

Distribution of the Vaquita, *Phocoena sinus*, Based on Sightings from Systematic Surveys

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ABSTRACT

Sightings of 37 groups of vaquitas, *Phocoena sinus*, with an estimated total of 62 individuals, are reported from six major systematic surveys and four small boat surveys in the Gulf of California, México, carried out between May 1992 and December 1993. All vaquita sightings but one occurred on the western side of the northern Gulf of California, where nearly all previous confirmed sightings have occurred. Furthermore, vaquitas have been seen in this area in all seasons, suggesting year-round occupancy. Stranding data, mortalities in fishing nets and sightings of live animals all confirm that the present distribution of *P. sinus* is concentrated in a small area near Rocas Consag in the northwestern Gulf of California.

KEYWORDS: VAQUITA; NORTH PACIFIC; SIGHTINGS SURVEY; STRANDING; INCIDENTAL CAPTURE

INTRODUCTION

Phocoena sinus, the vaquita or Gulf of California harbor porpoise, is the only cetacean known to be endemic to México (Vidal *et al.*, 1993). In the original description of the species, Norris and McFarland (1958) described the geographic range as the northern Gulf of California and probably extending south along the Mexican coast. However, based on skeletal remains found in the northern Gulf of California, the lack of skeletal remains at other locations in the Gulf and a few confirmed sightings of live animals, Brownell (1986) concluded that the range of the vaquita was limited to the upper Gulf of California. Subsequent sightings (Silber, 1988; 1990; Silber and Norris, 1991), stranding data and deaths in fishing nets (Vidal, 1995) have supported this conclusion. There are some reports, of questionable reliability, of vaquitas occurring outside the upper Gulf of California (reviewed in Brownell, 1986; Silber, 1990; Barlow *et al.*, 1993; Vidal, 1995).

This paper presents the results of surveys carried out in the Gulf of California during 1992 and 1993 and addresses the question of current vaquita distribution. The surveys took place during different months of the year and the question of possible seasonal migration of vaquitas is also addressed.

METHODS

In the late summer and early fall of 1993, the Southwest Fisheries Science Center (SWFSC) of the US National Marine Fisheries Service conducted a marine mammal line-transect survey jointly with the Mexican Secretaría de Pesca (SEPESCA) along the coast of California and Baja California. As part of the SWFSC cruise, the 52m research vessels *David Starr Jordan* and *McArthur* conducted transects in the Gulf of California between 3 August and 2 November 1993 (Table 1). North-south primary transect lines were spaced 30 minutes of longitude (about 26 n.miles) apart from the northern end of the Gulf to the south, ending at a line connecting Cabo San Lucas and Cabo Corrientes (Fig. 1). Some secondary east-west transect lines at intervals of 60 n.miles were traversed after the primary transects were completed. Transect lines ended at a depth of 20m; thus, some potential vaquita habitat in shallow water was not searched.

In normal searching mode, three observers searched by eye with the additional use of hand-held 7X binoculars and pedestal-mounted 25X binoculars; however, while in the area where vaquitas had previously been seen, additional observers were used and a stratum of more closely spaced transect lines was added (Gerrodette, 1994). The eye height of the observers was 10.7m above the water. The location of a sighting was calculated from the position of the ship, determined by the ship's Global Positioning System (GPS), and the bearing and distance from the ship to the sighting. Distance from ship to sighting was measured with calibrated reticles in the 7X and 25X binoculars.

Five seasonal line-transect surveys were carried out by the Programa Nacional de Investigación y Conservación de Mamíferos Marinos de México (PNICMM) of SEPESCA between July 1992 and October 1993 (Table 1). Each survey used two identical 34m Mexican Navy patrol vessels and a 24m research vessel from the Instituto Nacional de la Pesca, except for the last cruise (no.5 in Table 1), which had only two Navy vessels. Each survey covered from the northern end of the Gulf to the 28th parallel (Figs 2-6). On each vessel 4-6 observers were located approximately 5.5m above the water and searched by eye and with 7X and 10X binoculars. The first of these surveys in July 1992 concentrated search effort in the northern Gulf of California, with scattered effort elsewhere (Fig. 2).

Table 1

Cruise dates and transect lengths (n. miles) for cruises conducted by the Southwest Fisheries Science Center (SWFSC), the Programa Nacional de Investigación y Conservación de Mamíferos Marinos (PNICMM) and the Instituto de Biología of the Universidad Nacional Autónoma de México (IBUNAM) in the Gulf of California, México.

