

**KILLER WHALE (*Orcinus orca*):
Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock**

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim, 1978, and Forney and Wade, 2006). Killer whales are found throughout the North Pacific. Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where pods have been labeled as ‘resident,’ ‘transient,’ and ‘offshore’ (Bigg et al. 1990, Ford et al. 2000) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994).

Several studies provide evidence that the ‘resident,’ ‘offshore,’ and ‘transient’ ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the ‘transient’ and ‘resident’ ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000).

Until recently, transient killer whales of Alaska had only been studied intensively in southeastern Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two communities of transients which were never found in association with one another, the so-called ‘Gulf of Alaska’ transients and ‘AT1’ transients. Neither of these communities associates with transient killer whales that range from California to southeastern Alaska, which has been termed the ‘west coast’ community. ‘Gulf of Alaska’ transients are seen throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients are primarily seen in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with ‘Gulf of Alaska’ transients. Transients that associate with the ‘Gulf of Alaska’ community have been found to have two mtDNA haplotypes, neither of which is found in the west coast or AT1 communities. Members of the AT1 community share a single mtDNA haplotype. Transient killer whales from the ‘west coast’ community have been found to share a single mtDNA haplotype that is not found in the other communities. Additionally, all three communities have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found, as well, as Saulitis (1993) described acoustic differences between ‘Gulf of Alaska’ transients and AT1 transients. For these reasons, the

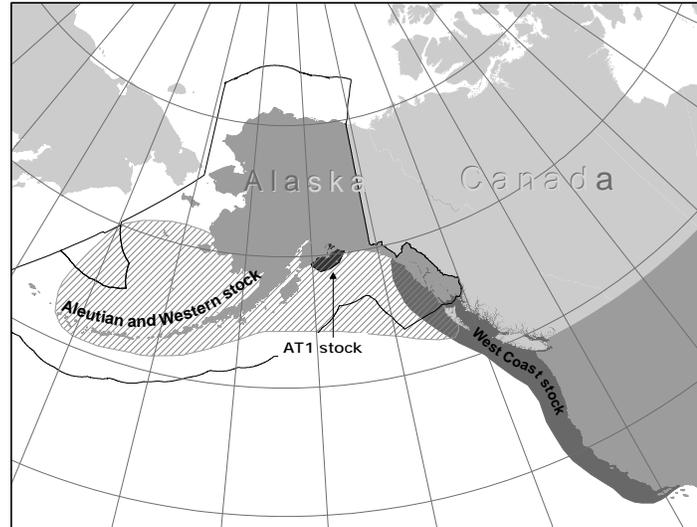


Figure 23. Approximate distribution of killer whales in the eastern North Pacific (shaded area). The distribution of the eastern North Pacific Resident and Transient stocks are largely overlapping (see text).

'Gulf of Alaska' transients are considered part of a population that is discrete from the AT1 population, and both of these communities are considered discrete from the 'west coast' transients.

Recent research in western Alaska, particularly along the south side of the Alaska Peninsula and in the eastern Aleutian Islands, have identified transient killer whales that share acoustic calls and mtDNA haplotypes with the Gulf of Alaska transients (NMML unpublished, North Gulf Oceanic Society unpublished), suggesting transient whales there may be part of the same population as Gulf of Alaska transients. However, samples from the central Aleutian Islands and Bering Sea have identified mtDNA haplotypes not found in Gulf of Alaska transients, suggesting the possibility there is some population structure in western Alaska. At this time, there are insufficient data to further resolve transient population structure in western Alaska. Therefore, transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes 'Gulf of Alaska' transients. Killer whales are also seen in the northern Bering Sea and Beaufort Sea, but little is known about these whales and they are assumed to be part of this stock if they are transient-type whales.

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (Saulitis 1993, Ford and Ellis 1999) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirms that three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients.

Based on data regarding association patterns, movements, acoustics, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from British Columbia through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea (see Fig. 23), 5) the AT1 transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. 'Transient' whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.

In recent years, a small number of the 'Gulf of Alaska' transients (identified by genetics and association) have been seen in southeastern Alaska; previously only 'west coast' transients had been seen in southeastern Alaska. Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock occupies a range that includes all of the U.S. EEZ in Alaska, though few individuals from this population have been seen in southeastern Alaska.

