HUMPBACK WHALES AND OTHER MARINE MAMMALS OFF COSTA RICA, 1996-99

REPORT OF RESEARCH DURING OCEANIC SOCIETY EXPEDITIONS IN 1999 IN COOPERATION WITH ELDERHOSTEL VOLUNTEERS

Prepared by

John Calambokidis
Kristin Rasmussen
and
Gretchen H. Steiger
Cascadia Research
Waterstreet Building
218½ W Fourth Ave.
Olympia, WA 98501
www.CascadiaResearch.org
(360)943-7325

Sponsored by
Oceanic Society Expeditions
Fort Mason Center, Bldg. E
San Francisco, CA 94123
(415)441-1106

August 1999

TABLE OF CONTENTS

INTRODUCTION

Cascadia Research in collaboration with Oceanic Society has conducted a long-term research effort on humpback whales and other marine mammals off the Pacific coast of Costa Rica. In January and February 1999, we continued this research with Elderhostel volunteer support. For the first time in 1999, we also conducted a separate research cruise sponsored by National Geographic using the 50' schooner *Russamee* surveying humpback whales from Mexico to Costa Rica and a suspected blue whale breeding area 500 miles offshore of Central America.

This report summarizes the research conducted on humpback whales and other marine mammals off southern Costa Rica as part of the Oceanic Society trips in 1999. We also summarize the results from all four years of research in this region and consider the significance of the findings in relation to our research off the west coast of the U.S. and our broader survey of Central America. Cascadia Research, in conjunction with Oceanic Society Expeditions, and Elderhostel volunteer support, has conducted surveys based from Drake Bay, Costa Rica for two to four week periods in January and February between 1996 and 1999. Until these studies began in 1996, little information was available on humpback whales and other marine mammals that inhabit the waters off the west coast of Costa Rica.

Humpback whales make seasonal migrations between high-latitude feeding areas and low latitude wintering areas where they mate and give birth to calves. Their populations were depleted by commercial whaling and in the North Pacific have recently been determined to number about 8,000 (Calambokidis *et al*. In Press). Humpback whales return annually to defined feeding areas in coastal waters, this includes the waters off California where about 900 humpback whales return annually to feed (Calambokidis *et al*. 1996a, 1999, In press).

In the North Pacific, they were thought to use three primary wintering areas: the waters near Mexico, Hawaii, and Japan. Within each of these three regions are a number of subareas. It was not until research conducted in the 1990s that it became clear that some humpback from the North Pacific were also using Costa Rica as a wintering ground (Calambokidis *et al.* 1996b, 1998, Steiger *et al.* 1991, Rasmussen *et al.* 1995, Acevedo and Smultea 1995). This research has provided some of the first information available about the number and behavior of humpback whales using Costa Rican waters.

The project has several scientific objectives:

1. Determine the number of whales using Costa Rican waters as a wintering area.

2. Examine for evidence of whale preference for specific areas and habitats within the region.

3. Determine the movement patterns and migratory destinations of these whales.

4. Evaluate whether it is the same individuals that return annually to Costa Rican waters or if different animals use the area each year.

5. Further evaluate if humpback whales seen in Costa Rican waters are engaged in breeding behaviors similar to other North Pacific wintering grounds.

6. Document the occurrence of other marine mammals in Pacific waters off Costa Rica including the habitats and regions that they inhabit.

METHODS

Small boat surveys

Small boat surveys were conducted in all four years (1996-99) from Drake Bay Wilderness Camp on the Osa Peninsula, Costa Rica, located in the southwestern section of the Pacific coast (Figure 1). The boats used were primarily 24 ft fiberglass boats equipped with twin 40-60 hp outboard motors and driven by experienced boat captains familiar with the local area. A total of 16 dedicated boat surveys and two opportunistic surveys were conducted on 10 days in 1999 between 26 January and 7 February (Table 1). These surveys totaled approximately 1,249 nmi (Table 2) and encompassed much of the southwest coast of Costa Rica (Figure 1). All surveys started at Drake Bay Wilderness Camp and predominately covered the area offshore to Isla del Caño, north to Dominical, and southeast into Golfo Dulce (Figure 2). Survey effort in all four years has been consistent in both the areas covered and the total effort which has involved from 18 to 27 surveys covering from 1,205 to 1,734 nmi per year (Table 2, Figure 1).

Two teams of volunteers assisted in observing for marine mammals as well as collecting the data in 1999. Each team volunteered for one week. Two boats were used each day with 6-8 observers each (including a team leader). Observation points to the front, sides, and back were divided among observers. Position information was based on a hand-held GPS (Global Positioning System) kept aboard each boat. Positions were generally recorded every 30-60 minutes as well as with each sighting. Weather conditions, including sea state, cloud cover, swell height, wind speed, and water temperature were recorded at intervals throughout the survey. Observers recorded information on each surfacing and the behavior of whales during each encounter.

Photographic identification

Humpback whales seen were approached to obtain identification photographs of individual animals. We used photographic identification procedures that have been developed by us and other researchers in studies of humpback whales around the world. Whales were approached slowly from behind and followed until they made a deep dive and typically raise their flukes in the air. If the whale did not raise its flukes, dorsal fin photographs were taken for identification purposes. We used *Nikon* 35mm cameras equipped with a motor drive, databacks to print the date on each frame of film, 300mm telephoto lenses, and *Ilford* HP5+, a high-speed black-and-white film.

Acoustic monitoring

Both survey boats in 1998 and 1999 utilized hydrophones to listen for and record vocalizations of humpback whales while in 1996 and 1997 only a single hydrophone was used. Several models of hydrophones have been used over the four years of research including those designed by Bev Ford (Offshore Acoustics) and Don Norris (Biomon). Both hydrophones used in 1999 were from Offshore Acoustics (sensitivity -154 dBV/uPa $\pm$4 dB at 100 Hz, frequency response from 6 Hz to 14 kHz $\pm$3 dB). One system was used with a 10m cable and the other with a 20m cable. When humpback whale songs were heard clearly, recordings of 30-60 minutes of song were generally made onto either Digital Audio Tape (DAT) with a *Sony* TCD-D7 DAT recorder

(frequency response 20-14,000 Hz, 32 Hz sampling rate) or cassette tape with an *Aiwa* Super Bass HS-JS135W stereo cassette recorder.

Hydrophones were also used to help find and locate whales. Hydrophones were usually deployed every 30 minutes with each boat position and weather update. If whales were heard, a more intensive search of the area was made to try and locate the whale. The relative intensity of the song was used to judge the approximate range to the singing whale. Whales were heard at distances up to 5-10 nmi.

