DISTRIBUTION AND SEASONAL OCCURRENCE OF HUMPBACK WHALES (*Megaptera novaeangliae*) COWS WITH CALVES IN COASTAL WATERS OF ECUADOR

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ABSTRACT

The distribution and seasonal occurrence of humpback whales (*Magaptera novaeangliae*) cows with calves were analyzed during the breeding season (June-October) around the Santa Elena Peninsula, Ecuador (2°10' S, 81°00' W). In 571 trips carried out between 2001 and 2008 aboard whalewatching boats, 135 groups containing cows with calves were recorded: 89 cow/calf pairs alone (CC) and 46 accompanied by one or more escort whales (CE). CC groups distributed in significantly shallower waters than CE groups (18.79m, *SD* = 9.66 and 23.63m, *SD* = 10.81, respectively; *p* = 0.011); particularly during the afternoon hours when the difference was around 8m. However, the distance of the sightings to the coast was not significantly different. First CE groups were recorded 20 days after the first CC groups and peaked with a delay of five days in respect to CC groups, suggesting a segregation of cow/calf pairs in the first days after birthing. Two cow/calf pairs were recorded with the same escort, in one case after one day and in a second case after four days. The maximum span of time for an identified cow with calf in the breeding area was 61 days. Our results show similarities with other breeding areas but also some differences, which are likely caused by different breeding and nursing strategies associated to particular environmental, ecological and social pressures. We warned about the potential impact that the increase of coastal activities may have on cows with calves nursing around this area.

KEY WORDS: South America, humpback whales, breeding grounds, distribution, conservation.

INTRODUCTION

The north-western coast of South America constitutes the breeding area for Southeast Pacific humpback whales (*Megaptera novaeangliae*), referred to as the Breeding Stock G (IWC, 2006). After feeding during the austral summer (December-April) in waters around the Antarctic Peninsula and south of Chile (Stevick *et al*., 2004; Acevedo *et al*., 2007), whales belonging this stock migrate to low latitudes in winter looking for warm and coastal waters off Ecuador, Colombia, Panamá and Costa Rica for breeding (Flórez-González, 1991; Félix and Haase, 2001; Florez-Gonzalez *et al*., 2007; Rassmussen *et al*., 2007). Cows and calves are typically observed in this zone beginning in August, but they can be sighted as late as November and even December (Félix and Haase, 2001; Florez-Gonzalez *et al*., 2007).

During the breeding season in the Southeast Pacific, the species exhibits a heterogeneous distribution according the age and class composition and breeding state (Félix and Haase, 2005). While the species maintains in general a neritic distribution in waters of less than 200m in depth, cows with calves prefer even shallower waters close to the coast (Félix and Haase, 1997, 2005; Flórez-González *et al*, 2007; Rassmussen *et al*., 2007), in similar way as in other breeding areas (e.g. Winn *et al*., 1975; Smultea, 1994; Ernst and Rosenbaum 2003). Different than other species whose habitat is mainly based on prey availability, humpback whales during the breeding season do not feed. Hence, habitat use of cows with calves are

driven by other environment variables that modulate birthing and nursing, probably in response to ecological and social pressures such as predation risk (Chittleborough, 1953; Herman and Antinoja, 1977), males harassment (Chittleborough, 1958; Smultea, 1994; Craig *et al*, 2002), energy conservation (Whitehead and Moore, 1982; Elwen and Best, 2004), among others. Some adult individuals associate with cow/calf pairs, which are generally males and referred to as escorts (Herman and Antinoja, 1977; Clapham *et al.*, 1992), and could provide some benefits for the pair, especially regarding defence and protection (Chittleborough, 1953; Herman and Antinoja, 1977; Herman and Tavolga, 1980; Glokner and Venus 1983). Consequently, the association of one or more males eventually may be an option for a newly mother. However, adult males joining a cow/calf pair could also be the cause of nursing disruption, injuries to the calf or even its separation due to the aggressiveness of males during the mating process (Smultea, 1994).

