Spatial Distribution and Abundance of Tanner and Red King Crab Inside and Outside of Marine Reserves in Glacier Bay, Alaska

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Abstract. Closure of commercial fishing for Tanner crab (*Chionoecetes bairdi*) and red king crab (*Paralithodes camtschaticus*) in parts of Glacier Bay National Park created a network of five protected areas. The purpose of this study was to determine the relative abundance and spatial distribution of king and Tanner crab inside and outside of the marine reserve network. Using crab pots, we systematically sampled Glacier Bay and estimated the density and relative abundance of crabs. Our data demonstrate that reserves in close proximity to each other have very different crab abundances; the majority of the Tanner crab were in two reserves, and most (73 percent) of the king crab were in a small part of a single reserve. This study demonstrates the value of systematic sampling for marine reserve design and location.

Introduction

In 1999, the U.S. Congress closed fishing in parts of Glacier Bay National Park, creating one of North America's largest marine reserves. Throughout the world marine protected areas are promoted as effective tools for managing fisheries while simultaneously meeting marine conservation goals and maintaining marine biodiversity (Agardy, 1997). To evaluate marine reserve efficacy and measure population changes in response to protection, it is essential to understand the abundance, age (or size) structure, and spatial distribution of populations inside and outside the reserves (National Research Council, 1999).

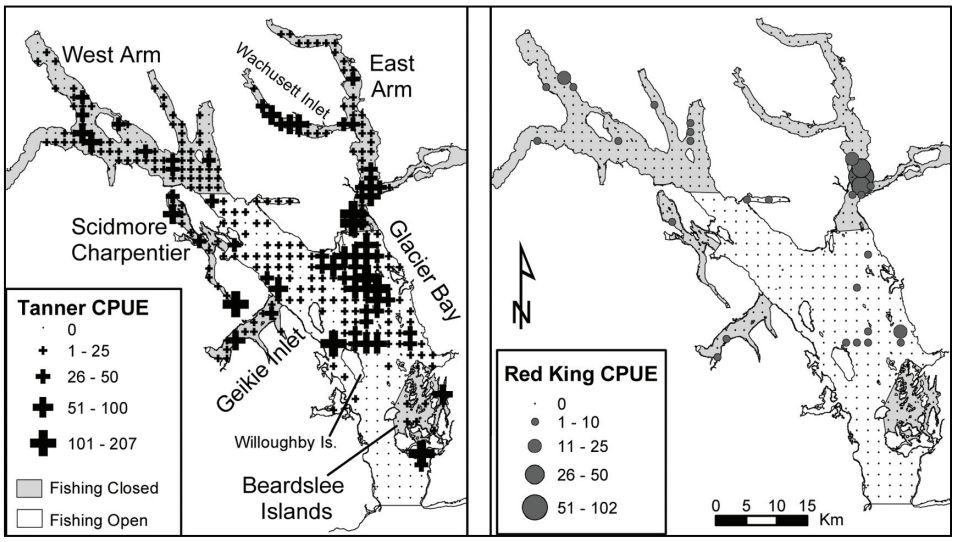

Figure 1. Catch per unit effort (CPUE) of Tanner crab and red king crab during a systematic survey of Glacier Bay. Commercial fishing is closed in five areas of the Bay and remains open in the central Bay.

The fisheries closures in Glacier Bay provide an important opportunity to study marine reserve design and effectiveness for high latitude species such as king and Tanner crabs. The legislation closed commercial fishing for Tanner crab (*Chionoecetes bairdi*) in five areas (fig. 1) in Glacier Bay, forming a network of closures. The central part of the Bay remains open to Tanner crab fishing, but is scheduled for closure upon the retirement of current commercial permit holders (Department of the Interior, 1999). For red king crab (*Paralithodes camtschaticus*), all of Glacier Bay proper was closed to commercial fishing in 1999.

The purpose of this study was to determine the relative abundance and distribution of king and Tanner crab inside and outside the marine reserve network in Glacier Bay. Information from this survey will be used to (1) describe the distribution of Tanner and red king crabs in a large fjord estuarine system; (2) predict the effectiveness of the reserves in Glacier Bay; and (3) provide baseline data to measure the effectiveness of marine reserves over time.

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Methods

In July and August 2002, the relative abundance of Tanner and red king crabs was estimated by systematically sampling 415 stations throughout Glacier Bay. Crabs were collected using conical, top-loading, commercial Tanner crab pots. To target juvenile and female crabs, a commercial shrimp pot was attached to each of the conical Tanner crab pots with a 20 m tether. A U.S. Geological Survey research vessel, the USGS R/V *Alaskan Gyre*, was used to deploy and retrieve crab pots. Sixteen pots were set each afternoon and pulled the next morning after a soak time of 15 to 20 hours. As the pots were retrieved, we counted and identified all organisms to species. Carapace sizes, width for Tanner crabs, and length for king crabs, were measured to the nearest millimeter with vernier calipers.

