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

NOTE – NMFS has preliminary genetic information on killer whales in Alaska which indicates that the current stock structure of killer whales in Alaska needs to be reassessed. NMFS is evaluating the new genetic information. In the interim, new information on killer whale mortality levels is provided within this report. A complete revision of the killer whale stock assessments will be postponed until the stock structure evaluation is completed and any new stocks are identified.

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, 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 Alaska 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 whales have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) 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; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals, 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, Black et al. 1997, Dahlheim and White 2010).

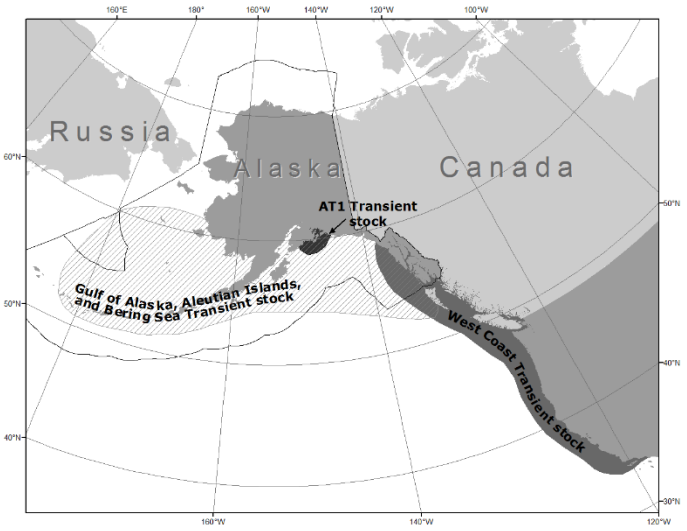

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text).

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). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2012). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

Until recently, transient killer whales in Alaska had only been studied intensively in Southeast 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 populations of transients which were never found in association with one another, the so-called "Gulf of Alaska" transients and "AT1" transients. Gulf of Alaska transients are documented 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. Recently, on one occasion, members of the Gulf of Alaska transient population were seen in association with the transient killer whales that range from California to southeastern Alaska, the West Coast Transients, which are identified by a unique mtDNA haplotype (Matkin et al. 2012). Photographs have identified 14 out of 217 whales considered "outer coast" transients in British Columbia that were also photographed in Alaska waters and considered Gulf of Alaska transients (Matkin et al. 2012, Ford et al. 2013). Transients that are within the Gulf of Alaska population have been found to have two mtDNA haplotypes, neither of which is found in the West Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the West Coast stock have been found to share a single mtDNA haplotype that is not found in the other stocks. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found between these stocks by Saulitis (1993) and Saulitis et al. (2005). For these reasons, the 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.

Biopsy samples from the eastern Aleutians and south side of the end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska; however, nuclear DNA analysis strongly suggest they belong to a separate population (Parsons et al. 2013). Samples from the central Aleutian Islands and Bering Sea have identified mtDNA haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. At this time 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 observed in the northern Bering Sea and Beaufort Sea that have the physical characteristics of transient type whales, but little is known about these 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) confirm that at least 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 (Fig. 1).

Based on data regarding association patterns, acoustics, movements, 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 Washington State 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 southeastern Alaska 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, 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 Marine Mammal Laboratory (MML) 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). MML identified 43 whales

and 11 matches were found between the NGOS and MML catalogues. Since that time an additional 22 whales have been added to the NGOS catalogue (Matkin et al. in prep.). Therefore, a total of 136 transients (104 + 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/MML catalogue (NGOS/MML 2012) now contains 451 individually identifiable whales (not counting unmarked calves and 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 (451) with the Gulf of Alaska count (136), a total count of 587 individual whales have been identified in catalogues of this stock.

MML 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 a 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. 2010). 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 2012). 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 587 individual whales have been identified in the photograph catalogues from the Gulf of Alaska (Matkin et al. in prep.) and from western Alaska (NGOS/MML 2012). The photograph catalogue estimate of transient killer whales is a direct count of individually identifiable animals. However, the number of catalogued whales does not necessarily represent the number of live animals. Some animals may have died, but whales cannot 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 2001-2012, 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 and the entire range has not been surveyed, the estimate of abundance based on the number of uniquely identified individuals catalogued is likely conservative. The catalogue count is slightly higher than the 20 th 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 587 animals based on the count of individuals using photo-identification.

