

- WÜRSIG, B., AND C. CLARK. 1993. Behavior. Pages 157–199 in J. J. Burns, J. J. Montague and C. J. Cowles, eds. The bowhead whale. Special Publication Number 2. The Society for Marine Mammalogy, Lawrence, KS.
- WÜRSIG, B., E. M. DORSEY, M. A. FRAKER, R. S. PAYNE, W. J. RICHARDSON AND R. S. WELLS. 1984. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: surfacing, respiration, and dive characteristics. Canadian Journal of Zoology 10:1910–1921.
- WÜRSIG, B., E. M. DORSEY, M. A. FRAKER, R. S. PAYNE AND W. J. RICHARDSON. 1985. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: A description. Fishery Bulletin, U.S. 83:357–377.

BERND WÜRSIG, Texas A&M University at Galveston, Department of Marine Biology, Galveston, Texas 77551, U.S.A.; e-mail: wursigb@tamug.tamu.edu; WILLIAM R. KOSKI and W. JOHN RICHARDSON, LGL Ltd., environmental research associates, 22 Fisher St., P. O. Box 280, King City, Ontario L7B 1A6, Canada. Received 3 November 1997. Accepted 1 February 1998.

MARINE MAMMAL SCIENCE, 15(1):210–220 (January 1999)  
© 1999 by the Society for Marine Mammalogy

EVIDENCE OF A FEEDING AGGREGATION OF  
HUMPBACK WHALES  
(*MEGAPTERA NOVAEANGLIAE*) AROUND KODIAK  
ISLAND, ALASKA

The known summer feeding range of the North Pacific humpback whale (*Megaptera novaeangliae*) extends from California, along the coasts of Oregon, Washington, and Alaska, into the Bering Sea, along the Aleutian Islands, the Sea of Okhotsk (Tomilin 1957), and to northern Japan (Rice 1977). In feeding areas of the northeastern Pacific Ocean, humpback whale photoidentification research has been concentrated off California (Calambokidis *et al.* 1993), southeastern Alaska (Darling and McSweeney 1985, Baker *et al.* 1986, 1992; Perry *et al.* 1990), Prince William Sound in Alaska (von Ziegesar 1992), the Oregon and Washington coasts (Calambokidis *et al.* 1993), and British Columbia (Darling and McSweeney 1985; Graeme Ellis, unpublished data). Results of these photoidentification studies have documented that individual whales tend to return to the same general areas in subsequent years (Darling and McSweeney 1985, Baker *et al.* 1986, Calambokidis *et al.* 1996, von Ziegesar *et al.* 1994). Comparisons between these photographic data sets have found one match between California and southeastern Alaska (seen in California in the spring) (North Pacific Humpback Whale Working Group, unpublished data; Calambokidis *et al.* 1996), six matches between southeastern Alaska and Prince William Sound (Perry *et al.* 1990; von Ziegesar *et al.* 1994; Olga von Ziegesar, Janice Straley, Dan McSweeney, unpublished data), and 11 matches between

northern British Columbia and southeastern Alaska (Darling and McSweeney 1985; Straley 1994; Janice Straley and Graeme Ellis, unpublished data). These results suggest that there may be more interchange among the feeding aggregations from northern British Columbia up the coast to Prince William Sound than with the California feeding aggregation.

Little is known about humpback whale movements and the discreteness of feeding aggregations in waters west of Prince William Sound, Alaska. The study of individual humpback whales in Alaska began with the use of Discovery Tags in the 1950s (Ivashin and Rovnin 1967, Ohsumi and Masaki 1975). The recovery of 13 tags showed that seven individuals returned in subsequent years to the area where they were marked: two returned to the Bering Sea, three to waters south of the Aleutian Islands, and two to the western Gulf of Alaska. The remaining six whales were marked in one of these three areas and recovered in another (Ohsumi and Masaki 1975). The only study using photographs to identify humpback whales west of Prince William Sound (15 whales) found no matches to whales in Prince William Sound or southeastern Alaska (Baker *et al.* 1986).

