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First records of orca, *Orcinus orca* (Linnaeus, 1758) (Mammalia Cetacea), predation on sharptail ocean sunfish, *Masturus lanceolatus* (É. Liénard, 1840) (Pisces Molidae), with novel components of foraging behaviour discovered through social media

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ABSTRACT Foraging techniques for orca - *Orcinus orca* (Linnaeus, 1758), killer whale, Mammalia, Cetacea), have been documented since at least the 16th century and in the last few decades a wide range of behaviours such as 'carousel feeding', 'intentional stranding' and 'karate-chopping' have been added to the species repertoire. During a recent global review, where records were sourced primarily through social media postings, orca interactions with the large species of ocean sunfish - *Mola* spp. and *Masturus lanceolatus* (É. Liénard, 1840) (Actinopterygii, Tetraodontiformes, Family Molidae) - were collated. We discovered orca utilizing novel components of foraging strategies on these fishes. Specifically, after targeting the molids pectoral fins, the orca; (i) created a wound in the side of the molid and removed the intestines (and potentially other organs) from the still-alive molid and consumed them and (ii) then disarticulated the molid and inserted their rostrum (maxillae & mandibles) into the body cavity to extract tissue. These behaviours were documented in the South Atlantic, Oceania and the eastern Pacific Ocean, with those in the latter including what we believe to be the first confirmed predation by orca of *Ma. lanceolatus*. That, coupled with the novel behaviours described, may suggest an orca ecotype which has yet to be formally described, highlighting how social media can be used to document biodiversity.

KEY WORDS Killer whale; predation; new species; social media; molid.

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INTRODUCTION

The foraging behaviour of orca - *Orcinus orca* (Linnaeus 1758), also known as killer whales - has held fascination for naturalists and scientists since at least the mid-16th century. A drawing of an adult male orca attacking a mother-calf whale pair was depicted as early as 1558 (Gesner, 1558) and descriptions of attacks on prey are given from as early as the mid-17th century (Gaius, 1669). Foraging strategies and diet have continued to be described throughout the ages (Dudley, 1724; Dewhurst, 1834; Eschricht, 1866; Richard & Neuville, 1936; Cotton, 1944) with more recent additions including diverse strategies such as *inter alia* 'carousel feeding' (Similä & Ugarte, 1993), 'intentionally stranding' (López & López, 1985) and 'karate-chopping' (Visser, 2005). Likewise, new species of prey for orca continue to be revealed (Visser et al., 2010; Dunn & Claridge, 2014; Wellard et al., 2016; Visser et al., 2023).

Ocean sunfish are large marine fishes, typically found in tropical and temperate waters, although at times they range into cooler waters (Caldera et al., 2020). Currently, three genera and four species are recognised; the ocean sunfish *Mola mola* (Linnaeus 1758), giant sunfish *Mola alexandrini* (Ranzani 1839), the hoodwinker sunfish *Mola tecta* Nyegaard, Sawai, Gemmell, Gillum, Loneragan, Yamanoue et Stewart, 2017 (Sawai et al., 2018), and the sharptail sunfish *Masturus lanceolatus* (Liénard, 1840) (Fricke et al., 2020), hereafter collectively referred to as molids. The third genus is monotypic and contains the small species slender sunfish *Ranzania laevis* (Pennant, 1776), which is not discussed further herein.

Consumption of large molids, including scavenging, has been described for birds, elasmobranchs, pinnipeds and orca: see reviews in Nyegaard et al. (2019) and Visser et al. (2023). Many records prior to the revision of the genus *Mola* (Sawai et al., 2018) note the molids as *M. mola*, however, some of these may have been mistaken for other molid species. Two molid species were recently confirmed as prey for orca, based on imagery of the interactions; *M. mola* and *M. alexandrini* (Visser et al., 2023).

As part of that Visser et al. (2023) study, we assessed videos and photographs that were sourced online via popular social media platforms. During that process we noticed orca behaviour which repeated across videos and included targeting of the molid fins and utilization of novel components of foraging strategies. We also identified a species of molid that had not previously been documented as prey for orca. Herein we describe these orca behaviours in detail and provide evidence of the new orca prey species (*Ma. lanceolatus*).

MATERIAL AND METHODS

During the aforementioned review, we identified interactions captured on video and/or photos, where molid fin targeting behaviours and/or novel foraging methods were evident. These all originated from social media platforms. For each interaction we noted the; date, location, point-of-view (POV) of the observer, molid species, number of molids, the age/sex class of the orca involved and the behaviour of the orca.

The molid species was established to the lowest possible taxonomic level based on the morphology visible in the imagery (Sawai et al., 2020) and size was estimated as Total Length [TL; anterior-most to posterior-most point], based on the size relative to the orca, combined with a subjective judgement of the molid morphology.

Following Visser et al. (2023), we noted the number of orca involved in the interaction (rather than all orca present) and their age/sex class. Dyads (defined as at least one individual confirmed as an adult female and at least one individual confirmed as calf/juvenile) were noted, as not only was there the potential for cultural transmission (see explanations in Visser et al., 2023), but calves (who would likely still be suckling) or juveniles (who may supplement their solid food intake with suckling) may also influence foraging behaviour of their mothers. Additionally, for this publication we noted when neonates [newly born orca of ~2–2.5 m long (Ford, 2018)] were present. Although it is unlikely that the neonates consumed the molids, lactation for cetaceans is a metabolically expensive process (Oftedal, 1997) and as such impacts the mothers nutritional requirements. We noted if any of the orca were pregnant as, like lactation, it is metabolically challenging.

