

Distribution and Relative Abundance of Humpback Whales off Western Puerto Rico during 1995-1997

ILSE M. SANDERS¹, JOSÉ C. BARRIOS-SANTIAGO^{1*}, AND RICHARD S. APPELDOORN²

¹ Department of Biology, Chemistry and Environmental Sciences, Inter American University of Puerto Rico, San Germán, Puerto Rico 00683 isanders@sg.inter.edu

² Department of Marine Sciences University of Puerto Rico Mayagüez, Puerto Rico.

*Present Address: University of Maryland, College Park, MD.

ABSTRACT.—Observations of humpback whales (position, number and presence of calf) were obtained from a commercial whale-watching vessel during January to March 1995 to 1997 along the northwestern coast of Puerto Rico. These data represent the only information available for this area over a 15-year period. Two-hundred thirty-six whales were sighted during the three years. Relative abundances (sightings/trip) were similar during 1995 and 1997, while in 1996 abundance was greater with a distinct peak during the beginning of March. For mothers with calves, sightings were most frequent within the 0-50 m and 50-100 m depth ranges, while other humpbacks were distributed throughout all depth ranges. Compared to other whales, the proportion of mothers with calf was higher in the shallowest depth range (0-50 m) for the three years. Trends in abundance and depth distributions are consistent with previous investigations, both in Puerto Rico and elsewhere. Our study extends the spatial distribution of the humpback whales off northwestern Puerto Rico showing the importance of other offshore areas away from the insular platform.

KEYWORDS.—Whales, humpback, *Megaptera novaeangliae*, Puerto Rico, distribution, abundance

INTRODUCTION

The majority of humpback whales (*Megaptera novaeangliae*) from the North Atlantic Ocean migrate from their feeding grounds to the West Indies for the winter (Smith et al. 1999). In the northern Caribbean, major concentrations have been found on Silver and Navidad Banks (Winn et al. 1975; Whitehead and Moore 1982; Mattila et al. 1989) and in Samana Bay, Dominican Republic (Mattila et al. 1994; Mattila et al. 2001). Smaller concentrations have been observed in the Mona Passage off western Puerto Rico (Mattila 1984; Mignucci-Giannoni 1998; Mattila et al. 2001) and on Virgin Bank in the northern Leeward Islands (Mattila and Clapham 1989). However, a recent (2000) acoustic and visual survey (Swartz et al. 2001) reported whale

densities in the Mona Passage and Cabo Rojo bank comparable to those from Silver Bank. These warm and protected waters are important humpback breeding and calving grounds. Mattila (1984) conducted surveys along the northwest coast of Puerto Rico between 1979 and 1983 and identified 438 humpback whales by fluke and dorsal fin photographs. He also observed the locations of singers and mothers-calf pairs. Studies of their distribution on principal breeding grounds in the West Indies, including western Puerto Rico, were conducted in 1992 and 1993 (Mattila et al. 2001).

This study reports the observations of humpback whales made from the *Viking Star*, a commercial whale-watching vessel, during January to March 1995 to 1997. Although these observations were not collected according to a random survey design, the resulting data have a high temporal resolution and were collected in a consistent manner over the three-year pe-

ms. received March 24, 2004; resubmitted October 11, 2004; accepted January 18, 2005

riod. Equally important, these observations represent the only data on the number and distribution of humpbacks in western Puerto Rico during 1995-1997, and they extend the spatial range of observations to areas more offshore than surveyed in earlier years.

METHODS AND MATERIALS

Observations of marine mammals were conducted from the *Viking Star*, a 43-m commercial whale-watching vessel, during the winter months in Puerto Rico. Cruises began in the middle of January and extended to the middle of March in 1995 and to the second half of March during 1996 and 1997. The earliest cruise recorded was January 11, 1996 and the latest, March 21, 1997. The *Viking Star* sailed from Puerto Real, Puerto Rico (between Boquerón Bay and Mayagüez Bay) and frequently stopped at Rincón to pick up/drop off additional passengers (adding a half hour to the trip). The trips started around 0900 and ended between 1600 and 1800. The total area encompassing all observations was approximately 120 km², with the total area surveyed over the course of a season extending north to Punta Borinquen (Punta Agujereada, in Mattila 1984) and west to Desecheo Island (Fig. 1). The distance and the direction traveled for each trip were determined by the captain and followed no set pattern, but were affected by the success of having found whales on previous trips.

