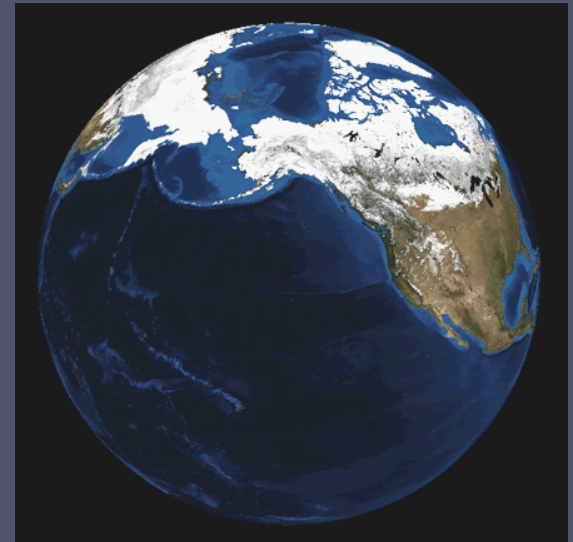# Using alternative samplers to analyze forage fish trends in the Gulf of Alaska

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Lenfest

The goal:
Develop ecosystem indicators to track forage fish trends as an important component of ecosystem assessments provided to fishery managers

The challenge:
Despite their ecological importance, there are few long term time series of non-commercially targeted forage fish in Alaska

Forage fish "ban" in Alaska prevents the development of targeted fisheries

Included are:

Pacific sand lance *Ammodytes spp.*

Capelin *Mallotus villosus*

There are no good long-term time series of directed capelin or sand lance surveys
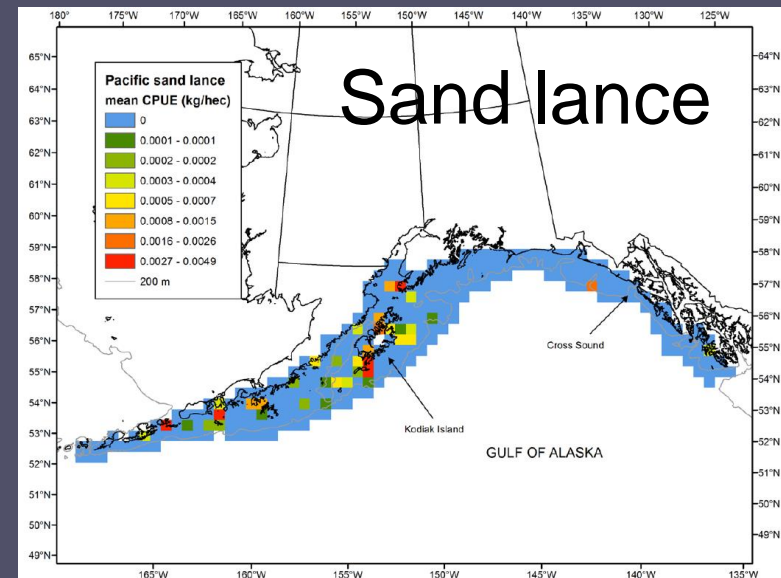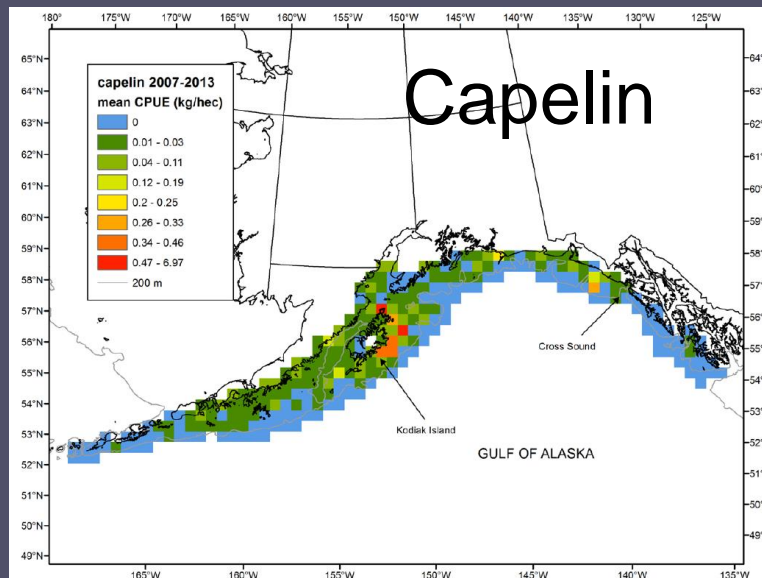
Short and/or localized time series:
- beach seines
- surface trawls