This article describes the seasonal distribution of cow/calf pairs during the breeding season in Ecuador. We attempt to identify the environmental and social variables that would motivate their presence in shallow areas and how these patterns are affected when escort whales are involved. Our results show similitude with other better studied breeding areas such as the Hawaiian Islands and the Caribbean, but also some differences that would be related with particular geographic and environmental features of the studied area. This study, besides contributing to the understanding of the reproductive behaviour of this species, provides baseline information for conservation efforts and coastal management.

MATERIALS AND METHODS

Study Area

The study area covers some 120km^2 around the Santa Elena Peninsula, located in the south-central coast of Ecuador (2°10' S, 81°00' W). Our base was Salinas, a major tourist village in the north-eastern tip of the Peninsula. The Santa Elena Peninsula is the westernmost point of Ecuador toward the Pacific Ocean and is surrounded by a narrow shelf (Figure 1). Depth increases gradually from the Peninsula tip to the west; reaching 100m in depth 13km offshore, and then the slope increases one order of magnitude. The shallow area is wider north of the peninsula than to the south; sandy and rocky bottoms characterize this zone. The geographic particularities of the site allow rapid access to the whales' migratory corridor (Félix and Haase, 2005).

The area is also characterized by the seasonal influence of the cold and productive Humboldt Current from the south and warm tropical waters of the Panama Bight from the north, forming the Equatorial Front. The front moves from north to south along the coast of Ecuador depending on the strength of the Southeast Pacific anticyclonic winds (Cucalón, 1996). During the humpback whales breeding season, the Equatorial Front is located in its northernmost position off the central part of Ecuador, causing the sea surface temperature in this zone varies between 22 and 25ºC.

Trips

Trips around the Santa Elena peninsula tip to study humpback whales during the breeding season (June-October) were conducted between 2001 and 2008 aboard whalewatching boats, as part of a long-term study of this population along the coast of Ecuador (see Felix and Haase 2001, 2005). During the study, 18 different boats between 8 and 15m in length and between 10 and 30 passengers of capacity were used. Boats usually departed in the morning at 9:00-10:00 and returned to port two or three hours later. Usually one trip per day was made, but in the peak of the season (August) two and sometimes three trips a day were conducted. Most whale groups were found near the coast within a radius of 5nm of the peninsula tip in depths between 10 and 100m (Félix and Haase, 2005). During the study

period, 571 trips were made, 1,215 groups were approached in 930.9 hours spent at sea (Table 1).