We defined the interaction according to the orca categories of Visser et al. (2023) (their Table 2), whereby Predation involved killing the molid and subsequent consumption may have been; (a) unknown, (b) suspected or, (c) confirmed.

For interactions where the molid was already dead when the observation began, we presumed it had been killed by the orca (rather than being found dead by the orca). This assumption was made based on the limited records of orca scavenging, and that those are predominantly associated with whaling vessels (Whitehead & Reeves, 2005) or discards of fish from freezer (Couperus, 1994) and seiner trawlers (van Opzeeland et al., 2005).

Where videos were available, they were reviewed in an iterative way, particularly noting orca behaviours which were repeated across other interactions. Each was studied at various play-back speeds, including frame-by-frame, to ascertain the finer details of the behaviours. Photographs were assessed to establish if behavioural aspects were similar to those in the videos or if they provided additional information. Extracted frames and/or still photographs were used to illustrate behaviours and for some, diagrams outlining key aspects of the behaviour were created.

To ascertain if orca used similar or novel behaviours during molid predation, compared to predation on other taxa, we assessed the orca behaviour alongside our working knowledge of the published literature documenting orca predation and evaluated a subset which; (a) described specific events and/or (b) discussed orca predation in general. We searched for; (i) targeting of the pectoral fin(s) and/or, (ii) eating of intestines and/or, (iii) rostrum (maxillae and mandibles) insertion into the body cavity. For our definition of 'pectoral fin', although we excluded the wing-tips of rays as they did not have a clearly defined 'joint' on the body like an appendage, we did include the pectoral fins of cetaceans, the fore-flippers of turtles and pinnipeds as well as the wings of penguins as we considered these to be analogous appendages to the pectoral fins of molids. During our review of the literature, we included the stomach contents of orca, where the authors specifically made mention of whole or parts of pectoral fins, fore-flippers and/or intestines e.g., "*harbour seal claws (8 hind, 6 fore)*" (Heise et al., 2003). We excluded instances of orca predation where the prey item was; (1) consumed whole e.g., "*… engulf[ed] the sea otter in its mouth*" (Hatfield et al., 1998) and/or, (2) compromised e.g., wounded from whaling or on a line, (Whitehead & Reeves, 2005; Passadore et al., 2015) and/or, (3) records from captivity as the behaviour of confined orca has been so highly modified (Marino et al., 2019).

RESULTS

Overview of interactions

From the dataset described in Visser et al. (2023), we extracted (*n* = 8) orca-molid interactions (Fig. 1, Table 1) for which there were videos or photographs which depicted the orca behaviours we had identified. They were sourced from Facebook (*n* = 1), YouTube (*n* = 2) and Instagram (*n* = 5). Upon contacting sources of the accounts, additional information (a blog and a private source) were also included (Table 1). In all but one in-

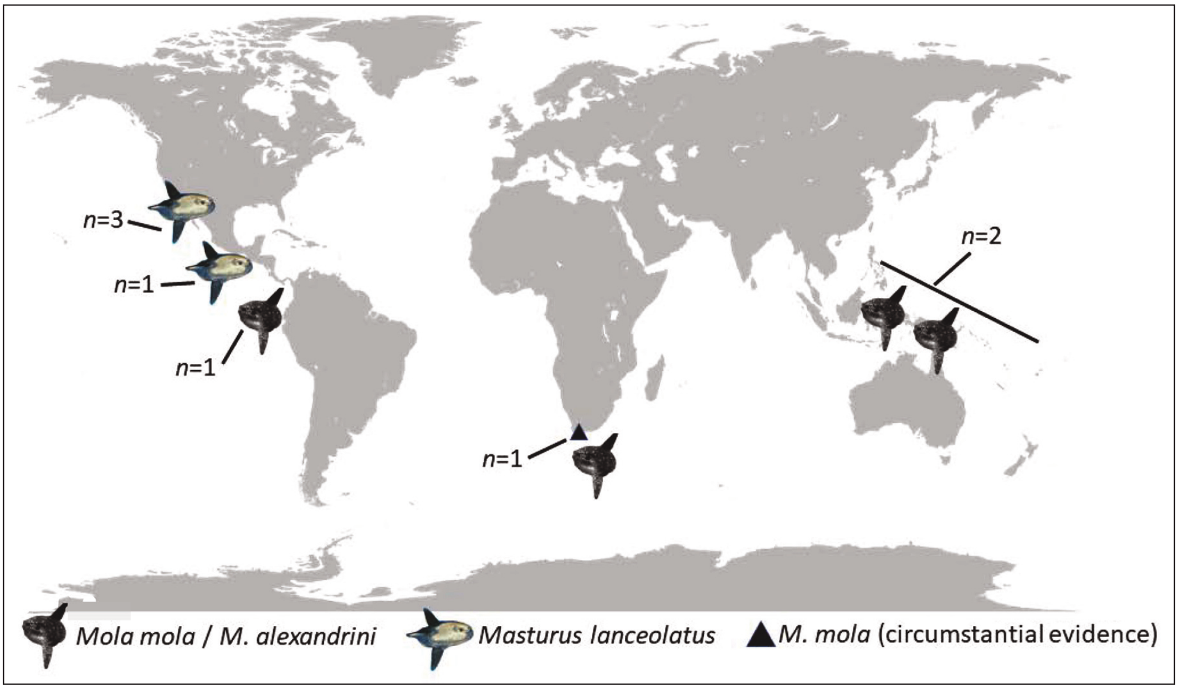


Figure 1. Orca-molid interactions, by molid species. Seven of the eight records were distributed in the eastern Pacific Ocean rim and in Oceania, whilst one was documented off South Africa. See Table 1 for details.

