Water mass variations in pelagic fish, jellyfish and zooplankton community composition in the N. Bering and S.E. Chukchi Seas

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Introduction

Distributions of juvenile pelagic fish, jellyfish and their prey in the northern Bering Sea (NBS) and Chukchi Sea are not well documented. Relationships between pelagic fish and water mass characteristics are also poorly understood. In September 2007, fisheries oceanography surveys were conducted in the NBS and SE Chukchi Seas. PRIMER statistical analysis was used to define water mass groups, compare community composition among water mass groups for fish, jellyfish and zooplankton and to determine environmental factors driving taxonomic variation. These background data are an important first step for assessing future climate change effects on pelagic ecosystem functioning in sub-Arctic and Arctic regions.

Methods

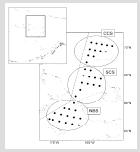


Fig 1. Stations sampled (dots) 4-17 Sept. 2007 by NOAA fisheries vessel, *R/V Oscar Dyson*. Bathymetry contours at 50m.

Latitudinal regions:
N. Bering Sea (NBS)
S. Chukchi Sea (SCS)
Central Chukchi Sea (CCS).

Data collection:
- Surface temperature (T), salinity (S), chlorophyll a (chla): (Thermosalinograph (TSG) SBE45 & SBE38 & Turner model 700 fluorometer)
- Vertical profiles of T & S (SBE 911 CTD)
- Surface nutrients (5 m discrete samples)
- Zooplankton vertical tows (Juday net, 168 µm mesh)
- Forage fish (primarily juveniles) and jellyfish (Surface rope net: Can trawl model 300, spread 60 m, depth 10 m, towed for 30 min at 3.5 to 5 knots).

Data analysis:
Statistical analysis were conducted with **PRIMER** (Plymouth Routines in Multivariate Ecological Research). **CLUSTER** analysis with **SIMPROF** (similarity profiles) tests were used to group normalized T & S data. We separately grouped surface data from the TSG (5 m), and water column data from CTD profiles (mean T and S over the water column). A larger number of water mass groups were defined, than with oceanographic characterization using T & S ranges (Weingartner 1997).

Surface groups (Fig 2):
- Alaska Coastal Water low salinity (ACW low S)
- Alaska Coastal Water high salinity (ACW high S)
- Bering Shelf Water (BSW)
- Anadyr Water (AW).

Water column groups (Fig 4):
- ACW low S
- ACW high S
- BSW and AW combined (BSAW)
- Transitional between ACW and BSW (TW).

Species composition within each water mass group were compared (Fig 3, 5). Water column groups were used for zooplankton biomass, and surface groups used for fish abundance & jellyfish biomass. All taxa data were square root (sqrt) transformed prior to analysis.

ANOSIM (analysis of similarity routine) was used to determine if community composition was significantly different between water mass groups (Table 1).

BEST analysis used to determine environmental factors (e.g. T, S, density, chla, nutrients, lat, long, station depth) that best explain community composition of zooplankton and jellyfish biomass and fish abundance.

Mean water column data

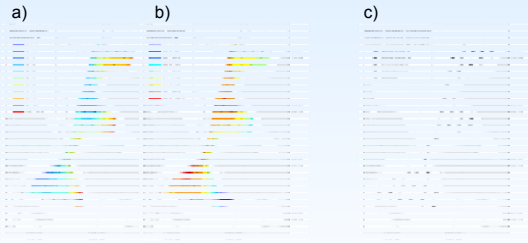
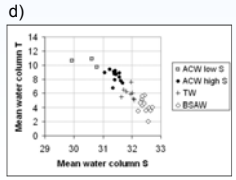


Fig 2. Plots of mean water column a) temperature (°C), and b) salinity from CTD, c) water mass groupings from CLUSTER routine in PRIMER, and d) TS.



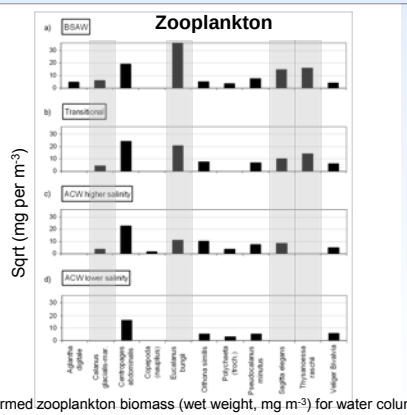


Fig. 3. Sqrt transformed zooplankton biomass (wet weight, mg m^{-3}) for water column groups a) BSAW, b) transitional, c) ACW high S and d) ACW low S.

- **Large zooplankton taxa (large copepods, chaetognaths and euphausiids), shown by shading, had highest biomass in BSAW and lowest was in ACW low S.**
- **Small zooplankton more evenly distributed across water masses.**

Table 1. Zooplankton, jellyfish and fish community composition differences between water mass groups (ANOSIM, R values shown). Significant diff. ($p < 0.05$) in **red**.