Long time series, but strong catchability bias:
- Bottom trawl surveys 1984 - present
  - 1984 – triennial
  - 1999 – biennial to present

Mean bottom trawl survey CPUE 2007-2013

Capelin

Sand lance

However, those same bottom trawl surveys are designed to catch groundfish, some of which have evolved to catch forage fish

- Stratified random design, 1984-2015
- Stomach content analysis
- 22-88 inch, May-Sept
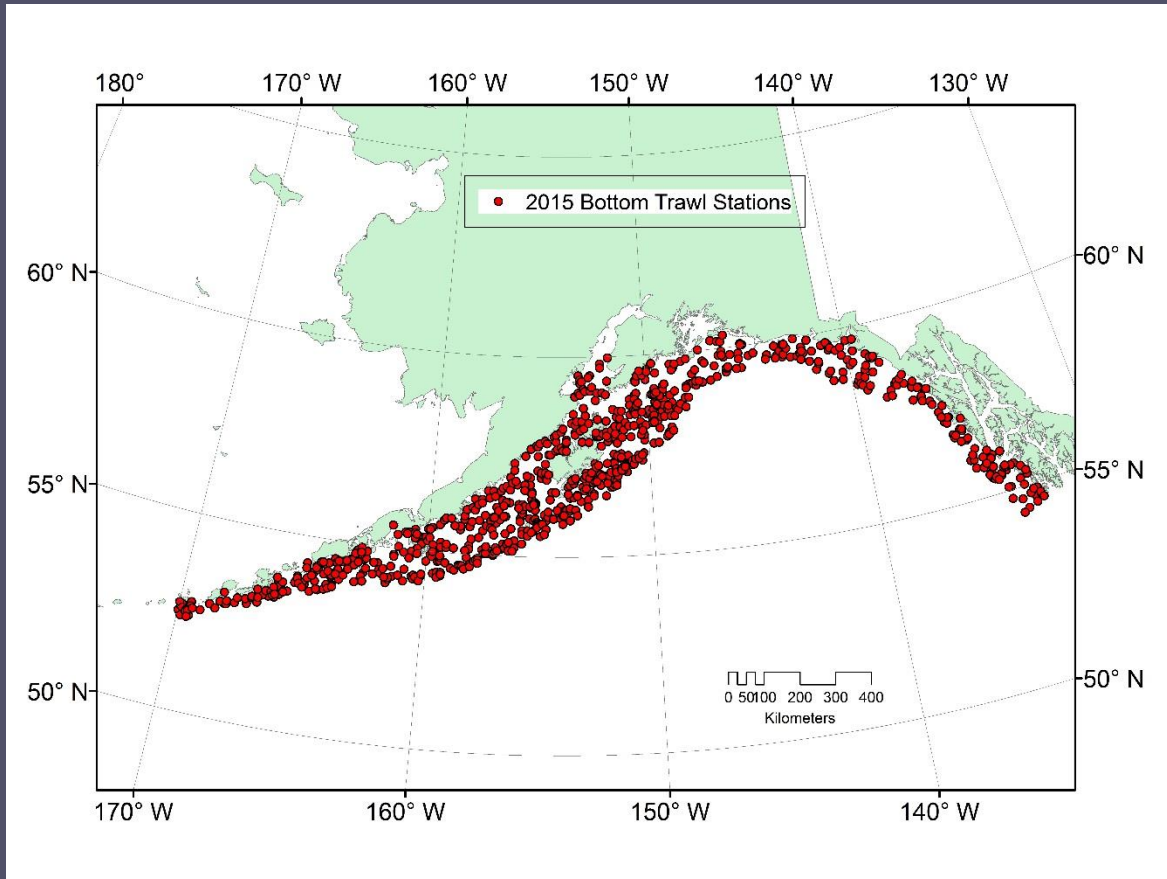- Capelin #/ predator length/ year