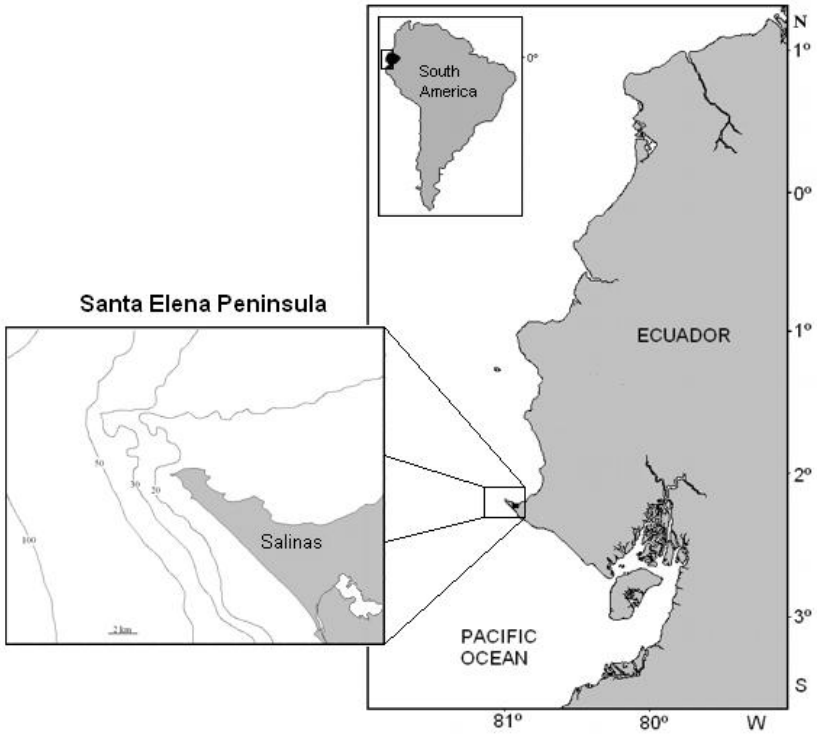

Figure 1. The study area on the coast of Ecuador.

Table 1. Research effort developed during the period 2001-2008 off the Santa Elena peninsula.

	2001	2002	2003	2004	2005	2006	2007	2008	TOTAL
Trips	32	35	30	77	74	96	104	123	571
Sightings	68	78	78	147	148	213	221	262	1,215
Whales	160	174	176	322	349	466	555	628	2,830
Sighting time (h)	32.5	34.4	48	68.2	59.1	82.4	92.9	96.1	513.6
Navigation time (h)	69.8	66.0	71.5	136.3	94.8	153.9	167.3	171.3	930.9

Data collection

During the sightings, information on group size, composition, behavior, diving time, bearing, among other information, was written down on field sheets designed for this purpose. Additionally, sightings were recorded with GPS, taking the first position at the beginning of the observation and then every 15 minutes until the boat left the whales, when a final position was taken. Photographs to identify individual whales were taken with analogical cameras and slide film ISO 200 in the first three years and in subsequent years with digital cameras of 6-10 megapixels equipped with 70-300mm zoom lenses. The identification was based on the coloration pattern of the ventral side of the flukes (see Katona, *et al*., 1979) as well as the shape of dorsal fins. The latter were more effective in the case of cows with calves, because cows usually do not raise their flukes. A catalogue of cow/calf dorsal fins was made and was useful because the combination of the two dorsal fins in one photograph facilitated the comparison process and reduced the mismatching error of comparing fins instead one at a time. Dorsal fins were used, however, only for identification in the short-term (within the same season).

Groups

A group was defined as all individuals present within a radius of 100m which moved in the same direction and generally maintained a coordinated breathing pattern. For this study, we took into account only those groups containing cows with calves, that is, those groups in which were present a small individual (<6m in length) accompanied by at least one adult, one of them presumably its mother (*n* = 135, 12.5% of total groups observed). We defined two types of groups containing a cow with calf: those involving only the cow/calf pair (refereed to as CC) and those in which one or more escort whales accompanied the cow/calf pair (referred to as CE+). We assumed that in CE+ groups, the individual who remained closer to the calf was its mother.

Distribution

To examine the distribution of the groups, we use the first position taken during the approaching phase. Data were analyzed with the GIS software DIVA 4.0 (Hijman *et al*., 2004). The distances to the coast for each sighting were approximated with the navigation chart I.O.A. 105, produced by the Oceanographic Institute of the Navy of Ecuador (INOCAR). Sighting depths were approximated through the Environmental Research Division's Data Access Program (ERDDAP) of the National Oceanic and Atmosphere Administration (NOAA), data set: Topography, SRTM30 + Version 6.0, with a resolution of 30 arc second (1km^2) (Becker *et al*., 2009; Sandwell and Smith, 2009).

RESULTS

Groups recorded

Two thirds of the recorded groups (*n* = 89, 65%) involved only cow/calf pairs (CC), while the remaining 46 groups (35%) included the cow/calf pair and at least one escort (CE+). In the case of CE+ groups, their occurrence decreased inversely to the number of escorts present. Most CE+ group involved only one escort (CE+1) (*n* = 33, 53%), with only 13% in groups of CE+2, 5% in groups of CE+3 and 1.6% in groups with 4 or 5 escorts. One of eight CE+2 groups and the five CE+4 and CE+5 were breeding groups (also referred to as competitive groups, Tyack and Whitehead, 1983, Baker and Herman, 1984). Given the low frequency in some categories, for purposes of subsequent comparisons, all groups containing one or more escorts were incorporated into a single category (CE).

