Aquatic Mammals 2022, *48*(5), 436-448, DOI 10.1578/AM.48.5.2022.436

Evidence of Type A-Like Killer Whales (*Orcinus orca*) Predating on Marine Mammals Along the Atacama Desert Coast, Chile

Ana M. García-Cegarra[1, 2]

[1]*Centro de Investigación de Fauna Marina y Avistamiento de Cetáceos (CIFAMAC), Jesús Tejada 621, Mejillones, Chile*
E-mail: albatracu@gmail.com
[2]*Instituto de Ciencias Naturales Alexander von Humboldt, Facultad de Ciencias del Mar y Recursos Biológicos, Universidad de Antofagasta, Campus Coloso S/N, Antofagasta, Chile*

Abstract

Killer whales (*Orcinus orca*) are marine apex predators distributed across the world's oceans. In the last 40 years, researchers have increasingly differentiated killer whales into ecotypes based on genetics, morphology, behaviour, acoustic repertoire, habitat, and trophic ecology. While killer whale ecotypes in the Northern Hemisphere are well studied, the recognition of distinct killer whale forms in the Southern Hemisphere is mainly limited to Antarctic waters. Although present in less studied regions, such as along the Atacama Desert coast in the Southeast Pacific Ocean, limited information is available regarding their biology or trophic ecology. Herein, multiple lines of evidence are presented for killer whale predation on marine mammals in northern Chile. Using information from systematic boat-based surveys, whale-watching tour surveys, and reports from fishermen/citizen scientists, 19 killer whale sightings are reported along the coast of northern Chile (from the Arica and Parinacota region in the north to the Atacama region in the south). Killer whales were photo-identified as corresponding to the Southern Hemisphere Type A-like ecotype according to their dorsal fin shape and white eye patch. One killer whale pod, which included two males, one female, one juvenile, and one calf, was resighted six times from 2016 to 2021 in northern Chile and was observed hunting South American sea lions (*Otaria flavescens*), dusky dolphins (*Lagenorhynchus obscurus*), and long-beaked common dolphins (*Delphinus cf. capensis*). Killer whales were observed taking advantage of large aggregations of sea lions associated with the offshore purse-seine fishery. Adult killer whales used the hulls of fishing vessels to prevent sea lions from escaping. Photo-identification analysis of a fin whale (*Balaenoptera physalus*) catalogue from Mejillones Peninsula showed that 2.6% of all identified whales had apparent rake marks from killer whale teeth on their dorsal fins. These data show that Type A-like killer whales in northern Chile prey on several species of marine mammals.

Key Words: killer whales, *Orcinus orca*, diet, Southeast Pacific, sea lions, dusky dolphins, fin whales, Chile

Introduction

The killer whale (*Orcinus orca*) is a cosmopolitan cetacean species distributed from tropical to cold waters in all ocean basins (Ford, 2009). They are marine top predators, feeding on a range of different prey such as cephalopods, teleost fishes, sharks, rays, marine turtles, and birds, as well as other marine mammals such as sea lions, porpoises, dolphins, and whales (Nøttestad et al., 2002; Ford et al., 2005; Alava et al., 2009, 2013; Ford, 2018; Totterdell et al., 2022). According to variations in morphology, habitat use, behaviour, prey preferences, and genetics, killer whales have been classified into several ecologically specialized lineages or ecotypes (Pitman & Ensor, 2003; LeDuc et al., 2008; Morin et al., 2015; Foote et al., 2016; Hoyt, 2019). At the global level, researchers have identified 10 killer whale ecotypes, five from the Northern Hemisphere (three from the northwestern [NW] coast of North America and two in the North Atlantic) and five from the Southern Hemisphere, mainly around Antarctica (Types A, B1, B2, C, and D; Pitman & Ensor, 2003; Van Waerebeek et al., 2010; Pitman et al., 2011; Durban et al., 2016). In areas of high marine productivity, two or more ecotypes can co-occur in sympatry (Riesch et al., 2012). For example, in the North Pacific, the resident fish predators are found in the NW and northeastern (NE) Pacific, while the marine mammal predators or transient (officially named now as "Bigg's killer whales") and offshore (fish and shark specialists) ecotypes are present in the NE Pacific (Ford et al., 2005; Ford, 2018).

In the NE Atlantic, Type 1 (fish-eaters with some seals and small cetaceans in the diet) and Type 2 (minke whale [*Balaenoptera acutorostrata*] specialists) ecotypes co-occur. In the Southern Hemisphere, the Type A killer whale ecotype are specialist predators of Antarctic minke whale (*Balaenoptera bonaerensis*), the pack ice large Type B1 ecotype are specialist predators of seals, the Gerlache small Type B2 ecotype are mainly penguin eaters, the Ross Sea Type C ecotype prey on Antarctic toothfish (*Dissostichus mawsoni*), and the Subantarctic Type D ecotype prey on other fish (Hoyt, 2019). The Antarctic ecotypes B1, B2, and C differ from Type A in their dorsal cape, whereas Types B1 and B2 individuals have large eye patches, and Type C individuals have smaller, forward-slanted eye patches (Pitman & Ensor, 2003; Durban et al., 2016). Body sizes vary, with Type B1 being larger than Type B2, and Type C being the smallest killer whale ecotype with lengths of ~5 m (Fearnbach et al., 2011).

Some ecotypes are resident in a certain marine–coastal area, while others are transient, feeding in similar habitats across a wider spatial area (Dahlheim & White, 2010). To date, there have been no recorded instances of transient killer whales from the North Pacific preying on fish, while there are no records of resident killer whales preying on marine mammals (Ford et al., 1998; Saulitis et al., 2000; Dahlheim & White, 2010).

Killer whale ecotypes have specialized foraging strategies, and several studies have argued that behavioural differences among ecotypes are examples of distinct cultures—that is, behaviour transmitted by social learning (Baird & Whitehead, 2000; Whitehead, 2020). For example, the Type B ecotype of Argentina are well known for their dramatic strategy of beaching themselves to capture South American sea lions (*Otaria flavescens*) and southern elephant seals (*Mirounga leonina*, Linneaus 1758) (López & López, 1985; Hoelzel, 1991; Iñíguez, 2001). This is an important form of cultural specialization given that foraging methods are transmitted within ecotypes from parents to offspring, from generation to generation, through social learning in the same matrilineal group, and imitation of conspecifics has been considered to be a form of cultural transmission (Hoelzel, 1991; Guinet & Bouvier, 1995; Baird & Whitehead, 2000; Whitehead, 2020).

Culture is defined here as "information that is capable of affecting individuals' behaviour, acquired from other individuals through teaching, imitation and other forms of social learning" (Laland et al., 2010, p. 138). Teaching is a powerful form of social learning but is difficult to demonstrate in nature. Social learning has been observed in several cetaceans, including the Atlantic spotted dolphin (*Stenella frontalis*), where information may be transmitted to conspecifics vertically (mother/offspring), horizontally (peer/peer), and obliquely (non-parental/juvenile) (Bender et al., 2009). Prey transfer from mother to calves has been observed in the freshwater Tucuxi dolphin (*Sotalia fluviatilis*), and there is some evidence of maternal teaching behavior in Atlantic spotted dolphins where mothers display different foraging techniques in the presence of their calves (Spinelli et al., 2006; Bender et al., 2009). In Argentina, female killer whales modify their stranding foraging behaviour in the presence of naive juvenile observers (presumably their calves) (Guinet & Bouvier, 1995). However, evidence of incidences of mother–calf pair teaching are scarce in killer whale populations.

Killer whale foraging methods and consumption patterns have been well studied in the North Atlantic, North Pacific, Eastern Tropical Pacific, and Antarctica (Vargas-Bravo et al., 2019). Conversely, there is a lack of information regarding foraging strategies or prey preferences from killer whale ecotypes from the Southeast (SE) Pacific, likely reflecting limited research effort. In the Galápagos Islands, killer whales have been observed preying on ocean sunfish, mobulid rays, sharks, sea turtles, sea lions, and Bryde's whales (*Balaenoptera brydei*) (Sonnino Sorisio et al., 2006; Alava & Merlen, 2009; Alava et al., 2013; Alarcón-Ruales et al., 2018). In Perú, the first record of three killer whales preying on South American sea lions was reported at San Juan de Marcona in August 1986 (Van Waerebeek et al., 1988). García-Godos (2004) further documented killer whale predation on pilot whale (*Globicephala* sp.), bottlenose dolphin (*Tursiops truncatus*), South American sea lions, and South American fur seals (*Arctocephalus australis*). Killer whales have also been observed displaying predatory behavior towards humpback whales (*Megaptera novaeangli*ae), blue whales (*Balaenoptera musculus*), and South American sea lions. Humpback whale flukes have also been observed with tooth rake marks both in Perú and in Chilean Patagonia (Capella et al., 2018; Testino et al., 2019). However, there are no records of killer whales preying on other cetacean species such as dolphins or whales in northern Chile.