Pacific Halibut

Arrowtooth Flounder

Pacific Cod

Walleye Pollock

Seabirds have also evolved to catch forage fish

- Central place foragers
- Bring fish back to feed chicks
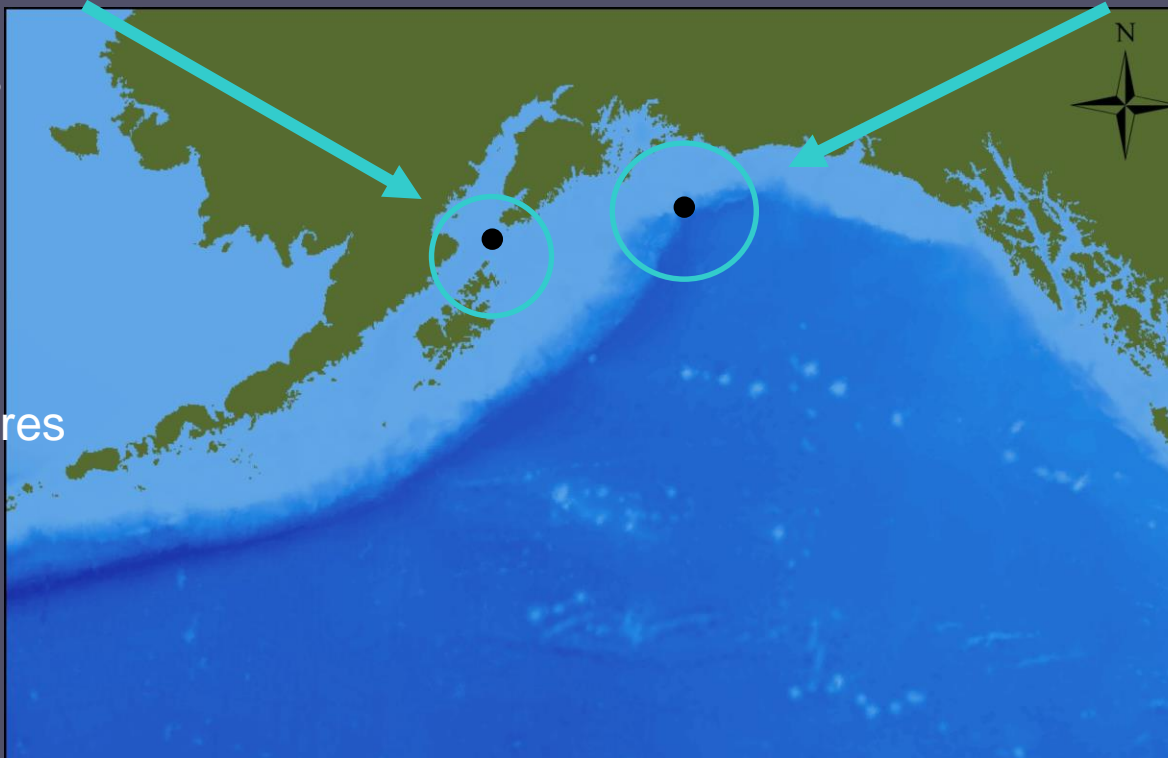- Long time series
- % by num/species/colony

East Amatuli Island

Middleton Island

Tufted Puffins
1995 – 2014

Black-legged
Kittiwakes
1990 – 2015

Common Murres
1995 - 2013

Rhinoceros Auklet
1986 - 2015

Potential biases when using predators as samplers:

- selection or preference for certain prey types

- differing foraging ("sampling") patterns

Does looking for consistent patterns in forage fish trends across a diverse suite of samplers address potential catchability/preference biases?

