Volume and Freshwater Transports from the North Pacific to the Bering Sea

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The southeastern Bering Sea circulation is dominated by the eastward Alaskan North Slope Current (ANSC) north of the Aleutians and the northwardward Bering Slope Current (BSC) flowing along the eastern Bering Sea shelf break. Cross-shelf exchange from the BSC supplies freshwater to the eastern Bering Sea shelf and ultimately to Bering Strait and the Arctic. Because the Aleutian passes (primarily Amakua Pass) supply the ANSC and the BSC, it is important to quantify the transport of mass and freshwater through the passes and to examine variability in these transports.

Four moorings, spanning the width of Amakua Pass, have been deployed since 2001. Data from these moorings allow qualitative assessment of the transports through this important pass. In addition, transports through some of the other passes can also be evaluated, although with more limited datasets and higher uncertainty. Variability in transports through the passes is related to the direction of the zonal winds, with westward winds resulting in higher northward transport. Freshwater transport through Amakua Pass alone is large enough to account for the cross-shelf supply of freshwater needed to supply the estimated transport through Bering Strait into the Arctic. Estimates for the remainder of the eastern Aleutian passes show a decrease in mass transport and a freshening of bottom water in Amakua Pass in 2008. Ongoing measurements in the Aleutian Passes are critical to understanding the influence of these waters on the Bering Sea and the Arctic.

INTRODUCTION

The freshwater flux through Bering Strait has been estimated at 2500 km³ yr⁻¹ (Woodgate and Aagaard, 2005) relative to a reference salinity of 34.8. Aagaard et al. (2006) estimate a freshwater budget for the Bering Sea shelf that includes freshwater inflow through Unimak Pass of ~1200 km³ yr⁻¹, cross-shelf supply of freshwater to the shelf of ~1000 km³ yr⁻¹ (precipitation – evaporation of ~80 km³ yr⁻¹), and runoff of ~320 km³ yr⁻¹ (Aagaard et al., 2006; see their Fig. 2). These numbers sum to balance the flux through Bering Strait.

Because the Aleutian passes supply freshwater to the ANSC and ultimately the BSC, it is important to quantify the transport of volume and freshwater through the passes and to examine variability in these transports. The focus here is on quantifying the volume and freshwater transports through the central Aleutian Passes. Due to the relative wealth of data in Amakua Pass, a case study of volume and freshwater flux in that pass will set the stage for the influence of seasonality and stratification. Estimates for the remainder of the eastern Aleutians are also discussed.

Maximum freshwater transport occurs in January with the minimum occurring in October. Most of the transport occurs on the eastern side of the pass, with AMAP freshwater transport accounting for 74% of the northward component. Roughly two thirds of the northward freshwater transport occurs in the upper 200m of the water column. This shallow layer provides the source water for on-shelf freshwater transport to the Bering Sea shelf.

Unfortunately, we do not have sufficient data to examine the seasonal cycle of transport or salinity in any other Aleutian passes. Freshwater transport is estimated for the major eastern and central Aleutian passes from volume transports estimates from the literature (Woodgate et al., 2005; Reed, 1995; Stabeno et al., 2002) and average salinity estimates (Ladd et al., 2005). This section provides a summary of the freshwater transport across the passes.

CONCLUSIONS

The BSC supplies water to the eastern Bering Sea shelf. Mass balances suggest that cross-shelf exchange must supply ~0.5 Sv to the shelf from the BSC (Aagaard et al., 2006). As the source of the shallow part of the BSC flow through Amakua Pass is the ultimate source of this cross-shelf exchange. This cross-shelf exchange also provides a source of freshwater to the shelf and ultimately to flow through Bering Strait. The freshwater flux through Bering Strait has been estimated at 2500 km³ yr⁻¹ (Woodgate and Aagaard, 2005) relative to a reference salinity of 34.8. Aagaard et al. (2006) estimate a freshwater budget for the Bering Sea shelf that includes cross-shelf supply of freshwater to the shelf of ~1000 km³ yr⁻¹. We estimate the supply of freshwater through the eastern central Aleutian passes of ~1100 km³ yr⁻¹, more than ten times the amount needed to supply the eastern Bering Sea shelf. Freshwater transports through Amakua Pass account for roughly half (~500 km³ yr⁻¹) of the total flux through the pass. Interannual variability may result in fluctuations on the order of 25%. Because the supply of freshwater from the North Pacific is so much higher than the cross-shelf exchange required to balance the freshwater budget, the flux through Bering Strait is probably not sensitive to changes in freshwater flux through the Aleutian Passes. Instead, it is probably more sensitive to the dynamics of cross-shelf exchange (eddies, upwelling/downwelling winds, strength of BSC).