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Distribution of Killer Whales in the Warm Temperate and Tropical Eastern Pacific

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ABSTRACT

Records of killer whale occurrence for the warm temperate and tropical eastern Pacific Ocean are summarized from 11 strandings/collections and 581 observations. Levels of sighting effort are identified and used to interpret trends in distribution and movement. Killer whales occur from the Gulf of California more or less continuously along the Pacific Coast from 35°N to just below 5°S. Nearly all records off California and western Baja California were within 150 nm of the coast. North of 20°N, there were only four widely scattered offshore sightings beyond 150 nm. South of 20°N, 56.6% of all sightings were within approximately 300 nm of the coast and 78.4% within 600 nm. Two offshore clusters of sightings occurred, (1) 7° to 14°N, 127° to 139°W and (2) within a band between the equator and 5°N from the Galapagos Islands to 115°W. Herds contained up to 75 animals, with a mean of 5.3 animals per herd. An estimated 91% of the herds contained fewer than 10 animals.

INTRODUCTION

Killer whales, *Orcinus orca,* are cosmopolitan in distribution. There are records of their occurrence from virtually all oceans and major seas and from all ocean zones (for review see Leatherwood and Dahlheim, 1978; Dahlheim, 1981). Concerning their relative abundance by habitat, Mitchell (1975) states that although reported from tropical waters and the open sea, killer whales appear to be most prevalent in the colder waters of both hemispheres, with centers of greatest abundance within 800 km of major continents. Details adequate to support summary statements about the species' distribution and relative abundance, however, have only been reported for four areas: northeast Atlantic (Jonsgård and Lyshoel, 1970); northwest Atlantic (Sergeant and Fisher, 1957); inland marine waters of Washington State, US and British Columbia, Canada in the northeast Pacific (Bigg, MacAskie and Ellis, 1976; Chandler, Goebel and Balcomb, 1977); and coastal Japan (Nishiwaki and Handa, 1958; Kasuya, 1971). Beyond the odd sighting record there is little or no published information currently available on such populations in other regions. This paper reviews the data available from 1907 through 1979 on killer whale occurrence in the eastern Pacific Ocean from latitude 15°S and longitude 160°W, north to latitude 35°N and east to the coastline (Fig. 1).

MATERIALS AND METHODS

Data collection and methods of analysis were the same as those used by Leatherwood, Perrin, Kirby, Hubbs and Dahlheim (1980) for Risso's dolphin, *Grampus griseus.* We reviewed all previously published and unpublished strandings and collections of killer whales in the study area. These data were summarized and their locations plotted and examined for distributional patterns (Fig. 2). All previously published data on sightings of killer whales were reviewed and tabulated.

We examined 306 unpublished observations of free-ranging killer whales from the National Marine Fisheries Service (NMFS) tuna-dolphin observer program (1974–79). An additional 275 unpublished at-sea sightings were available from our files and from the files of other individuals and agencies. We carefully examined these unpublished sighting records for reliability of identification. Interviews with observers and/or the use of photographs assured us of the accuracy of many records. Descriptions of animals with striking black and white coloration, a white oval eye patch, and prominent erect dorsal fin (all diagnostic field characteristics of *Orcinus orca*) aided in verification of the remainder. We discarded questionable records.

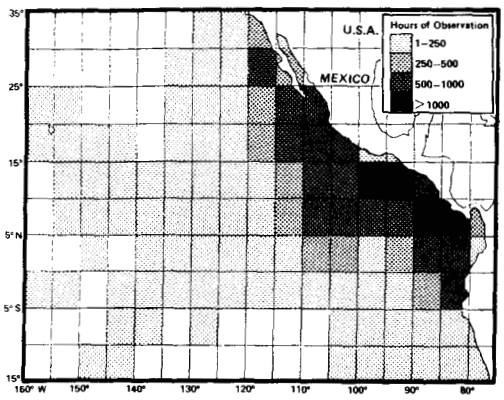

Fig. 1. Survey effort by NMFS dolphin-tuna observer program (1974–79), in hours of ship time by 5° square.