The use of hydrophones on both boats in both 1998 and 1999 allowed us to locate whales based on the time of arrival of the song to each boat. This was accomplished by having one boat transmit the song over the radio to the other boat. The boat hearing the song later was farther from the source of the song (the whale) and would reposition ahead of the other boat. This process was continued in a series of leap-frog movements until both boats were equally close to the whale and the song could be heard clearly through the boat without the hydrophone. We would then remain in position until the whale was seen.

RESULTS AND DISCUSSION

Humpback whale sightings

More sightings of humpback whales were made in 1999 than any previous year (Table 2). There were 32 sightings of 60 humpback whales (including duplicate sightings by different boats) made during the study (Tables 1-2). Humpback whales were seen on all 10 days surveys were conducted from 26 January through 7 February 1999 and on 83% of boat trips (15 of 18). On average 3.3 whales were seen per survey with a sighting rate of 0.048 per nmi searched (Table 2). The number of sightings and every measure of sighting rate per unit of effort were higher in 1999 than any previous year (Table 2).

The large number of whales seen in 1999 included a higher proportion of mothers and calves compared to previous years (Table 3). A majority of the sightings (60%) in 1999 included mothers and calves. In the three previous years only 0 to 11% of sightings included mothers and calves (Table 3). As a result of this, the proportion of single whales (including singers) was lower in 1999 than previous years).

The proportion of single animals (55% for singers and non-singers for all three years) in our study prior to 1999 had been higher than generally reported for other wintering grounds in the North Pacific and North Atlantic. The 1999 findings of a high proportion of mothers with calves and lower proportion of singers results in the overall averages for our study now being more in line with results reported elsewhere. In the North Atlantic, 42% of sightings on Samana Bank (Mattila *et al.* 1994) and 49% of sightings on Virgin Bank were singletons (Matilla and Clapham 1989). Along the Hawaiian Island chain only 30% of animals were reported to be single whales (Mizroch *et al.* 1996).

The large number of mothers and calves seen in 1999 confirms this region may be more of a typical breeding ground for humpback whales. Although mothers with calves had been seen in past years, the proportion had been low. Along with the sightings of mother-calf pairs there may have been additional pregnant females present that had not yet given birth. In past years we have documented pregnant females as well as calves that appeared to have been born very recently and which still had folds in their skin. In both 1996 and 1997, we sighted an adult whale traveling without a calf and later that year saw the same whale off California with a calf (ID #10233 and 10988). In both these cases, the adult animal was seen in Costa Rica traveling with another whale that was either known or suspected to be a male. These findings of pregnant females and newborn calves confirms females use these waters to give birth.

Water temperatures may have played a role in why so many whales were seen in 1999 (Table 4). Water temperatures were significantly different between years from 1996 to 1999 (ANOVA, $p<0.001$) and temperature in 1999 (27.7°C, n=242, SD=1.1) was significantly lower than each of the previous three years (t-tests, $p<0.001$ in all three cases). The 1999 findings are in contrast to 1998 when water temperature was unusually high (29.1°C, n=205, s.d.=0.88) and sighting rates of humpback whales very low.

As in past years, humpback whales were primarily seen between Isla del Caño and the mainland (Figure 2). Sightings in 1999, however, were more concentrated close to shore along the mainland at the NW tip of the Osa Peninsula. Two additional sightings were made farther south off the Peninsula but none were made north towards Dominical where whales had been seen in most past years.

Although not a part of the current study, the findings from the larger survey conducted by the *Russamee* along the entire coast from southern Mexico to northern Costa Rica have relevance to this study. That survey revealed that during the same period humpback whales were being seen off southern Costa Rica, there were more whales scattered along the entire Central America coast north to Mexico. Sighting densities in many other areas of the Central American coast were similar or higher than those found around Drakes Bay. This means that the number of humpback whales using Central American waters as a wintering area is larger than we had previously documented. The findings from the Drakes Bay research also have greater applicability in understanding how some of these areas are used.

Photo-identification

Humpback whales were only identified on 7 occasions representing 4 different individual humpback whales in 1999 (Table 5). Of these four individuals identified in 1999, one (10525) had been seen in a past year (1997) in Costa Rica and all four had been seen previously off California (Table 5). The low number of whales identified was partly the result of the high proportion of mothers and calves and the infrequency with which these animals raised their flukes allowing an adequate identification photograph to be taken.

The four whales identified in Costa Rica in 1999 had been seen off California as far back as 1987 and as recently as 1998 (Table 5). Sighting locations for these whales off California were mostly off central and northern California. Only one whale had been seen once off southern California. Sightings off central and northern California included Monterey Bay and the Gulf of the Farallones north to Pt. St. George near the Oregon border.

The total number of different individuals that has been identified off southern Costa Rica (including one from Panama) in winter months now is 34 (Table 6). This is now providing a large and useful sample for comparison to other areas, particularly California. The rate with which we have matched whales identified off Costa Rica to those we know from our research off California remains high (Table 6). Of the total of 34 different humpback whales off Costa Rica, 29 (85% again) have been seen previously off California. Because we have not identified all California whales (we typically find that 15-20% of whales we see off California have not been identified previously) the match rate of Costa Rica whales to California indicates Costa Rican waters are almost exclusively used by humpback whales that migrate to California. This overall rate is higher than has been documented between any other winter and feeding regions that scientists have examined. The exclusive use of a wintering area by animals from a single feeding area is different than has been documented for other humpback whale wintering areas that have been studied in the North Pacific and North Atlantic. At other wintering areas, humpback whales have been documented traveling to multiple different feeding areas. This may be the result of Costa Rica

being the farthest south wintering area for North Pacific humpback whales and California being the most southern feeding area.

A surprising finding was that whales identified in different wintering areas showed a preference for where they were seen feeding off California. Whales identified in Costa Rica were more likely to feed off southern California then northern California while whales that were known to have wintered in Mexico were more likely to be seen feeding off northern California than southern California. This pattern was apparent in our overall matches (Calambokidis *et al.* In press) although not necessarily from the small 1999 sample alone. Although humpback whales are clearly capable of extremely long migrations, it appears that those wintering off Costa Rica, the southern-most wintering areas for North Pacific humpback whales, are more likely to seek feeding areas that are farther south and do not require as long a migration.

