

Revised 12/30/2016

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Alaska Resident 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 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, Black et al. 1997, Dahlheim and White 2010).

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). 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.

Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Within the resident ecotype, association data were used to

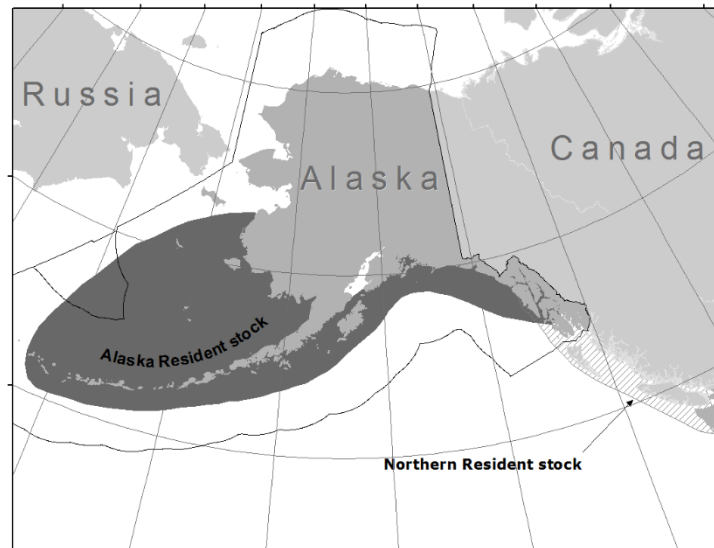


Figure 1. Approximate distribution of resident killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text).

describe three separate populations in the North Pacific: Southern Residents, Northern Residents, and Alaska Residents (Bigg et al. 1990; Ford et al. 1994, 2000; Dahlheim et al. 1997; Matkin et al. 1999). In previous stock assessment reports, the Alaska and Northern Resident populations were considered one stock. Acoustic data (Ford 1989, 1991; Yurk et al. 2002) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) have now confirmed that these three units represent discrete populations. The Southern Resident population is found in summer primarily in waters of Washington state and southern British Columbia and has never been seen to associate with other resident stocks. The Northern Resident population is found in summer primarily in central and northern British Columbia. Members of the Northern Resident population have been documented in southeastern Alaska; however, they have not been seen to intermix with Alaska Residents (Fig. 1). Alaska Resident whales are found from southeastern Alaska to the Aleutian Islands and Bering Sea. Intermixing of Alaska Residents have been documented among the three areas, at least as far west as the eastern Aleutian Islands.

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.

Resident killer whales ranging from Southeastern Alaska to Kodiak Island have been observed in regular association during multipod encounters since 1984 (Matkin et al. 2010). Tagging data also indicates the range of killer whales seen in these aggregations extends from Southeastern Alaska to south of Kodiak Island (Matkin et al. 2010). Although recent studies have documented movements of Alaska Resident killer whales from the Bering Sea into the Gulf of Alaska as far north as southern Kodiak Island, none of these whales have been photographed further north and east in the Gulf of Alaska where regular photoidentification studies have been conducted since 1984 (P. Wade, pers. comm., MML-AFSC, Seattle, WA, 10 December 2012; unpublished data; Matkin et al. 2010). The resident-type killer whales encountered in western Alaska possibly belong to groups that are distinct from the groups of resident killer whales in the Gulf of Alaska because no call syllables or call patterns (sequence of syllables) between groups were found to match (Matkin et al. 2007).

POPULATION SIZE

The Alaska Resident stock includes killer whales from southeastern Alaska to the Aleutian Islands and Bering Sea. Preliminary analysis of photographic data resulted in the following minimum counts for resident killer whales belonging to the Alaska Resident stock (Note: individual whales have been matched between geographical regions and missing animals likely to be dead have been subtracted). In southeastern Alaska, 109 resident whales have been identified as of 2009 (MML and North Gulf Oceanic Society (NGOS), 3430 Main Street, Suite B1, Homer, Alaska; unpublished data). In Prince William Sound and Kenai Fjords, another 675 resident whales have been identified as of 2009 (Matkin et al. 2003; C. Matkin, North Gulf Oceanic Society, pers. comm.).

Beginning in 2001, dedicated killer whale studies were initiated by the NMFS Marine Mammal Laboratory (MML) in Alaska waters west of Kodiak Island, including the Aleutian Islands and Bering Sea. Between 2001 and 2009, using field assessments based on morphology, association data, and genetic analyses, additional resident whales were added to the Alaska Resident stock. Internal matches within the MML data set have been subtracted, resulting in a final count of western Alaska residents for 2001-2012 as 1,475 whales. Studies conducted in western Alaska by the NGOs have resulted in the collection of photographs of approximately 600 resident killer whales; however, the NGOs and MML data sets have not yet been matched so it is unknown how many of these 600 animals are included in the MML collection. Another 41 whales were identified off Kodiak between 2000 and 2003 by the NGOs. These whales are added to the total of western Alaska residents although they have not been matched to MML photographs.

