

# An Updated Trophic Model of the Eastern Chukchi Sea

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## Background

- A preliminary mass-balance food web model of the eastern Chukchi Sea has previously been developed, primarily by using historical data, characterizing the ecosystem in the late 1980s and early 1990s (Whitehouse 2013).
- As part of the Arctic Ecosystem Integrated Survey (Arctic EIS) we are updating this model with more current data gathered during the Arctic EIS and other contemporary projects, to provide a description of the food web that better reflects current conditions in the eastern Chukchi Sea.

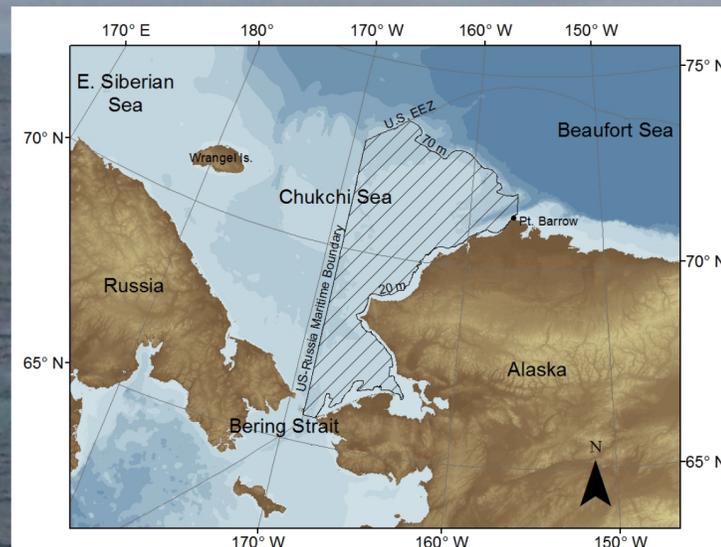


Figure 1. The model area in the eastern Chukchi Sea (filled with hatched lines).

## Highlights

### Model balancing

- Initial attempts to balance the food web model indicated that biomass estimates of most fish groups derived from trawl survey data were insufficient to match the consumptive demands of predators and that densities needed to be several times greater (Figure 2). This is likely a reflection of the low catchability of some species to the bottom trawl gear, patchy fish distribution, interannual variation in fish abundance, and spatial limitations of trawl survey coverage.
- The biomass estimate for Misc. shallow fish (pricklebacks, poachers, and others) increased substantially and had the highest biomass amongst fish functional groups. This was the result of the new diet data for fishes which showed fishes from this group to be an important component of the diet of piscivorous fishes (safron cod, sculpins, and others).

### New Functional Groups

- The new diet data for fishes revealed unexpected levels of piscivory in some snailfish species. When predator and prey species were within the same functional group, this created computational problems which prevented model balancing. To remedy this, we created two new functional groups, one for the variegated snailfish (*Liparis gibbus*), and one for all other snailfish (Liparidae).
- A new functional group for Alaska skate (*B. parmifera*) was added because a live adult was caught in the south-central Chukchi Sea during the 2012 Arctic EIS bottom trawl survey. In the eastern Chukchi Sea, beach cast specimens of Alaska skate have previously been found near Pt. Hope and Kivalina in 2010, and additionally, Alaska skates were found at several locations in the northern Bering Sea in 2010 (Mecklenburg et al. 2011).

### Trophic structure

- The model highlights the importance of the benthos in the eastern Chukchi Sea. Benthic invertebrates are the dominant component of the food web in terms of biomass and energy flow (Figure 3).

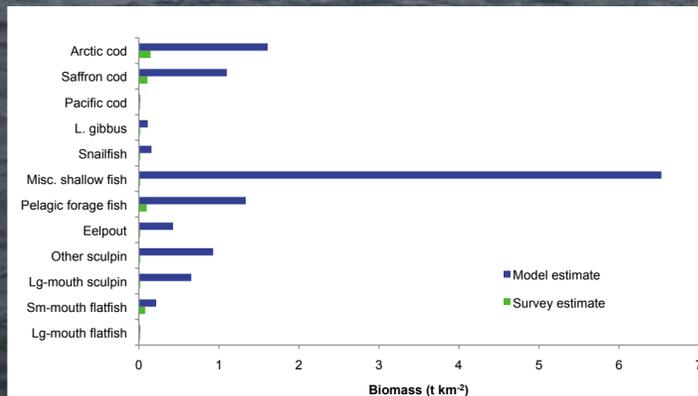


Figure 2. Biomass estimates ( $t\ km^{-2}$ ) of fish in the eastern Chukchi Sea. Trawl survey estimates are derived from the catch data of the 2012 Arctic EIS bottom trawl survey (Goddard et al. 2013). The model estimates are derived from our Ecopath model and are the minimum biomass required to support the modeled predator demand.