Resightings

Ten within-year re-sightings of nine different groups containing a cow/calf pair were made (Table 2). Re-sightings ranged from between 0 and 61 days. It was considered a re-sighting on day 0 when a group containing the same cow/calf pair was recorded twice in the same day, morning and afternoon, in different trips. In 80% of the cases, re-sightings occurred within 9 days after the sighting. Six groups were re-sighted as the same type of group as recorded the first time (4 CC and 2 CE). Two groups were first seen as CC and the second time were recorded accompanied by escorts (CE+5 and CE), while one CE group changed to CC in the same day and then was recorded as CE again two days later.

It was interesting that in the two cases of CE groups re-sighted again as CE, the escorts were the same individuals. In one case, the re-sighting occurred after one day and in the second case, after four days. In contrast, in the CE group re-sighted as CC and then as CE again, the escorts were different in the first and third sightings, showing different degrees of stability in this type of group.

Table 2. Groups of cows with calves re-sighted within the same season. Data includes the dates of the sighting and subsequent re-sightings, the time sightings (days), and the type of group (CC or CE as defined previously).

ID	Date 1st sighting	Group type	Date 1st re-sighting	Group type	Date 2nd re-sighting	Group type	Days
NN1	25-sep-04	CE	26-sep-04	CE			1
NN2	12-jul-04	CC	11-sep-04	CC			61
NN3	30-ago-06	CC	08-sep-06	CC			9
NN4	31-jul-06	CC	06-aug-06	CE			6
NN5	29-aug-07	CE	02-sep-07	CE			4
Nº 1165	23-aug-07	CC	25-aug-07	CE+5			2
Nº 1447	17-aug-08	CC	06-sep-08	CC			20
Nº 1421	31-aug-08	CE	31-aug-08	CC	02-sep-08	CE	2
Nº 1382	21-aug-08	CC	21-aug-08	CC			0

Distribution

Both CC and CE groups showed a similar distribution pattern, with a concentration of sightings north and close to the peninsula tip, although CC groups were observed closer to the coast and in shallower waters than CE groups (Figure 2). Both groups were recorded within a similar range of depths (10-60m) and distance to shore (0.1-9km). On the average CC groups were located 2.4km offshore (*SD* = 1.95) in waters of 18.79m in depth (*SD* = 9.66, n=83), while CE groups were found on the average to 2.83km offshore (*SD* = 1.94) and waters of 23.63m in depth (*SD* = 10.81, *n* = 44). Only the difference in depth distribution was statistically significant (*t* =- 2.57, *p* = 0.011).

