

DISTRIBUTION AND MOVEMENTS OF RISSO'S DOLPHIN, *GRAMPUS GRISEUS*, IN THE EASTERN NORTH PACIFIC

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ABSTRACT

Records of occurrence are summarized from 22 strandings/collections and 210 sighting records from miscellaneous sources. When available, levels of effort have been identified and utilized to interpret the trends in distribution and movement apparent from the data. Risso's dolphins occur from at least the Equator (southern end of area examined) north to approximately latitude 50° N, with regions of apparently very low density centering at about latitude 20° and 43° N. Records from northern and inshore portions of the range were most numerous during late spring through early fall. Both within and among years, periods of greatest abundance for the species north of latitude 43° N, near Monterey Bay, California, and over the southern California continental borderland appear to correspond with protracted periods of warm water. Groups contained from 1 to an estimated 220 animals, about a geometric mean of 10.7. An estimated 76.4% of the groups contained fewer than 20 animals.

The Risso's dolphin or gray grampus, *Grampus griseus*, is widely distributed in tropical and temperate waters around the world. It occurs on the western side of the Atlantic Ocean from at least Newfoundland (approximately lat. 50° N, Leatherwood et al. 1976) south to Cape Horn (approximately lat. 53° S, Norris⁶), and in the Gulf of Mexico (True 1885; Gunter 1954; Paul 1968) and the Caribbean (Caldwell et al. 1971). On the eastern side of the Atlantic it occurs from the Shetland Islands, Scotland (Turner 1892), south to the Cape of Good Hope (approximately lat. 34° S, Barnhard 1954), including the North Sea (Schultz 1970), and throughout the Mediterranean Sea complex (Bazzauti 1910; Tamino 1953; Pilleri and Gühr 1969), including the Adriatic (Trois 1883; Ninni 1901; Carrucio 1906; Riedl 1965; Pilleri and Gühr 1969). It also occurs in the Red Sea (Hershkovitz 1966) and in the Indian Ocean (Ellerman et al. 1953;

Weber 1923), at least to the Indo-Australian Archipelago, and on the west side of the Pacific Ocean from the Commander Islands (approximately lat. 55° N, Sleptsov 1961) south to New Zealand (Hector 1873; Parker 1934; Alpers 1960; Gaskin 1968; Baker 1974), including the South China Sea, the Philippine Sea (Baker 1974), and the waters around the New Hebrides (Maxwell 1952), the Solomon Islands (Dawbin 1966), and New Guinea (Gaskin 1972). On the eastern side of the Pacific it has been reported from the Bering Sea (Clark 1945) and British Columbia (Guiguet and Pike 1965) south to Valparaiso, Chile (Aguayo 1975), and Cape Horn (Norris see footnote 6), including the Gulf of California (Leatherwood et al. 1979). That Risso's dolphins are present in Hawaiian waters as well is indicated by three sightings and a stranding on Maui in 1977 (E. W. Shallenberger⁷). Davies (1963) remarked on the species' overall distribution that it is basically tropical but extends its ranges poleward to overlap the ranges of temperate forms, though they generally do not penetrate so far into high latitudes. In all areas, the species' distribution is known only from infrequent stranding records and at-sea sightings, and published accounts continue to restate those records, often without adding substantial new data. Details of the animal's distribution and movements are not reported. This paper reviews the information available through 1975 on Risso's

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⁶Norris, K. S. 1968. Cruise report of the R/V *Hero*, November 12-December 11, Valparaiso-Puntarenas, Chile, 11 p. Coastal Marine Laboratory, University of California, Santa Cruz, CA 95060.

⁷E. W. Shallenberger, Curator, Sea Life Park, Waimanalo, HI 96795, pers. commun. to Leatherwood September 1977.

dolphins in the portion of the eastern Pacific from the Equator and long. 145° W north and east respectively, from strandings, collections, and sighting records, and examines the data for patterns in distribution, movement, and seasonal occurrence.

METHODS

Inherent in the approach to this paper is the opinion that for this as for other areas, there are numerous scientists and organizations which have small amounts of information of little significance alone, but when the data are combined, they can yield a better understanding of what is known about a given cetacean species (e.g., see Leatherwood and Walker (1979) on *Lissodelphis borealis*).

We reviewed previously published records of at-sea sightings of Risso's dolphins in the study area (Table 1). We then examined over 250 previously unpublished reports of sightings of the species in the area from 1958 to 1975⁸ for reliability of identification. Interviews with observers and

photos assured us of the accuracy of most records. Descriptions of animals with slate gray to nearly all-white coloration, extensive scarring, a bifurcated melon, and a prominent dark dorsal fin, all distinctive characteristics of Risso's dolphins (Figure 1), aided in verification of the remainder. We discarded questionable records.

Many of the reports included estimates of herd size. Since many of these were stated as ranges (e.g., 30-40 animals), we used the midpoint of each estimate. If the estimate was such that the midpoint was a half number (e.g., an estimate of 10-15 animals) we took the lower of the numbers (e.g., 12).

Some records also included measurements of sea surface temperature at or near the location of the observation. The few of those most important to interpreting apparent trends in the more northern portions of the study area were used, along with annual summaries of temperature trends.

Incidental sighting records alone cannot be used to reliably determine trends in distribution, movements, or abundance. Data on sighting effort are essential. Although a few major marine surveys have been conducted in the study area, effort is difficult to quantify for most other sources of

⁸A summary of verified records of observations of *Grampus griseus* in the northeast Pacific is available from Leatherwood or Perrin.

TABLE 1.—Previously published at-sea sightings of Risso's dolphins in the eastern North Pacific. In the few cases where collections were reported, as in Orr (1966), herds from which animals were collected are not included as sight records.

Source	Date	Location	Number in school
Hubbs (1960)	? 1960	Isla Guadalupe, Mexico	Unreported
Fiscus and Niggol (1965)	18 Mar. 1958	38°30' N, 124°15' W	"Many animals"
Guiguet and Pike (1965)	22 July 1958	50°00' N, 145°00' W	1
Fiscus and Niggol (1965)	27 Jan. 1959	36°45' N, 122°33' W	3
Fiscus and Niggol (1965)	4 Feb. 1959	35°12' N, 122°05' W	50+
Fiscus and Niggol (1965)	8 Feb. 1959	35°44' N, 122°43' W	2
Fiscus and Niggol (1965)	18 Mar. 1959	41°42' N, 125°53' W	10+
Fiscus and Niggol (1965)	28 Mar. 1959	40°52' N, 125°19' W	5
Guiguet and Pike (1965)	11 Oct. 1959	50°00' N, 145°00' W	6
Guiguet and Pike (1965)	15 Aug. 1960	50°00' N, 145°00' W	5
Guiguet and Pike (1965)	4 Sept. 1960	50°00' N, 145°00' W	4
Daugherty (1972)	? 1971	Midway between San Diego (Pt. Loma) and San Clemente Island, Calif.	50
Leatherwood et al. (1972)	? 1971	05°00' N, 87°04' W	Unreported
Leatherwood et al. (1972)	? 1971	11°00' N, 109°30' W	Unreported
Leatherwood et al. (1979)	13 Feb. 1974	24°52' N, 108°58' W	5-10
Leatherwood et al. (1979)	13 Feb. 1974	28°21' N, 112°30' W	2



FIGURE 1.—Risso's dolphins off southern California, 1973. The animal's distinctive whitish head (in adults), scarring, and high subtriangular dorsal fin enhance the reliability of "incidental" observational records. (Photo by G. E. Lingle, courtesy Naval Oceans Systems Center, San Diego, Calif.).

data. The following information on effort, from which we feel reliable trends may be determined, exists for the survey programs in the study area.