Current Population Trend

Recently Matkin et al. (2012) analyzed photographic data collected since 1984 and determined Gulf of Alaska transients in the northern Gulf of Alaska have had stable numbers. At present, reliable data on trends in population abundance for the Aleutian Islands and Bering Sea portion of this 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 = 5.87 animals (587 × 0.02 × 0.5). Although only a few individuals have been observed in Canadian waters, 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

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Three of the federally-regulated U.S. commercial fisheries, monitored for incidental mortality and serious injury of marine mammals by fishery observers, incurred serious injury and mortality of killer whales (unknown stock) in 2010-2014: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands rockfish trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data).

Fishery observers have collected tissue samples from many of the killer whales that were killed incidental to U.S. commercial fisheries. Genetic analyses of samples from seven killer whales collected between 1999 and 2004 have confirmed that Alaska Resident killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands flatfish trawl (n = 3) and Bering Sea/Aleutian Islands Pacific cod longline fisheries (n = 1) and that Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands pollock trawl fishery (n = 3) (M. Dahlheim, NMFS-AFSC-MML, pers. comm., 20 February 2013). Given the overlap in the range of transient and resident stocks in Alaska waters, unless genetic samples can be collected from animals injured or killed by gear or the ship's propeller, these events are assigned to both the transient and resident stock occurring in that area. Thus, the estimated mean annual mortality and serious injury rate of one killer whale in 2010-2014 will be assigned to both the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and the Alaska Resident stocks of killer whales (Table 1).

Typically, if mortality or serious injury occurs incidental to U.S. commercial fishing, it is due to interactions with the fishing gear. However, reports indicate that observed killer whale mortality incidental to Bering Sea/Aleutian Islands trawl fisheries often occurs due to contact with the ship's propeller (e.g., the 2010 mortality in the Bering Sea/Aleutian Islands rockfish trawl fishery).

Table 1. Summary of incidental mortality and serious injury of Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010	obs data	99	0	0	0.4 (+0.2)[c] (CV = 0)
	2011		100	0	0	
	2012		99	0 (+1)[a]	0 (+1)[b]	
	2013		99	2	2	
	2014		99	0	0	
Bering Sea/Aleutian Is. rockfish trawl	2010	obs data	99	1	1	0.2 (CV = 0)
	2011		99	0	0	
	2012		100	0	0	
	2013		99	0	0	
	2014		99	0	0	
Bering Sea/Aleutian Is. Pacific cod longline	2010	obs data	64	0	0	0 (+0.2)[f] (CV = N/A)
	2011		57	0	0	
	2012		51	0 (+1)[d]	0 (+1)[e]	
	2013		66	0	0	
	2014		64	0	0	
Minimum total estimated annual mortality						1 (CV = 0)

[a]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0.4 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
[d]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[e]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[f]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2010-2014 is one Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale, based on observer data (Table 1).

Subsistence/Native Harvest Information

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

Other Mortality

Collisions with boats may be an occasional source of mortality or serious injury of killer whales. For example, a killer whale struck the propeller of a vessel in the Bering Sea/Aleutian Islands rockfish trawl fishery in 2010 (Table 1).

Other Issues

Killer whales are known to depredate longline catches in the Bering Sea (Dahlheim 1988; Yano and Dahlheim 1995; Perez 2003, 2006; Sigler et al. 2003) and in the Gulf of Alaska (Sigler et al. 2003, Perez 2006). In addition, there have been many reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels (Perez 2006). However, resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

STATUS OF STOCK

The Eastern North Pacific 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, a minimum estimate of the mean annual mortality and serious injury rate due to U.S. commercial fisheries (1 whale) is greater than 10% of the PBR (10% of PBR = 0.6) and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. A minimum estimate of the total annual level of human-caused mortality and serious injury (1 whale) is less than the PBR (5.9). 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 are currently unknown.

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