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Short Note

Observations of Attacks on Sei and Fin Whales by Killer Whales in Magellanic Sub-Antarctic Waters, Chile

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Killer whales (*Orcinus orca*) are one of the most cosmopolitan cetaceans, but they primarily concentrate in nutrient-rich regions of higher latitudes (Forney & Wade, 2006). They are considered one of the most highly social apex marine predators that prey on invertebrates, fish, seabirds, sharks, and marine mammals (Heyning & Dahlheim, 1988; Pyle et al., 1999). In some regions, populations have been observed to exhibit specialized foraging and feeding behaviors adapted to prey availability, feeding on a narrow range of prey in the eastern North Pacific, off southeastern Alaska, in the Russian Far East, in Punta Norte in southern Argentina, and in Antarctic waters (de Bruyn et al., 2013; Jourdain et al., 2017). Five different killer whale ecotypes have been proposed (Types A, B [small], B [big], C, and D) for the Southern Hemisphere, each with its own physiological, morphological, and social adaptations, as well as dietary specialization (Pitman, 2011; Pitman & Durban, 2012; de Bruyn et al., 2013). For example, in Antarctica, Type A mainly feeds on minke whales (*Balaenoptera bonaerensis*; Pitman & Ensor, 2003), whereas Type B mostly preys on pinnipeds but can also include whales and penguins in its diet (Pitman & Durban, 2010). Type C is a fish specialist, particularly preying on the Antarctic toothfish (*Dissostichus mawsonii*; Lauriano et al., 2020), while Type D is suspected to feed on fish, including the Patagonian toothfish (*Dissostichus eleginoides*; Tixier et al., 2016). Along the coast of South America, dietary specialization has also been described, such as in Punta Norte, Argentina, where individual killer whales hunt seals and sea lions (Lopez & Lopez, 1985).

While foraging behaviors of certain killer whale populations are well-understood (Reeves et al., 2006), information on the importance of large whales as prey has resulted in considerable debate, both prior to the whaling era (e.g., Mizroch & Rice, 2006; Reeves et al., 2006) and also today (e.g., Mehta et al., 2007). Records of attacks and predation by killer whales on several species of baleen whales worldwide include blue (*Balaenoptera musculus*; Totterdell et al., 2022), fin (*Balaenoptera physalus*; García-Cegarra, 2022; Pitman et al., 2023), gray (*Eschrichtius robustus*; Melnikov & Zagrebin, 2005), humpback (*Megaptera novaengliae*; Pitman et al., 2015), minke (Ford et al., 2005), sei (*Balaenoptera borealis*; Ford & Reeves, 2008), and sperm (*Physeter macrocephalus*; Pitman et al., 2001) whales. However, in high latitudes, baleen whales are apparently not frequently attacked by killer whales (Mehta et al., 2007) and, consequently, such events have been rarely documented in sub-Antarctic

waters, particularly around South America. Only one report, as far as we know, has previously mentioned killer whales attacking sei whales along the South Pacific, particularly in Golfo de Penas, Patagonia, southern Chile (Olavarría et al., 2019; Pérez-Álvarez et al., 2021). Noteworthy, sei whales are classified as "Endangered" by *The IUCN Red List of Threatened Species* (Cooke, 2018).

The Beagle Channel comprises over 190 km in the 54° S latitudinal belt between Tierra del Fuego (Argentina and Chile) and Cape Horn (Figure 1), and is part of the Cape Horn Biosphere Reserve (Rozzi et al., 2012). In this region, killer whales prey on toothfish and pinnipeds, as well as gulls, penguins, and shags (Hucke-Gaete et al., 2004; Häussermann et al., 2013; Capella et al., 2014). Although not previously identified as a prey item, Goodall et al. (2007) reported the first two attacks on sei whales in Tierra del Fuego, and later Häussermann et al. (2013) observed a killer whale attack on a sei whale in the Chonos Archipelago. Recent evidence also suggests that during the largest baleen whale mass mortality event ever recorded worldwide, which primarily concerned sei whales and was likely caused by harmful algal blooms (Häussermann et al., 2017), some deaths could be attributed to predation by killer whales (Olavarría et al., 2019; Pérez-Álvarez et al., 2021). Herein, we report a series of six predation events of killer whales on sei and fin whales during two austral summer/autumn seasons (2020, 2021) in the Beagle Channel, sub-Antarctic waters, Chile (54° S), five of which were fatal.