Interactions between killer whales and fishing operations have been documented in several oceans (Visser, 2000; Dalla Rosa & Secchi, 2007; Tixier et al., 2010, 2016; Camiñas et al., 2018; Dahlheim et al., 2022). In the Mediterranean Sea, killer whales take advantage of longline tuna fisheries to prey on Atlantic bluefin tuna (*Thunnus thynnus*) (Camiñas et al., 2018). In SE Australia, killer whales prey on blue-eye trevalla (*Hyperoglyphe antarctica*) captured in commercial longline fisheries (Gimonkar et al., 2022), while in the subantarctic waters of

Crozet Archipelago and southern Chile, the two genetically distinct Type A and Type D killer whale ecotypes have also been observed interacting with fisheries as an opportunity to prey on Patagonian toothfish (*Dissostichus eleginoides*) (Roche et al., 2007; Tixier et al., 2010; Amelot et al., 2022). Here, killer whales remove fish from longlines (Tixier et al., 2019). This type of interaction started with the expansion of the commercial longline Patagonian toothfish fishery in the 1990s, and killer whales developed new foraging strategies when their main prey became scarce (Tixier et al., 2019). Although interactions between killer whales and longline fisheries are well documented, their exploitation of fishing vessel hulls to prey on pinnipeds and other marine mammals are not, with a single reported case of killer whales attacking a sperm whale (*Physeter macrocephalus*) from the Patagonian toothfish fishery in southern Chile (Hucke-Gaete et al., 2004).

Killer whales are distributed in waters adjacent to Chilean-administrated territories from Pisagua (13° S) to the Bellinghausen Sea (70º S) and to the Juan Fernández Islands (Aguayo-Lobo et al., 1998). From the coast of the fjords of Chilean Patagonia (53º S) to Central-North Chile (29º S), Type A killer whales have been observed feeding on pinnipeds (South American fur seals and South American sea lions) (Capella et al., 1999; Hückstädt & Antezana, 2004; Goetz et al., 2008). Type A killer whales in Chilean Patagonia also prey on pinnipeds near the salmon aquaculture facilities (Sepúlveda & Oliva, 2005; Capella et al., 2018). Chile is the second largest producer of farmed Atlantic salmon in the world, and production is centered in this region. Extensive aquaculture attracts pinnipeds which feed on farmed and escaped salmon (Sepúlveda et al., 2015). Killer whales likely benefit directly from pinniped aggregation associated with salmon farms, which increases the availability of food; and adults have been observed sharing their pinniped prey with their calves (Haüssermann et al., 2013; Capella et al., 2018). Other work has shown that killer whales also benefit from sea lion aggregations associated with vessels from the industrial purse-seine fishing fleet targeting jack mackerel (*Trachurus murphyi*) in central Chile (Hückstädt & Antezana, 2004). Here, killer whales take advantage of the presence of fishing vessels in offshore waters to locate and prey on South American sea lions far from their nearshore rookeries (Hückstädt & Antezana, 2004).

Although the coastal waters of northern Chile are extremely productive and support large populations of potential killer whale prey, the presence of killer whales has just been reported by fishermen of the Antofagasta region, and their type and/or foraging ecology has not been formally characterized (Aguayo-Lobo, 1975; Guerra-Correa et al., 1987). To further understand the occurrence, distribution, and predatory behavior of killer whales in the SE Pacific, this study provides a first description of the presence of killer whales in northern Chile and a characterization of the hunt strategies they use to prey on marine mammals.

Methods

Observations of killer whales in northern Chile were obtained through systematic boat-based surveys, whale-watching surveys, and a citizen science project involving fishermen from the Atacama Desert coast of northern Chile.

Systematic Boat-Based Surveys

Systematic boat-based surveys to study cetacean presence were performed in Mejillones Bay (23° 5' 57.65" S, 70° 27' 43.31" W) covering an area of 380.67 km^2 during the austral spring/summer (October to February) in consecutive years (2016 to 2021). This region of the Atacama Desert coast has recently been recognised as a potential area for the observation of cetacean species (García-Cegarra et al., 2021). Surveys were conducted from an 8 m boat with 50 hp outboard motor under sea conditions with Beaufort sea states of < 3, wave heights < 1.5 m, and visibility of at least from 1 to 5 km (Williams & Thomas, 2009). Surveys were conducted during daylight hours between 0800 and 1400 h. Two experienced observers searched for cetaceans, scannning by eye and with 15 × 50 binoculars beyond 90° on both sides of the vessel. When cetaceans were observed, time, sea state, GPS location, sighting angle and distance from the boat, group composition, and behavior were recorded. Digital photographs of each cetacean species observed in the region, including fin whales (*Balaenoptera physalus*), dusky dolphins (*Lagenorhynchus obscurus*), long-beaked common dolphins (*Delphinus cf. capensis*), or killer whales, were obtained with a Canon T5i reflex camera (for details about the cetacean species observed in the area, see García-Cegarra et al., 2021).

Whale-Watching Surveys

Whale-watching surveys were performed with a local tour operator in Mejillones Bay during the austral summer of 2020 (January-February). Whale-watching tours lasted 3 hours (0900 to 1200 h) in an 11 m boat with a 75 hp outboard engine and a total capacity of 16 passengers. The tour departed from the Mejillones fishing port and followed a route to the cliffs at Punta Angamos to allow passengers to observe marine fauna such as sea lions, cetaceans, and Humboldt penguins (*Spheniscus humboldti*). During the tour, the boat stopped when killer whales were observed, and a marine biologist guide noted the geographic

position, took photographs, and recorded data about the number of individuals observed and their behaviour.

Fishermen/Citizen Science Data

Fishermen taking part in a citizen science project provided details of killer whale sightings from artisanal and industrial purse-seine fishing operations from Mejillones. Purse-seine fishing activity was focused on the capture of Peruvian anchovy (*Engraulis ringens*) along the coast of northern Chile. Fishermen used mobile phones to record videos of events—for example, when killer whales were seen to be preying on South American sea lions. Videos were sent to the author for analysis. Information gathered from these videos included killer whale sighting date, location, behaviour, group size, apparent foraging strategy, and prey species.

Photo-Identification and Distribution Analysis

Photos obtained during systematic boat-based surveys, whale-watching, or fishing activities were used to generate a photo-identification catalogue of killer whales and other cetaceans, such as fin whales, in the region. Photos were selected that were perpendicular to the dorsal fin of individuals, capturing both the right and left sides and the white eye patch of killer whales when possible. Images obtained were classified according to their quality and recognisable nicks and notches in dorsal fins. The catalogue of fin whales' dorsal fins used in this study was compiled at Mejillones Peninsula in the period 2016 to 2021 based on best-quality photographs. Classification was performed according to the nicks, marks, amputations, pigmentation, and killer whale tooth rake marks in their dorsal fins. Tooth rake marks were defined as a set of three or more parallel and equidistant linear scars on the dorsal fin (Mehta et al., 2007; Capella et al., 2018). Killer whales were catalogued as adults, juveniles, and calves according to their size relative to the boat and the height and shape of their dorsal fin. Foraging behaviour of killer whales was classified according to the marine mammal prey species (e.g., dusky dolphin, South American sea lion, fin whale) and the source of the data (i.e., systematic boat-based surveys, whale-watching tours, or citizen science data). High density areas of killer whales were estimated with the Kernel Density Estimator method using the 'Spatial Analysis Tools' in *ArcMap* (*ArcGIS*, Version 10.4.1; ESRI, 2021).

Results

A total of 19 observations of killer whales were registered from northern Chile between 2016 and 2021 (Table 1). Groups ranged between one and five individuals (mean = 3.4; median = 4; ± SD = 1.4). Three sightings of killer whales were obtained through systematic boat-based surveys, three sightings through whale-watching tours, and 13 sightings through fishermen's observations (Table 1).

