The Mammal-Eating Killer Whales of Glacier Bay National Park and Preserve: Hunting with the Strong Silent Types

by Volker B. Deecke, Janice M. Straley, Dena R. Matkin and Christine M. Gabriele

Photograph courtesy of Volker Deecke

Prey remains recovered from a killer whale kill for genetic analysis to determine the prey species (harbor seal in this case). Typically we are able to recover only small bits of blubber or tissue—large fragments such as this one are the exception.

(Left) Female transient T086 breaching in Icy Strait during an attack on a Dall's porpoise.

Photograph courtesy of Volker Deecke

Killer whales in Alaskan waters: an introduction

Like two tribes inhabiting the same home range but keeping out of each other's way, two distinct forms, or ecotypes, of killer whales inhabit the coastal waters of the northeastern Pacific. Resident killer whales, one ecotype, live in large stable groups and feed exclusively on fish, predominantly on salmon *(Oncorhynchus spp.),* while the second ecotype, transient killer whales, feed exclusively on warm-blooded animals. Their primary prey are marine mammals *(Ford et al. 1998, Saulitis et al. 2000),* although they also take sea birds on occasion. Resident killer whales can be found frequently and predictably in the straits and inlets of southeastern Alaska and Prince William Sound in the summer months because they follow salmon on their annual migration through these coastal waters. By comparison, members of the transient ecotype are stealthy nomads. Presumably because of the lower density of their prey populations and the fact that their prey would quickly cue in on their presence, transients rarely linger for long in the same area. They often cover large distances in a single day, making them difficult to study.

We already know that transient killer whales along the west coast of North America are divided into several distinct populations. The best-studied are the West Coast Transients, a population that ranges from central California to southeastern Alaska. While some of its members use only a sub-section of the geographic range, some individuals have been seen in places as far apart as Glacier Bay and Monterey Bay, even in the same year *(Goley and Straley 1994).* A second population, the Gulf of Alaska Transients, frequents the open waters of southern Alaska as far west as Kodiak Island and east to Sitka Sound. The third population is a small isolated group of eight individuals, named the AT1 Transients, found in Prince William Sound and the Kenai Fjords. Since the AT1 Transient population no longer contains any reproductive females, it is destined to go extinct *(Matkin et al. 1999).* Other populations of mammal-eating killer whales are known to exist off the Aleutian Islands and in the Bering Sea, but research in these logistically challenging areas has only begun.

The waters of Glacier Bay National Park and Preserve (Glacier Bay NP&P hereafter) provide important habitat for several species of marine mammals. Several thousand harbor seals congregate near tidal glaciers and on terrestrial haulouts in spring and summer to have their young and to molt *(Matthews and Pendleton 2006),* and some individual seals forage year-round throughout Glacier Bay. Concentrations of Steller sea lions can be found at haulouts at Point Carolus, and on South Marble Island