POPULATION SIZE

In January 2004 the North Gulf Oceanic Society (NGOS) and the National Marine Mammal Laboratory (NMML) held a joint workshop to match identification photographs of transient killer whales from this population. That analysis of photographic data resulted in the following minimum counts for 'transient' killer whales belonging to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock. In the Gulf of Alaska (east of the Shumagin Islands), 82 whales were identified by NGOs, including whales from Matkin et al. (1999) as well as whales identified in subsequent years (but not including whales identified as part of the AT1 population). NMML identified 43 whales and 11 matches were found between the NGOs and NMML catalogues. Therefore, a total of 114 transients (82 + 43 - 11) have been identified in the Gulf of Alaska. In the Aleutian Islands (west of and including the Shumagin Islands) and Bering Sea, the combined NGOs/NMML catalogue (D Ellifrit, North Gulf Oceanic Society, pers. comm.) now contains 438 whales (not counting two gulf of Alaska transient whales that have been photographed in that region). All have been photographed in the past ten years. Combining the Aleutian Islands and Bering Sea count (438) with the Gulf of Alaska count (114), a total count of 552 individual whales have been identified in catalogs of this stock.

NMML conducted killer whale line-transect surveys for 3 years in July and August in 2001-2003. These surveys covered an area from approximately Resurrection Bay in the Kenai Fjords to the central Aleutians. The surveys covered an area from shore to 30-45 nautical miles offshore, with randomly located transects in a zigzag pattern. Estimated transient killer whale abundance from these surveys, using post-encounter estimates of group size, was 249 (CV = 0.50), with 95% confidence interval of 99-628 (Zerbini et al. 2007).

Mark-recapture methods were used to estimate the number of mammal-eating "transient" killer whales using the coastal waters from the central Gulf of Alaska to the central Aleutian Islands, using photographs collected

during the three line-transect surveys (Zerbini et al. 2007), along with photographs collected from a variety of additional surveys during the same time period (Durban et al. in press). A total of 154 individuals were identified from 6,489 photographs collected between July 2001 and August 2003. A Bayesian mixture model estimated seven distinct clusters (95% Probability Interval = 7-10) of individuals that were differentially covered by 14 boat-based surveys exhibiting varying degrees of association in space and time, leading to a total estimate of 345 whales (95% Probability Interval = 255 – 487). This estimate is higher than the line-transect estimate for at least two reasons. First, the line-transect estimate provides an "instantaneous" (across ~40 days) estimate of the average number of transient killer whales in the survey area, whereas the mark-recapture methods provide an estimate of the total number of whales to use the survey area over the three years, which is known to be greater due to the long distance movements documented by satellite tags (J. Durban, Southwest Fisheries Science Center, pers. comm.). Second, the mark-recapture estimate included photographic data from a broader seasonal time period, and therefore includes transient killer whales documented in the False Pass/Unimak Island area in spring where they aggregate to prey on gray whales on migration (Matkin et al. 2007). Many of these whales have not been seen in that region in the summer. However, mark recapture estimates do not include most of the Bering Sea and Pribilof Islands.

It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as the Bering Sea and Pribilof Islands that were outside the line-transect survey area. The photo catalogue also encompasses a much longer time period (through 2008). Additionally, the number of whales in the photographic catalogue is a documentation of all whales seen in the area over the time period of the catalogue; movements of some individual whales have been documented between the line-transect survey area and locations outside the survey area. Accordingly, a larger number of transient killer whales may use the line-transect survey area at some point over the 3 years than would necessarily be found at one time in the survey area in July and August in a particular year.

Minimum Population Estimate

The 20th percentile of the line transect survey estimate is 167. The 20th percentile of the mark-recapture estimates of 345 is ~303. A total count of 552 individual whales have been identified in the Gulf of Alaska, Aleutian Islands, and Bering Sea transient killer whale stock. The photograph catalogue estimate of transient killer whales is a direct count of individually identifiable animals. However, the number of cataloged whales does not necessarily represent the number of live animals. Some animals may have died, but whales can not be presumed dead if not resighted because long periods of time between sightings are common for some 'transient' animals. The catalogue for the western area used data only from 1999 to 2009, decreasing the potential bias from using whales that may have died prior to the end of the time period. However, given that researchers continue to identify new whales, the estimate of abundance based on the number of uniquely identified individuals cataloged is likely conservative. The catalogue count is slightly higher than the 20th percentile of the mark-recapture estimates, in part because it included data from areas such as Prince William Sound and the Bering Sea that were outside the survey area.

