Geographical shifts in the spatial distribution of Northeast Pacific groundfish populations

Franz J. Mueter[1], Bernard A. Megrey[2], and Jeff M. Napp[2]

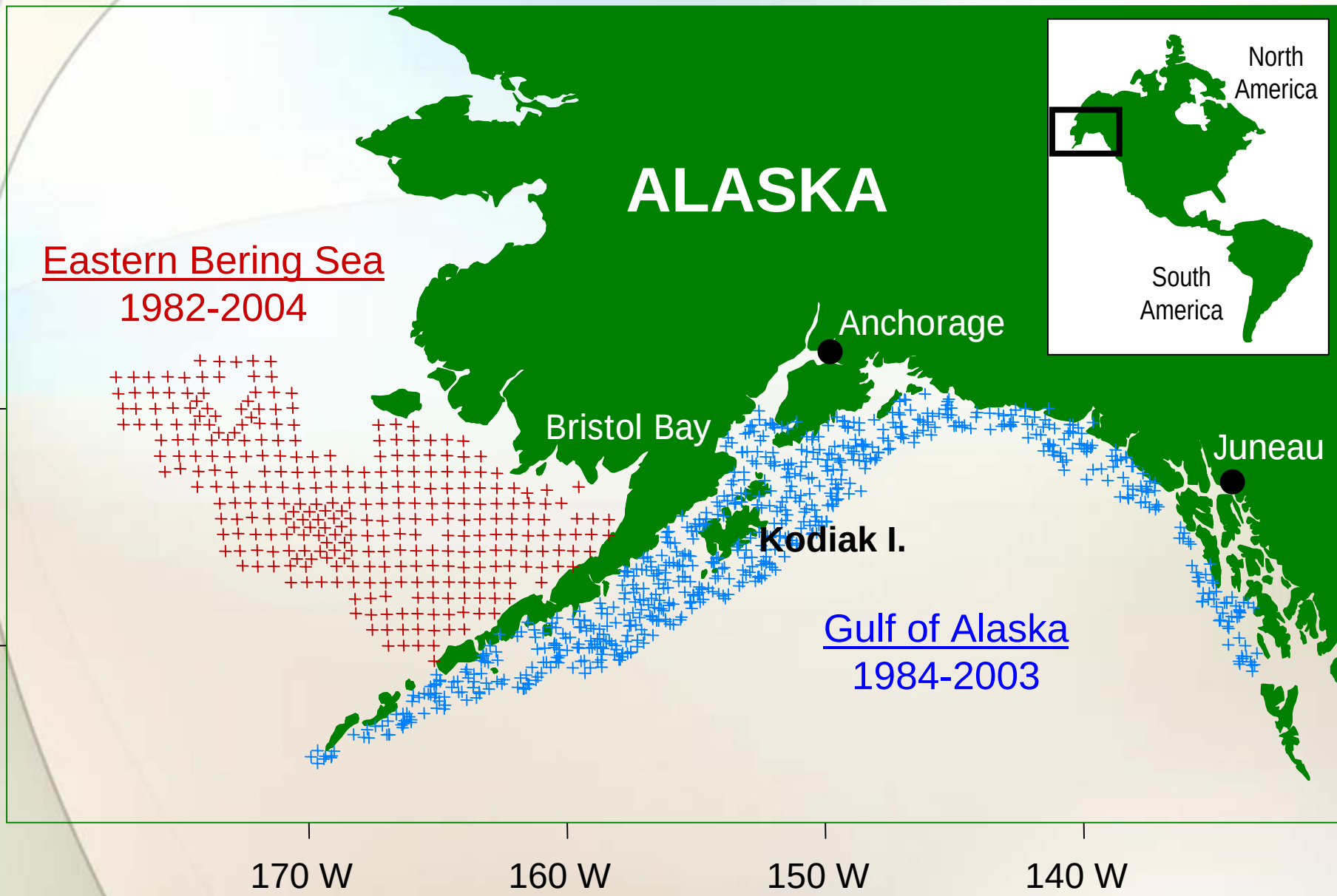
1 Joint Institute for the Study of the Atmosphere and the Oceans, P.O. Box 354235, University of Washington, Seattle, WA 98115, USA.
E-mail: fmueter@alaska.net

2 National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, USA 98115.

Objectives

- **Quantify changes in spatial distribution of demersal fish and invertebrates in the Northeast Pacific Ocean**
  - **Bering Sea (59 taxa)**
  - **(Gulf of Alaska, U.S. West Coast)**
- **Examine potential causes**
  - **Bottom temperature**
  - **Abundance (density dependence)**
  - **Residual long-term trends**
- **Test for northward shift in response to warming trend?**