For the current study, humpback whales were photographed during killer whale surveys conducted in 1992 and 1993, and a large-whale survey in 1994, both by the National Marine Fisheries Service (NMFS). These surveys followed line-transect methods and recorded all cetaceans sighted in Alaskan waters near Kodiak Island, along the south side of the Alaska Peninsula and eastern Aleutians, and in the southeastern Bering Sea. The 1992 and 1993 surveys were conducted by the Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML) from 9 July to 22 August 1992 (Dahlheim and Waite 1993) aboard the F/V *Brielyn Marie* and from 13 July to 24 August 1993 (Dahlheim 1994) aboard the F/V *Glorita*. The 1994 survey was conducted by the Southwest Fisheries Science Center from 6 August to 30 August 1994 aboard the NOAA Ship *Surveyor* (Forney and Brownell 1996). When humpback whales were encountered, line-transect surveys were suspended, if circumstances allowed, to take identification photographs. Nikon 8008 cameras (primarily) with motordrives and 300-mm lenses were used with Fuji 1600 black-and-white or Ilford 400 black-and-white film to photograph the undersides of humpback whale flukes (Katona *et al.* 1979). Negatives and contact sheets were analyzed to select the best fluke photographs of individual whales. The best photograph of each whale was printed and then visually compared to the following photographic collections: (1) 140 individual whales photographed in Prince William Sound from 1977 to 1991 (von Ziegeler 1992); (2) 9 individual whales photographed in Prince William Sound in 1993 (NMML unpublished data); (3) 500 individual whales photographed in southeastern Alaska by McSweeney, Straley, and Jurasz in 1989 (NMML, unpublished data); (4) 464 individual whales photographed from southeastern Alaska (1975–1985) and 95 from the Gulf of Alaska including Prince William Sound (1977–1985) (Perry *et al.* 1988); and (5) 5,177 photographs of an unknown number of individuals from the NMML humpback whale matching system taken in Alaska (Mizroch *et al.* 1990). This last assembly of photographs

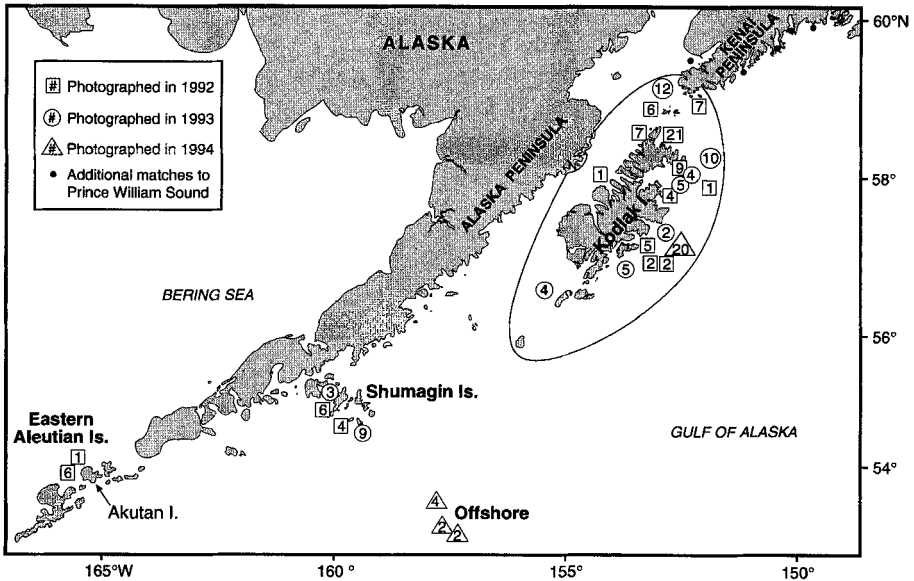


Figure 1. Locations and numbers of photoidentified humpback whales during NMFS surveys in 1992–1994.

includes most of the collections above, but also includes photographs taken through 1996 by researchers in Alaska, and other sets not available elsewhere.