Whales were sighted from late morning until late afternoon. Data were recorded by group (or single whale) sighted. For each group sighted the following were recorded: species name, number of individuals, date, time, and estimated location coordinate (latitude and longitude based on distance from the boat and the boat's location as recorded using Global Positioning System). Records included the presence of calves, females with calves (assumed female because of the association), number of blows, water temperature, and name of the closest point to land. Identification of individuals was not made.

For some groups sighted, location was

only recorded as a descriptive position without latitude and longitude coordinates. In cases where specific location could be approximated from the information available, latitude and longitude were estimated and included in the data. When there was insufficient information to approximate a location, the group record was not included. For analysis, whales were classified as "mothers with calf" or "others".

The data from the humpback whale observations was analyzed using ArcView-GIS and ArcInfo-GIS. All coordinates (map and whale locations) were then projected into Puerto Rico State Plane, NAD83 coordinate system. Depth at sighting locations was estimated from a high resolution bathymetry map (Puerto Rico Bathymetry Files, 2004) constructed from raw data of 6 seconds resolution, at its best. A 250 x 250 m grid was built by Kriging, brought in with Spatial Analyst (ArcView-GIS), the whales sighted were superimposed, and depth at each sighting recorded. To compare the depth distributions of whales to that of the underlying seabed, a polygon enclosing the total area of whale sightings was used to approximate the study area. This allowed for estimates of percent areas by depth.

Depth was divided into the following zones: 0-50 m, 50-100 m, 100-200 m, 200-300 m, 300-500 m, and 500+ m (maximum depth in the study area was 2549 m). The percents of "females with calf" and of "other" humpbacks were calculated for each zone, summed over all three years; the percent of the study area was also calculated for each zone.

In order to make comparisons with previous observations of humpbacks in western Puerto Rico, sighting dates were divided into the same 2-week periods as in Mattila and Clapham (1989) between January 15 and March 11, with an additional period between March 11 and March 25. A measure of relative abundance was calculated as the number of whales observed per boat trip (approximately 7 to 9 hours). Abundance is only an estimate because individual whales were not identified, and the same whale could have been seen on the same day, or on subsequent days.