In March 2020 and from February to April 2021, we recorded six predation events by killer whales of 12 individuals of sei whales and two fin whales (Table 1; bulleted list following table). These events were documented by photographs and videos taken by observers and resident biologists on Navarino Island (Figure 1). Events 1, 5, and 6 were direct observations of attacks; Events 2 and 3 were documented after the attacks had occurred (stranded animals); and Event 4 was a video record of a fatal attack shared with us. The Supplemental Video for this short note is available on the *Aquatic Mammals* website.

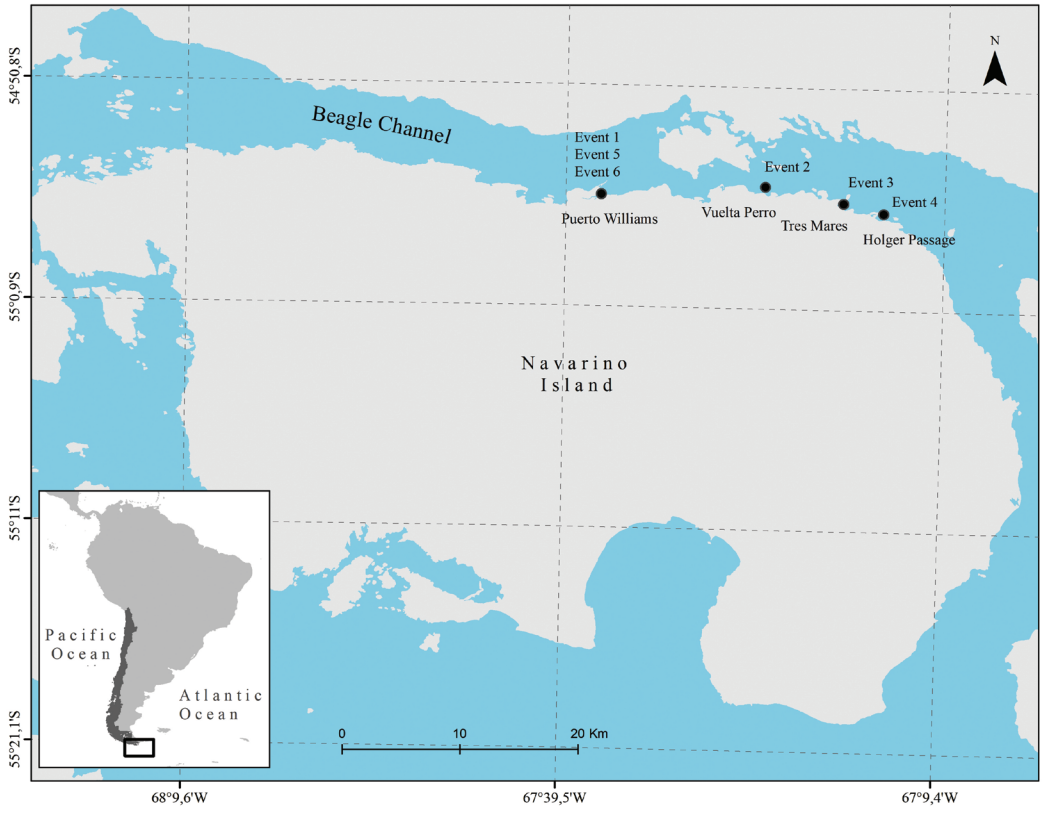

Figure 1. Area of the six events of killer whale (*Orcinus orca*) attacks on sei (*Balaenoptera borealis*) and fin (*Balaenoptera physalus*) whales in sub-Antarctic waters, southernmost Chile (54° S).

