

# Assemblage structure and spatial distribution of groundfish in the northern Bering Sea in relation to environmental variation

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## Introduction

Evidence is accumulating that the Bering Sea is undergoing a northward biogeographical shift as a result of atmospheric and hydrographic forcing that may be climate-related. Climate change in the both Bering Sea and the regions of the Arctic have been dramatic, and one of the most obvious aspects has been the reduced extent and earlier melting of seasonal pack ice. The main question is weather and how the benthic fish community in the northern Bering Sea impact on the ecosystem in response to changes in water temperatures and sea ice coverage. The immediate goal is to predict groundfish distribution under scenarios of increasing bottom water temperatures in the Bering Sea.

## Methods and materials

**1. Sampling:** Groundfish samples were collected in spring 2006 and 2007 in the northern Bering Sea around St. Lawrence Island (SLI) (Figure 1).

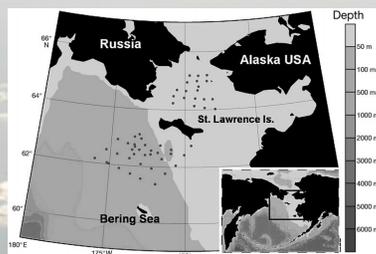


Figure 1. Study area in the northern Bering Sea and station locations in 2006 and 2007.

**2. Environmental data:** Fourteen environmental variables were measured at each trawl station: (1) depth (m), (2) bottom water temperature ( $^{\circ}\text{C}$ ), (3) bottom water salinity, (4) bottom water silica ( $\mu\text{mol l}^{-1}$ ), (5) bottom water nitrite and nitrate ( $\mu\text{mol l}^{-1}$ ), (6) bottom water phosphate ( $\mu\text{mol l}^{-1}$ ), (7) bottom water ammonium ( $\mu\text{mol l}^{-1}$ ), (8) bottom water chlorophyll *a* ( $\text{chl a}$ ,  $\text{mg m}^{-3}$ ), (9) integrated water column  $\text{chl a}$  ( $\text{mg m}^{-2}$ ), (10)  $\text{chl a}$  in surface sediments ( $\text{mg m}^{-2}$ ), (11) surface sediment grain size ( $\phi$ ), (12) total organic carbon of surface sediments (TOC, %), (13) total organic nitrogen of surface sediments (TON, %), and (14) surface sediments C/N (wt/wt).

3. Assemblage structure and bio-env linkage: Primer V6

## Results

### 1. Environmental conditions in two trawl survey stations

- Ice cover was lower in 2007 than in 2006 (Figure 2)
- Warmer bottom water occurred north of SLI (-0.4 to  $0.6^{\circ}\text{C}$ )
- Sediment grain size (indicator of current speed) was finer silt/clay south of SLI, coarser sandy in north of SLI.
- The timing of spring bloom is different in 2006 (pre-bloom condition) and 2007 (bloom condition).

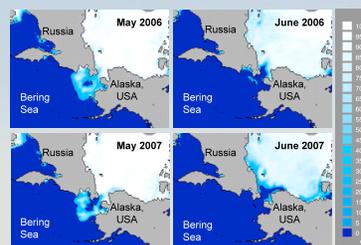


Figure 2. Sea ice concentration in May and June 2006 and 2007 (image edited from the Sea Ice Index; Fetterer et al. 2008).

### 2. Groundfish spatial distribution

- Arctic cod, Bering flounder, snailfish co-occurred mainly in southwest and at a few stations north of SLI  $\rightarrow$  South cluster (Figure 3).
- Arctic staghorn sculpin and Arctic alligatorfish dominated in north of SLI in 2006, and shorthorn sculpin in 2007  $\rightarrow$  North cluster (Figure 3).

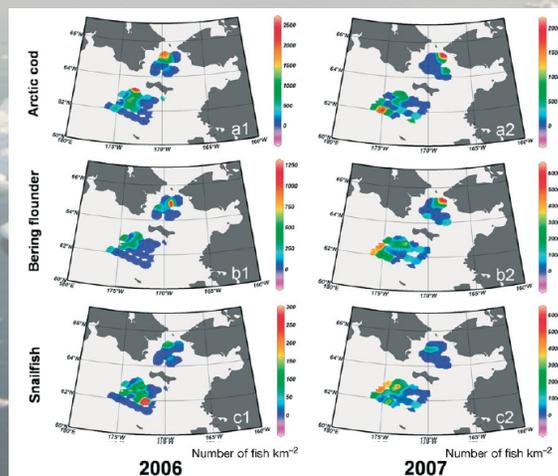


Figure 3. to be continued.

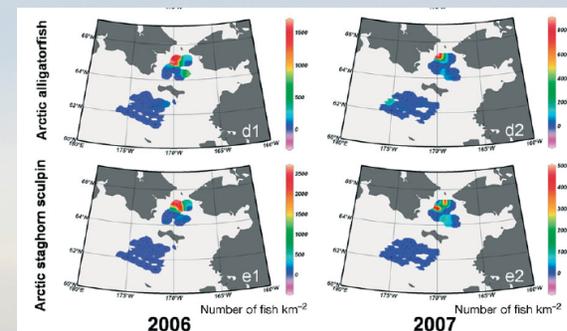


Figure 3. Spatial pattern of groundfish by abundance in 2006 and 2007

### 3. Relationship with environmental factors

- In 2006, bottom water nitrate + nitrite, bottom water  $\text{chl a}$  (or integrated water column  $\text{chl a}$ ), sediment grain size and sediment C/N were best correlated with fish distributions from BIO-ENV procedure ( $\rho = 0.46$  and  $0.45$ ).
- In 2007, bottom water temperature and sediment grain size were identified as the environmental variables that best explained fish distribution ( $\rho = 0.51$ ).

## Discussion

- Different habitats support different benthic fish assemblages.
- Sediment grain size had significant influence on groundfish distributions in this study.
- Nutrients had stronger relationships with fish distribution in 2006 (cold, pre-bloom conditions), whereas sediment grain size and bottom water temperature were more important in 2007 (warm, bloom conditions).

## References

- Fetterer F, Knowles K, Meier W, Savoie M (2008) Sea ice index. National Snow and Ice Data Center, Boulder, CO
- Cui X, Grebmeier JM, Cooper LW, Lovvorn JR, North CA, Seaver WL, Kolts JM (2009) Spatial distributions of groundfish in the northern Bering Sea in relation to environmental variation. *Mar Ecol Prog Ser* 393:147-160