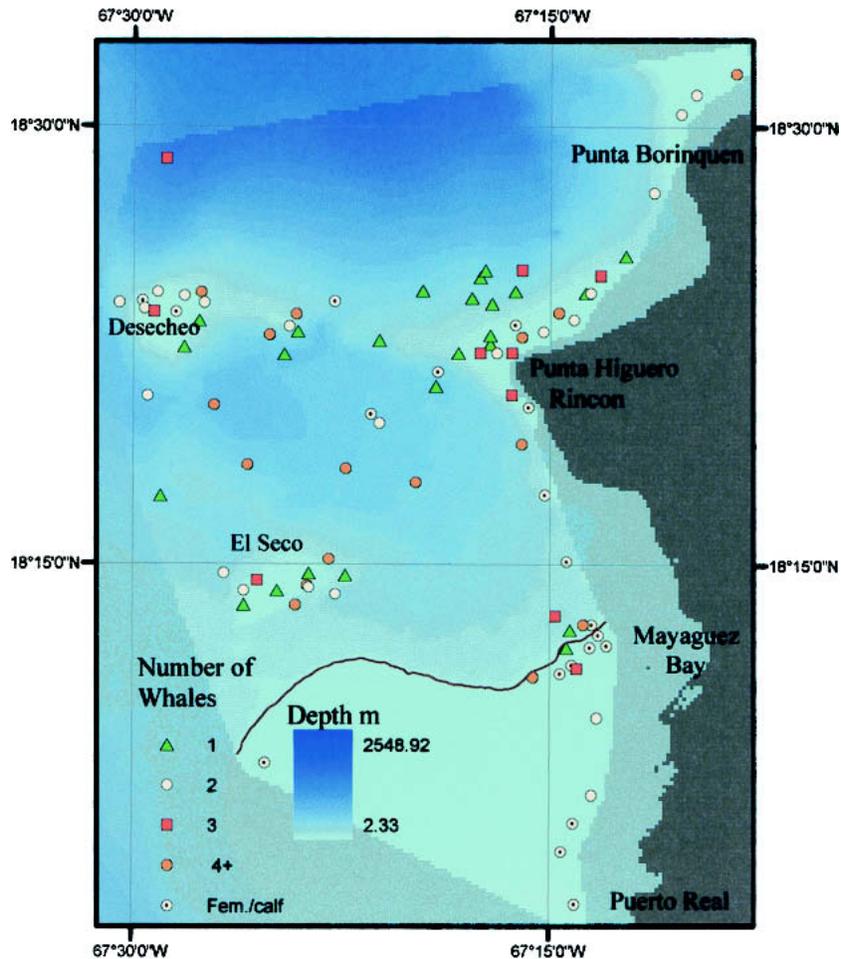


FIG. 1. Bathymetry map of northwest Puerto Rico showing the Humpback whales positions relative to depth (meters) between January and March, 1995, 1996 and 1997. The number of whales at each sighting (○) is given in the legend and color-coded in the map; females with calf are designated by a point inside the circle. Depth range is 2.33 m to 2548.92 m. A line is drawn to show the shelf break at 100 m.

RESULTS

Humpback whales were sighted off the western coast of Puerto Rico between Puerto Real on the south, north of Punta Borinquen on the north, and to Desecheo Island on the east during 1995, 1996 and 1997 (Fig 1). Sightings were most frequent around Rincón, Desecheo Island, El Seco shoal and at the entrance to Mayaguez Bay. A small cluster of sightings were also found at a shallow bank just to the east of Desecheo Island. Females with calf were observed throughout the area, but were

sighted more often between Puerto Real and Mayaguez Bay. Whales were sighted at depths between 7 and 1905 meters.

Two hundred thirty-six humpback whales were sighted during the three years: 32 in 1995, 153 in 1996, and 51 in 1997 (Table 1). Relative abundance was highest during early March of 1996 (8.7 whales/trip) and lowest during the second half of March 1996 (1.0 whale/trip). In 1995 and 1997 the numbers of whales per trip observed for each 15-day time period were similar and fairly constant, while 1996 shows a greater number per time period

TABLE 1. The observed number of humpback whales, the number of trips, the number of humpbacks per trip, and the number of females with a calf per trip, during two week periods starting at January 15 through March 11 for 1995, and through March 25 for 1996 and 1997, on the west coast of Puerto Rico. A trip's duration was a maximum of 9 hrs.

Time period	Year	Whales	Trips	Whales/trip	Females with calf/trip
15 Jan–28 Jan	1995	3	2	1.5	0.5
	1996	15	5	3	0.2
	1997	9	3	3	1
29 Jan–11 Feb	1995	0	0		
	1996	27	5	5.4	0.2
	1997	10	4	2.5	0
12 Feb–25 Feb	1995	17	6	2.8	0.5
	1996	57	9	6.3	0
	1997	3	2	1.5	0
26 Feb–11 Mar	1995	12	5	2.4	0.6
	1996	52	6	8.7	0.5
	1997	23	8	2.9	0.5
12 Mar–25 Mar	1995	0	0		
	1996	2	2	1	0
	1997	6	2	3	0.5
Total		236	59		

TABLE 2. Total and percentage of females with calf and other humpback whales by depth zone off northwest Puerto Rico during 1995–1997. For comparison, the percent of the total area cover by sighting by depth zone is also given.

Year	Humpback whales	0–50m	50–100m	100–200m	200–300m	300–500m	500+m
1995	Female/calf	1	2	1	1		2
	Other Humpbacks	3	1	3	2	4	6
1996	Female/calf	3		1			1
	Other humpbacks	26	28	13	18	9	46
1997	Female/calf	3	3		1		
	Other Humpbacks	12	8	3	6	2	4
Totals	Total Female/calf	7	5	2	2		3
Percents	% Female/calf	36.8	26.3	10.5	10.5	0	15.8
	Total Other Humpbacks	41	37	19	26	15	56
	% Other Humpbacks	21.1	19.1	9.8	13.4	7.7	28.9
	% Total Area Cover	19.4	4.9	5.1	8.3	16.5	45.8

during the beginning of March (Table 1). This difference between 1996 and the other years was significant (Friedman Test: $\chi^2 = 6.4$, $p < 0.05$).

