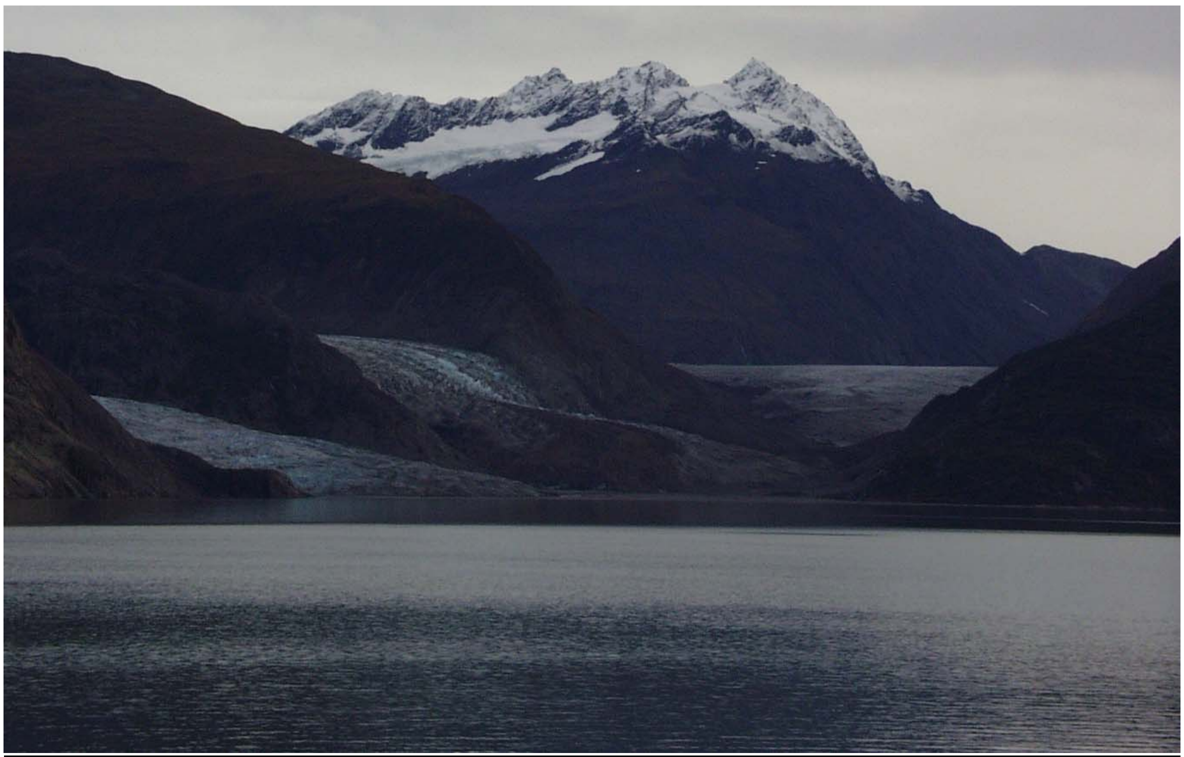
Monitoring of oceanographic properties of Glacier Bay, Alaska

2004 Annual Report



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Introduction

Glacier Bay is a recently (300 years ago) deglaciated fjord estuarine system that has multiple sills, very deep basins, tidewater glaciers, and many streams. Glacier Bay experiences a large amount of runoff, high sedimentation, and large tidal variations. High freshwater discharge due to snow and ice melt and the presence of the tidewater glaciers makes the bay extremely cold. There are many small- and large-scale mixing and upwelling zones at sills, glacial faces, and streams. The complex topography and strong currents lead to highly variable salinity, temperature, sediment, primary productivity, light penetration, stratification levels, and current patterns within a small area.

The oceanographic patterns within Glacier Bay drive a large portion of the spatial and temporal variability of the ecosystem. It has been widely recognized by scientists and resource managers in Glacier Bay that a program to monitor oceanographic patterns is essential for understanding the marine ecosystem and to differentiate between anthropogenic disturbance and natural variation.

This year's sampling marks the 12th continuous year of monitoring the oceanographic conditions at 23 stations along the primary axes within Glacier Bay, AK, making this a very unique and valuable data set in terms of its spatial and temporal coverage.

