# On-shelf transport of oceanic zooplankton in the Bering Sea.

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## BACKGROUND

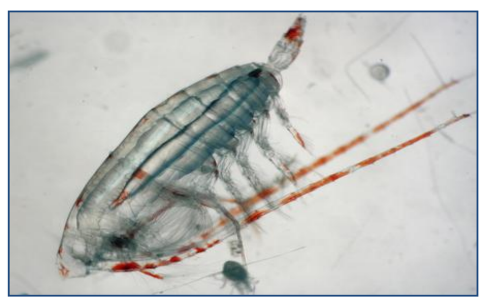


**Figure 1. Oceanic zooplankton *Neocalanus sp.***

- *Neocalanus* (Figure 1) are zooplankton that require deep water to successfully reproduce so tend to occur in oceanic and shelf-break habitats.
- Shelf-break fronts in the Eastern Bering Sea reduce cross-shelf advection over the outer-shelves potentially retarding on-shelf transport of the oceanic copepods. South-Easterly winds October-May are thought to increase on-shelf flow over the southern shelf.
- Because *Neocalanus* are large-bodied with a high energy content they are an important food source for juvenile stages of commercially important fish such as pollock, capelin and salmon in the Bering Sea.
- Annual differences in forage and commercial fish stocks in the Bering Sea may depend on climatic and oceanographic conditions promoting on-shelf transport of *Neocalanus*.
- Timing of on-shelf transport of *Neocalanus*, and the key physical processes determining the degree and extent of this transport are unclear.

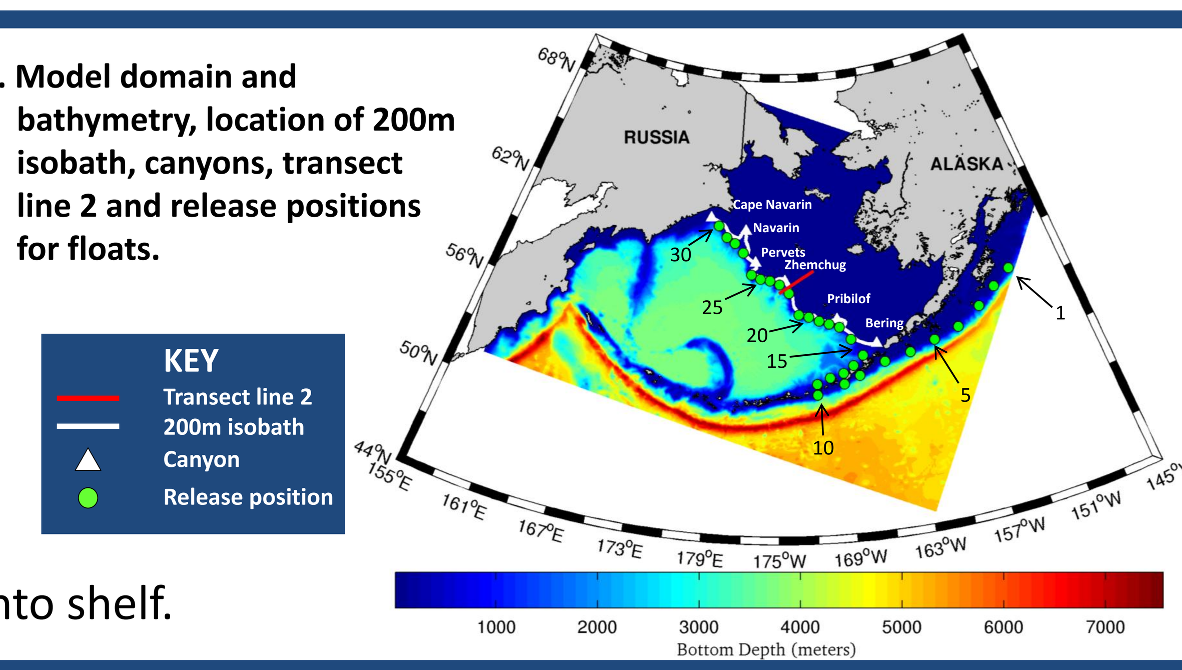
## OBJECTIVE:

**Determine most significant factors affecting timing, location and intensity of on-shelf zooplankton transport in the Eastern Bering Sea.**

## METHOD

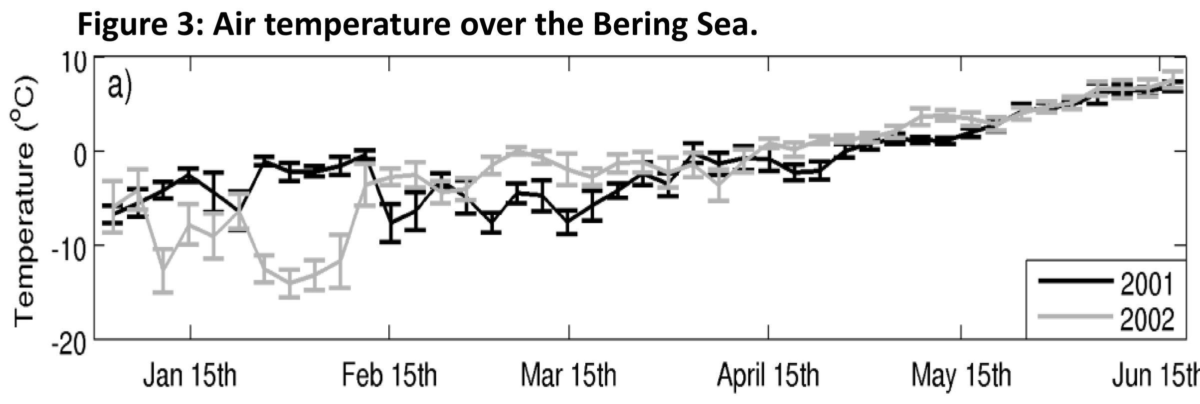
- Float track model embedded in a 3D oceanographic model (ROMS) to simulate transport of Neocalanus.
- Model grid resolution: 4km with 60 vertical layers covering Bering Sea (Figure 2).
- Simulated float speeds and directions validated against ECO-FOCI drifters 2001.
- Floats were initialized throughout January and February at 700m depth along 1000 m isobath (Figure 2).
- Behavior rules added to floats to simulate seasonal zooplankton vertical migration.
- Simulation years: 2001 and 2002 + experiments conducted with increased/decreased winds and air temperature.
- Assessed numbers and residence time of floats in different regions of shelf, and determined where floats crossed onto shelf.

**Figure 2.** Model domain and bathymetry, location of 200m isobath, canyons, transect line 2 and release positions for floats.