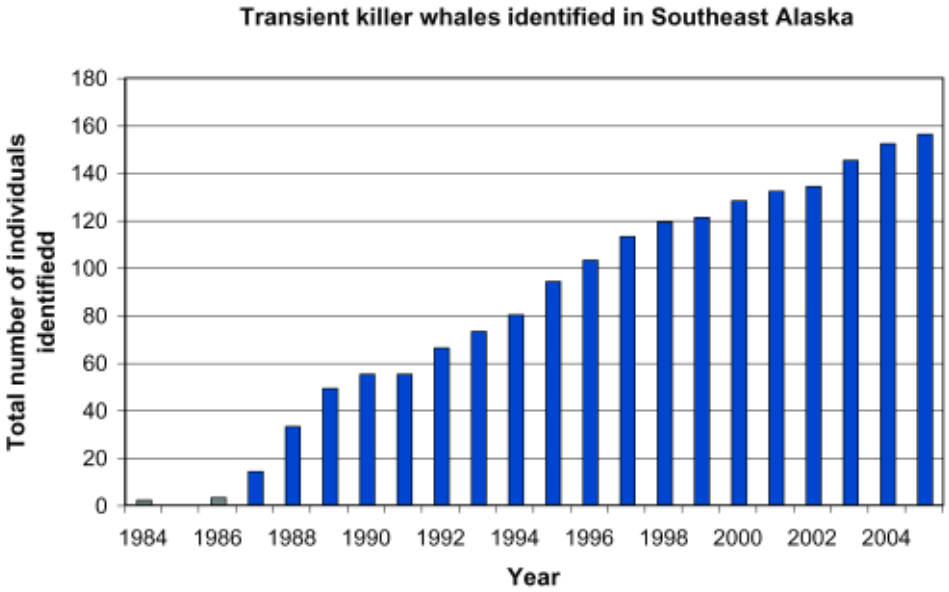

Figure 1. Discovery curve showing the cumulative number of individual transient killer whales identified in and up to a given year in southeastern Alaska. The data suggests that we have not yet identified all members of the West Coast Transients.

where their numbers can exceed 600 individuals. In addition, harbor porpoises are commonly sighted in Glacier Bay, although little is currently known about their abundance. Humpback whales can be seen on a daily basis in the summer and minke whales occasionally feed in the lower Bay.

Glacier Bay NP&P is one of the best places to view and study transient killer whales: the movements of transient killer whales are typically unpredictable, but in Glacier Bay members of the West Coast Transient population can be seen regularly during the summer months. This high frequency of sightings suggests that Glacier Bay provides important habitat for transients. At the same time, these mammal-eating killer whales play an important role in Glacier Bay's ecosystem. As apex predators they are key players in the intricate mechanics of a rich marine food web sustained by nutrient-rich runoff from the glaciers and long summer daylight.

The purpose of our study is to delineate the role of transient killer whales in the ecosystem of Glacier Bay, but also to determine the importance of Glacier Bay (and Glacier Bay NP&P) to the well-being and conservation of the West Coast Transient population. Only by gaining an understanding of the number of individual killer whales using the area, their frequency of occurrence in the park, their movements, diet, and behavior can we expect to address these questions. Our research uses photographic identification of individuals to document which animals are seen in the park. We follow groups of whales using surface observations and acoustic monitoring to document predation events. These techniques help us determine prey preference and the frequency with which predation occurs. Finally, we are conducting acoustic research to document how the animals use their acoustic habitat and how anthropogenic noise may impact their ability to communicate.

The photographic identification of individual killer whales

Photographic identification of individual killer whales is the basis of all research on these uniquely marked animals. Information gained from long term photographic records is used to document births, deaths, associations with other individuals, age at first calving and behavioral parameters. This information is crucial to fully understanding killer whale population dynamics. At Glacier Bay NP&P, photographic records of killer whales date back to 1986. Researchers take black and white photographs of the left side of each whale, recording details of the dorsal fin and saddle patch. Identifiable whales are recorded, catalogued and compared to existing catalogs of whales from the west coast of North America.

One hundred fifty-six transient whales, members of the West Coast population, have been identified in southeastern Alaska *(see Figure 1)*, making transients the more numerous ecotype. In comparison, 122 killer whales of the resident ecotype have been documented. One transient female has been recorded in Glacier Bay every year since 1988. She is sighted most often in Glacier Bay in June and July, in constant company of her three offspring.

Whereas in many parts of their range, transient killer whales typically hunt in small groups of three to five individuals, in Glacier Bay it is not uncommon to see large groups of up to 35 whales *(Matkin et al. 2006)*. Such large groups are made up of members of several matrilines (family groups consisting of one female and her offspring) and groups may travel together for several days before breaking up. The function of such multi-matriline aggregations is currently not fully understood, but they are a rare occurrence in waters outside of Glacier Bay and Icy Strait, and may play an important role in social interactions between members of the West Coast Transient population.