Observations were distributed along a distance of ~1,200 km along the Atacama Desert coast in northern Chile, from Chañaral de Aceituno (29º S, III Region) to the Arica and Parinacota Region (18º S) (Figure 1A). Kernel density results show that observations of killer whales were concentrated in the Mejillones Peninsula with ~29 individuals/km^2 observed (Supplemental Figure S1; supplementary material for this article is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammals-journal.org/index.php?option=com_content&view=article&id=10&Itemid=147). Along the Mejillones Peninsula, observations of killer whales were distributed in waters of depths ranging from 3.1 to 380 m (mean = 83; median = 115; ± SD = 113; Figure 1B). A total of five individual killer whales were photo-identified and catalogued according to their dorsal fin and body size as two adult males, one female, one juvenile, and one calf (Figure 2). We named this pod the "*Menacho"* pod. Recapture analysis showed that the *Menacho* pod was resighted in 2018, 2019, and 2020 along the coast of northern Chile, with a maximum distance of 700 km between the most northern and southern observations (Table 1). In 22% of sightings (n = 4), killer whales were observed predating on South American sea lions; in 11% of observations (n = 2), they pursued dusky and long-beaked common dolphins; while in 67% of the remaining observations, they were engaged in normal swimming behaviour (Table 1).

During a systematic boat-based survey conducted in Mejillones Bay in November 2018, a group of five killer whales was observed preying on South American sea lions. These individuals were photo-identified as members of the *Menacho* pod. Based on the intermediate-sized eye patch (larger than Type A ecotype but smaller than Type B ecotype) (Figure 2), oriented parallel to the body axis (similar to Type A and Type B ecotypes), and the presence of a visible dorsal cape (similar to Type B ecotype but lacking in Type A ecotype), we can differentiate killer whales from northern Chile as a Type A-like Southern Hemisphere ecotype; also, their white patch eye is larger than Type A but smaller than Type B (Pitman & Ensor, 2003).

Later (17 July 2019), a pod of five killer whales was observed north of this location (between the regions of Tarapaca and Antofagasta), pursuing a group of South American sea lions during purse-seine fishing activities. Fishermen recorded a video of the attack showing sea lions attempting to escape from the killer whales and their aggregation in large numbers adjacent to the hull of the fishing

Table 1. Nineteen observations of killer whales (*Orcinus orca*) from northern Chile, 2016 to 2021

Date	Location	Latitude (S)	Longitude (W)	Group size	Group composition	Calves	Behaviour	Source
19 July 2016	Chacaya	20° 57'	70° 26'	5	Unknown	0	Foraging	Fishermen
2 June 2017	Punta Angamos	23° 00' 28.41"	70° 31' 26.58"	4	1 M, 1 F, 2 J	0	Swimming	Fishermen
1 July 2017	Coloso	23° 46' 53.97"	70° 30' 28.14"	1	1 M	0	Swimming	CIFAMAC
24 November 2017	Coloso	23° 45' 02.47"	70° 28' 28.38"	3	Unknown	1	Swimming	Divers
25 November 2018	Mejillones Bay*	22° 58' 08.44"	70° 31' 19.54"	5	2 M, 1 F, 1 J, 1 C	1	Feeding on sea lions	CIFAMAC
25 February 2019	Chañaral de Aceituno*	28° 59' 42.68"	71° 33' 08.20"	4	2 M, 1 F, 1 C	1	Swimming	Whale watching
16 July 2019	Loa	21° 17' 07.32"	70° 19' 41.92"	5	2 M, 1 F, 1 J, 1 C	1	Feeding on sea lions	Fishermen
19 July 2019	Chacaya	22° 56' 52.53"	70° 22' 28.15"	5	Unknown	1	Swimming	Fishermen
29 July 2019	Chacaya	23° 00' 04.90"	70° 27' 05.70"	3 or 5	Unknown	1	Feeding on sea lions	Fishermen
16 October 2019	Mejillones Bay*	23° 03' 40.17"	70° 26' 39.28"	4	1M, 1 F, 1 J, 1 C	1	Feeding on sea lions	CIFAMAC
8 February 2020	Punta Angamos*	22° 59' 28.19"	70° 33' 49.75"	1	1 M	1	Feeding on dusky dolphins	Whale watching
8 February 2020	Mejillones Bay*	23° 03' 55.66"	70° 28' 49.58"	5	2 M, 1 F, 1 C, 1 J	1	Feeding on dusky and long-beaked common dolphins	Tourist
3 June 2020	Tocopilla	22° 02' 40.07"	70° 13' 45.60"	2	Unknown	0	Swimming	Marine ecologist
22 July 2020	Playa Grande	22° 59' 31.96"	70° 23' 35.37"	4	Unknown	0	Swimming	Fishermen
2 December 2020	Punta Camarones Arica	19° 13' 05.80"	70° 18' 36.72"	4	1 M, unknown	1	Swimming	Fishermen
21 December 2021	Chañaral de Aceituno*	29° 03' 53.24"	71° 35' 25.20"	5	2 M, 1 F, 1 C, 1 J	1	Swimming	Whale watching
1 June 2021	Antofagasta Bay	23° 41' 55.49"	70° 26' 33.07"	2	2 M	0	Swimming	CONAF
5 August 2021	La Portada	23° 32' 16.93"	70° 29' 04.61"	2	2 M	0	Swimming	CONAF
9 August 2021	Hornitos	22° 54' 39.60"	70° 22' 40.89"	3	1 M, 1 F, 1 J	0	Swimming	Fishermen

*Recaptures of *Menacho* pod of killer whales

vessel in an apparent attempt to hide from the killer whale pod (Supplemental Video sequence S1). The video footage shows an adult male killer whale escorting a calf during the pursuit of sea lions alongside the boat (Figure 3D). Fishermen stated that they have repeatedly observed such behaviours in which killer whales take advantage of the fishing activity to hunt sea lions.

Other observations involve solitary feeding behaviours. On 8 February 2020, a single adult male killer whale was observed preying on dusky dolphins during a whale-watching tour in Mejillones Peninsula (Figure 3A). Photo-identification of the dorsal fin shape and white eye patch corresponded with a *Menacho* pod of killer whales. A pod of ~200 dusky dolphins was observed rapidly swimming and porpoising away from the pursuing solitary killer whale (Figure 3B). At one moment, the killer whale leaped completely out of the water in what was likely a successful attack on a dusky dolphin. The other dusky dolphins of the group swam away

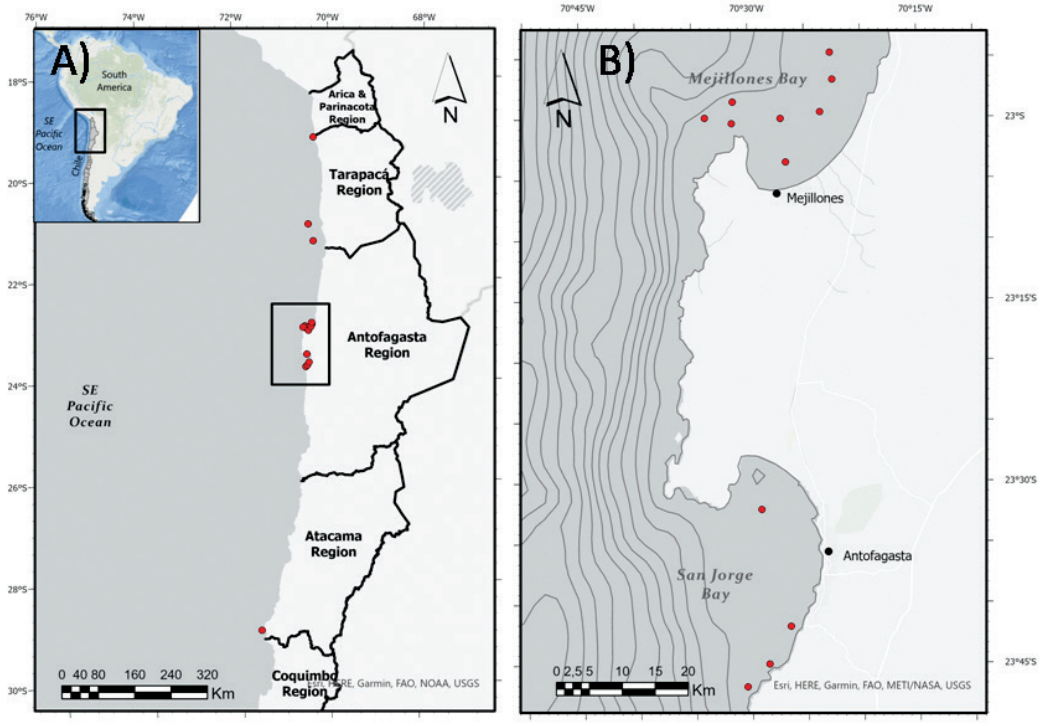

Figure 1. Map showing locations of killer whale (*Orcinus orca*) observations (circles) along (A) the northern Chilean coast, and (B) map of the Mejillones Peninsula with sightings of killer whales shown relative to coastal bathymetry (isobaths = 250 m).