#	Date	Location	Camera position	Type	Videographer/ Photographer	# of molids, species, size	[# of orca], age/sex class	Orca Behaviour	Molid status (caveat)	Source
#1	20170131	Ecuador, Galápagos Islands, San Cristobal	T/S	Video	Francis Zavala, Galápagos Eco Fishing	x1, *Mola alexandrini* Est. 2 - 2.5	[5] 2x Adult female 3x Calf/juvenile	✓ Timid (+ x2 fast rushes) ✓ Target pectoral fin (suspected) ✓ Push sunfish using fins	Killed (Suspected)	YouTube [1]
#2	20180105	Papua New Guinea, Kimbe Bay	T/S & U/W	Video	Rachel Stewart, Matthew Barry, Walindi Dive Resort	x1, *Mola mola* Est. 2 - 2.5	[2] 1x Adult female 1x Calf/juvenile	✓ Timid ✓ Target pectoral fins (bleeding) ✓ Push sunfish using fins	Killed (Suspected)	YouTube [2]
#3	20191013	Malaysia, South Kapalai	U/W	Video	Vito Maffei, Scuba Junkie	x1, *Mola alexandrini* (likely) Est. 1.5 - 2	[1] 1x Calf/juvenile	✓ Timid ✓ Target pectoral fin (fin missing)	Killed Consumed	Facebook [3]
#4	20210205	Costa Rica, Pacific Coast	U/W	Video & Photo	Dario Nessi	x1, *Masturus lanceolatus* (likely) Est. 1.5	[5] 1x adult male 2x Adult female (P) 2x Calf/juvenile + neonate x2	✓ Consume intestines ✓ Split molid ✓ Insert rostrum	Killed Consumed	Instagram [4]
#5*	20210208	South Africa, False Bay, Simon's Town	T/S	Photo	David Hurwitz, Dani Abras, Simon's Town Boat Company	x1, *Mola mola* Est. 1.5 - 2	[1] 1x Adult male	✓ Extract intestines ✓ Consume intestines (suspected)	Killed Consumed (Suspected)	Instagram [5] Private
#6**	*circa* 20210823	Mexico, Sea of Cortez	U/W	Photo	Frida Lara	x1, *Masturus lanceolatus* Est. 1 - 1.5	[2] 1x Adult female (P) 1x Calf/juvenile + neonate x1	✓ Consume intestines (suspected) ✓ Split molid ✓ Insert rostrum	Killed Consumed	Instagram [6]
#7	20220611	Mexico, La Ventana, Isla Cerralvo	U/W	Video & Photo	Ryan Sault, Breeanna Platter, Giacomo Rossi	x1, *Masturus lanceolatus* Est. 1.5 - 2	[5] 2x Adult female (P) 2x Calf/juvenile 1x undetermined + neonate x1	✓ Timid ✓ Target pectoral fins (bleeding) ✓ Extract intestines ✓ Consume intestine ✓ Split molid ✓ Insert rostrum	Killed Consumed	Instagram [7] Blog [8]
#8	20220803	Mexico, Cabo San Lucas	U/W	Video	Evans Baudin	x1, *Masturus lanceolatus* Est. 1.5 - 2	[3] 1x Adult female 2x Calf/juvenile	✓ Target pectoral fin (fin missing) ✓ Extract intestines (suspected) ✓ Consume intestine (suspected) ✓ Split molid ✓ Insert rostrum	Killed Consumed	Instagram [9]

Table 1. Orca-molid interactions documented in videos/photos and reviewed in this study. Orca behaviours and molid status were confirmed unless stated as suspected. See text for details. Date is yyyymmdd. Abbreviations: # = interaction number, T/S = topside, U/W = underwater, * = interaction details based on circumstantial evidence, ** = original, unedited video/photos were not available, (P) = at least one female involved was pregnant. See Reference section for links 1-9.

stance, the authors/videographers/photographers kindly made their original, unedited material available for this study. The interactions were distributed in Oceania and the eastern Pacific Ocean (n = 7), with one circumstantial record off South Africa (Fig. 1).

The number of orca involved ranged from one (n = 2) to five (n = 3). Where the group size was a single animal, one was a solitary adult male, whilst the other was a single calf/juvenile. However, although the latter was documented foraging alone on the molid, at least one other orca was documented in the area at the same time - but was not observed to participate in the predation (see Visser et al., 2023). The remaining six interactions all included Dyads, and at least four neonates were documented, with the latter all occurring during the four *Ma. lanceolatus* interactions. Three of the eight interactions involved orca who were pregnant (Table 1).

Molids

Within each of the eight interactions, only one molid was involved. We were able to confirm predation on three molid species; *M. alexandrini*, *M. mola* and *Ma. lanceolatus* (Table 1), with the four of *Ma. lanceolatus* being, what we believe, the first records of predation by orca of this species.

