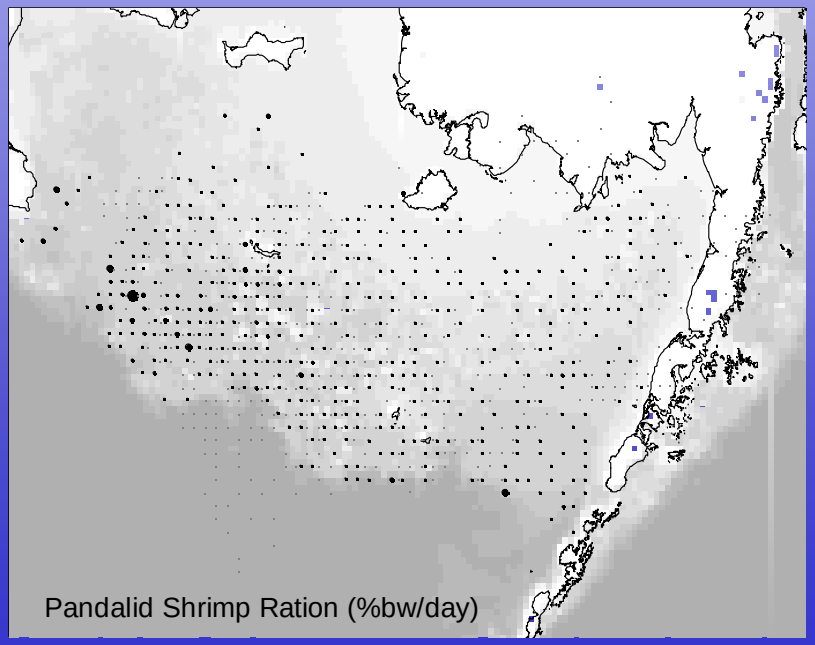




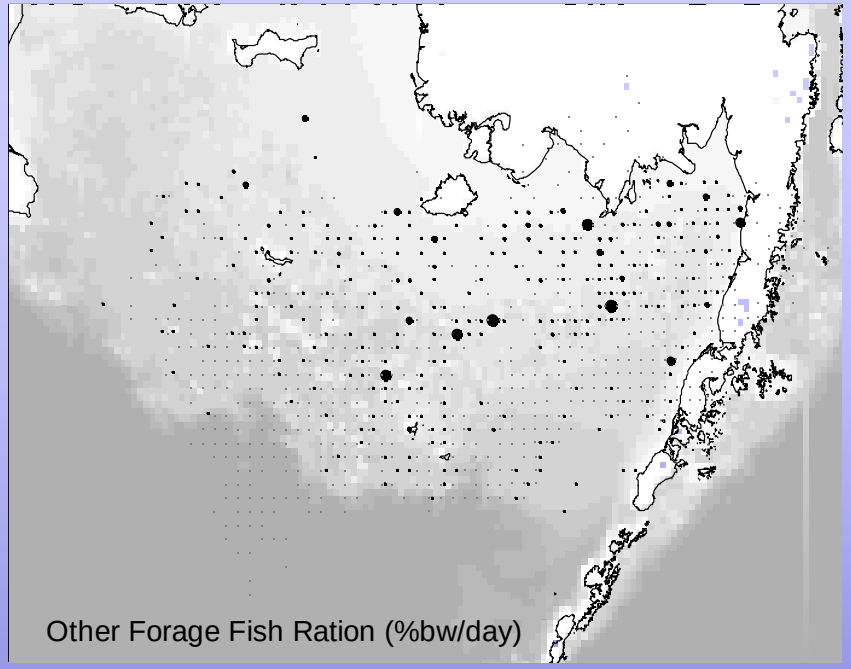
By prey type,
May-Sept

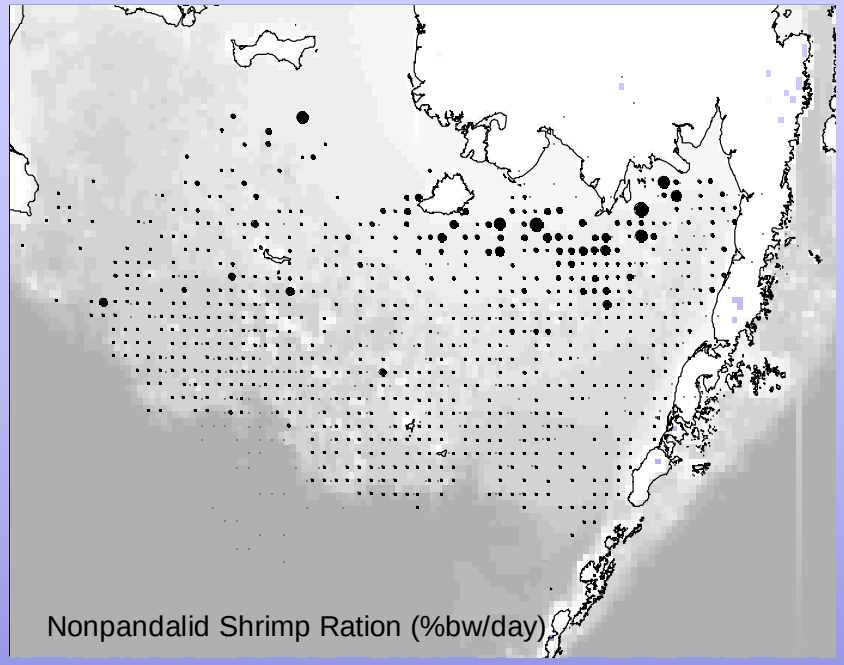


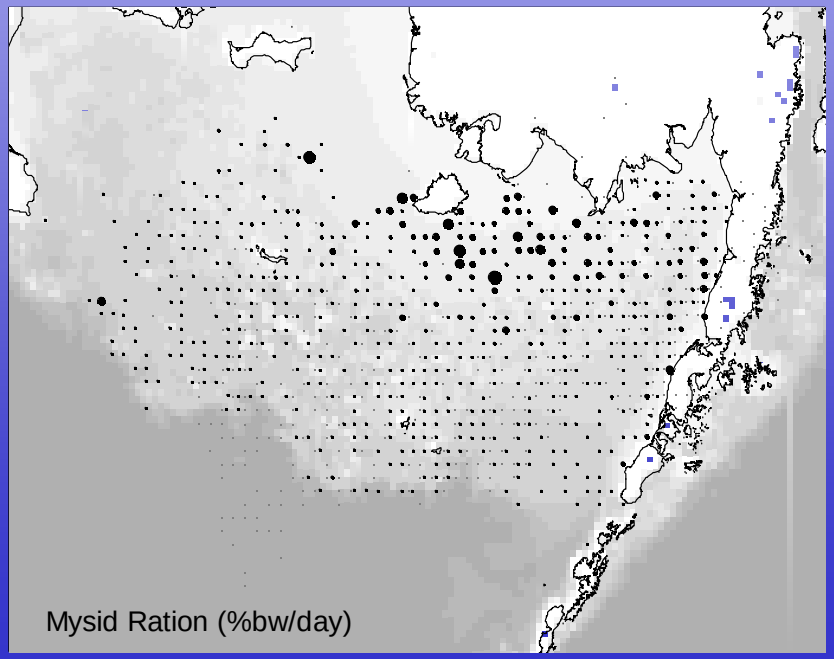




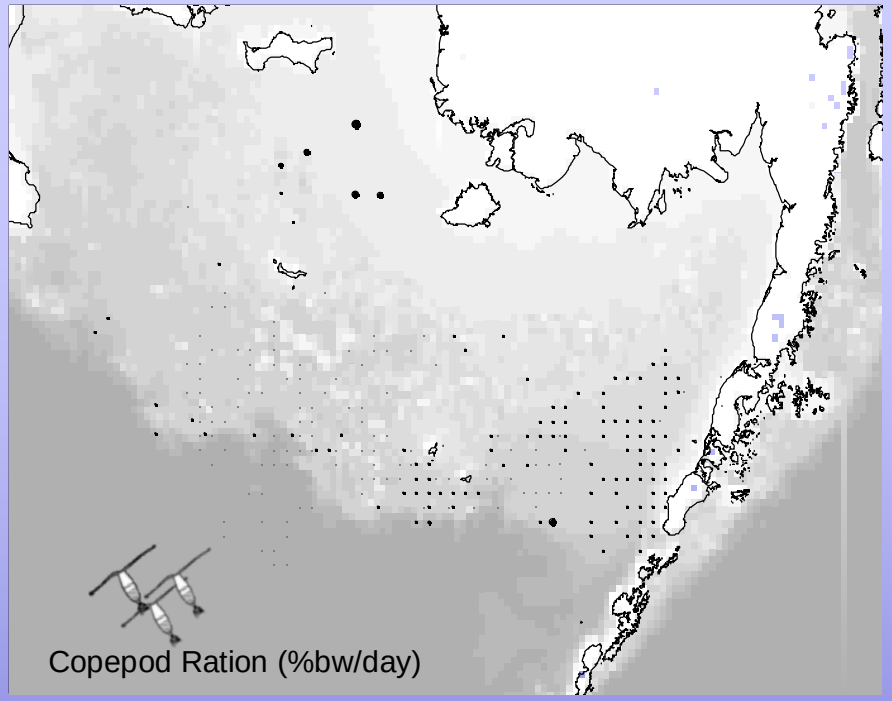
- Northern “cold pool” prey province

