USCGC Healy Cruise HLY09-04:
Circulation, Cross-shelf Exchange, Sea Ice, and Marine Mammal Habitat on the Alaskan Beaufort Sea Shelf

Robert S. Pickart (WHOI)

Cruise HLY09-04 of the USCGC *Healy* took place from 23 July–6 August, 2009 in the western Beaufort Sea. Three related projects were carried out under the direction of R. Pickart (WHOI), H. Simmons (UAF), and K. Stafford (UW). The first project, funded by the National Ocean Partnership Program (NOPP#1), aims to determine the fate of river water entering the Beaufort shelf and to understand how the shelf circulation, stratification, and marine mammal habitat respond to storms in the presence of the pack-ice and land-fast ice. The second project, entitled Ice-Covered Ocean Response to Atmospheric Storms (ICORTAS) aims to understand the generation of internal waves by ocean storms. The third project, also funded by the National Ocean Partnership Program (NOPP#2) aims to identify and document the occurrence, frequency, and persistence of wind-driven shelf-slope exchange events during the summer and early fall, and the associated impacts on bowhead whales. These three projects are closely related geographically and in scientific scope, hence it made sense to carry out components of the respective field programs on the same cruise. The objectives of the cruise were (1) to recover the oceanographic and whale hydrophone moorings for NOPP#2; (2) to recover and turn around the mid-shelf/upper-slope oceanographic and whale hydrophone moorings for NOPP#1; (3) to recover the ICORTAS moorings on the outer slope; (4) to occupy conductivity/temperature/depth (CTD) sections across the shelfbreak boundary current; (5) to deploy the Arctic Observing Network (AON) boundary current mooring at 152°W; and (6) deploy a meteorological buoy for atmospheric scientists at the International Arctic Research Center. All objectives were successfully completed (although a few of the whale hydrophone moorings were not recovered due to release problems).

Brief Synopsis

The science party embarked the *Healy* in Barrow, AK on 23 July, and science operations began several hours later. The study domain is shown in Fig 1, extending from Barrow Canyon to approximately 149°W near the mouth of the Colville River. During the cruise we generally worked from west to east, deploying moorings during the day and occupying CTD sections in the evening. After a few days we returned to Barrow to embark the Chief of Naval Research and the Oceanographer of the Navy for an overnight visit. The two admirals were briefed on high latitude topics of interest to the Office of Naval Research (ONR) as well as scientific operations aboard the *Healy*. The admirals also observed the recovery of one of the NOPP #1 moorings. After the ONR visit, the remainder of the mooring work was finished and the CTD survey was completed. Near the end of the cruise a meteorological buoy was deployed near the site of the AON mooring in the western Arctic boundary current. The science party dis-embarked the ship shortly thereafter on 6 August. Fig 1 shows the locations of the 9 CTD sections occupied across the boundary current and Barrow Canyon (the section across the head of the canyon was occupied twice). The site of

the AON mooring is shown by the blue square. This is the fifth deployment of the mooring (including last year during NOPP#1). The location of the meteorological buoy is indicated by the black open square. The buoy was successfully recovered on 14 September on the next leg of the *Healy*, providing a 6-week timeseries of meteorological conditions during the summertime open water period. The AON mooring collected oceanographic data during this time, which will provide a unique opportunity to investigate the atmosphere-ocean coupling in the Alaskan Beaufort Sea.

Some Preliminary Results

The CTD survey of the western Arctic boundary current carried out on HLY09-04 is the first such synoptic snapshot of the Pacific Water component of the current along the Alaskan Beaufort Sea. Fig 2 shows the vertical sections of potential temperature (color, °C) overlain by potential density (contours, kgm^{-3}). The sections are presented from west (Barrow Canyon) to east (approximately 149°W). Section 9 was a repeat of section 4 at the head of the canyon (the latter occupation (section 9) extended farther onshore and offshore). The CTD section to the west of Barrow Canyon (section 8) is not shown in Fig 2.