Females with calf were most frequently sighted within the 0–50 m and the 50–100 m depth zones (Table 2 and Fig. 2). This was true for the three years of data. Mothers with calf were most frequently observed at the following areas: the broad western shallow shelf by Puerto Real, south of Mayagüez Bay close to shore, Rincon, and close

to Desecheo Island. One mother with calf was found on the shallow bank south of El Seco shoal and east of Puerto Real (Cabo Rojo). Pooling the data from the three years (Table 2) the trend of females with calf being disproportional distributed in the two shallowest depth zones and avoiding the deepest two zones was highly statistically significant (G-test; $G = 98.97$, $p < .001$). Other humpback whales, while more evenly dispersed across shallow, intermediate and deeper areas were, nevertheless, also not

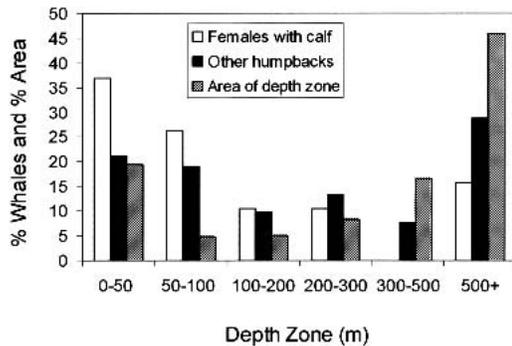


FIG. 2. Total % of females with calf, other humpback whales, and % of the total area covered by depth zone (m).

randomly distributed by depth but avoided the two deepest zones (G -test; $G = 23.97$, $p < .001$).

DISCUSSION

Both annual and seasonal differences were observed in the temporal abundance of whales. While it cannot be said with certainty that the data for 1996 represents a true increase in the abundance of whales within the area that year, it is unlikely that it is due to "learning" by the *Viking Star* crew or that in the following year whales shifted to a location outside the range of observations. The *Viking Star* had several years of whale-watching experience (with the same captain and crew) prior to its arrival in Puerto Rico; the subsequent decline in the number of whales observed in 1997 also argues against a learning factor in 1996. Mattila (1984) reported high abundances of whales further to the north by Punta Borinquen and eastward. While the *Viking Star* did not often travel as far as Punta Borinquen, it did on a few trips. If whales had shifted to that area, it is unlikely given both the demonstrated capability to cover that area and the stated goal of observing whales that the vessel would not have gone there if whales were abundant in this area in 1995 and 1997.

Only during 1996 was there a clear indication of a temporal increase in abundance with a particular time period. During this year there was a continuous build up in the

number of whales sighted until the beginning of March, followed by a precipitous decrease. This increase, then decrease, in abundance could be due to movement among other sites in the Caribbean, such as Samana Bay in the Dominican Republic, or possibly due to the late arrival of humpbacks coming from northern waters and then leaving the area. The mean humpback whale residency time for Silver Bank, Navidad Bank, Mona Passage and the northwestern tip of Puerto Rico during 1992 and 1993 was 16.9 days (S.D. = 12.74) for males and 11.4 days (S.D. = 8.82) for females (Mattila et al. 2001). Mattila and Clapham (1989) reported seasonal peaks in abundance (number of humpback whales sighted per hour) in 1985 and 1986 on Virgin Bank during the second half of February, and suggest a shift in abundance from east to west with a peak during the beginning of March off the northwest coast of Puerto Rico in 1982 and 1983.

In contrast, the number of mothers with calf observed in the present study stayed fairly constant from year to year, and their abundance within a season did not appear to be related to a particular time period. They were sighted when relative abundance was high as well as during January and the second half of March when the relative number of whales sighted was low. Mattila (1984) found that mother/calf pairs were not as transient as other classes of humpback whales as evidenced by a higher percentage of mothers re-sighted within a season.

Areas of greatest observed abundances seem associated with shallow areas, particularly near Rincon (Pta. Higuero), Desecheo Island, and El Seco shoal (up to 20 m depth). In this last area, Swartz et al. (2001) found a cluster of whales during acoustic soundings. Whales were also observed in near the insular shelf/slope at the entrance to Mayagüez Bay, between Mayagüez Bay and Puerto Real, and at Punta Borinquen at approximately 2 km off the coast.

Other studies have also suggested that humpback whales are preferentially found in shallower areas (see Mignucci-Giannoni 1998). In particular, Mattila (1984) reported an inshore distribution (within the 200m

depth range and approximately 2 km from land) for mothers with calf at Punta Agujerada (Punta Borinquen) and Punta Higuero (Rincón) in northwest Puerto Rico between 1979 and 1983, and suggested that they are taking advantage of the relatively calmer waters for protection and calving. A higher percentage of mothers with calf were also found inshore at Virgin Bank (Mattila and Clapham 1989) and in Samana Bay, Dominican Republic (Mattila et al. 1994).