Predators sample different parts of the water column
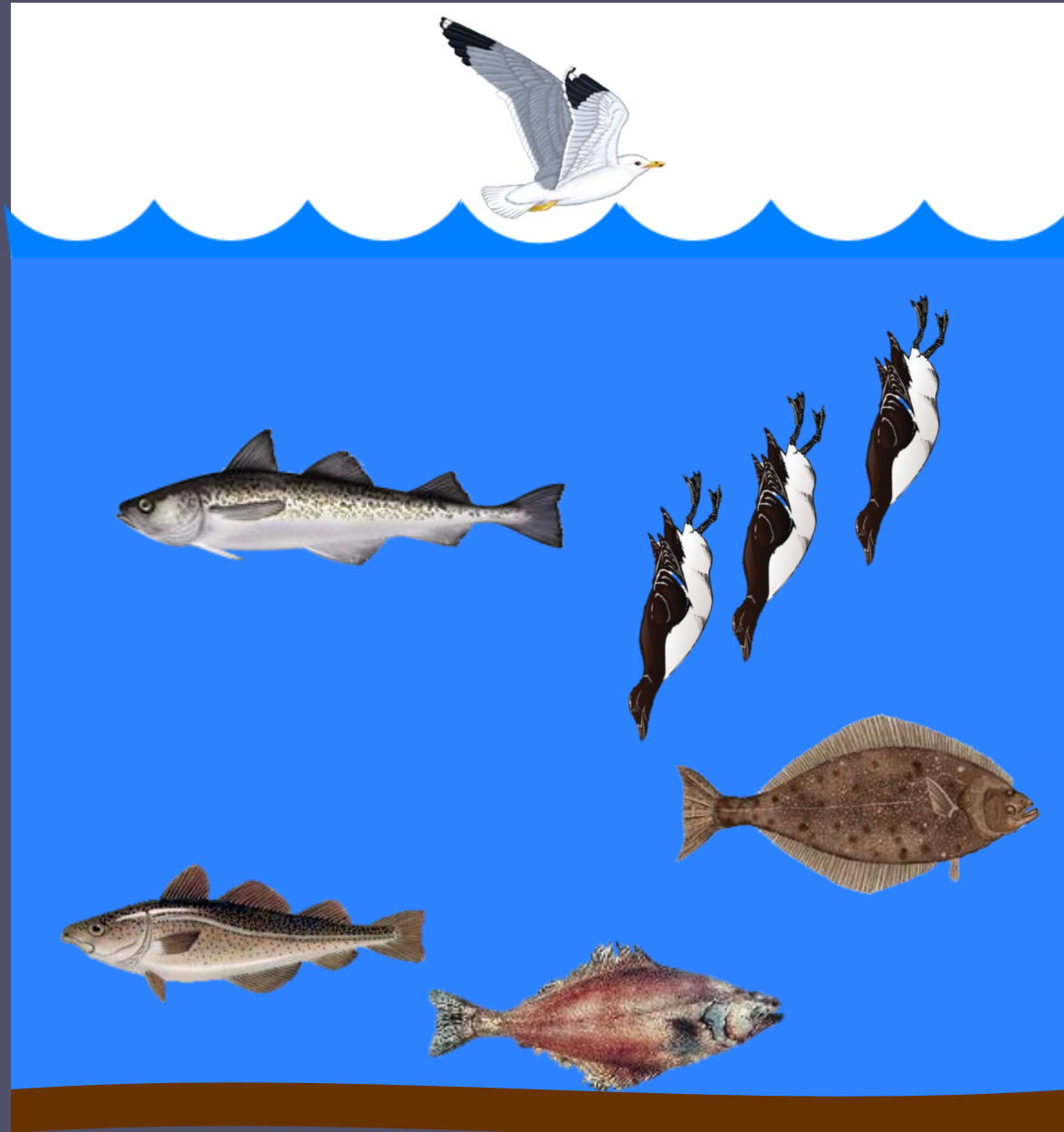
Dynamic Factor Analysis (DFA)

- Like a PCA for time series

- From the R package MARSS (multi-autoregressive state space models)