During the 1992 study, 82 individual humpback whales were photographed: 65 from the Kodiak Island area, 10 from the Shumagin Islands, and 7 from the eastern Aleutian Islands (north of Akutan Island) (Fig. 1). In 1993, 54 individuals were identified: 42 from Kodiak Island waters and 12 from the Shumagin Islands (Fig. 1). In 1994, 28 individuals were identified: 20 from Kodiak Island waters and 8 approximately 150 nm south of the Shumagin Islands (Fig. 1, Table 1). From the total of 164 individually identified whales, eight were resighted in the Kodiak Island area between years (Table 2). An additional nine individual whales were photographed in the Kodiak Island region in 1991 by von Ziegeler. One of these was matched to the Kodiak Island photographs (Table 2). Adding these to the data set makes a total of

Table 1. Number of humpback whales identified in the study area during the years 1991–1994.

	Kodiak Island	Shumagin Islands	Offshore	Eastern Aleutian
1991	9	—	—	—
1992	65	10	—	7
1993	42	12	—	—
1994	20	—	8	—
Total	136 w/ 9 resightings = 127	22	8	7

Table 2. Humpback whales matched between years within the Kodiak Island region. Whale designations refer to those used by the NMML system,<sup>a</sup> von Ziegesar,<sup>b</sup> and Waite.<sup>c</sup> The North Pacific Humpback Whale Working Group (NPHWWG) reference number is given for each whale.

NPHWWG Ref #	1980 <sup>a</sup> ( <i>n</i> = 21)	1991 <sup>b</sup> ( <i>n</i> = 9)	1992 <sup>c</sup> ( <i>n</i> = 65)	1993 <sup>c</sup> ( <i>n</i> = 42)	1994 <sup>c</sup> ( <i>n</i> = 20)
2070			#3	#3	
25630			#29	#29	
65	[65]		#39		
25645			#41	#41	
25652			#48		#48
25663			#60		#60
6411	[6411]			#85	#85
25726				#86	#86
25712				#88	#88
19648		SH4		#106	

164 different humpback whales photoidentified from 1991 to 1994: 127 from the Kodiak Island region, 22 near the Shumagin Islands, 8 offshore of the Shumagin Islands, and 7 from the eastern Aleutian Islands. During the matching process to other photographic sources, two matches were made to whales photographed in Kodiak Island waters during a survey conducted in 1980 (Rice and Wolman 1982) (one of which was one of the nine matched already within the Kodiak region) (Table 2). These whales photographed in 1980 were not included in the total number of whales for the Kodiak Island region because the population could have changed significantly during those 11 yr.

Two of the whales sighted off Kodiak Island were each photographed twice in 1992. One moved south 68 km in six days, while the other moved 10 km in one day.

Four of the 127 whales from the Kodiak Island region and one of eight from the offshore waters (1994) were matched to whales in Prince William Sound. Two of the 127 whales from Kodiak Island were matched to whales in southeastern Alaska (Fig. 2). No matches were found to whales from the Shumagin Islands or the eastern Aleutian Islands. Matches between areas are given in Table 3. Five matches have also been made by von Ziegesar between Prince William Sound to areas just outside of the Kodiak Island region (Fig. 1).

The largest number of matches (four) occurred between Kodiak Island and Prince William Sound. We tested the hypothesis that the whales of the Kodiak Island region and Prince William Sound are a single homogeneous population. If so, then the expected number of matches between the two areas ( $n_{12}$ ) can be calculated using a binomial estimator as

$$n_{12} = \frac{n_1 n_2}{N} \quad (1)$$

where,  $n_1$  and  $n_2$  are the number of identified whales in each area and  $N$  is