Methods

The Glacier Bay oceanographic monitoring project was designed for the acquisition, analysis, and modeling of fjord-estuarine oceanographic data in Glacier Bay, Alaska. In 2004, sampling of Glacier Bay's oceanographic conditions was conducted four times, including the months of March, June, July, and October (Table 1). Repeated sampling of the lower Bay stations during both peak flood and slack high conditions was conducted in the month of June. Recent compilation and analysis of Glacier Bay's oceanographic data set led to suggestions for sampling consistency among years, by concentrating the core sampling on March, July, October and either December/January (time period of low variability), with June and/or August noted as additional beneficial time periods (Etherington et al. 2004).

Oceanographic sampling was conducted using the standard protocol for the Glacier Bay oceanographic monitoring program (Hooge et al. 2004). Sampling consisted of performing a single CTD (conductivity, temperature, depth) cast at each station (Fig. 1). Data were collected for each 1 m depth bin of the water column from the surface to within 10 m of the bottom, or to a maximum depth of 300 m. This specific model of Seabird CTD is limited to depths of 300 m. Some stations are located at depths greater than 300 m. From each depth bin, the following parameters were measured: 1) salinity (psu) –calculated from conductivity; 2) temperature (ºC); 3) irradiance (microEinsteins m^{-2}) – measure of photosynthetically active radiation (PAR); 4) optical backscatterance (OBS) (mg L^{-1}) – measure of turbidity; 5) fluorescence (mg m^{-3}) – a proxy for chlorophyll-a concentration; 6) density of water (σ_t) – derived from salinity and temperature.

Euphotic depth was defined as the depth at which the amount of PAR equals 1% of that measured at the surface (thus, euphotic depth measures the depth at which light availability becomes minimal). An index of stratification was calculated to describe the stability of the water column. Differences in the density of the water column between consecutive 1 m depth bins were calculated so that an overall mean of density change could be determined ($\Delta\sigma_t\ m^{-1}$) for a specified stratum of the water column. Similar stratification indices have been used in other studies to quantify water column stability (e.g., Bowman and Esaias 1981, Sime-Ngando et al. 1995).

Oceanographic characteristics were defined for the top 15 m of the water column. Means of temperature, salinity, stratification, OBS, and chlorophyll-a were calculated over the surface stratum of 0-15 m for each cast. This depth stratum was chosen because it is the most dynamic region of the water column within Pacific fjords (the density typically reaches 90% of the deep water value by 10-15 m; Pickard and Stanton 1980), including Glacier Bay (Hooge and Hooge 2002). Additionally, the depth stratum of 0-15 m is a zone of high biological production in southeast Alaska estuarine systems (Ziemann et al. 1991, Hooge and Hooge 2002). For example, temporal patterns of chlorophyll-a concentrations within Auke Bay, AK varied only slightly when depth-integrated values for 0-15 m were compared to those for 0-35 m (Ziemann et al. 1991), suggesting that almost all of the phytoplankton occurred in the top 15 m. Further, Robards et al. (2003) demonstrated that the most forage fish biomass within Glacier Bay was found within the shallowest water layer (<25 m), irrespective of bottom depth.

Results and Discussion

Salinity

In 2004, regional and seasonal patterns of surface water salinity generally followed the average spatial and temporal salinity patterns over the years 1993-2002 presented in Etherington et al. (2004) (Fig. 2). There was a decline in salinity of surface waters as you move from the mouth to the head of the Bay. June sampling data describes a high salinity concentration at the mouth and central parts of the bay (e.g., stations 0, 1,2, 3, 4), and a decrease in salinity as you move to the head of the West Arm (e.g., stations 16, 17, 19, 20). Salinity differences among stations were more apparent in the summer and fall months compared to spring sampling (Fig. 2). Greater standard errors were evident for June, July, and October compared with sampling done in March. These higher standard errors calculated from the top 15 meters of the water column represent a large variation of salinity within depth layers. This variation within the top 15m suggests high freshwater input at surface layers. Since water density is mainly a reflection of salinity, rather than temperature in Glacier Bay (Hooge and Hooge 2002, Etherington et al. 204) and other high latitude systems, these large variations in salinity suggest highly stratified waters. Standard errors of salinity are higher as you move towards the head of the bay, indicating greater freshwater input and stratification. In October 2004, there was high variation in salinity within the top 15 m in the upper portions of the East and West Arms as well as in Geikie Inlet. This amount of variation in salinity or stratification was not as apparent in October of 2003 (Etherington, 2004). In addition, salinity values were considerably lower in October 2004 compares with October 2003. These results suggest