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. A total of 9,053 km of tracklines were surveyed between the Kenai Peninsula (~150°W) and Amchitka Pass

(~179°W). A total of 41 on-effort sightings of killer whales were recorded, with an additional 16 sightings off-effort. Estimated abundance of resident killer whale from these surveys was 991 (CV = 0.52), with a 95% confidence interval of 380-2,585 (Zerbini et al. 2007).

The line transect surveys provide an “instantaneous” (across ~40 days) estimate of the number of resident killer whales in the survey area. It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as Prince William Sound and the Bering Sea that were outside the line-transect survey area. 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 resident 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.

Combining the counts of known resident whales gives a minimum number of 2,347 (Southeast Alaska + Prince William Sound + Western Alaska; 121 + 751 + 1,475) killer whales belonging to the Alaska Resident stock (Table 1).

Table 1. Numbers of animals in each pod of killer whales belonging to the Alaska Resident stock of killer whales. A number followed by a “+” indicates a minimum count for that pod.

Pod ID	1999/2000 estimate (and source)	2001/2004 estimate (and source)	2005-2012 estimate (and source)
Southeast Alaska			33 (Matkin et al. in prep.)
AF22			
AF5	49 (Dahlheim et al. 1997, Matkin et al. 1999)	61 (C. Matkin, NGOS, pers. comm.)	46 (Matkin et al. in prep.)
AG	27 (Dahlheim et al. 1997, Matkin et al. 1999)	33 (C. Matkin, NGOS, pers. comm.)	42 (Matkin et al. in prep.)
AZ	23+ (Dahlheim, AFSC-MML, pers. comm.)	23+ (Dahlheim et al. 1997)	Not seen since prior to 1997
Total, Southeast Alaska	99+	117+	121 (excluding AZ)
Prince William Sound	Matkin et al. 1999	Matkin et al. 2003 and C. Matkin, NGOS, pers. comm.	Matkin et al. in prep.
AA1	---	8	8
AA30	---	---	24
AB	25	19	20
AB25	---	10	19
AD05	---	16	22
AD16	7	4	9
AE	16	19	17
AH01		9	9
AH20		12	12
AI	7	7	8
AJ	38	42	57
AK	12	13	19
AL	---	---	23
AN10	20	27	36
AN20	assume 9	33	30
AS2	assume 20	21	31
AS30		14	19
AW		24	27
AX01	21	20	33
AX27		24	26
AX32		15	18
AX40		14	16
AX48		20	23
AY	assume 11	18	21
Unassigned to pods	138 (C. Matkin, NGOS, pers. comm.)	112	220

Pod ID	1999/2000 estimate (and source)	2001/2004 estimate (and source)	2005-2012 estimate (and source)
Total, Prince William Sound/ Kenai Fjord/ Kodiak	341	501	751
Western Alaska	Dahlheim et al. 1997 and MML unpublished data²	2001/2003 MML unpublished data²	2001-2012 MML/NGOS unpublished catalog²
Unassigned to pods (MML)	68+	464	1,475 (H. Fearnbach, NOAA-SWFSC, pers. comm., April 2013)
Total, Western Alaska	68+	505	1,475
Total, all areas	507	1,123	2,347¹

¹Although there is strong evidence (Matkin et al. 2003, 2010) the resident killer whale numbers have been increasing in the Gulf of Alaska, the bulk of the increase from the 2001-2004 counts to the 2005-2009 counts is believed to be due to the discovery of new animals, not recruitment. Animals reported here have been photographed in the 2001-2012 period. ²Available from M. Dahlheim, Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

Minimum Population Estimate

The survey technique utilized for obtaining the abundance estimate of killer whales is a direct count of individually identifiable animals. Thus the minimum population estimate (N_{MIN}) for the Alaska Resident stock of killer whales based on photo-identification studies conducted between 2005-2009 is 2,084 animals (Table 1). Other estimates of the overall population size (i.e., N_{BEST}) and associated $CV(N)$ are not currently available. Given that researchers continue to identify new whales, the estimate of abundance based on the number of uniquely identified individuals known to be alive is likely conservative. However, the rate of discovering new resident whales within southeastern Alaska and Prince William Sound is relatively low (MML, unpublished data). Conversely, the rate of discovery of new whales in western Alaska was initially high (i.e., 2001 and 2002 field seasons). However, recent photographic data collected during 2003 and 2004 indicates that the rate of discovering new individual whales has decreased.

Using the line-transect estimate of 991 ($CV = 0.52$) results in an estimate of N_{MIN} (20th percentile) of 656. This is lower than the minimum number of individuals identified from photographs in recent years, so the photographic catalogue number is used for PBR calculations.