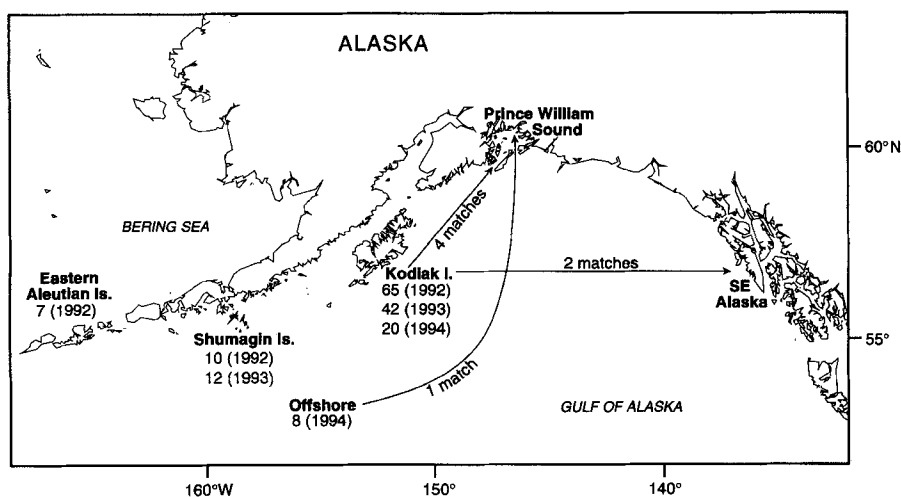


Figure 2. Matches of humpback whales made between feeding areas. Lines do not indicate actual movement. Numbers preceding years indicate number of whales photo-identified that year.

the estimated population for the entire region that includes Prince William Sound and Kodiak Island. If this is a single homogeneous population, the Kodiak Island data then represent a consistent annual sample of this population. Thus, we estimate  $N$  by the Schnabel method (Seber 1973) to be 651 (95% CI = 406–1,569), using the years 1991, 1992, 1993, and 1994 in the Kodiak Island data as separate capture events. Using this population estimate ( $N = 651$ ) and the number of whales photo-identified around Kodiak Island ( $n_1 = 127$ ) and in Prince William Sound during the three most recent years (1989–1991) in von Ziegeler (1992) and the 1993 NMML collection (unpublished data) ( $n_2 = 104$ ), 20 matches (95% CI = 8–33) are expected between the Kodiak Island photographs and the Prince William Sound collection. This is significantly different from the four that were observed ( $t$ -test  $P < 0.003$ ). This result indicates that the populations are not homogeneous and suggests that separate groups of whales frequent Kodiak Island and Prince William Sound with a few individuals circulating between these two regions.

Considering that the Kodiak Island whale group is not homogeneous with the Prince William Sound group, we then asked what fraction of the Kodiak Island group ( $f_{12}$ ) does circulate to Prince William Sound. We again used a binomial estimator for this fraction as

$$f_{12} = \frac{n_{12}N_2}{n_1n_2} = \frac{n_{12}}{n_1p_2} \quad (2)$$

where,  $n_{12}$  is the number of matches found (four), and  $p_2$  is the ratio of the number of identified whales ( $n_2$ ) to total whales ( $N_2$ ) in Prince William Sound, including the circulating whales. There is no published abundance estimate for Prince William Sound so we considered two possibilities using the second

Table 3. Humpback whales matched between areas and months and years that each whale was identified. Whale designations refer to those used by Waite,<sup>a</sup> von Ziegeler,<sup>b</sup> McSweeney,<sup>c</sup> Straley,<sup>d</sup> Herman,<sup>e</sup> and Jacobsen.<sup>f</sup> The NPHWWG reference number is given for each whale.

NPHWWG Ref #	Kodiak Island <sup>a</sup> ( <i>n</i> = 127)	Prince William Sound <sup>b</sup>	Southeastern Alaska
5247	#17 (July 1992)	X-1 (May, August 1997, June 1978, August 1979, August 1980, May 1984, June 1985, June, July 1990, June 1991) X-59 (August 1990) Y-3 (June 1978, August 1980, July 1983, July 1988, June 1989, May 1990) Y-34 (May 1986, June 1989)	PN343 <sup>c</sup> (1989) JSI FS93-13-7 <sup>d</sup> (August 1993) #506 <sup>e</sup> (July 1981) DM37 <sup>e</sup> (1989) JJ12 <sup>f</sup> (July 1989) #506 <sup>d</sup> (Sept 1992)
11211 6710	#91 (July 1993) #93 (July 1993)		
4200 25632	#169 (July 1994) #30 (July 1992)		
112	#101 (July 1993)		
19418	Offshore Shumagin, <i>n</i> = 8 #176 (August 1994)	Z35 (July 1989)	