Documenting killer whale predation

Decreases in marine mammal populations in western Alaska have led researchers to speculate that mammal-eating killer whales may have contributed to these declines and may be preventing recovery *(Springer et al. 2003)*. However, data to support this theory are currently scarce. Researchers are just beginning to recognize when predation occurs, and identifying the prey can be difficult because the whales often leave only small bits and pieces behind. In southeastern Alaska, most populations of prey species for transient killer whales (in particular, Steller sea lions, Dall's and harbor porpoises, and harbor seals) are stable or increasing in abundance. Glacier Bay, where harbor seals have declined over 70% during the past decade *(Mathews and Pendleton 2006)*, is a notable

exception. Interestingly, during the same time period in Glacier Bay, sea otters have increased from zero in 1992 to about 2,400 individuals in 2004 *(Bodkin et al. 2004, USGS unpublished data)*.

Our methods for observing predation take patience and perseverance. Once initial photo-identification is complete, we follow the killer whales at a slow, constant speed at a distance of 200 yards (183 m) or more while observing the group's behavior. We do not want to disrupt their normal traveling and foraging behavior. If we observe a change in behavior that may indicate predation, noting the exact time and location of the event, we approach to within 100 yards (91 m) and document any signs of a possible kill. For the smaller species that are quickly consumed, it is usually difficult to see an actual kill, but scavenging birds or the sudden onset of vocal behavior often provide cues that a kill has occurred. Larger prey such as Steller sea lions or Dall's porpoise take more time to subdue so that these kills are easier to detect. Once the kill has been completed, we attempt to identify the prey species using visual observation, photographic documentation and the recovery of small prey fragments for genetic analysis. To recover remains, we typically approach close to where the whales dove and gather tiny bits of skin and blubber from the water using a fine-mesh dip net *(see photo page 5)*. We do this quickly because nearby birds are often as keen as we are to recover prey remains.

Since 1986, feeding ecology studies in the Glacier Bay area have determined that West Coast Transients primarily take harbor seals (40%), harbor porpoises (23%), Steller sea lions (16%), seabirds (14%), Dall's porpoises (5%) and minke whales (2%). Transients rarely harass humpback whales or sea otters and have never been seen killing either species *(Matkin et al. 2006)*. Clearly, harbor seals are an important prey species in the waters of Glacier Bay. They may be even more important than our current research suggests because seal kills are difficult to detect, a fact that biases our predation estimates downward. As we become better at detecting predation, we hope to refine these rates to reflect the true importance of harbor seals in the diet of killer whales in Glacier Bay and in southeastern Alaska in general.

The vocal behavior of transient killer whales: Communication with costly calls

Killer whales are acoustic animals that rely primarily on sound for orientation, communication, and location of their prey (using echo-location or by listening for prey sounds). Vision is extremely limited underwater, but sound propagates freely through this medium and presents an effective channel to obtain information about their environment and to transmit information through it. However, acoustic communication is associated with costs, which are far greater for mammal-eating killer whales than for fish-eating whales.

The primary prey of resident killer whales, Pacific salmon, have poor hearing at the frequencies of killer whale communication, so eavesdropping is not a concern. Playback experiments have shown that harbor seals, the primary prey of transient killer whales, respond strongly to transient