Some overlap of Northern Resident whales occur with the Alaska Resident stock in southeastern Alaska. However, information on the percentage of time that the Northern Resident stock spends in Alaska waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1996).

Current Population Trend

Data from Matkin et al. (2003) indicate that the component of the Alaska Resident stock that summers in the Prince William Sound and Kenai Fjords area is increasing. With the exception of AB pod, which declined drastically after the *Exxon Valdez* oil spill and has not yet recovered, the component of the Alaska Resident stock in the Prince William Sound and Kenai Fjords area increased 3.2% (95% CI = 1.94 to 4.36%) per year from 1990 to 2005 (Matkin et al. 2008). Although the current minimum population count of 2,084 is higher than the last population count of 1,123, examination of only count data does not provide a direct indication of the net recruitment into the population. At present, reliable data on trends in population abundance for the entire Alaska Resident 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), and 3.3% over the period 1984-2002 (Matkin et al. 2003). Until additional 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 (Wade and Angliss 1997). Thus, for the Eastern North Pacific Alaska Resident killer whale stock, $PBR = 24$ animals ($2,347 \times 0.02 \times 0.5$).

ANNUAL 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 mortality and serious injury of killer whales (unknown stock) between 2010 and 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 Alaska Resident and Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stocks of killer whales (Table 2; Breiwick 2013; MML, unpubl. data).

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 the 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 2. Summary of incidental mortality and serious injury of Alaska Resident 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	

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
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)

^aTotal mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.

^bTotal 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).

^cMean 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).

^dTotal mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.

^eTotal 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).

^fMean 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 Alaska Resident killer whale, based on observer data (Table 2).

Subsistence/Native Harvest Information

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

Other Mortality

During the 1992 killer whale surveys conducted in the Bering Sea and western Gulf of Alaska, 9 of 182 (4.9%) individual whales in 7 of the 12 (58%) pods encountered had evidence of bullet wounds (Dahlheim and Waite 1993). The relationship between wounding due to shooting and survival is unknown. In Prince William Sound, the pod responsible for most of the fishery interactions experienced a high level of mortality: between 1986 and 1991, 22 whales out of a pod of 37 (59%) disappeared (Matkin et al. 1994). The cause of death for these whales is unknown, but it may be related to gunshot wounds or effects of the *Exxon Valdez* oil spill (Dahlheim and Matkin 1994). It is unknown who was responsible for shooting at killer whales.

There have been no obvious bullet wounds observed on killer whales during surveys in the Bering Sea and western Gulf of Alaska (J. Durban, NMFS-SWFSC, pers. comm.). However, researchers have reported that killer whale pods in certain areas exhibit vessel avoidance behavior, which may indicate that shootings occur in some places.

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). Resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

Fisheries observers report that large groups of killer whales in the Bering Sea follow vessels for days at a time, actively consuming the processing waste (NMFS-AFSC, Fishery Observer Program, unpubl. data). On some vessels, the waste is discharged in the vicinity of the vessel's propeller (NMFS, unpubl. data); consumption of the processing waste in the vicinity of the propeller may be the cause of the propeller-caused mortalities of killer whales in the trawl fisheries.

STATUS OF STOCK

The Eastern North Pacific Alaska Resident stock of killer whales is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. The minimum abundance estimate for the Alaska Resident stock is likely underestimated because researchers continue to encounter new whales in the

Gulf of Alaska and western Alaska waters. Because the population estimate is likely to be conservative, the PBR is also conservative.

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 less than 10% of the PBR (10% of PBR = 2.4) and, therefore, is 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 not known to exceed the PBR (24). Therefore, the Eastern North Pacific Alaska Resident 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.

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. Southwest Fisheries Science Center Administrative Report LJ-97-11, 25 p. Available from SWFSC, NMFS, 8901 La Jolla Shores Drive, La Jolla, CA 92037.
- Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales (*Orcinus orca*) as revealed by DNA analysis. Ph.D. Dissertation, University of British Columbia, Vancouver, BC, Canada. 97 p.
- 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, p. 386-406. In P. S. Hammond, 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.
- Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247, 174 p.
- 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.
- Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.
- Committee on Taxonomy. 2012. List of marine mammal species and subspecies. Society for Marine Mammalogy, www.marinemammalscience.org, consulted on 12 December 2012.
- Dahlheim, M. E. 1988. Killer whale (*Orcinus orca*) depredation on longline catches of sablefish (*Anoplopoma fimbria*) in Alaskan waters. NWAFC Processed Report 88-14, 31 p. Available online: <http://www.afsc.noaa.gov/Publications/ProcRpt/PR%2088-14.pdf>. Accessed December 2016.
- Dahlheim, M. E., and C. O. Matkin. 1994. Assessment of injuries to Prince William Sound killer whales, p. 163-171. In T. R. Loughlin (ed.), *Marine Mammals and the Exxon Valdez*. Academic Press, Inc., San Diego, CA.
- Dahlheim, M. E., and J. M. Waite. 1993. Abundance and distribution of killer whales (*Orcinus orca*) in Alaska in 1992. Annual report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.
- Dahlheim, M. E., and P. A. White. 2010. Ecological aspects of transient killer whales (*Orcinus orca*) as predators in southeastern Alaska. *Wildl. Biol.* 16:308-322.
- 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 p. + appendices.
- Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit, and K. C. Balcomb. 2008. Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): occurrence, movements, and insights into feeding ecology. *Mar. Mammal Sci.* 24:719-729.