From San Diego to Equator—National Marine Fisheries Service (NMFS) observers, aboard tunaboats working primarily out of San Diego, Calif, surveyed the area from San Diego south to the Equator from 1966 through 1975. The majority of effort was concentrated in January and February, declining rapidly through April to no effort in the Commission Yellowfin Regulatory Area (CYRA) of the Inter-American Tropical Tuna Commission by the third quarter (Figure 2). It is evident that there has been very little effort in the nearshore portion of the tropical CYRA during the third and fourth quarters, although there were six chartered cruises between September and December. Far-offshore fishing and research activity continued throughout the year. Because the vessels return north to San Diego, running anywhere from 12 mi offshore to beyond the continental shelf off Baja California, effort appears to have been adequate throughout that area to detect major

seasonal changes in composition of marine mammal fauna. This is the only program for the area for which extensive and quantified data on effort and sightings were available.

Since 1968, cruises of the Naval Ocean Systems Center, San Diego (NOSC, formerly Naval Undersea Center), have examined the continental shelf area off northwestern Baja California during winter and spring (October-December and February-April). Vessels of the Scripps Institution of Oceanography with marine mammal observers aboard have cruised extensively among the San Diego-Guadalupe Island-Cedros Island triangle for over 30 yr.

Southern California Continental Borderland—Survey effort has been extremely heavy over the continental shelf from Ensenada north to Point Conception. Norris and Prescott (1961) reported on activities of Marineland of the Pacific, primarily between Catalina and Santa Barbara Islands and the mainland shore near Los Angeles. Leatherwood (1974), Evans (1975), and Leatherwood and Walker (1979) summarized NOSC aerial

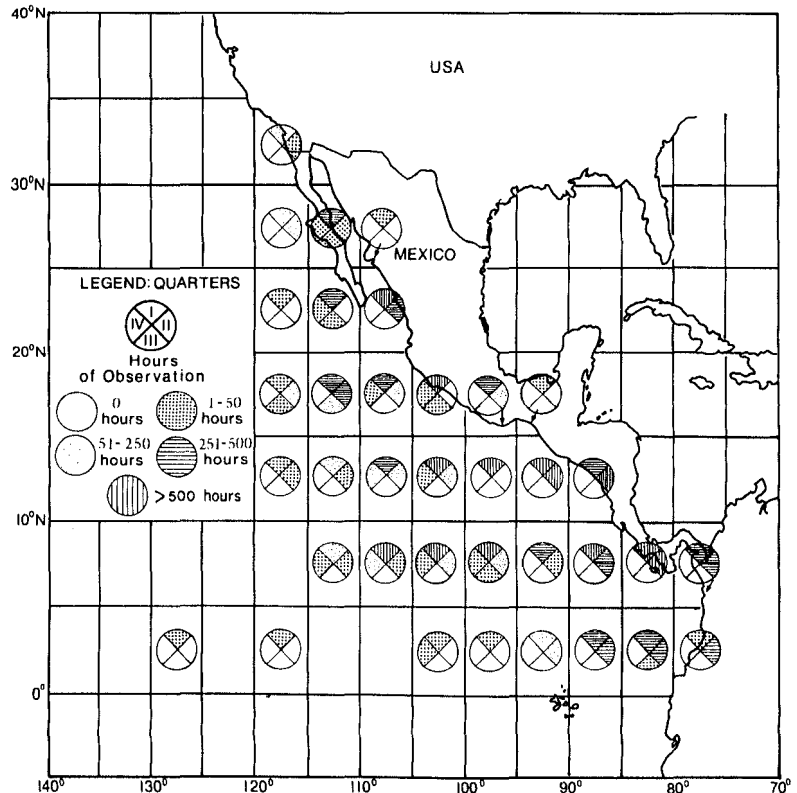


FIGURE 2.—Relative numbers of hours of observation by NMFS/SWFC observers aboard tunaboats in the eastern tropical Pacific by quarter of year, 1974-75.

and ship survey effort in this area for 1968-75. Norris et al.⁹ summarized Bureau of Land Management (BLM) aerial and ship surveys during 1975 and 1976. Although variable by month, we consider this combined effort adequate at all seasons to have detected trends in composition of marine mammal fauna for the borderland and adjacent continental slope. Coverage was particularly thorough for the area in 1975, when NOSC and BLM programs overlapped.

Offshore Southern and Central California—During 1967 and 1968, cruises of the Smithsonian Institution's Pacific Ocean Biological Survey program surveyed the outer California Channel Islands and the area from lat. 29° to 37° N and seaward to long. 126° W during all quarters of the year. Marine mammal observations by experienced personnel were logged for all cruises (R. L. Brownell, Jr.¹⁰).

Offshore Baja California North to Washington—More recent coverage of the area from lat. 25° N to Washington State, primarily offshore, has been provided by NMFS observers out of the Southwest Fisheries Center (SWFC) placed on commercial albacore boats. In 1971-75, observers

⁹Norris, K. S., T. P. Dohl, R. C. Guero, L. J. Hobbs, and M. W. Honnig. 1976. Cetaceans; numbers, distribution, and movements in the southern California Bight. 192 p. Draft report to Bureau of Land Management, OCSEAP, from Coastal Marine Laboratory, University of California, Santa Cruz, CA 95060.

¹⁰R. L. Brownell, Jr., U.S. National Museum of Natural History, National Fisheries and Wildlife Laboratory, Wash., DC 20560, pers. commun. to Leatherwood June 1975.

TABLE 2.—Months during 1961-75 in which marine mammal watches were maintained aboard one or more albacore vessels (×) in the eastern Pacific (1971-75), by 5° increments of latitude. A total of 15 vessels were involved.¹⁻⁴

Lat. (° N)	May	June	July	August	September
45-50				×	×
40-45		×	×	×	×
35-40		×	×	×	
30-35	×	×	×		
25-30	×	×	×		

¹Lauris, R. M., and Associates. 1972. Report of joint National Marine Fisheries Service - American Fisherman's Research Foundation albacore studies conducted during 1971 and 1972. Spec. Publ. SWFC, NMFS, NOAA, La Jolla, Calif., 78 p.

²Lauris, R. M., and Associates. 1973. Report of joint National Marine Fisheries Service - American Fisherman's Research Foundation albacore studies conducted during 1973. Spec. Publ. SWFC, NMFS, NOAA, La Jolla, Calif.

³Lauris, R. M., and Associates. 1974. Report of joint National Marine Fisheries Service - American Fisherman's Research Foundation albacore studies conducted during 1974. Admin. Rep. 25-74-47, SWFC, NMFS, NOAA, La Jolla, Calif.

