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Demersal and larval fish assemblages in the Chukchi Sea

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ABSTRACT

A multidisciplinary research cruise was conducted in the Chukchi Sea in summer 2004 during which we investigated assemblages of small demersal fishes and ichthyoplankton and the water masses associated with these assemblages. This study establishes a baseline of 30 demersal fish and 25 ichthyoplankton taxa in US and Russian waters of the Chukchi Sea. Presence/absence of small demersal fish clustered into four assemblages: Coastal Fishes, Western Chukchi Fishes, South Central Chukchi Fishes, and North Central Chukchi Fishes. Habitats occupied by small demersal fishes were characterized by sediment type, bottom salinity, and bottom temperature. Abundance of ichthyoplankton grouped into three assemblages with geographical extent similar to that of the bottom assemblages, except that there was a single assemblage for Central Chukchi Fishes. Water-column temperature and salinity characterized ichthyoplankton habitats. Three water masses, Alaska Coastal Water, Bering Sea Water, and Winter Water, were identified from both bottom and depth-averaged water-column temperature and salinity. A fourth water mass, Resident Chukchi Water, was identified only in the bottom water. The water mass and habitat characteristics with which demersal and larval fish assemblages were associated create a baseline to measure anticipated effects of climate change that are expected to be most severe at high latitudes. Monitoring fish assemblages could be a tool for assessing the effects of climate change. Climate-induced changes in distributions of species would result in a restructuring of fish assemblages in the Chukchi Sea.

1. Introduction

There is significant evidence that the Arctic climate is warming extremely rapidly and the impacts of that warming will cause significant changes throughout the ecosystem (ACIA, 2004). Surface air temperatures were as much as 3 °C warmer in 2000–2005 than previously noted in the northern Bering and Chukchi Seas (Grebmeier et al., 2006), which is the focal area of RUSALCA (Russian American Long-term Census of the Arctic) and the source of this study. With Arctic warming, the northern Bering Sea is shifting from a shallow, ice-dominated system in which bottom-dwelling fishes prevail to one more dominated by pelagic fishes (Grebmeier et al., 2006).

Little is known about the changes occurring in the Chukchi Sea ecosystem. Interannual variability in the current structure of the Chukchi Sea has been documented (Weingartner et al., 1999), but specific long-term changes in hydrography have not been recorded. This lack does not mean such changes do not exist, but rather that there has not been a regular monitoring of this ecosystem. Even less information is available about fishes than about the physical structure in the Chukchi Sea Because of the paucity of information about fishes, the North Pacific Fishery Management Council has adopted a precautionary approach and has made the eastern Chukchi Sea unavailable for commercial fisheries (NPFMC, 2008). This establishes a clear need for baseline information for fishes in the Chukchi Sea.

The Chukchi Sea consists of distinct water masses that are connected to the Bering Sea by northward water transport through Bering Strait (Fig. 1; Weingartner, 1997). The Alaska Coastal Current flows rapidly northward along the east side of the Bering Strait and is recognizable as the mass of warm, dilute Alaska Coastal Water (ACW) along the east side of the Chukchi Sea and north into the Arctic Ocean. Bering Sea Water (BSW), composed of a mixture of Bering Shelf and Anadyr Waters, flows along the central and western Bering Strait to the north. Resident Chukchi Water (RCW) is found offshore in the northern Chukchi Sea and is separated from ACW by a semi-permanent front that extends from surface to bottom at ~70–71°N (Weingartner, 1997). Winter Water (Pickart et al., 2005, 2010) is a subsurface mass of very cold and salty water in western Herald Canyon that remains from the preceding winter (Coachman et al., 1975). Some the hydrographic features observed in the Chukchi Sea are permanent while others are transient; all are expected to have significant biological implications (Weingartner et al., 1999) and to be important determinants of fish and plankton distributions.