Orca behaviour

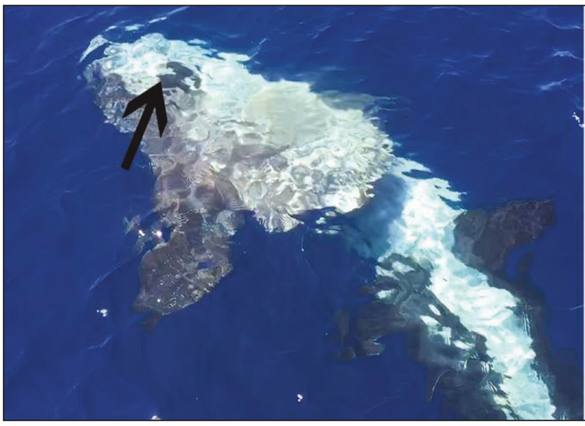
We assessed the behaviour of the orca in (*n* = 6) videos, two of which also had photographs available. A further two records had only photographs (Table 1), however these provided sufficient evidence to allow assessment of some aspects of the orca behaviour.

During four of the interactions where video was available, we noted that the orca generally behaved in a way that could subjectively be described as 'timid' or 'cautionary'. In essence, the orca were slow to approach the molids and typically approached from behind or below (noting however, that the molid was also actively attempting to keep its clavus to the orca, see Nyegaard et al., 2023, for details regarding these molid behaviours). Even when the molid was fatally wounded, the orca still exhibited this slow behavioural tempo. One interaction (#1) differed as the orca behaviour included not only slow approaches, but also at least two much faster 'rushes', both of which resulted in 'Evade' behaviours by the molid (see Visser et al., 2023 their Figs. 13, 14). We could not assess all eight of the interactions for this timid/cautionary behaviour because not all observations included video (e.g., interaction #5) and in some instances the observers arrived on site after the molid had already been killed (e.g., interactions #4 & #8).

<u>Targeting</u>

The targeting of molid pectoral fins was documented in five interactions (Table 1). At times the orca deliberately maneuvered to be under the molid (including by inverting) and orientated towards the pectoral fin (Figs. 2, 3 and see Fig. 23 in Visser et al., 2023). Targeting of the pectoral fin was also evidenced by bleeding from the base of the fin(s) (Figs. 3, 4 and see Fig. 21 in Visser et al., 2023) and/or injuring the fin(s) or fin-base and/or removal of the fin(s) (Figs. 5, 6). Additionally, in one interaction the orca had also removed the extremities of both the dorsal and anal fins (Fig. 6 and see Supplemental Material 1 (S–1), Fig. S–1.1). In another interaction, tissue was documented protruding from the eye area (Fig. 5).

During interaction #2, filmed both topside and underwater, an orca targeted the pectoral fin when it placed the tip of its lower jaw (i.e., the mandibular symphysis area) against the base of the molid's pectoral fin (Fig. 7), but we noted that during this process the orca did not open its mouth to grasp the pectoral fin. At the same time as targeting the pec-



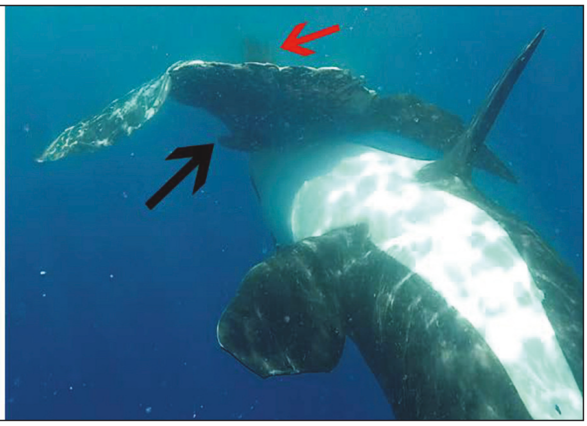


Figure 2 (left). Interaction #2. An adult female orca has inverted herself and begun to move under a *M. mola* lying parallel to the surface, in order to target the left pectoral fin of the molid (arrow indicates the right pectoral fin). See Fig. 3 for underwater view. Frame from video by Matthew Barry. Figure 3 (right). Interaction #2. The same orca and molid pair as in Fig. 2, viewed from underwater as the orca approaches closer to the left pectoral fin (black arrow indicates tip), whilst a small amount of blood (red arrow) can be seen near the right pectoral fin (not visible here). Frame from video by Rachel Stewart.

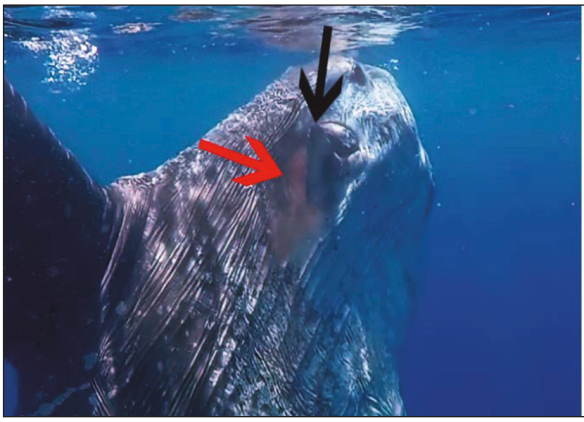
toral fin, the orca propelled the molid forward, which it achieved by placing its own pectoral fins near or against the base of the dorsal and anal fins of the molid and swimming forward. In this context, the targeting appeared to be an attempt to 'steer' the sluggish/non-reactive molid as it was pushed forward and closer to the surface. During interaction #1, documented from topside only, the behaviour of the orca closely resembled, and was comparable in its execution to that observed underwater in interaction #2, but was performed at the surface.

Extraction of intestines

During three interactions the orca were either suspected or confirmed to extract the intestine from the molid. During interaction #7, a *Ma. lanceolatus* had a large Y-shaped wound in its right side (Fig. 8), yet it was still alive and continued to sluggishly exhibit 'Evade' behaviours (as defined by Nygaard et al., 2023). See Figs. S–1.2–1.4 with regards to the wound extending around the base of the pectoral fin and potentially to the gill opening. Additionally, we noted that the molid had a remnant of its intestine which protruded occasionally out of its mouth (see Figs. S–1 1.5–1.7).