- DeMaster, D. P. 1996. Minutes from the 11-13 September 1996 meeting of the Alaska Scientific Review Group, Anchorage, Alaska. 20 p. + appendices. Available from Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.
- Ford, J. K. B. 1989. Acoustic behaviour of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. *Can. J. Zool.* 67(3):727-745.
- Ford, J. K. B. 1991. Vocal traditions among resident killer whales (*Orcinus orca*) in coastal waters of British Columbia. *Can. J. Zool.* 69(6):1454-1483.
- Ford, J. K. B. 2011. Killer whales of the Pacific Northwest coast: from pest to paragon. *Whalewatcher* 40(1):15-23.
- 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. 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 p.
- 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. 104 p.
- Forney, K. A., and P. R. Wade. 2006. World-wide abundance and density of killer whales, p. 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.
- 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.
- 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, p. 1-100. *In* J. J. Brueggeman (ed.), *Oregon and Washington marine mammal and seabird surveys. Final Report 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. Hered.* 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. O., G. M. Ellis, M. E. Dahlheim, and J. Zeh. 1994. Status of killer whales in Prince William Sound, 1985-1992, p. 141-162. *In* T. R. Loughlin (ed.), *Marine Mammals and the Exxon Valdez*. Academic Press, Inc., San Diego, CA.
- Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society. 96 p.
- Matkin, C. O., G. Ellis, L. Barrett-Lennard, H. Yurk, E. Saulitis, D. Scheel, P. Olesiuk, and G. Ylitalo. 2003. Photographic and acoustic monitoring of killer whales in Prince William Sound and Kenai Fjords. *Exxon Valdez Oil Spill Restoration Project 030012, Final Report*, North Gulf Oceanic Society, 60920 Mary Allen Ave, Homer, AK 99603. 118 p.
- Matkin, C. O., L. Barrett-Lennard, H. Yurk, D. Ellifrit, and A. Trites. 2007. Ecotypic variation and predatory behavior of killer whales *Orcinus orca* in the eastern Aleutian Islands, Alaska. *Fish. Bull., U.S.* 105:74-87.
- Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* 356:269-281.
- Matkin, C. O., G. Ellis, D. Herman, E. Saulitis, R. Andrews, A. Gaylord, and H. Yurk. 2010. Monitoring, tagging, acoustics, feeding habits and restoration of killer whales in Prince William Sound/Kenai Fjords 2003-2009. EVOS Trustee Council Restoration Project 090742 Final Report, North Gulf Oceanic Society, Homer, AK.

- Matkin, C. O., G. Ellis, D. Herman, E. Saulitis, R. Andrews, and A. Gaylord. In prep. Monitoring, tagging, feeding habits and restoration of killer whales in Prince William Sound/Kenai Fjords 2010-2012. EVOS Trustee Council Restoration Project 10100742 Final Report, North Gulf Oceanic Society, Homer, Alaska.
- Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32:914-916.
- Morin, P. A., F. I. Archer, A. D. Foote, J. Vilstrup, E. E. Allen, P. R. Wade, J. W. Durban, K. M. Parsons, R. Pitman, L. Li, P. Bouffard, S. C. A. Nielsen, M. Rasmussen, E. Willerslev, M. T. P. Gilbert, and T. Harkins. 2010. Complete mitochondrial genome phylogeographic analysis of killer whales (*Orcinus orca*) indicates multiple species. Genome Res. 20:908-916.
- 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 p.
- 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, 194 p.
- Riesch, R., L. G. Barrett-Lennard, G. M. Ellis, J. K. B. Ford, and V. B. Deecke. 2012. Cultural traditions and the evolution of reproductive isolation: ecological speciation in killer whales? Biol. J. Linn. Soc. 106:1-17.
- 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 Pacific Fishery Management 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 p.
- 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.
- Yurk, H., L. Barrett Lennard, J. K. B. Ford, and C. O. Matkin. 2002. Cultural transmission within maternal lineages: vocal clans in resident killer whales in southern Alaska. Anim. Behav. 63:1103-1119.
- 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.