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Short Note

First Record of a Live-Stranded Killer Whale (*Orcinus orca*) in Coastal Ecuador and Insights on Killer Whale Occurrence in Ecuadorian Waters

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Killer whales (*Orcinus orca*) are one of the most extensively distributed marine mammals worldwide and an apex predator (Dahlheim & Heyning, 1999; Ford, 2009, 2018; Jefferson et al., 2015). In the Southeastern Tropical Pacific, killer whales appear to be distributed around the equatorial marine zone (i.e., 0º, 85º W) located at about 400 to 500 km off the Ecuadorian coast, based on 195 killer whales photo-identified during the period 1986 to 2006 (see Figures 1 & 2 in Olson & Gerrodette, 2008). The group size of killer whales observed in the oceanic waters of the Eastern Tropical Pacific and off Ecuador ranges from six to 14 animals (Olson & Gerrodette, 2008); while around the Galapagos Islands, the pods range from one to 48 individuals (Merlen, 1999; Denkinger et al., 2013). However, records of killer whales in Ecuadorian coastal waters usually describe small size groups, ranging between one to 10 individuals (Alava et al., 2011, 2013; Bublichenko, 2015; see Table 1). Conversely, Merlen (1999) reported that killer whale group sizes observed in waters off the Galápagos Islands averaged 3.1 animals, ranging from one to nine individuals, although some groups found offshore (i.e., oceanic waters with a depth greater than 1,000 m) are larger (mean = 5.1, range = 1 to 48; Merlen, 1999).

While the species is commonly found in waters off Ecuador and the Galapagos Islands (Merlen, 1999; Alava et al., 2011, 2013; Alarcón et al., 2012; Smith, 2012; Denkinger et al., 2013; Bublichenko, 2015; O'Hern et al., 2017), information is incomplete about the abundance and distribution of killer whales in the marine coastal waters of Ecuador (Alava et al., 2011; O'Hern et al., 2017). This cetacean is considered "Near Threatened" in Ecuadorian waters, including the Galápagos waters (Alava et al., 2011), yet data providing insights into its population dynamics, behavior, and foraging ecology in the marine-coastal areas of Ecuador are sparse.

More data exist for Galapagos waters, where killer whale predation events and interactions with other marine animals suggest that this species exhibits at least two kinds of predatory habits: one focused on bony fish, sharks, and manta rays, and the other on large whales (i.e., sperm whales [*Physeter macrocephalus*] and baleen whales), small-toothed cetaceans (e.g., bottlenose dolphins [*Tursiops truncatus*] and short-beaked common dolphins [*Delphinus delphis*]), and Galapagos otariids (Merlen, 1999; Sonnino Sorisio et al., 2006; Alava & Merlen, 2009; Alava et al., 2013). Additionally, a pod of killer whales was video-documented interacting/playing with and presumably hunting a Galapagos green sea turtle (*Chelonia agassizii*) in waters off Isabela Island, Galapagos Islands, in September 2018 (Roth, 2018).

Despite multiple reports of killer whales observed in waters around the Galapagos and along Ecuador's coast, there has never been a reported stranding for this species in the existing published literature at the local level for this region (Chiluiza et al., 1998; Alava et al., 2011; Félix et al., 2011). Although multiple stranding records have been documented for several species of cetaceans (i.e., humpback whales [*Megaptera novaeangliae*], Bryde's whales [*Balaenoptera edeni*], sperm whales, short-beaked common dolphins, bottlenose dolphins, striped dolphins [*Stenella*

Table 1. Documented observations and unpublished records of killer whales (*Orcinus orca*) in coastal waters of Ecuador from 1996 to June 2017