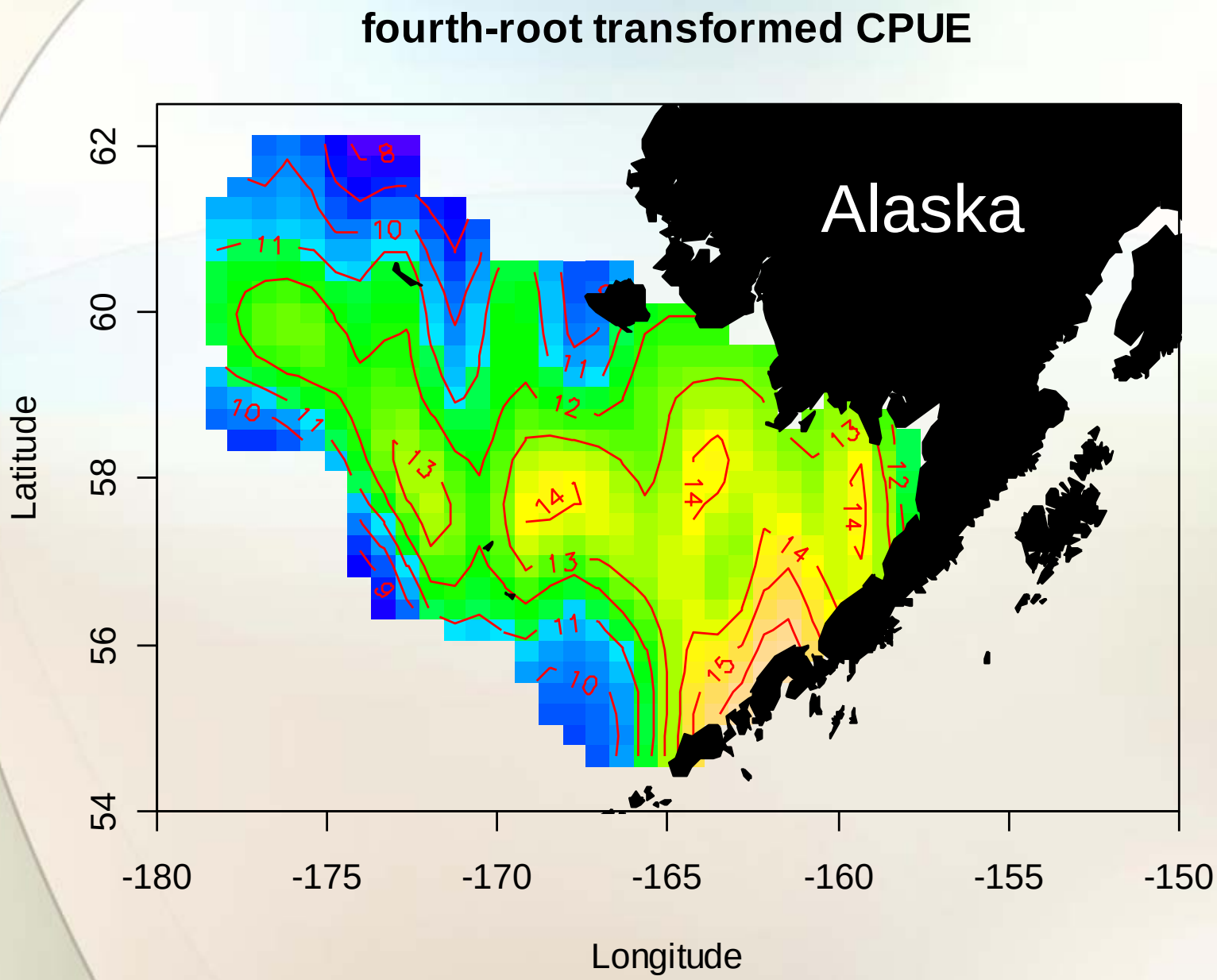
Data: CPUE from bottom trawl survey



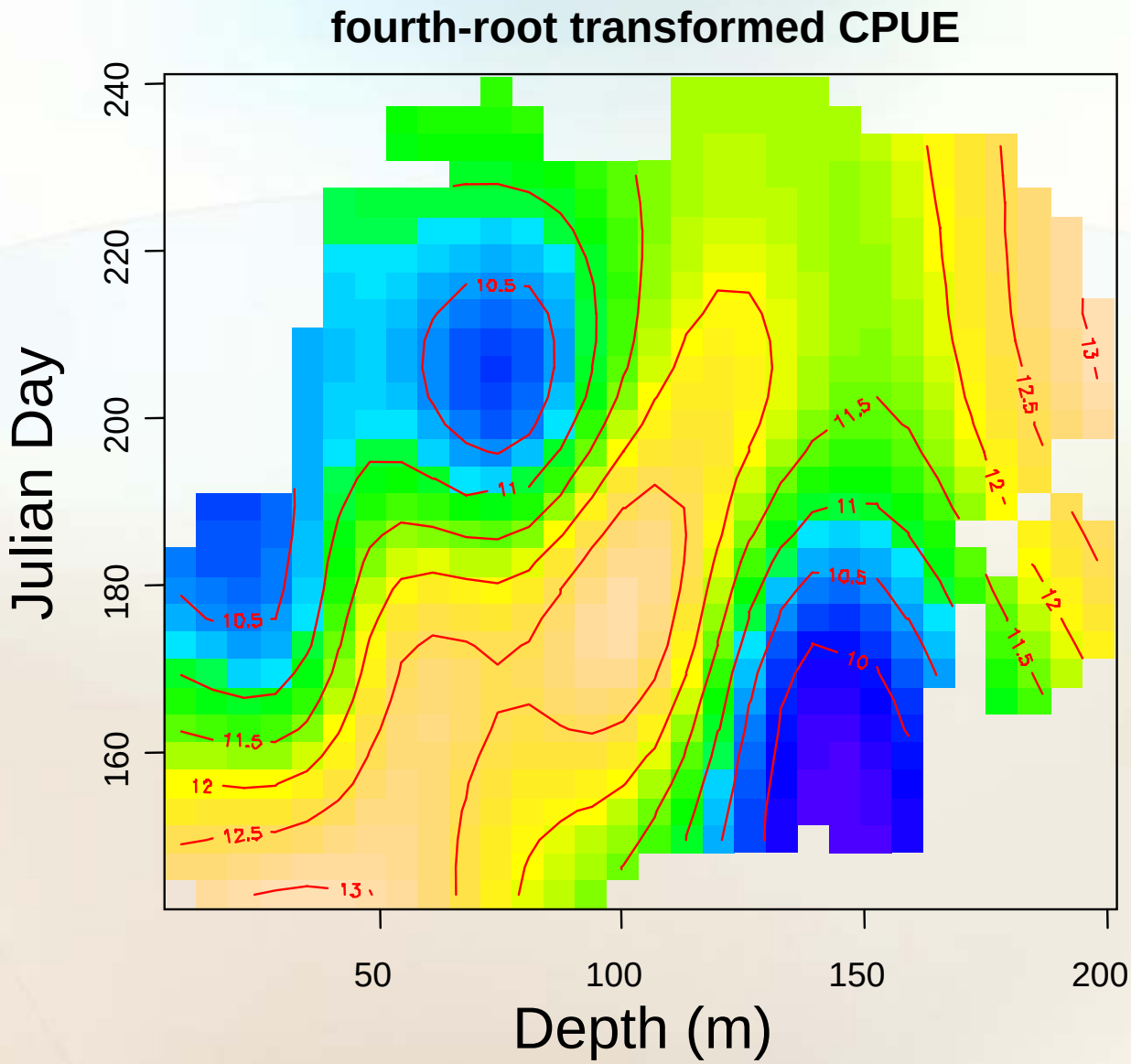
Approach: quantifying shifts in distribution

- Estimate & remove average spatial pattern
  - Anomalies in probability of occurrence