⁴Lauris, R. M., R. J. Lynn, and R. N. Nishimoto. 1975. Report of joint National Marine Fisheries Service - American Fisherman's Research Foundation albacore studies conducted during 1975. Spec. Publ. SWFC, NMFS, NOAA, La Jolla, Calif.

aboard 15 working albacore boats reported marine mammal observations made between May and September from lat. 25° to 46° N (Table 2). Although the time and location of their activities varied annually with the albacore migration, coverage was generally restricted to summer and generally moved north as the season progressed.

Nearshore Central California—Recent aircraft and ship surveys by the University of California at Santa Cruz have examined the area from about Point Conception north, with the most extensive sampling effort in Monterey Bay. Coverage near Monterey Bay has been year-round (J. D. Hall¹¹). Infrequent cruises by personnel from Hopkins Marine Station and Moss Landing Marine Laboratory have examined the same area (A. Baldrige¹²).

Oregon and North—With one important exception, recorded survey effort begins to decline as one moves north from California. NMFS albacore-boat observer programs conducted in the summer have extended north of Point Conception (Table 2), and one NOSC marine mammal cruise was conducted from San Diego to Kodiak, Alaska, in April 1971. The primary effort, however, including extensive coverage of the area from Seattle north through the Gulf of Alaska and northwest to the Aleutian Islands and the Bering Sea, has been that by cruises of the NMFS Northwest and Alaska Fisheries Center (NWAFC) Pelagic Fur Seal Research Program. Over the past 10 yr, these cruises have primarily spanned the fall and winter months (C. H. Fiscus¹³). Other research cruises by NWAFC have begun in the Seattle area and worked south to southern California in January, February, and March (Fiscus and Niggol 1965), while still others beginning in San Francisco have worked south to the Revillagigedo Islands in winter and spring (Rice 1963a, b).

The remainder of the sighting effort for the northeastern Pacific is difficult to assess, though it

¹¹J. D. Hall, U.S. Fish and Wildlife Service, Office of Biological Services, 800 A Street, Suite 110, Anchorage, AK 99501, pers. commun. to Leatherwood August 1975.

¹²A. Baldrige, Library, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Fla.; present address: Hopkins Marine Station, Pacific Grove, CA 93950, pers. commun. to Leatherwood 1975.

¹³C. H. Fiscus, Northwest and Alaska Fisheries Center Marine Mammal Division, NMFS, NOAA, 7600 Sand Point Way NE Seattle, WA 98115, pers. commun. to Leatherwood June 1976.

is clearly sporadic and has concentrated on coastal regions near population centers.

The areas of coverage of the most important programs considered in this report are summarized in Figure 3. (The expanded area coverage of the SWFC tunaboat-observer program is shown in Figure 2).

RESULTS

Strandings and Collections

As nearly as we can determine, 22 strandings and/or collections of specimens of *G. griseus* have been recorded in the northeastern Pacific since about 1872 (Figure 4).

1. (Published). In the late 19th century, probably in 1872, although the exact date is undeterminable, Charles M. Scammon obtained two lower jaws from Monterey, Calif. (Scammon 1874). Dall (1874) used these two lower jaws as the basis for his description of *G. sternsii*, later rejected as a species by True (1889) because it was indistinguishable from *G. griseus* (G. Cuvier 1812). One lower jaw and two teeth were deposited in the U.S. National Museum (USNM 13021), though True could not make his measurements agree with Dall's and tentatively said that it was "apparently neither the No. 1 nor the No. 2 of Mr. Dall's description" (True 1889). The whereabouts of the second mandible or, if True's

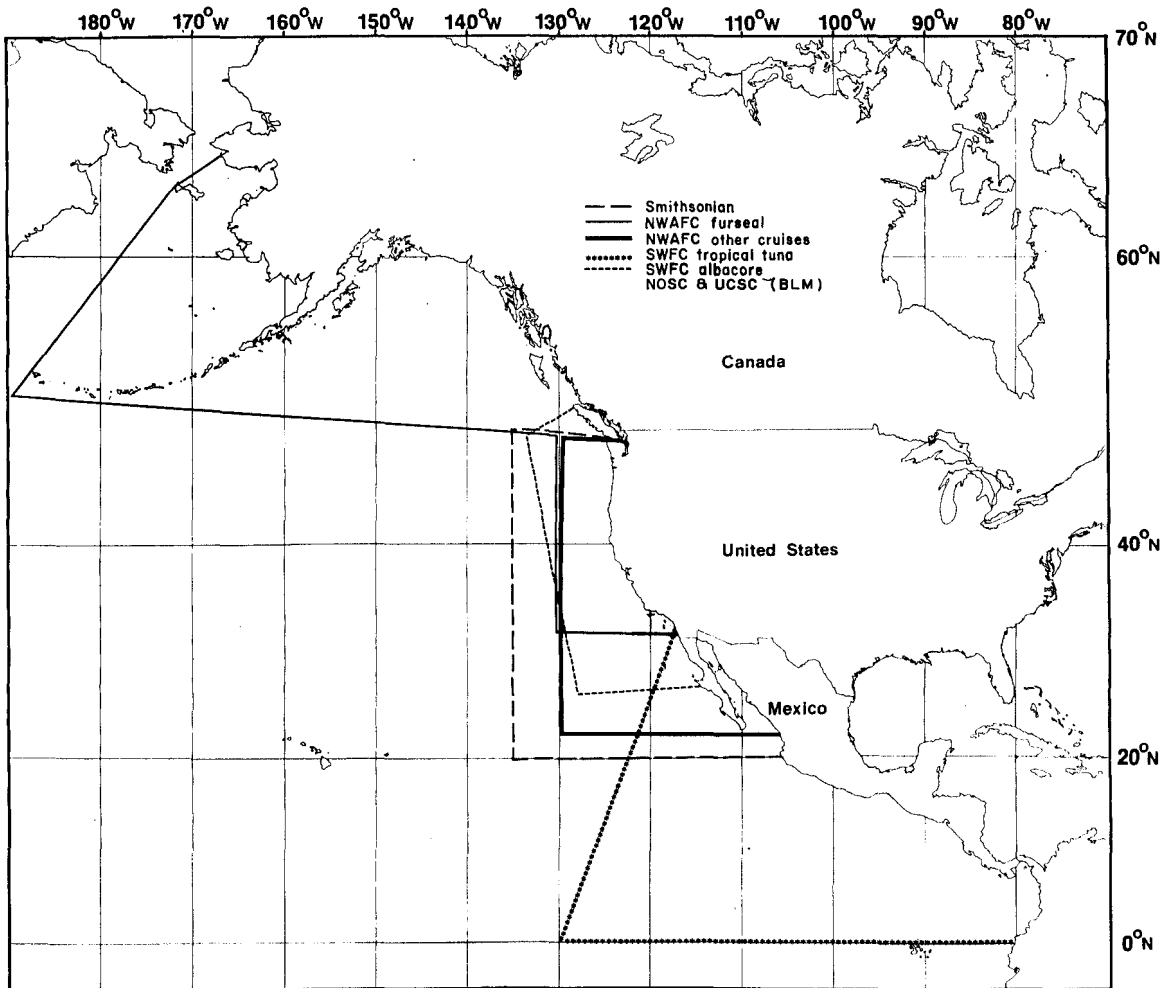


FIGURE 3.—The eastern North Pacific north of lat. 15°N, showing areas surveyed by major marine mammal survey programs (1958-75). See text for details of documentation.