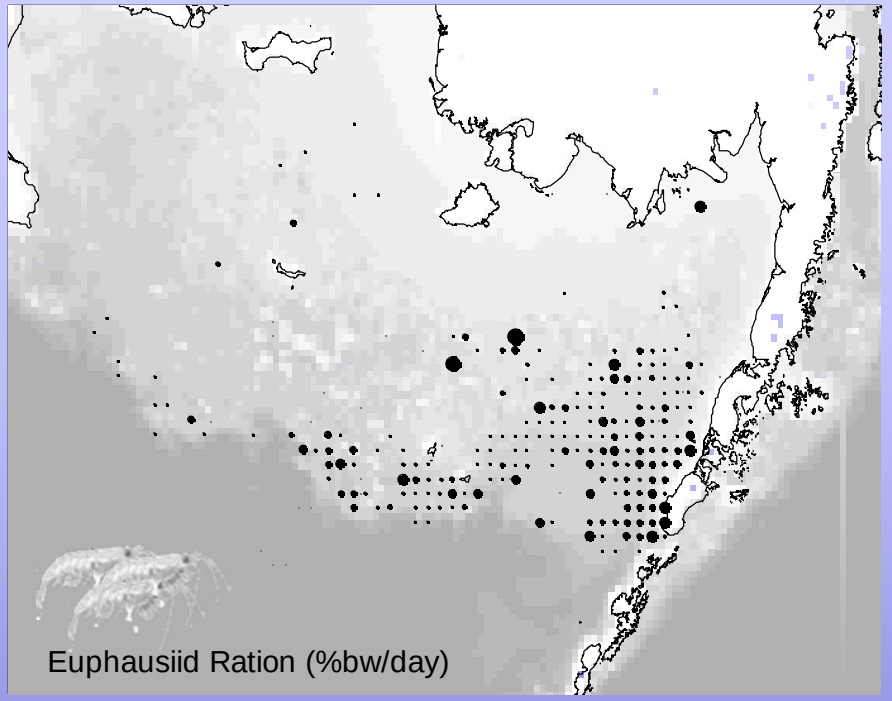


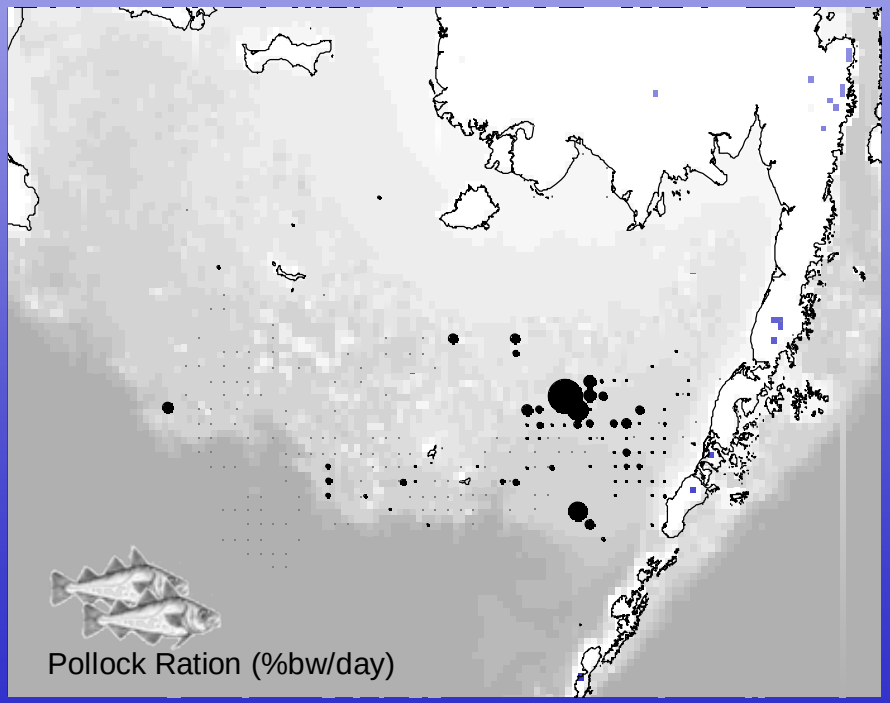




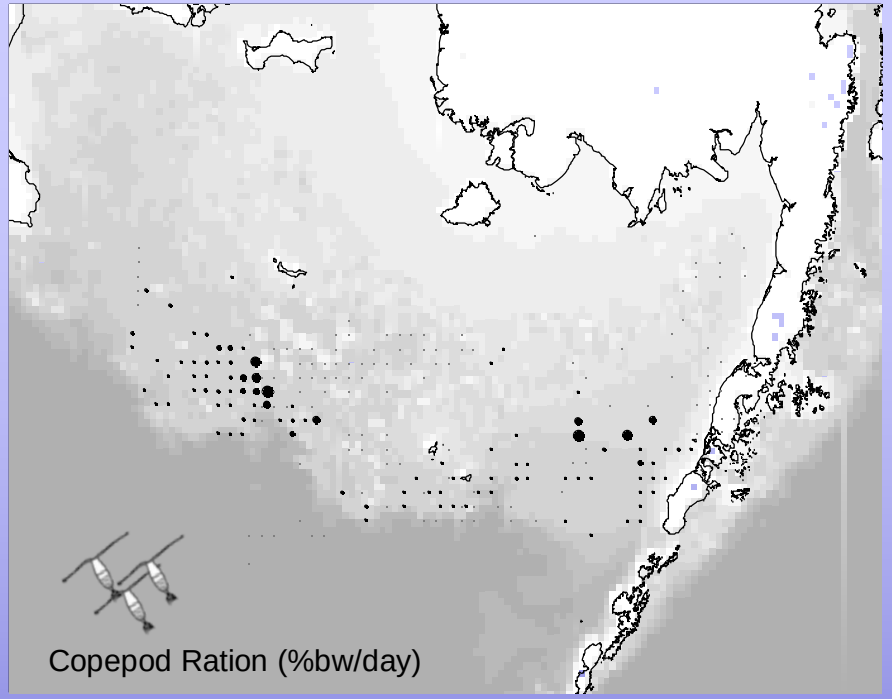
- “Bristol Bay” prey province

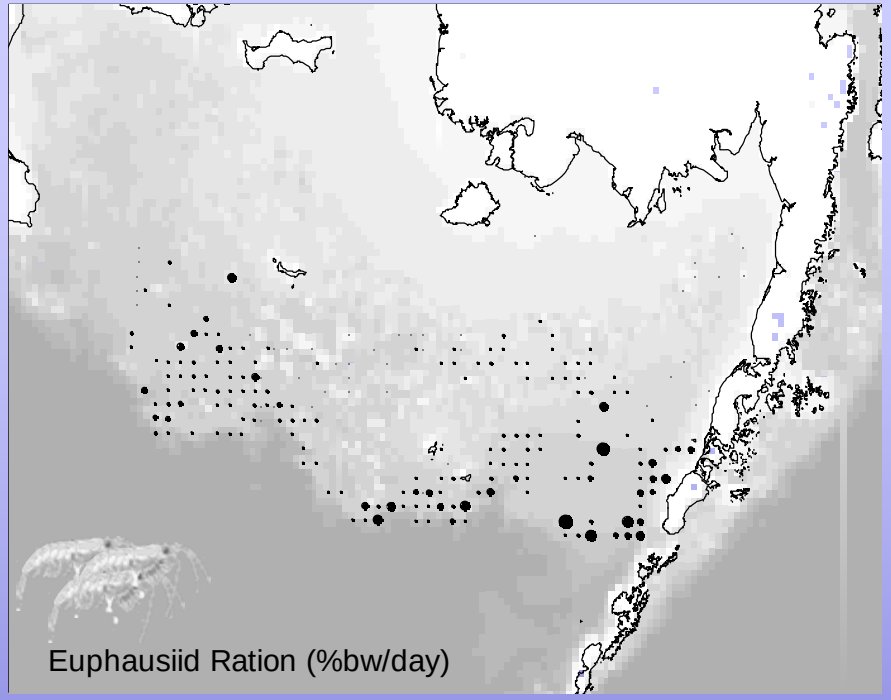


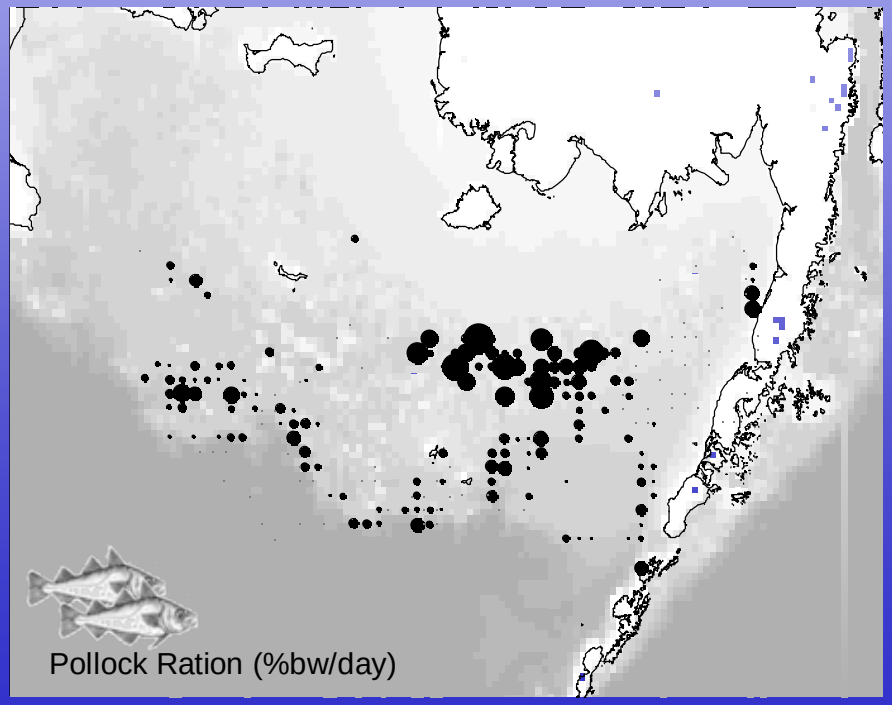




- Jan-Apr pollock diets (primarily observer samples)

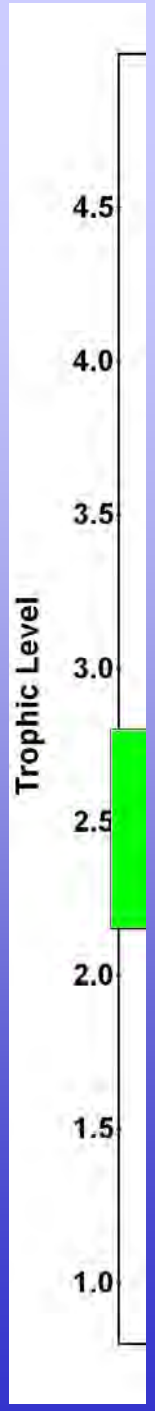






- Oct – Dec pollock diets

Trophic level?



- Length of pathway (number of steps) from primary production.
- "Trophic level" is seen as an index of feeding methods and guild position and has recently been elevated to importance in ecosystem-based approaches to management: "Trophic level of the catch".
- "Trophic level" is also researched as an index of bottom-up process variation linking climate and fish; e.g. an index of turnover time, bottom-up processes, addressing the importance of the microbial loop.