Thus, the minimum population estimate (N_{MIN}) for the Gulf of Alaska, Aleutian Islands, and Bering Sea transient stock of killer whales is 552 animals based on the count of individuals using photo-identification.

Current Population Trend

At present, reliable data on trends in population abundance for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of 'resident' killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). Until stock-specific data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor (F_R) for this stock is 0.5,

the value for cetacean stocks with unknown population status with a mortality rate $CV \geq 0.80$ (Wade and Angliss 1997). Thus, for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale stock, $PBR = 5.5$ animals ($552 \times 0.02 \times 0.5$). The proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, Pacific Biological Station, Canada, pers. comm.)

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

In previous assessments, there were six different federal commercial fisheries in Alaska that could have had incidental serious injuries or mortalities of killer whales and were observed. In 2004, the definitions of these fisheries were changed to reflect target species; these new definitions have resulted in the identification of 22 observed fisheries that use trawl, longline, or pot gear. Of these fisheries, there were three which incurred serious injury and mortality of killer whales (any stock) between 2002 and 2006: the BSAI flatfish trawl, the BSAI pollock trawl, and the BSAI Pacific cod longline. The mean annual (total) mortality rate for all fisheries for 20002-20046 was 1.6 ($CV = 0.48$). Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006). A single serious injury/mortality event occurred in the BSAI Greenland turbot longline in 2007.

Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006). Over the past few years, observers have collected tissue samples of many of the killer whales which were killed incidental to commercial fisheries. Genetics analyses of samples from the killer whales have indicated that the mortalities incidental to the BSAI flatfish trawl and the BSAI Pacific cod fisheries are of the “resident” type, and mortalities incidental to the BSAI pollock trawl fishery are of the “transient” type (M. Dahlheim, NMML-AFSC, pers. comm.). Thus, the mean annual estimated level of serious injury and mortality of the Gulf of Alaska, Aleutian Islands, Bering Sea transient killer whale stock for 2002-2006 is 0.4/year (Table 29).

Table 29. Summary of incidental mortality of killer whales (Eastern North Pacific Transient stock) due to commercial fisheries and calculation of the mean annual mortality rate. Mean annual takes are based on 2002-2006 data. Data from 2007 and 2008 are preliminary; estimates of percent observer coverage and CVs are not currently available for some preliminary data. Details of how percent observer coverage is measured is included in Appendix 6.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
BSAI pollock trawl	2002	obs data	80.0	1	1	0.41 (CV = 0.22)
	2003		82.2	0	1 ¹	
	2004		81.2	0	0	
	2005		77.3	0	0	
	2006		73.0	0	0	
	2007		95.0	0	0	
	2008		88.6	0	0	
BSAI Greenland turbot longline	2007	obs data	68.9	1 ²	1.5	0.75 (CV = 0.56)
	2008		—	0	0	
Estimated total annual takes						0.41 (CV = 0.22)

¹ Killer whale mortality seen by the observer, but not in a monitored haul.

² Genetics are not available to confirm whether this observed mortality was of a resident or transient killer whale. Thus, this mortality will be reflected in both SARs.

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska or Canada.

Other Mortality

Collisions with boats are another source of mortality. One mortality due to a ship strike occurred in 1998, when a killer whale was struck by a propeller of a vessel in the Bering Sea groundfish trawl fishery.

Other Issues

Killer whales are known to predate on longline catch in the Bering Sea (Dahlheim 1988; Yano and Dahlheim 1995; Perez 2003; Perez 2006; Sigler et al. 2003) and in the Gulf of Alaska (Sigler et al. 2003, Perez 2006). In addition, there are many reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels (Perez 2006). However, the ‘resident’ stock of killer whales is most likely to be involved in such fishery interactions since these whales are known to be fish eaters, while ‘transient’ whales have only been observed feeding on marine mammals.

STATUS OF STOCK

The Gulf of Alaska, Aleutian Islands, and Bering Sea transient stock of killer whales is not designated as “depleted” under the MMPA or listed as “threatened” or “endangered” under the Endangered Species Act. Based on currently available data, the estimated annual U. S. commercial fishery-related mortality level (0.4) exceeds 10% of the PBR (0.3) and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury (0.4 animals per year) is less than the PBR (3.1). Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population (OSP) level are currently unknown.