from the killer whale, which remained in the area for ~10 min. No blood or dolphin remains were observed. Later in the afternoon of the same day, a group of five killer whales identified as the *Menacho* pod was observed chasing a mixed group of dusky and long-beaked common dolphins in Mejillones Bay. The attack was recorded opportunistically by an Unmanned Aerial Vehicle (UAV) flown by tourists (Supplemental Video sequences 2 & 3, courtesy of Ignacio Leyton).

In the video, killer whales are observed chasing dusky and long-beaked common dolphins. The two males remained behind the dolphin group, while the killer whale mother with her calf swam by the right flank of the smaller dolphin group. No effective predation of dolphins was observed, but the pursuit lasted for ~40 min until the dolphin group separated into two smaller groups and continued swimming northward while the killer whales regrouped. There is additional evidence of at least attempted predation by killer whales on other cetaceans in the Mejillones Peninsula. A total of 151 fin whales were catalogued according to their dorsal fin from waters adjacent to the Mejillones Peninsula between 2016 and 2021 (A. Arriagada, unpub. data). Of these, 2.6% (n = 4) of the individuals displayed visible killer whale tooth rake marks on their dorsal fins (Figure 4).

Discussion

This study provides strong evidence for the existence of killer whales in northern Chile that feed on marine mammals, including South American sea lions, dusky dolphins, and long-beaked common dolphins. We also provide a description of killer whales benefiting from the presence of purse-seine fishing boats to corral and hunt sea lions, and of an adult male killer whale showing a calf, potentially its own, how to pursue sea lions during fishing operations. Furthermore, we observed four fin whales with presumed killer whale teeth rake marks on their dorsal fins, indicating that killer whales attack fin whales in a likely attempt to prey on these large cetaceans.

Combined with the observations of their trophic ecology, morphological analysis indicates that the killer whales observed during this study correspond to a Southern Hemisphere Type A-like ecotype. While Type A ecotype has been observed

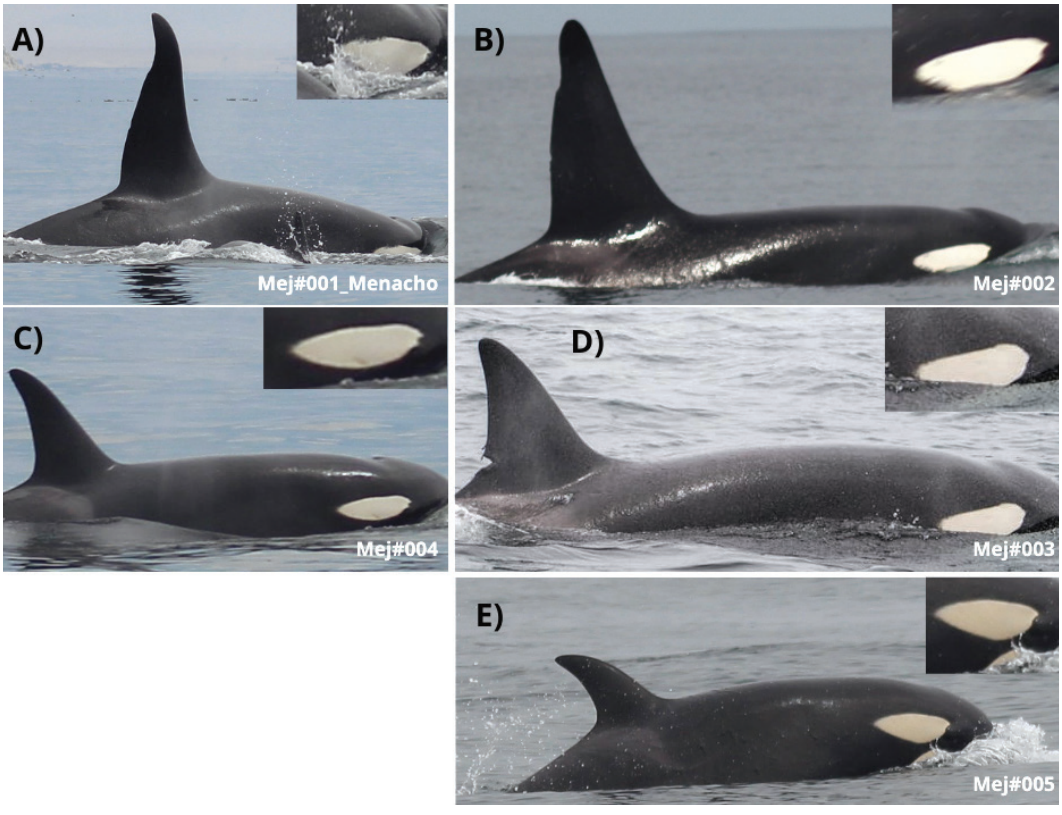

Figure 2. Photo catalogue of dorsal fins and white eye patch of killer whales belonging to the *Menacho* pod from northern Chile: (A) *Menacho* male, (B) second male observed in *Menacho* pod, (C) male juvenile observed in *Menacho* pod, (D) female of *Menacho* pod, the potential mother of (E) calf of *Menacho* pod. All show the white eye patch shape and body colour pattern. Eye patch shape in *Menacho* pod is bigger than Type A but smaller than Type B Southern Hemisphere ecotypes. (*Photo credits:* [A, B, C & E] A. García-Cegarra in Mejillones Bay; and [D] Turismos Orca in Chañaral de Aceituno)

in Antarctica feeding mainly on minke whales and in the Chilean Patagonia mainly on pinnipeds and fishes such as Patagonian toothfish during long-line fishing operations, Type B ecotype has been observed just in Antarctica feeding mainly on seals (Hucke-Gaete et al., 2008; Häussermann et al., 2013; Capella et al., 2018). Herein, we describe for the first time the presence of a dolphin and sea lion specialist killer whale Type A-like ecotype with an intermediate-sized white eye patch (between Type A and Type B sized white eye patch) horizontal to body axis, and the presence of a dorsal cape similar to the Type A ecotype.

The lack of genetic or morphological studies of killer whales in the Humboldt Current limits the identification of a specific killer whale ecotype in northern Chile. For example, statistically significant differences in skull morphology have been observed in other delphinid species of the Humboldt Current such as the dusky and long-beaked common dolphin (Van Waerebeek, 1992). Genetically distinct stocks of Burmeister's porpoises (*Phocoena spinipinnis*) and dusky dolphins have been described in the SE Pacific separating Peruvian from Chilean individuals (Cassens et al., 2003; Rosa et al., 2005). Obtaining skin tissue samples of killer whales for genetic analysis is difficult due to limited research effort, and just four killer whale strandings registered along the coast of Chile in the last 50 years makes it difficult to perform genetic studies for the Chilean killer whale population (Alvarado-Rybak et al., 2020). The killer whale group size average of 3.4 animals is similar to average pod sizes observed in the Galápagos Islands of 3.1 and 3.4 animals/pod, as well as in the nearshore waters of Ecuador's continental coast (Merlen, 1999; Denkinger et al., 2013; Alava et al., 2019). This relatively small pod size observed in northern Chile is characteristic and comparable to Bigg's killer whales (transient orcas) off the coast of British Columbia, Canada, that feed on marine mammals (Baird & Dill, 1996; Ford, 2018).