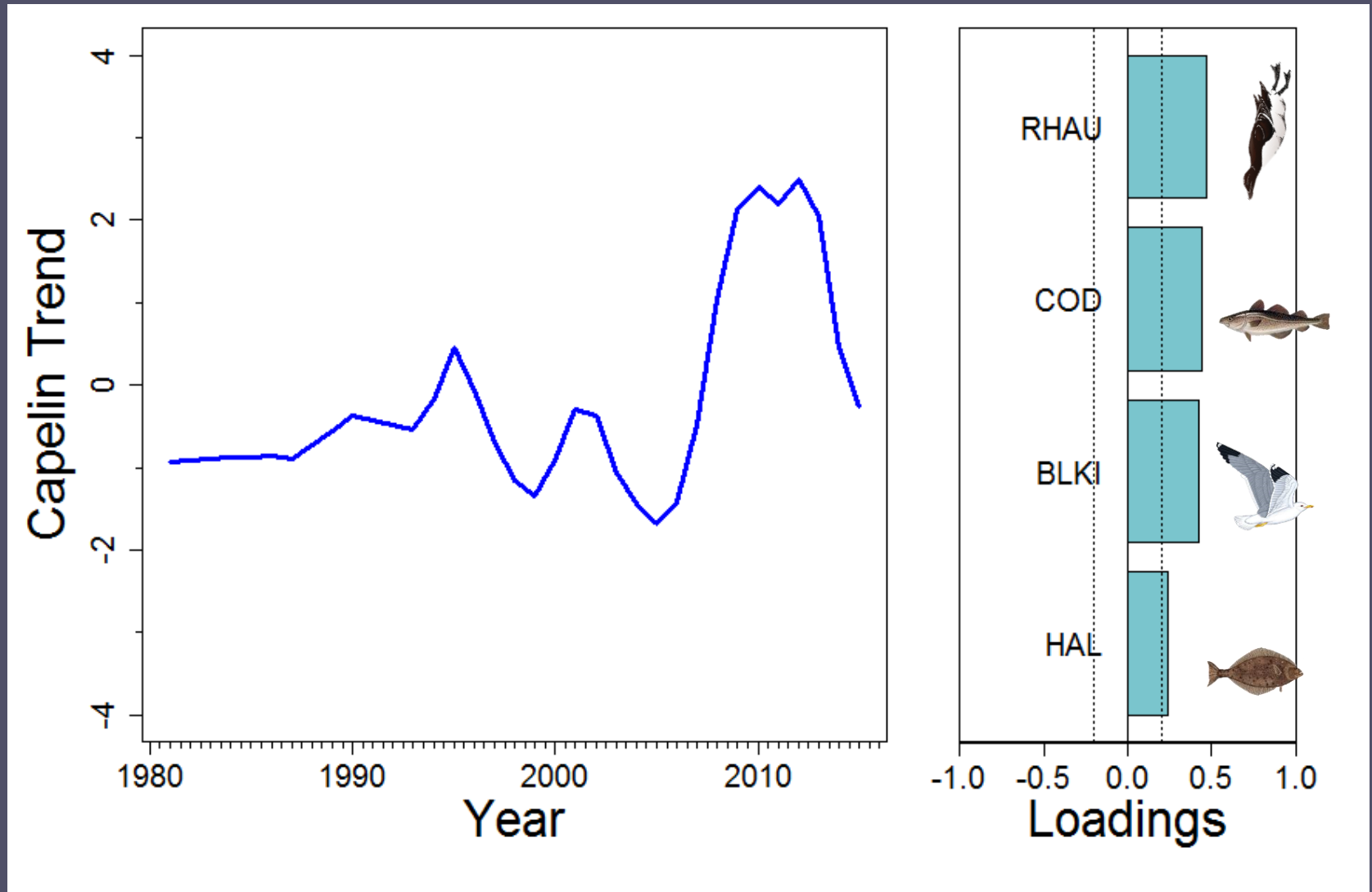- Allows for model selection

- Tested for 1-5 common trends

Question:

Can we find 1 common forage fish trend among these time series?

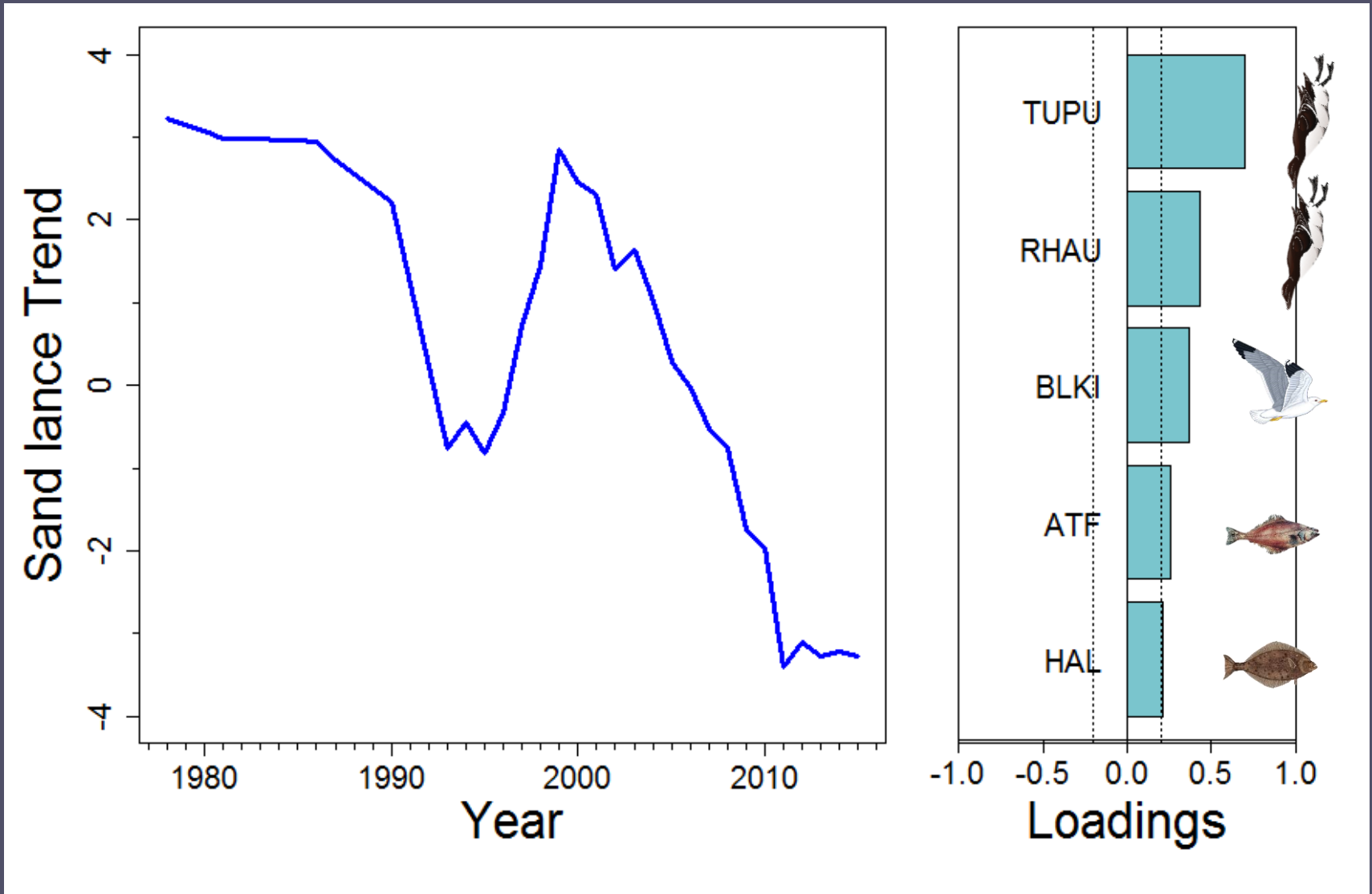If so, we assume that this is a good indicator of forage fish trends