Cruise	Dates	Transect length
SWFSC	3 August - 2 November 1993	2,369
PNICMM #1	16-26 July 1992	1,438
PNICMM #2	18-30 October 1992	1,755
PNICMM #3	15-26 March 1993	1,868
PNICMM #4	23 June - 3 July 1993	1,660
PNICMM #5	15-24 October 1993	1,140
IBUNAM #1	May-June 1992	200
IBUNAM #2	November-December 1993	154
IBUNAM #3	May-June 1992	220
IBUNAM #4	November-December 1993	69
Total		10,873

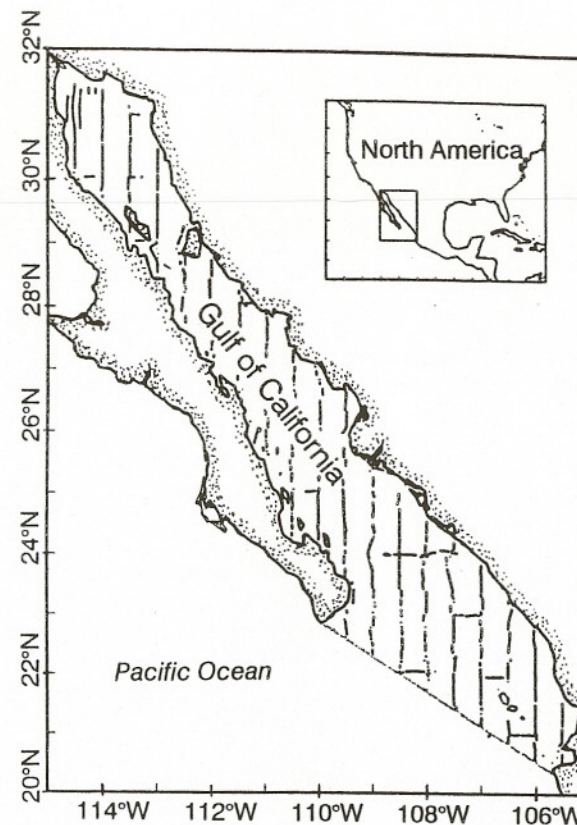


Fig. 1. Map of the Gulf of California, México and trackline surveyed on the Southwest Fisheries Science Center cruise, 3 August-2 November 1993.

For the other four surveys, 35 east-west transects, 20 n.miles long, were pre-selected at random in each of the three sub-areas from a grid of parallel lines separated by 5 minutes of latitude, but coverage during each cruise varied depending mainly on weather conditions (Figs 3-6). Location of the ship was determined by triangulation, portable GPS units or dead reckoning.

Four small boat (4.5-7m) surveys were carried out by the Instituto de Biología of the Universidad Nacional Autónoma de México (IBUNAM) between May 1992 and December 1993 (Table 1). Each survey used 3-4 observers in a boat with an outboard motor to search near the shore and out to the vicinity of Rocas Consag, offshore from the town of San Felipe. The eye height of observers was 1-2m above the water. Location was determined by triangulation and in the last survey (no.4 in Table 1), by GPS. The small boats surveyed areas closer to shore than was possible with the larger vessels, but searching did not cover a systematic grid and search effort time was much less than for the SWFSC and PNICMM cruises. Therefore, the cruise tracks are not shown in the figures. Also in contrast to the previously described line-transect surveys, searching during the IBUNAM cruises was confined to 50m on each side of the vessel.