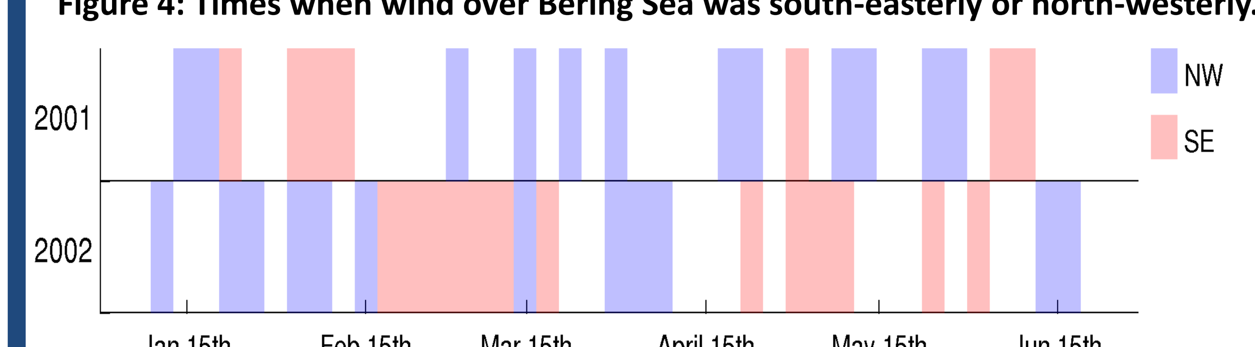

## RESULTS

**Figure 3: Air temperature over the Bering Sea.**



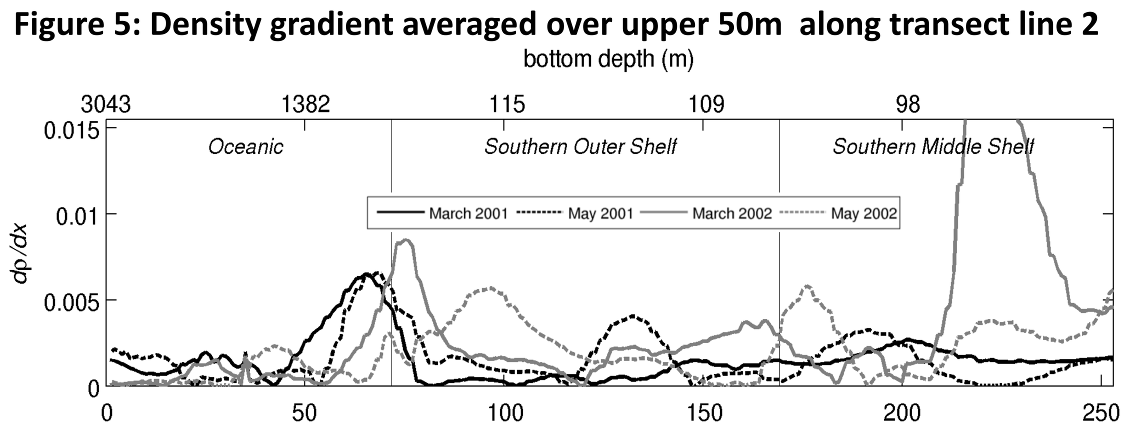

For much of January and early February, 2002 was colder than 2001. From early March to mid May there were several periods when 2002 was significantly warmer than 2001 (Figure 3).

**Figure 4: Times when wind over Bering Sea was south-easterly or north-westerly.**




In 2001 there was a sustained period of south-easterly wind from late January to early February but wind was not from this direction again until a brief period in May. In 2002, wind was south-easterly from late February to the middle of March and again from the end of April through May (Figure 4).

**Figure 5: Density gradient averaged over upper 50m along transect line 2**




Density gradients indicate location of fronts. Along transect line 2 (see Figure 2 for location) fronts formed on the shelf break in both years. In 2001 frontal strength and location did not vary from March to May. In 2002, the front was relatively strong in March but had weakened and moved shelf-wards by May.