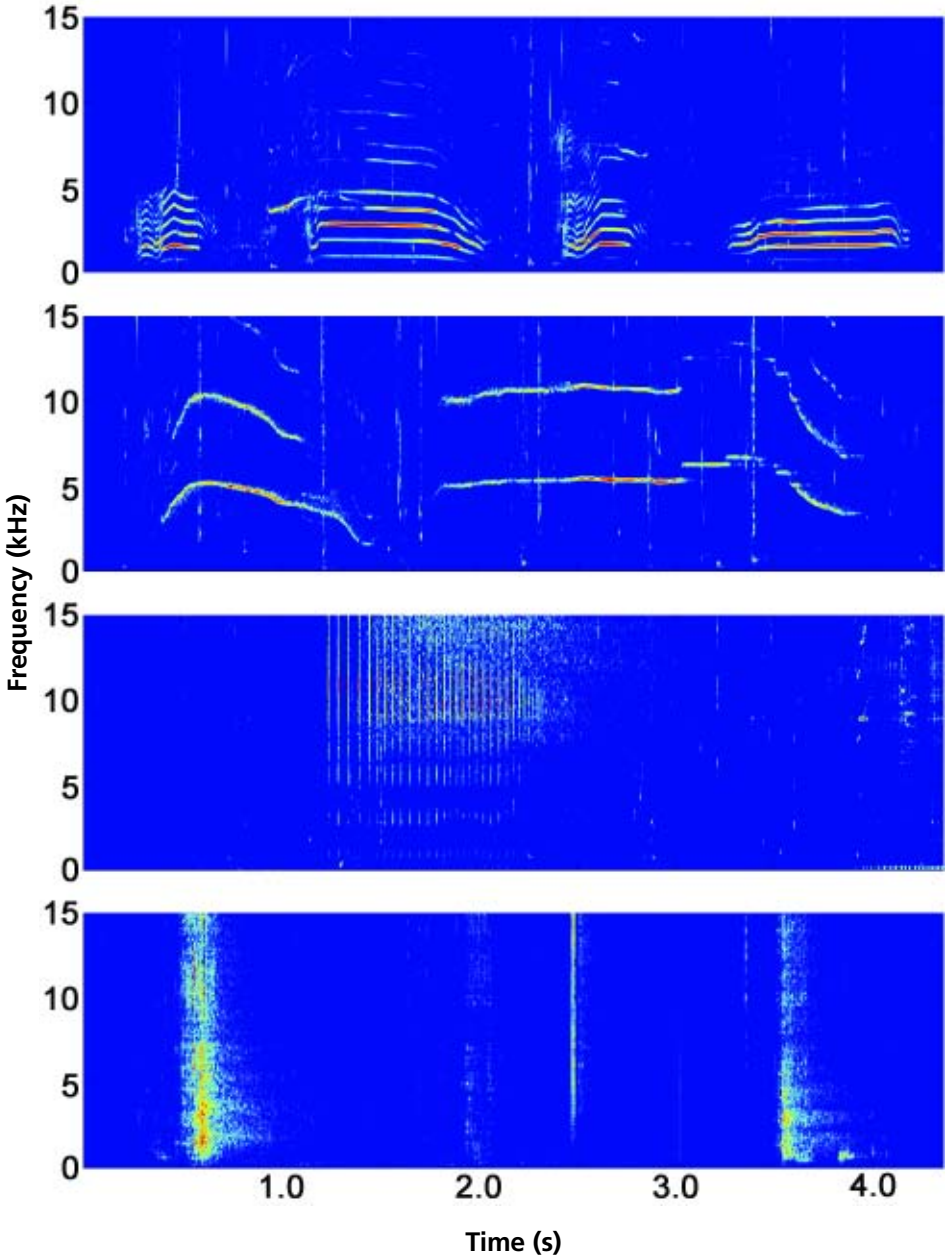

Figure 2. Spectrograms of pulsed calls, whistles, echolocation clicks and prey-handling sounds recorded from transient killer whales.

Photograph courtesy of Michael de Roos

Figure 3. Numerous research projects are running in parallel in Glacier Bay NP&P and provide a wealth of information to analyze interactions between species. This photo shows harbor seal PV05GB05 (foreground with radio tag) being attacked by transient killer whale T085A while humpback whale #1795 looks on.

calls *(Deecke et al. 2002)*. Transients probably risk warning their prey every time they call. One of the objectives of our acoustic research is to determine how this high cost has shaped vocal communication of transient killer whales.

The underwater environment can be a noisy place: up near the glaciers, melting bergs of glacier ice release millions of bubbles of air compressed by the weight of the glaciers, creating a loud curtain of white noise called ice fizz. This could mean that in addition to providing hiding spots on or amongst the floes, areas of floating ice near tidal glaciers provide an acoustic refuge for harbor seals, because the noise prevents killer whales from detecting seals acoustically. However, environmental noise can interfere with killer whale hearing throughout their range. Natural sounds include noise generated by waves, rain, or other animals. Increasingly, anthropogenic noise such as that generated by ships may be affecting the whales' ability to maintain contact and communicate with sound. Therefore, another objective of our acoustic research is to determine the effect of anthropogenic noise on the transient killer whales of Glacier Bay.

