Large copepods as leading indicators of walleye pollock recruitment: observed and geostatistical model (VAST) results in the SE Bering Sea

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Study area: Southeastern Bering Sea
Sea ice and temperature are important in establishing feeding conditions for pelagic species in the eastern Bering Sea.

Connor & Lauth (2017)
Age-1 Walleye Pollock abundance by year

Ianelli, J. (2017)
Fisheries oceanography surveys (BASIS)

- mid-August to early Oct
- 2001-2018 (ongoing)
- Station spacing ~ 60 km
- CTD (T, S, Fluor, PAR, O2)
- Nutrients, Chla
- Zooplankton bongo tows (150 and 505 µm)
- Surface (top 20 m) trawl for forage fish (juvenile Walleye Pollock primarily age 0)
Age-0 pollock energy content and weight by year

Energy content X weight = energy content per fish
KJ/g X g/fish = KJ/fish

Heintz et al. (2013) DSR2
Age-0 pollock energy content (SE Bering Sea) vs. survivorship to year 1

Age-0 pollock diets (% composition)

Figure 70: Percent composition of age-0 pollock prey from the middle domain in the southeastern Bering Sea. On-board diet analyses are conducted during the late summer/early fall BASIS survey and are available soon after the survey is completed.

Heintz et al. (2016) Alaska Marine Ecosystem Status Report
Zooplankton: SE Bering Sea (Aug/Sept)

Eisner, et al. (2014), DSR2

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Question

• Can we predict Walleye Pollock abundance at age 3 (first year in fishery) from large copepod abundance during age 0 year (3 years prior)?
Methods

Age 3 pollock abundance estimated from ground fish summer bottom trawl survey data (Ianelli, 2017).

Large copepods collected with bongo net oblique tows on BASIS surveys, mid-August to September.

*Calanus marshalle/glacialis*

*Neocalanus* spp.

*Metridia pacifica*

Large copepod abundance estimates (sum of 3 taxa)

• Observed means among stations (number m$^{-2}$)

• Vector Auto-regressive Spatial Temporal (VAST) model to estimate encounter probability and positive catch rate (Thorson et al, 2016)

  Estimated spatial and spatial-temporal variation

  Specified gamma distribution, spatial resolution of 50 knots
Station grid by year
Observed & VAST model estimates of large copepod abundance

Observed

VAST
Observed & VAST model estimates of large copepod abundance

Observed

VAST
Mean large copepod abundance index (Number m⁻²) by year

Pink = warm, low ice
Blue = cold, high ice
Age-3 pollock & zooplankton indices

VAST zooplankton abundance estimate explains 69% (an additional 22%) of the variability in pollock abundance
Age-3 pollock & environmental indices

- SST from bottom trawl survey, Jun-mid Aug
- Ice cover index = average ice concentration for box (56°-58°N, 163-165°W) for Jan-March
- Cold pool index = areal extent of cold pool (< 2°C), Jun-mid Aug

Cold pool index explains 54% of the variability in age-3 pollock abundance
Predictions from large copepod index (VAST model)
Conclusions

• Age-3 pollock abundance is best estimated by large copepod abundance (VAST model) from age 0 year; estimates using cold pool area may also be useful ($R^2 = 0.69$ vs 0.54).

• VAST model improves fit, particularly for years with reduced sampling effort (e.g., 2008).

• Age-3 pollock abundances for 2015 and 2016 year classes (abundances in 2018 and 2019) are predicted to be below average in the southeastern Bering Sea.

• Plans to use the large copepod indicator in pollock stock assessment modeling efforts in future.