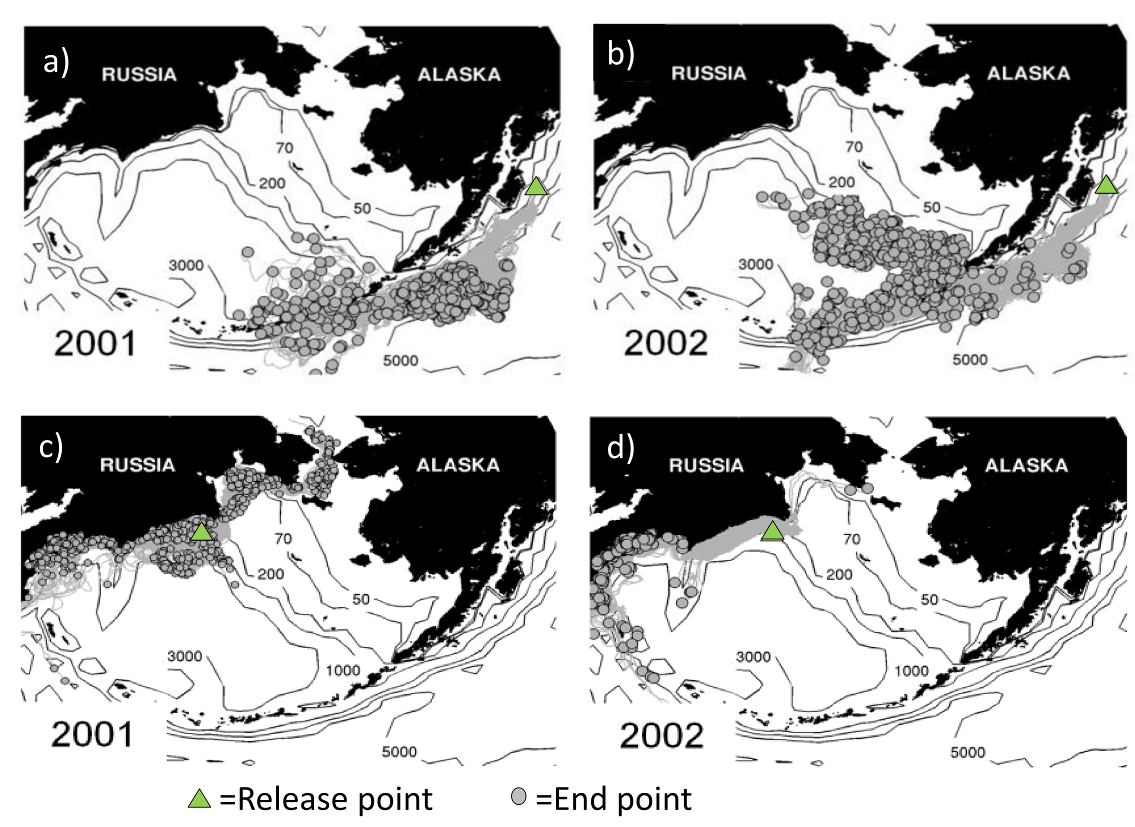
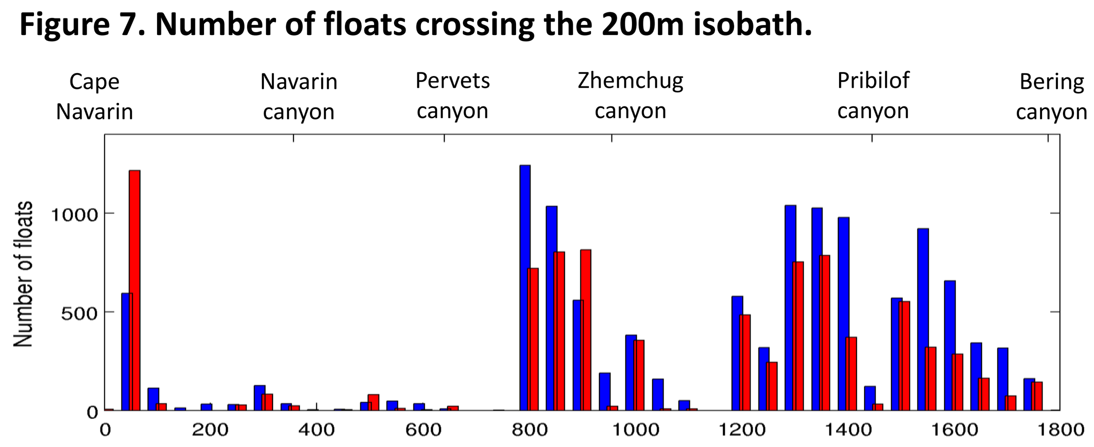



**Figure 6: Float trajectories and end locations on June 18th**

Floats released in the Alaskan stream as far east as Kodiak are transported to the Bering Sea shelf. More floats were transported onto the southern Bering shelf in 2002 than 2001 (Figure 6 a,b & Figure 7). Conversely, more floats were transported onto the northern Bering shelf in 2001 than 2002 (Figure 6 c,d & Figure 7).

**Figure 7. Number of floats crossing the 200m isobath.**




On-shelf transport was heterogeneous along the shelf break (Figure 7). Elevated transport occurs in the region of Bering and Pribilof canyons in the Southern Bering Sea, in the vicinity of Zhemchug canyon, and around Cape Navarin in the Northern Bering Sea.