Some of the matches between California and Costa Rica provide insight into the transit times and migration distances of these whales. Two of the whales seen in 1999 in Costa Rica had been seen in the late summer or fall of the previous year off California. One of these sets a new distance record for the migratory distance covered by these whales from Costa Rica. ID 11243 was seen on 6 October 1998 off Pt. St. George at the Oregon/California border and was resighted in Costa Rica on 6 February 1999. This represents a minimum straight-line distance of 5,427 km in 4 months. This is more impressive given that the distance traveled was likely much greater and the interval probably much shorter than we documented. The shortest transit time we have documented in any year was a whale we saw off northern California on 1 December 1995 (one of our last surveys of the season) that we saw a mere 56 days later on 26 January 1996 during our first survey off Costa Rica. The straight-line distance between these two points is 5,200 km. Even in this case the actual transit was probably shorter in time and longer in distance than this indicates; this whale likely stayed longer off California, arrived earlier off Costa Rica, and may have traveled to other areas than revealed by our observations. As coincidental as this pair of sightings seems, we have had several other resightings of the same whale thousands of miles away just a few months apart.

Humpback whale song

Once again in 1999, we frequently heard humpback whale singing and obtained recordings on six occasions (Tables 4 and 7). Humpback whales are known for their complex songs, heard primarily on the breeding grounds. Only the males sing the songs, and whales sing a similar song from a region each year. On 52 of the 238 (21%) times we deployed the hydrophone in 1999, we heard singing at a rate similar to findings in past years (Table 4). This is consistent with the conclusion that the higher number of whales seen in 1999 was the result of more mothers and calves and not a reflection of an increase in males that produce the song.

The locations where singing was heard in 1999 generally agreed with the locations of sightings (Figure 3). Song was primarily heard in a region stretching from around Isla de Caño to Drakes Bay (Figure 3). Singing was also heard near where a humpback was spotted along the south side of the Osa Peninsula and up north of Dominical. In 1996 and 1997 but not 1998, we also heard singing north off Isla Ballena and Dominical. This is a region where we have seen whales in past years (Figure 2) but did not in 1999, although the singing confirms there were whales there in 1999.

On two occasions the identity of singers was determined and recordings obtained (Table 7). Both are therefore likely males and their known sex will help in interpreting their behavior in the future. One was already known to be a male from a skin biopsy off California. To date, all the known sex animals we have positively documented returning multiple years have been males. It is hard to conclude much about females because we see them less often and especially for mothers with calves, have had trouble getting identification photographs.

We also successfully obtained recordings of humpback whale songs on six occasions in 1998 (Table 7) and three of these were excellent recordings on high-quality Digital Audio Tape (DAT). This provides a major addition to our growing library of recordings of songs off Costa Rica (Table 7). With this library, we will be able in the future to examine patterns of song change over time and similarities with recordings made in other wintering areas.

Other marine mammals

Besides humpback whales, three other species of marine mammals, all species of dolphin, were documented during the surveys in 1999 (Table 8). These sightings were particularly valuable because of the limited information available on marine mammals off Costa Rica. One of these sightings was of spinner dolphin, a species we had not seen in past years. With that sighting, we have documented 11 different species of marine mammals in our study area from 1996 to 1999 (Table 7). A brief summary of each species is provided below.

Large baleen whale sighting

No large baleen other than humpback whale was seen in 1999. A single Bryde's whale was seen on 26 January 1998. It was observed along the south side of the Osa Peninsula and was swimming south. This medium-size whale is in the same family (Balaenopteridae) as humpback whales. Unlike most other baleen whales, it is generally confined to warmer tropical and temperate waters. It was identified by its streamlined shape, smaller size (30-40 ft), and three head ridges. This was our first sighting of this species in our research, although its occurrence in this region is not surprising. The only other species of baleen whale, besides humpback and Brydes whales, seen in our research, was a single sighting of a likely fin whale in 1997.

Toothed whales

Two sightings of groups of 5 and 30 false killer whales were made in 1998 on 27 and 29 January. On both occasions we got very close looks because they approached the boat to bowride. One whale dove down out of our sight, and then resurfaced with a red rockfish in its mouth. It carried the fish around in its mouth and passed it to another animal nearby. False killer whales were also seen once in 1996. Two of the sightings (one in 1996 and one in 1998) were made on the west side of Isla del Caño while the other sighting (in 1998) was off Drakes Bay (Figure 5). This species has been reported frequently in Golfo Dulce and off Isla de Coco in Costa Rica (Acevedo-Gutierrez *et al.* 1997). Local naturalists reported frequently sighting pilot

whales in the study area. We never encountered pilot whales in our surveys and suspect at least some sightings of false killer whales may be mistakenly identified as pilot whales.

Sperm whales and killer whales, which had been seen in 1996 and 1997 (Table 7, Figure 5), respectively, were not seen in 1998. Sperm whales primarily inhabit deeper offshore waters, where we saw them in 1996. Our surveys are usually in shallower waters with the exception of a few segments just barely off the shelf edge so the infrequent sightings of this species is to be expected.

Dolphin species

Five dolphin species have been seen during the study, three of them in 1999. Spotted dolphins were by far the most frequently seen marine mammal species in our surveys accounting for 154 sightings of 2,368 animals over the four seasons of study. The number of sightings and animals seen in 1999 was higher than previous years. The distribution of spotted dolphin sightings reveals they were seen throughout the area we surveyed. Highest concentrations of sightings were surrounding Isla del Canos and off the west edge of the Osa Peninsula.

Bottlenose dolphins were also seen all four years and throughout the study area (Table 7). They were not as commonly seen around Isla del Canos and many of our sightings came around the periphery of our primary survey area. A quarter of the sightings of bottlenose dolphins were made during our few surveys out to the shelf edge northwest of our primary study area suggesting this is a better habitat for this species than the principal areas we surveyed. Bottlenose dolphins were also seen in Golfo Dulce during some of the trips we made there. Group sizes were generally small.

A number of other species have only been sighted in single years. One dolphin species, spinner dolphins, were seen for the first time in our study in 1999. This is a fairly common dolphin known to occur in this region but we had been unable to positively identify it in past surveys. Several other species not seen in 1999 have only been seen in one previous year. A group of approximately 50 common dolphins were seen during one of our few surveys off the continental shelf edge at the northwest tip of our survey coverage on 12 February 1998. This species is relatively common in offshore waters of the eastern tropical Pacific but had not been seen in the areas of our surveys. We also had our first sighting of rough-toothed dolphins in 1998. A group of 20 rough-toothed dolphins was seen on 5 February SW of Dominical. Photographs taken during the sighting clearly showed the absence of a crease between the melon and beak, indicative of this species. Rough-toothed dolphins are considered relatively uncommon throughout most of their tropical range (Leatherwood and Reeves 1983).

CONCLUSIONS

Principal findings of the research have included:

- Humpback whales regularly use Costa Rican waters as a calving and breeding area with sightings of mother-calf pairs, pregnant females, and singing males.

- The number of animals and especially mothers and calves varied among years with a high number present in 1999.

- North Pacific humpback whales migrate farther south than previously known.

