

Sperm whale, *Physeter macrocephalus*, harassment by killer whales, *Orcinus orca*, in the western South Atlantic Ocean

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Predation risk imposes strong selective pressure on organisms who continuously develop behavioral strategies to survive (Connor, 2000; Rosier & Langkilde, 2011; Sucunza et al., 2015). Protection of calves by babysitting has been proposed as one of the major forces driving the evolution of the sociality of female sperm whales, *Physeter macrocephalus* Linnaeus, 1758 (Whitehead, 1996). Killer whales, *Orcinus orca* (Linnaeus, 1758), are the most successful marine top predators and have been observed preying on many different cetacean species, including large mysticete and sperm whales (Jefferson et al., 1991; Pitman et al., 2001).

The sperm whale is a cosmopolitan species that can be found near the ice edge at both poles and at all latitudes in between (Rice, 1989; Whitehead, 2009). Higher densities of sperm whales are generally observed in regions of deep water, usually associated

with highly productive areas (Whitehead, 2009; Di Tullio et al., 2016). In the western South Atlantic Ocean, the distribution of sperm whales extends south to the coast of Argentina, where abundance seems to be high (Rice, 1989; Degradi et al., 2011). In Brazilian waters, this species has been seen throughout the coast in all seasons, with higher frequencies in summer and spring (Ramos et al., 2001, 2010; Pinedo et al., 2002; Andriolo et al., 2010; Di Tullio et al., 2016). Sperm whales, including solitary adult males, females, calves and juveniles, were the most frequent cetacean species sighted during cetacean surveys in offshore waters of Rio Grande do Sul State, southern Brazil (Pinedo et al., 2002; Di Tullio et al., 2016). Pinedo et al. (2002) suggested the year-round importance of the shelf edge as a possible migration route and/or feeding ground for this species.

Killer whales are widely distributed throughout all ocean basins, but they are more common at higher latitudes, particularly in regions of high ocean productivity (Forney & Wade, 2006). In the western South Atlantic Ocean, killer whales have been observed in coastal and offshore waters (Lodi & Hetzel, 1998; Secchi & Vaske Jr., 1998; Siciliano et al., 1999; Iñíguez, 2001; Dalla Rosa et al., 2002; Di Tullio et al., 2016; Ott et al., 2017), with increasing records toward the south where a higher occurrence of killer whales was related to the high productivity of the Brazil-Malvinas Confluence (Passadore et al., 2014; Padula et al., 2022). Although killer whales have been recorded year-round in Brazilian waters (Dalla Rosa et al., 2002), their abundance and distribution in the region are still poorly known. Sightings have mainly been reported in southeastern and southern Brazil and were concentrated during spring and summer along coastal waters (Lodi & Hetzel, 1998; Siciliano et al., 1999; Santos & Netto, 2005; Santos & Silva, 2009; Ott et al., 2017). In offshore waters, records were concentrated in southern Brazil and come from studies on the interaction between killer whales and longline fisheries (Secchi & Vaske Jr, 1998; Dalla Rosa & Secchi, 2007) and dedicated cetaceans surveys (Di Tullio et al., 2016).

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Figure 1. Killer whales, *Orcinus orca*, harassing sperm whales, *Physeter macrocephalus*, in southern Brazil. Note the antipredator tactics of the sperm whales: A) rolling over on their side exposing their fluke; B) close together at the surface.

Reports of direct observation of attacks by killer whales on large whales are scarce (Hucke-Gaete et al., 2004; Reeves et al., 2006; Alava et al., 2013), and to date too little is known about predator-prey strategies. In Brazilian waters, killer whales were only witnessed preying upon a franciscana, *Pontoporia blainvillei* (Gervais & d'Orbigny, 1844) (Santos & Netto, 2005) and a minke whale (*Balaenoptera* spp.) (Troina et al., 2020). The difficulties of conducting research in oceanic waters as well as the apparent low density of killer whales off the Brazilian coast could explain the absence of more observations of killer whale predation on cetacean species in the region. Here, we describe killer whales harassing a group of sperm whales in offshore waters of Brazil and discuss aspects of attack-defense strategies.

