Mean Hydrographic Structure of the Beaufort Shelf and Slope

Robert S. Pickart

Woods Hole Oceanographic Institution, Woods Hole MA 02543

1. MOTIVATION

The interior Canada Basin is populated by large numbers of relatively small diameter eddies (e.g. Manley and Hunkins, 1985), which undoubtedly play an important role in the ventilation of the Arctic halocline (Figure 1). While it is unclear precisely where and how the eddies are formed, one thing is certain---the eddies originate from the boundary. Hence it is of high interest to investigate the circulation and water mass properties along the boundary of the Canada Basin, which in turn will shed light on possible mechanisms for eddy formation.

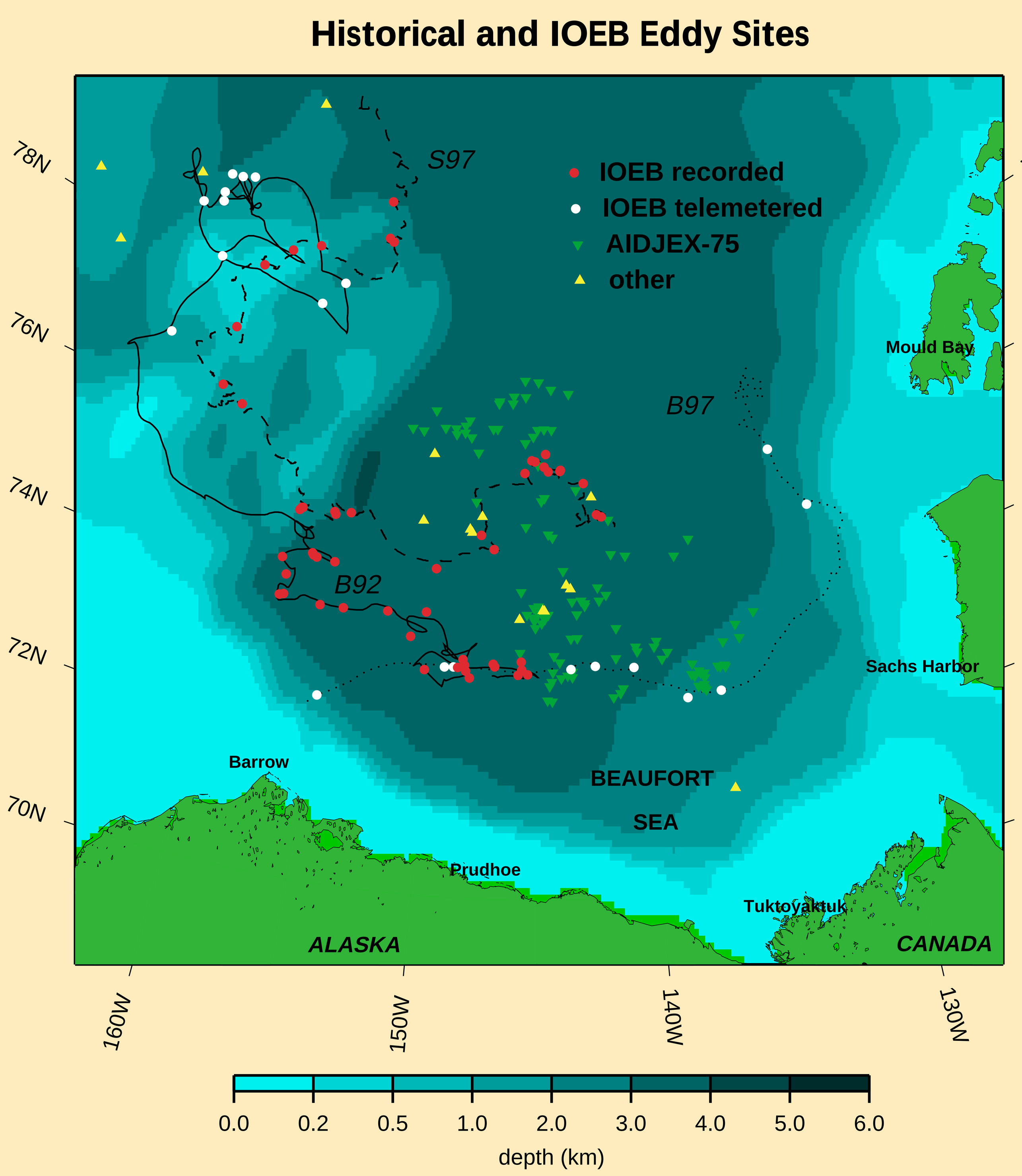

Figure 1: Historical observations of Arctic Eddies in the interior Canada Basin (from Plueddemann et al., 1999).