Date	Location	Killer whale pod size	Remarks	References/sources
July 1997	Machalilla National Park	2	Two adult killer whale males attacked humpback whales (a mother–calf pair).	Scheidat et al., 2000
September 2002*	Machalilla National Park	8	Killer whales attacked a group of humpback whales.	C. Castro, pers. comm., Pacific Whale Foundation, September 2002; Castro & González, 2002; Castro & Scheidat, 2005
1996-2004	Machalilla National Park	~6 (based on a pod observed during an attack)	Eight sightings of killer whale predation on humpback whales (e.g., groups of 1 to 3 individuals with the presence of a calf in one case); the humpbacks exhibited defensive behavior when they were charged and attacked by killer whales.	Castro & Scheidat, 2005
18 August 2005	Bajo Atacames (Esmeraldas Province)	2	Two adult killer whale males were observed attacking humpback whales.	J. Denkinger, pers. comm., 18 August 2005, cited in Alava et al., 2013
28 July 2013**	Machalilla National Park, Puerto López	3-10	Killer whales' predatory event on humpback whales at 3.2 km from Puerto Lopéz.	D. Cardenas, pers. obs., & C. Castro, pers. comm., Pacific Whale Foundation, 27 May 2015
19-26 May 2013	Offshore waters at the southwest of the buffer area of Santa Clara Island Wildlife Reserve, Gulf of Guayaquil	9	Groups of three to five killer whales were observed twice in 19 May 2013 during seismic surveys; a presumably juvenile animal was also observed in 26 May 2013.	Bublichenko, 2015
10 January 2015	Isla de la Plata/ La Plata Island, Machalilla National Park	5	A pod of five killer whales were observed by tourists in a tour boat in waters close to La Plata Island.	Digital observations evidenced in a video posted online (https://www.youtube.com/watch?v=t6PepwNvOQI)
2016	Puerto López	1	A killer whale was observed in inshore waters by the beach, but the animal did not beach.	C. Castro, pers. comm., Pacific Whale Foundation, 4 April 2018
June 2017	Santa Elena Puntilla Marine-Coastal Fauna Reserve (REMACOPSE)	3	A pod of three killer whales was observed in waters off Santa Elena Puntilla.	P. Jiménez, pers. obs., FEMM, June 2017

*Media source: https://www.eluniverso.com/2002/09/10/0001/18/1FE3197F6D134843A682603175B0DD5E.html
**Media source: https://www.eluniverso.com/noticias/2013/08/09/nota/1264051/paso-orcas-natural-poco-comun

coeruleoalba], spotted dolphins [*Stenella attenuata*], Risso's dolphins [*Grampus griseus*], pygmy killer whales [*Feresa attenuata*], false killer whales [*Pseudorca crassidens*], short-finned pilot whales [*Globicephala macrorhynchus*], Cuvier's beaked whales [*Ziphius cavirostris*], and dwarf sperm whales [*Kogia sima*]) through systematic monitoring and opportunistic records along Ecuador's mainland coast since the late 1980s (Chiluiza et al., 1998; Félix et al., 2011; Jiménez et al., 2018; P. Jiménez, pers. obs./unpub. data, FEMM, September 2018), killer whales were not among the cetaceans recorded as stranded.

Thus, the aim of this note is to describe the first live-stranding of a killer whale calf along the mainland coast of Ecuador and its rescue by the local community. To the best of our knowledge after searching the literature, there are no previous records or photo documentation of dead or live-stranded killer whales for Ecuador in the

published literature or in museums. We have found no current evidence or records of strandings for this particular cetacean species along the Ecuadorian coast in the past (two of the authors, JJA and PJ, have been involved in monitoring marine mammal strandings with the Ecuadorian Foundation for the Study of Marine Mammals [FEMM] since the early 1990s), nor reports from other government or non-governmental organizations (NGOs).

Along these lines, we also provide some information related to sightings of killer whales off the Santa Elena Peninsula, Machalilla National Park, and other areas along coastal Ecuador (Table 1). Preliminary data on killer whale stranding events along the west coast of South America (i.e., Colombia, Peru, and Chile) in the Southeastern Pacific were also surveyed by reviewing the literature available and consulting marine mammal experts in the region.

