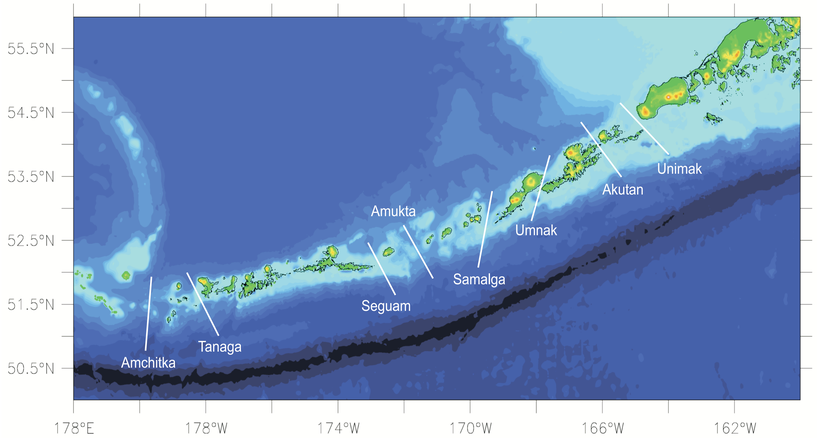
Physical Oceanography of the Eastern Aleutian Passes

Carol Ladd[1], George Hunt, Jr.[3], Calvin Mordy[1], Ron Reed[2], Sigrid Salo[2], Phyllis Stabeno[2]

[1]Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, WA
[2]Pacific Marine Environmental Laboratory, NOAA, Seattle, WA
[3]Department of Ecology and Evolutionary Biology, University of California, Irvine, CA



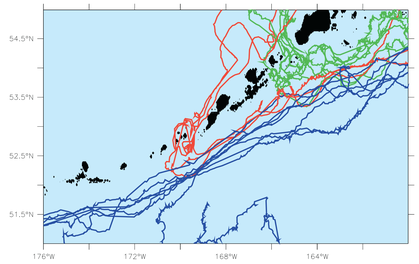
Map of the eastern Aleutian Islands. The location of the passes sampled during the 2001 and 2002 hydrographic cruises are noted.

ABSTRACT

Two research cruises (June 2001 and May-June 2002) were undertaken in the eastern Aleutian Islands on the R/V Alpha Helix. These cruises constituted an integrated multidisciplinary examination of the environment in the habitat of the endangered western population of the Steller sea lion (*Eumetopias jubatus*).

During June 2001, 116 CTD casts were taken in and around the eastern Aleutian passes. Nutrient and fluorescence data were also collected. Four along-pass sections (Unimak, Akutan, Amukta, and Seguam Passes) and two across-pass sections (Seguam and Amukta) detailed the water properties and geostrophic transport within the passes.

Properties of the surface waters during both 2001 and 2002 illustrate dramatic spatial variability in the region. Surface waters in the North Pacific tend to be warmer and fresher than surface waters on the Bering Sea side of the Aleutian Islands. In addition, water properties are highly variable within each ocean basin from east to west along the Aleutian chain. In the North Pacific, surface waters tended to be significantly warmer and fresher east of Samalga Pass than to the west in both years. Surface nutrient concentrations also exhibited substantial differences with low nutrient concentrations (NO_3, PO_4, and SiO_4) east of Samalga Pass and higher concentrations west of Samalga Pass. These data suggest that Samalga Pass may have been the western limit of the Alaska Coastal Current during the summers of 2001 and 2002.



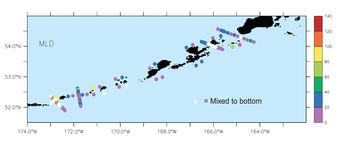
Drifter trajectories for drifters that crossed 160ºW in 2001. Drifter trajectories illustrate the tendency for Gulf of Alaska water to flow into the Bering Sea through either Unimak Pass (green) or Samalga Pass (red) but rarely through any of the other eastern passes. All of the blue drifter trajectories eventually turn south into the North Pacific – usually around 180º near Amchitka Pass. The trajectories are related to on/off-shelf position at 160ºW with drifters in shallowest water flowing through Unimak Pass, drifters in deeper water but still on the shelf flowing through Samalga, and drifters at the shelf break continuing along the shelf-break and eventually turning south around 180º.

2001 Cruise

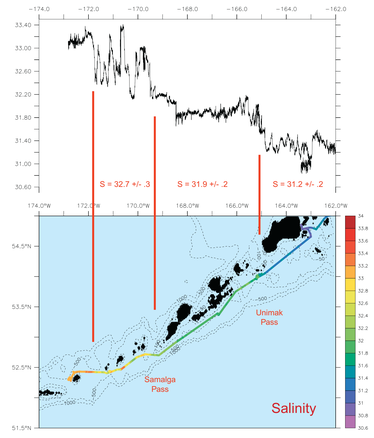
Sea surface temperature (SST), surface salinity, and surface nitrate during the June 2001 cruise. Note the change in surface water properties east vs. west of Samalga Pass, particularly south of the Aleutian Islands.