2. SETTING

Of particular significance is the region east of Point Barrow, along the boundary of the Beaufort Sea (Figure 2). Pacific-origin water exiting the Chukchi Sea at Barrow Canyon is constrained dynamically to "turn the corner" and flow eastwards as a boundary current (Chapman, personal communication). Hence the major question is, does such a flow exist? And if so, is the basic structure of this current conducive for baroclinic instability and hence eddy formation?

3. DATABASE

Historical hydrographic data, spanning the period 1951--1987, have been compiled in the region of the Beaufort shelf and slope (Figure 2). The majority of the data were collected in summer and fall. The data set is a mix of both bottle and CTD data, obtained from the National Oceanographic Data Center (U.S.), the Marine Environmental Data Service (Canada), and other sources (e.g. HYDROBASE). The maximum depth of significant data coverage is 1500m, which includes the Atlantic layer.

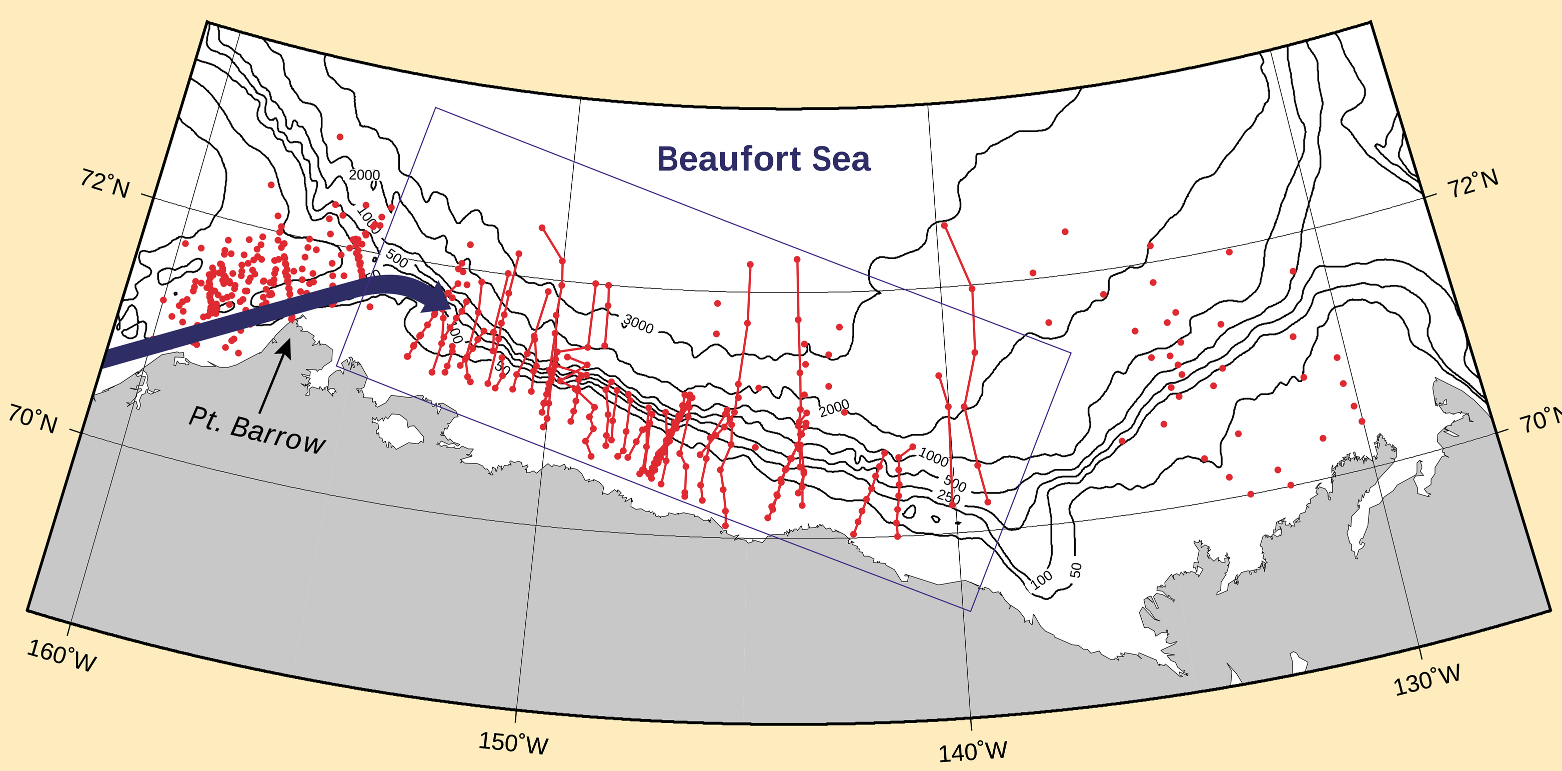

Figure 2: Available hydrographic data in the vicinity of Barrow Canyon and the Beaufort continental shelf and slope. The domain of interest is denoted by the blue box. The schematic arrow represents water exiting the Chukchi Sea.

4. APPROACH

The methodology employed is as follows. First, all synoptic hydrographic sections were identified and extracted from the historical database---there are 42 such sections (Figure 2). Next, using the IBCAO bathymetric data set, an average cross-stream bottom profile was constructed for the region. Each section was then mapped onto this average bathymetric coordinate system, and objectively interpolated onto a uniform grid (Figure 3). Finally, the interpolated synoptic sections were combined to form mean sections of various hydrographic variables. Standard deviation fields were also produced.