On the morning of 27 February 2018 at 0930 h, a killer whale calf was found alive on the beach at Cadeate (1° 51' 58.72" S, 80° 44' 25.39" W; Figure 1), a fishing community located at the north part of the Santa Elena Peninsula (Santa Elena Province, Ecuador; Figure 1). The stranding occurred at the onset of a perigean spring tide, ranging from a low tide of ~0.50 m to a high tide of 2.20 m, which is a relatively large tidal range for this area. The body length of the calf was estimated to be 2.5 to 3.0 m (Figures 2 & 3), which indicates that it was not a newborn calf. Based on a recent study assessing the size and long-term growth trends in southern resident killer whales of known age from the Northeastern Pacific (Fearnbach et al., 2011), the plausible estimated age for this calf was ≤ 1 y (i.e., inferred from the relationship of maximum estimate of lengths vs observed/estimated ages of southern resident killer whales using Figure 4 in Fearnbach et al., 2011).

Since the physical examination of body condition (i.e., body mass index) is the most fundamental parameter to assess health in cetaceans (Moore et al., 2018), an initial assessment of calf body condition from its appearance in photos suggests that the animal did not exhibit signs of external injuries or wounds, but it had a depression on both the melon and at the back of the skull (Figure 2), which are indications of emaciation (Read & Murray, 2000; Fearnbach et al., 2018). While the exact causes for this isolated stranding are unclear, we suggest that the calf's health may

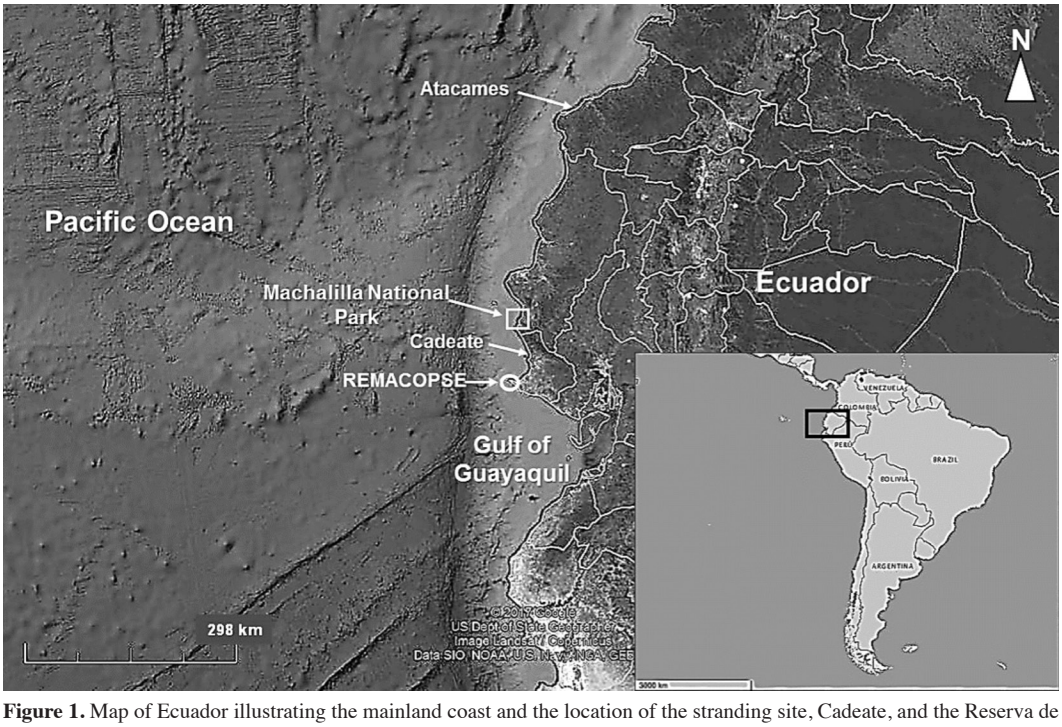

Figure 1. Map of Ecuador illustrating the mainland coast and the location of the stranding site, Cadeate, and the Reserva de Producción Faunistica Marino Costera Puntilla de Santa Elena (REMACOPSE; white circle) in Santa Elena Province, as well as the coastal region of the Machalilla National Park (white square) in the Manabí Province and Atacames in the Esmeralda Province where killer whales are regularly observed.