Table 1. Description of attacks by killer whales (*Orcinus orca*) on sei (*Balaenoptera borealis*) and fin (*Balaenoptera physalus*) whales in the Beagle Channel, sub-Antarctic Chile. SV = Supplemental Video.

Record	Data	Site	Coordinates	Date (d/mo/y)	Species	Individuals (No.)	Description
Event 1	Observation (SV 1, 2, 3)	Puerto Williams	54° 55' 55" S, 67° 36' 49" W	9/3/2020	*B. borealis*	2	Fatal attack
Event 2	Photo/video record (SV 4)	Vuelta Perro	54° 55' 49" S, 67° 23' 33" W	9/2/2021	*B. borealis*	1	Stranded; bite marks on tail and abdomen
Event 3	Photo record (SV 5)	Tres Mares	54° 56' 04" S, 67° 17' 44" W	26/2/2021	*B. borealis*	4 (1 male and 2 females confirmed + 1 fetus)	Stranded; bite marks on tail and head
Event 4	Video record (SV 6)	Holger Passage	54° 56' 30" S, 67° 14' 16" W	26/2/2021	*B. borealis*	2	Fatal attack
Event 5	Observation (SV 7)	Puerto Williams	54° 55' 59" S, 67° 36' 44" W	11/4/2021	*B. borealis*	3	Failed attack
Event 6	Observation (SV 8)	Puerto Williams	54° 56' 1" S, 67° 37' 8" W	22/4/2021	*B. physalus*	2	Fatal attack (1 confirmed individual)

- *Event 1: 9 March 2020* – The first predation event occurred in the Beagle Channel, Puerto Williams Bay, during midday, on 9 March 2020 (Figure 2). A group of seven killer whales (Figure 3A, inset, courtesy of Igor Bely), including two adults (a female and a male) and five juveniles, were observed attacking an adult and juvenile sei whale (Figure 3A). The group pursued both whales into the shallow waters of the bay; then, the female and juvenile killer whales approached, flanked, and constantly rammed them, forcing the sei whales underwater by lunging onto its dorsal peduncle (Supplemental Video). Meanwhile, the male killer whales milled nearby at a distance of 200 to 500 m from the shore (Supplemental Video). The juvenile killer whales were observed mainly attacking the tail of the sei whales, occasionally pushing them under water. The juvenile sei whale, presumably attempting to escape, went directly into shallower waters and got stranded on shore. The attack continued, following the same behavioral pattern towards the second individual. When the adult female killer whale rammed the sei whale, the juveniles replicated the behavior. The adult sei whale also got stranded. Subsequently, the female killer whales approached that stranded individual and dragged it back into the water. Finally, the adult whale moved into deeper waters of the bay, where it performed a rapid escape (15.4 m/s) between two docks, repeatedly thrashing its tail vertically with a powerful splash (Supplemental Video). After that, the sei whale and the whole group of killer whales moved further into deeper waters of the bay (~1 km from the shore), where our observations ceased. In total, the predation event lasted for 3.5 h. The carcass of the stranded sei whale showed bite marks on its tail and abdomen.

- *Event 2: 9 February 2021* – Event 2 occurred on 9 February 2021, where an adult sei whale was found stranded ~14 km (air distance) east of Puerto Williams Bay with bite marks on its tail and abdomen (Figure 3B; Supplemental Video).