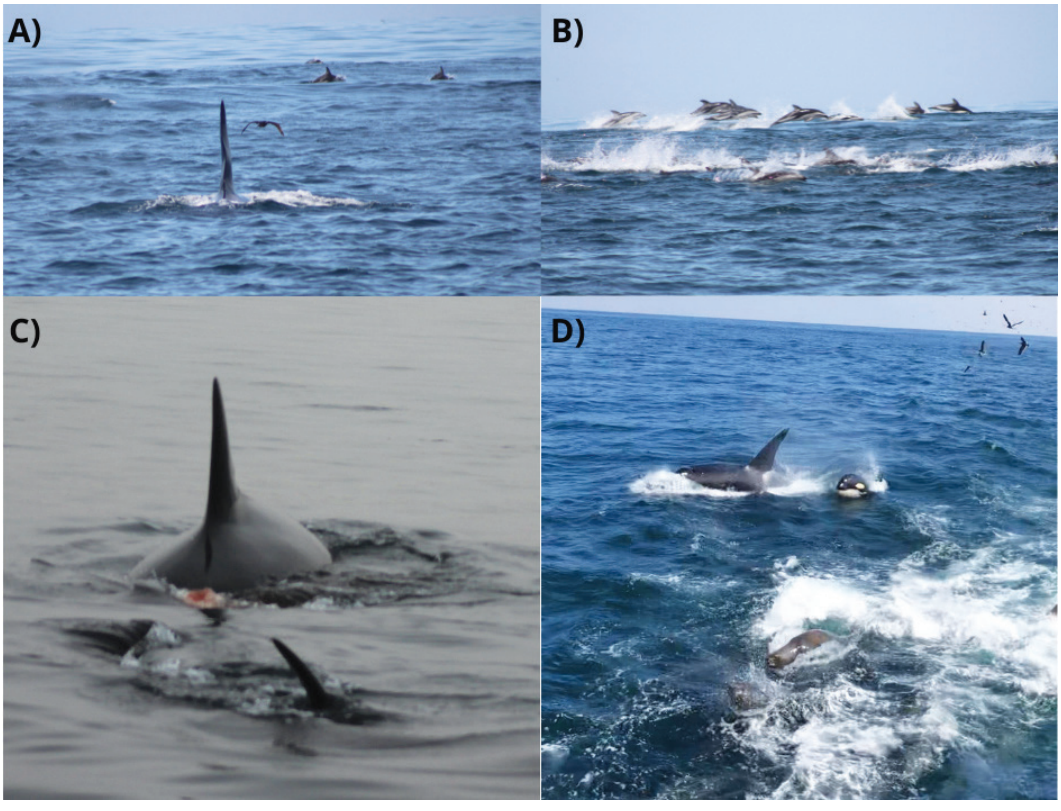

Figure 3. Evidence of killer whale hunting dusky dolphins (*Lagenorhynchus obscurus*) and sea lions (*Otaria flavescens*) in northern Chile: (A) a single male adult killer whale chasing a group of dusky dolphins; (B) the same group of dusky dolphins stampeding and porpoising to escape the killer whale attack; (C) *Menacho* pod eating a sea lion in Mejillones Bay on 16 October 2019; and (D) male and calf killer whales pursuing and cornering sea lions adjacent to the vessel hull of the fishing boat as hunting strategy. (*Photo credits:* [A & B] obtained by A. García-Cegarra, [C] courtesy of Juan Menares, and [D] courtesy of Tommy, a fisherman)

By combining information gathered over both space and time, we have been able to describe the presence of the *Menacho* male killer whale pod. This pod includes two male adults, one female, one juvenile, and one calf. To date, the *Menacho* pod has been observed six different times foraging on sea lions and pursuing pods of hundreds of dusky and long-beaked common dolphins for feeding. This is a similar pattern to those from studies in southern Chile reporting killer whales predating on sea lions in Chilean Patagonia (Häussermann et al., 2013). However, to our knowledge, the *Menacho* pod has not been observed in southern Chile and is not included in the killer whale catalogue of Chilean Patagonia (Häussermann et al., 2013; Capella et al., 2018). The *Menacho* pod has not been encountered off Perú or in the Eastern Tropical Pacific off the Galápagos Islands or in Ecuador (Alarcón et al., 2012; Pacheco et al., 2019; Testino et al., 2019). We have observed the presence of a solitary adult male killer whale preying on dusky dolphins in our study region, but this individual was not "Phantom," a solitary male that has been observed in eastern Pacific waters from Perú to México (Pacheco et al., 2019). Our observations of killer whales pursuing and preying on sea lions and dolphins do not allow any estimates of the relative contribution of each prey to the killer whale diet. For example, across British Columbia and wider southern Alaska, it is known that transient killer whales largely consume harbor seals (*Phoca vitulina*) (95%), with harbour porpoises (*Phocoena phocoena*) providing a much smaller percentage (5%). Conversely, in Prince William Sound (southern Alaska), killer whales feed equally on harbor seals and Dall's porpoises (*Phocoenoides dalli*) (Saulitis et al., 2000). These differences likely reflect differences in the prey availability as harbour seals are less abundant in Prince William Sound compared to

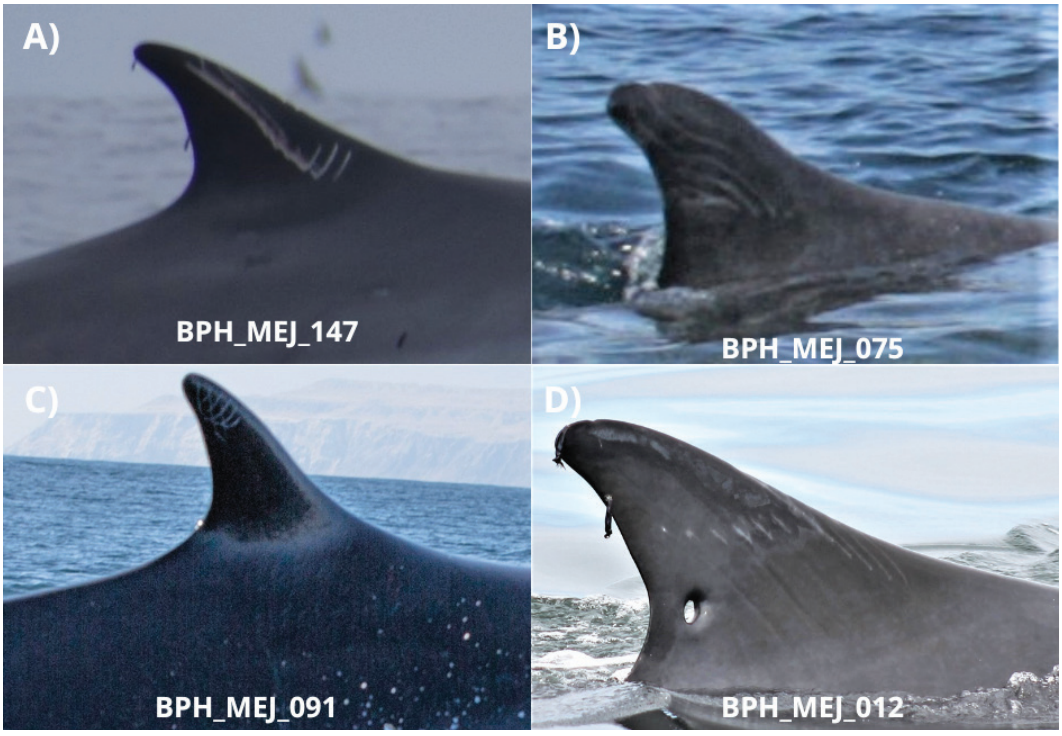

Figure 4. Rake marks of presumed killer whale teeth on dorsal fins of fin whales (*Balaenoptera physalus*) from Mejillones Peninsula, northern Chile (*Photo credit:* A. García-Cegarra)

British Columbia, and killer whales may switch to prey that are less easy to capture such as Dall's porpoises (Saulitis et al., 2000).

Observations of pods of killer whales hunting sea lions during anchovy purse-seine fishing activities and using fishing vessels to corral and prey on sea lions have previously been described from central and southern Chile (Hückstädt & Antezana, 2004). However, Hückstädt & Antezana (2004) reported observations of killer whales from four purse-seine fishing activities associated with the jack mackerel fishery in October 1999, but authors did not obtain photos of the killer whales to identify them. Unfortunately, this precludes a photographical comparison to examine whether this killer whale pod was the same as the one described herein from northern Chile. For the first time in the SE Pacific, we report the presence of an adult male and a calf cornering sea lions against the fishing vessels and pursuing them. The presence of an adult and a calf during a hunting event can be interpreted as a form of cultural transmission—that is, vertical transmission of information as previously described from killer whales. Whitehead et al. (2020) described killer whales transmitting their knowledge and hunting strategies from parents to offspring (vertically), and stated that these strategies (cultures) are specific to different killer whale pods belonging to the same ecotype.