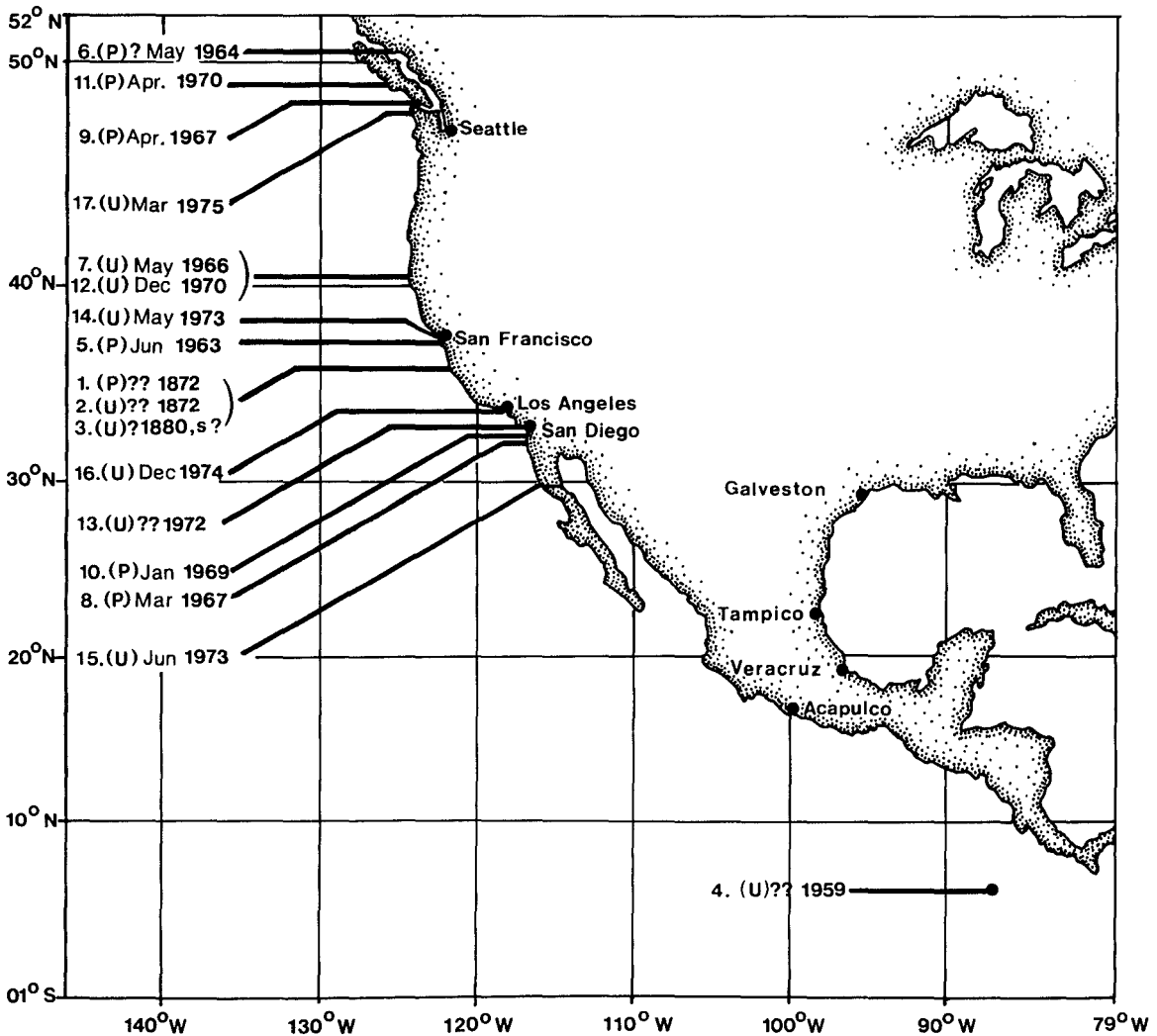


FIGURE 4.—Dates and approximate locations of strandings and collections of Risso's dolphins in the eastern North Pacific (1972-75) numbered in chronological order. The letters in parentheses indicate whether the record has (P) or has not (U) been previously published.

observations are correct, both mandibles described by Dall, are unknown, as is the identity of USNM 13021.

2. (Unpublished). During the same period, exact date also undeterminable, Scammon collected a second specimen which he also forwarded to True at the U.S. National Museum (USNM 21163). Like the first, this specimen was reportedly taken in Monterey Bay, Calif. (C. H. Gilbert¹⁴).

¹⁴C. H. Gilbert undated letter to W. Dall, in possession of Hubbs.

3. (Unpublished). There are three remaining specimens from the Pacific coast of North America in the collection of the U.S. National Museum. One (USNM 28066) was purchased from fishermen in Monterey; one (USNM 49895) was taken from an unidentified locality in California; and the third (USNM 49347) was collected by C. H. Gilbert, presumably also in Monterey. Interestingly, in referring to this last specimen in his correspondence with Dall, Gilbert (see footnote 14) wrote "In addition to that, I have the complete skeleton of a calf about 6 months old. The species is abundant in Monterey

Bay and additional specimens could be secured for you if you desire."

4. (Unpublished). In 1959, a single lower jaw identifiable as that of a Risso's dolphin was brought to Hubbs from Isla de Coco ("Cocos Island"), lat. 05°32' N, long. 87°04' W. The location of the specimen is currently unknown.

5. (Published). On 11 June 1963, a 325.0 cm male apparently dead from gunshot wounds stranded on the beach 0.9 km from Princeton by the Sea, San Mateo, Calif. The account of the stranding and its workup includes a description of the specimen, analysis of stomach contents, miscellaneous external measurements and organ weights, and some cranial measurements (Orr 1966). The specimen was deposited in the collection of the California Academy of Sciences, San Francisco (CAS 13461, Orr 1966). This account represents the first continental eastern Pacific record of the species published since the late 19th century.

6. (Published). In May 1964, a single 11-ft (334.0 cm) Risso's dolphin was observed alive in Big Bay on the west side of Stuart Island, British Columbia (approximately lat. 50°20' N, long. 125°00' W). The animal was shot, dissected, and discarded. The caudal peduncle and flukes were later recovered and placed in the collection of the British Columbia Provincial Museum (BCPM 9077). The animal was reported by the collectors to have been feeding on squid and to have had a heavy intestinal parasite load (Guiget and Pike 1965).

7. (Unpublished). On 13 May 1966, Robert E. Jones (Museum of Vertebrate Zoology, Berkeley, Calif.) found a long dead but complete carcass of a stranded male approximately 10 km south of Cape Mendocino, Humboldt County, Calif. The total length of the specimen was 9 ft 7.5 in (293.9 cm). The skull and left flipper were collected and deposited at the Humboldt State University (HSC-66-4).