Figure 2. A killer whale calf (~2.5 m) stranded alive at Cadeate, Santa Elena Peninsula, on 27 February 2018. People from the local community assisted in returning the calf to the sea; there was no report of the calf afterwards. The black and white coloration pattern, typical of this species, is observed. Open access information retrieved from www.extra.ec/actualidad/pobladores-devolvieron-al-mar-una-orca-varada-en-santa-elena-BE2053663. (*Photo credit*: Joffre Lino)

have been compromised and that it became separated from its mother. It is unknown whether the animal was weaned at the time of the stranding and, if not, it may not have been able to obtain sufficient nutrition.

The animal was pushed into deep water by local people and fishers from the Cadeate fishing community in an effort to rescue it. The calf was lifted from the beach by holding the calf's fins and carried to the sea, as indicated by anecdotal information in a local newspaper. While the well-meaning community rescue operation pushed the calf back into the sea, it is very unlikely that emaciated cetaceans can survive, even if refloated, because of changes in buoyancy and metabolic exhaustion (Moore et al., 2018). No information on the behavior of the calf, including initial swimming behavior, refloating, or breathing rate, was recorded after the stranding. In the subsequent hours of daylight following the stranding event, biologists and technical personnel of the Ministry of Environment–Ecuador (MAE) also deployed a visual monitoring effort along the shorelines at the north coast of the Santa Elena Peninsula to observe whether the calf returned to shallow waters or the beach. Following the return of the animal to the water and a monitoring period of several hours, the fate of the calf was unknown, with no observed sightings in the ocean or on the beach.

To further assess the external body condition, a thorough analysis of the state of the animal depicted in additional photos provided by technical personnel and rangers of the MAE to the second author (PJ) revealed an extremely thin animal in very poor condition with indented melon and concave dorsal surfaces with marked depression behind the skull likely due to the loss of fat reserves and emaciation (Read & Murray, 2000; Figures 3A & 3B); these conclusions were based on the clinical assessment of three of the authors (JJA, PF, and LB-L) and an expert in marine mammal health and cetacean body condition (M. Haulena, pers. comm., Marine Mammal Research Program, Ocean Wise–Vancouver Aquarium, 2 March 2017).

These external symptoms were crucial while assessing the calf's health as the region behind the skull has been shown to be a sensitive indicator of nutritional status in cetaceans as cetaceans lose adipose tissue in this area when they are in poor body condition (Bradford et al., 2012; Joblon et al., 2014). Comparably, the melon is a structure with large fat and connective tissue in the forehead of all toothed whales between the blowhole and tip of the snout; its function is to focus sounds used in the production of an echolocation beam (McKenna et al., 2012). The presence of an unusually thin blubber layer and epaxial musculature (i.e., external depression posterior to the nuchal crest of the skull) indicates poor body condition

and may indicate the incidence of chronic disease (Read & Murray, 2000). Thus, an impairment of the melon structure in this animal could have influenced the production of sounds for echolocation, possibly contributing to the stranding. For instance, physical trauma (i.e., from acoustic pollution) in cetaceans affecting the acoustic fatty tissues of the melon involved in sound transmission has been documented (Weilgart, 2007).

