Perspectives on an Invading Predator—Sea Otters in Glacier Bay

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Abstract. Since 1995, numbers of sea otters (*Enhydra lutris*) in Glacier Bay have increased from just a few to nearly 2,400 in 2004. Immigration and reproduction have both contributed to this rapid increase. Abundant populations of benthic invertebrates, including clams, mussels, crabs, and urchins, are providing the prey resources to support this rapid increase. Unutilized habitat remains widely available. In areas of Glacier Bay colonized by sea otters, densities of clams are 3–9 times greater and mean sizes of clams are twice as large than in areas long occupied by sea otters outside Glacier Bay. Further, colonized areas in lower Glacier Bay have greater intertidal urchin and clam densities and biomass compared to areas not colonized. In addition to abundant prey, Glacier Bay has provided refuge from human harvest of sea otters that is not afforded elsewhere, likely contributing to the high rate of population growth.

Introduction

During most of the early 20th century, sea otters were absent from large parts or areas of their habitat in the North Pacific. Subsequent expansion into unoccupied habitat by remnant and translocated populations resulted in rapid rates of recovery throughout much of the species' historic range (Bodkin and others, 1999). This situation afforded an opportunity to evaluate relations between sea otters and the ecosystems they inhabit, providing one of the best-documented examples of top-down forcing on the structure and function of nearshore marine ecosystems in the North Pacific Ocean (Kenyon, 1969; VanBlaricom and Estes, 1988; Riedman and Estes, 1990; Estes and Duggins, 1995). Documented effects of sea otter foraging include declines in the abundance and size of benthic invertebrates and increases in the diversity and complexity of nearshore ecosystems.

By the end of the 20th century recovering sea otter populations in Alaska began to stabilize or decline in some areas. In some cases declines could be attributed to predation (Estes and others, 1998), while other populations equilibrated with available space and prey resources (Bodkin and others, 2000). However, relations between sea otter density, prey density, and immigration remain largely unexplored in Alaska.

Prior to about 1998, sea otters were effectively absent from Glacier Bay. In anticipation of sea otters moving into the area, we initiated studies in 1994 to describe the process of recolonization. Our research included annual surveys of sea otter abundance and distribution, and quantitative descriptions of the nearshore macro-invertebrate populations that existed in Glacier Bay. Our objectives in this summary are to: (1) describe the numerical process of sea otter colonization, (2) compare data on sea otter prey populations in Glacier Bay, between areas initially colonized and those not colonized, and (3) compare prey population densities and sizes in Glacier Bay prior to recolonization with those in Port Althorp, an area near Glacier Bay occupied by sea otters for about 25 years.

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Methods

From 1994–2004, surveys of sea otter distribution and relative abundance have been conducted in Cross Sound, Icy Strait, and Glacier Bay. The distribution surveys consist of tracks flown parallel to shore and include all habitat out to the 100 m bathymetric contour. Numbers of animals observed, group sizes, and locations were recorded. We assumed that detection probabilities remained comparable among surveys and therefore our counts provide an index of abundance that is comparable over time.

In 1999, we initiated a second type of survey that was designed to provide estimates of sea otter abundance that were corrected for animals not detected (Bodkin and Udevitz, 1999). Transect selection and sampling was proportional to expected sea otter abundance with most effort taking place over waters from 0–40 m in depth. Intensive searches were periodically conducted within transects to estimate the proportion of sea otters not detected. Counts are adjusted for area not surveyed and detection probabilities less than1.0 to obtain a population size estimate.

Beginning in 1999, we randomly sampled intertidal clam and urchin populations throughout Glacier Bay, and at Port Althorp (Bodkin and others, 2000), where sea otters have been present for at least 20 years (fig. 1). All clam and urchin samples collected were identified, counted, and measured. In addition to the random sites, we sampled a supplementary suite of selected sites within preferred clam habitat (PCH), designated by the presence of abundant clam siphons and shell litter. Beginning in 2001, we sampled subtidal clam and urchin populations at selected sites throughout Glacier Bay and Port Althorp (Bodkin and others, 2002). Sites were selected based on extensive reconnaissance via diving and surface deployed drop cameras and clams and urchins were processed as for intertidal sampling.