Alternatively, do multiple common trends exist among different predator groups (ie., fish vs. bird)?

A single trend model fit the capelin data best

Equal variance covariance R error structure

A single trend model fit the sand lance data best, too

Unconstrained R error structure

So what can we do with these indicators?

1. Incorporate them into assessments of ecosystem state

2. Also, explore which environmental signals might be related to these forage fish trends

3. …

2016 Western Gulf of Alaska Report Card

Ecosystem Considerations 2016
Status of the Gulf of Alaska Marine Ecosystem

Capelin Index

* Pacific Decadal Oscillation (Winter)
Fresh Water Input
* Mesozooplankton Biomass
* Copepod Community Size
* Motile Epifauna Biomass
* Capelin DFA Index
* Apex Fish Biomass
* Black-legged kittiwake Reproductive Success
* Steller Sea Lion Non-pups
* Human Population (Homer Kodiak)
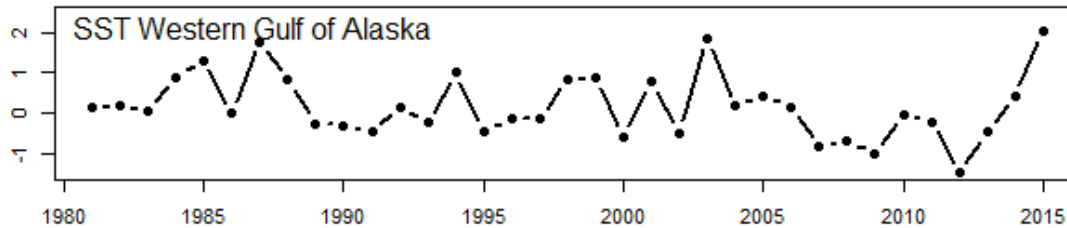
1970   1980   1990   2000   2010   2016
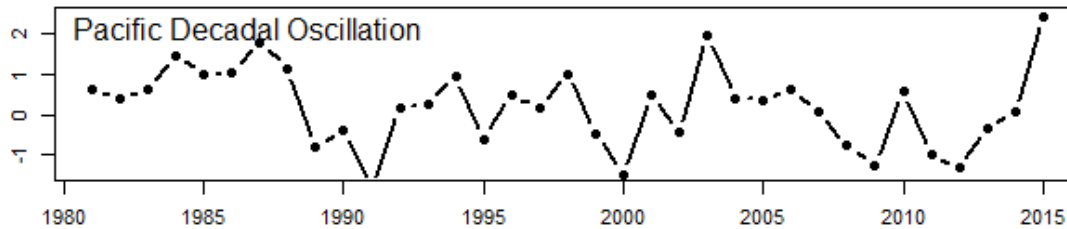
Environmental Time Series