- Our study area is used by a small group of humpback whales many of which return in multiple years to this area.

- Humpback whales from this region are almost exclusively animals that use the California feeding area.

- A total of 11 marine mammal species were documented in Costa Rican coastal waters and provided some of the first details of these species in these waters.

This information will be valuable in protecting and managing marine mammals in Costa Rica. Tourism in Costa Rica has increased dramatically over the last 20 years, especially with visitors interested in terrestrial and marine wildlife. An expansion of resorts and tourist activities in Drakes Bay has occurred over the four years of this research. With these increasing activities and interest in whales and marine mammals, it is important we learn more about the populations of many of these species to be better to protect them and educate people.

The findings of the research off southern Costa Rica have gained a particular value in the context of our larger survey of Central American waters conducted with the schooner *Russamee*. That study revealed that large portions of the Central American coast are used as a wintering ground for humpback whales. This could mean this area collectively represents a wintering ground for far more humpback whales than we have suspected in the past. Detailed information in this broader region has only been gathered off southern Costa Rica, so this information provides an important insight into how whales use this larger area.

ACKNOWLEDGMENTS

This research was supported by Oceanic Society Expeditions and Elderhostel; Birgit Winning, Silke Schroeder, Randi Reiremo, Sherri Shannon, and Mary-Jane Schramm at Oceanic Society arranged many of the logistics for the field base. We are grateful to those who made this research possible, especially the dedicated volunteers and all of the folks at Drake Bay Wilderness Camp. Herbert, Marleny, and Fernando of Drake Bay Wilderness Camp provided logistical help and support. Boat captains with Drakes Bay provided skillful driving as well as assistance with sightings, especially Roger, Alex, and Omar. Marco Saborio provided logistical support and sighting information. John Tresemer provided sighting information. Mary-Jane Schramm provided helpful comments on an earlier draft of this report. We thank these people and organizations.

For the 1999 research we especially want to thank the Trip Leaders, Izzy Szczepaniak and Heather Harding, who did an excellent job leading the research and the Elderhostel volunteers who participated in the two teams. Research team volunteers in 1999 were as follows:

Trip 1: 25 January to 1 February 1999	**Trip 2: 1 to 8 February 1999**
Gerry and George Coon	Gerry and George Coon
George and Carol Nichols	Marcia Blacklin
Don Horst	Bobbie and Jack Keables
Bill and Terry Kenney	John Lukaszewicz
Dick Kraeuter	Lynn Kershner
Pat Horlacher	Betty and Tom Schmoyer
Dale and Carol English	Dick and Rachel Paull
Marvin and Maxine Turbeville	Greg and Jan Zelewski

REFERENCES

Acevedo, A. and A. Smultea. 1995. First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overal of northern and soutehrn hemisphere populations. Marine Mammal Science 11:554-560.

Acevedo-Guierrez, A., B. Brennan, P. Rodriguez, and M. Thomas. 1997. Resightings and behavior of false killer whales (*Pseudorca crassidens*) in Costa Rica. Marine Mammal Science 13:307-314.

Calambokidis, J., G.H. Steiger, J.R. Evenson, K.R. Flynn, K.C. Balcomb, D.E. Claridge, P. Bloedel, J.M. Straley, C.S. Baker, O. von Ziegesar, M.E. Dahlheim, J.M. Waite, J.D. Darling, G. Ellis, and G.A. Green. 1996a. Interchange and isolation of humpback whales off California and other North Pacific feeding grounds. Marine Mammal Science 12:215-226.

Calambokidis, J., K. Rasmussen, G.H. Steiger. 1996b. Humpback whales and other marine mammals off Costa Rica. Report of research during Oceanic Society/Elderhostel expeditions in 1996. Report to Oceanic Society Expeditions, San Francisco, California.

Calambokidis, J., K. Rasmussen, and G.H. Steiger. 1998. Humpback whales and other marine mammals off Costa Rica, 1996-98. Report on research during Oceanic Society Expeditions in 1998 in cooperation with Elderhostel volunteers. Cascadia Research, 218½ W Fourth Ave., Olympia, WA 98501

Calambokidis, J., T. Chandler, K. Rasmussen, G.H. Steiger, and L. Schlender. 1999. Humpback and blue whale photographic identification research off California, Oregon, and Washington in 1998. Final report to Southwest Fisheries Science Center, Olympic Coast National Marine Sanctuaries, and University of California at Santa Cruz. Cascadia Research, 218½ W Fourth Ave., Olympia, WA 98501. 35pp.

Calambokidis, J., G.H. Steiger, K. Rasmussen, J. Urbán R., K.C. Balcomb, P. Ladrón de Guevara P., M. Salinas Z., J.K. Jacobsen, C.S. Baker, L.M. Herman, S. Cerchio and J.D. Darling. In Press. Migratory destinations of humpback whales that feed off California, Oregon and Washington. *Marine Ecology Progress Series*.

Calambokidis, J., Steiger G.H., Straley, J.M., Herman, L.M., Cerchio, S., Salden, D.R., Urbán R., J., Jacobsen, J.K., von Ziegesar, O., Balcomb, K.C., Gabriele, C.M., Dahlheim, M.E., Uchida, S., Ellis, G., Miyamura, Y., Ladron de Guevara P., P., Yamaguchi, M., Sato, F., Mizroch, S.A., Schlender, L., Rasmussen, K. and Barlow, J. In Press. Movements and population structure if humpback whales in the North Pacific Basin. *Marine Mammal Science*.

Gerrodette, T. and D.M. Palacios. 1996. Estimates of cetacean abundance in EEZ waters of the eastern tropical Pacific. Administrative Report LJ-96-10, Southwest Fisheries Science Center, La Jolla, California.

Leatherwood, S, and R.R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. Sierra Club Books, San Francisco, CA. 302pp.

Matilla, D.K. and P.J. Clapham. 1989 Humpback whales , *Megaptera noaeanglae*, and other cetaceans on Virgin Bank and the in the northern Leeward Islands, 1985 and 1986. Canadian Journal of Zoology 67:2201-2211.

Matilla, D.K., P.J. Clapham, O. Vasquez, and R.S. Bowman. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. Canadian Journal of Zoology 72:1898-1907.

Mizroch, S. A., D. Glockner-Ferrari, D. Salden, H. Bernard, J. Mobley, and L. Baraff. 1996. Report of a pilot study to estimate abundance, within-season residency, and rate and direction of movement of humpback whales in Hawaiian waters, Winter 1995. Pages 131-161 *in* Annual reports of research carried out on the population biology of marine mammals by the National Marine Mammal Laboratory, Seattle, WA.