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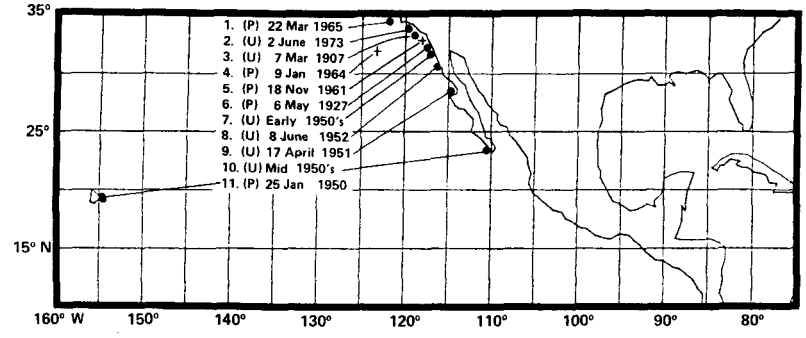

Fig. 2. Strandings (•) and collections (+) of killer whales (1907–79). (P) = Published record and (U) = Unpublished record. Numbers (1–11) refer to numbered paragraphs in the text.

Table 1

Principal sources of unpublished sighting records of killer whales in the study area. The two programs marked * maintained records of survey effort and are discussed in text

Institution/Activity	Approximate portion of study area covered	Approximate period and effort
I. US National Marine Fisheries Service		
A. Southwest Fisheries Center (Figs 1 and 3)		
1a. Dolphin-tuna observer program and associated research cruises	Principally lats 35°N to 15°S, coast to approximately long 160°N	1968–73—heavy effort nearshore Jan–Feb, declining and moving seaward throughout year, some coastward research Qtr. 4.
*1b. As above	As above	1974–79—generally as above, but effort data available as number of ship survey hours per 5° square (see Fig. 1).
B. National Marine Mammal Lab (Fig. 4)		
1. Research cruises	Lats 25°N to 35°N within 150 nm of shore[1]	1960s—sporadic coverage.
2. Pelagic Fur Seal Program	N of lat 32°N and E of long 130°W[1]	1960s—sporadic coverage.
II. Naval Ocean Systems Center (Fig. 3)		
A. Ship surveys	Within 100 nm of coast, So. Calif. & Baja Calif. and throughout Gulf of Calif.	1965–75—misc. cruises all seasons but principally winter and spring.
*B. Aerial surveys	Southern California Bight, above lat 32°N	1968–75—29,000 nm surveyed, representing all seasons (see Leatherwood and Walker, 1979).
III. Scripps Institution of Oceanography (Fig. 4)		
A. Research cruises	Principally within 100 nm of coast of California and Baja Calif, and in Gulf of California	1950–79—misc. cruises with no indication of survey effort by area or season.
IV. Smithsonian Institution Pacific Ocean Biological Survey (Fig. 4)	Lat 27°N to lat 35°N, coast to long 120°W	1967–68—unable to quantify effort by area or season.

[1] Principal program effort was farther north; effort in areas indicated was peripheral.
Additional sources include: The University of Southern California, the Natural History Museum of Los Angeles County, San Diego Museum of Natural History, Marineland of the Pacific, and numerous colleagues (Fig. 4).

Principal institutions contributing unpublished sighting records and statements of their effort in the area are listed in Table 1. Additional sources are referenced in acknowledgements. Records were grouped into two categories: (1) those sightings from the two programs in which effort has been quantified (NOSC aerial surveys, 1968–1975, and NMFS dolphin-tuna observer programs, 1974–79) and (2) miscellaneous sightings, including those for which there was no evidence of associated level of effort and those from programs for which effort could be only subjectively described.

For the NMFS dolphin-tuna observer program, 1974–79, effort—as number of ship survey hours per 5° square—and locations of sightings were plotted by quarter and

examined for patterns of occurrence. All effort (Fig. 1) and sightings (Fig. 3) from all quarters were then combined and re-examined. For the years represented by this analysis, survey effort was sufficient at all seasons and latitudes for us to have detected major trends in distribution of cetacean fauna if they existed. Miscellaneous records were plotted (Fig. 4) and their distribution examined for evidence of patterns in killer whale occurrence.

Many of the sighting records included estimates of herd or group size. For those estimates stated as ranges (e.g. 10–20 animals), we used the midpoint for group size. If the midpoint was a half number, we rounded down.