- *Event 3: 26 February 2021* – Three weeks later, on 26 February 2021, we documented two events of stranded adult sei whales on the same day. A group of three adult sei whales, one of which was a pregnant female (photo of fetus in Supplemental Video), stranded in the shallow waters of Tres Mares estuary, ~40 m width (Figure 1), approximately 20 km east of Puerto Williams Bay (Event 3). All individuals showed typical teeth marks of killer whales (Figure 3C), including the fetus, apparently aborted during the decomposition process of the mother. We were able to measure three of the whales: the female sei whale measured 16.8 m, the fetus 3.5 m, and one of the two male sei whales measured 15.5 m.

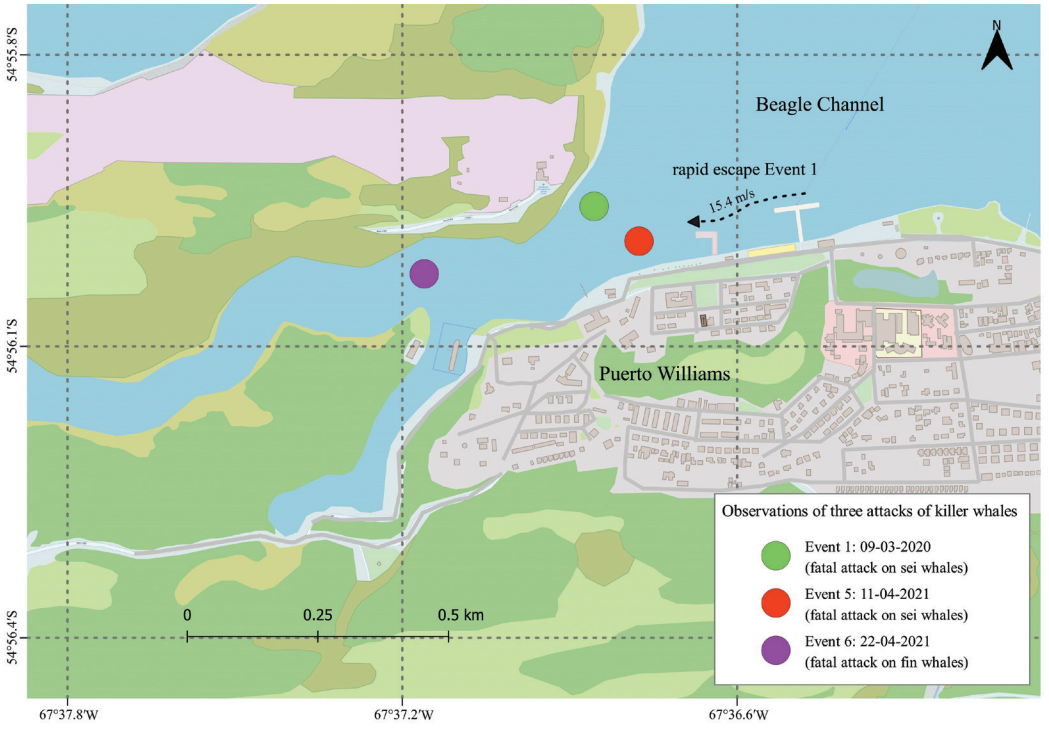

Figure 2. Approximate area of observations of two attacks of killer whales on sei and fin whales in the Beagle Channel, southern Chile (54° S). The arrow indicates the flight stretch and velocity. The map was obtained from OpenStreetMap contributors (www.openstreetmap.org).

- *Event 4: 26 February 2021* – Event 4 occurred on the same day as Event 3, during which two adult sei whales had been attacked in Holger Passage (Figure 1), ~ 24 km to the east of Puerto Williams Bay and only ~ 3 km away from Event 3 (Figure 3D; Supplemental Video, courtesy of Yves Boulac). The video shows at least five killer whales charging at an adult sei whale (14.6 m) that was floating adjacent to a steep rocky shore in shallow water, which was later observed to have teeth rake marks and detached skin all over the abdomen. Later that day, another dead sei whale was located floating in the kelp nearby.