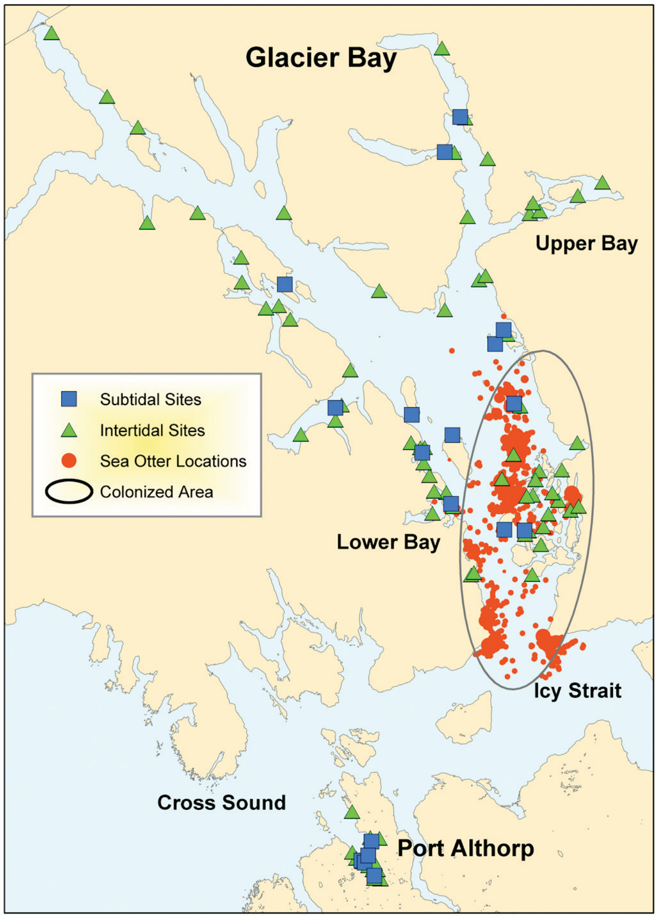

Figure 1. Glacier Bay and Port Althorp intertidal and subtidal study sites and cumulative results of Glacier Bay sea otter surveys (1994–2004).

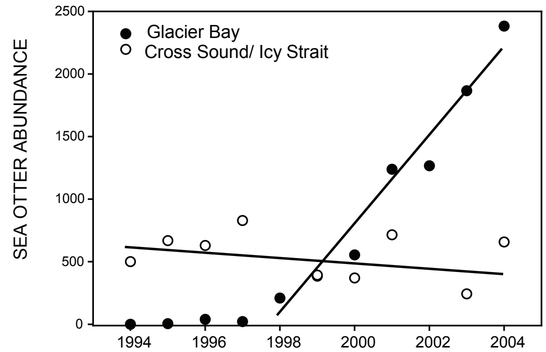

Figure 2. Trends in sea otter abundance in Glacier Bay and adjacent waters from 1994–2004. Surveys in Glacier Bay after 1998 are corrected for detection; however, surveys in Cross Sound/Icy Strait are not. Lines are from linear regression.

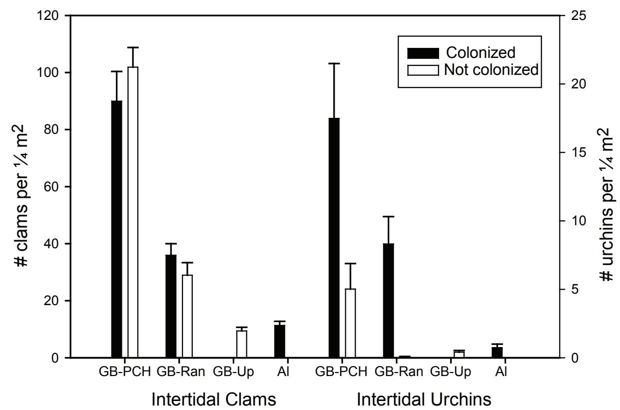

Figure 3. Densities of intertidal clams and urchins (number/1/4m^2) in areas of Glacier Bay colonized by sea otters, not colonized by sea otters, and from Port Althorp (AI) where sea otters have been present for at least 20 years. GB-PCH=preferred clam habitat sites in Glacier Bay; GB-Ran=lower Glacier Bay random sites; GB-Up=upper Glacier Bay random sites.

Results

Sea otter surveys: Sea otter populations in Cross Sound and Icy Strait declined slightly between 1994 and 2004 averaging about -7 percent per year, although the trend was not significant (fig. 2). There has been limited eastward expansion of sea otters in Icy Strait during this period.

The 2004 estimate of sea otter abundance in Glacier Bay is 2,381 (se 594) (fig. 2). Sea otters were rare visitors in Glacier Bay between 1988 and 1996, but by 1997 residence was established near Pt. Carolus, Pt Gustavus, and in the vicinity of Sita Reef and the northern Beardslee Islands (fig. 1). The sea otter population in Glacier Bay has been increasing significantly at an average annual rate of 50 percent between 1998 and 2004.