The animal also exhibited depressions at both sides of the head and posterior part of the skull around the white patches (see Figure 3B); a similar condition was observed in 11 endangered southern resident killer whales photo-identified using drone-based aerial photogrammetry methods (i.e., allowing accurate measurements of body condition such as length, growth, and shape) in the Northeastern Pacific, where two to four individuals died within a few days or weeks (Durban et al., 2015; Barrett-Lennard, unpub. data, 2 March 2017; Barrett-Lennard & Thornton, 2017; Fearnbach et al., 2018). These individuals exhibited poor and declining body conditions as measured by the small head width (HW) to the blowhole–dorsal fin (BHDF) ratio (i.e., an index to assess nutritional status; Fearnbach et al., 2018). A distinctive feature of marked emaciation observed in these resident killer whales was the typical "peanut head appearance" (see Figure 1 in Fearnbach et al., 2018), which was also seen in our killer whale calf stranded in Cadeate (Figure 2).

A young calf is presumed to have a low chance of surviving in the long term without its mother or another female to care for it (see Francis & Hewlett, 2007). Calf mortality in some populations of resident killer whales (e.g., Northeastern Pacific) has been reported to range from 40 to 50% (Baird, 2000; Olesiuk et al., 2005). While the strong dependency of the calf for nutrition and survival is of paramount importance, there is evidence that calves less than 2 y old have survived following the loss of their mothers (Francis & Hewlett, 2007). Killer whale calves nurse on high fat milk from their mothers for 1 to 2.5 y (Asper et al., 1987; Heyning, 1988; Kastelein et al., 2003), with a decreasing reliance on milk from the 1st to the 4th year and a concomitant increase in consumption of solid prey (Newsome et al., 2009).

Considering the state of emaciation observed in this calf, possible causes of stranding might be malnourishment or some disease condition resulting in impairment of its ability to forage. However, while a clinical assessment would be necessary for a definitive pathologic and etiologic diagnosis, Gaydos et al. (2004) highlighted the role of infectious diseases caused by pathogenic agents such as bacteria, fungi, and viruses in reducing cetaceans' fecundity and reproductive success,

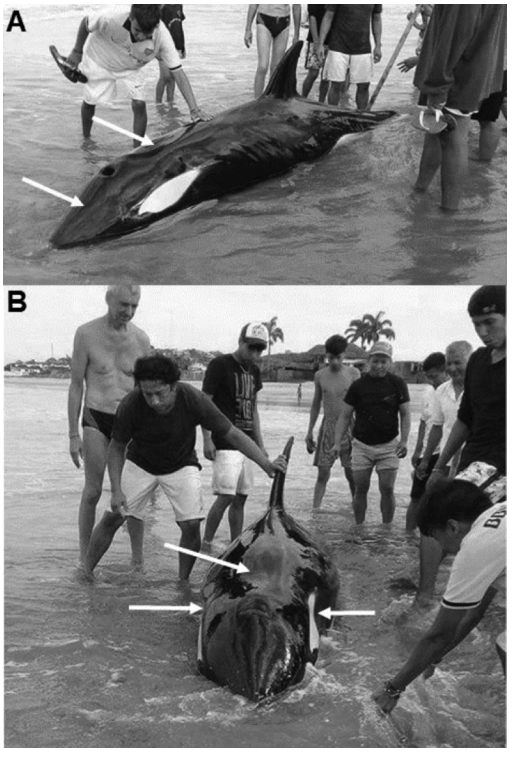

Figure 3. Photos of the stranded killer whale calf assisted by local people of the community at Cadeate. Body condition noted as follows: (A) Lateral view of the left side of the calf with white arrows pointing to a marked depression on the melon and concave region behind the skull; and (B) frontal view of the calf with white arrows pointing to the depressed regions behind the skull, indicating symptoms of emaciation. (Photos provided to Fundación Ecuatoriana para el Estudio de Mamíferos Marinos [FEMM] as courtesy of Ariana Sancan and Oscar Carreño [Ministry of Environment–Ecuador])

causing disease in killer whales in captivity and the wild, and producing epizootics in free-ranging populations of killer whales as well as in several other odontocete species. For instance, cetacean viruses such as morbilliviruses and papillomaviruses, as well as bacteria *Brucella* spp. and the parasite *Toxoplasma gondii*, are considered to interfere with population abundance by inducing high mortalities, lowering reproductive success, or by synergistically increasing the virulence of other diseases (Van Bressem et al., 2009).