Subset of important indicators for the Gulf of Alaska as selected by expert groups
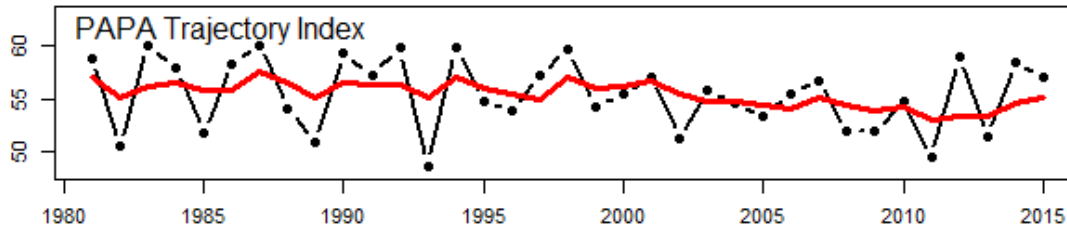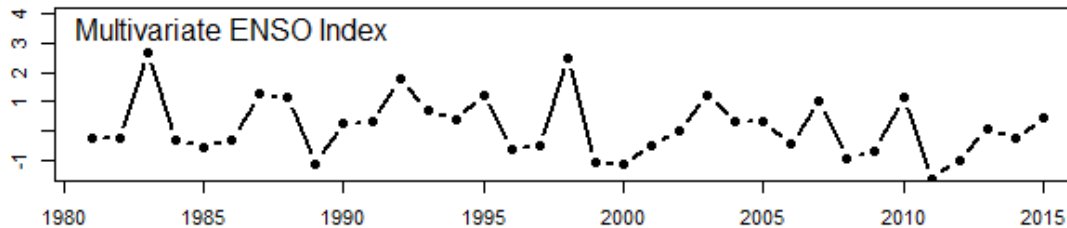

PAPA Trajectory Index – winter surface current simulation

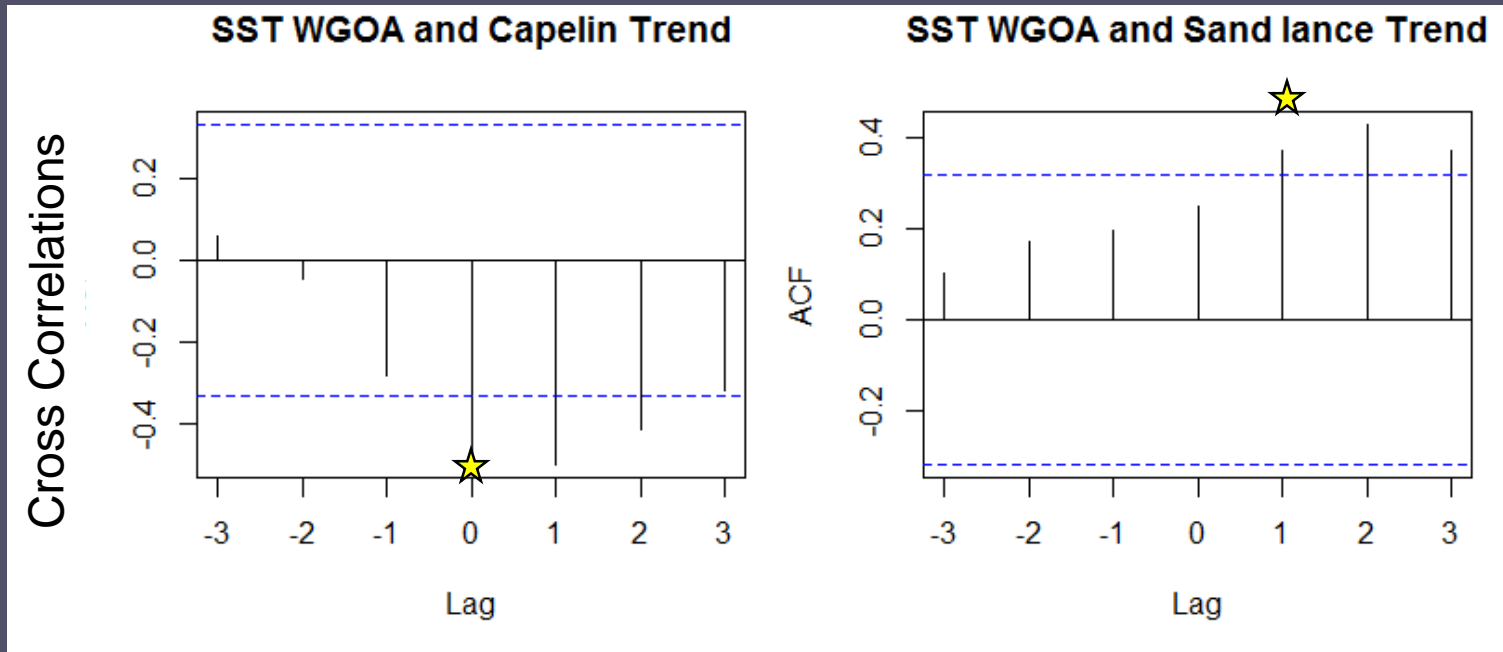SST Western Gulf of Alaska – NDJFM average from ERSSTv4

