USCGC Healy Cruise HLY08-04: Circulation, Cross-shelf Exchange, Sea Ice, and Marine Mammal Habitat on the Alaskan Beaufort Sea Shelf

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Cruise HLY08-04 of the USCGC *Healy* took place from 7-13 August, 2008 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 deploy the oceanographic and whale hydrophone moorings for NOPP#2; (2) to deploy the mid-shelf/upper-slope oceanographic and whale hydrophone moorings for NOPP#1; (3) to deploy the ICORTAS moorings on the outer slope; and (4) to occupy several conductivity/temperature/depth (CTD) sections across the shelfbreak boundary current. Due in part to the exceptionally good weather on the cruise and the hard work of the *Healy* crew and science party, we successfully completed all of our objectives.

Brief Synopsis

The science party embarked the *Healy* in Barrow, AK on 7 August, 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 stations in the evening (several whale hydrophone moorings from a different experiment were recovered as well). Because of the complexity of the tall moorings in the eastern part of the domain, and the uncertainty of the International Bathymetric Chart of the Arctic Ocean (IBCAO) in a portion of the region, bathymetric surveying was necessary before beginning the mooring operations. Bottom mapping was also carried out using *Healy's* Seabeam in order to fill in some of the gaps in the composite multi-beam data set of the western Arctic. After the eastern moorings were deployed, the ship steamed to the west and carried out a few additional mooring evolutions, including a whale hydrophone recovery that was aborted earlier because of ice cover. The final whale hydrophone mooring was deployed 20 nm northeast of Barrow on the return trip, and the science party dis-embarked the ship shortly thereafter on 13 August.

Fig 1 shows the locations and types of moorings deployed during the cruise. In total, 9 oceanographic moorings (cyan, blue, and green squares) and 9 whale hydrophone moorings (magenta triangles) were deployed (two of the whale hydrophones were part of the oceanographic moorings). One sees that, among the three programs, 4 oceanographic moorings were deployed near the shelfbreak providing good alongstream coverage of the shelfbreak current over roughly 200 km. Similar broad coverage is provided by the whale hydrophone moorings, with the addition of two sets of triads that will allow estimates of source levels of whale calls and an index of the numbers of animals calling at any one time. The composite mooring array near 149°W, representing a combination of NOPP#1 and ICORTAS, extends from the 13 m isobath to the deep continental slope. This provides unprecedented coverage of an Arctic shelf and slope, extending from the land-fast ice zone to the pack-ice offshore. Finally, four CTD sections were occupied during the cruise across the shelfbreak and slope, two of them along the eastern mooring line.

Some Preliminary Results

Two of the other observational components of NOPP#1 occurred at the same time as HLY08-04. The three inshore moorings of the eastern array (black squares in Fig 1) were deployed by the R/V *Annika Marie* just before the *Healy* arrived at the site (T. Weingartner, UAF). Immediately following this, high resolution hydrographic/velocity mapping was carried out in the vicinity of the inshore moorings using a Remote Environmental Monitoring Unit (REMUS), deployed from the *Annika Marie* (A. Plueddemann, WHOI). Fortuitously, with the *Healy* working offshore and the REMUS sampling onshore, a composite synoptic hydrographic/velocity section was occupied on 12 August from the inner shelf to the deep slope along the mooring line. Note that such an extended section would be impossible to carry out from a single platform, hence this snapshot is unique.

Fig 2 shows the shallow part of the composite potential temperature section (color) overlaid by salinity (contours). (There is a small gap because the REMUS experienced battery problems limiting its offshore range.) There are numerous interesting features in the section. For example, note the two bands of very warm water ($> 4°$C) in the upper 10 m, one near the shelfbreak and one on the inner shelf. The inshore band of water is likely riverine in origin, and appears to be embedded in an alongstream flow with significant thermal wind shear. The warm offshore water is likely part of the shelfbreak jet, which is advecting warm water ($> 3°$C) throughout the top 40 m. This current is the eastward extension of the Alaska Coastal Current, and the seaward lens of warm water centered near 35 m depth (stations 37-38) is likely an eddy pinching off of the current. Of interest is the strong stratification on the inner shelf, and the presence of a "cold pool" on the mid-shelf near the bottom. It is likely that this cold water originated from offshore and was transferred onto the shelf during a wind event. Such shelf-basin exchange processes are one of the topics of NOPP#1. Included in Fig 2 are the mooring locations and regions of sampling (thick dashed lines) of the eastern array line. Obviously the moorings won't capture all of the detail seen in the hydrographic section, but the spacing of instruments will provide a quantitative description of the hydrographic and velocity structure of the shelf and slope, while the whale hydrophones will provide concurrent information on the marine mammals. This will allow us to address many aspects of this fascinating system over an annual cycle, including how the system responds to the seasonal presence of land-fast ice and pack-ice.