Rasmussen, K., G.H. Steiger, J. Calambokidis. 1995. Evidence of a humpback whale wintering area off Costa Rica. pp. 93 in: Abstracts Eleventh Biennial Conference on the Biology of Marine Mammals, Orlando, Florida, 14-18 December 1995. Society for Marine Mammalogy, Lawrence, KA.

Steiger, G.H., J. Calambokidis, R.Sears, K.C. Balcomb, and J.C. Cubbage. 1991. movement of humpback whales between California and Costa Rica. Marine Mammal Science 7:306-310.

Steiger, G.H. and J. Calambokidis. In Press. Reproductive rates of humpback whales off California. *Marine Mammal Science.*

LIST OF TABLES AND FIGURES

FIGURES

TABLES (in attached Excel file with Tables on separate sheets)

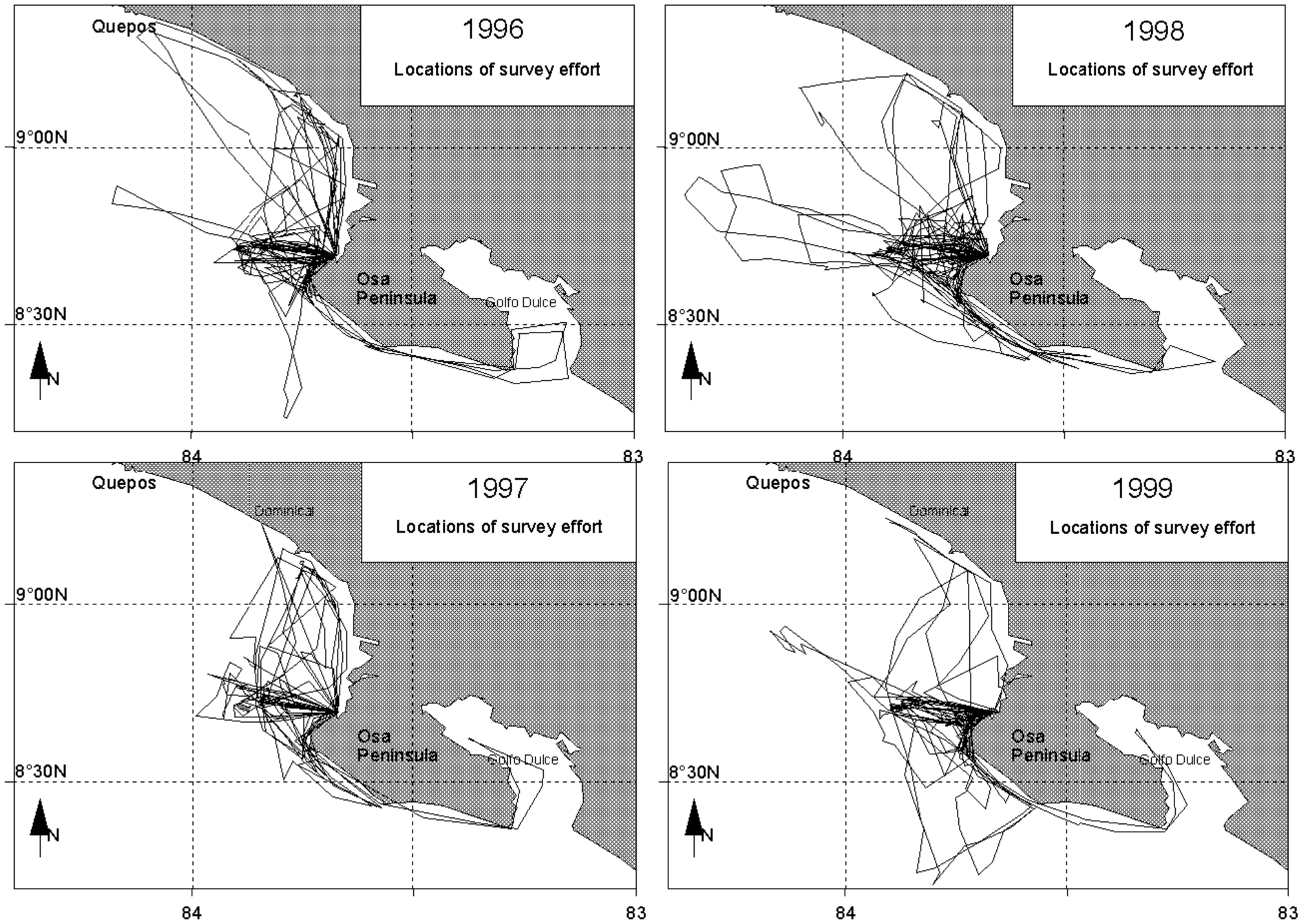

Figure 1. Locations of survey effort by year, 1996-99.