The data collected by the *Viking Star* did not result from random sampling and are therefore subject to potential biases, such as counting the same whale twice on a given trip. However, biases are inherent in the assessment of humpback whales, even using more conventional methods. Notable examples include previous shore based studies of humpback distributions (where sighting data is subject to visibility, wind and sea conditions, time of day, distance from shore, etc. or data from extended cruises or cruises using acoustic techniques (e.g., Swartz, et al. 2001), where exact position (and hence path width) and number cannot be accurately estimated. As a consequence, procedures to standardize or control for these biases are used, yet caution still should be used when interpreting the results. Counting the same whale on the same day could introduce bias, but the comparisons made here are ones of years, seasons, and depth. It is difficult to imagine how the potential for counting the same whale twice on the same day would have affected these results to any large degree. Time based comparisons would require that the probability of counting the same whale twice somehow varied significantly among years or seasons. Similarly, the analysis of distributions based on depth would require that the probability of counting an individual twice would somehow be a function of depth. A check of the most likely scenario for such a depth bias, where outbound and inbound tracks tend to converge, found zero cases where whales were observed in similar locations on outbound and inbound tracts.

The depth distributions and temporal dynamics of the humpback whales ob-

tained from data collected by the *Viking Star* in northwest Puerto Rico during 1995-1997 can be seen to serve two purposes. First, similarities to those of other studies provide corroboration for general patterns of seasonal abundance and spatial distribution. Second, our data increase our knowledge base both spatially, by extending the distribution of the humpback whales to include areas around Desecheo Island and El Seco shoal, and temporally, by filling a gap in the data on humpback whales in Puerto Rico during three years: 1995, 1996 and 1997

Acknowledgments.—We thank the *Viking Star* captain and crew for all their assistance to make the observations of the humpback whales. We also thank Phil Clapham for providing valuable criteria on an earlier version of the manuscript. Francisco Pagán prepared the bathymetry map using data from Aurelio Mercado from which our map was built. Idelfonso Ruiz and William Hernández helped in the map preparation. The data analysis was initiated while two of the authors were on sabbatical at the University of Rhode Island.

LITERATURE CITED

- Mattila, D. K. 1984. Humpback whales in the Mona Passage, Puerto Rico: a summary. Report from the Center for Coastal Studies, Provincetown, MA.
- Mattila, D. K., and P. J. Clapham. 1989. Humpback whales, *Megaptera novaeangliae*, and other cetaceans on Virgin Bank and in the northern Leeward Islands, 1985 and 1986. *Can. J. Zool.* 67:2201-2211.
- Mattila, D. K., P. J. Clapham, S. K. Katona, and G. S. Stone. 1989. Population composition of humpback whales, *Megaptera novaeangliae*, on Silver Bank, 1984. *Can. J. Zool.* 67:281-285.
- Mattila, D. K., P. J. Clapham, O. Vásquez, and R. S. Bowman. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. *Can. J. Zool.* 72: 1898-1907.
- Mattila, D. K., et al. 2001. Humpback whale habitat use in the West Indies. Working paper of the Scientific Committee of the International Whaling Commission. SC/53/NAH 3.
- Mignucci-Giannoni, A. A. 1998. Zoogeography of Cetaceans off Puerto Rico and the Virgin Islands. *Caribbean Journal of Science* Vol. 34:173-190.
- Puerto Rico Bathymetry Files. 2004. Sponsored by the Puerto Rico Sea Grant College Program and com-

- piled by Aurelio Mercado, MS. University of Puerto Rico, Mayagüez, Puerto Rico.
- Swartz, S. L., A. Martinez, J. Stamates, C. Burks, and A. A. Mignucci-Giannoni. 2001. Acoustic and Visual Survey of Cetaceans in the Waters of Puerto Rico and the Virgin Islands; February-March 2001. NOAA Technical Memorandum NMFS-SEFSC-463.
- Whitehead, H., and M. J. Moore. 1982. Distribution and movements of West Indian humpback whales in winter. *Can. J. Zool.* 60:2203-2211.
- Winn, H. E., R. K. Edel, and A. G. Taruski. 1975. Population estimate of the humpback whale (*Megaptera novaeangliae*) in the West Indies by visual and acoustic techniques. *J. Fish. Res. Board Can.* 32:499-506.