- *Event 5: 11 April 2021* – On 11 April 2021, a group of seven killer whales chased three adult sei whales in Puerto Williams Bay (Figures 2 & 3E). After 20 min of observation, one of the sei whales chased a juvenile killer whale while bolting towards the deeper waters of the channel (Supplemental Video). The sei whales escaped to the west of the Beagle Channel, followed by the entire group of killer whales, until we could no longer observe them. The fate of this group of sei whales is unknown.

- *Event 6: 22 April 2021* – Finally, Event 6 occurred on 22 April 2021 in Puerto Williams Bay (Figure 2). A group of seven killer whales chased two fin whales, focusing on the larger individual (Figure 3F; a detailed report on this attack based on a social media posting can be additionally found in Pitman et al., 2023). This attack lasted for about 2 h and followed the pattern observed in 2020 and 11 d earlier. Close to the shore, adult female killer whales took turns ramming the fin whale, while males were swimming around at the periphery of the hunt. Already very injured, the fin whale was observed thrashing and rolling nose-first against the shore (Supplemental Video). After several charges and bites, the killer whales were able to drag the fin whale into the deeper waters in the center of the bay. During this time, adult female killer whales were observed surfacing on top of the fin whale in order to drown it. A day after the event, the Chilean Navy and the National Service of Fisheries and Aquaculture towed the carcass of the fin whale to shore. We were able to observe bite marks on the abdomen, tail, and tongue, indicative of killer whale predation.

Figure 3. (A) Fatal attack by killer whales on two sei whales in Puerto Williams Bay, Magellanic sub-Antarctic Chile (9 March 2020, Event 1; photo by Omar Barroso); the inset shows a group of seven killer whales in the Beagle Channel, probably the same group as in Event 1 (photo taken with a drone on 10 March 2020; courtesy of Igor Bely); (B) stranded sei whale with bite marks on tail and abdomen in Vuelta Perro (9 February 2021, Event 2; photo by Omar Barroso); (C) stranded individual after killer whale attack on three adult sei whales with characteristic bite marks on head in Tres Mares (26 February 2021, Event 3; photo by Diego Illanes); (D) fatal attack of sei whale by killer whales in Holger Passage (26 February 2021, Event 4; courtesy of Yves Boulac); (E) failed attack by killer whales on two sei whales in Puerto Williams Bay (11 April 2021, Event 5; photo by Omar Barroso); and (F) fatal attack by killer whales on a fin whale in Puerto Williams Bay (22 April 2021, Event 6; photo by Omar Barroso).

Figure 4. (A) Female killer whale with a dorsal fin with three recognizable marks (attack on 9 March 2020, Event 1; photo by Omar Barroso), (B) same female during attack on 26 February 2021 (Event 4; courtesy of Yves Boulac), and (C) same female before attack on 11 April 2021 (Event 5; photo by Omar Barroso).

The photographic records of the three attacks on sei whales revealed that the same adult female, identified by three characteristic scars on the dorsal fin (Figure 4), participated in the attacks. Unfortunately, the mostly opportunistically collected audiovisual material did not have sufficient enough quality to identify further individuals based on less visible characteristics than scars.

Our observations describe a series of predation events by killer whales on large baleen whales and the participation of the same female in three different attacks in Magellanic sub-Antarctic waters south of Tierra del Fuego. This is a novel study for the area, in a region where there is little available information on cetaceans. Killer whale attacks on sei whales have rarely been documented (e.g., Goodall et al., 2007), and there is only one published record of a killer whale attack on fin whales in Chile before this study (Pitman et al., 2023). It may be relevant to mention that our records are from 2020/2021, a period with reduced traffic by cruise and cargo ships, which normally constantly use the Beagle Channel, due to the COVID-19 pandemic. There is evidence that marine mammals were sighted more often in temporarily less-disturbed environments during the pandemic (e.g., Coll, 2020; Loh et al., 2022).