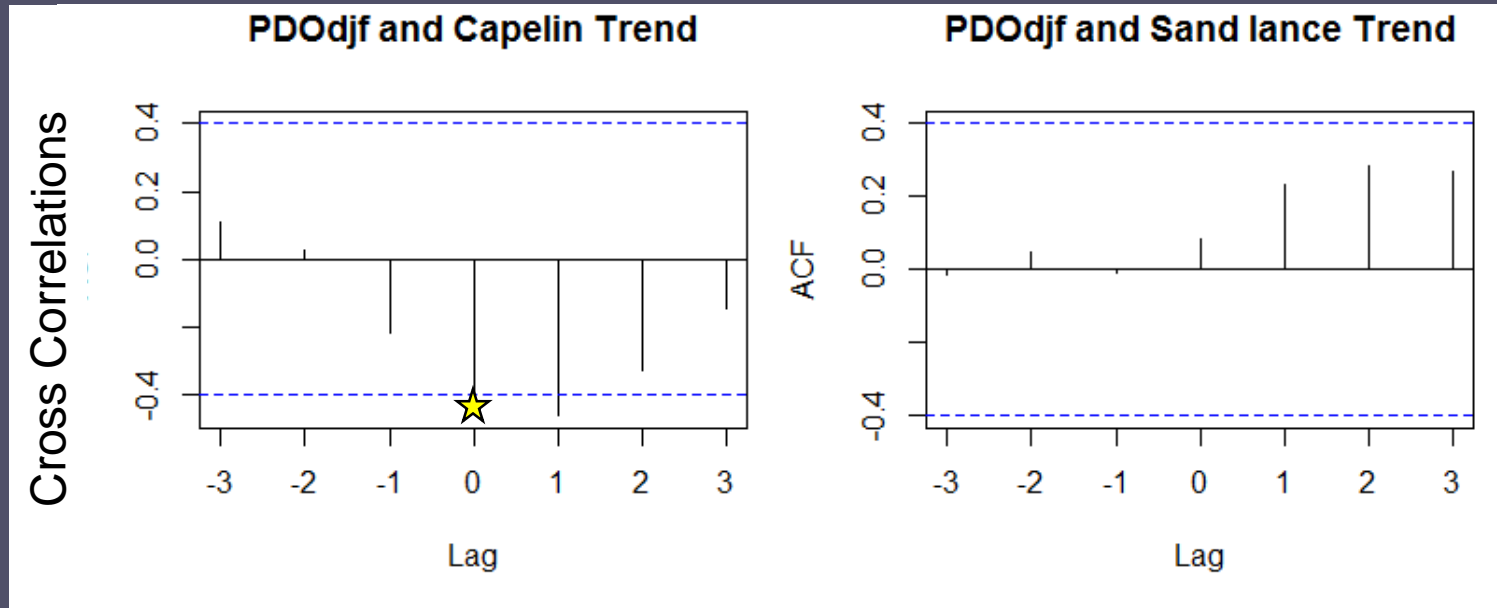Pacific Decadal Oscillation during winter

Multivariate ENSO Index- Dec Jan

Cross correlations indicate capelin are negatively correlated with SST and sand lance are positively correlated with SST at about a 1 year lag

Cross correlations indicate capelin but not sand lance are negatively correlated with PDO

Summary and Conclusions

DFA showed that there were common forage fish trends among a diverse suite of forage fish predators

These common trends can serve as robust indicators of capelin and sand lance trends

Predators can serve as "alternative samplers" in the absence (or not) of long term directed forage fish surveys

Next Steps

- Expand "samplers" to include net or acoustic surveys

- Run DFAs with SST, PDO as a covariates

- Develop DFA indicators for myctophids and age-0 pollock

- Develop forage fish indicators for the Eastern Bering Sea and Aleutian Islands