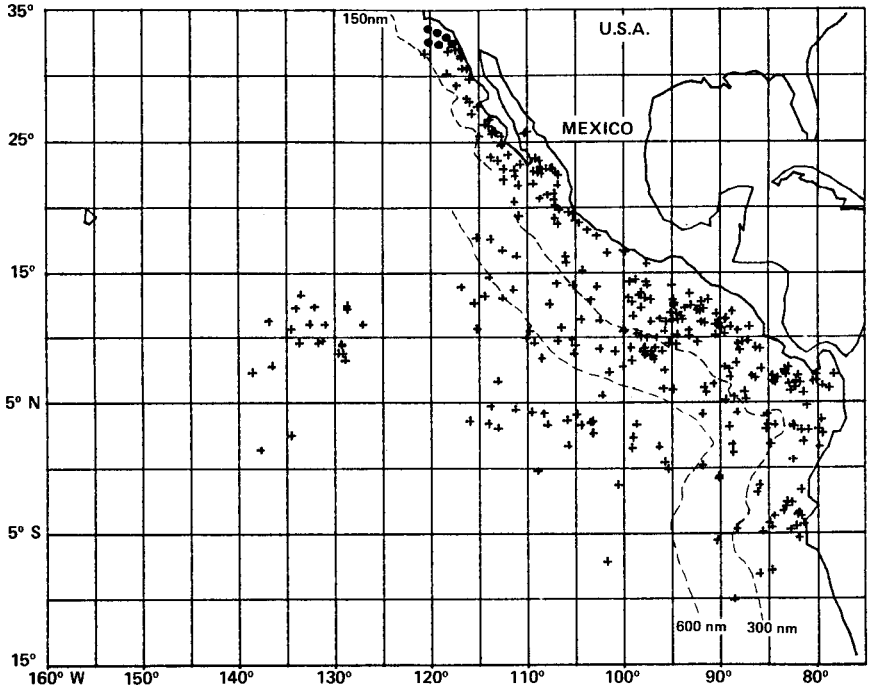

Fig. 3. Observations of killer whales by NOSC (●) and NMFS (+) programs (1968–79).

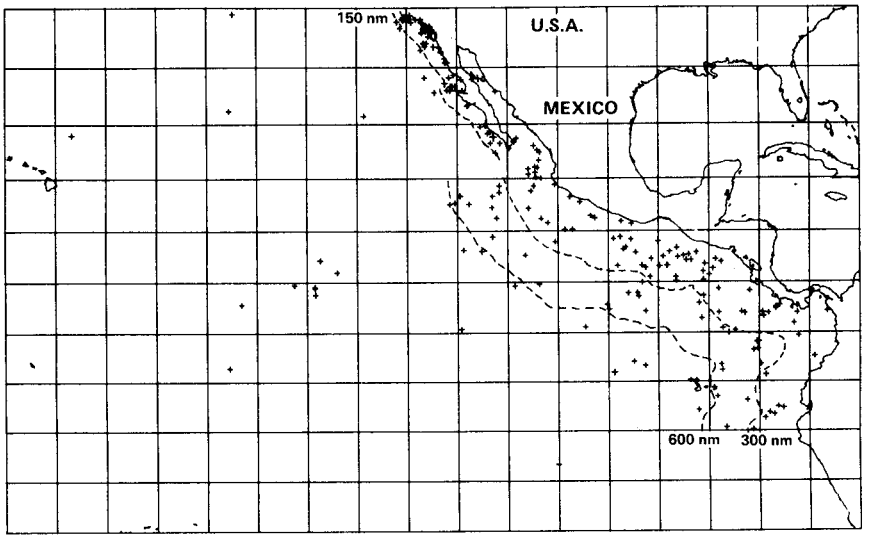

Fig. 4. Miscellaneous observations of killer whales (1939–76).

RESULTS

Strandings and collections

We were able to find data for only 11 specimens of the killer whale in the study area: nine strandings, one live-capture, and one killed (Fig. 2). The letters in parentheses below indicate whether the record has (P) or has not (U) been previously published. Specimens are discussed below in chronological order:

3. (U) On 7 March 1907 the US National Museum, Smithsonian Institution catalogued a water-worn earbone (USM 49909) collected on an unspecified date by B. Traske at Avalon, Santa Catalina Island, California (James G. Mead, pers. comm., 16 June 1980).
6. (P) On 6 May 1927 a 'juvenile' killer whale of unreported sex and length was collected at Hermosa Beach, Los Angeles County, California (33°50'N, 118°25'W). The skull is in the collection of the Museum of Natural History of Los Angeles County—LACM 30461 (Caldwell and Brown, 1964).
11. (P) On 25 January 1950 an estimated 6.09 m (20 ft) male killer whale washed ashore on Ka Lae, South Point, Kau District, Island of Hawaii. No materials were collected and we have been unable to locate the photographs or additional data reportedly collected. This account constitutes the first published record of a killer whale from the Hawaiian Islands (Richards, 1952).
9. (U) On 17 April 1951 a partial skull was collected by W. Mayer at Viscaino Bay, Baja California, Mexico. This specimen is in the Los Angeles County Museum—LACM 22791 (John Heyning, pers. comm., 3 Oct. 1980).
8. (U) On 8 June 1952 Carl L. Hubbs uncovered a weathered skull of a killer whale at Punta Cabras, Baja California, Mexico, at approximately lat 31°20'N (Hubbs' field notes, 1952).
7. (U) On an unspecified date, thought to have been in the early 1950s (Laura Hubbs, pers. comm., 1978), a killer whale was found dead on the beach at Del Mar, California. We were unable to locate data or specimen material from the stranding.
10. (U) On an unspecified date, though to have been in the mid-1950s (Laura Hubbs, pers. comm., 1978), a killer whale was found dead on the beach at 23°25'N, 109°20'W. Apparently, no materials were collected.
5. (P) On 18 November 1961 a 5.21 m (17 ft) female killer whale was taken alive in a turning basin in the harbor of Newport, California (33°58'N, 117°55'W) and transported to Marineland of the Pacific, Palos Verdes, California, where it died two days later. Details of the capture, behavior, and postmortem examination of the whale are included in the account of the stranding (Caldwell and Brown, 1964). The complete skeleton of the specimen is in the Museum of Natural History of Los Angeles County (LACM No. 52455).
4. (P) On 9 January 1964 a free-swimming 5.65 m (18.54 ft) female killer whale was collected at 35°50'N, 120°31°W. The stomach contained remains of 2 moonfish and 2 carcharinid sharks. The skull is in the collection of the National Marine Mammal Laboratory—NMML No. 9860 (Rice, 1968).
1. (P) On 22 March 1965 a 7.4 m (24.28 ft) male killer whale was collected at 34°23'N, 121°16'W. The stomach contained baleen and blubber of a minke whale, *Balaenoptera acutorostrata*. The skull is in the collection of the National Marine Mammal Laboratory—NMML 1965–4 (Rice, 1968).
2. (U) On 2 June 1973 a 3.30 m (10.83 ft) immature male killer whale was found dead on the beach at Willow Cove, Santa Cruz Island, California. This animal was estimated to have been less than 1.5 years old. The stomach contained miscellaneous remains of a young California sea lion, *Zalophus californianus*. The entire skeleton was collected and taken to the Natural History Museum of Los Angeles County—LACM No. 54444 (Leatherwood field notes, 1973).

At-sea sightings

We observed 19 published articles containing records or summaries of observations of free-ranging killer whales in the study area (Table 2). In addition we assembled 581 reliable previously unpublished sighting records (a complete list is available from the senior author).

The distribution of the 581 sightings, from sources dating 1939–79, can be summarized as follows. The six records from NOSC aerial surveys, 1968–75, and the 306 from NMFS dolphin-tuna observer program, 1974–79, are shown in Fig. 3. No significant differences were apparent in distribution by quarter which could not readily be explained by variable effort. Therefore, all effort (Fig. 1) and all sightings (Fig. 3) from this program were displayed as cumulative summaries for all years and months combined. In this form, the distribution of the sightings is very similar to that from the 269 miscellaneous records (Fig. 4). Records from both sources extend from the Gulf of California more or less continuously along the Pacific Coast from 35°N to just below 5°S. Nearly all records off California and western Baja California were within 150 nm of the coast. Above 20°N, there are only four widely scattered pelagic records beyond 150 nm. Below 20°N, 56.6% (223 of 394) of all records were within approximately 300 nm of the coast and 78.4% (309 of 394) of the records were within 600 nm of the mainland coast.

Of particular interest, however, are the two clusters of sightings which occurred, one in the same general offshore area where miscellaneous sightings were concentrated (7° to 14°N, 127° to 139°W), and a second within a band between the equator and 5°N from the Galapagos Islands to 115°W. There was no seasonal pattern apparent in occurrence of animals in either of these zones which could not be readily related to variable effort.