Results and Discussion

Tanner crabs were widely distributed throughout Glacier Bay, and 69 percent of the pots captured at least one crab. The only area where crabs were consistently not captured was the main channel of the lower Bay, between Willoughby Island and the mouth of the Bay (fig. 1). The absence of Tanner crabs in this area suggests poor habitat for this species. The existence of a habitat barrier could restrict movement of Tanner crabs between Glacier Bay and Icy Strait. If this is the case, the Tanner crab population in the Bay may be dependent on larval flux for connectivity between the larger crab metapopulations in southeastern Alaska.

Densities of Tanner crabs were not significantly different between the reserve network and the area open to commercial fishing in the central Bay (fig. 2). However, densities of adults and juvenile Tanner crabs varied among reserves; the average catch of adults was higher in the East Arm, Geikie Inlet, Scidmore-Charpentier Inlet, and the central Bay than the other two reserves (fig. 2). The higher density of juvenile crabs in the reserves was due to their high concentrations in Wachusett Inlet and the distal ends of Scidmore-Charpentier Inlet, both narrow glacial fjords (fig. 1). These areas possibly represent nursery areas for Tanner crabs. If so, their inclusion in the marine reserves is particularly important for long-term effectiveness.

In contrast to the widespread distribution of Tanner crabs, red king crabs were highly aggregated; 73 percent of the king crabs were captured in seven adjacent stations near the mouth of the East Arm reserve (fig. 1). These data indicate that design of an effective marine reserve for red king crab will require detailed sampling to delineate patches of high density.

Conclusions and Management Implications

Our data show that reserves in close proximity have very different abundances of king and Tanner crabs; not all reserves are created equal. This study demonstrates the value of systematic sampling for marine reserve design and location. The ongoing marine reserve research in Glacier Bay will provide valuable information to managers, scientists, and the public to evaluate the utility of reserves as a management tool for solving local, national, and global marine conservation issues.

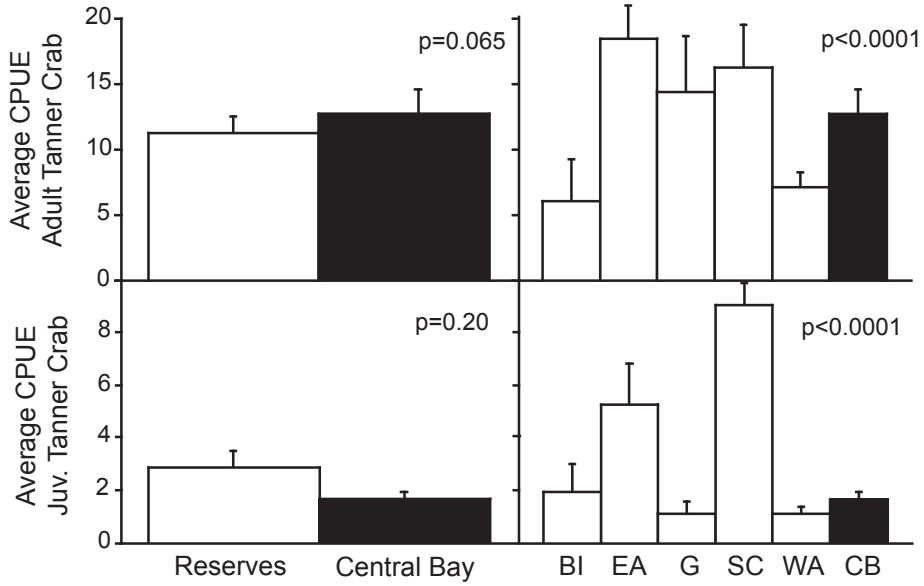

Figure 2. Average catch per unit effort (CPUE) (+1 standard error) of adult and juvenile Tanner crabs in the reserves and the central Bay, which is still open to commercial fishing. Differences between the central Bay and all the reserves combined were tested with a t-test; differences among reserves were tested with ANOVA, both tests were performed on log+1 transformed data due to the non-normal distribution of the data. BI=Beardslee Islands, EA=East Arm, G=Geikie Inlet, SC=Scidmore-Charpentier Inlets, WA=West Arm, CB=Central Bay.

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U-shaped glacial valley at the head of Dundas Bay. (Photograph by Bill Eichenlaub, National Park Service.)