CITATIONS

- Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. *Can. J. Zool.* 66 (11):2582-2585.
- Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. *Oecologia* 89:125-132.
- Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. *Fish. Bull., U.S.* 93:1-14.
- Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25 pp.
- Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales as revealed by DNA analysis. Doctoral thesis. Univ. British Columbia, Vancouver, BC, Canada.
- Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Pp. 386-406 *In* Hammond, P. S., S. A. Mizroch, and G. P. Donovan (eds.), *Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters*. Rep. Int. Whal. Comm. Special Issue 12.
- Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643-646.
- Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). *Ecology* 74(5):1444-1454.
- Dahlheim, M. E. 1988. Killer whale (*Orcinus orca*) depredation on longline catches of sablefish (*Anoplopoma fimbria*) in Alaskan waters. NWAFC Processed Rep. 88-14, 31 pp. (Available online: <http://www.afsc.noaa.gov/Publications/ProcRpt/PR%2088-14.pdf>).
- Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 pp. + appendices.
- Durban, J., Ellifrit, D., Dahlheim, M., Waite, J., Matkin, C., Barrett-Lennard, L., Ellis, G., Pitman, R., LeDuc, R., and Wade, P.R. 2010. Photographic mark-recapture analysis of clustered mammal-eating killer whales around the Aleutian Islands and Gulf of Alaska. *Mar. Biol.* 157:1591-1604.
- Ford, J. K. B., and G. M. Ellis. 1999. Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska. University of British Columbia Press, Vancouver, BC. 96 pp.
- Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Comm. 32:671-679.

- Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 102 pp.
- Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer whales: The natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. Second edition. University of British Columbia Press, Vancouver, BC, Canada.
- Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull., U.S. 93:15-26.
- Forney, K. A., and P. R. Wade. 2006. World-wide abundance and density of killer whales. Pp. 145-162. In J. A. Estes, D. P. DeMaster, D. F. Doak, T. M. Williams, and R. L. Brownell, Jr. (eds.), Whales, Whaling, and Ocean Ecosystems. University of California Press.
- 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. Can. J. Zool. 72:1528-1530.
- Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pp. 1-100 In Brueggeman, J. J. (ed.), Oregon and Washington Marine Mammal and Seabird Surveys. Final Rep. OCS Study MMS 91-0093.
- Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.
- Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the Eastern North Pacific, and genetic differentiation between foraging specialists. J. Heredity 89:121-128.
- Hoelzel, A. R., A. Natoli, M. Dahlheim, C. Olavarria, R. Baird and N. Black. 2002. Low Worldwide genetic diversity in the killer whale (*Orcinus orca*): implications for demographic history. Proc. R. Soc. Lond. 269: 1467-1473.
- Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.
- Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Nat. 104:362-371.
- Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society. 96 pp.
- Matkin C. O., L. G. Barrett-Lennard, H. Yurk, D. Ellifrit, A. W. Trites. 2007. Ecotypic variation and predatory behavior among killer whales (*Orcinus orca*) off the eastern Aleutian Islands, Alaska. Fish. Bull., U.S. 105: 74-87.
- Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Bd. Can. 32:914-916.
- Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. Special Issue 12:209-242.
- Perez, M. A. 2003. Compilation of marine mammal-fisheries interaction data from the domestic and joint venture groundfish fisheries in the U.S. EEZ of the North Pacific, 1989-2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-138. 145 pp.
- Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167.
- Saulitis, E. L. 1993. The behavior and vocalizations of the "AT" group of killer whales (*Orcinus orca*) in Prince William Sound, Alaska. MS thesis, University of Alaska, Fairbanks.
- Sigler, M. F., C. R. Lunsford, J. T. Fujioka, and S. A. Lowe. 2003. Alaska sablefish assessment for 2004. In Stock Assessment and Fishery Evaluation Report for the Groundfish Fisheries of the Bering Sea/Aleutian Islands Regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, Section 3:223-292.
- Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

- Yano, K., and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish. Bull., U.S. 93:355-372.
- Zerbini, A. N., J. M. Waite, J. Durban, R. LeDuc, M. E. Dahlheim and P. R. Wade. 2007. Estimating abundance of killer whales in the nearshore waters of the Gulf of Alaska and Aleutian Islands using line-transect sampling. Mar. Biol. 150(5):1033-1045.