8. (Published). On 18 March 1967, an adult male stranded alive at Cantomar (Rosarita Beach), 42 km south of Tijuana, Baja California, Mexico (approximately lat. 32°18' N, long. 117°00' W). It was taken to Sea World in San Diego, Calif., where it survived for a short time. A photo of this animal appeared in the *San Diego Union* 28 March 1967 on page B-5. This specimen was 307.0 cm long (Harrison et al. 1969) and weighed 850 lb (386 kg) (measured by Hubbs).

Although the specimen was reportedly deposited in the San Diego Natural History Museum, the Museum has no record of the specimen and its whereabouts are unknown.

9. (Published). On 20 April 1967, a 258 cm male apparently dead from a gunshot wound in the head was found stranded at Makkaw Bay, Wash. (lat. 48°19' N, long. 124°40' W). The dolphin had been dead an estimated 1 mo. Its stomach contained squid beaks and fragments. The skull and postcranial skeleton were preserved in the collection of NWAFC, NMFS, NOAA, Seattle, Wash. (Stroud 1968).

10. (Unpublished). On 21 January 1969, a 309 cm adult male stranded alive at Imperial Beach, San Diego County, Calif. The animal was taken to Sea World, San Diego, where it died the night of 21-22 January 1969. The complete skeleton was collected by Raymond M. Gilmore and deposited in the San Diego Natural History Museum (SDNHM 21554) (R. M. Gilmore¹⁵).

11. (Published). On 17 April 1970, a 266 cm male washed ashore on the east side of Vargas Island, British Columbia (lat. 49°10' N, long. 125°58' W). The skull, axial skeleton, and bones from one pectoral appendage were collected and placed along with a complete photo series (Photofile No. 51) in the collection of the Vertebrate Museum, Department of Zoology, University of British Columbia (UBC 9464). The report of the stranding includes external measurements, organ weights, and an analysis of stomach contents (Hatler 1971).

12. (Unpublished). On 26 December 1970, a male neonate was collected from the beach in Shelter Cove, Humboldt County, Calif. The entire specimen (Field No. WJH 71-1) was deposited at the Humboldt State University (HSU 1620) (W. J. Houck¹⁶).

13. (Unpublished). In August of 1970, responding to a radio call from local fishermen, F. Brocata and B. Falcone of Marineland of the Pacific investigated a call about an "albino" pilot whale which had been harpooned by fishermen between Santa Cruz and Santa Rosa Islands, Calif. When Marineland's research boat, the MV *Geronimo*, approached the whale, which turned out to be a Risso's dolphin, the animal managed to

¹⁵R. M. Gilmore, Research Associate, San Diego Natural History Museum, San Diego, CA 92112, pers. commun. to Leatherwood 1975.

¹⁶W. J. Houck, Humboldt State University, Arcata, CA 95521, pers. commun. to Leatherwood 1975.

pull out the harpoon and swim away (W. A. Walker¹⁷).

14. (Unpublished). On 20 May 1973, an immature female was found stranded on southeast Farallon Island, off San Francisco, Calif. (approximately lat. 37°42' N, long. 123°00' W). The available measurements for the specimen are as follows: total length 270 cm, dorsal fin 27.5 cm, axilla-tip of flipper 5 cm, origin of flipper to tip of lower jaw 46.5 cm, anus-tip of lower jaw 178 cm, width of flukes 62 cm. The specimen was not collected (R. L. Brownell, Jr. see footnote 10).

15. (Published). On 18-19 June 1973, four females and a fifth animal of undetermined sex, all about 13 ft long (400 cm) and weighing 500-600 lb (73-77 kg) stranded alive at Punta Bufeo, Baja California, about 100 mi (160 km) south of San Felipe on the northwest coast of the Gulf of California (approximately lat. 29°55'20" N, long. 114°26'20" W). All five animals were towed out to sea (dead), and no materials were retrieved (Leatherwood et al. 1979).

16. (Unpublished). On 8 December 1974, a female stranded alive at the Manhattan Beach Pier, Los Angeles, Calif. (approximately lat. 33°55' N, long. 118°25' W). The animal was alive when it was collected by Marineland of the Pacific but died almost immediately after collection. It was photographed, measured, and necropsied at the Los Angeles County Museum of Natural History, where it is currently held as specimen LACM 47145. Detailed findings will be reported elsewhere (W. F. Samaras and D. R. Patten¹⁸).

17. (Unpublished). On 10 March 1975, a 348 cm female stranded alive at Port Discovery, Wash., in the Strait of Juan de Fuca (about lat. 48°02' N, long. 122°52' W), perhaps driven ashore by killer whales. The animal was recovered alive and taken to Seattle Marine Aquarium where it died on 11 March. The complete skeleton is in the collection of the NWAFC (No. 1975-1).

At-Sea Sightings

We found 16 previously published records of at-sea sightings of Risso's dolphins for the study area (Table 1) and 194 additional previously un-

published reliable records (see footnote 8) (Figure 5). When examined by latitude (Figure 5), the distribution of sightings falls into three major groups—those from the Equator to approximately lat. 20° N (Zone I); those thence north to approximately lat. 43° N (Zone II); and those north of lat. 43° N (Zone III). Zones I and II are separated by a broad region characterized by very few sightings, centering at about lat. 20° N and extending from lat. 14° to 29° N. All except two sightings in that area of low density were within 60 mi of the Mexican coast, though seaward of the continental shelf. The separation between Zones II and III is less pronounced, centering at lat. 43° N and extending from lat. 38° to 45° N.

Regarding seasonality, records in Zone I are almost exclusively limited to first and second quarters, and the majority of those from Zone III are from the period July through October. Both of these apparent seasonal fluctuations result from the biases in observation effort discussed above. Those from Zone II are distributed throughout the year. Records from north of Point Conception (lat. 35° N) are most numerous in the third quarter (Figure 6).

Off southern California (approximately lat. 31°-35° N), records from 1959 to 1975 were sporadic, reaching a peak of 11 in 1974 (Table 3). Until 1971 the majority of sightings for the area were seaward of the 100-fathom curve; however, beginning in 1971 and increasing in frequency through 1974 (9 of 11) and 1975 (3 of 3), most sightings were over the continental shelf.

Although surface water temperatures were not reported for most sightings, Risso's dolphins have been sighted in waters ranging from 28° to 10° C. Sightings in Zone I cover the full range of temperatures reported for the area. Sightings off southern California in 1974 and 1975 were associated with water temperatures above 19° C. Of the 22

TABLE 3.—Summary of sightings of Risso's dolphins off southern California (about lat. 31°-36° N), 1959-75, showing the frequency of encounter over and seaward of the continental shelf.

Year	Total no. sightings	Over continental shelf	Seaward of continental shelf
1959	1	1	0
1960	1	1	0
1965	1	0	1
1966	3	0	3
1967	9	0	9
1968	3	1	2
1971	4	4	0
1972	4	4	0
1973	3	2	1
1974	11	10	1
1975	3	3	0

¹⁷W. A. Walker, 21 Barkentine Road, Rancho Palos Verdes, CA 93704, pers. commun. to Leatherwood 1975.

¹⁸W. F. Samaras, Research Associate, and D. R. Patten, Curator, Department of Mammals, Los Angeles County Museum of Natural History, Los Angeles, CA 90007, pers. commun. to Leatherwood 1975.

