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

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

The goal:
Develop ecosystem indicators to track forage fish trends as an important component of ecosystem assessments provided to fishery managers.
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
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
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
Tufted Puffins
1995 – 2014

Common Murres
1995 - 2013

Middleton Island
Black-legged Kittiwakes
1990 – 2015

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 (i.e., 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.
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. …
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 covariate
- Develop DFA indicators for myctophids and age-0 pollock
- Develop forage fish indicators for the Eastern Bering Sea and Aleutian Islands