The survey revealed a remarkably varying hydrographic structure of the boundary current over the 300 km distance sampled. During the course of a given year there are generally three types of Pacific Water that are advected by the boundary current: Alaskan Coastal Water (typically between 0°C and 7°C), Chukchi Summer Water (typically between -1°C and 1°C), and Pacific Winter Water (typically between -1.8°C and -1.6°C). These different water masses appear seasonally, with some occasional overlap. However, the survey conducted on this cruise indicates that all three water masses can be found within a short segment of the boundary current, with very abrupt transitions between the different states. As seen in the figure, Chukchi Summer Water dominated the boundary current in the eastern part of the domain (lines 6 and 7), while the cold and dense Pacific Winter Water was found farther upstream, from 154.8°W (line 3) into Barrow Canyon. Finally, during the re-occupation of the section at the head of Barrow Canyon (line 9), Alaskan Coastal Water was present on the eastern side of the canyon. This complex interplay of water masses (and the concomitant changes in dynamical structure of the flow) indicates that the current is even more variable than previously thought. It is important to sort out the various factors at work in contributing to this variability, and what the ramifications are for issues like shelf-basin exchange and ventilation of the interior basin. The present data set provides valuable information towards a more thorough investigation of such issues.

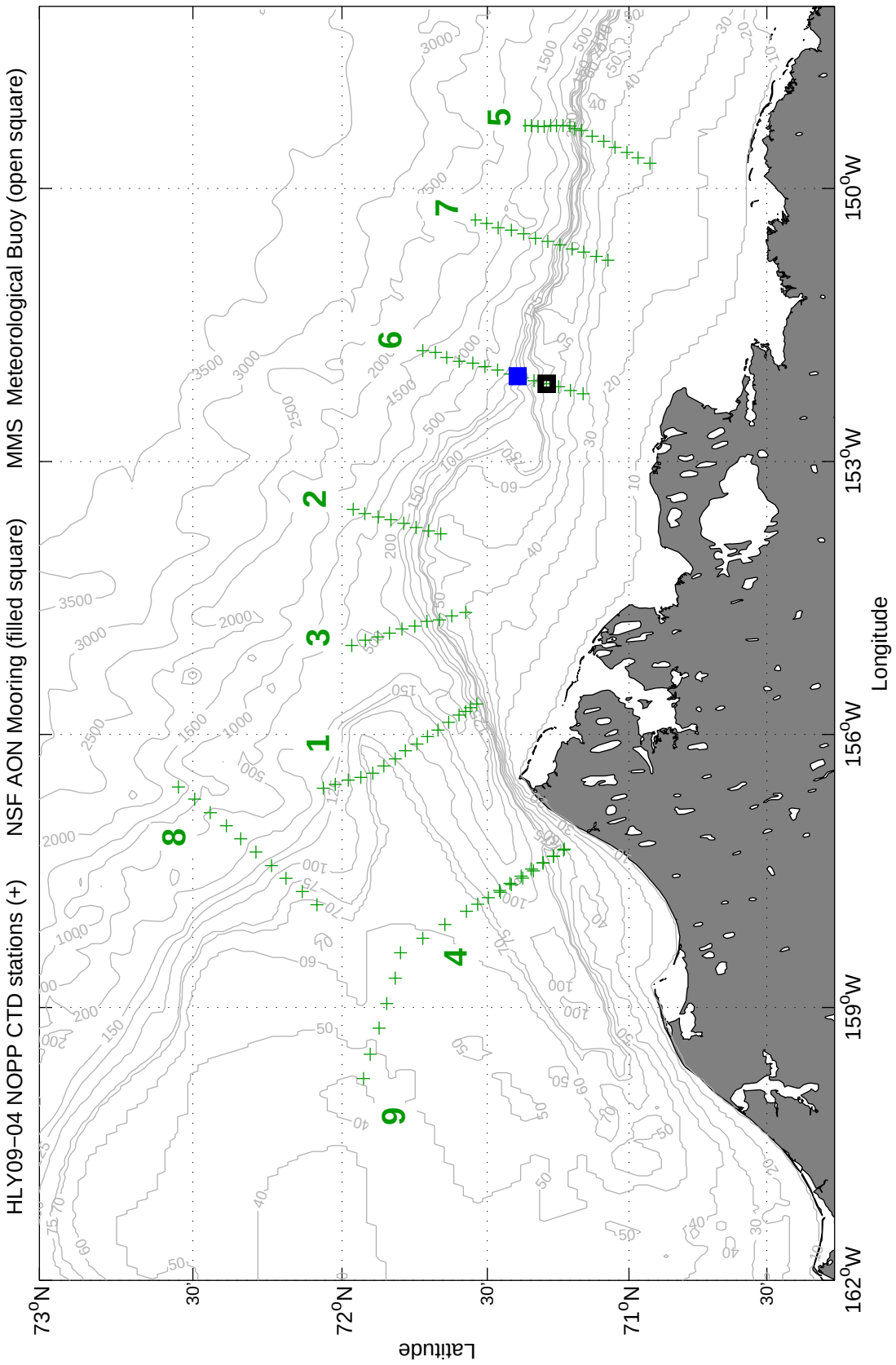

Figure 1: Locations of the CTD sections occupied during HLY09-04 (green +'s). The filled blue square denotes the AON mooring, and the open black square shows the meteorological buoy. The bathymetry is from IBCAO version 2.