formulation: (1) that all of the whales had been photoidentified,  $p_2 = 1.0$  (using the data set described in the paragraph above, *i.e.*,  $N_2 = 104$ ); or (2) based on the statement that in recent years fewer than 10% new whales are recorded each year (von Ziegesar 1992), that a conservative lower limit for the proportion  $p_2$  identified is 0.50 (*i.e.*,  $N_2 < 210$ ). Calculating for both possibilities with equation 2 we estimate that 3% to 6% of the Kodiak Island whales also visit Prince William Sound.

For southeastern Alaska, the number of whales captured (on film) is unknown, because the many different sources of photographs have not been reduced to one set of known individuals. Therefore, Equation 1 cannot be applied. The most recent annual abundance estimate of humpback whales in southeastern Alaska is 404 for the period 1985 to 1992 (95% CI = 350–458; Straley *et al.* 1995). In the NMML matching system, of 3,908 photographs of whales in southeastern Alaska, 2,542 photographs have been matched to at least one other photograph and, on average, 41 other photographs, reducing the 2,542 photographs to at most 619 individuals. A thorough analysis has not been conducted to find matches between all available photographs, but we assume the majority of matched whales represent unique individuals. The high number of resightings per whale and the large number of identified whales relative to the abundance estimate suggests that most ( $50\% < p_2 < 100\%$ ) of the whales in southeastern Alaska are represented in the NMML photograph collection. Using the second formulation in equation 2, we estimate that 2%–3% of the Kodiak Island whales also spend time in southeastern Alaska. This result suggests that different whales frequent Kodiak Island and southeastern Alaska with a small number of individuals circulating between these two regions.

The large number of humpback whales identified in Kodiak Island waters ( $n = 127$ ) and the low number of matches to other areas ( $n = 6$ ) suggest that this region supports a separate feeding aggregation of whales. Also, Calambokidis *et al.* (1996) found no matches between the Kodiak region and the feeding area of humpback whales off California. The low match rate across regions is similar to the rates of matching found between the other northern British Columbia/Alaska aggregations. It is clear that considerable site fidelity exists at identified feeding areas but that some movement between areas also occurs. There is likely considerable variation in site fidelity among individual whales.

Two possibilities may account for the relatively low number of resights within the Kodiak Island area between years. It may be that the population of humpback whales is large and so the relatively small number of photographs allowed for only a few matches. As a crude comparison, the number of individual whales photographed in this study during 1992 (65) and 1993 (42) was far less than the number of humpback whales observed during the line-transect surveys, 258 and 240, respectively. An alternate possibility is that the Kodiak Island aggregation is smaller than estimated, but some whales do not return each year, instead going to other areas not considered in this study. In southeastern Alaska, the total number of individual whales identified from

1985 to 1992 was nearly double the number observed in any given year. It was concluded that most of the missed whales did not return every year as they were observed in subsequent years (Straley *et al.* 1995). Further study is necessary to document the number of whales and the degree of site fidelity in the Kodiak Island area.

Katona and Beard (1991) suggest that Atlantic humpback whales found in different feeding regions in different years might have been en route to their final feeding destination. Migration routes of humpback whales from wintering grounds to their feeding grounds in the North Pacific Ocean are unknown. All the matches presented here were of sightings in different years, so it is unknown whether these whales were ever in different feeding areas in the same year. However, because of the small number of matches between areas, it is apparent that the whales in the Kodiak Island region are not all migrating through on their way to either Prince William Sound or southeastern Alaska. Although there were no matches to Kodiak among the 22 whales identified in the Shumagin Islands, the data are too few to indicate reliably whether whales in Kodiak Island waters extend their range to the west.