Comparing two methods

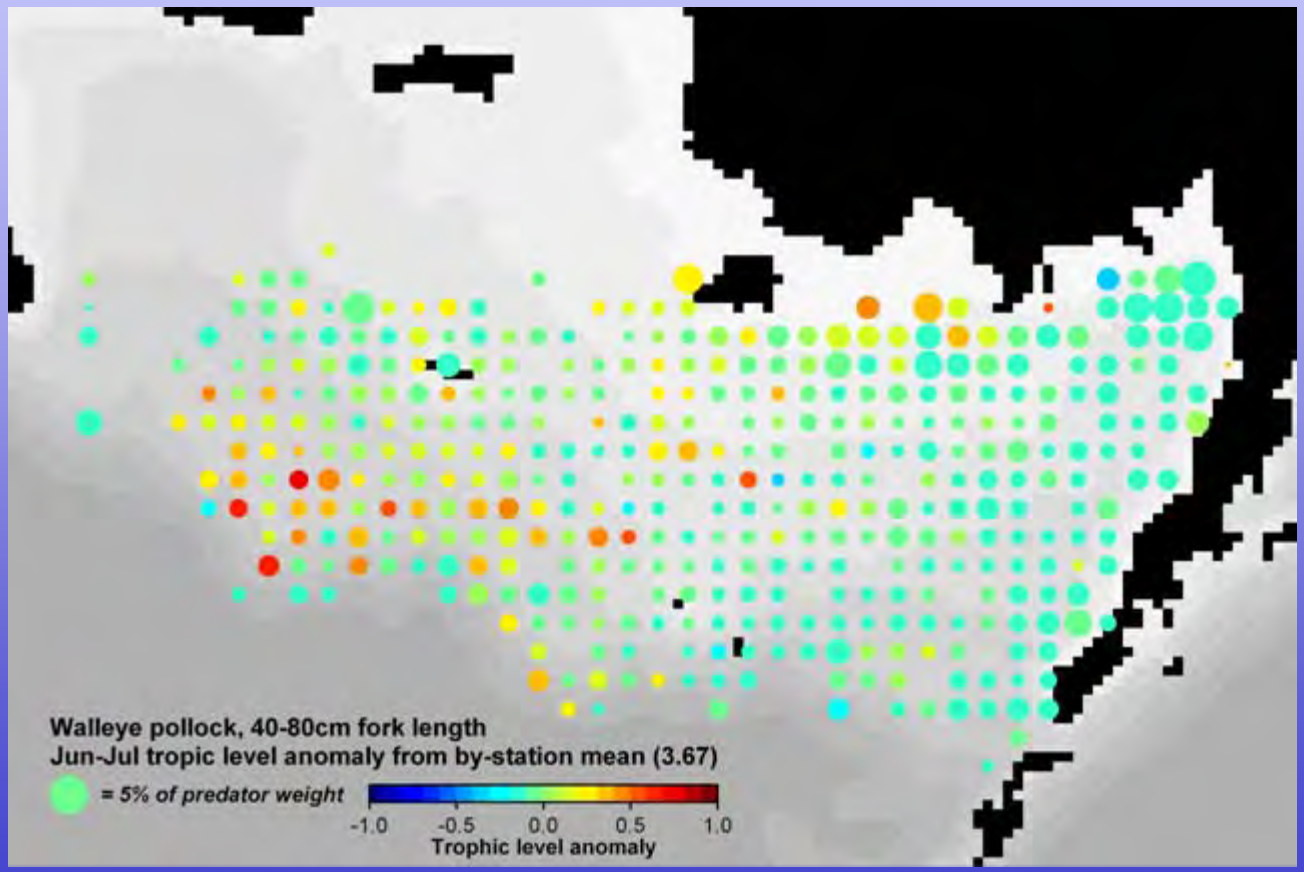
- Traditional from stomach content weights:
  - "Lower" organisms are given a fixed value
    - e.g. phytoplankton = 1, copepods = 2, euphausiids = 2.5
    - TL = 1 + stomach-content weighted average of prey

- Stable isotope ratios of nitrogen
    - ^{15}N:^{14}N stable isotope ratio difference from standards ($\delta^{15}N$) of muscle tissue from 2,100 samples of 22 species or species groups multiple seasons and regions (NPRB-funded study).
    - Theory/lab: Difference increases 3-3.5 ‰ / trophic level.

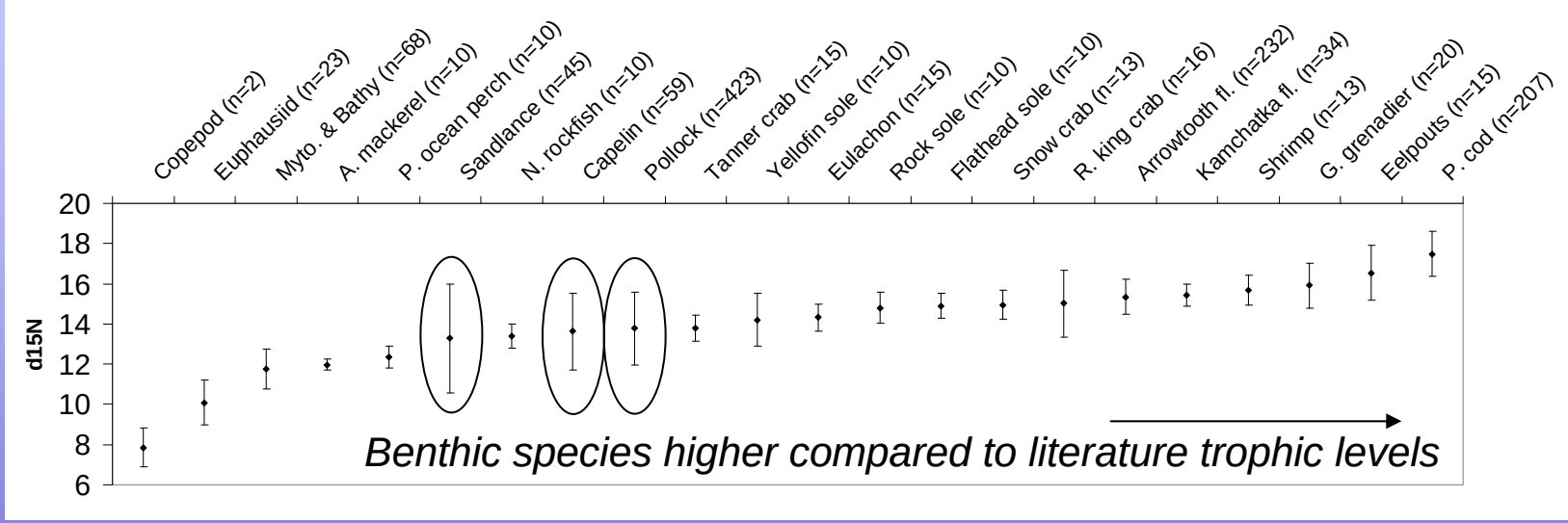
Geographic patterns in stomach-calculated trophic level