  - Anomalies in CPUE-where-present
- Quantify spatial gradients in anomalies for each survey year
  - Latitude / alongshore distance
  - Depth
- Estimate trends in gradients over time

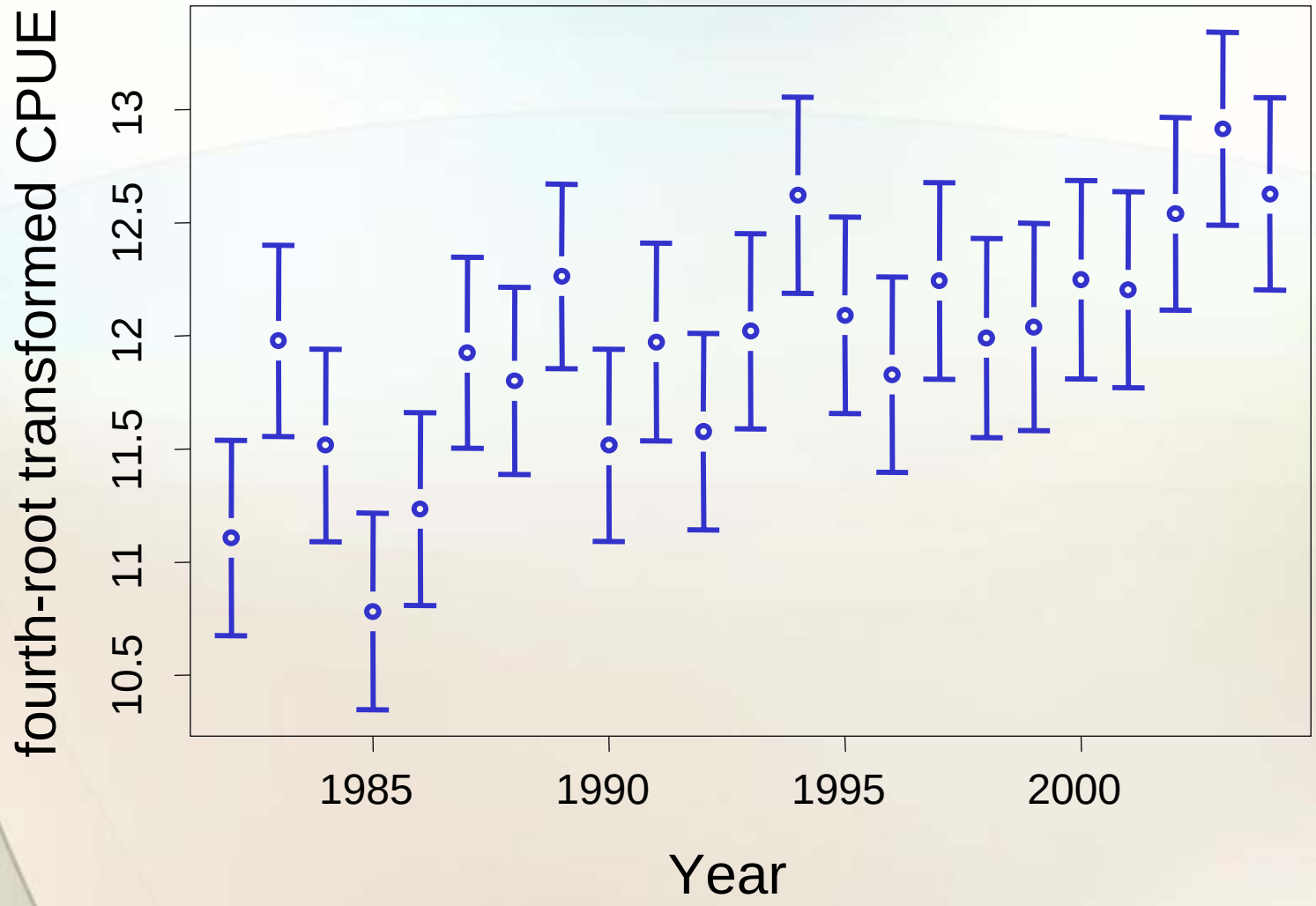
Total CPUE: average spatial pattern 1982-2004