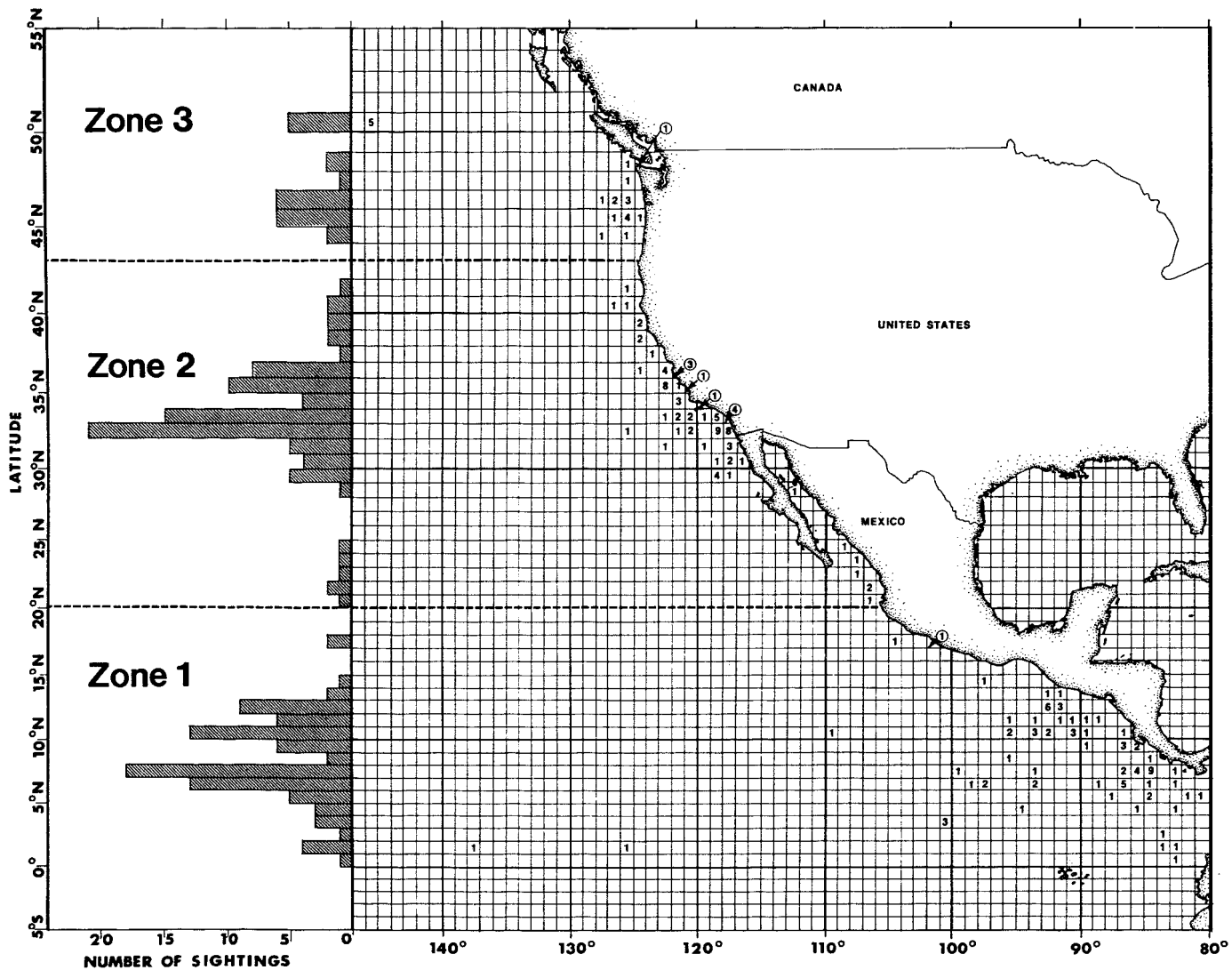


FIGURE 5.—At-sea sightings of Risso's dolphins in the eastern North Pacific (1958-75) by 1° square and frequency by 1° of latitude based on 210 sightings.

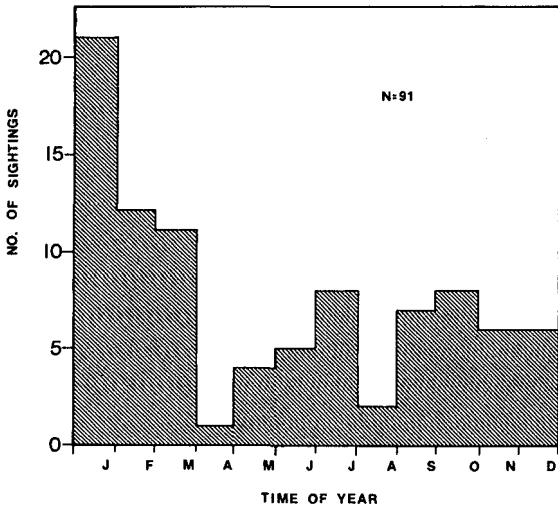


FIGURE 6.—Frequency of sightings of Risso's dolphins by month in Zone II in the eastern North Pacific (defined in Figure 5).

most northern records, the 4 from February to April were associated with water temperatures of 12° and 13° C, unusually high temperatures for the season.

Of the records, 12 published and 191 unpublished provided usable estimates of herd sizes. Numbers of animals sighted ranged from 1 to 220, about a geometric mean of 10.65. About 75% of the groups contained fewer than 20 animals (Figure 7). No statistically significant differences could be demonstrated among herd sizes from different zones (I, II, III) or different seasons (Mann-Whitney *U* Test, $\alpha = 0.05$).

SUMMARY AND DISCUSSION

Risso's dolphins are clearly abundant and widely distributed year-round in tropical and warm temperate waters of the northeastern Pacific.