	Cast just to southwest of Samalga Pass	Cast just to southeast of Samalga Pass
Surface Temperature	5.0ºC	7.2ºC
Surface Salinity	33.0 psu	32.1 psu
Surface Nitrate	23.2 µmol/kg	0.2 µmol/kg

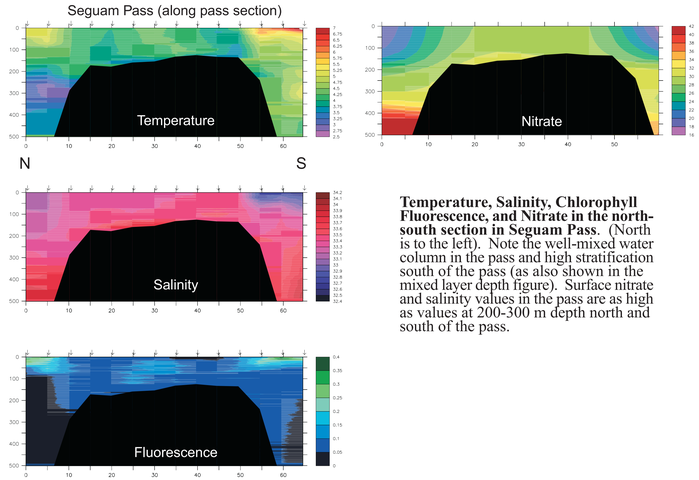
Mixed Layer Depth during the June 2001 cruise. Calculated as the depth at which density (σ_t) is 0.1 kg/m^3 greater than at the surface. White dots signify that the water column is mixed to the bottom.



Mixed layer depths are generally deepest in the passes (especially Seguam) and/or on the northern side of the passes. This suggests that the stratified water that enters the pass from the south (as shown by current meters and drifter trajectories) is mixed in the passes and the well-mixed water flows northward out of the pass into the Bering Sea. Note that surface Nitrate exhibits a similar pattern (elevated in and just north of the passes) suggesting that mixing in the passes is introducing nitrate into the surface layer.

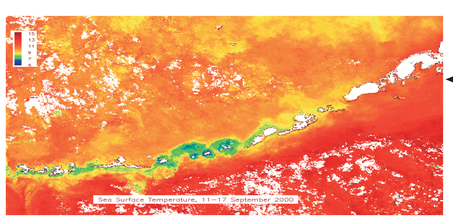


Underway surface salinity during the 2001 cruise. The trace of surface salinity plotted vs. longitude illustrates the sharp fronts associated with both Unimak Pass and Samalga Pass. Surface waters are freshest (due to the influence of the Alaska Coastal Current (ACC) east of Unimak Pass. The freshest part of the ACC hugs the coastline and turns north to flow through Unimak Pass. The saltier off-shore portion of the ACC continues to flow southwest along the Aleutians until it reaches Samalga Pass (the first pass deeper than 100m) where it turns north to flow through Samalga Pass. Shelf water west of Samalga Pass in the North Pacific has a much reduced (negligible?) influence from the ACC and is much saltier.



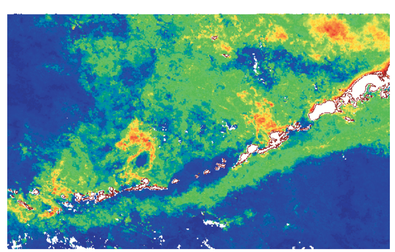
Temperature, Salinity, Chlorophyll Fluorescence, and Nitrate in the north-south section in Seguam Pass. (North is to the left). Note the well-mixed water column in the pass and high stratification south of the pass (as also shown in the mixed layer depth figure). Surface nitrate and salinity values in the pass are as high as values at 200-300 m depth north and south of the pass.

Satellite Data



Sea Surface Temperature from satellite (AVHRR) averaged over 11-17 September 2000. Surface Temperatures along the Aleutian Islands are much cooler west than east of Samalga Pass. In addition, SST is cooler within and just north of the passes. This pattern is consistent with the mixed layer depth and nitrate patterns discussed above.

Average August-September chlorophyll (mg/m^3) from SeaWiFS. Low chlorophyll levels are exhibited in the passes west of Samalga Pass relative to those further east.



Conclusions and Implications:

The strong east-west shift in physical properties (in both 2001 and 2002) of the surface waters along the Aleutian Passes suggests that Samalga Pass was the westernmost pass with a significant northward flow of Alaska Coastal Current Water. Drifter trajectories support this hypothesis. Samalga Pass is likely significant to the physical system for a combination of reasons: Samalga is the easternmost pass deeper than 100m; the shelf width changes near Samalga (wider shelf west of the pass), and the configuration of islands changes at Samalga (big islands/small passes east of Samalga; small islands/big passes west of Samalga).

In addition to the shift in the physical properties, strong shifts in chlorophyll concentrations, species composition of marine birds and their diets, and species composition and abundance of cetaceans were also observed. These striking step-functions in the physics, primary production, zooplankton types and biomass, and in the species composition and foraging ecology of marine birds as one goes from eastern to central Aleutian Islands suggest shifts in the marine ecosystem at similar locations to those where sea lion diets change.

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