We are collecting data on the loudness of calls to understand the distance over which killer whales are able to hear each other and to determine the effect of human-generated noise on their communication. We also want to test if vocal communication is associated with specific behavior contexts and whether the animals call preferentially in certain locations within Glacier Bay. We are interested to find out whether transients call more quietly than residents in order to avoid detection by their marine mammal prey. To address these questions, we follow groups of killer whales while towing hydrophones (underwater microphones) to record their vocalizations and to determine the distance of a calling whale to our recording system. Knowing how far a vocalizing whale is away allows us to calculate how loud its call was when the whale made it.

Our results have shown that compared to resident killer whales, transients rarely vocalize and limit their sound communication to a few, narrowly defined behavior contexts. Transient killer whales typically hunt in silence and only vocalize after a successful kill *(Deecke et al. 2005)*, when other prey animals may already have been warned by the ramming and slapping sounds generated during the kill *(see Figure 2)*. In a few instances, we have also recorded vocal behavior that was indicative of social interactions between group members, not after an attack. Our preliminary results on the loudness of calls suggest that vocal behavior after an attack is significantly quieter than the calls of resident killer whales and is probably directed at other members of the hunting group. The differences between the vocal behavior of residents versus transients is probably due to the far more sensitive hearing of marine mammal prey. On occasion, however, we have recorded transient calls that were as loud as or louder than those of residents. This form of vocal behavior probably represents an attempt to establish acoustic contact with other distant groups in the area. Observational information collected in Glacier Bay and elsewhere suggests that these loud calls are audible over 20 miles (32 km).

Transient killer whales in Glacier Bay National Park: A synthesis

Conducting research in Glacier Bay NP&P brings the benefit of working in a location where numerous research projects are running in parallel. Researchers are studying the foraging behavior and population dynamics of harbor seals in Glacier Bay *(e.g., Mathews and Pendleton 2006)* providing us with a new perspective for analyzing the movement patterns and behavior of transient killer whales. Since 2001, the park has maintained a permanent hydrophone at Bartlett Cove to monitor underwater ambient noise levels and the loudness of shipping noise in the lower part of Glacier Bay *(Kipple and Gabriele 2003)*. We can use this information to better assess the effect of noise on killer whale communication. Detailed bathymetry and sound speed profiles are available for much of the bay *(Etherington et al. 2004)* allowing us to model the sound propagation and frequency-dependent attenuation of killer whale calls. This complementary research has provided a rich background of biological and geophysical information that allows us to obtain a far more comprehensive understanding on the behavior of transient killer whales and the role they play in their ecosystem *(see Figure 3)*.

Our findings suggest that the West Coast Transient killer whales play a significant role in Glacier Bay's ecology: they structure the marine mammal community and thereby

indirectly affect many other players in this complex marine food web. Just as transients are an important part of Glacier Bay, the park is important to West Coast Transients. Glacier Bay is the largest area of tidewater glaciers in the range of this population and may well be one of only a few areas capable of sustaining large groups of transient killer whales. Because of their high metabolic demand, killer whales can only form large groups in places where food is consistently abundant such as Glacier Bay with its seasonal concentration of harbor seals and other marine mammals. The frequency with which we observe large groups comprised of members of several matrilines suggests that this area is important for maintaining social processes in the West Coast Transient population. The large temporary aggregations of transients may play an important role in mate choice and in enforcing social bonds between members of the population that only encounter each other infrequently. In order to ensure the health of the West Coast Transient population of killer whales, it is therefore our responsibility as researchers, as managers, and as concerned citizens to ensure that the integrity of Glacier Bay's marine ecosystem is maintained for the future.

