

**SOCIETY FOR MARINE MAMMALOGY: SMALL GRANTS IN AID OF
RESEARCH (2018)**

PROJECT TITLE: Evaluation of the singing behavior of humpback whale (*Megaptera novaeangliae*) from two contrasting acoustic environments: Revillagigedo Island and Mexican Central Pacific

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ANNUAL SUMMARY REPORT

Hydrophones were submerged 105 times off the Colima and Jalisco coasts and 15 times off Socorro Island during the winter 2019 field season. That is, the sampling effort to detect the presence of humpback whales consisted of 120 hydrophone deployments (Table 1). Out of this total number, 26 submarine recordings were obtained in the Colima and Jalisco coasts in Mexican Central Pacific (MCP) using the passive method, for a total duration of 956 h, 32 min, 10 sec, and a total of 33 recordings were obtained using the manual method, for a total duration of 7 h, 43 min, 57 sec. Recordings were distributed among the four quadrants in which the MCP study area was divided; however, a greater number of recordings of longer duration were obtained in quadrant “c”, which corresponded to the bays of Manzanillo. Around Socorro Island in Archipelago of Revillagigedo, recordings were obtained using the passive method in the four quadrants in which the study area was divided, for a total duration of 50 h, 54 min, 50 sec; whereas only one recording with a 5 min duration was obtained using the manual method. It should be noted that most recordings around the island were obtained in quadrants “E” and “W” (Table 1).

Table 1. Number of hydrophone deployments, submarine recordings using passive and manual methods, as well as times of duration (h: min: sec), in the Mexican

Central Pacific (quadrants: Jalisco (a), north Colima (b), bays of Manzanillo (c), and south Colima (d)) and Socorro Island (quadrants: north (N), south (S), east (E), west (W)) during the 2019 season.

	Quadrants	Deployments	Submarine recordings with passive method	Duration	Submarine recordings with manual method	Duration
MEXICAN CENTRAL PACIFIC	a	32	5	198:43:05	12	02:32:24
	b	16	0	00:00:00	4	02:17:30
	c	54	21	766:49:05	15	02:29:03
	d	3	0	00:00:00	2	00:25:00
SOCORRO ISLAND	N	2	0	00:00:00	0	00:00:00
	S	6	0	00:00:00	0	00:00:00
	E	4	2	28:23:56	90	00:00:00
	W	3	2	22:30:54	1	00:05:00
	TOTAL	120	30	1016:27:00	34	7:48:57

Of the recordings containing male humpback whale vocalizations, only those recordings that met quality requirements necessary for the analysis of song structure were used. These requirements were: a) that the recording lasts over 15 min, to guarantee that the entire song has been recorded, b) that the sounds emitted by the whale are sharp or clear, which depends on the distance from the whale to the hydrophone and on environmental noise, and c) that only one singing male is recorded to avoid noise overlap. To achieve this, spectrograms were used to identify the song elements (Fig. 1).

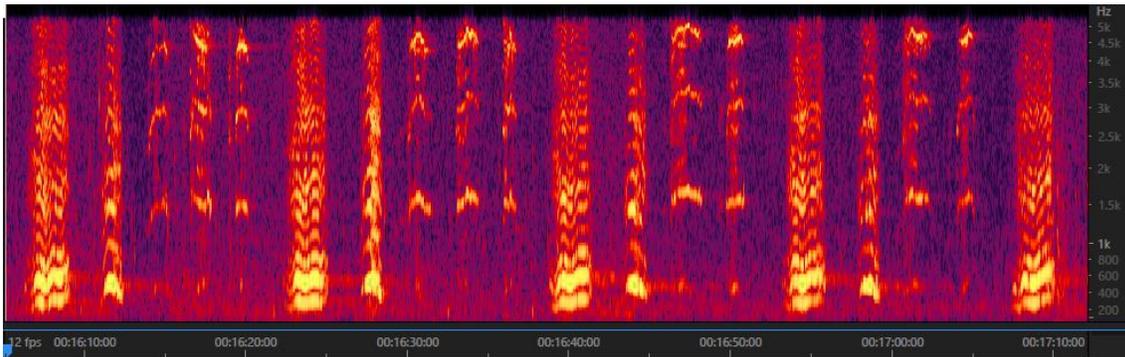


Figure 1. Example of a song segment spectrogram from a male humpback whale (Megaptera novaeangliae) recorded during winter 2019 off the Colima and Jalisco coasts. Time recorded (1 min on the x axis) against frequency of the units forming a particular phrase (in Hz on the y axis).

