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Southeast Alaskan shelf from southern tip of Baranof Island to Kayak Island: Currents, mixing and chlorophyll-*a*

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ABSTRACT

During 2011 and 2013, an integrated ecosystem study was undertaken on the Southeast Alaska shelf and slope. As part of that study, a total of 8 moorings were deployed each year along the coast of Baranof and Chichagof Islands, in Cross Sound and at Icy Point. In addition, 18 satellite-tracked drifters were deployed during the two field years. The goals of this manuscript are to describe: the coastal currents in southeastern Alaska; the processes affecting them; and how the physics modify the nutrients and primary production in the region. Mixing in Cross Sound is an important source of nutrients for the shelf north of the sound, resulting in prolonged production during summer. While the Alaska Coastal Current is not a continuous feature along the entire Gulf of Alaska coast, it does exist from southern tip of Baranof Island to Cross Sound, and again northwest of Yakutat. The narrowness of this shelf coupled with the meanders and eddies in the Alaska Current result in large amounts of on-shelf flow of slope water and off-shelf flow of coastal water. While local currents and summer winds were similar in 2011 and 2013, 2011 was characterized by low chlorophyll-*a* concentrations throughout the spring–summer, while chlorophyll concentrations in 2013 were typical. The cause of this difference remains unclear, but bottom-up processes likely contributed to the low chlorophyll-*a* concentrations in 2011.

1. Introduction

Flow in the basin along the coast of Gulf of Alaska (GOA) is dominated by the northward flowing Alaska Current, which turns southwestward and intensifies near Kodiak Island becoming the Alaskan Stream. On the shelf is the swift, counter-clockwise flowing Alaska Coastal Current (ACC), which is forced by downwelling-favorable winds and characterized by a low-salinity core that arises from outflow from the many rivers and streams that flow into the GOA (Stabeno et al., 2004). This coastal flow extends 10–40 km offshore. Coastal flows with a low-salinity core have been identified along the North Pacific coast starting as far south as the British Columbia shelf (Kowalik et al., 1994) and extending as far west as Samalga Pass in the Aleutian Islands (Ladd et al., 2005b; Stabeno et al., 2005). While the physics that force and structure these flows (downwelling-favorable winds and a line source of freshwater) are similar, the resulting coastal currents are not a continuous "river," but are interrupted by a series of deep canyons and troughs that cut into the shelf (Stabeno et al., 2004, 2016).

Over the last 30 years, measurements have been made in the ACC from Seward to as far west as Samalga Pass, resulting in a large database of oceanographic measurements. Long-term time series include both the Seward Line along which data have been collected since the early 1970s (Royer, 1981) and "Line 8" at the mouth of Shelikof Strait (Fig. 1), which has been occupied regularly since 1982 (Stabeno et al., 2004). The coastal flow in the eastern GOA, however, has only a limited number of measurements (Weingartner et al., 2009). Thus, much of our understanding of the ACC system is extrapolated from results in the northern GOA. This paper presents the first current measurements on southeastern Alaska shelf and at the exit to Cross Sound.

The ACC in the northern GOA varies seasonally, with strong, downwelling-favorable winds resulting in mean transport of $\sim 1\times 10^6\ m^3\ s^{-1}$ during the fall and winter months (Stabeno et al., 2004, 2016). During summer, the winds and flow are weaker ($\sim 0.5\times 10^6\ m^3\ s^{-1}$). Maximum freshwater runoff occurs in late summer and fall, resulting in low salinity (<26) on the shoreward edge of the ACC (Stabeno et al., 2004). During winter and spring the salinity at the core of the northern ACC, while still fresher than the surrounding waters, is generally >30.