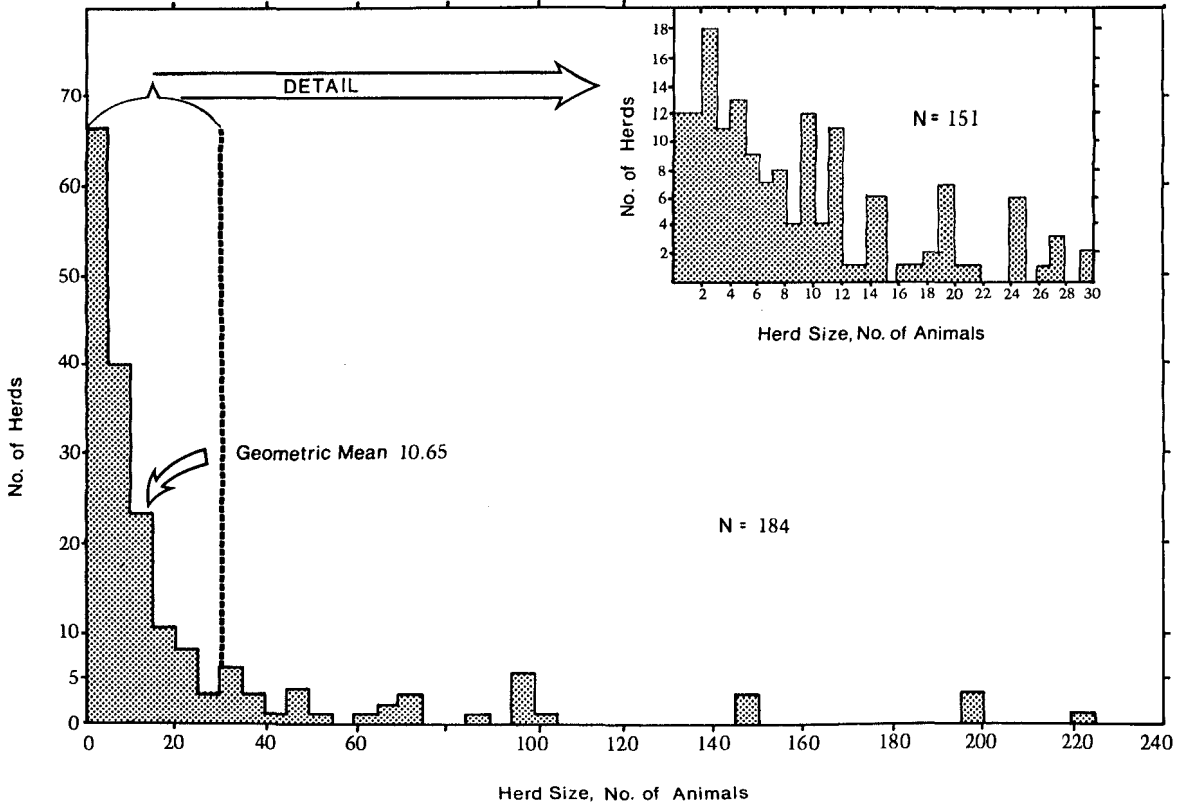


FIGURE 7.—Distribution of estimated "herd" sizes of Risso's dolphins, in the eastern North Pacific (1958-75). Inset gives detail for herd sizes with <30 animals.

The rather dramatic decrease in the number of sightings north of about lat. 13° N and the very limited number of offshore sightings in the broad belt from about the latitudes of Cedros and Guadalupe Islands south to approximately Acapulco, appear to reflect an area of apparent very low density in the species' distribution, since survey effort in the area was heavy even where no sightings were reported. Pronounced distributional gaps in portions of the same ocean area have been documented for *Delphinus delphis* (Evans 1975) and *Stenella* spp. (Perrin 1975).

Risso's dolphins appear to occur year-round in offshore waters from about central Baja California northward to about San Francisco. Movements onto the continental shelf of southern California are seasonal and appear to be related to surface temperatures. For example, records of Risso's dolphins over the continental shelf were more numerous in 1974 than in previous years since 1968, despite an equal effort, and more numerous than in 1975, despite increased survey effort in that year. In 1974 and 1975, surface temperatures were unusually high (California Cooperative Oceanic Fisheries Investigations¹⁹).

A poorly defined area of apparent low density in distribution, centering at about lat. 43° N, probably reflects generally poor sampling in the area from about San Francisco north to the latitude of Seattle and not any real change in the species' density there.

Records from lat. 45° to 51° N are most abundant during summer and are primarily off the continental shelf. Like the movements onto the southern California continental borderland and those into more northern latitudes, this change appears to relate to warming of surface waters.

The reports of abundance near Monterey in the late 19th century seem inconsistent with modern records of low abundance in the area. It may well be that this indication of the common occurrence of the species in Monterey Bay in the 1870's and 1880's represents a holdover of the occurrence of tropical animals in central California in the 1850's (Hubbs 1948). This being the case, the movement of Risso's dolphins north and inshore in some abundance during that period is consistent with behavior in 1974 and 1975 off southern California. Southward movements of the Dall's porpoise,

Phocoenoides dalli, into southern California (Norris and Prescott 1961) and seasonal movements of the right whale dolphin, *Lissodelphis borealis* (Leatherwood and Walker 1979), and the Pacific whitesided dolphin, *Lagenorhynchus obliquidens* (Leatherwood and Reeves 1978), in the eastern North Pacific have been similarly linked to seasonal changes in water temperature.

Despite extensive survey effort in the northern temperate and Arctic eastern Pacific, Risso's dolphins have not been reported north of lat. 51° N. Therefore, since it provided no new data, the summary report of the species' occurrence in the Bering Sea (Clark 1945) is of doubtful accuracy.

Considered together, these records tend to support Davies' (1963) summary of the species' distribution, at least in the northeast Pacific. It appears, as he contended, to be primarily tropical, extending its range poleward to overlap with temperate forms, though not penetrating as far into high latitudes. Perhaps the most important point supported by these records is the dynamic nature of distribution of this (and probably other) marine mammal species. In addition to well-documented short-term and seasonal movements, there appears to have been a long-term fluctuation in the boundaries of species' ranges, apparently in responses to long-term environmental changes.

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¹⁹California Cooperative Oceanic Fisheries Investigations. Unpublished data in files of CalCOFI at the Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, La Jolla, CA 92038.