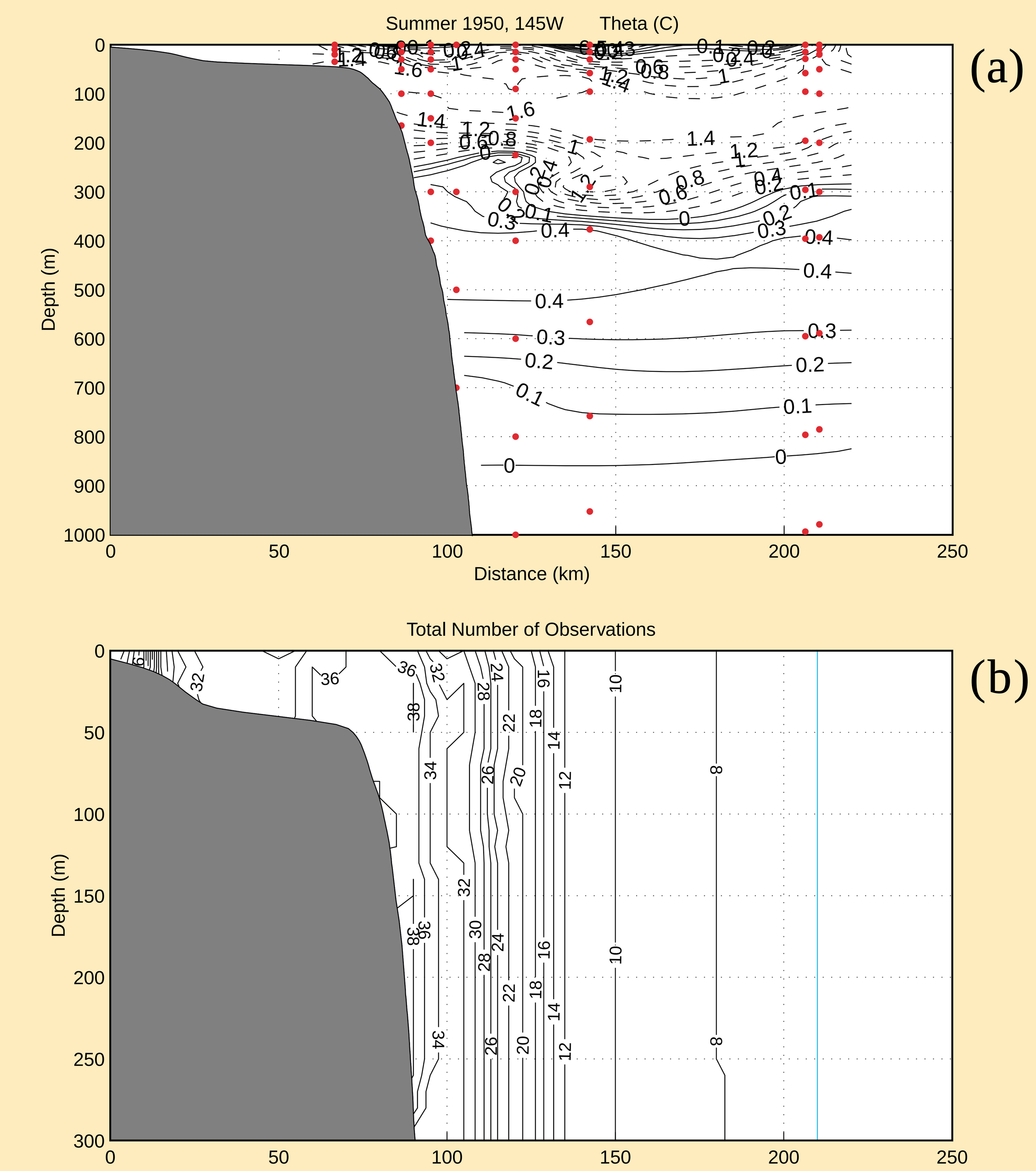

Figure 3: (a) Example of a single interpolated potential temperature section. (b) Total number of hydrographic observations.