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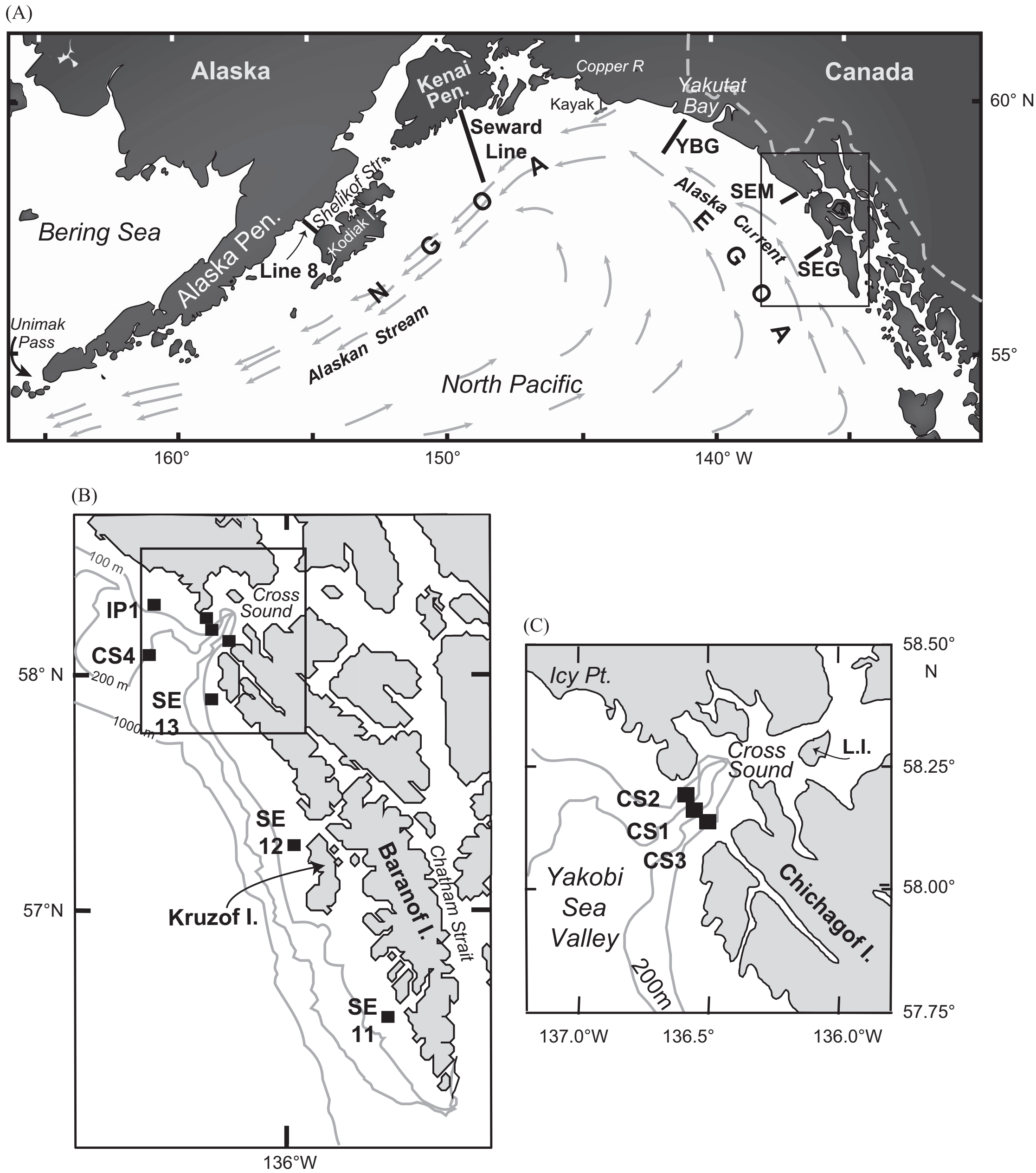

Fig. 1. (A) The general flow in the Gulf of Alaska basin. The locations of the selected hydrographic transects are shown. Parts (B) and (C) show the locations of the eight mooring sites (black squares) in southeast Alaska and the bathymetry of the region. LI on map (C) indicates Lemesurier Island.

The Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP) began in 2010. The purpose of the study was to better understand how climate and ocean conditions influence the survival of several species of ecologically important marine fishes during their first year of life. There are two geographic foci: the northern and eastern GOA (NGOA and EGOA, respectively in Fig. 1). The goals of this manuscript are to describe: the coastal currents in southeastern Alaska; the processes affecting them; how the physics modify the nutrients and primary production in the region; and the differences in physical forcing in 2011 and 2013. This paper integrates physics through chlorophyll, primarily using data collected as part of GOAIERP and provides the physical foundation (currents and mixing) for other papers in this special issue.

2. Data and methods

2.1. Moorings

In March 2011, eight moorings (Tables 1 and 2; Fig. 1B and C) were deployed along the southeast coast of Alaska. Three of them (SE12, SE13 and IP1) were taut-wire moorings, measuring temperature (SBE-37, SBE39, RCM-9), salinity (SBE-37 and SeaCats), currents (RCM-9) and chlorophyll fluorescence (WETLabs Eco-fluorometer) at selected depths. In addition, the mooring at Icy Point (IP1) measured nitrate (Satlantic ISUS). The remaining five moorings (CS1, CS2, CS3, CS4 and SE11) consisted of upward looking 300 or 75 kHz acoustic Doppler current profilers (ADCP) with a SBE-37 attached to the float. The central mooring in Cross