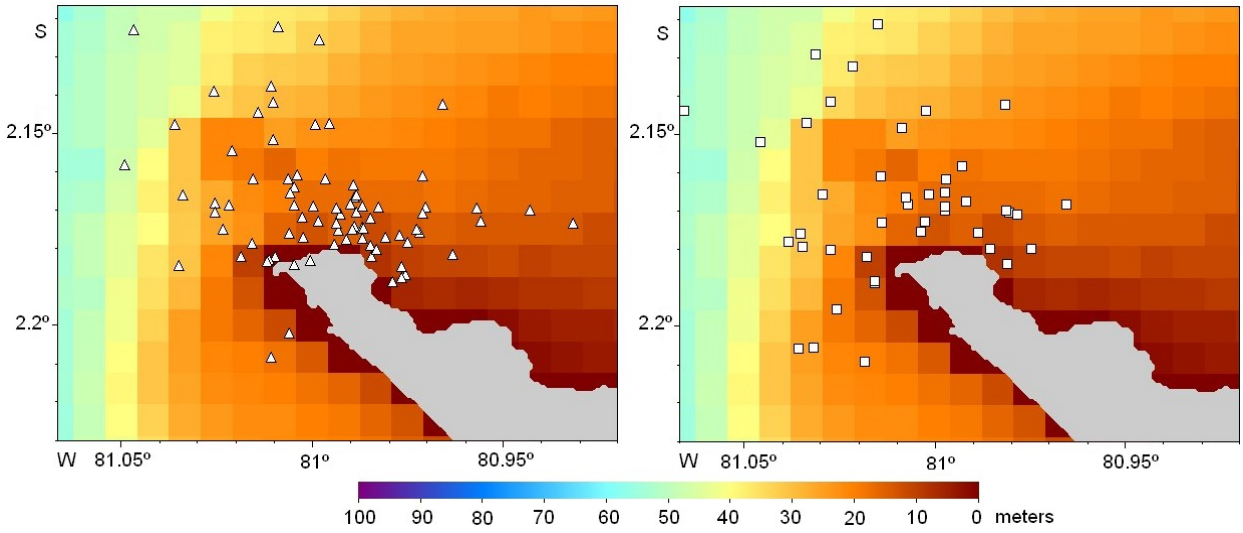

Figure 2. Distribution of cow/calf pairs CC (Δ) (left) and escorted groups CE (□) (right) with respect to depth (meters) around Santa Elena Peninsula during the period 2001-2008. Each colored square represents 1km^2.

A further analysis of depth/distribution with respect to the time of day was made. For this purpose, sightings were pooled in two periods: morning (8:00-12:59) and afternoon (13:00-18:00). For CC groups, the average depth in the morning was 4m deeper (20.22m, *SD* = 10.2, *n* = 53) than in the afternoon (16.26m, *SD* = 8.2, *n* = 30) but not significantly different (*t* = 1.81, *p* = 0.07). Neither was significantly different the average distance to the coast (3.07km, SD = 1.5 and 2.67km, SD = 1.58, respectively, *t* = 1.12, *p* = 0.27). In the case of CE groups, no significant difference in the depth between the morning (23.27m, *SD* = 9.89, *n* = 29) and afternoon hours was found (24.33m, *DE* = 12.74, *n* = 15) (*t* = 0.1353, *p*> 0.089), nor

in the distance to the coast (3.32km, SD = 1.6 and 3.59km, SD= 1.7, respectively t = 0.50, p = 0.614). Interestingly, the average depth of groups CC and CE in the morning was not significantly different (t = 1.3, p = 0.19), but it was in the afternoon when the average depth between both type of groups was over eight meters (t = 2.57, p = 0.013). These results indicate that most of the variability found between distribution of both types of groups is caused by the shallower distribution of cow/calf pairs in afternoon hours.

Seasonality

The seasonal distribution was assessed taking into account the days elapsed from the beginning of the season until the day when a group was recorded. The beginning of the season was located arbitrarily on 30 June of each year because it was the earliest date in which a cow with calf was recorded. In the first 20 days of the season only CC groups were observed; the first CE group was recorded on day 24. The presence of both CC and CE groups increased as the season progressed. The peak of the CC groups occurred between days 40-45 and remained fairly constant until day 85. The presence of CC groups declined abruptly towards the end of the season (day 104). The peak of the CE groups started on the average 5 days later than CC groups and was shorter (between days 50 and 64). Between days 85 and 98, similar numbers of CC and CE groups were recorded, but thereafter CE groups were three times more abundant than the CC groups (Figure 3).