None of the 22 identified whales from the Shumagin Islands were matched to whales in other known feeding areas in Alaska or California (this report, Calambokidis *et al.* 1996, respectively). Brueggeman *et al.* (1989) suggest that there are discrete groups of humpback whales in the Shumagin Island region based on concentrations of whale sightings during aerial (1985) and vessel (1987) surveys. But again, there are too few photographed whales and no resightings from this study to speculate on the abundance or movements of humpback whales in the Shumagin Island area.

During the 1992 and 1993 surveys, few humpback whales were sighted west of the Shumagin Islands. The seven whales photoidentified off the eastern Aleutian Islands in 1992 were found just north of Akutan Island. Adverse weather in 1993 in the Bering Sea prevented a sufficient search; only two humpback whales were seen and no photographs were taken. Stewart *et al.* (1987) found no humpback whales near Akutan Island during aerial surveys from late July to late August 1984. Whaling records, however, indicate that the waters around Akutan Island once supported a large number of humpback whales from June through September (Reeves *et al.* 1985). Although none of the seven whales identified in this area were matched to other areas, the sample size is too small to draw any conclusion about the possibility that the area supports a discrete feeding aggregation.

One of the eight whales photoidentified offshore from the Shumagin Islands was matched to a Prince William Sound whale. It is unknown whether humpback whales remain offshore during an entire feeding season. These whales were all photographed in August, when some whales may begin to move away from a feeding area.

In summary, this study represented the first effort to photograph large numbers of humpback whales west of Prince William Sound. The results suggest that, although there is a small degree of exchange to other Alaskan feeding areas, the Kodiak Island region supports a separate feeding aggregation. The

North Pacific humpback whale populations may segregate into separate feeding areas similar to North Atlantic humpback whale populations, where at least five geographically distinct feeding aggregations have been described (Katona and Beard 1991). Additional studies in Alaska, especially west of Prince William Sound, are needed to better define feeding areas in Alaska.

#### ACKNOWLEDGMENTS

We thank the researchers who participated in the Gulf of Alaska photoidentification work: W. Armstrong, K. Balcomb-Bartok, S. Benson, T. Chandler, K. Chumbley, D. Ellifrit, J. Evenson, J. Lerczak, B. Mathews, B. Miller, R. Osborne, J. Sease, F. Sharpe, J. Stern, M. Strick, J. Swenson, and R. Towell. D. McSweeney, C. Jurasz, and J. Straley did a tremendous job collecting and analyzing humpback whale photographs during the 1989 oil spill work. This work could not have been carried out without the cooperation of countless researchers involved in humpback whale research in Alaska who have collected, analyzed, and contributed their photographs to the National Marine Mammal Laboratory for inclusion in the humpback whale matching system. Figures were prepared by W. Carlson of the Graphics Unit at the Alaska Fisheries Science Center. Critical reviews were provided by R. Angliss, J. Baker, H. Braham, J. Calambokidis, D. DeMaster, S. Katona, D. Rice, D. Rugh, and J. Stern. This work was supported in part by Marine Mammal Population Assessment funds from the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, Maryland. This research was carried out under the U.S. Marine Mammal Protection Permit # 748 and Permit #791.