The interaction was observed during a sperm whale survey conducted off southern Brazil from 03 to 21 December 2012 aboard the *R/V Atlântico Sul* of the Universidade Federal do Rio Grande. The main objective of this survey was to assess the distribution and movement patterns of sperm whales on the outer continental shelf and slope (water depths ranging from 150 to 2,000 m). Two observers searched for marine mammal groups with the assistance of 7x50 Fujinon binoculars during daylight and under acceptable weather/sea conditions (*i.e.* Beaufort scale between 0 and 5, and no rain). The environmental conditions (including glare and swell height) and sighting data (including species and group size) were recorded in WinCruz software.

On 16 December 2012 at 19:55h (Greenwich Mean Time -3), a group of four killer whales was observed harassing a group of twelve sperm whales, including at least one calf (Figure 1). This event occurred in waters 1,100 m deep and 267 km offshore of Rio Grande do Sul, southern Brazil (30°28' S, 47°40' W). No adult males of either species were observed during the interaction. One observer took photos, while two others video-taped the interaction. Although the event started near sunset, sighting conditions were good with Beaufort scale of 1–2. The encounter was recorded approximately 15 min before low-light conditions precluded further observations, and was acoustically-monitored for 55 min (results available in Andriolo et al., 2015).

The sperm whales were approximately 200 m from the vessel when the killer whales were spotted heading toward them. The killer whales first harassed a calf that was 10–20 m away from the main sperm whale group. Although no biting or blood were seen, the calf appeared agitated, raising its head out of the water while moving in the direction of the group. After the calf entered the group, the killer whales elicited a pronounced fear response by the sperm whales, which were seen rolling over on their sides, exposing their flukes (Fig. 1A) and raising their heads out of the water. At this time, the sperm whales were close together at the surface, all heading in the same direction (Fig. 1B).

After this first interaction, the killer whales appeared at the surface 60–100 m away from the sperm whales. The sperm

whales did not flee; they swam slowly, close together in a line formation. The killer whales approached the sperm whales at least three more times, although the first one appeared to be the most aggressive since the sperm whales apparently decreased their defensive behavior (e.g. fluke-ups) afterwards. The observed approaches were always from the flank or rear, never from ahead (Figure 1). After 14 min of observation, the killer whales were seen moving slowly away from the area.

Little information is available about killer whales interacting with marine mammals in Brazilian waters, and as far as we know, there is no published observation of predation on sperm whales in the region. Although the interaction appeared to have resulted in no evident injuries for the sperm whales, this account provides rare insights into the interaction between killer whales and sperm whales in the western South Atlantic Ocean.

Pitman et al. (2001) proposed that sperm whales react in two different ways, according to the number of individuals in the group, during defensive aggregations at the surface. The authors suggest that small groups (10–15 individuals) would form the *marguerite* (Nishiwaki, 1962) with individuals in a circle with their heads together and tails pointed out (Pitman et al., 2001), while larger groups would form a tight flotilla. Although it was estimated that there were 12 individuals in the sperm whale group (including at least one calf), the sperm whales did not form the *marguerite*. They remained close together at the surface, forming a line abreast, resembling a tight flotilla as described by Pitman et al. (2001). Antipredator tactics can vary according to perceived risk of predation at both the individual and group levels (Lima and Dill, 1990; Weller et al., 1996; Lima and Bednekoff, 1999).

The killer whales clearly harassed the sperm whale calf first. Although the calf appeared to be away from the main sperm whale group, it was not possible to rule out the presence of an adult near by a few meters below the water surface (Whitehead, 1996). The killer whales appeared to avoid the heads of the sperm whales; however, the exact tactics were hidden, as they generally remained under the surface when approaching the sperm whales. There was no indication (e.g. blood at the surface, pieces of flesh) that the killer whales killed or seriously injured any of the sperm whales. Killer whales regularly approach large cetaceans for probing and testing them, and although sperm whales are recognized for their great potential in fending off killer whales, they are predated upon by killer whales (Pitman et al., 2001). This single event provides new information to the scarce knowledge about killer whale interactions with marine mammals off Brazil and to better understand the importance of killer whales in shaping life-history traits of sperm whales.

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