The intestine had been removed as evidenced by the vestiges protruding from the wound (Figs. 8 and S–1.2, 1.3) and observations of orca carrying the intestines (Figs. 9, 10 and S-1.8–1.10). The length of one piece of the intestine was at least 4 m, i.e., over half the length of the orca (Figs. 9 and S-1.8), whilst another piece was at least 2 m in length (Fig. 10). Within this one interaction, at least three individuals were documented and uniquely identified using the pigmentation variations of their eye-patches (following Visser & Mäkeläinen, 2000 and see Figs. S-1.11–S–1.13 for details). One of those was pregnant, based on the rotund shape of her abdominal region (Fig. 10).

During interaction #5, in what we have categorized as 'circumstantial evidence', the intestines of a *M. mola* were documented. The lone male orca "*was grabbing, diving and swimming*" with the molid and subsequently submerged with it (pers. comm. David Hurwitz). The orca remained in the general location, with 'milling' dives (i.e., indicative of foraging on prey as described in Visser et al., 2010) and during the entire interaction a Cape fur seal (*Arctocephalus pusillus pusillus* Schreber, 1775), accompanied the orca (Fig. 11). One hour and 16 minutes after the molid was last seen at the surface, and in the location where the orca continued to mill, the Cape fur seal surfaced with a portion of molid intestines (Fig. 12), which were presumably extracted from the molid by the orca, based on the latter's foraging behaviour (pers. comm. David Hurwitz, Dani Abras). The Cape fur seal proceeded to flick the intestines (Figs. 12 and S–1.14, 1.15) in a similar way to that documented for pinnipeds feeding on a range of prey (Hocking



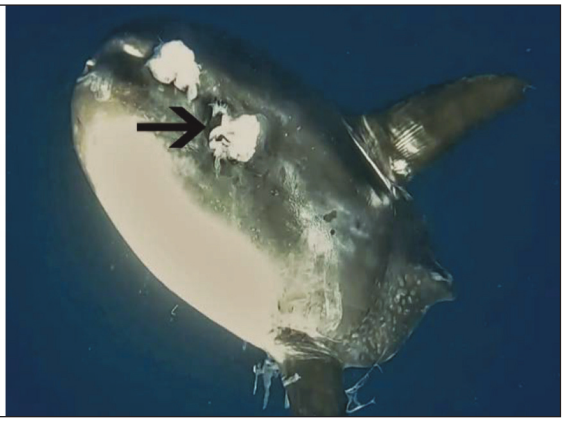
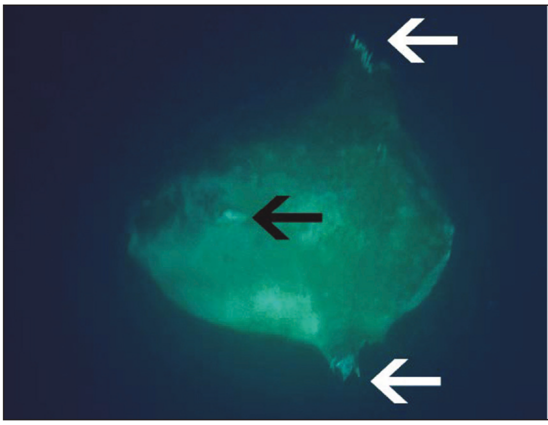


Figure 4 (left). Interaction #2. The same molid as in Figs. 2 and 3, bleeding (red arrow) from the area behind the right pectoral fin. The tip of fin (black arrow) is angled towards the camera. Frame from video by Rachel Barry.
Figure 5 (right). Interaction #8. The remains of a *Ma. lanceolatus* which is missing the pectoral fin (arrow indicates a small piece of skin at the base of where the pectoral fin was previously attached). The protruding flesh, above the arrow, appears to extrude from the eye. Frame from video by Evans Baudin.

et al., 2015). The seal subsequently consumed the molid intestines (pers. comm. David Hurwitz), in what we believe to be the first record of predation on *M. mola*, for this species of pinniped.

Consumption of intestines

During interaction #7, after the various orca carried sections of *Ma. lanceolatus* intestines, they



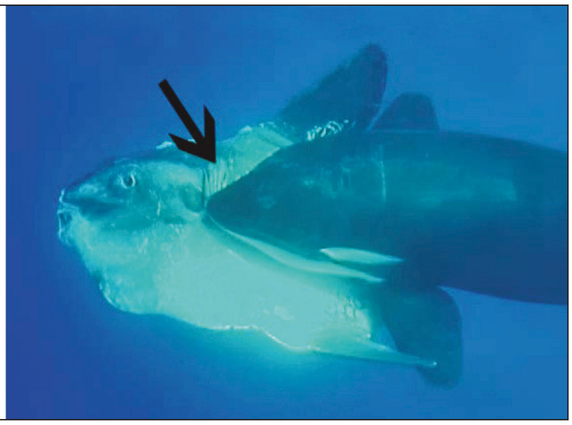


Figure 6 (left). Interaction #3. A non-reactive, fatally wounded (or already dead) molid, *M. alexandrini*, with the left pectoral fin missing (black arrow indicates remaining base of fin) and the extremities of the dorsal and anal fins bitten off (white arrows). Frame from video by Vito Mafei. Figure 7 (right). Interaction #2. A juvenile orca interacting with the same molid as in Figs. 2–4. The orca targeted the base of the molids left pectoral fin (arrow indicates tip) with the tip of its mandibles (mouth closed), in an apparent attempt to 'steer' the molid whilst propelling it forward. The orca had hooked its pectoral fins under the dorsal and anal fins of the molid whilst swimming. Frame from video by Rachel Barry.