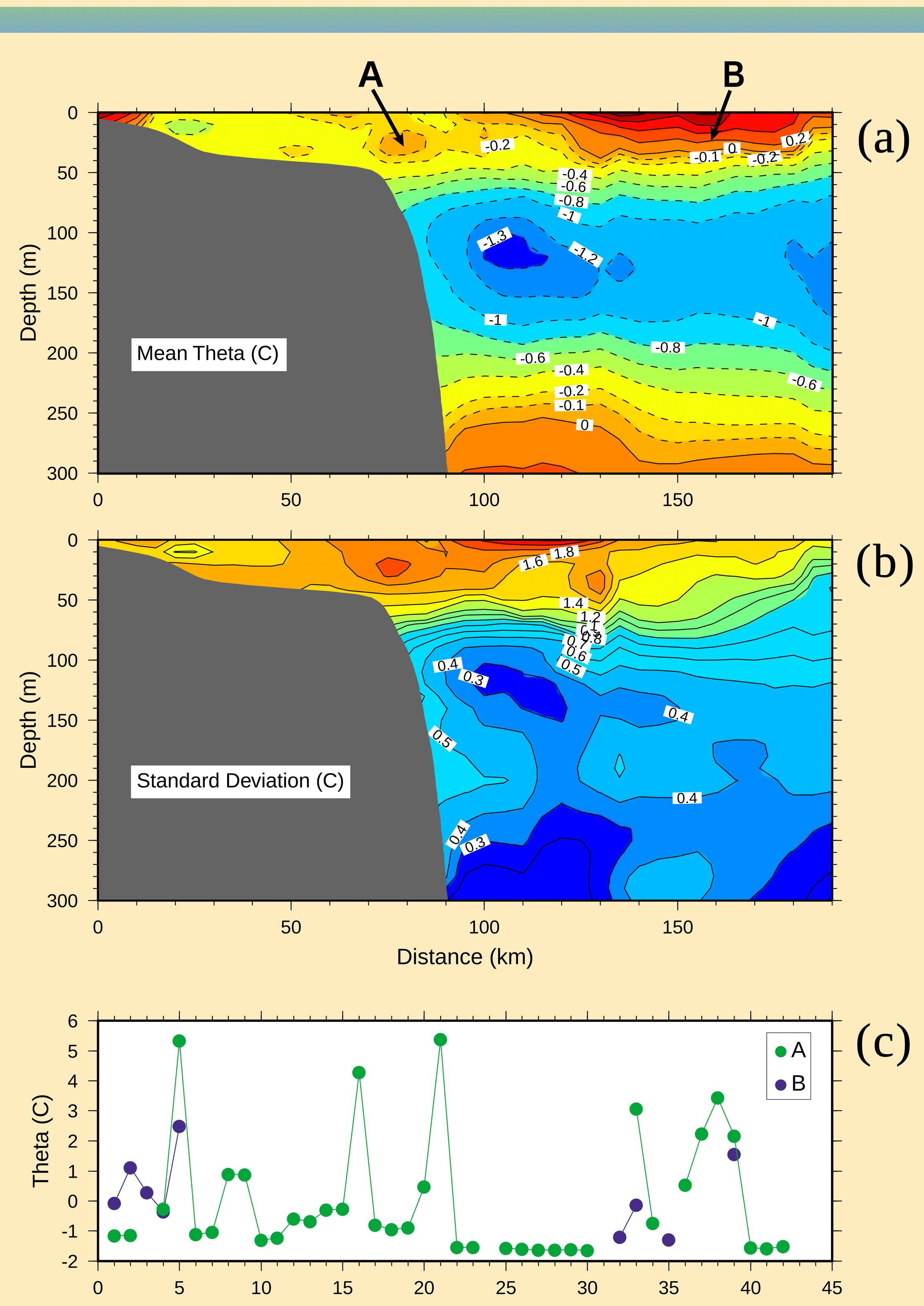

Figure 4: Vertical sections of (a) Mean Potential Temperature, and (b) Temperature standard deviation. (c) Individual temperature measurements at the two locations marked A and B in (a).

5. RESULTS

The composite hydrographic sections reveal the unique nature of the Beaufort shelfbreak.

Potential Temperature: In the upper layer there are two distinct temperature extrema: a narrow core of warm water at the shelfbreak, and a broader area of warmer water further offshore (these are labeled A and B respectively in Figure 4a). Interestingly, the inshore signal has a much higher standard deviation (Figure 4b). Clearly, warm Bering Strait Summer Water is present intermittently at the shelfbreak (Figure 4c). By contrast, the cold subsurface water mass just seaward of the upper slope is more stationary (Figure 4a, b).

Salinity and Potential Density: The salinity (and hence density) gradients imply a mean baroclinic jet situated against the upper slope (Figure 5a). The sense of the shear implies maximum baroclinic eastward flow near 150m depth. Interestingly, the strongest flow is inshore of the coldest water at these depths (Figure 5b), where instead there is enhanced temperature variance (Figure 4b).