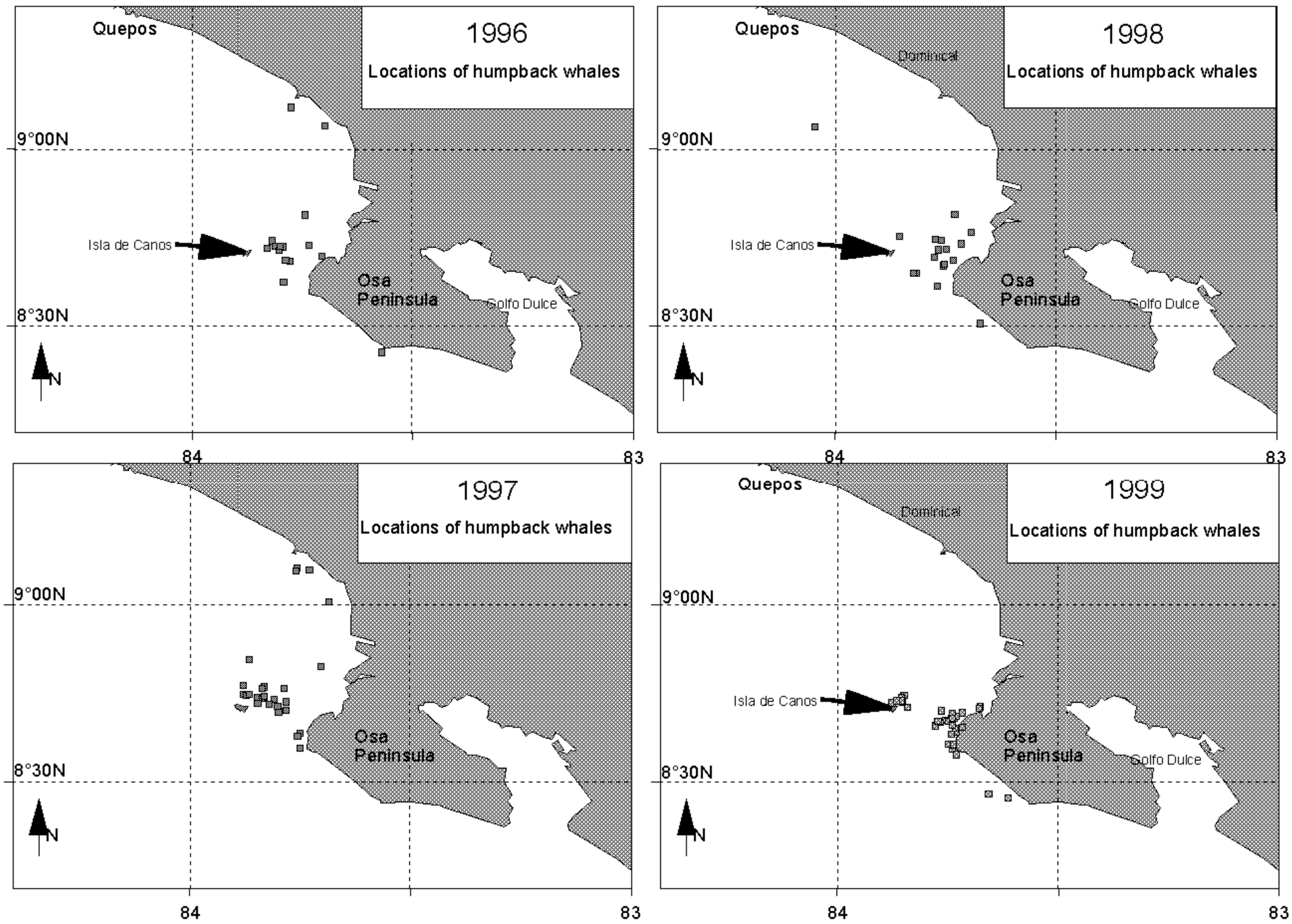

Figure 2. Locations of humpback whale sightings by year, 1996-99.

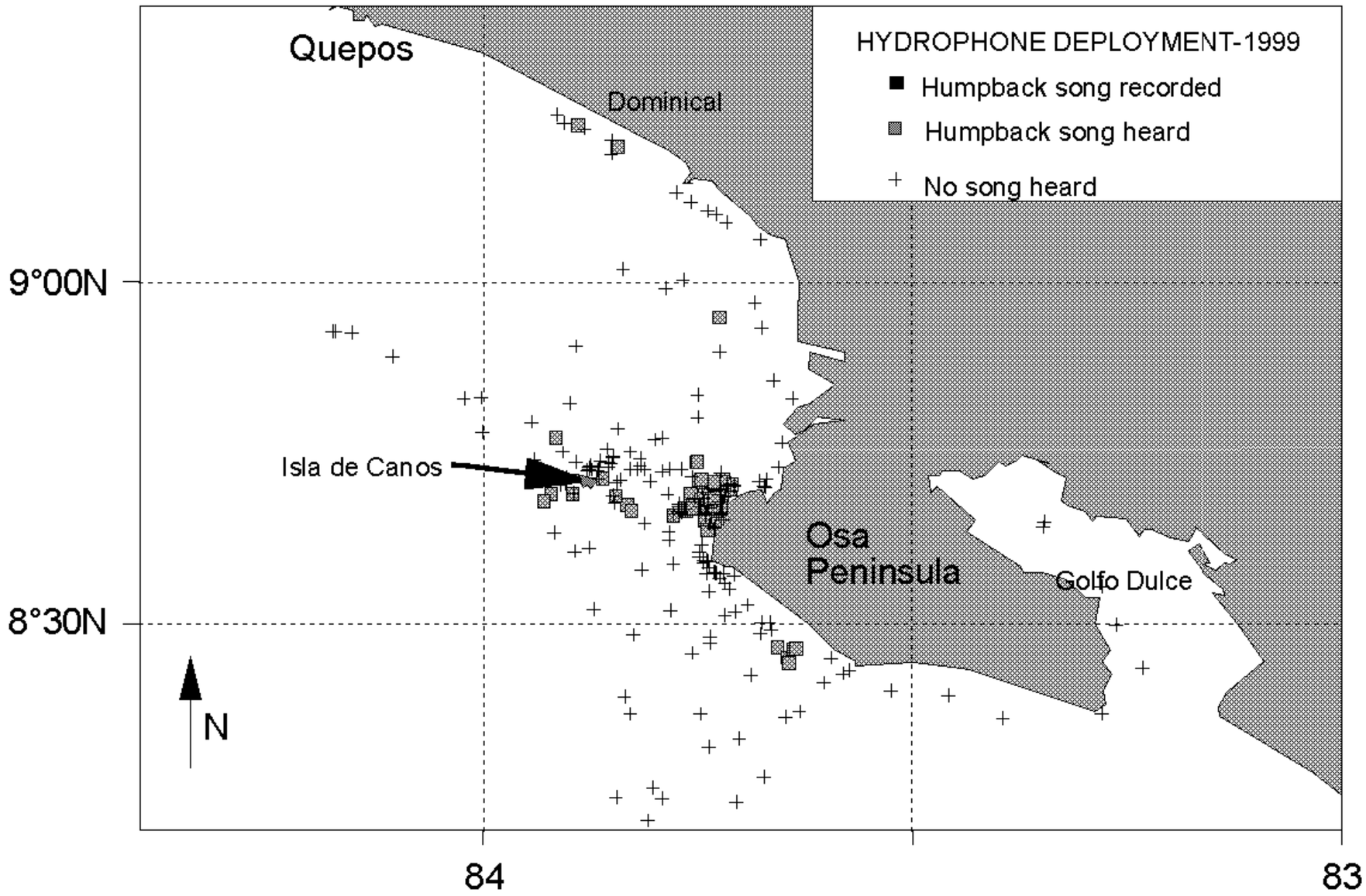

Figure 3. Locations that hydrophones were deployed and results in 1999.

Table 1. Dates and times boat surveys were conducted out of Drake Bay, Costa Rica, with number of humpbacks and other species seen in 1999.