Of the 581 unpublished sighting records, 508 provided usable estimates of herd sizes. Distributions of estimated herd sizes from the two data sets were compared. Because they were not significantly different (ANOVA; $P = 0.05$) the herd size data were pooled and grouped by 5° latitudinal belts and by seasons. Number of animals sighted within a herd ranged from 1 to 75, with a mean of 5.3 animals per herd. About 91% of the herds observed contained fewer than ten animals (Fig. 5). No differences could be demonstrated among herd sizes from different areas (5° bands of latitude) or among seasons (ANOVA; $P = 0.05$).

Table 2

Previously published at-sea observations of killer whales in the eastern North Pacific.

Source	Date	Location	Number in herd
Lacépède (1804)	Unreported	08°15′N, 79°00′W	Unreported
Scammon (1874)	Unreported	Off southern Calif. and the Baja Peninsula	Unreported
Banks (1931)	Unreported	24°45′N, 110°34′W	2
Allen (1939)	Unreported	32°51′N, 117°19′W	Unreported
Anonymous (1951)	9 May 1951	32°35′N, 117°15°W	Unreported
Brown & Norris (1956)	29 Oct 1954	34°10′N, 119°50′W	5
	3 Nov 1954	34°25′N, 119°40′W	7
	4 Nov 1954	33°45°N, 118°30′W	2
	18 Dec 1954	33°45′N, 118°30′W	11
	28 Dec 1954	33°45′N, 118°30′W	10
	14 Dec 1955	33°45′N, 118°30′W	1
	Unreported	25°00′N, 141°45′W	Unreported
Harder & Johannessen (1960)	Unreported	03°30′N, 141°45′W	Unreported
Van Gelder (1960)	Unreported	30°30′N, 116°06′W	4
Anonymous (1961)	28 Oct 1961	32°50′N, 117°19′W	10
Norris & Prescott (1961)	1940	Estero de Punta Banda, Baja California, Mexico	Unreported
	? May 1949	33°45′N, 118°30′W	3
	? Apr 1952	24°30′N, 111°45′W	5–7
	? Aug 1955	33°30′N, 119°00′W	6
	25 Nov 1956	33°36′N, 118°03′W	6
	1 Dec 1956	32°38′N, 117°17′W	8
	26 Nov 1958	Iron Bound Bay, Catalina Island	5
Lévèque (1963)	Unreported	Galapagos Islands	Unreported
Stephens (1963)	Unreported	Point Dume, Calif.	1
	? Mar 1959	28°20′N, 115°39′W	1
	? June 1960	La Jolla Cove, Calif.	4
	? Jan 1962	33°00′N, 117°10′W	1
	? Apr 1963	33°00′N, 117°00′W	4
Burrage (1964)	26 Jan 1964	32°50′N, 117°18′W	Unreported
Fiscus & Niggol (1965)	19 Mar 1958	34°05′N, 120°25′W	1
	6 Feb 1959	35°15′N, 121°54′W	2
	20 Feb 1959	34°39′N, 122°21′W	2
Leatherwood, Evans & Rice (1972)	Unreported	Notes distribution off So. California; Baja California, Mexico; and in pelagic tropical Pacific	Unreported
Gilmore (1976)	2 Sept 1953	La Jolla, California	3
	12 Apr 1954	La Jolla, California	16
	28 May 1954	La Jolla, California	4
	? July 1954	La Jolla, California	Unreported
	4 Sept 1954	La Jolla, California	3
	? Sept 1955	La Jolla, California	2
	25 Sept 1955	La Jolla, California	2
	20 Mar 1956	La Jolla, California	1
Norris et al. (1976)	Jan–Dec 1975–76	Southern California Bight	Unreported
Aguayo (1975)	Unreported	Notes distribution off Chile	Unreported
Leatherwood & Dahlheim (1978)	Unreported	Notes distribution California coast, around islands of Baja California, Mexico, and in the Gulf of California	Unreported

DISCUSSION

From the available data, strandings of killer whales in the study area would appear uncommon. The low frequency with which killer whales strand along the heavily populated and well-patrolled shores of southern California and extreme northwestern Baja California may be related to the apparent scarcity of killer whales in that area (see discussion of NOSC aerial surveys above; Norris, Dohl, Guero, Hobbs and Honig, 1976) or to a generally low tendency of this species to strand even when it is present in substantial numbers. For example, in the waters of Puget Sound, Washington, and British Columbia, where a population which numbers at least 216 individuals (and is seasonally supplemented by other emigrants) is carefully monitored (Bigg *et al.*, 1976) and well known to the public (Chandler *et al.*, 1977), only nine strandings have occurred in the last eight years (Michael Bigg, 20 May 1981, pers. comm.). Strandings of killer whales appear to be equally rare in other parts of the world.

