The Distribution and Abundance of Pacific Halibut in a Recently Deglaciated Fjord: Implications for Marine Reserve Design

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Abstract. In 1999, parts of Glacier Bay, Alaska, were closed to commercial fishing, creating a network of marine reserves. The goal of this project was to characterize the distribution and abundance of Pacific halibut in the reserves and in the area that remains open to commercial fishing. Thirty-nine longline sets were placed every four nautical miles starting outside the mouth of Glacier Bay and continuing to the end of each the East and West Arm reserves. Halibut were widespread in Glacier Bay and were caught at 38 of the 39 locations sampled. We observed decreases in halibut abundance in the upper reaches of the fjord in the West Arm reserve. The average catch of halibut in the East Arm reserve, however, was not significantly different from the central Bay and Icy Strait. Characterizing the differences in distribution and relative abundance of Pacific halibut throughout Glacier Bay is the first step in evaluating the effectiveness of the marine reserves in the Bay.

Introduction

Since at least 1900, the waters in Glacier Bay, Alaska, have supported a substantial commercial fishery for Pacific halibut (*Hippoglossus stenolepis*). In 1999, parts of Glacier Bay proper were closed to commercial fishing and the entire Bay is scheduled for closure upon retirement of all current commercial permit holders (U.S. Department of the Interior, 1999). Marine protected areas in other parts of the world have been shown to increase the size, density, and biomass of organisms and the diversity of protected populations (Halpern, 2003). The efficacy of the current patchwork of closures in Glacier Bay, however, and their ability to protect adult halibut from harvest is not known. Understanding of the spatial distribution, abundance, reproductive biology and dispersal behavior of harvested and unharvested species is needed to evaluate the effectiveness of the reserves.

The goal of this project was to characterize the distribution and abundance of Pacific halibut in the reserves and in the area that remains open to commercial fishing. Glacier Bay is a recently deglaciated fjord estuarine system with strong salinity, temperature, and turbidity gradients (P. Hooge, U.S. Geological Survey, unpub. data)). The distribution and abundance of marine organisms in fjords is strongly influenced by oceanographic gradients and the presence and proximity of glaciers (Carney and others, 1999; Hop and others, 2002; Taggart and others, 2003). We hypothesized that abundance of Pacific halibut would be correlated with distance from glaciers and that the abundance of halibut in the reserves near the glaciers would differ from the area in the lower Bay that remains open to commercial fishing. This paper summarizes results of longline surveys that were conducted in Glacier Bay; these results will aid in assessing the efficacy of the closures in the Bay.

Methods

Thirty-nine standardized longline sets were placed approximately every four nautical miles starting outside the glacial sill at the mouth of Glacier Bay and continuing to the tidewater glaciers at the end head of the East and West Arms (fig. 1). Eighteen sets were conducted in the area open

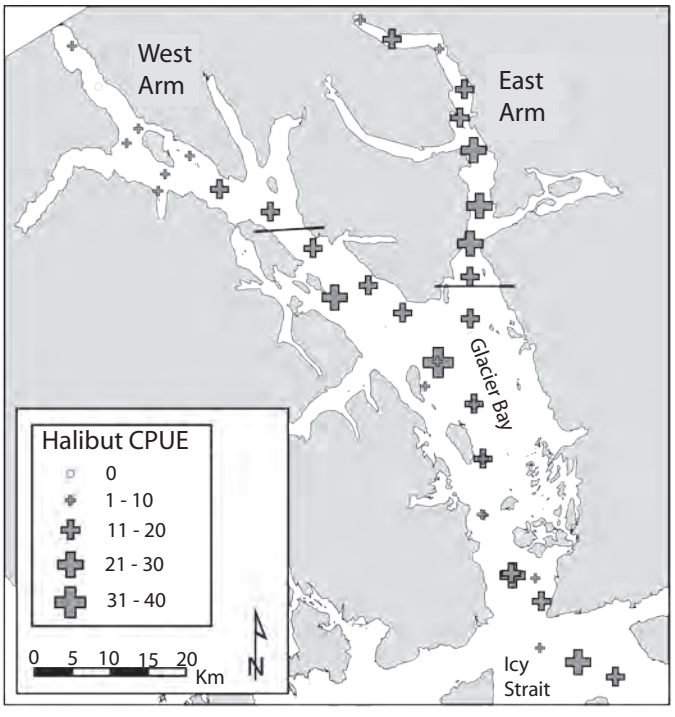

Figure 1. Location of 39 longline sets and the catch per unit effort (CPUE) of Pacific halibut (*Hippoglossus stenolepis*) in Glacier Bay, Alaska. The boundary of the marine reserves are noted with horizontal black lines; commercial fishing is closed in the East Arm and the West Arm; however, the main Bay and Icy Strait remain open to commercial fishing.

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to commercial fishing, 18 were placed in the reserves (9 in the East Arm and 9 in the West Arm), and 3 were set outside Glacier Bay in Icy Strait. Sampling was conducted in June 1994, and June–July, 1995.

Each longline set consisted of approximately 400 hooks; the hook spacing, hook size, and bait were the same for all sets. Soak time was 6 hours. Captured halibut were measured, and all other fish species were identified and measured.