Distribution by depth / time of year

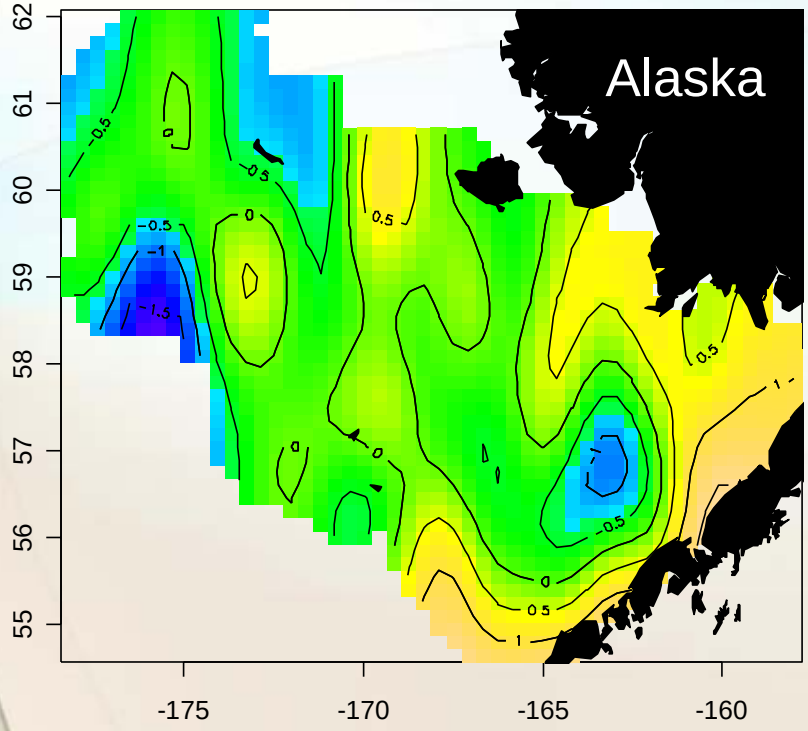


Annual means: Total CPUE

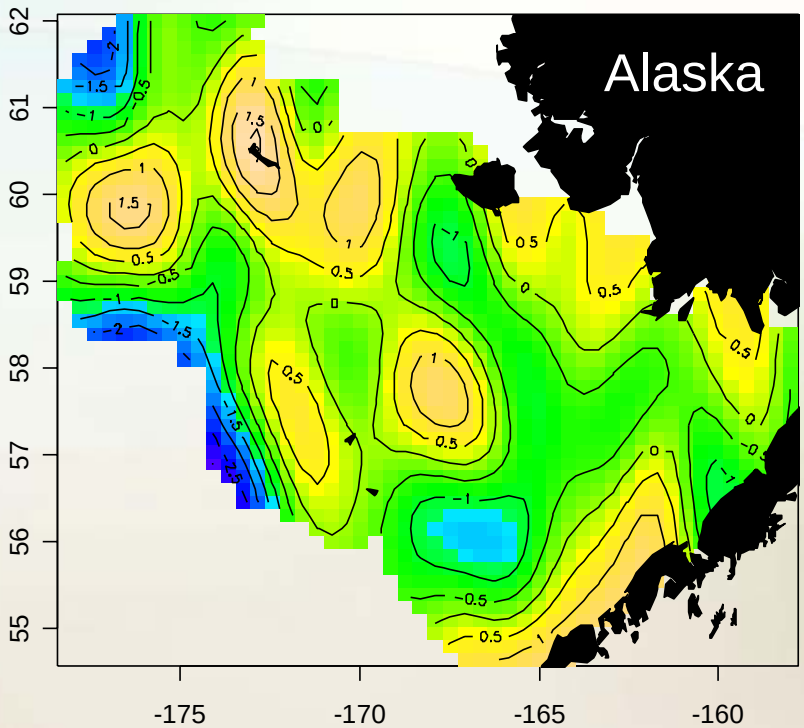


CPUE anomalies for two periods

1982 - 1986

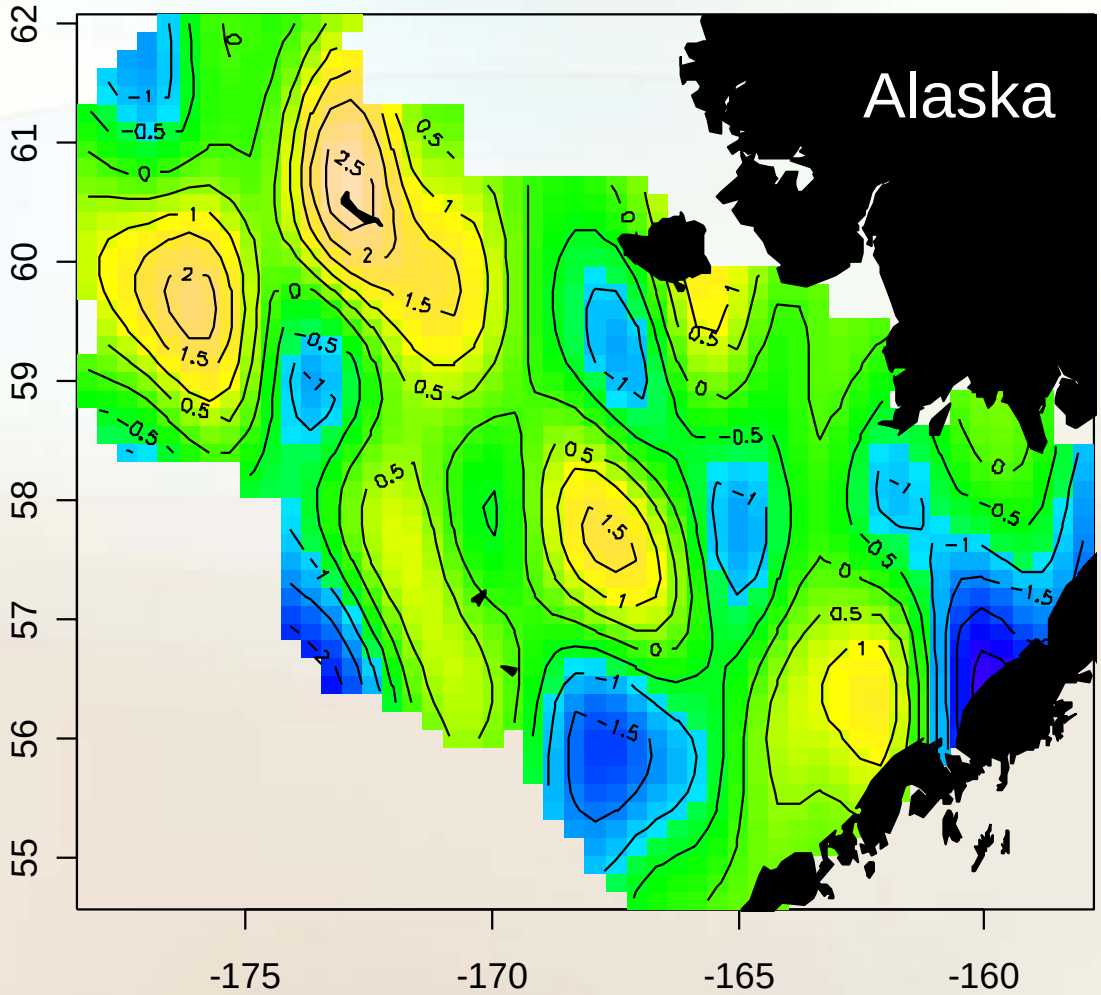


2000 - 2004



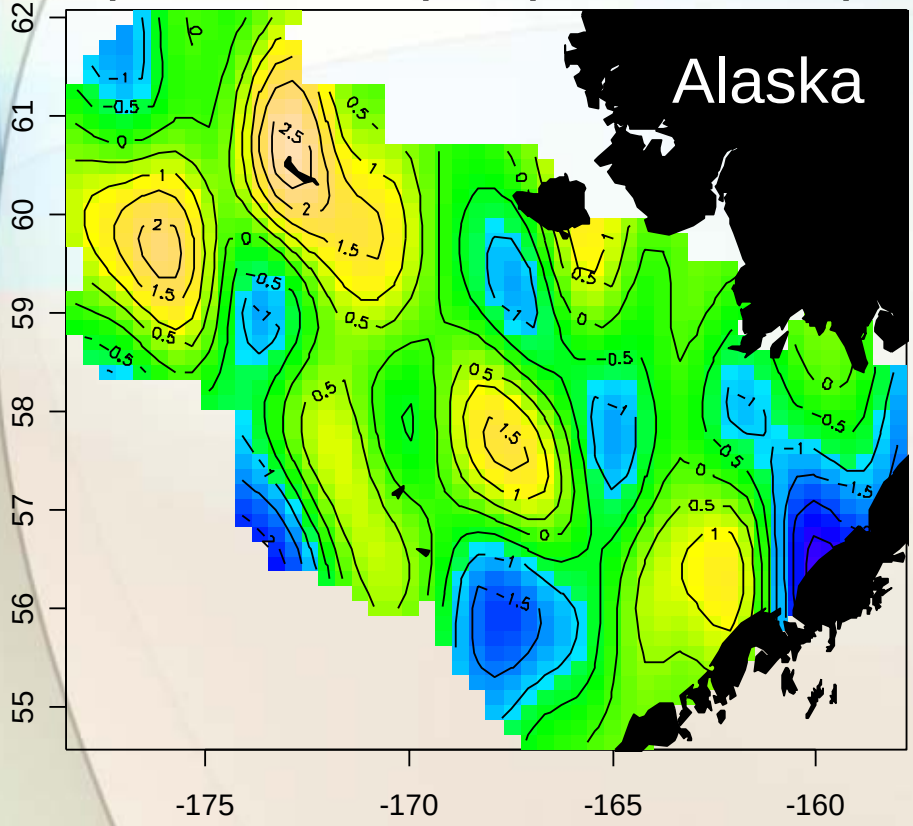
Difference in anomalies among periods

(2000-2004 anomalies) – (1982-1986 anomalies)