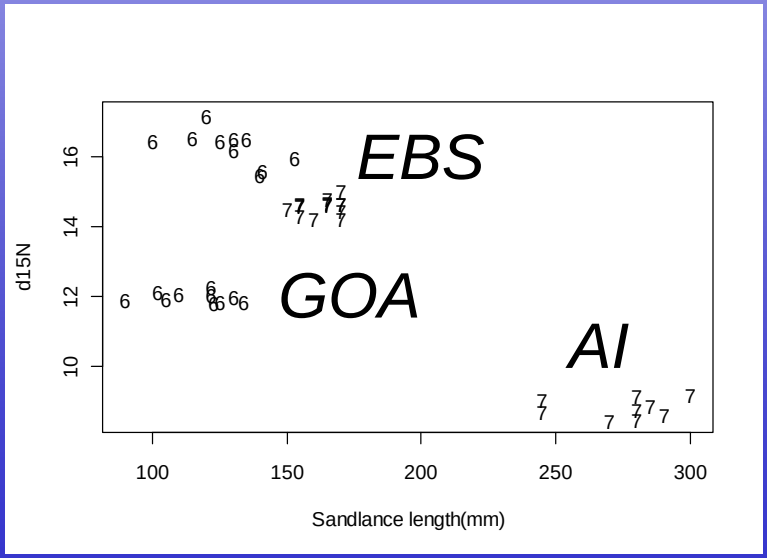
- For pollock 40-80cm fork length, long-term summer mean 3.67

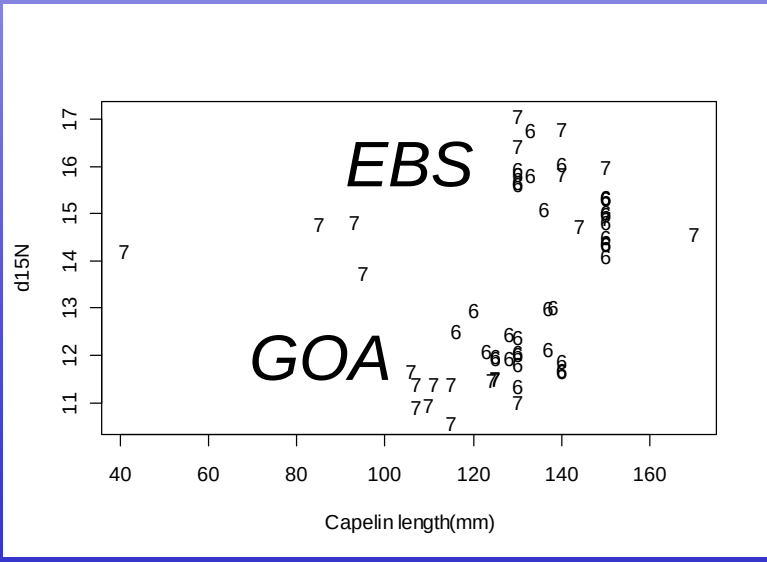
- ~60% euphausiids @ 2.53
- ~30% lg. copepods @ 2.50
- ~10% juv. Pollock
- @ 3.55



δ^{15}N of muscle tissue – across species and region (eastern Bering Sea, Gulf of Alaska, Aleutian Islands)