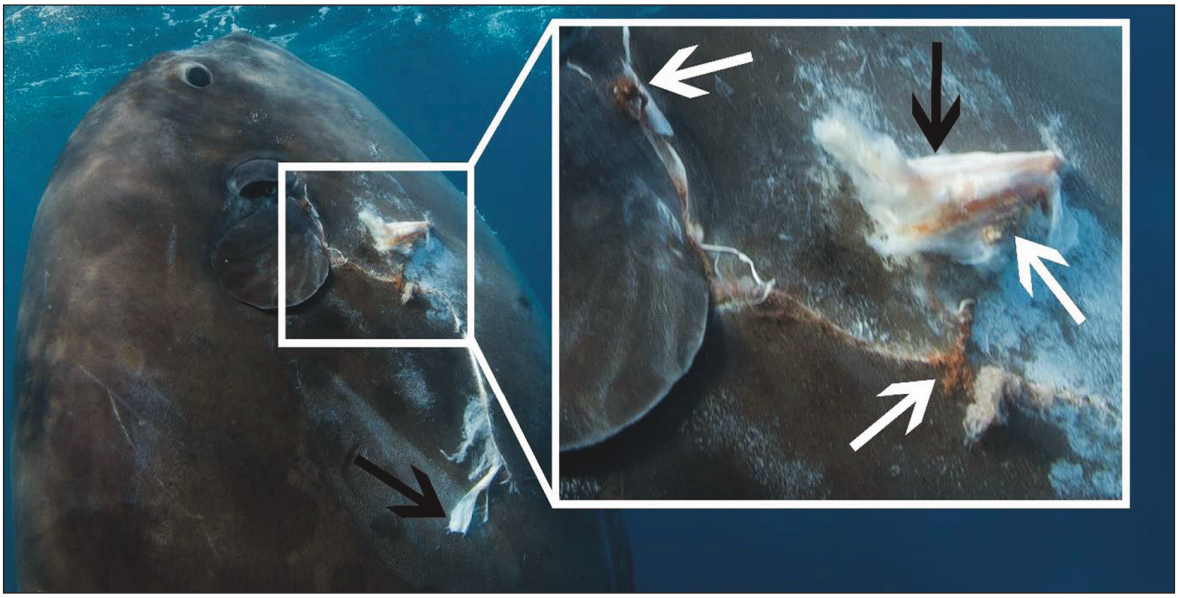


Figure 8. During interaction #7, the intestine (and potentially other internal organs) were removed by orca via a slit in the right side of the still-alive *Ma. lanceolatus*. Small remnants of the intestine were still attached and protruded from either end of the slit (black arrows, main and insert) along with unidentified granulated tissue (white arrows, insert). Note that the slit is Y shaped; the top left section encompasses the base of the pectoral fin which may be partially disarticulated (see S–1.2–1.4 for an additional angle of this wound), whilst the top right has a section of intestine protruding from it (black arrow insert). The longest section of the slit extends towards the posterior of the molid with connective tissue and a small portion of the remaining intestine (black arrow main image) protruding from it. Photo by Ryan Sault.

consumed them. Whilst biting into the intestines, smaller portions (~10–30 cm in length) were dislodged and dispersed into the water column and other orca from the group approached and consumed these (Fig. 13).

Split and disarticulated molids

We documented four interactions where during, and/or post, the process of extracting the intestines the molid was split further open (Fig. 14) and subsequently disarticulated (Fig. 15). The disarticulated remains included those which had dorsal and/or anal fins still attached (S–1.16 and see Fig. 25 in Visser et al., 2023) and/or parts of the clavus still attached (Fig. 15 and Fig. S–5.9 in Visser et al., 2023). As consumption continued and the larger sections of flesh got progressively smaller, some parts of the molid could still be identified e.g., the pectoral fin (Fig. 16). At times the skin showed orca teeth puncture marks (e.g., Fig. 17 and Fig. S–5.9 in Visser et al., 2023).

As consumption continued during the four interactions with *Ma. lanceolatus*, several of the remains were 'pockets' of skin and flesh (Fig. 18) which encompassed the 'capsule' (the thick subcutaneous layer as described by Davenport et al., 2018). As the molid remains were reduced in size, these pockets at times became 'V-shaped' (Fig. 18).


Figure 9 (left). Interaction #7. An orca carries a section of the *Ma. lanceolatus* intestine, estimated to be at least 4 m long. Photo by Ryan Sault. Figure 10 (right). Interaction #7. A second orca, a pregnant female, also carried another section of the molid's intestines, at least 2m in length. Photo by Ryan Sault.


Figure 11 (left). Interaction #5. A Cape fur seal (*Arctocephalus pusillus pusillus*) accompanied an adult male orca, the latter of whom predated on a *M. mola*. Photo by Dani Abras. Figure 12 (right). Interaction #5. The same Cape fur seal as Fig. 11, flicking the intestines of a *M. mola*. Photo by Dave Hurwitz.