Intertidal: The density of clams in Pt. Althorp is 3 times less than at sites in lower Glacier Bay and 9 times less than at PCH sites (fig. 3). At random sites, clam densities were 25 percent greater on transects within colonized areas compared to areas not colonized, however this difference is not significant and not mirrored in the PCH sites. Intertidal clams (*Protothaca* and *Saxidomus)* were about twice as large in Glacier Bay (41 mm and 67 mm, respectively) compared to Pt. Althorp (24 mm and 32 mm). Within Glacier Bay PCH sites, mean sizes of *Protothaca* and *Saxidomus* were significantly larger in areas not colonized. The computed biomass of intertidal clams is significantly greater at Glacier Bay sites than Pt. Althorp (fig 4) and was greater at colonized sites than those not colonized in Glacier Bay. The green sea urchin (*Strongylocentrotus droebachiensis*) was as much as 24 times more abundant in Glacier Bay than in Pt. Althorp, more than 100 times more abundant at the colonized sites, and 3 times more abundant in colonized PCH sites, compared to those not colonized (fig. 3). There was significantly greater urchin biomass in Glacier Bay compared to Pt. Althorp and, in Glacier Bay, areas colonized compared to areas not colonized (fig 4).

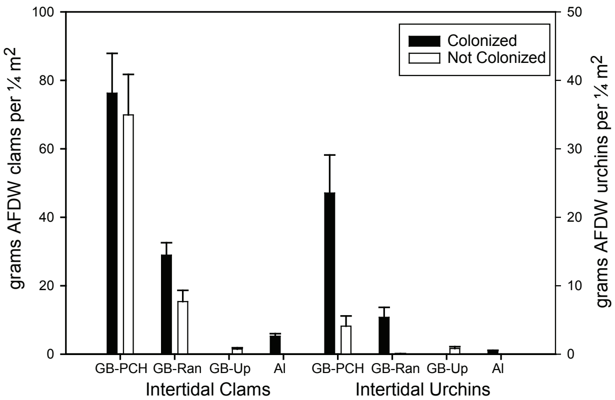

Figure 4. Calculated biomass (AFDW = ash free dry weight) of intertidal clams and urchins (number/1/4m^2) in areas of Glacier Bay colonized by sea otters, not colonized by sea otters, and from Port Althorp (AI) where sea otters have been present for at least 20 years. GB-PCH=preferred clam habitat sites in Glacier Bay; GB-Ran=lower Glacier Bay random sites; GB-Up=upper Glacier Bay random sites.

Subtidal: Clam densities ranged from 3 to 7 times more abundant in Glacier Bay than Pt. Althorp (fig. 5). Clam densities in colonized lower Bay sites were 42 percent less than in non-colonized areas. Mean sizes of subtidal clams were more than twice as large in Glacier Bay compared to Pt. Althorp. Subtidal urchins were nearly absent in Pt. Althorp, and were more abundant at colonized, compared to non-colonized areas in the lower Bay. Subtidal urchins were similar in size at sites within Glacier Bay, and about twice as large as urchins in Pt. Althorp. There was significantly greater urchin biomass in Glacier Bay compared to Pt. Althorp and in lower Glacier Bay areas colonized by otters had greater urchin biomass than areas not colonized (fig 6).

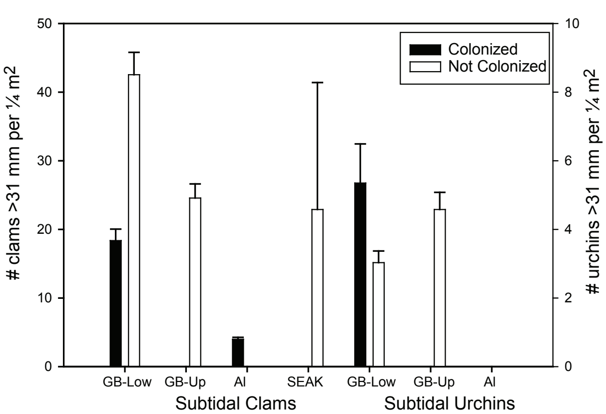

Figure 5. Densities of subtidal clams and urchins (number/1/4m^2). GB-Low=lower Glacier Bay selected sites; GB-Up=upper Glacier Bay selected sites; AI=Port Althorp selected sites; SEAK from Kvitek and Oliver (1992) data collected from nine widely dispersed occupied sites in southeast Alaska.