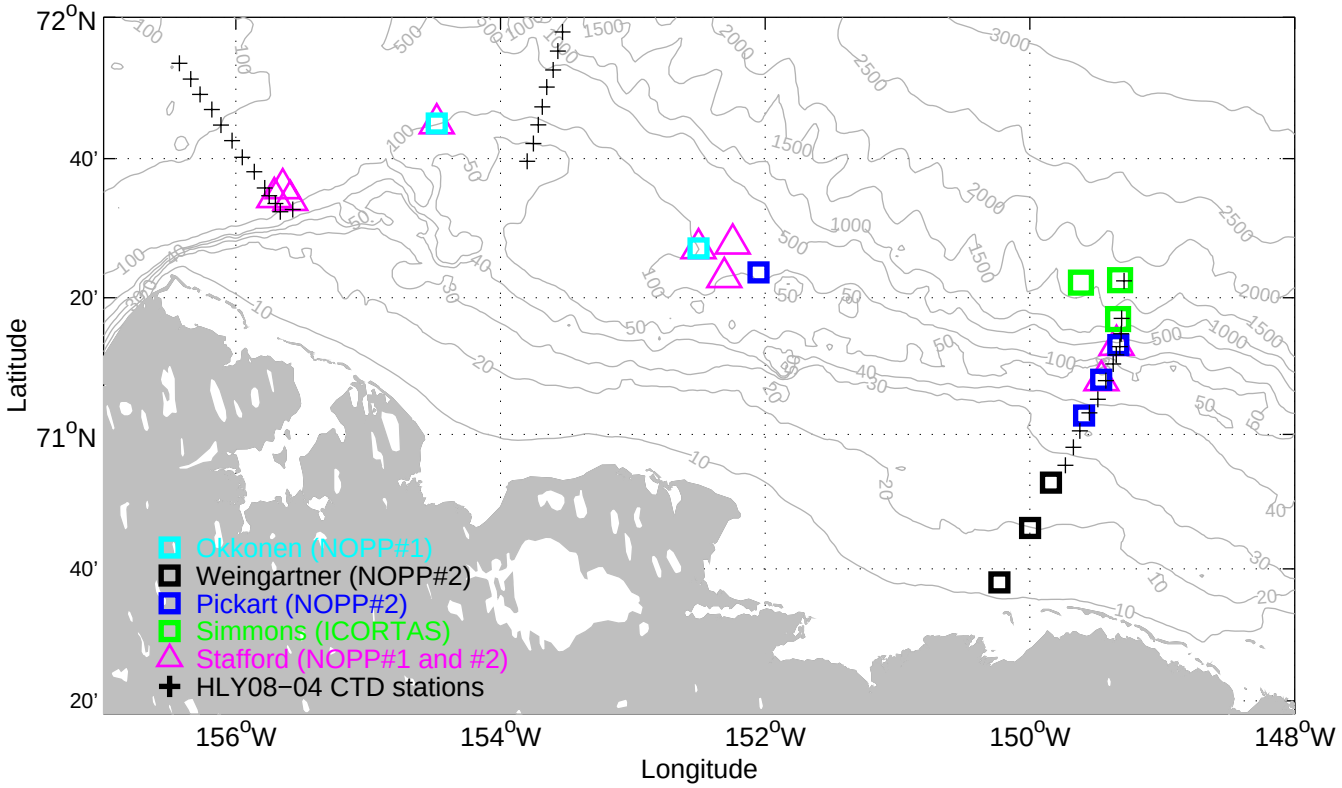

Figure 1: Mooring deployments and CTD sections occupied during HLY08-04. The squares denote oceanographic moorings, and the triangles are whale hydrophone moorings. Crosses denote the CTD stations. The bathymetry is from IBCAO version 2.