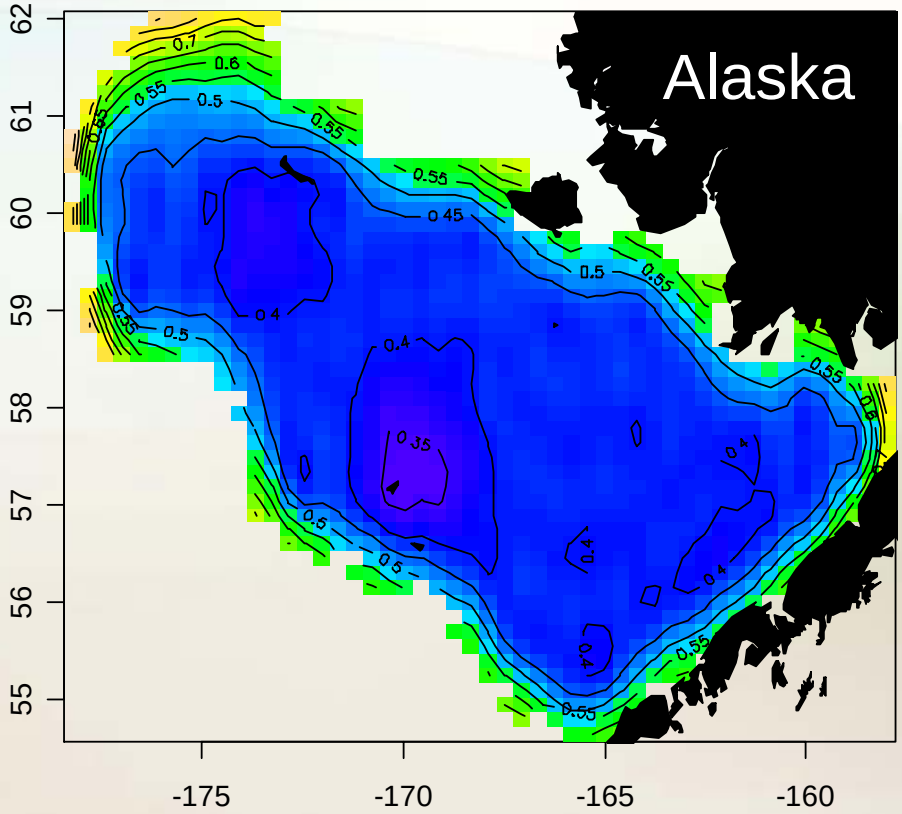


Differences in anomalies and SE

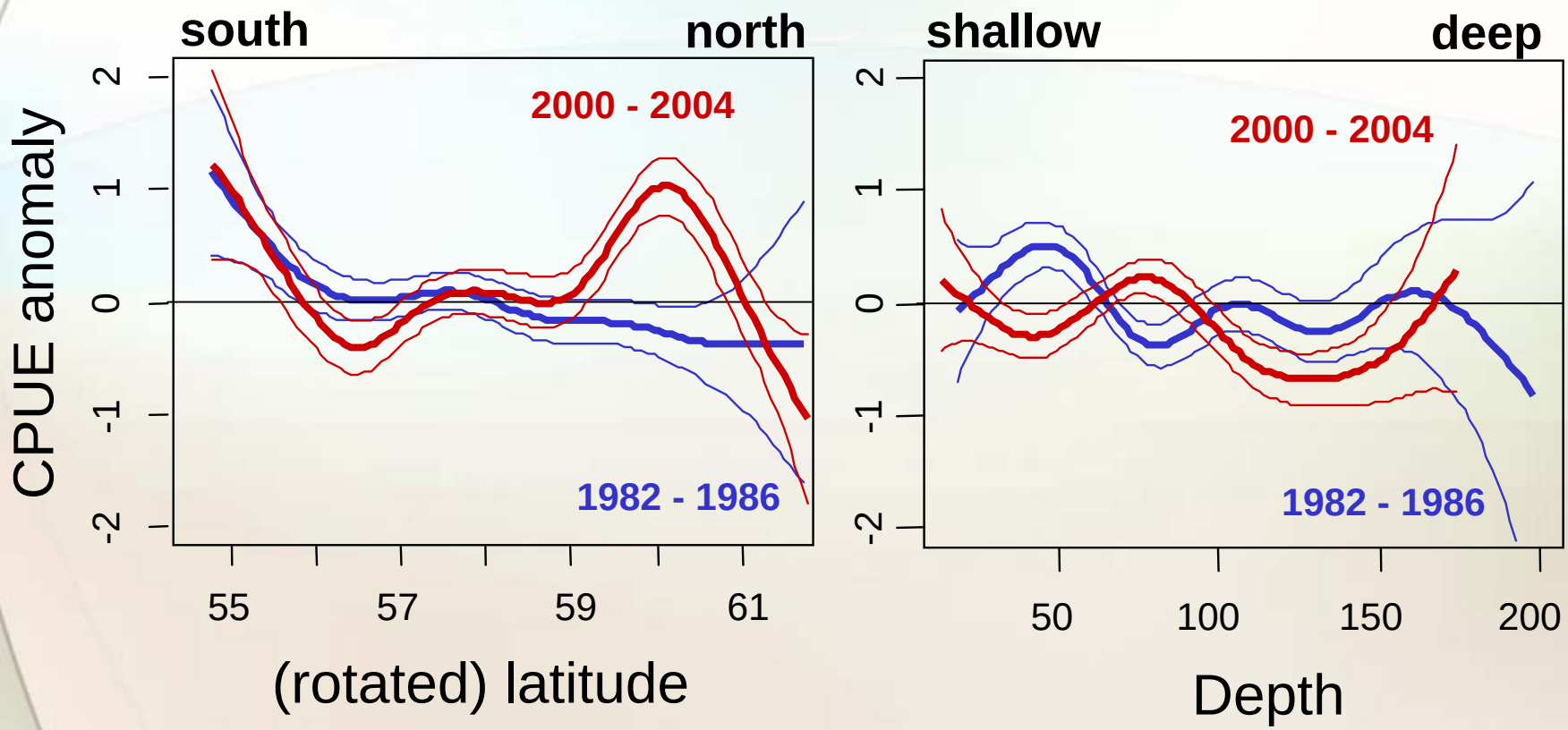
Differences:
(2000-2004) – (1982-1986)