Behavioral aspects of our observations coincided in most respects with previous descriptions of killer whale attacks on baleen whales. As witnessed by us, male killer whales primarily stay in the periphery of the hunts, while females and juveniles perform most attacks (Silber et al., 1990; Jefferson et al., 1991; Dahlheim & Towell, 1994; Melnikov & Zagrebin, 2005; Totterdell et al., 2022; Pitman et al., 2023). Even though male killer whales have been observed to be active in attacks on large whales (e.g., Flórez-González et al., 1994; Pitman et al., 2001; Sironi et al., 2008), their size (e.g., body, dorsal fin) could diminish the effectiveness of attacks of large whales due to their lower levels of speed and agility compared to the considerably smaller females (Reeves et al., 2006; Pitman et al., 2023).

The killer whale group sizes in our observations were similar to those reported for Chilean Patagonia by Häusermann et al. (2013) (mean = 4.2; range: 1 to 15; n = 117 sightings, excluding two large groups ≥ 30 animals) and by Capella et al. (2014) (5 ± 2.5 for calf groups; n = 43 sightings). Jefferson et al. (1991) stated that six to ten killer whales are often implicated in the predation of medium-sized whales. For fin whales in particular, Pitman et al. (2023) reported a mean of 10.9 ± 5.3 killer whales (range: 3 to 20; n = 11 attacks, considering the minimum numbers of sightings and excluding the fin whale attack in our study area); but for attacks on sei whales, we could not find any group size mentioned. A group size of three to four killer whales has been described as an optimum size to maximize the energy intake by killer whales feeding on marine mammals (Heithaus et al., 2018).

With regard to consumption of attacked whales in our study area, all of the bodies of stranded sei whales and the single fin whale showed tooth marks, but no further consumption of visible body parts. In the case of the fin whale predation event, we could confirm that the tongue was gone, consistent with previous observations of feeding patterns of baleen whales. The preference for the tongue could be because it provides nutritional value as has been suggested by Jefferson et al. (1991), who mention a preference for tongues and lips, as well as the preference for tongues and ventral grooves mentioned in Reeves et al. (2006), but it could also be related to teaching activity as described for killing led by female killer whales (Barrett-Lennard & Heise, 2006). Also, the many scars from killer whale teeth we saw on the bodies of fin and sei whales are frequently reported in literature. Scarring rates for

fin whales in the Southern Ocean were as high as 53% and were 24% for sei whales, particularly on the pectoral flippers and tail flukes (Shevchenko, 1975; but see Katona et al., 1988).

Yet, one aspect of our observations of killer whale attacks seems to diverge from earlier studies. Literature suggests that killer whales primarily target calves of large whales (e.g., Mehta et al., 2007; Pitman et al., 2015; Totterdell et al., 2022) as they represent vulnerable prey and a reduced danger to themselves (Reeves et al., 2006). Instead, our observations better match single studies reporting attacks not only on calves or juveniles, but also occasionally on adult baleen whales such as grey whales (Melnikov & Zagrebin, 2005; Weller et al., 2018). Unfortunately, we cannot provide the measurements of all sei whales in the attacks we observed (the fin whale measured 14.2 m; Pitman et al., 2023), but we can exclude that they were calves as they were larger than the adult female killer whales (i.e., > 7 m; Heyning & Dahlheim, 1988), while calves of sei whales measure ~4.5 m when born (Shefferly, 1999) and fin whales ~6 m (Mahalingam & Silberstein, 2010).

Our records also showed repeated, and mostly fatal, attacks (with the exception of Event 5) on sei whales during a 14-mo period in a very reduced space (within a 20-km stretch of the Beagle Channel). Although they are known to prey on the calves of large whales, the documentation of successful attacks on adult large whales is rare (Steiger et al., 2008; Pitman et al., 2015). Recently, however, Totterdell et al. (2022) reported killer whales killing and eating three blue whales in different attacks, one of them a healthy adult. This suggests that predation on baleen whales may be more frequent and relevant than previously considered, with potentially remarkable benefits for killer whale populations.

