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Johanna Linders
Robert S. Pickart
Göran Björk
G.W. Kent Moore

On the Nature and Origin of Water Masses in Herald Canyon, Chukchi Sea

Introduction

Pacific water flowing northward through Bering Strait brings a unique signature of temperature, salinity, and nutrients to the Arctic Ocean. After crosssing the wide and shallow Chukchi Sea (average depth of 50 m), the western branch of the Pacific water extends through Herald Canyon (Fig.1a).

Measurements in Herald Canyon are relatively sparse compared to the eastern part of the Chukchi shelf. As such, fundamental questions exist regarding the role of the canyon in influencing the outflow of Pacific-origin water to the Canada Basin. What is the nature and origin of the water masses in Herald Canyon, and do processes in and near the canyon promote water mass transformation? Or, is the canyon mainly an advective pathway through which water from Bering Strait transits relatively unchanged to the open ocean?

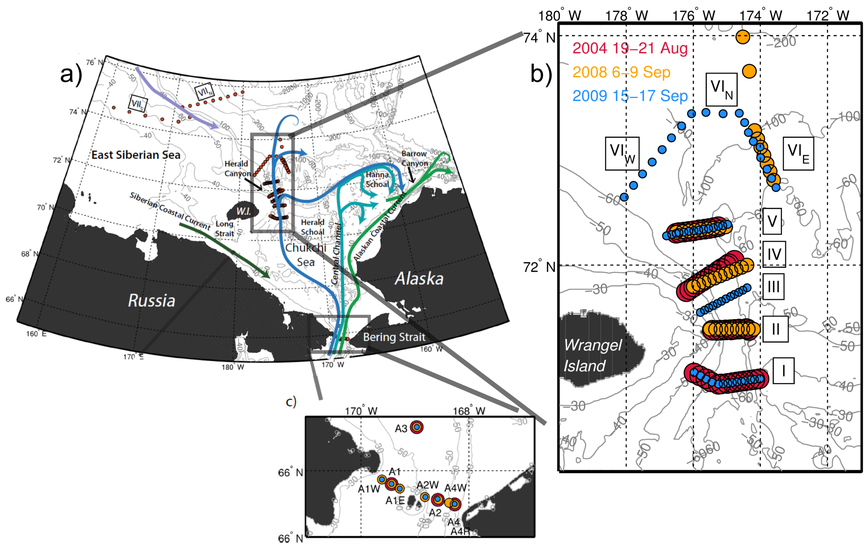

Fig.1(a) Map of the Chukchi Sea, including the Herald Canyon hydrographic sections and Bering Strait mooring array. Also shown is the western section VII (2008), situated on the outer-shelf / upper-slope of the East Siberian Sea. A schematic depiction of the circulation of the region is overlain (from Pickart et al., 2015). (b) Detailed map of the Herald Canyon region showing the hydrographic sections used in the study. (c) Detailed map of Bering Strait showing the additional mooring locations, color-coded as in (b).

As part of the Russian-American Long Term Census of the Arctic (RUSALCA) program and the International Siberian Shelf Study 2008 (ISSS-08), three summertime shipboard surveys of Herald Canyon were carried out during the first decade of the 2000s (Fig.1b). Herald Canyon has a length of approximately 160 km and the advective time for a water parcel to transit the canyon is around 5-6 days for the fastest flow.

Observations

The hydrographic observations inside Herald Canyon show a similar pattern between the years for most sections at depths below 25 m, especially in the eastern parts of the channel. At this time of year there is warm, less saline summer water on the eastern side, associated with strong northward velocities. Both newly ventilated and remnant winter waters were found in the canyon, but with lesser amounts in each survey. The predominant summer water was Bering Summer water, although, surprisingly, some Alaskan Coastal water resided in the canyon in the two later years (Fig.2 and Fig.3).