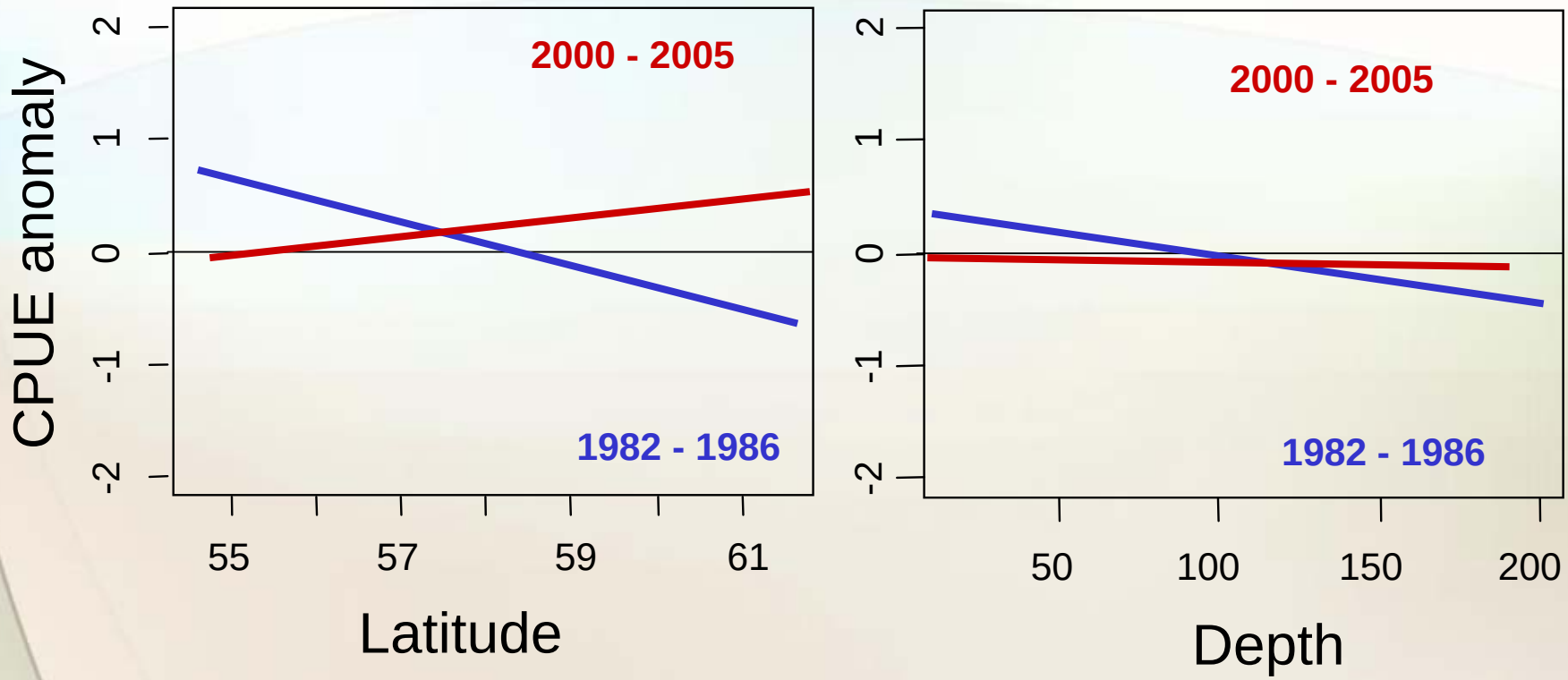
2 x Standard errors



Smooth trends by latitude and depth

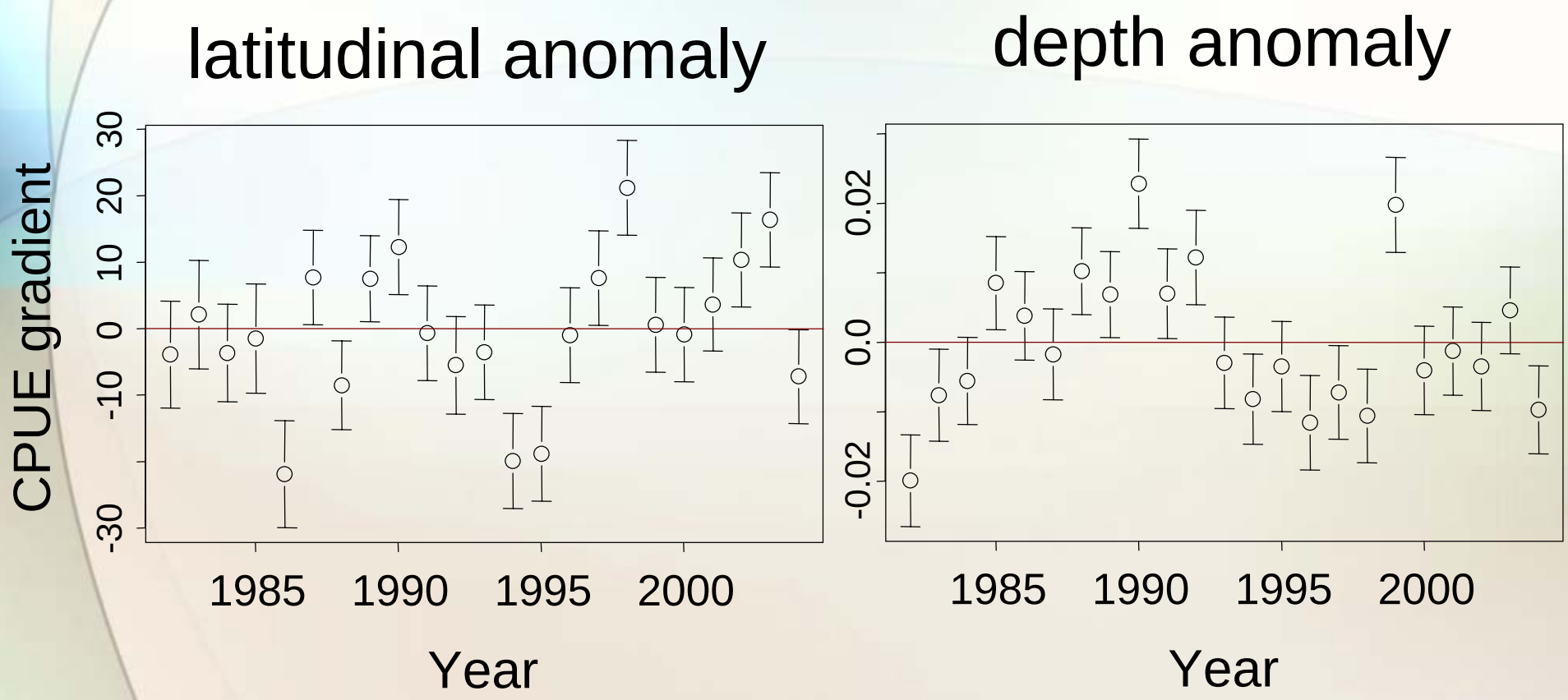


Smooth trends by latitude and depth



(Anomalies relative to 1982-2004 means)

Annual gradients in total CPUE by latitude and depth

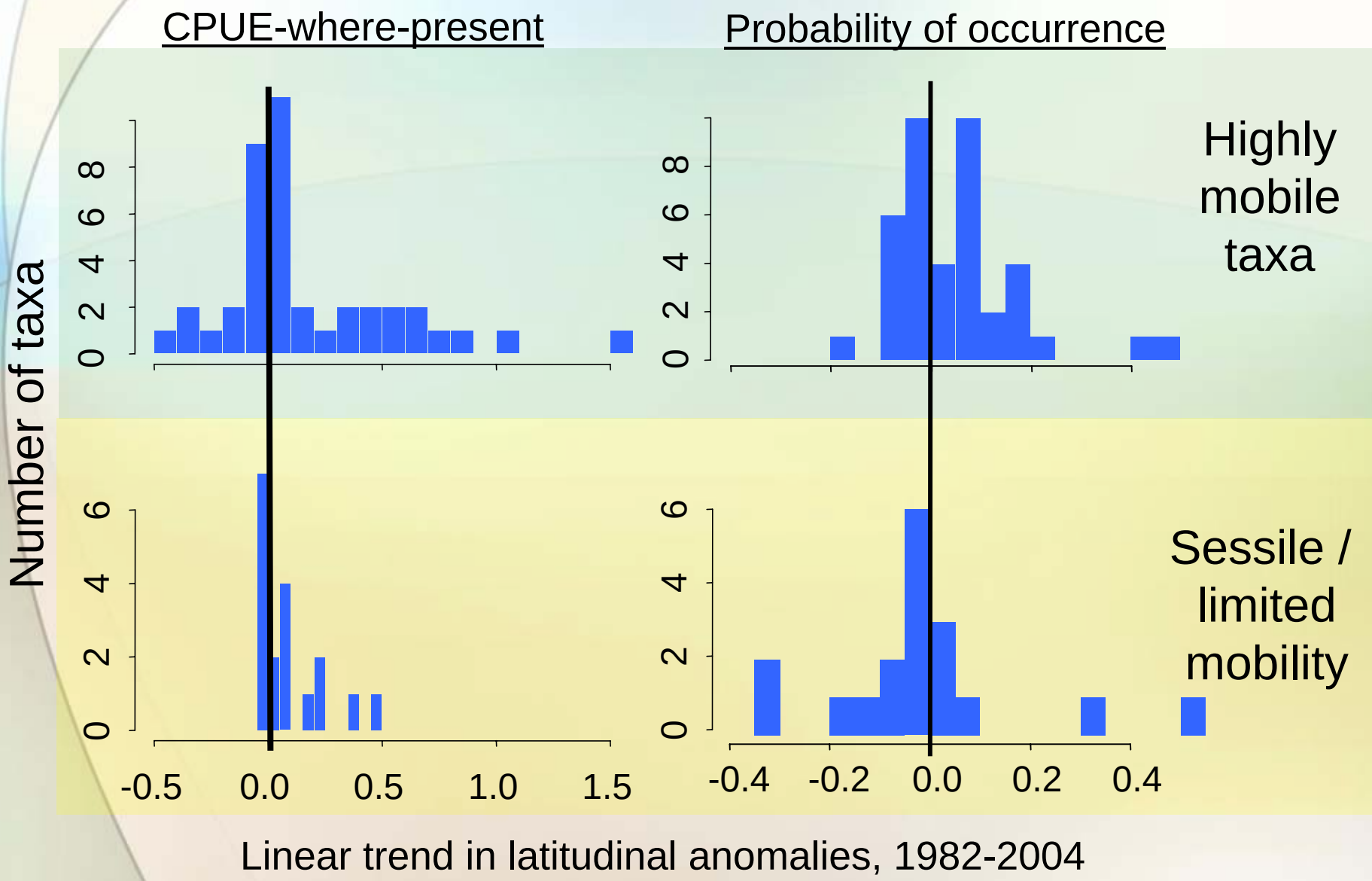


(± 2 SE confidence intervals TOO NARROW as they DO NOT account for spatial autocorrelation)

Indices for individual taxa

- **Probability of occurrence**
  - **Model presence / absence as function of latitude, longitude, bottom depth, Julian day, net width, and tow duration**
  - **Residuals (logit-scale) as indicators of anomalies in probability of occurrence**
- **CPUE-where-present**
  - **Model as function of latitude, longitude, bottom depth, Julian day, net width**
  - **Residuals (log-scale) as indicators of spatial anomalies in CPUE-where-present**