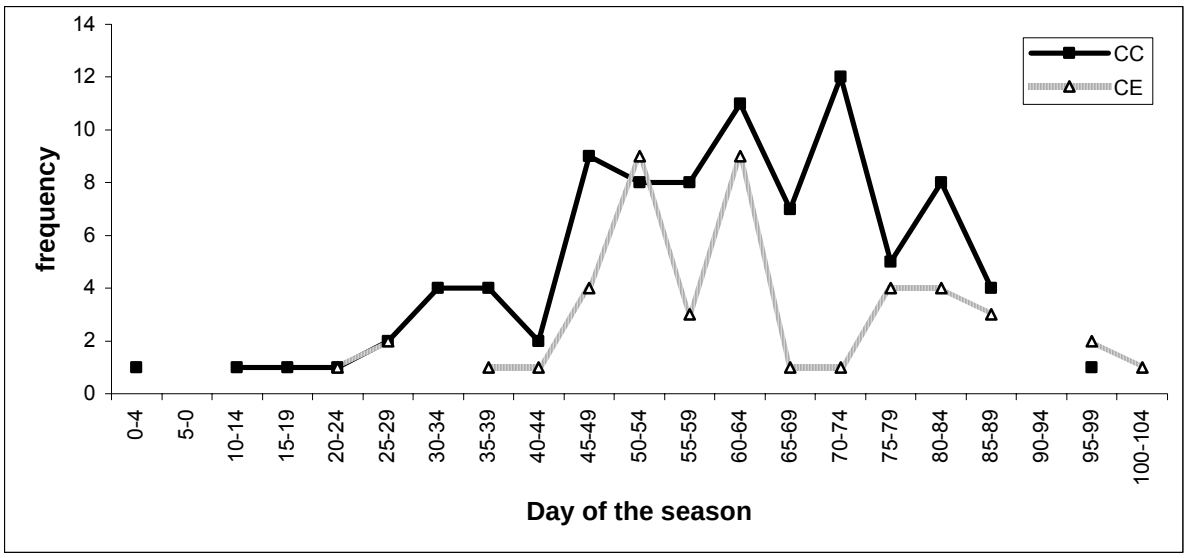

Figure 3. Seasonal presence of cow/calf pairs alone (CC) (black line) and cow with calf escorted (CE) (gray line). Data include the period 2001-2008.

DISCUSSION

In this study we confirm the preference of humpback whales cows with calves for shallow, coastal waters of Ecuador. We also confirmed that there exist some differences in respect of habitat use when the cow/calf pair is alone or accompanied by escorts. Such differences would respond to social, ecological and/or environmental pressures that we tried to establish. We also established that depth, more than the distance to the coast, drives the distribution of cows with calves in the nursing area.

Seasonality

An extended birthing period lasting at least three and a half months characterizes this breeding area, but no evidence that a cow/calf pair remained in the area throughout this period was found. The maximum span of time recorded in a cow/calf pair was almost half of

this period (61 days) and is similar to the maximum time we have recorded photo-identified whales based on the fluke coloration pattern in our study (67 days, unpublished data) which is comparable to what has been found in the Hawaiian breeding area (74 days) (Darling *et al.*, 1983). Nevertheless, it is not possible to be sure that this is a representative period of permanence in the reproduction area in every age/class. The available information suggests that there is an extended birthing season with some pregnant females arriving in June but most arrive in August. This agrees with findings in other breeding areas of both northern and southern hemisphere populations, where it has been determined that the last arriving class is females in late pregnancy (Dawbin, 1966, Craig *et al.* 2003).

The presence of the first escorted groups about 20 days after the first cow/calf pair and the lag of five days in the peak of abundance of CE groups respect to CC groups, suggest that cow with calves isolate themselves in the first days after giving birth, as reported in Hawaii (Antinoja and Herman 1977, Herman and Tavolga, 1980). This self-segregation time could be necessary for the cow to recover, but also to prevent other whales from injuring the calf (Smultea, 1994). This period of isolation could also strengthen affective bonds between cow and calf (Tavolga and Herman, 1980) and reduce the risk of predation. Once the isolation period finishes, cows with calves extend their range toward deeper waters where they could be joined by escorts. It is also possible that an escort joins the cow/calf pair while in transit from one area to another (Ernst and Rosenbaum, 2003).