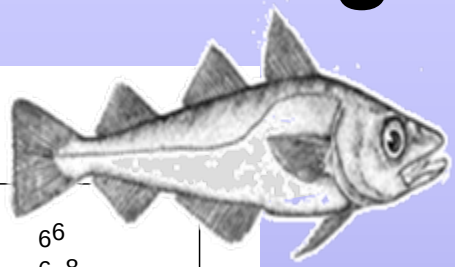


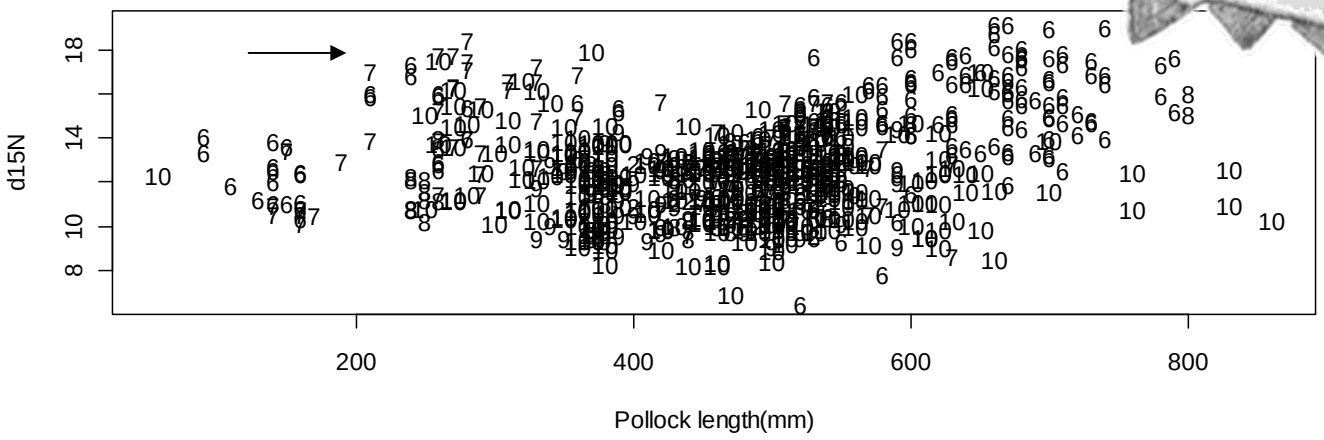


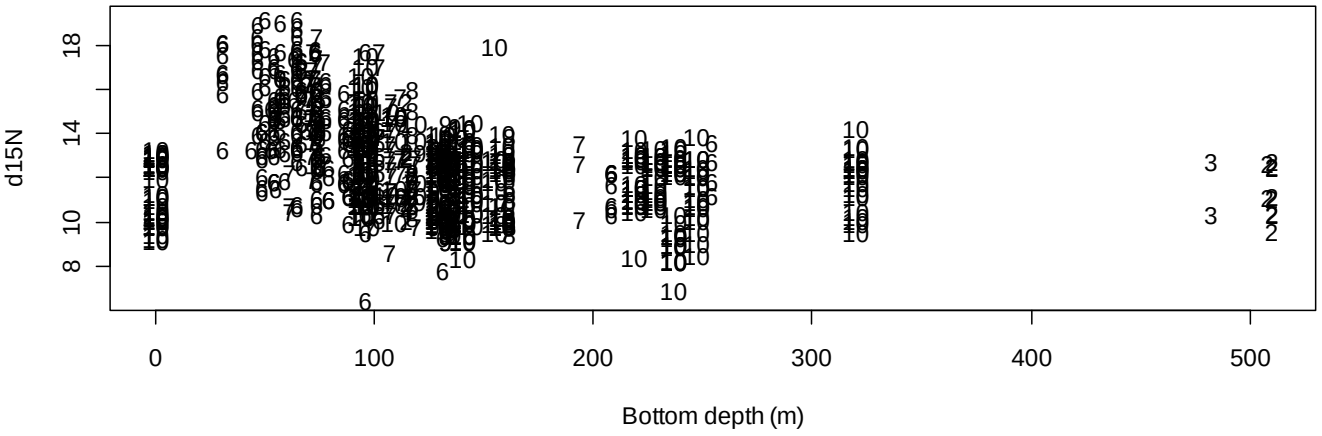


Pollock $\delta^{15}N$ by length in Bering Sea

Equivalent to large arrowtooth flounder





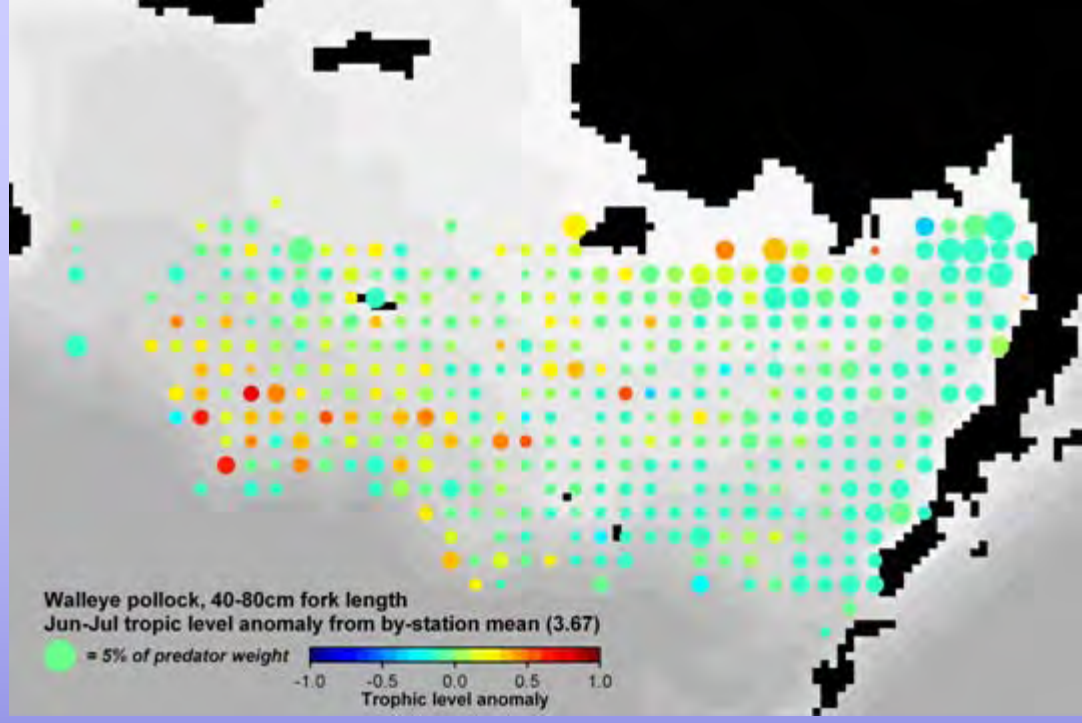


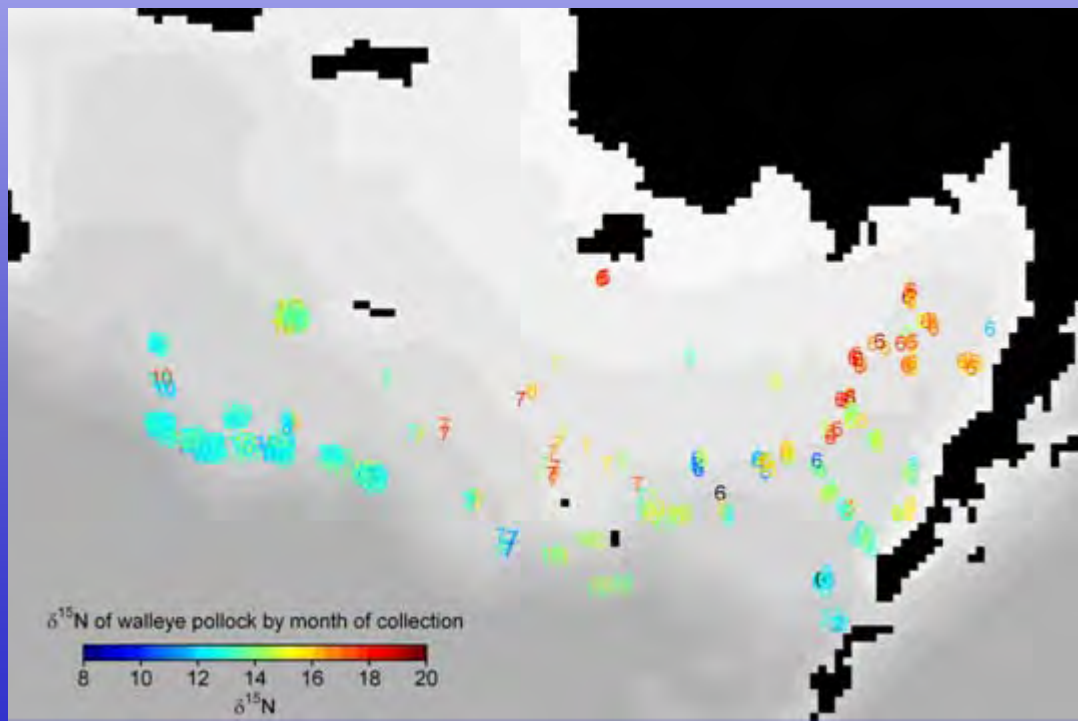
Double enrichment inshore?