Acknowledgements

We would like to thank the staff of Glacier Bay National Park and Preserve for passing on killer whale sightings, as well as for logistic support with all aspects of our study. We are also very grateful for the sightings information supplied by commercial and recreational boaters in Glacier Bay and Icy Strait. We would like to thank the following people for providing killer whale identification photographs, data on predation events, and for helping with various aspects of our research project: Alex Andrews, Scott Baker, Lance Barrett-Lennard, Douglas Chadwick, Michael deRoos, Graeme Ellis, John Ford, Robert Harrison, Craig Matkin, Janet Neilson, Anjanette Perry, Patrick–Antony Presi, Eva Saulitis, Mark Schroeder, Justin Smith, and Harald Yurk. Funding came from Glacier Bay National Park and Preserve, the National Marine Mammal Laboratory, the National Atmospheric and Oceanic Administration through the North Pacific Universities Marine Mammal Consortium, the US Marine Mammal Commission, the Vancouver Aquarium, and the North Gulf Oceanic Society.

REFERENCES

Bodkin, J.L, B.E. Ballachey, K.A. Kloecker, G.G. Esslinger, D.H. Monson, H.A. Coletti, and J.A. Estes. 2004.
Sea Otter Studies in Glacier Bay National Park and Preserve. Annual Report to Glacier Bay National Park and Preserve.
US Geological Survey, Alaska Science Center.
Anchorage, AK.

Deecke, V.B., J.K.B. Ford, and P.J.B. Slater. 2005.
The vocal behaviour of mammal-eating killer whales (Orcinus orca): Communicating with costly calls.
Animal Behaviour 69:395-405.

Deecke, V.B., P.J.B. Slater, and J.K.B. Ford. 2002.
Selective habituation shapes acoustic predator recognition in harbour seals.
Nature 420:171-173.

Etherington, L.L., P.N. Hooge, and E.R. Hooge. 2004.
Factors affecting seasonal and regional patterns of surface water oceanographic properties within a fjord estuarine system: Glacier Bay, AK.
Gustavus AK: US Geological Survey, Alaska Science Center.

Ford, J.K.B., G.M. Ellis, L.G. Barrett-Lennard, A.B. Morton, R. Palm, and K.C. Balcomb. 1998.
Dietary specialization in two sympatric populations of killer whales (Orcinus orca) in coastal British Columbia and adjacent waters.
Canadian Journal of Zoology 76:1456-1471.

Goley, P.D., and J.M. Straley. 1994.
Attack on gray whales (Eschrichtius robustus) in Monterey Bay, California, by killer whales (Orcinus orca) previously identified in Glacier Bay, Alaska.
Canadian Journal of Zoology 72:1528-1530.

Kipple, B.M., and C.M. Gabriele. 2003.
Glacier Bay Underwater Noise - August 2000 through August 2002.
Naval Surface Warfare Center - Carderock Division.
Technical Report NSWCCD-71-TR-2004/521.

Mathews, E.A., and G.W. Pendleton. 2006.
Declines in harbor seal (Phoca vitulina) numbers in Glacier Bay National Park, Alaska, 1992-2002.
Marine Mammal Science 22:167-189.

Matkin, C.O., G.M. Ellis, E.L. Saulitis, L.G. Barrett-Lennard, and D.R. Matkin. 1999.
Killer Whales of Southern Alaska.
Homer AK: North Gulf Oceanic Society.

Matkin, D.R., J.M. Straley, and C.M. Gabriele. 2006.
Killer whale feeding ecology and non-predatory interactions with other marine mammals in the Glacier Bay region of Alaska. In *Proceedings of the Fourth Glacier Bay Science Symposium, 2004,*
edited by J.F. Piatt and S.M. Gende.
US Geological Survey/Information and Technology Report. USGS/BRD/ITR-2006-00XX. Washington, D.C.

Saulitis, E.L., C.O. Matkin, L.G. Barrett-Lennard, K.A. Heise, and G.M. Ellis. 2000.
Foraging strategies of sympatric killer whale (Orcinus orca) populations in Prince William Sound.
Marine Mammal Science 16:94-109.

Springer, A.M., Estes, J.A., van Vliet, G.B., Williams, T.M., Doak, D.F., Danner, E.M., Forney, K.A. and Pfister, B. 2003.
Sequential megafaunal collapse in the North Pacific Ocean: An ongoing legacy of industrial whaling?
Proceedings of the National Academy of Sciences of the United States of America, 100:12223-12228.