How Many Euphausiids are There (Really) in the Eastern Bering Sea?

Patrick H. Ressler • Alaska Fisheries Science Center, NOAA Fisheries, 7600 Sand Point Way NE, Seattle, WA, U.S.A. *Presenting author, email: patrick.ressler@noaa.gov*
Alexei I. Pinchuk • Fisheries Division, University of Alaska Fairbanks, 17101 Point Lena Loop Rd., Juneau, AK, U.S.A.
Georgina A. Gibson • International Arctic Research Center, University of Alaska Fairbanks, P.O. Box 757340, Fairbanks, AK, U.S.A.
Joseph D. Warren • School of Marine and Atmospheric Sciences, Stony Brook University, 239 Montauk Hwy, Southampton, NY, U.S.A.

Euphausiids are important, but estimates of their biomass are uncertain

- **Key zooplankton taxon in the eastern Bering Sea (and elsewhere), linking lower trophic levels to top predators**
- **Absolute magnitude of standing stock in the Bering Sea (principally *Thysanoessa* spp.) is not well known**
- **We compare biomass estimates from nets, acoustics, and an NPZ model, and try to reconcile the differences.**

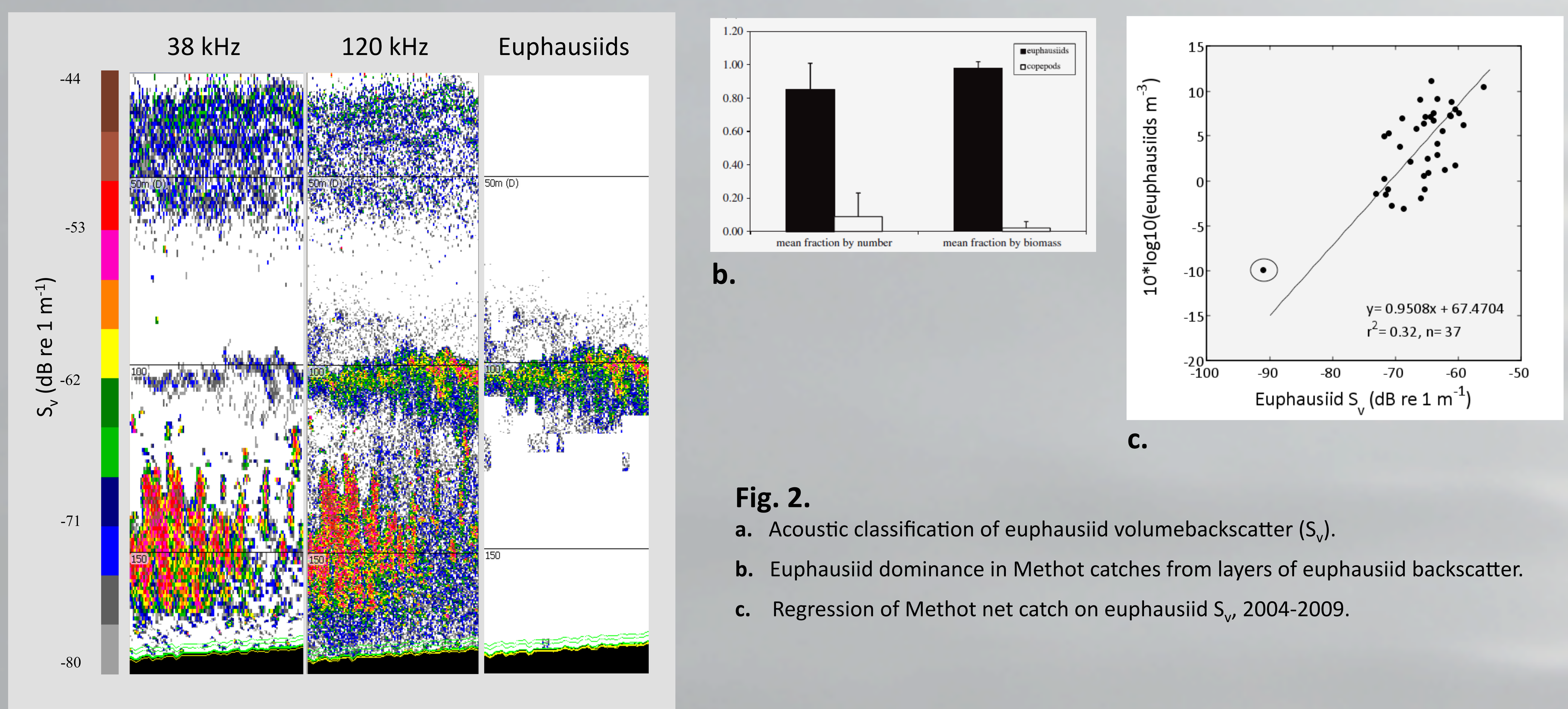
NET SAMPLING

- Plankton nets provide a physical sample and high taxonomic resolution, but coarse spatial resolution (Fig. 1).
- Euphausiid avoidance of nets could range from 2 to 5-fold at night and to 20-fold during daytime (Sameoto et al. 1993, Coyle and Pinchuk 2002, Wiebe et al. 2004, 2013).
- Euphausiid biomass (g C m^{-2}) from nighttime MOCNESS tows averaged 0.48 g C m^{-2} (SD averaged 0.69) on the outer shelf in June of 2008-2010. Assuming 5-fold avoidance at night would increase these numbers accordingly.