With respect to the reactions of prey, interestingly, in one of the three observations (Event 5, the failed attack), we witnessed the sei whale swimming close behind a juvenile killer whale when lunging out of the water, probably in reaction to the proximity of the sei whale (Supplemental Video). This might have been an unusual observation and merits further attention. Among the two antipredator strategies described for baleen whales by Ford & Reeves (2008), the *Balaenoptera* species appears to use a *flight* strategy which eventually results in rapid swimming away from the killer whales and no signals of defense once overtaken. In contrast, baleen whales using the *fight* strategy would actively defend themselves, defend their calves, or even form defensive groups. Which of the two antipredator strategies is employed primarily depends on the species' adaptations for high-speed swimming for successful fleeing or adaptations for enhanced turning ability for physical defense. Indeed, we observed a high-speed (15 km/h) escape from a sei whale in the 2020 attack (Event 1), similar to reports by Goodall et al. (2007) in Tierra del Fuego, Argentina. Of the three fin whale interactions with killer whales in the Gulf of California described by Ford & Reeves (2008), two showed high-speed chases (30 to 40 km/h), a phenomenon not witnessed by us. However, the two successful attacks we observed took place in the shallow waters of a bay, right at the entrance of two narrow (60 to 80 m) estuaries (Figure 2), allowing few options for rapid escapes. It is not clear whether the killer whales chased sei and fin whales into the bay or if they unintentionally got beached while fleeing, as suggested for minke whales by Ford et al. (2005).

We were further able to identify one female killer whale involved in three of the attacks. Repeated sightings of same individuals have been described as relatively rare. For instance, only seven of 49 killer whales (14.3%) identified from 119 sightings were observed more than once (Häussermann et al., 2013). Although we were not able to identify further individuals, we suggest that we probably observed the same group of killer whales hunting in the Beagle Channel. The presence of the identified females were reported in three (1, 4, and 5) events and of juveniles in two (1 and 6) events. Additionally, killer whale group sizes were similar (seven individuals) in three events (1, 5, and 6) with more than five individuals in event 4. A systematic photo-identification catalogue of killer whale sightings within the Beagle Channel could help to evaluate the level of residence of the individuals in the area and whether some degree of population and individual trophic specialization across Chilean sub-Antarctic waters occurs. Hucke-Gaete et al. (2004) described an example of such trophic specialization in killer whales continuously interacting with the bacalao fishery in sub-Antarctic waters. And more recently, Remili et al. (2023) reported individual within-population feeding specialization in killer whales of the North Atlantic.

In conclusion, our description of killer whale attacks in Magellanic sub-Antarctic waters highlights (1) that multiple attacks on sei whales by killer whales do indeed occur, despite the paucity of literature on these events (e.g., Goodall et al., 2007; Olavarría et al., 2019; Pérez-Álvarez et al., 2021); (2) that behavioral aspects such as the position of killer whale males during attacks, the pod size, and the return of individuals to the same location might be a particular feeding or teaching characteristic for killer whales in the study area; and (3) that some deaths of sei whales in massive mortality events as described by Häussermann

et al. (2017) could be partially attributed to killer whale predation (as suggested by Olavarría et al., 2019; Pérez-Álvarez et al., 2021). Given the ongoing debate on baleen whales as killer whale prey (e.g., Reeves et al., 2006; Mehta et al., 2007), we call attention to the need for long-term systematic studies on the trophic ecology and dietary plasticity of killer whales in sub-Antarctic waters, Chile. Notwithstanding, reporting opportunistic evidence of individual killer whale attacks (e.g., Alava et al., 2013; Totterdell et al., 2022) will continue to be a valuable contribution to improve our understanding of the world's marine top predators.

Note: The supplemental video for this short note is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147.

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