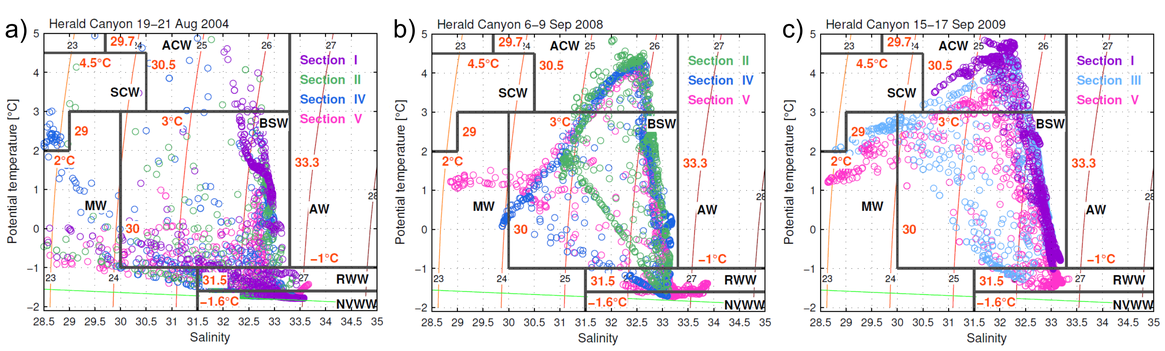

Fig.2 T-S diagram for Herald Canyon, color-coded by sections, including water mass definitions. ACW = Alaskan coastal water; BSW = Bering summer water; RWW = remnant Pacific winter water; NVWW = newly ventilated Pacific winter water; SCW = Siberian coastal water; MW = melt water; AW = Atlantic water. (a) Data from 2004, (b) data from 2008 and (c) data from 2009.

Conclusions

1. A large amount of Bering Summer water in the western channel of Bering Strait follows a relatively direct route into Herald Canyon during the summer months, with an estimated advective speed of 10-20 cm/s. (Fig.4). A mooring is thus needed in the western strait to monitor the full input to the Chukchi Sea.
2. The winter water observed in 2004 was consistent with a western Bering Strait source (with a slower advective speed of 5-8 cm/s). The dense water in the canyon during 2008 and 2009 was more in line with a northern source. This is consistent with section VII (2008) to the west of the canyon mouth.
3. Large-scale wind patterns and polynya activity on the shelf were also investigated. It was found that the former appears to impact more strongly the presence of dense water in Herald Canyon (figures not shown).