Moreover, the recent mass mortality of small-toothed cetaceans, including long-beaked common dolphins (*Delphinus capensis*), and Burmeister's porpoises (*Phocoena spinipinnis*) that were stranded along the northern coast of Peru was associated with cumulative multi-stressors

and anthropogenic impacts (e.g., pollution, underwater noise, and pathogens) exacerbated by the El Niño event (Alava, 2012). As an example, a juvenile female killer whale was found dead on Peru's coast (Moquegua Department) about 10 years ago when episodes of emerging diseases were detected in marine mammals along the coast and sea surface temperature anomalies were recorded at sea (see Table 2; Dr. C. Yaipen-Llanos, pers. comm., ORCA, 31 May 2018).

Likewise, underwater noise and physical disturbances have been associated with strandings of toothed cetaceans (e.g., Cuvier's beaked whales and melon-headed whales [*Peponocephala electra*]) in the North and Central South Pacific, including oceanic islands as reported elsewhere (Brownell et al., 2004, 2006, 2009; Southall et al., 2006). While naval ship sonar exercises, seismic exploration surveys, and large maritime traffic were not evidenced and/or witnessed in offshore

Table 2. Killer whale stranding events in the Southeastern Pacific (west coast of South America), including Colombia, Ecuador, Peru, and Chile

Country	Killer whale stranding (alive or dead)	Date	Number/ age category	Comments	Source/reference
Colombia	N/A	N/A	N/A	No reports of confirmed strandings of killer whales along the coast of Colombia, although few sightings and a low encounter rate of this species as well as a killer whale attack on humpback whales have been recorded in Colombian Pacific waters.	Flórez-González et al., 1994; Flórez-González & Capella, 1995; Palacios et al., 2012; Ávila et al., 2013; Dr. I. C. Ávila, pers. comm., 31 May 2018
Ecuador	Yes	February 2017	~1 y old calf (alive)	Lack of documented information or reports on killer whale strandings, but the species is relatively common and observed along waters of the Ecuadorian coast and Galapagos (see Table 1). The single case of a stranded killer whale calf was posted in local newspapers. The calf exhibited marked signs of emaciation and was rescued and returned to the sea by the local community.	Alava et al., 2011; this study Local newspapers: www.extra.ec/actualidad/pobladores-devolvieron-al-mar-una-orca-varada-en-santa-elena-BE2053663; https://www.eluniverso.com/noticias/2018/02/28/nota/6643618/orca-varada-playa-cadeate-volvio-mar
Peru	Yes	About one decade ago (~2008)	A juvenile female (dead)	No official reports of strandings to date, but the occurrence of killer whales has been documented in Peruvian waters. The isolated case of a juvenile female was not reported to the authorities when emerging infectious diseases in marine mammals and SST anomalies occurred in waters off Peru at the time of the stranding. There has not been any single records of stranded killer whales during systematic monitoring since 2001.	García-Godos, 2004; Testino et al., 2018; Dr. C. Yaipen-Llanos, anecdotal information/ pers. comm., 31 May 2018)
Chile	Yes	August 2017	An adult male (dead)	No official data or documented information on killer whale strandings exist, although the species has low occurrence in Chilean waters. A recent stranding event of an adult male was posted in the local newspapers. The individual was likely sick. Teeth marks were observed around the body of specimen, possibly generated by members of the pod assisting the male.	Capella et al., 1999; Viddi et al., 2010; Dr. R. Hucke-Gaete, pers. comm., 1 June 2018 Local newspapers: www2.latercera.com/noticia/quien-mato-la-orca-1904; www.t13.cl/noticia/nacional/orca-varada-santo-domingo

Note: N/A: Not available

and inshore waters adjacent to the stranding location (i.e., Cadeate) of the calf, the impact of acoustic pollution and the potential impairment of the calf's behaviour or health cannot be ruled out.