Buoyancy Frequency: The cold halocline is characterized by a plateau in buoyancy frequency (N) between 80-200m depth (Figure 5c). Note the tongue of low N which emanates from the upper slope and extends into the interior near 100m.

6. OPEN QUESTIONS AND FUTURE WORK

This simple analysis has raised various intriguing questions that will be addressed in the future using these data. For example, what is the nature of the baroclinic boundary jet, and how does it fit with Aagaard's (1984) concept of a deep-reaching Beaufort undercurrent? What is the source of the offshore layer of warm water? What processes lead to the observed distribution of buoyancy frequency? (e.g. are bottom boundary layer dynamics involved?) To help address such questions, historical current meter data from the region will be compiled and analyzed in conjunction with the hydrography.

REFERENCES:

Aagaard, K., 1984: The Beaufort Undercurrent. The Alaskan Beaufort Sea: Ecosystems and environments, Academic Press, 47-71.

Manley, T.O. and K. Hunkins, 1985: Mesoscale eddies of the arctic ocean. Journal of Geophysical Research, 90, 4911-4930.

Plueddemann, A., R. Krishfield and C. Edwards, 1999: Eddies in the Beaufort Gyre, Ocean-Atmosphere-Ice Interactions (OAII) All Hands Meeting, 20-22 October, 1999, Virginia Beach, VA.