**Figure 8: Percentage of floats found on southern Bering Sea shelf**

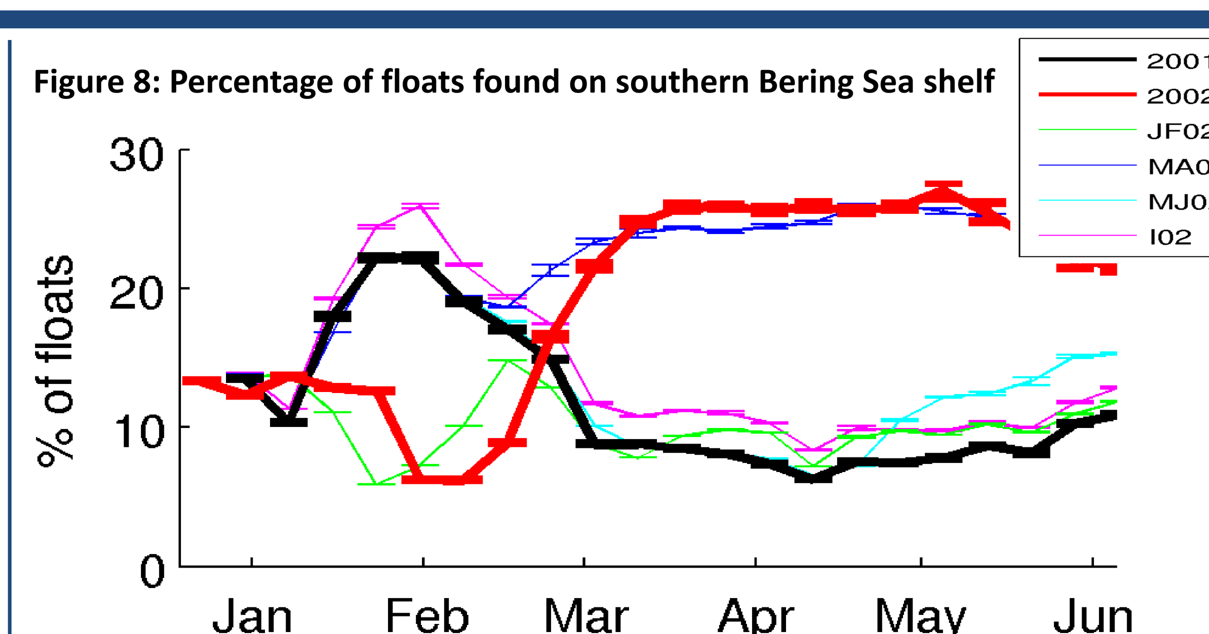
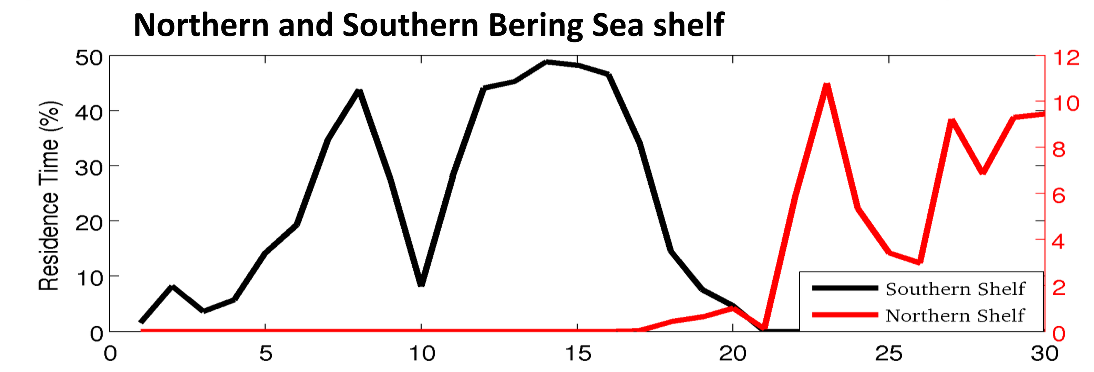