The proportion of escorted groups increased at the end of the season, probably in response to the decline in numbers of adult females that became pregnant and left the breeding grounds earlier (Dawbin, 1966, Baker and Herman, 1984; Mobley and Herman, 1985, Craig *et al*., 2002). While males prefer to mate with mature females without offspring, when the number of adult females decreases an alternative strategy for males could be to join cows with calves (Craig *et al*., 2002). As part of their strategy, males stayed longer with the cow/calf pair in a kind of guarding behavior (Mobley and Herman, 1985; and Corkeron Brown, 1995; Clapham, 1996), as showed in the two cases when escorts that remained one and four days with the same cow/calf pair were recorded. It is possible that some males chose this strategy to ensure mating by reducing competition with other males by moving toward shallow waters.

The few within-season re-sightings and the short time elapsed between them suggest that cows and calves stay for short time around and may only pass through the waters surrounding the Santa Elena Peninsula. In that sense, cows with calves appear to have similar levels of site fidelity as showed by other age/sex classes (Félix and Haase, 2001). This has been also observed in Hawaii, where cows with calves are continuously moving between islands as other classes do (Mate *et al*., 1997; Serchio *et al.*, 1998). The reason for such extensive movements even when the calf is small could be to prepare the calf for the migration or as a result of male harassment (Darling, 2001). Therefore, humpback whale cows with calves, in both archipelagos and continental breeding areas, would require extensive home ranges for nursing. Such places would meet specific geographic characteristics including depth and shelter, as well as other environmental conditions that remain undefined.

We found an important difference in the proportion of escorted to non-escorted groups in Ecuador in comparison to the Hawaiian breeding area. In Hawaii, the number of escorted groups is twice that of non-escorted groups (Glockner-Ferrari and Venus, 1983, Baker and Herman, 1984 Smultea, 1994). This difference may be the result of different male reproductive strategies, but it could also be caused by different sampling methodologies. In the Caribbean, Clapham *et al*. (1992) reported most cows with calves as being escorted by a single whale with a significantly lower proportion of competitive groups containing cows and calves than in Hawaii. The findings from the Caribbean are similar to what we found in our study area in Ecuador.

Distribution

Depth is the most important topographical feature in explaining the heterogeneous distribution of cows with calves in our study area. Data analysis shows a defined distribution pattern with CC groups closer to the coast in significantly shallower waters than CE groups. Such a difference has not been found in Hawaii (Smultea, 1994), but Ernst and Rosenbaum (2003) reported marginal differences in Madagascar. The most remarkable differences, however, occurred with respect to the time of day. CC groups tended to frequent shallower waters in the afternoon than in the morning, which was also noticed by Smultea (1994) in Hawaii, although the author did not find difference between cow/calf pairs alone and escorted pairs. On the other hand, Ernst and Rosenbaum (2003) described a segregation pattern even more complex, with groups of cows with calves in deeper water by mid day and in shallower water in the morning and late afternoon. It has been suggested that these diurnal movements of cows with calves tend to reduce interactions with conspecifics since breeding activities and aggression among adult whales would be more frequent in deeper waters (Helweg and Herman, 1994; Smultea 1994, Helweg and Herman, 1994; Ernst and Rosenbaum, 2003). An alternative explanation for diurnal movements of cows with calves could be the increase of noise during morning hours in populated coastal areas such as Salinas (see below). Underwater noise from coastal activities could motivate the departure of whales from the coast in the morning and return in the afternoon when the coastal activities decrease. Salden (1988) reported that cows with calves abandoned traditional resting areas near the coast toward waters 3-4km offshore in Hawaii, where the pairs could be easier approached by males, as a result of traffic increase.