Fig 1. Left to right: euphausiid, Methot net deployment, MOCNESS deployment, euphausiid catch.

ACOUSTIC SAMPLING

- Acoustic-trawl methods offer less taxonomic resolution, but high spatial resolution at a large scale (Fig. 1,2).
- Euphausiids dominate net catches in layers of euphausiid backscatter (Fig. 2). However, uncertainty in backscatter classification and in target strength (TS, the backscatter from a single euphausiid) propagates to computations of derived density and biomass.
- TS for EBS euphausiids was estimated using a physics-based model (Ressler et al. 2012, Smith et al. 2010, 2012). Acoustic estimates are usually much higher than net estimates (Warren and Wiebe 2003), here, ca. 50-fold higher on the outer shelf in June-July 2008-2010 (average 24.53 g C m^{-2}, SD averaged 25.77).
- TS can also be empirically estimated by regression of daytime, targeted Methot trawl catches on concurrently observed backscatter (S_v), though this estimate is also highly uncertain due to variability in the regression fit. Euphausiid TS estimated from this regression (-81.48 dB, solving regression in Fig. 2c for x where y= -10, assuming 10-fold avoidance by day) was ca. 8-fold higher than the average scattering model estimate (-90.54 dB), leading to a lower acoustic estimate of biomass.



a. b. c.

Fig. 2.

a. Acoustic classification of euphausiid volumebackscatter (S_v).
b. Euphausiid dominance in Methot catches from layers of euphausiid backscatter.
c. Regression of Methot net catch on euphausiid S_v, 2004-2009.