## Methods

- The food web was modeled with the Ecopath static mass-balance framework (Christensen and Walters 2004, ecopath.org). The Ecopath approach uses data commonly reported in fisheries and ecological studies and combines that data in a single modeling framework.
- Ecopath produces a “snapshot” description of the annual average conditions of the food web by incorporating information on biomass, diet composition, and rates for production and consumption for all functional groups on all trophic levels.
- The model describes the continental shelf ecosystem (< 70 m depth) of eastern Chukchi Sea, within US territorial waters (Figure 1).
- Biomass estimates for several fish and benthic invertebrate functional groups were updated with catch data from the 2012 Arctic EIS trawl survey of the eastern Chukchi Sea (Goddard et al. 2013).
- The food habits of fishes were updated with collections made during the 2012 Arctic EIS bottom trawl and surface trawl surveys. The contents of more than 2,000 stomachs from 37 species of fish were analyzed.

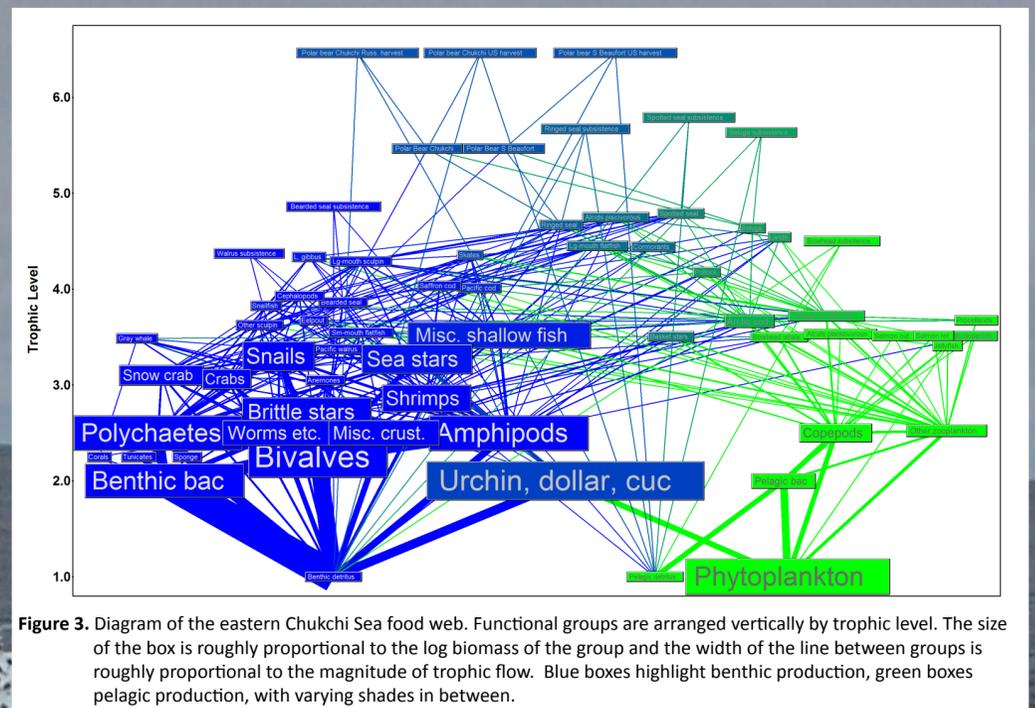


Figure 3. Diagram of the eastern Chukchi Sea food web. Functional groups are arranged vertically by trophic level. The size of the box is roughly proportional to the log biomass of the group and the width of the line between groups is roughly proportional to the magnitude of trophic flow. Blue boxes highlight benthic production, green boxes highlight pelagic production, with varying shades in between.

## Summary

- The eastern Chukchi Sea is a benthic dominated system with more energy flow through benthic compartments than through pelagic groups.
- Based on the consumptive demands of predators there may be more fish in this ecosystem than trawl survey data indicate. In particular, our miscellaneous shallow fish group (pricklebacks, poachers, and others) was an important prey item for several piscivores resulting in a substantial increase in the biomass estimate for this group.

## Future Directions

- Conduct a sensitivity analysis of the model to measure uncertainty in model input parameters.
- Use the Ecopath static mass-balance model parameters to initialize a dynamic Ecosim model of this ecosystem, and perform perturbation style analyses to examine the range of food web responses to disturbance and ecosystem resilience.

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