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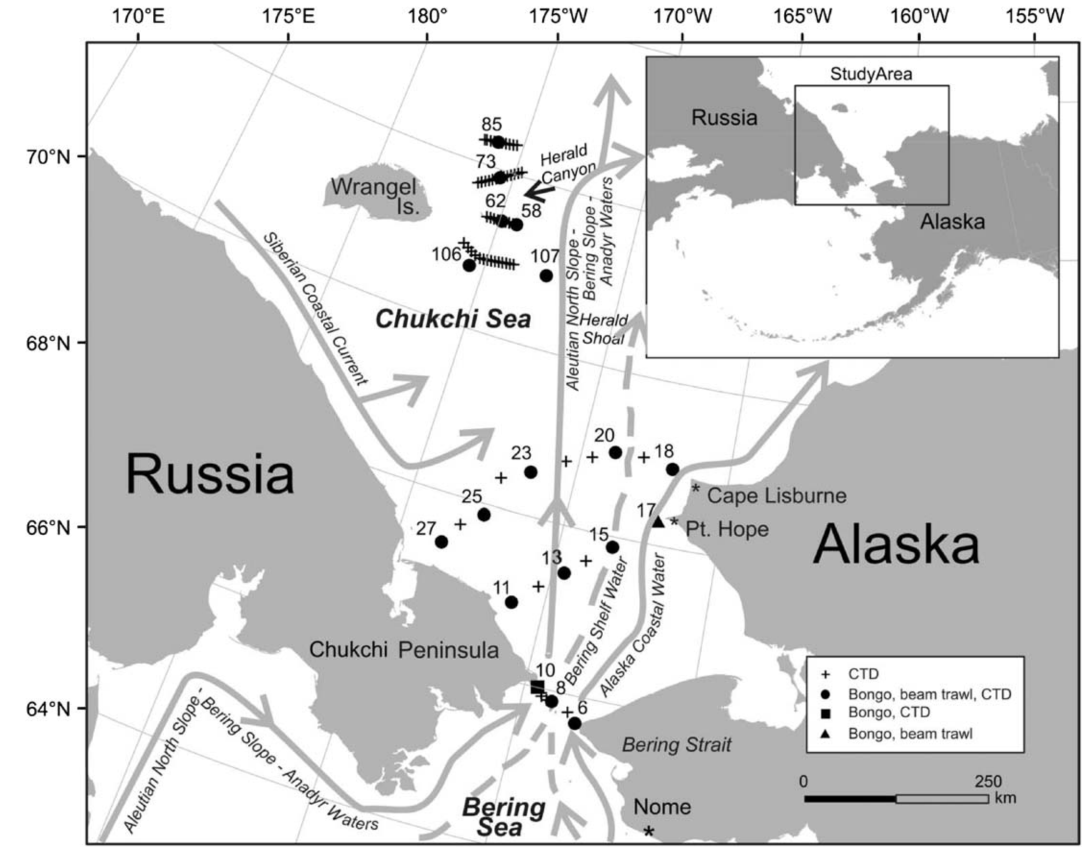

Fig. 1. Stations sampled August 2004. Symbols indicate type of gear deployed. Numbers indicate stations at which fish were collected. Arrows represent generalized flow of currents from the Bering Sea and in the Chukchi Sea (after Coachman et al., 1975, Weingartner et al., 1999, 2005).

Fish assemblages are composed of fishes with similar temporal or spatial distributions (Cowan et al., 1993) that possess one or more common characteristics. A stable fish assemblage is composed of the same taxa in the same proportions across time, though the geographic distribution of the assemblage might change (Fossheim et al., 2006). In addition to taxa that are abundant, species that are absent or not abundant also contribute in a notable way to the fish assemblage. Demersal fish assemblages are usually governed by temperature (Genner et al., 2004), depth (e.g., Mueter and Norcross, 2002), or a combination of these two factors, perhaps incorporating another variable such as substrate (e.g., Mueter and Norcross, 1999; Barber et al., 1997; Tissot et al., 2007). Ichthyoplankton assemblages are related to bathymetry (Duffy-Anderson et al., 2006), local topography, prevailing current patterns (Doyle et al., 2002), and water masses (Norcross et al., 2003, Quattrini et al., 2005).

This study specifically addresses assemblages of small demersal and larval fishes in the Chukchi Sea. Our focus is to detect water mass and habitat characteristics with which fish assemblages are associated. The findings documented here will provide a much-needed baseline of the distribution of small demersal and larval fishes in the Chukchi Sea and establish a means for future comparison in light of a changing climate.

2. Methods

2.1. Field collections and laboratory analyses

We collected physical oceanographic data, small demersal fishes, and ichthyoplankton 10–22 August 2004 aboard the R/V *Professor Khromov*. The cruise was an interdisciplinary investigation of the regional physical, biological, and chemical oceanography conducted by the RUSALCA Program in the Bering Strait and Chukchi Sea. Three transects were sampled in the southern Chukchi Sea between the Chukchi Peninsula of eastern Russia and Alaska at the Bering Strait, Point Hope, and Cape Lisburne (Fig. 1). Four transects were occupied across Herald Canyon in the northern Chukchi Sea to the east of Wrangel Island. Bottom depth and standard GPS positions were recorded. A SeaBird model SBE911+CTD profiler collected salinity, temperature, depth, turbidity, fluorescence, and oxygen data at 68 stations (Pickart, 2006; Pickart et al., 2010). No CTD data were collected at station 17. Small demersal fishes were collected at 17 stations using a beam trawl (Fig. 1). Ichthyoplankton was collected using a bongo net at the 17 bottom trawl stations plus station 10, which was not suitable for bottom trawling due to the presence of boulders. At 14 bottom trawl stations, a Van Veen grab was used to collect substrate; grain size was later analyzed and classified by type of sediment (J. Grebmeier, Univ. Maryland, pers. comm.). The presence of mud, sand, gravel, shell or rock in trawl contents was used to classify the substrate of the three bottom trawl stations at which no grab was taken.

Small fishes were collected from the sea floor with a plumb staff beam trawl with a 7 mm net mesh and 4 mm codend liner (Gunderson and Ellis, 1986). We modified the net by seizing a lead-filled line to the footrope for better bottom contact and using a 3.05 m beam to hold the net open; the effective fishing swath was 2.26 m, i.e. 74% of beam length. Fishing scope was approximately 3.5:1, and vessel speed was approximately 1.5 knots. At some sites the net was damaged or the catch was so large that it filled the net beyond the codend. Because these difficulties prevented us from calculating an accurate CPUE for every collection, bottom trawl analyses were conducted on presence/absence rather than