Humpback whale vocalizations were detected mainly in quadrant “a” in the MCP, which had 16 sites with song presence and quadrant “c”, which had 28 sites with song presence. Both quadrants corresponded to bays in the study area (a: Tenacatita Bay and c: the bays of Manzanillo). We, therefore, think that whales preferred those sites for singing because as has been suggested by other researchers, bays could favor sound propagation. On the contrary, quadrants “b” and “d”, corresponding to the north and south of Colima, had the lowest song occurrence (2 and 3 sites, respectively). These two quadrants were far away from the bays. Only quadrant “W”, to the west of Socorro Island, had song presence; that site was located close to a small cove (Fig. 2).

Regarding boat sounds in the MCP (Fig. 3), 51 sites with anthropogenic noise were identified. Quadrants “a” with 13 sites and “c” with 36 sites stood out (Tenacatita Bay and bays of Manzanillo, respectively). These quadrants coincided with areas where greater whale song activity was detected, so the interaction of the two sounds was evident. Moreover, the lowest occurrence of anthropogenic noise was detected at quadrants “b” and “d”, corresponding to the north and south of Colima; that is also where there was the least whale song activity. Socorro Island had only one site with presence of boats, in quadrant “S” to the south of the island, an area close to the Naval Sector. There was no anthropogenic activity around the rest of the island, so the interaction between whales singing and boats in this area was low (Fig. 4).

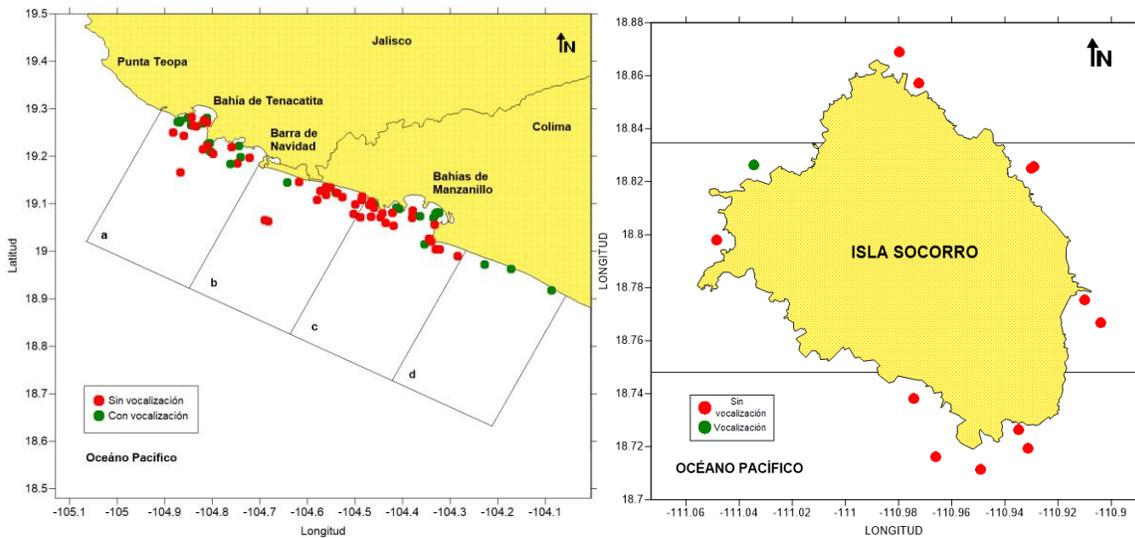


Figure 2. Location of recording sites with and without male humpback whale (*Megaptera novaeangliae*) vocalizations distributed in the Central Mexican Pacific (quadrants: Jalisco (a), north Colima (b), bays of Manzanillo (c), and south Colima (d)) and Socorro Island (quadrants: north (N), south (S), East (E), West (W)) during the 2019 season.