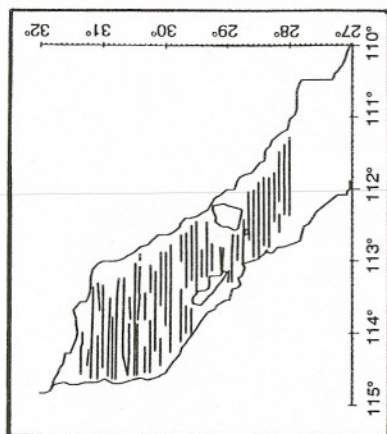


Fig. 4

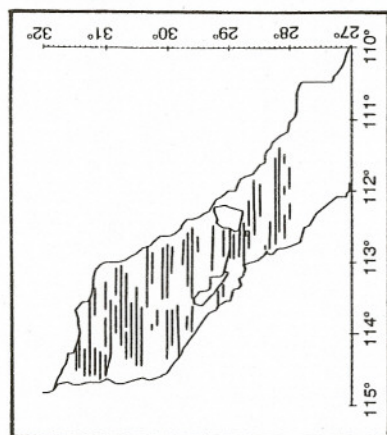


Fig. 3

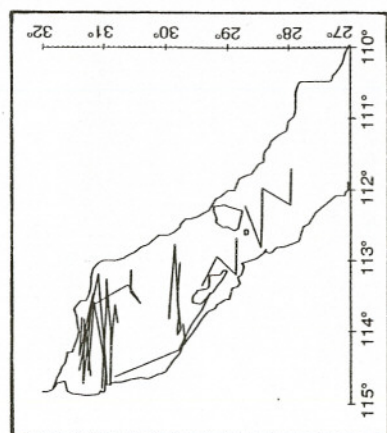


Fig. 2

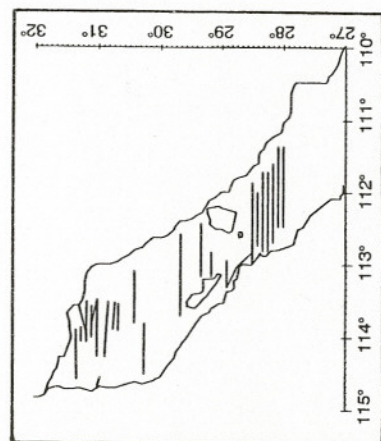


Fig. 6

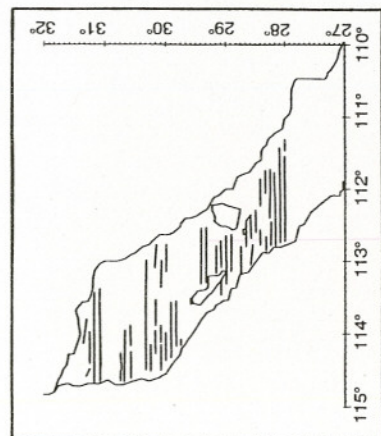


Fig. 5

Figs. 2–6. Trackline surveyed on the first to the fifth Programa Nacional de Investigación y Conservación de Mamíferos Marinos cruises.

Fig. 2: 16–26 July 1992.

Fig. 3: 18–30 October 1992.

Fig. 4: 15–26 March 1993.

Fig. 5: 23 June–3 July 1993.

Fig. 6: 15–24 October 1993.

Phocoena sinus was identified on the basis of body size, coloration (if seen) and dorsal fin shape and size. Vaquitas have a maximum length of 1.5m and a distinct triangular dorsal fin which is large in proportion to the size of the animal, with a convex leading edge and a vertical or slightly concave trailing edge (Brownell *et al.*, 1987; Leatherwood *et al.*, 1988). Other small odontocetes in the area (*Delphinus capensis* and *Tursiops truncatus*) are larger and have distinctly different dorsal fins.

RESULTS

Total trackline searching effort was 10,873 n.miles, 2,369 n.miles on the SWFSC cruise, 7,861 n.miles on the PNICMM cruises and 643 n.miles on the IBUNAM surveys (Table 1). Fig. 1 shows transects completed on the SWFSC cruise and Figs 2–6 show transects completed on the PNICMM cruises. There was a total of 1,749 marine mammal sightings, 508 on the SWFSC cruise, 1,168 on the PNICMM cruises and 73 on the IBUNAM surveys.

A total of 37 groups of vaquita, comprising of an estimated 62 individual animals, was recorded (Table 2). All but one sighting occurred in a small area in the northwestern part of the Gulf of California (Fig. 7). The other sighting occurred approximately 50 n.miles to the east of the others, south of the town of Puerto Peñasco. All vaquita sightings on the

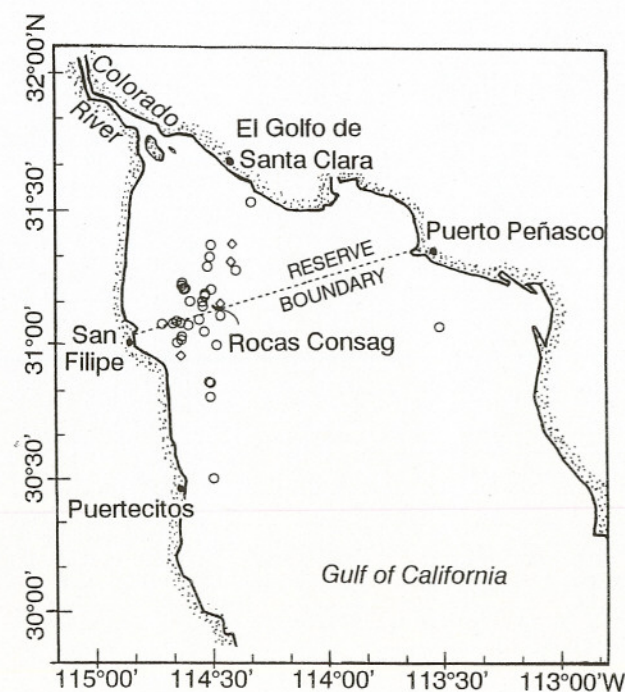


Fig. 7. Locations of the 37 vaquita sightings during 1992–1993 reported in this paper. Sightings with smaller-than-adult-sized animals are indicated with a diamond symbol. The boundary of the Upper Gulf of California and Colorado River Delta Biosphere Reserve is also shown as a dashed line.