Date	Leader	Time Start	Time End	Mn seen	# ID	Other species	Comments
26-Jan-99	HH	16:15	17:10	4	0	Sa	1 mother/calf pair, calf breaching
27-Jan-99	HH	8:15	17:03	3	1	Sa	singing heard
	IS	8:21	16:35	0	0	Sa	
28-Jan-99	HH	8:10	18:15	2	0	Sa	singing heard, breaching humpback
	IS	8:15	16:14	2	0	Sa	
30-Jan-99	HH	8:13	16:12	1	0	Sa	singing heard
	IS	8:16	17:25	0	0	Sa	singing heard
31-Jan-99	HH	8:01	16:40	4	1	Sa	1 mother/calf/escort pair, calf breaching and spyhopping, singing heard
	IS	8:10	16:41	4	0	Sa	1 mother/calf/escort pair, calf breaching and spyhopping, singing heard
3-Feb-99	HH	8:12	16:45	2	0	Sa	1 mother/calf pair
	IS	8:08	16:04	0	0	Sa	singing heard
4-Feb-99	HH	7:50	16:30	6	1	Sa	2 mother/calf pairs
	IS	8:11	17:50	7	1	Sa	3 mother/calf pairs, breaching
5-Feb-99	IS	16:00	16:00	2	0		On route to Corcovado mother/calf pair seen
6-Feb-99	HH	7:50	17:08	4	1	Sa, Ud	1 mother/calf/escort, breaching seen
	IS	7:50	17:15	5	0	Sa, Tt	1 mother/calf/escort, one mother/calf
7-Feb-99	HH	7:45	16:50	9	0	Sl, Sa	4 mother/calf pairs seen, friendly encounter with 1 mother/calf pair
	IS	7:02	15:55	5	0	Sa, Tt	1 mother/calf pair, 1 mother/calf/escort

Mn-humpback whale, Sa-spotted dolphin, Tt-bottlenose dolphin, Sl-spinner dolphin, Ud-unidentified dolphin,

Table 2. Summary of survey effort and humpback whale sightings off Costa Rica.

	Year				Total
	1996	**1997**	**1998**	**1999**	
Survey effort					
Start date	26-Jan	31-Jan	24-Jan	27-Jan	
End date	16-Feb	14-Feb	18-Feb	7-Feb	
Days with surveys	15	10	15	10	**50**
Total boat surveys	26	18	27	18	**89**
Survey nmi	1,581	1,205	1,734	1,249	**5,768**
Humpback sightings					
Sightings	15	27	18	32	**92**
Animals	19	45	25	60	**149**
Days whales seen	10	10	8	10	**38**
Surveys whales seen	13	14	12	15	**54**
Sighting rates					
Percent of days whales seen	67%	100%	53%	100%	**76%**
Percent of surveys whales seen	50%	78%	44%	83%	**61%**
Whales/survey	0.73	2.50	0.93	3.33	**0.43**
Whales per nmi	0.012	0.037	0.014	0.048	**0.026**

Table 3. Group composition of humpback whale sightings in study area off Costa Rica, 1996-98.

	1996		1997		1998		1999		Total	
	#	%	#	%	#	%	#	%	#	%
Lone singers	5	33%	2	7%	7	39%	5	16%	19	21%
Singles	5	33%	6	22%	4	22%	4	13%	19	21%
Pairs	3	20%	15	56%	5	28%	4	13%	27	29%
Mother/calf	0	0%	3	11%	2	11%	14	44%	19	21%
Mother/calf/escort	0	0%	0	0%	0	0%	5	16%	5	5%
Groups larger than 2	2	13%	0	0%	0	0%	0	0	2	2%
Undetermined	0	0%	1	4%	0	0%	0	0	1	1%
Total	15		27		18		32		92	

Table 4. Water temperatures (degrees C) observed during surveys off Costa Rica and the proportion of hydrophone deployments in which humpback whales were heard singing by year.

	Water temperature (C)			Hydrophone deployments		
Year	**n**	**Mean**	**SD**	**n**	**Song heard**	**%**
1996	135	28.3	0.8	79	19	24%
1997	111	28.2	0.8	82	13	16%
1998	205	29.1	0.9	255	54	21%
1999	242	27.7	1.1	238	52	22%

Table 5. Sighting histories of humpback whales identified off S. Costa Rica in 1999. Sightings off Costa Rica are shaded.

ID	Date	Time	Latitude	Longitude	Region	Num	Calves	Behavior	Comments
10143	10/5/87	10:07	38:13.0	123:22.0	Gulf of Farallones,CA	6	0		
10143	10/7/87	14:46	38:21.7	123:34.0	Gulf of Farallones,CA	2	0	Milling	
10143	10/7/87	15:29	38:22.0	123:34.5	Gulf of Farallones,CA	3	0	Milling	
10143	10/10/87	15:23	38:18.6	123:30.0	Gulf of Farallones,CA	3	0	Fast Travel	
10143	10/30/90	15 20	37 58.3	123 27.4	Gulf of Farallones,CA	4	0	Slow Travel	
10143	11/10/90	12 42	37 57.8	123 25.5	Gulf of Farallones,CA	2	0		
10143	10/6/91	14 30	41 53.7	124 28.0	Pt. St. George, CA	7	0	Milling	
10143	10/6/91	17 20	41 50.3	124 26.6	Pt. St. George, CA	12	0	Slow Travel	
10143	10/7/91	10 30	41 54.0	124 23.7	Pt. St. George, CA	5	0	Slow Travel	
10143	10/7/91	12 20	41 55.2	124 23.1	Pt. St. George, CA	2	0	Slow Travel	
10143	9/1/92	12 55	36 54.0	122 16.0	Monterey Bay, CA	2	0	Milling	
10143	9/22/92	14 35	38 06.5	123 30.2	Gulf of Farallones,CA	5	0	Slow Travel	
10143	11/14/92	15 23	38 27.2	123 32.5	Gulf of Farallones,CA	2	0	Slow Travel	
10143	9/26/93	14 36	37 39.1	123 01.2	Gulf of Farallones,CA	4	0	Slow Travel	
10143	10/15/93	17 09	38 09.3	123 25.0	Gulf of Farallones,CA	4	1	Milling	
10143	10/15/93	17 27	38 08.6	123 27.7	Gulf of Farallones,CA	5	0	Milling	
10143	11/7/95	14 25	38 01.0	123 30.0	Gulf of Farallones,CA	3	0	Milling	
10143	11/7/95	14 35	38 00.9	123 29.9	Gulf of Farallones,CA	5	0	Milling	
10143	2/4/99	08 11	08 41.4	083 44.3	Costa Rica	2		Stationary	
10143	2/4/99	09 23	08 40.1	083 44.8	Costa Rica	1	0	Fast Travel	
10520	7/16/91	15 00	35 07.0	120 47.5	San Luis, CA	5		Slow Travel	
10520	10/6/91	16 10	41 51.1	124 27.9	Pt. St. George, CA	12	0	Slow Travel	
10520	10/7/91	15 00	41 54.9	124 25.5	Pt. St. George, CA	4	0	Milling	
10520	8/29/92	17 30	38 07.0	123 19.7	Gulf of Farallones,CA	1	0	Slow Travel	
10520	9/11/92	15 00	38 04.2	123 31.2	Gulf of Farallones,CA	3	0	Slow Travel	Merged with S#17
10520	9/22/92	14 35	38 06.5	123 30.2	Gulf of Farallones,CA	5	0	Slow Travel	
10520	10/3/92	09 40	38 24.1	123 33.6	Gulf of Farallones,CA	3	0	Milling	
10520	9/23/93	15 25	37 39.4	123 00.5	Half Moon Bay, CA	4	?	Slow Travel	
10520	9/24/93	12 15	37 38.0	123 02.1	Gulf of Farallones,CA	8	0	Milling	
10520	9/26/93	14 36	37 39.1	123 01.2	Gulf of Farallones,CA	4	0	Slow Travel	
10520	9/7/95	12 37	34 13.5	120 01.8	Santa Barbara Ch., CA	2	1	Slow Travel	Cow with calf
10520	6/9/98	15 15	34 07.9	119 57.0	Santa Barbara Ch., CA	2	0	Milling	
10520	7/6/98	18 44	34 08.9	120 02.3	Santa Barbara Ch., CA	1	0	Slow Travel	
10520	9/2/98	08 52	37 40.9	123 07.4	Gulf of Farallones,CA	8	0	Milling	
10520	9/2/98	08 59	37 41.0	123 07.3	Gulf of Farallones,CA	5	0	Milling	
10520	1/31/99	15 41	08 39.9	083 45.9	Costa Rica	1	0	Stationary	Singing recorded
10525	10/6/91	16 10	41 51.1	124 27.9	Pt. St. George, CA	12	0	Slow Travel	
10525	10/16/91	15 10	41 51.5	124 29.1	Pt. St. George, CA	2	0	Milling	Skin sample indicates male
10525	10/16/91	15 25	41 51.5	124 28.5	Pt. St. George, CA	5	0	Milling	
10525	8/28/94	16 10	38 03.6	123 10.7	Gulf of Farallones,CA	2	0	Slow Travel	
10525	2/14/97	13 06	08 44.5	083 52.0	Costa Rica	2		Slow Travel	
10525	2/14/97	13 11	08 44.7	083 51.7	Costa Rica	2	0	Slow Travel	
10525	1/27/99	10 17	08 40.5	083 44.1	Costa Rica	1	0	Milling	Singing recorded
11243	10/6/98	15 30	41 53.1	124 25.5	Pt. St. George, CA	4	0	Milling	
11243	10/6/98	15 45	41 53.0	124 25.2	Pt. St. George, CA	7	0	Milling	
11243	10/6/98	16 34	41 53.4	124 25.1	Pt. St. George, CA	4	0	Milling	
11243	2/6/99	08 39	08 36.2	083 44.9	Costa Rica	1	0	Slow Travel	