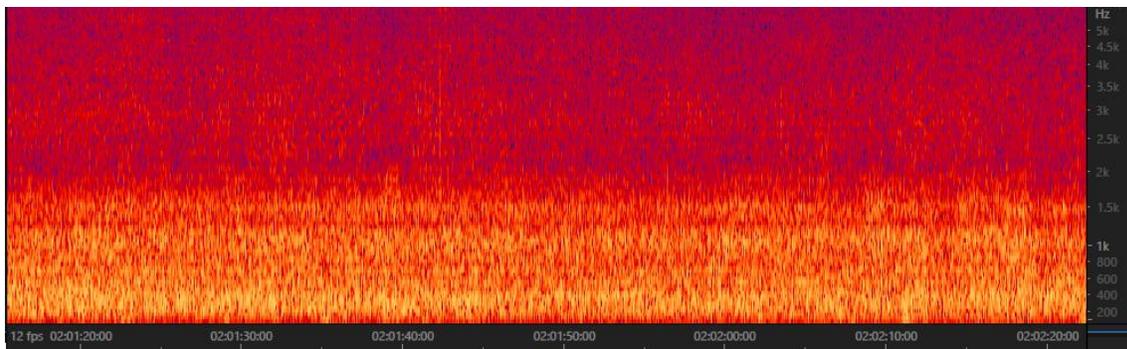


Figure 3. Example of a noise spectrogram produced by a boat traveling off the Colima and Jalisco coasts during the 2019 season. Time recorded (1 min on the x axis) against frequency of the units forming a particular phrase (in Hz on the y axis).

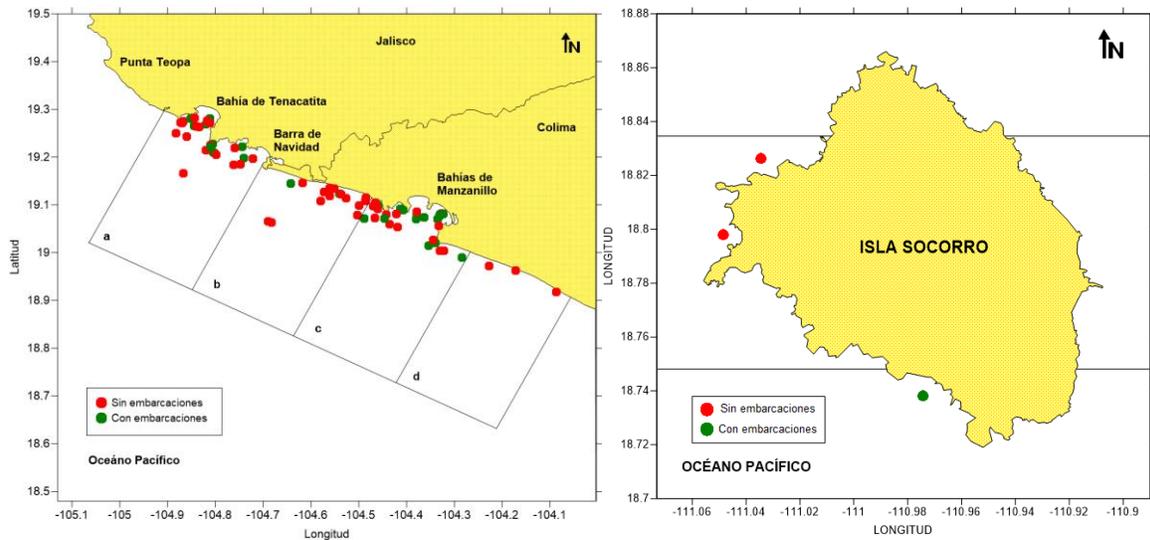


Figure 4. Location of recording sites with and without boat noise in the Mexican Central Pacific (quadrants: Jalisco (a), north Colima (b), bays of Manzanillo (c), and south Colima (d)) and Socorro Island (quadrants: north (N), south (S), East (E), West (W)) during the 2019 season.

Great differences in marine acoustic pollution were observed between the study areas during this project. Acoustic pollution was much greater off the MCP coast, and will no doubt increase because the commercial port of Manzanillo will grow in the future. Moreover, differences in the average structure of the songs were detected. These differences were probably associated with the natural evolution of this humpback whale population segment.

This project has been crucial to research the interaction between anthropogenic noise and whale songs in the two regions, especially in the Archipelago of Revillagigedo, which has been named a National Park by the Mexican government, so that interest on this subject has increased. However, our research objective has not yet been completely attained due to the low density of singing males detected around Socorro Island, as well as to logistic problems (lost and stolen equipment) that occurred with the acoustic recording equipment. We are therefore working on continuing with this project in the following season to increase the number of recordings of acoustic interactions in order to reach solid conclusions.