The presence of fin whales with killer whale tooth rake marks on their dorsal fin reported herein provides evidence that killer whales attack, and possibly prey on, fin whales in this area of the SE Pacific. Similar events have been described for humpback whales belonging to Stock G of the SE Pacific where ~12% of the humpback whales studied, from Antarctica to Ecuador, had killer whale rake marks on their flukes (Capella et al., 2018). In Perú, close to 20% of humpback whales studied in their breeding area had killer whale rake marks on their flukes (Testino et al., 2019). Evidence for killer whale attacks on baleen whales remains scarce in Chile: only a single published report of a killer whale attacking a sei whale (*Balaenoptera borealis*) in the Chilean Patagonia has been published (Haüssermann et al., 2013). However, other observations of killer whales attacking sei whales have been reported from Argentinian Tierra del Fuego (Goodall et al., 2007; Ford & Reeves, 2008).

The high density of sightings of killer whales using Mejillones Bay as a foraging area to prey on sea lions and dolphins may be indicative of the high abundance of these species in the area.

Mejillones Bay is known to have sightings of big groups of dusky and long-beaked common dolphins throughout the year with a greater presence in austral summer coinciding with the presence of killer whales (García-Cegarra et al., 2021). However, most research and citizen science efforts are conducted in Mejillones Bay. Hence, sightings of killer whales in Mejillones Bay may be due to research effort in the area as other observations have been reported by fishermen in northward remote locations along the Atacama Desert coast. Future work should emphasize the sharing of killer whale observations in northern Chile by a stronger citizen science program between regions. Fishing observers should be present during fishing activities by the National Service of Fishing and Aquaculture of Chile to improve the information about the interactions among sea lions and killer whales during purse-seine fishing activities.

Acknowledgments

I warmly thank Luis González from Turismos Orca for providing pictures and sightings' positions of killer whales in Chañaral de Aceituno. Thanks to Owen Polo for creating the kernel density map. Thanks to the fishermen from Mejillones who provided photos and sightings' positions of killer whales predating on sea lions through CIFAMAC NGO social media. I thank Ignacio Leyton for their drone videos during the *Menacho* pod encounter in Mejillones Bay. I warmly thank Dr. Chris Harrod for proofreading the English and the content of the manuscript. I warmly thank Dr. Koen Van Waerebeek for his revision of this manuscript, suggestions to improve it, and analysis of the Type A-like Southern Hemisphere killer whale ecotype. Systematic boat-based surveys were partially funded by Porpoise Conservation Society. AG was funded under the ANID FONDECYT Postdoctoral Fellow (3210483). Thank you to the two anonymous reviewers for their comments to improve this article.

Literature Cited

Aguayo-Lobo, A. (1975). Progress report on small cetacean research in Chile. *Journal of the Fisheries Research Board of Canada*, *32*(7), 1123-1143. https://doi.org/10.1139/f75-134

Aguayo-Lobo, A. D., Torres, D., & Acevedo, J. (1998). Los mamíferos marinos de Chile. 1. Cetacea [The marine mammals of Chile. 1. Cetacea]. *Serie Científica INACH*, *48*, 19-159.

Alarcón, D., Denkinger, J., & Gudiño, C. (2012). Orcinus orca *Ecuador ID catalogue 2012*. Galápagos Science Center, Universidad San Francisco de Quito.

Alarcón-Ruales, D., Denkinger, J., & Muñoz-Pérez, J. P. (2018). Adult sea turtle predation by orcas in Galapagos. In *Proceedings of the 38th Annual Symposium on Sea Turtles Biology and Conservation*, Kobe, Japan. 202 pp.

Alava, J. J., & Merlen, G. (2009). Video-documentation of a killer whale (*Orcinus orca*) predatory attack on a giant manta (*Manta birostris*) in the Galapagos Islands. *Latin American Journal of Aquatic Mammals*, *7*(1-2), 81-84. https://doi.org/10.5597/lajam00139

Alava, J. J., Jiménez, P. J., Fair, P. A., & Barrett-Lennard, L. (2019). First record of a live-stranded killer whale (*Orcinus orca*) in coastal Ecuador and insights on killer whale occurrence in Ecuadorian waters. *Aquatic Mammals*, *45*(1), 106-115. https://doi.org/10.1578/AM.45.1.2019.106

Alava, J. J., Smith, K. J., O'Hern, J., Alarcón, D., Merlen, G., & Denkinger, J. (2013). Observations of killer whale (*Orcinus orca*) attacks on Bryde's whales (*Balaenoptera edeni*) in the Galapagos Islands. *Aquatic Mammals*, *39*(2), 196-201. https://doi.org/10.1578/AM.39.2.2013.196

Alvarado-Rybak, M., Toro, F., Escobar-Dodero, J., Kinsley, A. C., Sepúlveda, M. A., Capella, J., Azat, C., Cortés-Hinojosa, G., Zimin-Veselkoff, N., & Mardones, F. O. (2020). 50 years of cetacean strandings reveal a concerning rise in Chilean Patagonia. *Scientific Reports*, *10*, 9511. https://doi.org/10.1038/s41598-020-66484-x

Amelot, M., Plard, F., Guinet, C., Arnould, J. P. Y., Gasco, N., & Tixier, P. (2022). Increasing numbers of killer whale individuals use fisheries as feeding opportunities within subantarctic populations. *Biology Letters*, *18*, 20210328. https://doi.org/10.1098/rsbl.2021.0328

Baird, R. W., & Dill, L. M. (1996). Ecological and social determinants of group size in transient killer whales. *Behavioral Ecology*, *7*(4), 408-416. https://doi.org/10.1093/beheco/7.4.408

Baird, R. W., & Whitehead, H. (2000). Social organization of mammal-eating killer whales: Group stability and dispersal patterns. *Canadian Journal of Zoology*, *78*, 2096-2105. https://doi.org/10.1139/z00-155

Bender, C. E., Herzing, D. L., & Bjorklund, D. F. (2009). Evidence of teaching in Atlantic spotted dolphins (*Stenella frontalis*) by mother dolphins foraging in the presence of their calves. *Animal Cognition*, *12*, 43-53. https://doi.org/10.1007/s10071-008-0169-9

Camiñas, J. A., Aguilera, R., Báez, J. C., Macías, D., Ortiz de Urbina, J., García-Barcelona, S., Meléndez, M. J., Rioja, P., Saber, S., Gómez-Vives, M. J., Godoy, D., & Majuelos, E. (2018). *Final report of the activities carried out by the IEO in the framework of the Pilot Action: Killer whale and fisheries interactions in the Strait of Gibraltar area* (Addendum to the MoU ACCOBAMS No. 06/2016/LB6410). 49 pp.

Capella, J., Gibbons, J., & Vilina, Y. (1999). The killer whale, *Orcinus orca* (Delphinidae) in Chilean waters between Arica and Cabo de Hornos. *Anales del Instituto de la Patagonia*, *27*, 63-72.