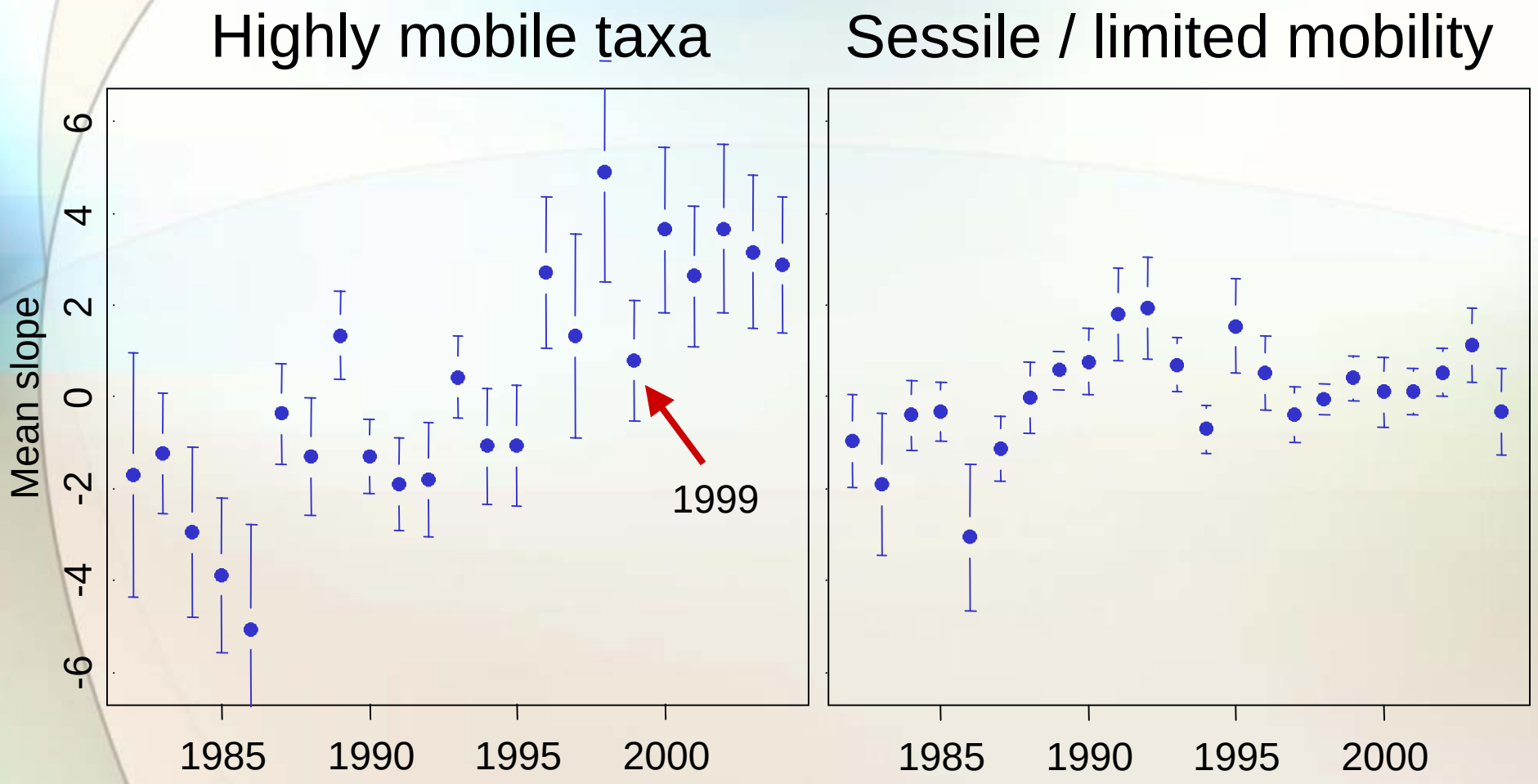
Trends in latitudinal anomalies across species



Trends in latitudinal anomalies (CPUE) selected taxa

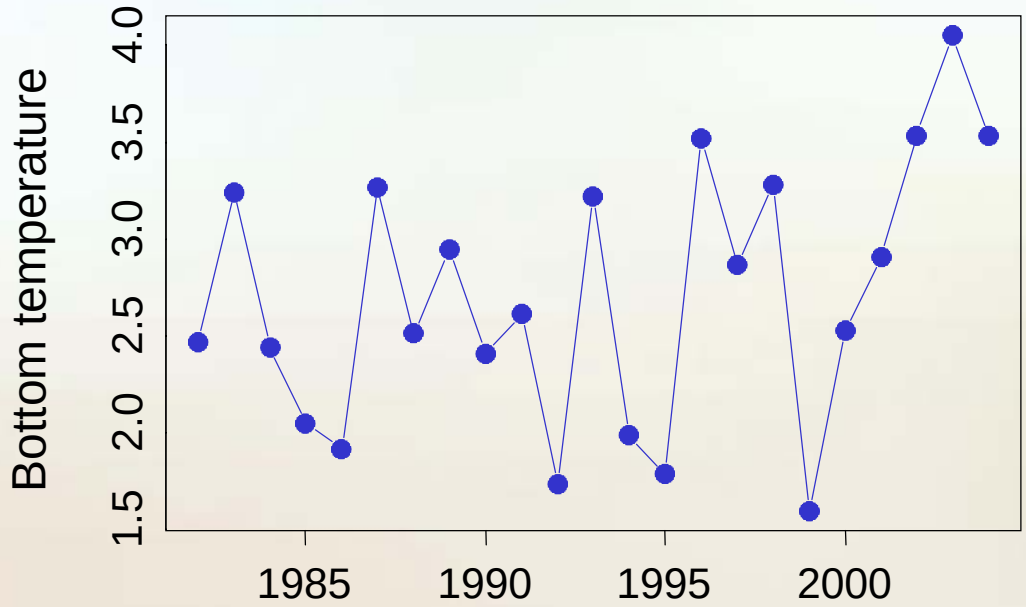
Taxon		Slope	P-value
Lepidopsetta sp.	rock sole	1.53	0.000
Theragra chalcogramma	walleye pollock	1.01	0.000
Scyphozoa	jellyfish	0.84	0.002
Limanda aspera	yellowfin sole	0.76	0.001
Rajidae	skates	0.65	0.000
Lycodes brevipes	shortfin eelpout	0.57	0.033
Hippoglossus stenolepis	Pacific halibut	0.47	0.018
Bathymasteridae	ronquils	0.42	0.011
Holothuroidea	sea cucumbers	0.37	0.035
tunicates		0.21	0.010
Podothecus acipenserinus	sturgeon poacher	0.18	0.027
Glyptocephalus zachirus	rex sole	-0.17	0.005
Myoxocephalus spp		-0.32	0.037
Hemilepidotus papilio	butterfly sculpin	-0.46	0.001