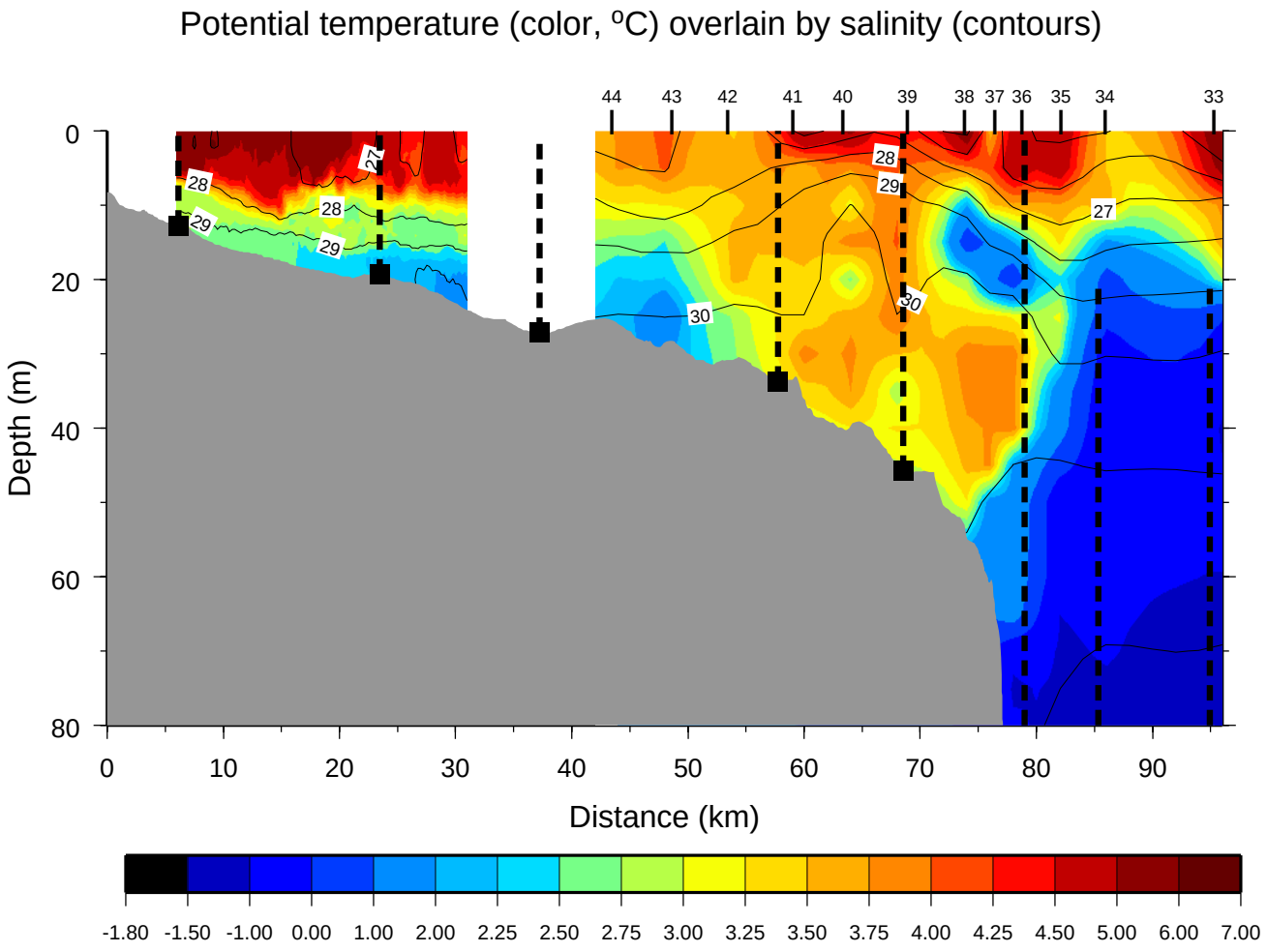

Figure 2: Shallow portion of the composite section of potential temperature (color) overlain by salinity (contours) occupied on 12 August, 2008. The inshore part of the section (5-30 km) was occupied by REMUS (horizontal spacing of measurements approximately 150 m), and the offshore part occupied by *Healy* (CTD station spacing marked along the top). The mooring locations are denoted by the black squares and thick dashed lines. The inner three moorings measure velocity throughout the water column and temperature/salinity at the base of the mooring; the middle three moorings measure temperature/salinity/velocity throughout the water column, with whale hydrophones situated next to the latter two; the outer two moorings (at these shallow depths) measure temperature to 20 m and velocity to the near-surface.