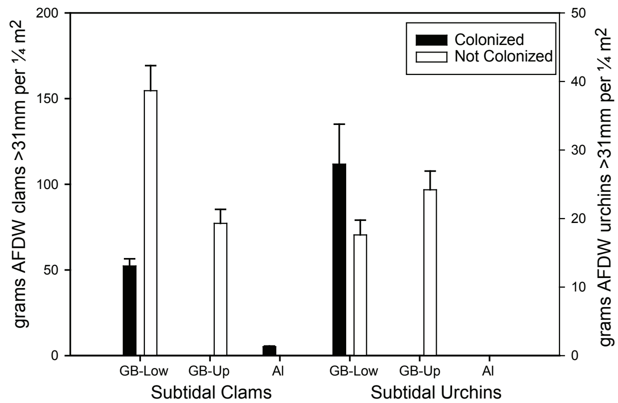

Figure 6. Calculated biomass (AFDW=ash free dry weight) of subtidal clams and urchins (number/1/4m^2). GB-Low=lower Glacier Bay selected sites; GB-Up=upper Glacier Bay selected sites; AI=Port Althorp; SEAK from Kvitek and Oliver (1992) data collected from nine widely dispersed occupied sites in southeast Alaska.

Discussion

Glacier Bay may be one of the few locations in Alaska where sea otters are currently increasing in abundance. The rate of increase of sea otters in Glacier Bay exceeds the theoretical maximum for the species (24 percent, Estes, 1990), requiring significant rates of immigration in addition to recruitment from local reproduction. The comparatively stable population outside Glacier Bay suggests that immigration of juveniles, as opposed to immigration of adults, as a likely mechanism contributing to growth. In contrast to the 50 percent annual growth rate of sea otters in Glacier Bay, since 1994, the average annual rate of change of sea otter abundance in Southeast Alaska as a whole has been -3 percent, including the increases in Glacier Bay. Kvitek and Oliver (1992) describe densities of subtidal clams (mean=22.9/1/4m^2) in the absence of sea otters throughout southeast Alaska that are comparable to those we describe in lower Glacier Bay, suggesting adequate prey to support sea otter population growth are present outside Glacier Bay.

Densities and mean sizes of intertidal and subtidal clams and urchins are greater in Glacier Bay than in nearby Pt. Althorp, where sea otters have been present for many years. This suggests a numerical response by sea otters to prey densities that incorporates high dispersal rates of juveniles. The densities of prey we estimated at Pt. Althorp may also provide an indication of the densities and sizes of clams and urchins that may persist in Glacier Bay following long-term occupation by sea otters. In Glacier Bay, sea otters first colonized habitats with greater urchin and intertidal clam densities and biomass, but not subtidal clam densities or biomass. Because our subtidal sites were not randomly selected, our density estimates may not accurately reflect subtidal clam and urchin densities in the colonized and non-colonized areas of lower Glacier Bay. Conversely, the intertidal sites were randomly selected and should provide unbiased estimates of prey populations. Thus, at least for the intertidal zone, it appears as though sea otters selected areas for colonization that supported the highest prey populations. Other factors, such as behavior and social organization may play a role in the spatial aspects of colonization.

While abundant prey and space resources support colonizing sea otters in Glacier Bay, similar prey densities in other areas of southeast Alaska are not supporting similar rates of increase. Causes of differences in population growth inside and outside of Glacier Bay not well known, but the lack of a human harvest in Glacier Bay is likely contributing to the rapid colonization process.

Management Implications

The rapid increase in sea otters in Glacier Bay National Park has serious and multifaceted implications to management of marine resources in Glacier Bay. First, predation by sea otters on a variety of invertebrates will have profound effects on the benthic community structure and function of the Glacier Bay ecosystem. Expected consequences include reduced sizes and density of many common and abundant species that currently support other avian, mammalian, fish, and invertebrate consumers. Expected indirect consequences include increases in macroalgae populations, including understory and canopy forming species that support populations of grazing invertebrates and provide habitat for a diverse assemblage of nearshore marine taxa. Managers need to understand the direct and indirect effects of sea otter colonization and predation to properly assign causes of changes observed in nearshore marine resources. Second, sea otters are protected from most disturbances by the Marine Mammal Protection Act, but because they often rest in groups nearshore they may be particularly susceptible to disturbance by Park visitors. And lastly, while there exists a legal harvest of sea otters in Alaska, there has been no reported take from within Glacier Bay. Managers need to recognize the role of Glacier Bay as a refuge, and potentially as a marine reserve as the Bay eventually becomes a source of emigrating sea otters.

Acknowledgments

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