In Table 2, we summarize reports of killer whale stranding events along the coasts of Colombia, Ecuador, Peru, and Chile (i.e., South American west coast). At least one stranding was found along the coast of each of these countries, except for Colombia. The scarcity of documented stranding data for killer whales in the Southeastern Tropical Pacific contrasts strongly with the spatial and temporal data of killer whale strandings (i.e., 371 stranded killer whales over the period 1925 to 2011) available for the North Pacific Ocean, including Japan, Russia, Alaska, British Columbia, Washington, Oregon, California, Mexico, and Hawaii (Gaydos & Raverty, 2010; Barbieri et al., 2013). In the North Pacific, killer whale strandings occurred year-round, but, at the regional level, specific seasonal differences were observed (Barbieri et al., 2013).

While the causes of the stranding of this killer whale calf could not be definitively determined, it is likely that maternal separation, poor nutritional condition, and dehydration contributed to the arrival of the animal on the beach. Sightings and records of free-swimming killer whales in Ecuador's coastal waters are shown in Table 1. Some of these observations were close to shore but did not result in strandings, suggesting that at least some members of the species are able to navigate shallow waters safely. For example, a killer whale approached inshore shallow waters at Puerto Lopéz (Manabí Province, Ecuador) in 2016, but it did not strand and returned to the sea (C. Castro, pers. comm., 4 April 2018). More recently, a small pod of killer whales with three individuals—an adult male and two adult females or large juveniles—was observed and video-recorded for the first time in the coastal waters of the Reserva de Producción Faunistica Marino Costera Puntilla de Santa Elena (REMACOPSE) (2° 11' 19.37" S, 81° 00' 39.61" W, Santa Elena Province; Figure 1) in June 2017 (P. Jiménez, pers. obs., FEMM, June 2017).

Killer whales have also previously been recorded around La Plata Island and in waters off the Machalilla National Park (1° 33' 45" S, 80° 49' 48" W), a Marine Protected Area (MPA) located off the central coast of Ecuador (Carvajal & Gutiérrez, 1995; Castro & González, 2002; Castro & Scheidat, 2005; Alava et al., 2011) and north of Cadeate (Figure 1). In this MPA and the surrounding waters, pods of killer whales ranging from two to 10 individuals have been observed attacking humpback whale calves and juveniles during the breeding season (i.e., June through September/October) since the late 1990s (see Table 1), with most of the recent sightings occurring in September 2002 and July 2013 (Scheidat et al., 2000; Castro & González, 2002; Castro & Scheidat, 2005; C. Castro, pers. comm., Pacific Whale Foundation, 27 May 2015). Occurrence of this species around waters of this MPA is becoming more consistent and frequent as a pod of five killer whales was also newly observed close to La Plata Island (Machalilla National Park) on 10 January 2015 (see Table 1). Farther north, two male killer whales were also observed attacking humpback whales, including mothers, calves, and escorts, during the breeding season in waters of Bajo Atacames, Esmeraldas Province (0° 52' N, 79° 50' W; Figure 1), off the northern coast of Ecuador, in August 2005 (Castro & Scheidat, 2005; Alava et al., 2013; J. Denkinger, pers. comm., 18 August 2015). As a comparison, killer whale group sizes observed in Galápagos coastal waters range from one to nine individuals, which is within the pod sizes reported along Ecuador's coastal waters (Alava et al., 2013; Bublichenko, 2015; C. Castro, pers. comm., 27 May 2015; P. Jiménez, pers. obs., June 2017; see Table 1). These observations suggest that killer whales are becoming more common in Ecuadorian waters in the last decades.

This note highlights the potential for developing effective measures to report and respond to incidents involving cetaceans in Ecuador. It can also be used as evidence to support future studies investigating population dynamics and structure, and the behavioral and foraging ecology of killer whales through collaboration and cooperation with other research groups—not only at the local level in the marine waters of Ecuador but also along the Pacific coast of South America—with the aim to develop coordinated stranding response protocols and to maintain a monitoring and research program for killer whales.

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