SWFSC cruise were made during August. Vaquita sightings on PNICMM cruises were made in March, June, July and October, while sightings on the IBUNAM surveys were made in May and November (Table 2).

The number of vaquitas in each group ranged from one to three (Table 2). The mean size of the observed groups was 1.68, with a standard deviation of 0.70. Four sightings involved animals smaller than adult size (Fig. 7). The SWFSC sighting on 11 August 1993

Table 2

Date, time, position and group size for sightings of vaquitas, *Phocoena sinus*, for (a) the Southwest Fisheries Science Center (SWFSC) cruise, (b) the Programa Nacional de Investigación y Conservación de Mamíferos Marinos (PNICMM) cruises and (c) the Instituto de Biología of the Universidad Nacional Autónoma de México (IBUNAM) cruises.

Date	Time	Latitude (°N)	Longitude (°W)	Group size
(a) SWFSC cruise				
08 August 1993	16:37	31°04.39'	113°31.18'	2
09 August 1993	06:41	31°22.46'	114°30.53'	1
09 August 1993	07:33	31°19.15'	114°30.83'	1
09 August 1993	08:09	31°17.69'	114°31.41'	1
09 August 1993	08:45	31°11.67'	114°32.03'	2
09 August 1993	08:53	31°11.20'	114°32.05'	1
09 August 1993	08:57	31°10.00'	114°32.67'	1
09 August 1993	09:05	31°08.97'	114°32.59'	2
09 August 1993	09:33	31°03.34'	114°32.19'	1
09 August 1993	10:39	30°51.84'	114°30.98'	1
09 August 1993	11:07	30°48.50'	114°30.71'	1
11 August 1993	06:22	31°14.07'	114°37.83'	1
11 August 1993	06:24	31°13.48'	114°37.97'	2
11 August 1993	06:26	31°12.63'	114°37.39'	2
11 August 1993	06:30	31°12.81'	114°36.99'	2
11 August 1993	06:30	31°12.87'	114°37.48'	2
11 August 1993	06:44	31°10.06'	114°35.88'	1
11 August 1993	07:08	31°05.26'	114°38.29'	1
11 August 1993	07:11	31°05.66'	114°39.24'	2
11 August 1993	07:21	31°01.43'	114°38.02'	1
11 August 1993	07:44	31°00.80'	114°39.13'	2
11 August 1993	07:59	30°57.85'	114°38.21'	3
11 August 1993	09:15	30°51.66'	114°30.61'	1
11 August 1993	13:07	31°16.87'	114°23.93'	2
11 August 1993	13:23	31°18.83'	114°25.24'	3
11 August 1993	13:56	31°22.70'	114°24.91'	3
(b) PNICMM cruises				
19 July 1992	09:27	31°05'	114°43'	2
20 October 1992	13:19	30°30'	114°30'	2
23 March 1993	12:22	31°00.24'	114°29.03'	1
29 June 1993	16:11	31°02.21'	114°37.94'	2
29 June 1993	16:54	31°05.11'	114°40.20'	2
29 June 1993	17:14	31°04.77'	114°36.27'	3
(c) IBUNAM cruises				
13 May 1992	13:30	31°32'	114°20'	1
23 May 1992	13:00	31°06'	114°33.5'	1
29 November 1993	14:20	31°12.65'	114°30.42'	3
29 November 1993	14:53	31°09.56'	114°28.01'	1
29 November 1993	15:27	31°06.92'	114°28.01'	2

at 0759 included a calf swimming close to an adult animal, another (on 11 August 1993 at 1323) contained a juvenile, while a third (on 11 August 1993 at 1356) contained a small animal, possibly a calf. The IBUNAM sighting of 29 November 1993 at 1453 was a young animal. No small animals were noted among the PNICMM sightings.