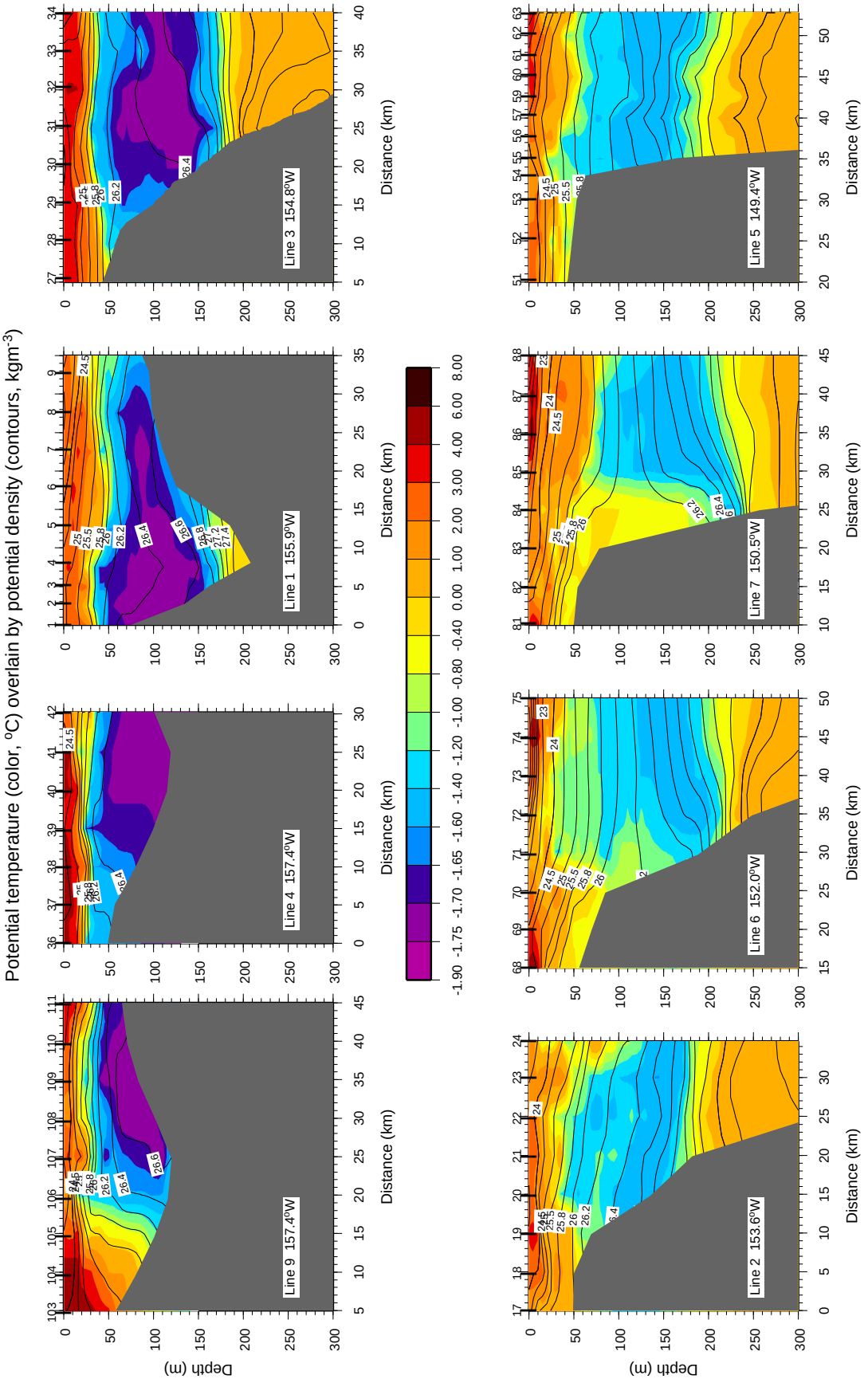

Figure 2: CTD sections occupied during HLY09-04. Station numbers are marked along the top axis. The viewer is looking to the west. 4