The distribution of cows with calves in shallow waters could be a critical issue for the species at this stage. It is possible that deeper water distribution where cow/calf pairs are easier joined by males would result in an impact on the survival of the offspring. An increased stranding rate of neonates in areas dominated by non-cow individuals in right whales *Eubalaena australis* off South Africa has been reported, which may be caused by inexperienced cows failing to avoid those sites or their inability to deal with male harassment (Elwen and Best, 2004). In general, shallow areas seem to discourage the presence of adult males because the maneuvers for mating require deeper waters (Smultea, 1994).

The necessity for shallow habitats for nursing explains the low number of cows with calves found in our study area. The proportion of groups containing cow/calf pairs in Salinas (12.5%) is just a fraction of the reported in other known nursing sites for the species in the Southeast Pacific such as Gorgona Island and Málaga Bay in Colombia, where cows with calves constitutes 28% and 58% of the total groups recorded, respectively (Flórez-Gonzáles *et al*., 2007). The entire Pacific coast of South America is characterized by a narrow shelf next to a deep trench; therefore zones with the appropriated depth for humpbacks cows and calves are uncommon off Ecuador and southward, but would be more abundant further north in Colombia and Panamá (Flórez-Gonzáles *et al*., 2007; Rasmussen *et al*, 2007). Although temperature has been attributed as the major environmental feature influencing the distribution of humpback whales in breeding areas (Dawbin, 1966; Rasmussen *et al*., 2007), the lack of appropriate areas for nursing south of the equator would be also a major reason why this population migrates so far north.

Not much information on the impact of potential predators of humpback whales in coastal waters of Ecuador is available. There is one report of killer whales attacking a humpback whale calf around the Machalilla National Park in Ecuador (Scheidat *et al*., 2000) and another one from Colombia (Flórez-González *et al*. 1994). In our study area we have recorded only once a group of killer whales (*Orcinus orca*) in close proximity to humpback whales but without visible interaction between the two species. In addition, we recorded a stranded neonate with signs of a possible killer whale attack in 2005. The lack of evidence of

humpback whale predators around the Santa Elena peninsula further explains the presence of cows and calves.

Management Implications

Due to their coastal habitat, cows with calves are the most vulnerable age/class to human related disturbances such as tourism, fisheries, shipping, pollution (chemical and noise) and habitat degradation, which must be addressed in coastal conservation and management plans (Smultea, 1994; Corkeron, 1995, Ernst and Rosenbaum, 2003).

The area around the Santa Elena peninsula tip experiences intense maritime traffic, especially by fishing boats, since two of the most important fishing ports (Santa Rosa and Anconcito) are located in Salinas. According to the last fishing census carried out in the mid '90s, there were about 1,000 artisanal fishing boats in these two ports (Solís-Coello and Mendívez, 1999), a number that has increased considerably over the last decade. Most of these boats carry out 1-2 days trips, so heavy traffic extends throughout the day in the area. Between 2004 and 2008, we recorded 13 cases of humpback whale entanglement in gillnets around the peninsula; in one case a cow and calf were involved (Félix *et al*., in press). Other coastal activities in the study area include bay tours, jet ski, whalewatching and sport fishing. Cows with newborn calves are particularly vulnerable to these activities and there is the risk that they could be displaced from the area if noise and traffic levels continue increasing, as documented in some sites in the Hawaiian Islands (see Smultea, 1994, Salden, 1988).

On 23rd September 2008, a marine area of 47,274.3ha with a coastal area of 173.4ha around the Santa Elena Peninsula tip was declared as a new protected area by the Ministry of Environment of Ecuador (Ministerial Agreement No. 1476). The classification of marine protected area provides an additional tool to regulate maritime activities around the peninsula. One of the aspects considered for this declaration was the need to protect the coastal habitat of humpback whales and promote sustainable practices. There is the expectation that the new protection status would allow the implementation of measures to regulate aspects such as boat speed, to define areas to avoid, and to restrict or eliminate the use of gillnets during the humpback whales breeding season. Considering the diversity of local stakeholders, authorities face a colossal challenge in the short-term in implementing management measures in this area.

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