Table 6. Results of photographic identification research of humpback whales in Costa Rica during winter through 1999.

Description	pre 1996	1996	1997	1998	1999	All Years
Number of identifications from Oceanic Society trip	0	12	19	12	5	48
Number of identifications contributed by others	5	4	0	0	0	9
Total identifications	5	16	19	12	5	57
Unique animals for period	5	13	11	7	4	34
New whales (not seen a previous year)	5	12	10	4	3	
Number matching California	4	11	8	6	4	29
Total percent matching California	80%	85%	73%	86%	100%	85%

Table 7. Times and locations of recordings of humpback whale songs, 1996-99.

Date	Time	Latitude	Longitude	Tape track	Comments
1996					
29-Jan-96	13 30	08 43.49	083 44.01	Tape 96-1 Pr. 5	ID-10541
07-Feb-96	10 02	08 56.2	083 40.1	Tape 96-2 Pr. 1	
12-Feb-96	09 35	08 40.99	083 47.16	Tape 96-2 Pr. 2-3	ID-10731
12-Feb-96	09 33	08 40.89	083 46.57	Tape 96-2 Pr. 4	ID-10731
15-Feb-96	10 40	08 42.13	083 50.51	Tape 96-3 Pr.1	
15-Feb-96	12 54	08 44.4	083 48.48	Tape 96-3 Pr.2	
1997					
13-Feb-97	10 17	09 05.7	083 43.5	Tape 97-1	ID-9047
13-Feb-97	11 33	09 06.9	083 45.5	Tape 97-1	ID-9047
1998					
02-Feb-98	08 50	08 45.9	083 41.9	Tape 98-1 Pr.1	
02-Feb-98	15 16	08 41.06	083 43.65	Tape 98-1 Pr.3	ID-10753?
02-Feb-98	13 15	08 41.2	083 45.9	Cassette	ID-10753
10-Feb-98	11 27	08 42.8	083 45.1	Tape 98-2 Pr.1	ID-10753
10-Feb-98	13 35	08 43.9	083 42.8	Tape 98-2 Pr.2	ID-10753
10-Feb-98	14 24	08 44.5	083 42.6	Cassette	ID-10753
13-Feb-98	09 41	08 38.9	083 49.3	Tape 98-2 Pr.3	ID-9003
16-Feb-98	12 33	08 46.2	083 49.6	Tape 98-3 Pr.1	ID-9003?
1999					
27-Jan-99	10 17	08 40.5	083 44.1	Tape 99-1 Pr.1	ID-10525
27-Jan-99	15 39	08 44.0	083 45.0	Cassette	
28-Jan-99	16 54	08 27.7	083 38.1	Tape 99-1 Pr.2	
30-Jan-99	09 32	08 40.9	083 43.84	Cassette	
30-Jan-99	12 06	08 41.7	083 43.5	Tape 99-1 Pr.3	
31-Jan-99	14 10	08 40.15	083 45.27	Cassette	ID-10520

Table 8. Summary of sightings of all species identified in study area off Costa Rica, 1996-1998.

	1996		1997		1998		1999		Total	
Species	**sightings**	**animals**	**sightings**	**animals**	**sightings**	**animals**	**sightings**	**animals**	**sightings**	**animals**
Baleen whales										
Humpback whale	15	19	27	45	18	25	32	60	92	149
Fin/Sei whale			1	1					1	1
Bryde's whale					1	1			1	1
Toothed whales									0	0
Sperm whale	2	5							2	5
False Killer whale	1	40			2	35			3	75
Killer whale			2	8					2	8
Dolphins									0	0
Spotted dolphin	20	448	36	358	35	614	63	948	154	2,368
Bottlenose dolphin	8	53	2	7	7	203	2	11	19	274
Common dolphin					1	50			1	50
Rough-toothed dolphin					1	20			1	20
Spinner dolphin							1	150		
Unidentifed dolphin	26	120	8	33	12	33	1	10	47	196