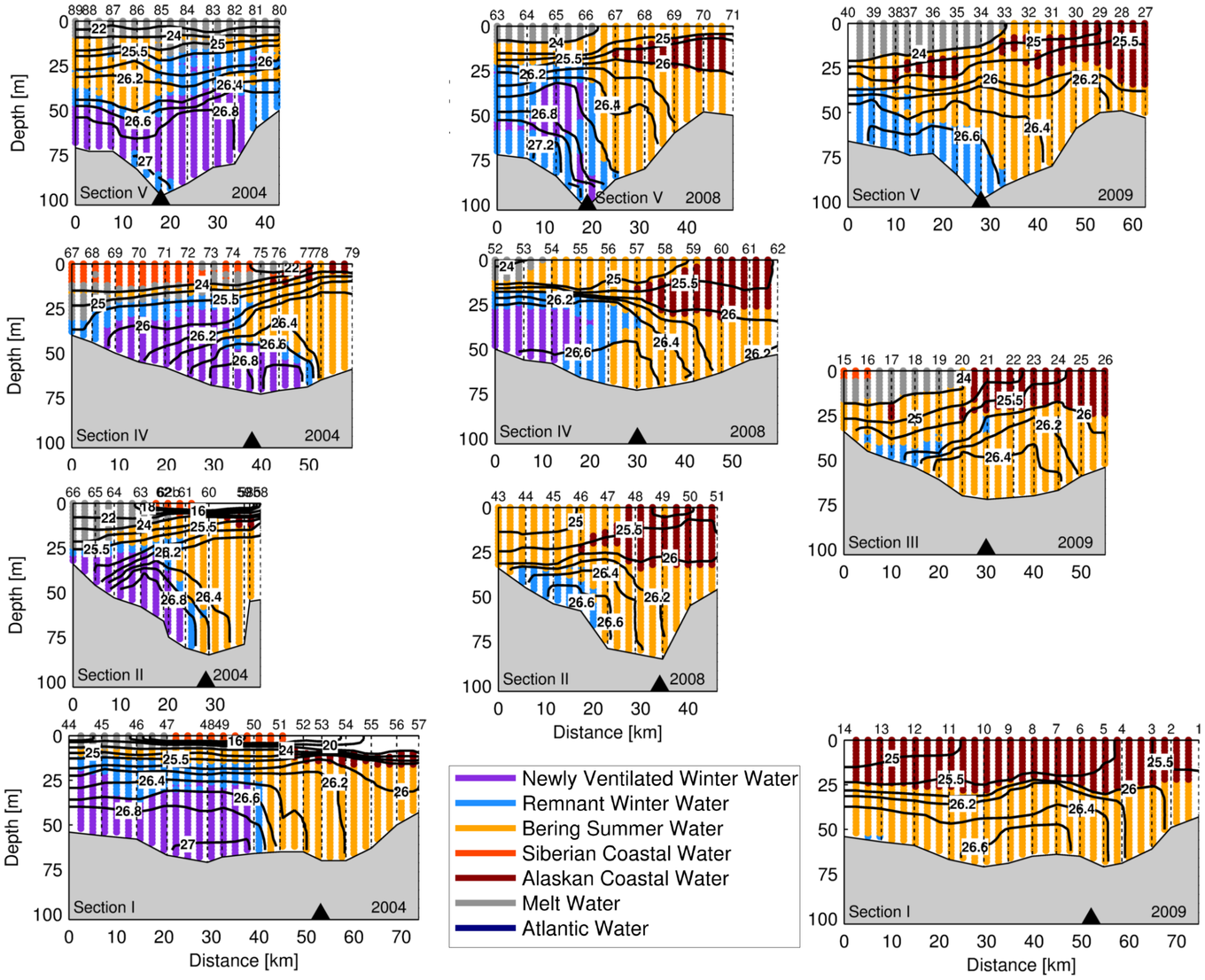

Fig.3 Vertical sections of the water masses in Herald Canyon, where each water mass is denoted by a different color (see the legend). Overlain on the sections is the potential density (contours, kgm-3). See Figure 2 for the definitions of the water masses. Each column is a different year.

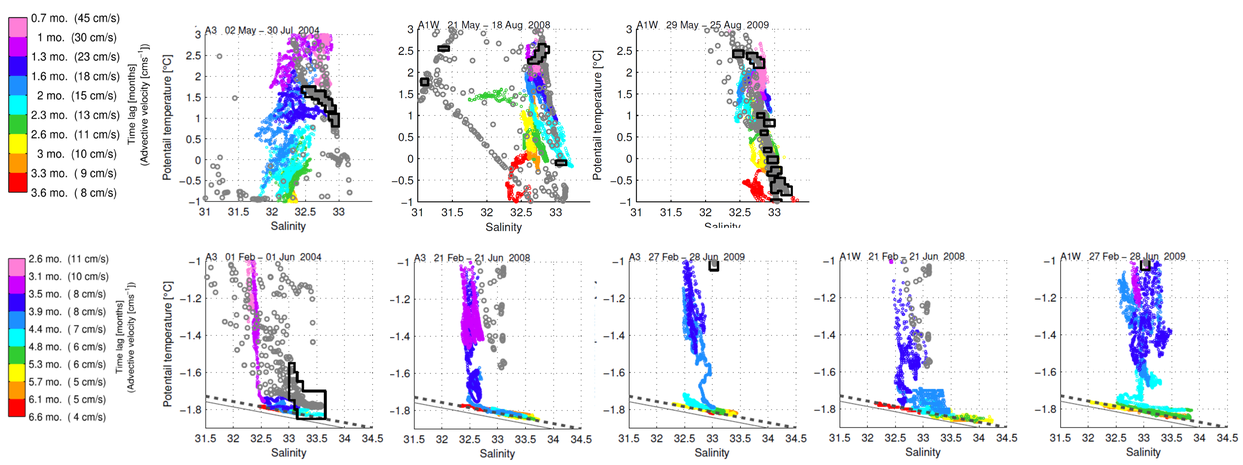

Fig.4 Comparison of the T-S properties of water measured by moorings in Bering Strait versus that measured at the head of Herald Canyon during the shipboard surveys in 2004, 2008 and 2009. The mooring data are color-coded by the time lag between the date of observation in Bering Strait and the date of the occupation of the Herald Canyon section for the given year. The light grey circles are the shipboard data, and the black polygons delimit the water mass modes for each occupation (i.e. T-S classes with higher volumes of water).