During each of these four records, at least one orca was observed placing its rostrum into the body cavity of the molid remains (Figs. 18, 19 and S–1.17), a component of orca feeding behaviour not previously documented (i.e., orca have not been documented inserting their 'faces' into the body cavity of their prey, Table 2). At times the insertion was nearly in as far as the mouth gape (Fig. 19) and in one instance where the molid was split but the remains were not V-shaped, the orca inserted its head half-way along the length of the eye-patch. During three interactions (#4, #6 & #7), where the orca were documented feeding in this way, pregnant orca were involved (Table 1, Fig. 10). During the same three interactions, neonates were also present, indicating that another adult female was lactating; i.e., heavily pregnant females, with a gestation of approximately 17 months (Reidenberg & Laitman, 2008), will not also be suckling a neonate. In interaction #6, only the photographs online were available (i.e., no additional images or data were provided). In those images, three orca were documented (a Dyad, where the female was pregnant, and both a calf/juvenile, and a neonate). The mother of the neonate was either not photographed, or her image was not posted online, but her presence was likely.

Comparison to other predation techniques

To ascertain if orca used similar or novel behaviours during molid predation, we assessed articles (n = 100) which discussed predation on 50 species (see S–2 for publications and species details). We searched for; (i) targeting of the pectoral fin(s) and/or, (ii) eating of intestines and/or, (iii) rostrum insertion into the body cavity, with only the targeting of pectoral fins recorded for other taxa (Table 2). Although this behaviour was documented, it was not prevalent e.g., 50 species were included in this assessment (with 10 species represented by three or more publications), yet targeting of pectoral fins was documented for fewer than half (n = 21) of these (see Table 2 for a summary and S–2 for details). However, within that subset of 21 species there was a strong bias towards pectoral fin targeting of cetacean species (n = 13) (with 6 species represented by three or more publications) compared to only two species of sharks (see S–2 for details).

We could find no descriptions of the extraction and/or consumption of the intestines by orca for any prey species (see Table 2 and S–2). Conversely, a number of publications either explicitly state that the intestines were not consumed e.g., "*The heart and most of the diaphragm appeared to have been removed, leaving the lungs, liver and the digestive tract virtually intact.*" (Best et al., 2010), and/or provided illustrations with the intestines still present after predation by orca e.g., Visser et al. (2023),

Figure 13. Interaction #7. One of the orca recovered a piece of *Ma. lanceolatus* intestine (~30 cm in length) from the water column and consumed it. Photo by Ryan Sault.

Orca behaviour / Taxa	Target pectoral fin	Consumes intestines	Inserts rostrum into body cavity
Elasmobranchs	✓	~	~
Teleosts	~	~	~
Chelonioids	✓	~	~
Aves	~	~	~
Pinnipeds	✓	~	~
Cetaceans	✓	~	~
Molids	✓	✓	✓

Table 2. A comparison of the orca predation behaviour recorded herein (Molids, grey row), to that on other taxa, with specific reference to; (i) targeting of the pectoral fin(s) and/or, (ii) eating of intestines and/or (iii) rostrum insertion into the body cavity. Publications (n = 100) were reviewed for these behaviours and 50 species were included in those publications; see S-2 for details.

their Figure S–4.3, with the caption "*The remains of an unidentified hard-shelled turtle predated on by orca. Note that nearly all of the tissue was eaten by the orca, but that intestines are left behind*". Additionally, at times, although the author(s) do not make mention of the intestines being consumed, assumptions can be made that they were not consumed when they state, for example, "*only the skin and tongue were eaten*" (Jonsgård, 1968).

DISCUSSION

Scientific publications, which utilize wildlife featured in social media, have included a range of topics *inter alia*; the monitoring of illegal trade (Sardari et al., 2022), investigating the scope of wildlife disturbance by humans (Cloutier et al., 2021), exposing animal welfare issues (Nghiem et al., 2012), documenting conservation benefits and risks (Bergman et al., 2022), assessment of charismatic species (Hausmann et al., 2017) and species' presence (Willemen et al., 2015). However, we could find remarkably few publications that illustrated how social media was utilized to provide evidence of the presence of new species; one notable exception was five fish species (Al Mabruk et al., 2021). Moreover, we could find no publications which utilized these platforms to collate data regarding new prey species and/or novel components of foraging behaviour for an apex predator.

Likewise, within the scientific literature we did not find any descriptions of the extraction and consumption of the intestines by orca for any prey species (see Table 2 and S–2), nor could we verify orca inserting the anterior of the head into the body cavity for any other taxa. These two novel components of foraging, when combined with the pectoral fin targeting, provide an insight into orca predation on molids which had previously remained elusive.

The targeting of pectoral fins appears to be an important facet of orca foraging strategy when pursuing molids, as >60% of the interactions documented herein include this component of predation behaviour (although we note that it may have been more prevalent than we documented, as the remaining events could not be assessed for targeting of pectoral fins). The behaviour escalated when the pectoral fin was injured, e.g., bleeding was evident in some instances. Due to our limited dataset and the opportunistic nature of these sightings, we can only speculate as to why this behaviour was occurring. Various authors comment on orca targeting and injuring the pectoral fins of cetaceans (e.g., Mehta et al., 2007; Gemmell et al., 2015), including that the orca bite the "*flippers of large whales presumably to slow or stop their movement*" (Jefferson et al., 1991). However, molids use their pectoral fins primarily to fine tune their movement (Harbison & Jannssen, 1987; Davenport et al., 2018), therefore similar injuries are unlikely to hold the same consequences for them. Since this behaviour has been documented when orca predate on other taxa (i.e., chelonioidea, elasmobranchs, aves, pinnipeds and cetaceans) there is the possibility that this foraging strategy, which is presumably successful given its prevalence, has been cross-pollinated and applied to molid foraging. Furthermore, it cannot be ruled out that cultural transmission of such behaviour is occurring and/or is manifested by specific orca populations (also known as ecotypes, see Visser et al., 2023 for a discussion about these).