Figure 8 shows the elevated percentage of floats that were on the Southern Bering Sea shelf in 2002 relative to 2001 from March onwards. Replacing different two month periods of wind forcing in 2001 with the 2002 equivalent reveals the importance of south-easterly wind. In experiment JF02 the previously SE wind seen in January and February 2001 was replaced with the NW wind from 2002. This reduced the percentage of floats on the shelf during this time to 2002 levels. Replacing wind forcing from May-June (MJ02) or replacing 2001 initial conditions with 2002 initial conditions (I02) did not have a notable effect on float transport. Replacing 2001 March–April forcing (MA02), which was primarily north-westerly in 2001, with 2002 forcing for this period, which was primarily south-easterly, dramatically increased the percentage of floats transported onto the shelf.

**Figure 9. Percentage of time floats from different release sites spent on the Northern and Southern Bering Sea shelf**




Floats with the highest residence time on the northern shelf came from release sites north of the Pribilof Islands while floats with the highest residence time on the southern shelf came from either the Alaskan Stream or the Bering Sea shelf break south of the Pribilofs (Figure 9).

## SUMMARY

- Wind direction more critical than wind strength, temperature or runoff to on-shelf zooplankton transport
- No strong relationship between monthly average frontal strength and on-shelf transport was found.
- Short periods of south-easterly winds in March-April promotes on-shelf transport over much of shelf but reduces transport over the Northern end of the shelf break around Cape Naverin.
- Source areas for zooplankton found on shelf varied only little inter-annually.
- Most on-shelf transport occurs in the vicinity of sub-marine canyons traversing the shelf break, or around Cape Navarin in the Northern Bering Sea.
- Prevailing wind direction in March is a potential predictor for abundance of oceanic zooplankton on the shelf .

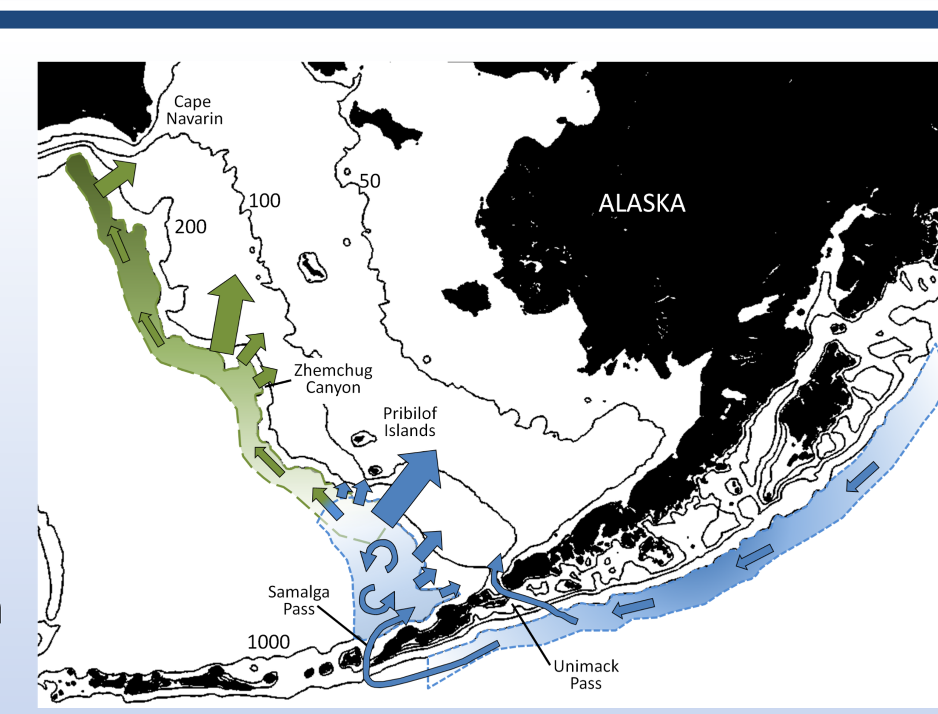



**Fig. 10. Main source areas and transport pathways for Oceanic zooplankton found on Bering Sea shelf.**

## AKNOWLEDGEMENTS

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