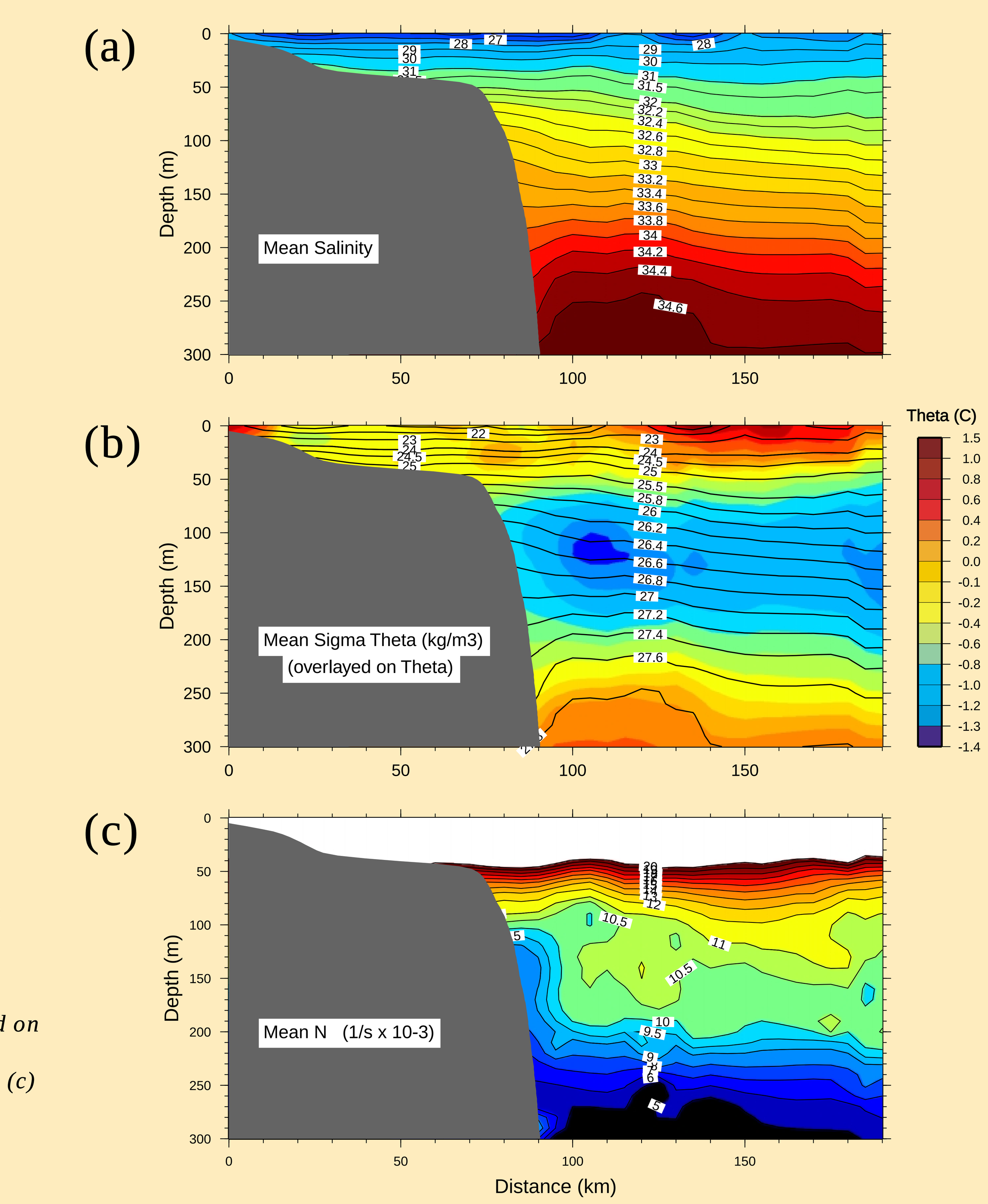

Figure 5: Vertical Sections of (a) Mean Salinity; (b) Mean Potential Density referenced to 0db (contours) overlayed on the mean potential temperature (color); (c) Mean Buoyancy Frequency.