Fish Movement: Capturing Feeding Ecology in a Climate to Fisheries Model

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• Model set-up

• Feeding ecology & Fish movement

• Emergent functional response & distributions

• Challenges

• Future directions
Bering 10K ROMS-NPZD-FEAST

- Climate input
- Physical oceanography (ROMS)
- Lower trophic level (NPZ)
- Upper trophic level (FEAST)
- Fishing effort allocation (FAMINE)

Operating model for Management Strategy Evaluation
Acknowledgements Modeling group

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Physical oceanography
(ROMS)

Lower trophic level
(NPZ)

Upper trophic level
(FEAST)

Fishing effort allocation
FAMINE

Climate input
NPZD-FEAST Food web
Capturing feeding ecology

- Prey preference is species specific
- Prey selectivity is size based
- Prey availability is based on prey abundance and size selectivity
- Emerging functional response
Capturing feeding ecology

Prey density

Encounter rate

Foraging rate ideal/maximum vs. Prey density (preferred joules/m^2)

Foraging rate ideal/maximum vs. Age of fish (days)
Capturing feeding ecology

- Follow prey: too static & get eaten
- Follow prey and diffuse: enough movement & get eaten, predator/prey high density clusters
- Follow prey, avoid predators, diffuse: enough movement, some get eaten, less clustering
- Follow and deplete prey, avoid predators and diffuse
Do fish make a difference in zooplankton?

NPZ ——> Fish one way feedback

NPZ <——> Fish Two way feedback
Large crustacean zooplankton as prey

Copepods + euphausiids

NPZ $\leftarrow$ Fish
Two way feedback

NPZ $\rightarrow$ Fish one way feedback

2004
2way

2004
1way
Seasonal distribution age 3+ pollock

Winter  Spring  Summer  Fall

2004 2way

2004 1way
Next slide: video of hindcast simulation for the eastern Bering Sea using Bering 10K ROMS-NPZD-FEAST

Compared weekly output for 2004 (warm year) and 2008 (cold year). Shown are bottom temperature with cold pool in dark blue; ice cover in white and icephytoplankton in green.
Seasonal distribution age 3+ pollock
Seasonal distribution age 3+ cod

Winter  Spring  Summer  Fall

2004

Winter  Spring  Summer  Fall

2008
Seasonal distribution age 3+ arrowtooth

Winter  Spring  Summer  Fall

2004

2008
Challenges: Distribution and abundance
GAM survey data & cold pool extent

Lauth and Kotwicki 2013 Deep Sea Research II

Walleye pollock (kg ha⁻¹)

High abundance

Low abundance
Future directions: Long term forecasts

Build library of forecasts based on different climate models (validated for eastern Bering Sea)

3 current forecasts to 2040
1 realization for each climate model

3 realizations per climate year by end of year
Future directions: Long term forecasts

Essential Fish Habitat + ROMS

EFH based on location, temperature, slope, tide, current

Use forecasted temperatures to get new distributions

Chris Rooper, Ned Laman, Dan Cooper (RACE Division, AFSC, NMFS, NOAA); contact Chris.Rooper@noaa.gov
Future directions: Long term forecasts

Fish Distribution
GAMS + ROMS

GAM based on cold pool extent at species specific temperature threshold

Use forecasted cold pool to get new distributions

Lauth and Kotwicki 2013 Deep Sea Research II
Challenge: phenology of primary and secondary production

Small copepods

Medium & Large copepods

Euphausiids

NPZ ——> Fish one way feedback

NPZ <——> Fish Two way feedback
Future directions: Short term forecasts

Modeled Jan 2012
Predicted Jan 2014
Predicted Jan 2015

Observed Jan 2012
Observed Jan 2014

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Summer 2015 prediction (single realization)