Average latitudinal anomalies



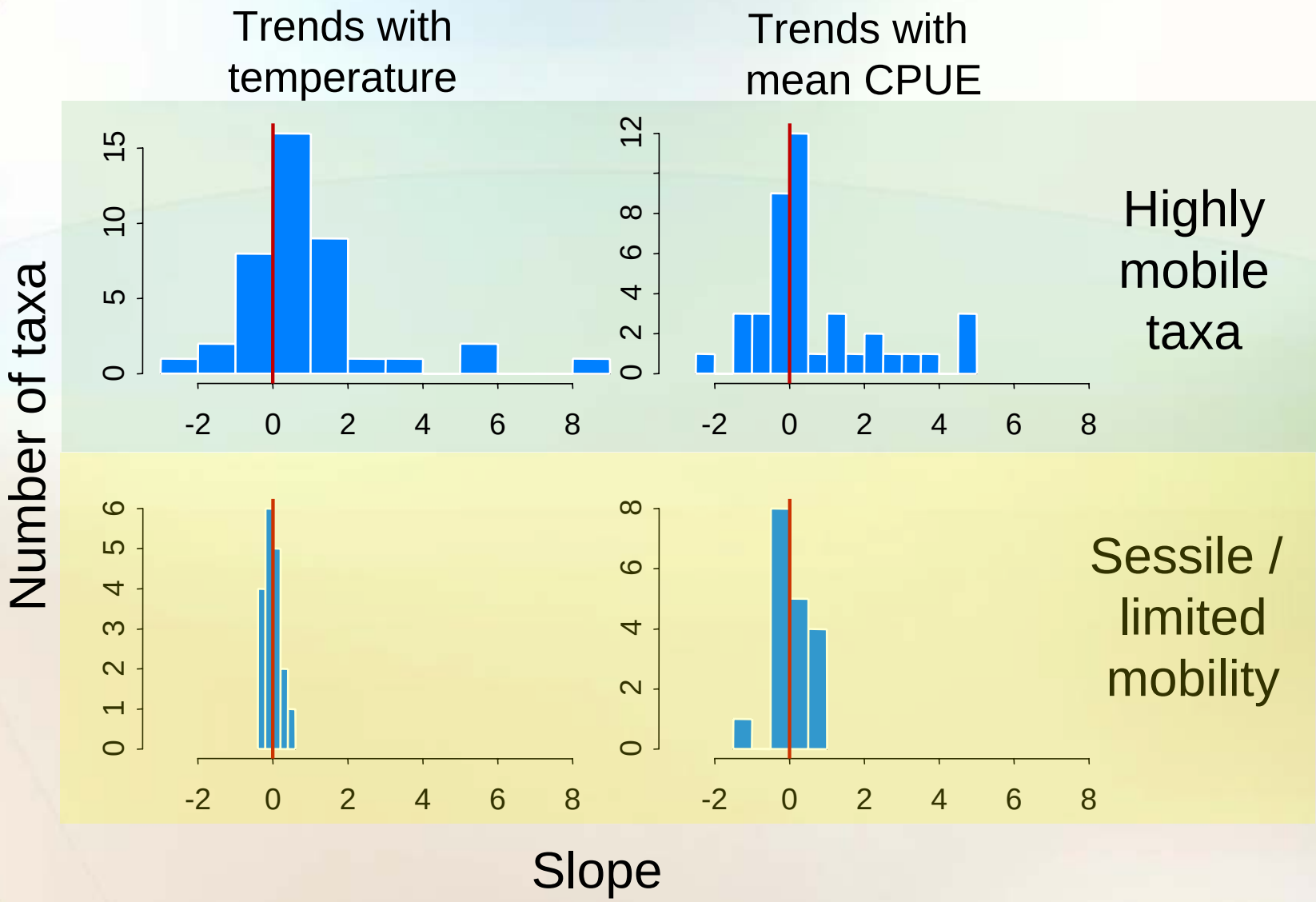
Potential causes of latitudinal shifts

- Temperatures
  - Estimated average bottom temperature within survey area by year

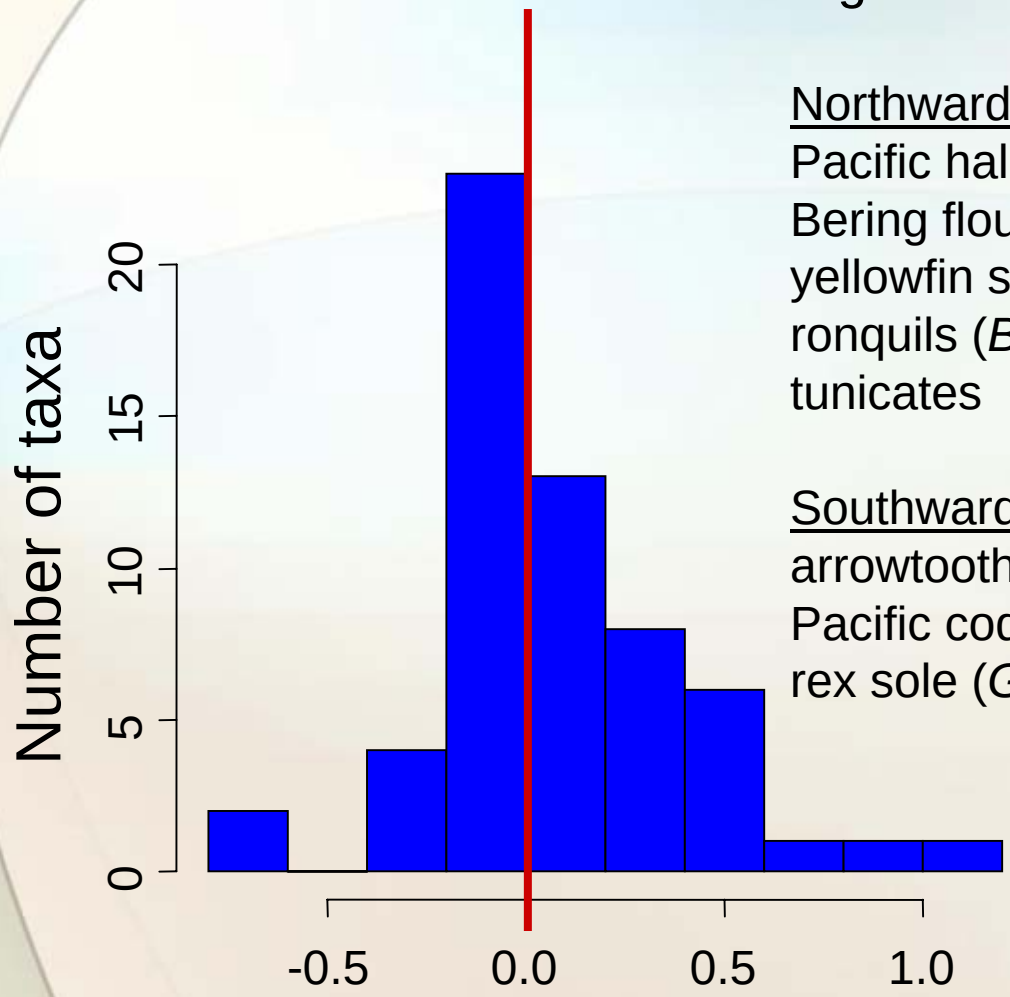


- Changes in abundance
  - Average CPUE by year for each species

Trends in latitudinal anomalies



Residual time trends in latitudinal anomalies



Significant trends ($p < 0.05$), 1982-2004:

<u>Northward shift</u>
Pacific halibut (*Hippoglossus stenolepis*)
Bering flounder (*Hippoglossoides robustus*)
yellowfin sole (*Limanda aspera*)
ronquils (*Bathymasteridae*)
tunicates

<u>Southward shift</u>
arrowtooth flounder (*Atheresthes stomias*)
Pacific cod (*Gadus macrocephalus*)
rex sole (*Glyptocephalus zachirus*)

Summary and conclusions

- Significant northward shifts in center of distribution of numerous demersal taxa on the eastern Bering Sea shelf over the last 20+ years
- Shifts related to changes in bottom temperature and abundance
- If current warming trend continues, biomass on northeastern Bering Sea shelf is likely to increase relative to the southeast
- Range extensions are likely because several species are near northern limit of their distribution

Acknowledgements

- The numerous NOAA fisheries scientists and crew that go out year after year to conduct surveys
- Jay Ver Hoef for advise on spatial modeling