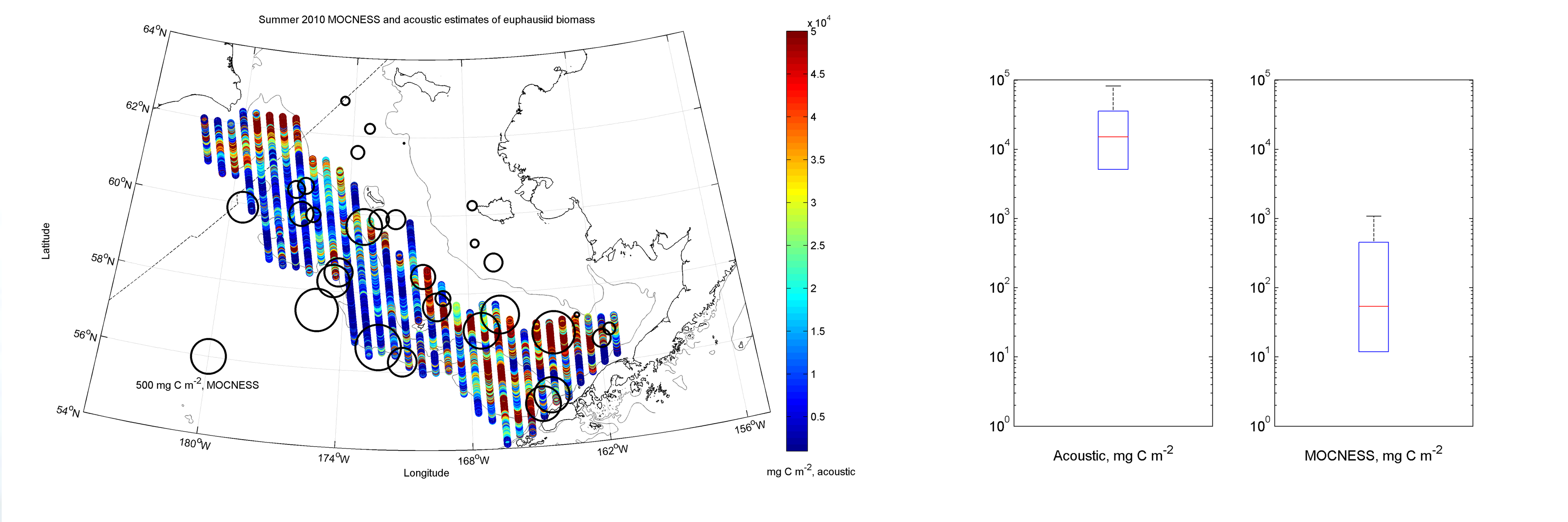


Fig 3. Left, overlay of MOCNESS (cruise TN250, 16 June – 14 July) and acoustic biomass estimates in 2010 (DY1006, 5 June – 7 August), right, boxplots of 2010 acoustic and MOCNESS data.

ECOSYSTEM MODELING

- Annual primary production on the Bering Sea shelf is thought to average 100-150 g C m^{-2} yr^{-1}. Assuming a 10% transfer efficiency to euphausiids and a P:B of 5 would yield standing stocks of 2-3 g C m^{-2}. Net capture estimates seem too low, while acoustic estimates seem too high.
- An NPZ (nutrients-phytoplankton-zooplankton) model has been constructed for the EBS shelf (Gibson and Spitz 2011). Euphausiids are only one of many dynamic components; incomplete knowledge of parameters and processes lead to large uncertainties in output. It was built upon and constrained in part by empirical measurements.
- After recent revisions to better account for diel vertical migration and persistence of euphausiid biomass on the shelf through the winter, the NPZ model estimates of summertime standing stock averaged 3.70 g C m^{-2} (SD 0.48) on the outer shelf in summers 2008-2009.

RECONCILING THE DIFFERENCES

Euphausiid biomass from MOCNESS catches and acoustic estimates were poorly correlated spatially (r^2= 0.02, p= 0.56; Fig. 3), probably because of patchiness and a several week time lag between these measurements. This contrasts with the correlation between concurrent, targeted Methot tow catches and euphausiid backscatter (Fig. 2). Our concern here is primarily with the very large difference in average magnitude between acoustic and net estimates (Fig. 3). Patchiness and differences in sampling resolution could contribute to these differences, but not fully explain them.

However, if we adjust averages of **MOCNESS biomass estimates upward by 5-fold** to account for avoidance, and **acoustic estimates downward by 8-fold** based on the empirical net catch-S_v regression estimate of TS, we obtain standing stock estimates that are close to one another and consistent with both assumptions of trophic transfer efficiency and estimated euphausiid biomass from the NPZ model.

Source	Mean g C m^{-2} (mean SD)
Net sampling	2.40 (3.47)
Acoustic	3.04 (3.20)
Ecosystem model	3.70 (0.48)

The biases in absolute magnitude proposed here do not affect the relative temporal or spatial patterns in these data or their use as relative indices. However, this uncertainty does affect the ability to draw conclusions about euphausiid productivity and consumption by predators.

CONCLUSIONS AND FUTURE WORK

- **Accounting for possible effects of net avoidance and TS model bias brings average net, acoustic, and NPZ model estimates of euphausiid biomass to order-of-magnitude agreement.**
- **Provisionally, treat biomass estimates from all sources as relative indices with a 'catchability'. Many analyses would be unaffected by a constant bias in absolute magnitude.**
- **To pursue absolute abundance, need *in situ* TS measurements, experimental validation of model TS and model parameters, quantification of net avoidance, continued refinement of NPZ model (a tall order).**
- **Continue to confront models with data, and data with models.**

Acknowledgments: NOAA-AFSC, The Bering Sea Project (NPRB, NSF), BEST Synthesis (NSF Grant # 1107250), NOAA-AFSC graphics department. The findings and conclusions in the paper are those of the authors and do not necessarily represent the views of the National Marine Fisheries Service.