Capella, J., Félix, F., Florez-González, L., Gibbons, J., Haase, B., & Guzman, H. M. (2018). Geographic and temporal patterns of non-lethal attacks on humpback

whales by killer whales in the eastern South Pacific and the Antarctic Peninsula. *Endangered Species Research*, *37*, 207-218. https://doi.org/10.3354/esr00924

Cassens, I., Van Waerebeek, K., Best, P. B., Crespo, A., Reyes, J., & Milinkovitch, M. C. (2003). The phylogeography of dusky dolphins (*Lagenorhynchus obscurus*): A critical examination of network methods and rooting procedures. *Molecular Ecology*, *12*, 1781-1792. https://doi.org/10.1046/j.1365-294X.2003.01876.x

Dahlheim, M. E., & White, P. A. (2010). Ecological aspects of transient killer whales *Orcinus orca* as predators in southeastern Alaska. *Wildlife Biology*, *16*, 308-322. https://doi.org/10.2981/09-075

Dahlheim, M. E., Cahalan, J., & Breiwick, J. M. (2022). Interactions, injuries and mortalities of killer whales (*Orcinus orca*) observed during fishing operations in Alaska. *Fishery Bulletin*, *120*, 79-94. https://doi.org/10.7755/FB.120.1.8

Dalla Rosa, L., & Secchi, E. (2007). Killer whale (*Orcinus orca*) interactions with the tuna and swordfish longline fishery of southern and southeastern Brazil: A comparison with shark interactions. *Journal of the Marine Biological Association of the United Kingdom*, *87*, 135-140. https://doi.org/10.1017/S0025315407054306

Denkinger, J., Oña, J., Alarcón, D., Merlen, G., Salazar, S., & Palacios, D. M. (2013). From whaling to whale-watching: Cetacean presence and species diversity in the Galapagos marine reserve. In S. J. Walsh & C. F. Mena (Eds.), *Science and conservation in the Galapagos islands: Frameworks & perspectives* (*Social and Ecological Interactions in the Galapagos Islands* book series, Vol. 1, pp. 217-243). Springer Science+Business Media, LLC. https://doi.org/10.1007/978-1-4614-5794-7_13

Durban, J. W., Fearnbach, H., Burrows, D. G., Ylitalo, G. M., & Pitman, R. L. (2016). Morphological and ecological evidence for two sympatric forms of Type B killer whale around the Antarctic Peninsula. *Polar Biology*, *40*, 231-236. https://doi.org/10.1007/s00300-016-1942-x

Fearnbach, H., Durban, J. W., Ellifrit, D. K., & Balcomb III, K. C. (2011). Size and long-term growth trends of endangered fish-eating killer whales. *Endangered Species Research*, *13*, 173-180. https://doi.org/10.3354/esr00330

Foote, A. D., Vijay, N., Àvila-Arcos, M. C., Baird, R. W., Durban, J. W., Fumagalli, M., Gibbs, R. A., Hanson, M. B., Korneliussen, T. S., Martin, M. D., Robertson, K. M., Sousa, V. C., Vieira, F. G., Vinar, T., Wade, P., Worley, K. C., Excoffier, L., Morin, P. A., Gilbert, T. P., & Wolf, J. B. W. (2016). Genome-culture coevolution promotes rapid divergence of killer whale ecotypes. *Nature Communications*, *7*, 11693. https://doi.org/10.1038/ncomms11693

Ford, J. K. B. (2009). Killer whale *Orcinus orca*. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.). *Encyclopedia of marine mammals* (pp. 650-657). Academic Press.

Ford, J. K. B. (2018). Killer whale: *Orcinus orca*. In B. Würsig, J. G. M. Thewissen, & K. M. Kovacs (Eds.), *The encyclopedia of marine mammals* (3rd ed., pp. 531-537). Academic Press/Elsevier. https://doi.org/10.1016/B978-0-12-804327-1.00010-8

Ford, J. K. B., & Reeves, R. R. (2008). Fight or flight: Antipredator strategies of baleen whales. *Mammal Review*, *38*(1), 50-86.

Ford, J. K. B., Ellis, G. M., Barrett-Lennard, L. G., Morton, A. B., Palm, R. S., & Balcomb III, K. C. (1998). Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. *Canadian Journal of Zoology*, *76*, 1456-1471. https://doi.org/10.1139/z98-089

Ford, J. K. B., Ellis, G. M., Matkin, D. R., Balcomb, K. C., Briggs, D., & Morton, A. B. (2005). Killer whale attacks on minke whales: Prey capture and antipredator tactics. *Marine Mammal Science*, *21*(4), 603-618. https://doi.org/10.1111/j.1748-7692.2005.tb01254.x

García-Cegarra, A. M., Toro, F., & Gonzalez-Borasca, V. (2021). Citizen science as a tool to assess cetacean diversity in the Atacama Desert coast. *Ocean and Coastal Management*, *213*, 105858. https://doi.org/10.1016/j.ocecoaman.2021.105858

García-Godos, I. (2004). Killer whale (*Orcinus orca*) occurrence off Peru, 1995-2003. *Latin American Journal of Aquatic Mammals*, *3*(2), 177-178. https://doi.org/10.5597/lajam00064

Gimonkar, Y., Lea, M. A., Burch, P., Arnould, J. P. Y., Sporcic, M., & Tixier, P. (2022). Quantifying killer whale depredation in the blue-eye trevalla commercial fisheries of south-east Australia. *Ocean & Coastal Management*, *221*, 106114. https://doi.org/10.1016/j.ocecoaman.2022.106114

Goetz, S., Wolff, M., Stotz, W., & Villegas, M. J. (2008). Interactions between the South American sea lion (*Otaria flavescens*) and the artisanal fishery off Coquimbo, northern Chile. *ICES Journal of Marine Science*, *65*(9), 1739-1746. https://doi.org/10.1093/icesjms/fsn152

Goodall, N. P., Boy, C., & Schiavini, A. C. M. (2007). Historical and modern records of cetaceans self-stranding to escape killer whale attacks. *Annual Reports of the International Whaling Commission* (SC59/SM17).

Guerra-Correa, C., Van Waerebeek, K., Portflitt, G., & Luna, G. (1987). Presencia de cetáceos frente a la segunda región de Chile [Presence of cetaceans off the second region of Chile]. *Estudios Oceanológicos*, *6*, 87-96.

Guinet, C., & Bouvier, J. (1995). Development of intentional stranding hunting techniques in killer whale (*Orcinus orca*) calves at Crozet Archipelago. *Canadian Journal of Zoology*, *73*, 27-33. https://doi.org/10.1139/z95-004

Häussermann, V., Acevedo, J., Försterra, G., Bailey, M., & Aguayo-Lobo, A. (2013). Killer whales in Chilean Patagonia: Additional sightings, behavioural observations, and individual identifications. *Revista de Biología Marina*

y Oceanografía, *48*(1), 73-85. https://doi.org/10.4067/S0718-19572013000100007

Hoelzel, A. R. (1991). Analysis of regional mitochondrial DNA variation in the killer whale: Implications for cetacean conservation. *Report of the International Whaling Commission*, Special Issue 13, 225-233.

Hoyt, E. (2019). *Orca: The whale called killer* (5th ed.). Firefly Books.

Hucke-Gaete, R., Moreno, C. A., & Arata, J. (2004). Operational interactions of sperm whales and killer whales with the Patagonian toothfish industrial fishery off southern Chile. *CCAMLR Science*, *11*, 127-140.

Hückstädt, L. A., & Antezana, T. (2004). Behaviour of southern sea lions in presence of killer whales during fishing operations in central Chile. *Scientia Marina*, *68*, 295-298. https://doi.org/10.3989/scimar.2004.68n2295

Iñíguez, M. A. (2001). Seasonal distribution of killer whales (*Orcinus orca*) in northern Patagonia, Argentina. *Aquatic Mammals*, *27*(2), 154-161.

Laland, K. N., Odling-Smee, J., & Myles, S. (2010). How culture shaped the human genome: Bringing genetics and the human sciences together. *Nature Reviews: Genetics*, *11*, 137-148. https://doi.org/10.1038/nrg2734

LeDuc, R. G., Robertson, K. M., & Pitman, R. L. (2008). Mitochondrial sequence divergence among Antarctic killer whale ecotypes is consistent with multiple species. *Biology Letters*, *4*, 426-429. https://doi.org/10.1098/rsbl.2008.0168

López, J. C., & López, D. (1985). Killer whales (*Orcinus orca*) of Patagonia and their behavior of intentional stranding while hunting nearshore. *Journal of Mammalogy*, *66*(1), 181-183. https://doi.org/10.2307/1380981

Mehta, A. V., Allen, J. M., Constantine, R., & Garrigue, C. (2007). Baleen whales are not important as prey for killer whales *Orcinus orca* in high-latitude regions. *Marine Ecology Progress Series*, *348*, 297-307. https://doi.org/10.3354/meps07015

Merlen, G. (1999). The orca in the Galápagos: 135 sightings. *Noticias de Galápagos*, *60*, 1-9.