DISCUSSION

The comprehensive survey effort of the cruises reported here has resulted in a significant increase in the total number of reported vaquita sightings. Brownell (1986) was critical of many sighting records and considered only four, all in the upper Gulf of California, to be reliable. However, descriptions of the vaquita's external appearance and morphology (Brownell *et al.*, 1987) has made field identification more reliable. Since the sightings reviewed by Brownell (1986), there have been two sightings (probably of the same individual) reported by Vidal *et al.* (1987), 51 by Silber (1990), seven by Silber and Norris (1991) and one by Barlow *et al.* (1993), all of which have been in the same area as the sightings reported here. Almost all vaquita sightings have occurred on the western side of the northern Gulf, west of 114°20'W. The majority of sightings have been in the vicinity of a rocky island named Rocas Consag (Fig. 7). However, shallow water near the delta of the Colorado River was not surveyed as systematically as deeper water (Figs 1–6). One sighting occurred on the eastern side of the northern Gulf, south of the town of Puerto Peñasco (Fig. 7) and on 13 May 1994 a new-born vaquita calf stranded on the beach near Puerto Peñasco (Boyer, 1994).

It is also important to consider the lack of vaquita sightings at other locations. The SWFSC cruise and four of the five PNICMM cruises surveyed large areas of the Gulf in a systematic manner and did not encounter vaquitas elsewhere, although many other cetaceans were seen. Vaquitas represented only 1.9% of all marine mammal sightings on the SWFSC and PNICMM cruises. Other recent surveys, although less systematic than those reported here, have also failed to find vaquitas in other locations (Wells *et al.*, 1981; Vidal *et al.*, 1987; pers. comm. of L. Ballance, L.T. Findley and B. Tershy reported in Silber, 1990).

Vaquitas, like harbour porpoises (*Phocoena phocoena*), are difficult to detect because they are small, surface inconspicuously and occur singly or in small groups. Therefore, it is unlikely that vaquitas were detected in those parts of the SWFSC and PNICMM cruises which were undertaken in conditions of Beaufort 4–5. However, calm conditions (Beaufort 0–2) under which vaquitas could be detected did occur in each survey. In particular, very calm conditions prevailed during the SWFSC cruise in the northwestern Gulf of California: 98% of searching effort took place in Beaufort 0–2 (Gerrodette, 1994).

Vidal (1995) has summarized all available stranding data. All skeletal material has been found in the upper part of the Gulf and none found south of the town of Puertecitos. As with sightings, the lack of vaquita skeletal material on other beaches, despite extensive collections of other species (Brownell, 1986; Vidal, 1995), is significant.

Vidal (1995) has also summarized fishing-related mortality. All confirmed incidental mortality has been from the northern Gulf, principally from the fishing towns of San Felipe, El Golfo de Santa Clara and Puerto Peñasco (Fig. 7). Fleischer *et al.* (1994) and D'Agrosa *et al.* (1995) have reported rates of vaquita mortality in various types of fishing nets.

Thus, the sightings of live animals, collections of bones on beaches and incidental mortality in fishing nets all support the conclusion that the distribution of *Phocoena sinus* is limited to a small area in the northwestern Gulf of California, with a majority of

sightings of live animals occurring north of 30°45'N and west of 114°20'W. Vaquita sightings were made in the same area in all seasons. Thus, vaquitas appear to occupy this area throughout the year (Silber and Norris, 1991) and do not migrate to other areas of the Gulf. However, this does not preclude the possibility that vaquitas may undergo seasonal movements on a small scale within the northwestern Gulf of California.

The mean group size of 1.68 from the sightings reported here is somewhat smaller than previous observations of about 1.9 (Silber, 1988; 1990; Silber and Norris, 1991), primarily due to the large number of single-animal sightings on the SWFSC cruise (Table 2). However, the majority of Silber's observations were made in the spring, while all SWFSC sightings took place during August. Group size may change during the year. Furthermore, it is probable that the observed mean group size on any survey is positively biased because of the greater probability of detecting larger groups. Hence the true mean group size is probably less than 1.68. There appears to be a tendency for smaller-than-adult-sized animals to be seen in groups. For the SWFSC sightings, each of the three sightings of smaller-than-adult-sized animals occurred in a group of three vaquitas. Moreover, these three sightings were the only groups of three animals among the SWFSC sightings. The sightings of Silber (1988) showed a similar pattern of calves occurring in the larger groups.

Both the US and Mexican governments have recognized that the vaquita is in danger of extinction and the vaquita is classified as endangered by the IUCN in its Red Data Book (Klinowska, 1991). A recovery plan for the species has been prepared (Villa Ramírez, 1993). The Mexican government established the Upper Gulf of California and Colorado River Delta Biosphere Reserve on 10 June 1993, with the objective of conserving various biological resources within the area, including the vaquita (Vidal *et al.*, 1993). The range of the vaquita is partly contained within this reserve, but 40% of sightings reported here have occurred outside the southern boundary of the reserve (Fig. 7).

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