#### LITERATURE CITED

- BAKER, C. S., L. M. HERMAN, A. PERRY, W. S. LAWTON, J. M. STRALEY, A. A. WOLMAN, G. D. KAUFMAN, H. E. WINN, J. D. HALL, J. M. REINKE AND J. ÖSTMAN. 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. *Marine Ecology Progress Series* 31:105–119.
- BAKER, C. S., J. M. STRALEY AND A. PERRY. 1992. Population characteristics of individually identified humpback whales in southeastern Alaska: Summer and fall 1986. *Fishery Bulletin*, U.S. 90:429–437.
- BRUEGGEMAN, J. J., G. A. GREEN, R. A. GROTEFENDT AND R. W. TRESSLER. 1989. Marine mammal habitat use in the North Aleutian Basin, St. George Basin, and Gulf of Alaska. Pages 97–108 in L. E. Jarvela and L. K. Thorsteinson, eds. *Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting*. Available from NOAA, NOS, Office of Oceanography and Marine Assessment, 222 W. Eighth Avenue, No. 56, Anchorage, AK 99513–7543.
- CALAMBOKIDIS, J., G. H. STEIGER AND J. R. EVENSON. 1993. Photographic identification and abundance estimates of humpback whales off California in 1991–1992. Final report 50ABNF110137 to the Southwest Fisheries Science Center, National Marine Fisheries Service, P. O. Box 271, La Jolla, CA. 67 pp.
- CALAMBOKIDIS, J., G. H. STEIGER, J. R. EVENSON, K. R. FLYNN, K. C. BALCOMB, D. E. CLARIDGE, P. BLOEDEL, J. M. STRALEY, C. S. BAKER, O. VON ZIEGESAR, M. E. DAHLHEIM, J. M. WAITE, J. D. DARLING, G. ELLIS AND G. A. GREEN. 1996. Interchange and isolation of humpback whales off California and other North Pacific feeding grounds. *Marine Mammal Science* 12:215–226.
- DAHLHEIM, M. E. 1994. Abundance and distribution of killer whales (*Orcinus orca*) in Alaska in 1993. Annual report for 1992 to the Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 28 pp.

- DAHLHEIM, M. E., AND J. M. WAITE. 1993. Abundance and distribution of killer whales (*Orcinus orca*) in Alaska in 1992. Annual report for 1992 to the Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. 29 pp.
- DARLING, J. D., AND D. J. MCSWEENEY. 1985. Observations on the migrations of North Pacific humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 63:308-314.
- FORNEY, K. A., AND R. L. BROWNELL, JR. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. Paper SC/48/O11 presented to the International Whaling Commission Scientific Committee. 15 pp.
- IVASHIN, M. V., AND A. A. ROVNIN. 1967. Some results of the Soviet whale marking in the waters of the North Pacific. Norsk Hvalfangst-Tidende 56(6):123-135.
- KATONA, S. K., AND J. A. BEARD. 1991. Humpback whales (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Memoirs of the Queensland Museum 30:307-321.
- KATONA, S. K., B. BAXTER, O. BRAZIER, S. KRAUS, J. PERKINS AND H. WHITEHEAD. 1979. Identification of humpback whales by fluke photographs. Pages 33-44 in H. E. Winn and B. L. Olla, eds. The behavior of marine animals. Volume 3. Cetaceans. Plenum Press, New York, NY.
- MIZROCH, S. A., J. A. BEARD AND M. LYNDE. 1990. Computer assisted photo-identification of humpback whales. Report of the International Whaling Commission (Special Issue 12):63-70.
- OHSUMI, S., AND Y. MASAKI. 1975. Japanese whale marking in the North Pacific, 1963-1972. Bulletin of the Far Seas Fisheries Research Laboratory (Shimizu) 12:171-219.
- PERRY, A., J. R. MOBLEY, JR., C. S. BAKER AND L. M. HERMAN. 1988. Humpback whales of the central and eastern North Pacific. A catalog of individual identification photographs. University of Hawaii Sea Grant, Honolulu, HI.
- PERRY, A., C. S. SCOTT AND L. M. HERMAN. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: A summary and critique. Report of the International Whaling Commission (Special Issue 12):307-317.
- REEVES, R. R., S. LEATHERWOOD, S. A. KARL AND E. R. YOHE. 1985. Whaling results at Akutan (1912-39) and Port Hobron (1926-37), Alaska. Report of the International Whaling Commission 35:441-457.
- RICE, D. W. 1977. The humpback whale in the North Pacific: Distribution, exploitation, and numbers. Pages 29-44 in K. S. Norris and R. R. Reeves, eds. Report on a workshop on problems of humpback whales (*Megaptera novaeangliae*) in Hawaii. U. S. Marine Mammal Commission. 1825 Connecticut Avenue, NW, Room 512, Washington, DC 20009.
- RICE, D. W., AND A. A. WOLMAN. 1982. Whale census in the Gulf of Alaska, June to August 1980. Report of the International Whaling Commission 32:491-497.
- SEBER, G. A. F. 1973. The estimation of animal abundance. Hafner Press, New York, NY.
- STEWART, B. S., S. A. KARL, P. K. YOHEM, S. LEATHERWOOD AND J. L. LAAKE. 1987. Aerial surveys for cetaceans in the former Akutan, Alaska, whaling grounds. Arctic 40:33-42.
- STRALEY, J. M. 1994. Seasonal characteristics of humpback whales (*Megaptera novaeangliae*) in southeastern Alaska. Master's thesis, University of Alaska, Fairbanks, AK. 121 pp.
- STRALEY, J. M., C. M. GABRIELE AND C. S. BAKER. 1995. Seasonal characteristics of humpback whales (*Megaptera novaeangliae*) in southeastern Alaska. Pages 229-237 in D. R. Engstrom, ed. Proceedings of the Third Glacier Bay Science Symposium, 1993. National Park Service, Anchorage, Alaska.
- TOMILIN, A. G. 1957. Mammals of the USSR and adjacent countries. Volume 9. Aka-