LITERATURE CITED

- AGUAYO, A.
1975. Progress report of small cetacean research in Chile. *J. Fish. Res. Board Can.* 32:1123-1143.
- ALPERS, A.
1960. A book of dolphins. *J. Murray, Lond.*, 147 p.
- BAKER, A. N.
1974. Risso's dolphin in New Zealand waters, and the identity of "Pelorus Jack." *Rec. Dom. Mus. Wellington* 8:267-276.
- BARNARD, K. H.
1954. A guidebook to South African whales and dolphins. *S. Afr. Mus., Cape Town, Guide* 4:1-3.
- BAZZAUTI, A.
1910. *Grampus griseus* (G. Cuv.). *Monit. Zool. Ital.* 21:85-95.
- CALDWELL, D. K., M. C. CALDWELL, W. F. RATHJEN, AND J. R. SULLIVAN.
1971. Cetaceans from the Lesser Antillean Island of St. Vincent. *Fish. Bull., U.S.* 69:303-312.
- CARRUCCIO, A.
1906. Sovra un raro delfino (*Grampus griseus* G. Cuvier) di recente catturato presso lo spiaggia di S. Vincenzo *Boll. Soc. Zool. Ital., Ser. II-VII*, p. 207-214.
- CLARK, A. H.
1945. Animal life of the Aleutian Islands. *Smithson. Inst., War Background Stud.* 21:48-54, 75-76.
- DALL, W. H.
1874. Catalogue of the Cetacea of the North Pacific Ocean, with osteological notes, and descriptions of some new forms; with special reference to the forms described and figured in the foregoing monograph of Pacific Cetacea, by Captain C. M. Scammon, U.S.R.M. *In* C. M. Scammon, *The marine mammals of the north-western coast of North America, described and illustrated: together with an account of the American whale-fishery*, p. 281-307. John H. Carmany and Co., San Franc.
- DAUGHERTY, A. E.
1972. Marine mammals of California. *Calif. Dep. Fish Game, Sacramento, Calif.*, 87 p.
- DAVIES, J. L.
1963. The antitropical factor in cetacean speciation. *Evolution* 17:107-116.
- DAWBIN, W. H.
1966. Porpoises and porpoise hunting in Malaita. *Aust. Nat. Hist.* 15:207-211.
- ELLERMAN, J. R., T. C. S. MORRISON-SCOTT, AND R. W. HAYMAN.
1953. Southern African mammals, 1758-1951. *Br. Mus. (Nat. Hist.) Lond.*, 363 p.
- EVANS, W. E.
1975. Distribution, differentiation of populations, and other aspects of the natural history of *Delphinus delphis* Linnaeus in the northeastern Pacific. Ph.D. Thesis, Univ. California, Los Ang., 145 p.
- FISCUS, C. H., AND K. NIGGOL.
1965. Observations of cetaceans off California, Oregon, and Washington. *U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 498, 27 p.
- GASKIN, D. E.
1968. The New Zealand cetacea. *N.Z. Fish. Res. Div., Fish. Res. Bull.* 1, 92 p.
1972. Whales dolphins and seals. Heinemann Educ. Books, N.Y., 200 p.
- GUIGUET, C. J., AND G. C. PIKE.
1965. First specimen record of the gray grampus or Risso dolphin, *Grampus griseus* (Cuvier) from British Columbia. *Murrelet* 46:16.
- GUNTER, G.
1954. Mammals of the Gulf of Mexico. *In* P. S. Galtsoff (coordinator), *Gulf of Mexico; its origin, waters, and marine life*, p. 543-551. *U.S. Fish Wildl. Serv., Fish. Bull.* 89.
- HARRISON, R. J.
1969. Reproduction and reproductive organs. *In* H. T. Andersen (editor), *The biology of marine mammals*, p. 253-348. Academic Press, N.Y.
- HATLER, D. F.
1971. A Canadian specimen of Risso's dolphin. *Can. Field-Nat.* 85:188-189.
- HECTOR, J.
1873. Notes on the whales and dolphins of the New-Zealand seas. *Ann. Mag. Nat. Hist., Ser. 4*, 11:104-112.
- HERSHKOVITZ, P.
1966. Catalog of living whales. *Bull. U.S. Natl. Mus.* 246, 259 p.
- HUBBS, C. L.
1948. Changes in the fish fauna of western North America correlated with changes in ocean temperature. *J. Mar. Res.* 7:459-482.
1960. The marine vertebrates of the outer coast. *In* Symposium: *The biogeography of Baja California and adjacent seas. Part II, Marine biotas*, p. 134-147. *Syst. Zool.* 9.
- LEATHERWOOD, J. S.
1974. Aerial observations of migrating gray whales, *Eschrichtius robustus*, off southern California, 1969-72. *Mar. Fish. Rev.* 36(4):45-49.
- LEATHERWOOD, S., D. K. CALDWELL, AND H. E. WINN.
1976. Whales, dolphins, and porpoises of the western North Atlantic. A guide to their identification. *U.S. Dep. Commer., NOAA Tech. Rep. NMFS Circ.* 396, 176 p.
- LEATHERWOOD, S., W. E. EVANS, AND D. W. RICE.
1972. The whales, dolphins, and porpoises of the eastern North Pacific. A guide to their identification in the water. *Nav. Underseas Cent. Tech. Publ.* 282, 175 p.
- LEATHERWOOD, S., C. L. HUBBS, AND M. FISHER.
1979. First records of Risso's dolphin *Grampus griseus* from the Gulf of California with detailed notes on a mass standing. *Trans. San Diego Soc. Nat. Hist.* 19:45-52.
- LEATHERWOOD, S., AND R. R. REEVES.
1978. Porpoises and dolphins. *In* D. Haley (editor), *The marine mammals of eastern North Pacific and Arctic waters*, p. 96-111. Pac. Search Press, Seattle.
- LEATHERWOOD, S., AND W. A. WALKER.
1979. The northern right whale dolphin, *Lissodelphis borealis* Peale, in the eastern North Pacific. *In* H. E. Winn and B. L. Olla (editors), *Behavior of marine animals. Vol. III, Natural history of cetaceans*, p. 85-141. Plenum Press, N.Y.
- MAXWELL, G.
1952. Harpoon venture. *The Viking Press, N.Y.*, 304 p.
- NINNI, E.
1901. Sulle catture di alcuni cetacei nel mare adriatico ed in particolare *Dolphinus Lursio*. *Neptunia* 8:1-9.

- NORRIS, K. S., AND J. H. PRESCOTT.
1961. Observations on Pacific cetaceans of California and Mexican waters. Univ. Calif. Publ. Zool. 63:291-402.
- ORR, R. T.
1966. Risso's dolphin on the Pacific Coast of North America. J. Mammal. 47:341-343.
- PARKER, W. R.
1934. 'Pelorus Jack.' Proc. Linn. Soc. Lond. 146:2-3.
- PAUL, J. R.
1968. Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico. J. Mammal. 49:746-748.
- PERRIN, W. F.
1975. Distribution and differentiation of populations of dolphins of the genus *Stenella* in the eastern tropical Pacific. J. Fish. Res. Board Can. 32:1059-1067.
- PILLERI, G., AND M. GHR.
1969. On the anatomy and behaviour of Risso's dolphin (*Grampus griseus* G. Cuvier). Invest. Cetacea 1:74-93.
- RICE, D. W.
1963a. Pacific coast whaling and whale research. Trans. 28th North Am. Wildl. Nat. Resour. Conf. 28:327-335.
1963b. The whale marking cruise of the *Sioux City* off California and Baja California. Nor. Hvalfangst-Tidende. 52:153-160.
- RIEDL, A.
1965. Fauna d'Italia. Bologna Ed. Calderina 3, 647 p.
- SCAMMON, C. M.
1874. The marine mammals of the north-western coast of North America, described and illustrated: together with an account of the American whale-fishery. John H. Carmany and Co., San Franc., 319 p.
- SCHULTZ, W.
1970. Über das Vorkommen von Walen in der Nord- und Ostsee (Ordn. Cetacea). Zool. Anz. 185:172-264.
- SLEPTSOV, M. M.
1961. Observations on the small cetacea of the far eastern seas and northwestern parts of the Pacific Ocean. [In Russ.] Akad. Nauk SSSR, Inst. Morfol. Zhivotn. 34:136-143.
- STROUD, R. K.
1968. Risso dolphin in Washington State. J. Mammal. 49:347-348.
- TAMINO, G.
1953. Ricupero di un *Grampus griseus* arenata sue lido di Ladispoli (Roma) ie 5 April de 1953. Boll. Zool. 20:45-48.
- TROIS, E. F.
1883. *Grampus rissoanus* - Notes on a specimen caught in the Adriatic. Atti Ist. Veneto Schieze, Lett. Arti. Venice, Ser. 6, 1:735-740.
- TRUE, F. W.
1885. A provisional list of the mammals of North and Central America, and the West Indian Islands. Proc. U.S. Natl. Mus. 7:587-611.
1889. Contributions to the natural history of the cetaceans, a review of the family Delphinidae. U.S. Natl. Mus. Bull. 36, 191 p.
- TURNER, W.
1892. Notes on some of the viscera of Risso's dolphin (*Grampus griseus*). J. Anat. Physiol. 26:258-270.
- WEBER, M.
1923. Die cetaceen der Siboga-Expedition. Siboga-Exped. Monogr., Bull. 97(58), 38 p.