- More euphausiids than copepods in pollock diet
- Euphausiids higher as well (more recycling when they eat whatever's there?)
- Simply feeding from different nitrogen sources?

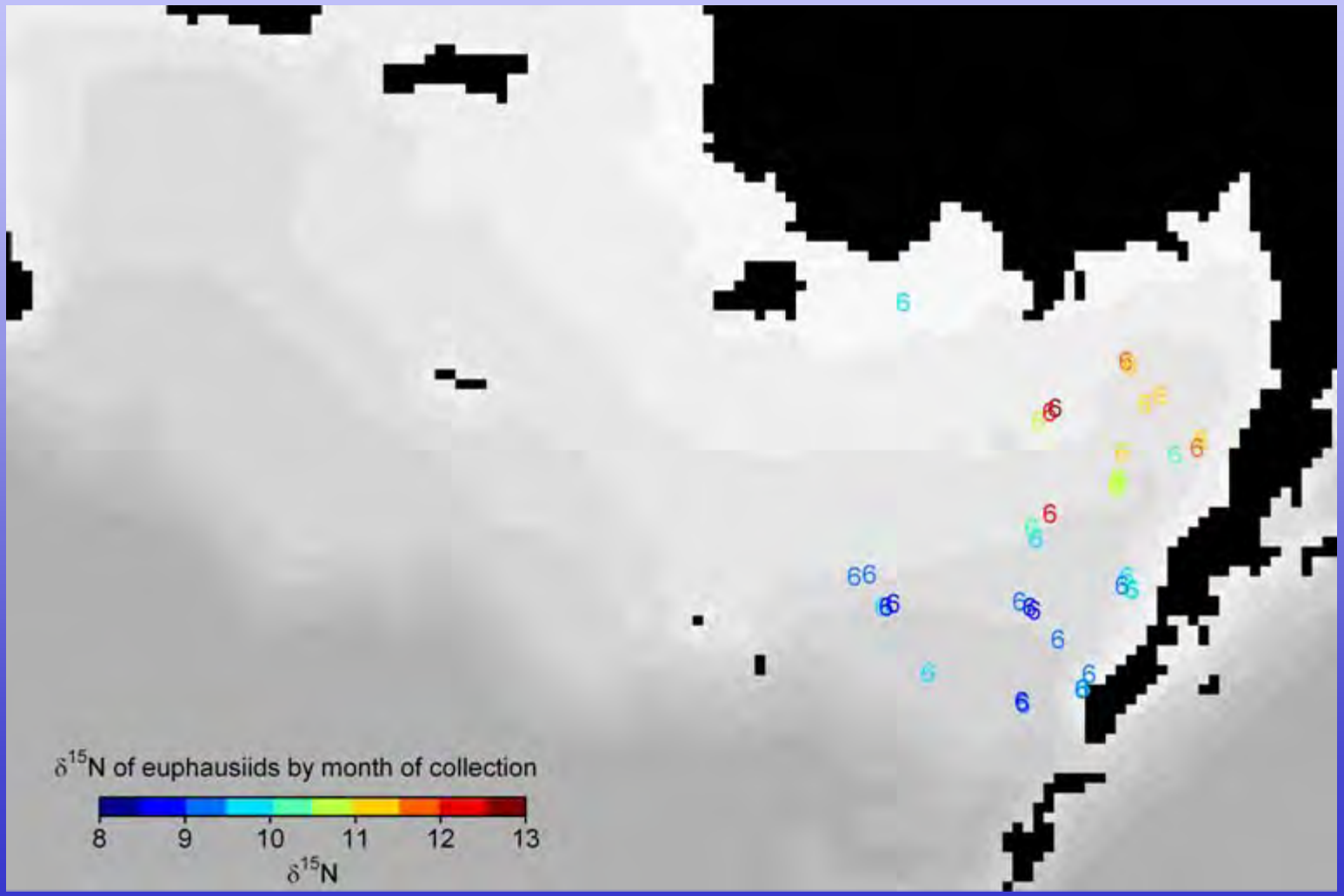
Geographic differences

- Stable isotope measurements are *opposite* what would be expected from stomach contents analysis.





δ^{15}N of 23 euphausiid samples taken from stomach contents



Conclusions

- Diet-measured trophic level and δ^{15}N-measured trophic level are measures of very different processes, and are not necessarily comparable.

- Diet-measurements indicate direct foraging mode (e.g. planktivory vs. piscivory) and are most relevant for fisheries management implications (e.g. balancing removals by trophic guilds).

- δ^{15}N measures bottom-up processes. Perhaps microbial cycling, perhaps food chain length, but perhaps nitrogen uptake sources or conditions

- *Long-term diet shifts? Caution needed in interpreting*.