Results and Discussion

Halibut were widespread in Glacier Bay; we captured halibut at 38 out of the 39 locations sampled (fig. 1). The depths sampled during this survey ranged from 50 to 438 m, and halibut were detected at all depths (fig. 2). In a previous survey of halibut distribution in a smaller area of central Glacier Bay, catch of halibut was determined to be associated with depth (Bishop and others, 1995). Our data, however, show no relationship between catch of halibut and depth (fig. 2). Our results are consistent with a broad-scale study of groundfish in British Columbia, where halibut also were widespread and catch did not have a consistent relation with depth (Perry and others, 1994).

A total of 503 halibut were captured; the average size was 98.4 cm, and the total size range was 17.2 to 185 cm.

The range of sizes of halibut was similar in the four regions sampled, but the size-frequency distributions of fish in the four regions were significantly different (Kruskal-Wallis: H=14.8, p=0.002) (fig. 3). Generally, fewer large fish were caught in the West Arm reserve than in the other three areas.

We hypothesized that abundance of Pacific halibut would be correlated with distance from glaciers and thus that abundance of halibut in the reserves would differ from the lower Bay. We calculated the average catch per unit effort (CPUE) of halibut in the two reserves, the main Bay, and Icy Strait and there were significant differences between regions (Kruskal-Wallis: H=12.3, p=0.006). Unexpectedly, the East Arm reserve was not significantly different from the central Bay and Icy Strait. The West Arm reserve, however, had lower CPUE of Pacific halibut than the other regions (fig. 4).

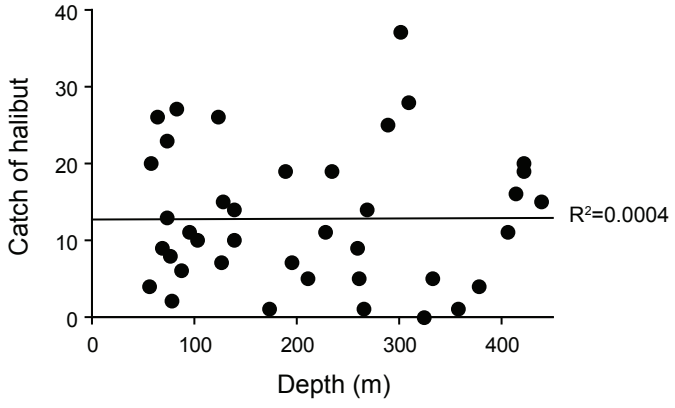

Figure 2. Relation between catch of Pacific halibut and depth of the longline set. R^2 value and 95 percent regression line are shown.

Conclusions and Management Implications

We observed decreases in halibut abundance in the upper reaches of the fjord, but contrary to our expectations the abundance was not strictly related to time since deglaciation. The East Arm reserve, parts of which were glaciated as recently as 20 years ago, had abundances similar to the central Bay and Icy Strait. Characterizing the differences

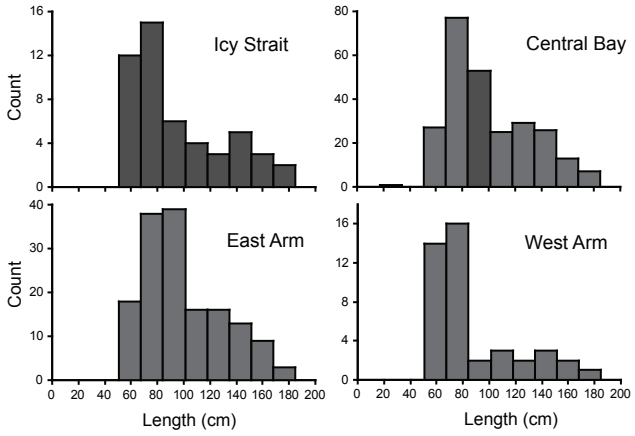

Figure 3. The size-frequency distributions of Pacific halibut caught in four regions of Glacier Bay.

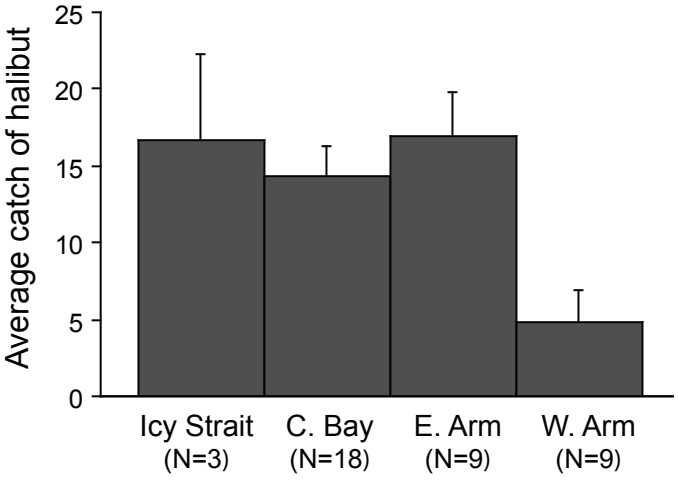

Figure 4. Average catch of Pacific halibut (+1 standard error) for each of the regions sampled in Glacier Bay. N=the number of longline sets conducted per region.

in distribution and relative abundance of Pacific halibut throughout Glacier Bay is the first step in evaluating the effectiveness of the marine reserves and allows us to answer the question: Are there animals in the reserve?

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