Water column group		Zooplankton
ACW low S	ACW high S	0.185
ACW low S	TW	0.212
ACW low S	BSAW	**0.739**
ACW high S	TW	0.021
ACW high S	BSAW	**0.336**
TW	BSAW	0.024

Surface group		Jellyfish	Fish
ACW low S	ACW high S	**0.188**	**0.343**
ACW low S	BSW	**0.581**	**0.569**
ACW low S	AW	1	0.901
ACW high S	BSW	**0.267**	0.046
ACW high S	AW	0.878	0.323
BSW	AW	0.022	0.584

- **Largest differences between: ACW low S and BSAW (zooplankton), ACW low S and BSW (jellyfish & fish).**
- **Differences between ACW low S & high S for fish and jellyfish communities.**

Surface data

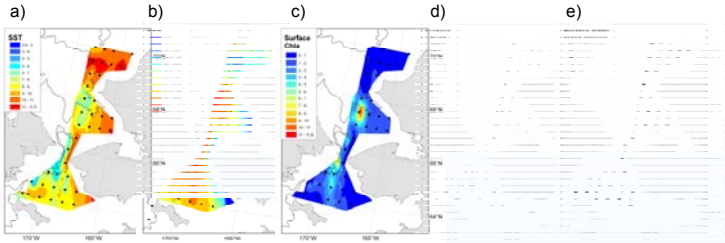
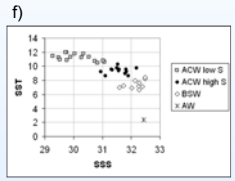
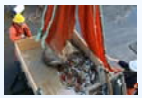


Fig 4. Plots of surface a) temperature (SST, °C), b) salinity (SSS) and c) chla from TSG, d) nitrate, e) water mass groupings from CLUSTER routine in PRIMER, and f) TS.





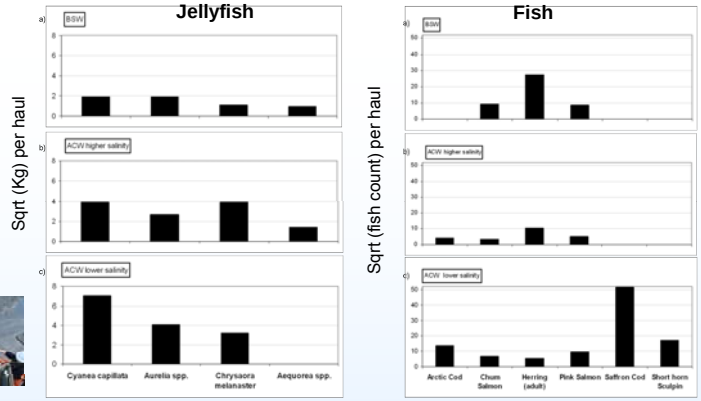


Fig. 5. Sqrt transformed jellyfish biomass (kg per haul), left panel, and sqrt transformed fish abundance (# per haul), right panel, for surface groups a) BSW, b) ACW high S, and c) ACW low S. Juvenile fish except for herring.

- **Jellyfish: In ACW low S, dominated by *C. capillata*, followed by *Aurelia* spp. and *C. melanaster*. In ACW high S and BSW, taxa more evenly distributed.**
- **Forage fish: In ACW low S, high counts of small fish (saffron cod, short-horn sculpin and Arctic cod) and moderate counts of large fish (chum & pink salmon and adult herring). In BSW, high counts of adult herring, moderate counts of pink and chum salmon. No cod or sculpins in ACW high S or BSW.**

Fig. 6. Abundance of a) saffron cod, b) Arctic cod, c) short horn sculpin, d) adult herring, e) chum salmon, and f) pink salmon. Juvenile fish except for herring.

Results and Conclusions

- **As expected, greatest differences in community composition were seen between ACW low S and BSAW/ BSW (Table 1). Fish and jellyfish community composition also varied between ACW low S & ACW high S indicating that separation of ACW into two water mass groups is biologically important.**
- **Juvenile saffron cod (*Eleginus gracilis*), Arctic cod (*Boreogadus saida*) and short-horn sculpins (*Myoxocephalus scorpius*) were most abundant in the central Chukchi Sea in ACW low S, characterized by high T, low chla, low nutrients, and small zooplankton taxa (Fig 2-6). In contrast, adult herring (*Clupea pallasii*) had high abundances in the N. Bering and S. Chukchi Seas in BSW, characterized by lower T, high chla, high nutrients and larger zooplankton taxa. Juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon had high abundances in the central Chukchi Sea in ACW and in Bering Strait in ACW and BSW, with variations possibly due to stock origination.**
- **Community composition was related to environmental factors, with highest correlations found for mean water column salinity, surface nitrate, and latitude for zooplankton, jellyfish, and fish, respectively, with 0.33, 0.62, and 0.62 rank correlations (ρ). For fish, a moderate correlation ($\rho = 0.33$) was also seen for surface T alone.**
- **Variations in water mass coverage due to a changing climate could significantly alter zooplankton, jellyfish and fish distributions in the N. Bering and S.E. Chukchi Seas.**

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