Morin, P. A., Parsons, K. M., Archer, F. I., Ávila-Arcos, M. C., Barrett-Lennard, L. G., Dalla Rosa, L., Duchêne, S., Durban, J. W., Ellis, G. M., Ferguson, S. H., Ford, J. K., Ford, M. J., Garilao, C., Gilbert, M. T. P., Kaschner, K., Matkin, C. O., Peterson, S. D., Robertson, K. M., Visser, I. N., Wade, P. R., . . . Foote, A. D. (2015). Geographic and temporal dynamics of a global radiation and diversification in the killer whale. *Molecular Ecology*, *24*, 3964-3979. https://doi.org/10.1111/mec.13284

Nøttestad, L., Fernö, A., & Axelsen, B. E. (2002). Digging in the deep: Killer whales' advanced hunting tactic. *Polar Biology*, *25*, 939-941. https://doi.org/10.1007/s00300-002-0437-0

Pacheco, A. S., Castro, C., Carnero-Huaman, R., Villagra, D., Pinilla, S., Denkinger, J., Palacios-Alfaro, J. D., Sanchez-Godinez, C., González-Ruelas, R., Silva, S., Alcorta, B., & Urbán, J. (2019). Sightings of an adult male killer whale match humpback whale breeding seasons in both hemispheres in the Eastern Tropical Pacific. *Aquatic Mammals*, *45*(3), 320-326. https://doi.org/10.1578/AM.45.3.2019.320

Pitman, R. L., & Ensor, P. (2003). Three forms of killer whales (*Orcinus orca*) in Antarctic waters. *Journal of Cetacean Research and Management*, *5*, 131-139.

Pitman, R. L., Durban, J. W., Greenfelder, M., Guinet, C., Jorgensen, M., Olson, P., Plana, J., Tixier, P., & Towers, J. R. (2011). Observations of a distinctive morphotype of killer whale (*Orcinus orca*), Type D, from subantarctic waters. *Polar Biology*, *34*, 303-306. https://doi.org/10.1007/s00300-010-0871-3

Riesch, R., Barrett-Lennard, L. G., Ellis, G. M., Ford, J. K. B., & Deecke, V. B. (2012). Cultural traditions and the evolution of reproductive isolation: Ecological speciation in killer whales? *Biological Journal of the Linnean Society*, *106*, 1-17. https://doi.org/10.1111/j.1095-8312.2012.01872.x

Roche, C., Guinet, C., Gasco, N., & Duhamel, G. (2007). Marine mammals and demersal longline fishery interactions in Crozet and Kerguelen Exclusive Economic Zones: An assessment of depredation levels. *CCAMLR Science Journal of the Scientific Committee and the Commission for the Conservation of Antarctic Marine Living Resources*, *14*.

Rosa, S., Milinkovitch, M. C., Van Waerebeek, K., Berck, J., Oporto, J., Alfaro-Shigueto, J., Van Bressem, M-F., Goodall, N., & Cassens, I. (2005). Population structure of nuclear and mitochondrial DNA variation among South American Burmeister's porpoises (*Phocoena spinipinnis*). *Conservation Genetics*, *6*, 431-433. https://doi.org/10.1007/s10592-005-4988-9

Saulitis, E., Matkin, G., Barrett-Lennard, L., Heise, K., & Ellis, G. (2000). Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. *Marine Mammal Science*, *16*, 94-109. https://doi.org/10.1111/j.1748-7692.2000.tb00906.x

Sepúlveda, M., & Oliva, D. (2005). Interactions between South American sea lions *Otaria flavescens* (Shaw) and salmon farms in southern Chile. *Aquaculture Research*, *36*(11), 1062-1068. https://doi.org/10.1111/j.1365-2109.2005.01320.x

Sepúlveda, M., Newsome, S. D., Pavez, G., Oliva, D., Costa, D. P., & Hückstädt, L. A. (2015). Using satellite tracking and isotopic information to characterize the impact of South American sea lions on salmonid aquaculture in southern Chile. *PLOS ONE*, *10*(8), e0134926. https://doi.org/10.1371/journal.pone.0134926

Sonnino Sorisio, L., De Maddalena, A., & Visser, I. N. (2006). Interaction between killer whales (*Orcinus orca*) and hammerhead sharks (*Sphyma* sp.) in Galápagos waters. *Latin American Journal of Aquatic Mammals*, *5*, 69-71. https://doi.org/10.5597/lajam00095

Spinelli, L. H. P., Jesus, A. H., Nascimento, L. F., & Yamamoto, M. E. (2006). Prey-transfer in the marine tucuxi dolphin, *Sotalia fluviatilis*, on the Brazilian coast. *Marine Biodiversity Records* [Published online]. https://doi.org/10.1017/S1755267206002351

Testino, J. P., Petit, A., Alcorta, B., Pacheco, A. S., Silva, S., Alfaro-Shigueto, J., Sarmiento, D., Quiñones, J., More-Eche, A., Motta, E., Fernandez, S., Campbell, E., Carrillo, G., Epstein, M., Llapapasca, M., & Gonzalez-Pestana, A. (2019). Killer whale (*Orcinus orca*) occurrence and interactions with marine mammals off Peru. *Pacific Science*, *73*(2), 261-273. https://doi.org/10.2984/73.2.7

Tixier, P., Gasco, N., Duhamel, G., & Guinet, C. (2016). Depredation of Patagonian toothfish (*Dissostichus eleginoides*) by two sympatrically occurring killer whale (*Orcinus orca*) ecotypes: Insights on the behavior of the rarely observed Type D killer whales. *Marine Mammal Science*, *32*, 983-1003. https://doi.org/10.1111/mms.12307

Tixier, P., Gasco, N., Duhamel, G., Viviant, M., Authier, M., & Guinet, C. (2010). Interactions of Patagonian toothfish fisheries with killer and sperm whales in the Crozet Islands Exclusive Economic Zone: An assessment of depredation levels and insights on possible mitigation strategies. *CCAMLR Science*, *17*, 179-195.

Tixier, P., Giménez, J., Reisinger, R. R., Méndez-Fernandez, P., Arnould, J. P. Y., Cherel, Y., & Guinet, C. (2019). Importance of toothfish in the diet of generalist subantarctic killer whales: Implications for fisheries interactions. *Marine Ecology Progress Series*, *613*, 197-210.

Totterdell, J., Wellard, R., Reeves, I. M., Elsdon, B., Markovic, P., Yoshida, M., Fairchild, A., Sharp, G., & Pitman, R. L. (2022). The first three records of killer whales (*Orcinus orca*) killing and eating blue whales (*Balaenoptera musculus*). *Marine Mammal Science*, *1*, 1-16. https://doi.org/10.1111/mms.12906

Van Waerebeek, K. (1992). Records of dusky dolphins, *Lagenorhynchus obscurus* (Gray, 1828) in the eastern South Pacific. *Beaufortia*, *43*(4), 45-61.

Van Waerebeek, K., Reyes, J. C., & Luscombe, B. A. (1988). Revisión de la distribución de pequeños cetáceos frente al Perú [Review of the distribution of small cetaceans off Perú]. In H. Salzwedel & A. Landa (Eds.), *Recursos y dinámica del ecosistema de afloramiento Peruano* [Resources and dynamics of the Peruvian upwelling ecosystem] (pp. 345-351). *Boletín del Instituto del Mar del Perú, Callao*, Vol. Extraordinario.

Van Waerebeek, K., Leaper, R., Baker, A. N., Papastavrou, V., Thiele, D., Findlay, K., Donovan, G., & Ensor, P. (2010). Odontocetes of the Southern Ocean sanctuary. *Journal of Cetacean Research and Management*, *11*(3), 315-346.

Vargas-Bravo, M. H., Elorriaga-Verplancken, F. R., Olivos-Ortiz, A., Morales-Guerrero, B., Liñan-Cabello, M. A., & Ortega-Ortiz, C. D. (2019). Ecological aspects of killer whales from the Mexican Central Pacific coast: Revealing a new ecotype in the Eastern Tropical Pacific. *Marine Mammal Science*, *37*(2), 674-689.

Visser, I. N. (2000). Killer whale (*Orcinus orca*) interactions with longline fisheries in New Zealand waters. *Aquatic Mammals*, *26*(3), 241-252.

Whitehead, H. (2020). Cultural specialization and genetic diversity: Killer whales and beyond. *Journal of Theoretical Biology*, *490*, 1-11. https://doi.org/10.1016/j.jtbi.2020.110164

Williams, R., & Thomas, L. (2009). Cost-effective abundance estimation of rare animals: Testing performance of small-boat surveys for killer whales in British Columbia. *Biological Conservation*, *142*, 1542-1547. https://doi.org/10.1016/j.biocon.2008.12.028