Killer whales were seen frequently in near-shore parts of the study area south of southern California. However, few strandings were reported for that area. One cannot rule out the possibility that the low number of stranding records in most of the study area simply reflects the inaccessibility of much of the shoreline of Baja California, Mexico, Central America, and northwestern South America and the infrequency with which these shores are visited by scientists and others who take note of such events. Certainly, no seasonal or geographical patterns can be ascertained from the data currently available.

The overall concentration of records nearshore clearly reflects a concentration of effort in those areas by the fishery on which these data depended. In 1974–78, alone, most coastal zones were surveyed from 500 to over 1000 hours. Those coastal zones were fringed by a band of zones which were surveyed for 250 to 500 hours. Outside of those, westward and southward, there was little or no effort. Effort was heaviest in the early months of the year,

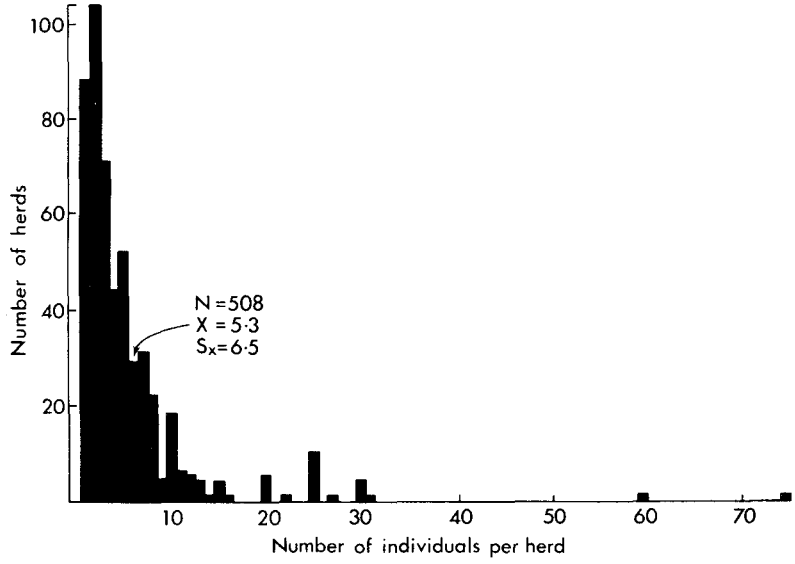

Fig. 5. Distribution of herd sizes of killer whales in the warm temperate and tropical eastern Pacific Ocean.

widely distributed but much of it concentrated near coasts. As the fishing season progressed that effort constricted in area and shifted its emphasis offshore and slightly southward (Au, Perryman and Perrin, 1979). The general decline in sightings offshore is, most likely, directly related to this pattern in effort. For that reason, the two areas of apparent offshore concentration are worthy of special note in that they occur within broad areas in which there were similar levels of effort but no sightings. Environmental features of the eastern tropical Pacific and their relationship to dolphin distribution are discussed by Au *et al.* (1979). These offshore concentrations of killer whales occur within the divergence zones of the North Equatorial Current and the Equatorial Counter Current, where other species of small delphinids have been reported. In the northwesternmost of these areas, similar concentrations are noted for bottlenose dolphins, *Tursiops* sp. (Walker, 1981) and pilot whales, *Globicephala* sp. (Reilly, 1977).

In other areas of the world, killer whale occurrence and movements have been related to movements of prey species, such as rorquals and seals off Canada (Sergeant and Fisher, 1957), herring off Norway and Iceland (Jonsgård and Lyshoel, 1970) and salmon in Puget Sound, Washington State (Balcomb, 1978). We do not know what killer whales feed on in the area covered by this report.

Herd sizes observed in the study area were smaller than those from the colder latitudes, where concentrations of 500 (Fiscus *et al.*, 1976) to 2.500 (J. Branson, Feb. 1980, pers. comm.) have been reported, but are consistent with those reported by Hall and Kelson (1959), 2–40 indi viduals, and Kasuya (1971), 1–30, $\bar{x} = 6$, for temperate waters.

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