- demii Nauk SSSR, Moscow (translated by the Israel Program for scientific Translations, Jerusalem, 1967). 717 pp.
- VON ZIEGESAR, O. 1992. A catalogue of Prince William Sound humpback whales identified by fluke photographs between the years 1977 and 1991. Report to the National Marine Mammal Laboratory, NMFS, NOAA, by the North Gulf Oceanic Society, P. O. Box 15244, Homer, AK 99603.
- VON ZIEGESAR, O., E. MILLER AND M. E. DAHLHEIM. 1994. Impacts on humpback whales in Prince William Sound. Pages 173–191 in T. R. Loughlin, ed. *Marine mammals and the Exxon Valdez*. Academic Press.

JANICE M. WAITE, MARILYN E. DAHLHEIM, RODERICK C. HOBBS, SALLY A. MIZROCH, NOAA, Alaska Fisheries Science Center, National Marine Mammal Laboratory, 7600 Sand Point Way N. E., Seattle, Washington 98115–0070, U.S.A.; e-mail: janice.waite@noaa.gov; OLGA VON ZIEGESAR-MATKIN, North Gulf Oceanic Society, P.O. Box 15244, Homer, Alaska 99603, U.S.A.; JANICE M. STRALEY, P.O. Box 273, Sitka, Alaska 99835, U.S.A.; LOUIS M. HERMAN, Kewalo Basin Marine Mammal Laboratory, University of Hawaii, 1129 Ala Moana Boulevard, Honolulu, Hawaii 96814, U.S.A.; JEFF JACOBSEN, P.O. Box 4492, Arcata, CA 95521, U.S.A. Received 15 July 1994. Accepted 20 February 1998.

MARINE MAMMAL SCIENCE, 15(1):220–227 (January 1999)  
© 1999 by the Society for Marine Mammalogy

## BENTHIC FORAGING ON STINGRAYS BY KILLER WHALES (*ORCINUS ORCA*) IN NEW ZEALAND WATERS

One method of foraging not previously reported for the killer whale is benthic foraging. This paper describes frequent feeding by killer whales on rays in shallow water off the North Island of New Zealand. Few accounts of killer whale predation on elasmobranchs (sharks, skates, and rays) have been reported worldwide (Fertl *et al.* 1996). However, rays may be important prey for killer whales in New Zealand.

Studies of the New Zealand population of killer whales have been on-going since December 1992. To date (December 1997) 117 individuals have been photoidentified, using methods developed by Bigg *et al.* (1987). Data were collected in an opportunistic manner. Killer whales were encountered after sightings were reported by the public (including whale and dolphin watching boats, fishermen, and Coast Guard). The whales were followed until such constraints as fuel, weather conditions, or the animals' behavior would cause the encounter to be terminated. Where possible, photographs of individual whales were taken, using a Nikon F90x camera with a 80–200 lens and Kodak 100 Select transparency film. Observations of behavior were recorded *ad libitum*