For the orca, the molid appendages may provide an access point into the body cavity in order to extract the internal organs and tissue. The large Y-shaped incision in the molid that we observed in interaction #7 appeared to be the result of the orca utilizing the pectoral fin in such a way. Similar use of the pectoral fins by orca to open the body cavity of elasmobranchs, has been documented for at least three species of sharks (Engelbrecht et al., 2019; Towner et al., 2022; Visser unpublished data) when the orca are targeting the lipid-rich livers.

The value of molids as prey for orca may be related to a number of factors, none of which appear to be mutually exclusive. For example, the high water content of molid tissues - up to 89.8% water for the thick subcutaneous layer (Davenport et al., 2018) and between 79–83% of the red and white fin muscle (Watanabe & Davenport, 2020) - is likely beneficial during metabolically challenging pregnancies (recalling that in this study at least three pregnant females were documented). Similarly, for toothed cetaceans lactation can be metabolically expensive as the milk can be composed of up to 77% water (Oftedal, 1997). Lactation was occurring in all (but the one case of the lone male) interactions, based on the presence of at least four neonates (all

Figure 14 (left). Interaction #8. A *Ma. lanceolatus* was split open, from the pectoral fin to the base of the dorsal and anal fins, by the orca. Frame from video by Evans Baudin. Figure 15 (right). Interaction #7. Typically, the molid was disarticulated, leaving large pieces of the body. In this case part of the clavus of the molid is visible (arrow), whilst the orca removes sections of the flesh and skin. Photo by Giacomo Rossi.

Figure 16 (left). Interaction #7. The pectoral fin is still attached (arrow) to this part of the molid as it is consumed by the orca. Photo by Giacomo Rossi. Figure 17 (right). Interaction #7. Some of the molid skin exhibited the distinctive puncture marks of orca teeth, seven from one row of either the mandible or maxillae are indicated (arrowheads). Photo by Ryan Sault.

during the *Ma. lanceolatus* interactions) and the presence of calves/juveniles in seven of the eight interactions. Regardless, the benefits of feeding on such water-rich prey likely has high value to any orca, as metabolizing ingested food is understood to be the primary source of fresh water for cetaceans (Ortiz, 2001; Rash & Lillywhite, 2019). We documented other non-pregnant orca feeding on molids, including single adult males, as have others (Gladstone, 1988; Halstead, 1996; Visser et al., 2023).

Despite molid intestines being consumed by people in some countries (Nyegaard et al., 2020), no data (to the best of our knowledge) are available regarding their nutritional value. Molid intestines occupy much of the abdominal cavity (Chanet et al., 2012), are continuous with the 'stomach' (Bemis et al., 2020) and are muscular and lengthy e.g., a *M. mola* (TL 128 cm) had an intestine which was 384 cm in length (Pastore, 2009). The orca documented herein clearly targeted the intestines, based on the removal of them before the molid had even expired and they consumed all sections of them, including small pieces. Equally, the orca consumed specific parts of the molid to the point where they inserted their jaws into the body cavity, including in the V-shaped ‘pockets’. Given the extensive literature on orca predation, to find these two new components of foraging behaviour, when targeting just one taxa, is suggestive they may be linked; e.g., these molid tissues are nutritionally valuable to the orca.

That high value may be one of the driving forces behind the timid/cautious behaviour documented in these interactions. Although it is not clear why the orca would behave in such a manner, as caution is not the typical predation strategy for this apex predator - e.g., see Similä & Ugarte (1993); Visser (2005); Wellard et al. (2016); Copello et al. (2021) for examples of less cautious foraging behaviours - it may be indicative of some facet of the interactions with molids of which we are as yet unaware. For example, given that molids have no obvious defenses, particularly as no evidence of the biotoxin tetrodotoxin has, to date, been found in any molids (Baptista et al., 2020; Baptista et al., 2022), we speculate that the orca potentially use a slow ‘stalking’ behaviour to reduce the likelihood of the molid fleeing (even when fatally wounded). Although generally perceived to be slow-swimming, this group of fishes can reach bursts of speed and exhibit agility which may enable the molid to escape (Nyegaard et al., 2023), albeit that they are unlikely to be able to match the speed of orca, who are believed to be the fastest of the odontocetes with speeds of up to 12.5m.sec^{-1} attained (Williams, 2008). Despite the superior swimming capabilities of the orca, a slow approach by the predator may still reduce the ‘flight’ response of the prey (Cooper Jr, 2006) and increase the probability of a successful predation event for the orca. Concurrently, a slow approach may also reduce the likelihood that a molid ‘thrashes’ or performs behaviours that may result in their rough skin (Gauldie, 1992; Babu et al., 2019) making contact with the sensitive orca skin (and/or eyes). Nyegaard et al. (2023) documented such ‘thrashing’ behaviour, which caused the orca to recoil from the molid and this resulted in the molid being able to (momentarily) evade the orca (see their Fig. 6). The removal of the extremities of both the dorsal and anal fins during one interaction, may also have been an attempt to reduce the possibility of the molid fleeing or reduce thrashing behaviour.

Despite the fact that molids and orca have similar depth-diving capabilities (Thys et al., 2017; Towers et al., 2018), molids have the advantage of not needing to return to the surface for air and thereby if a molid does deep dive, the orca have a reasonable risk of losing their prey. Although in seven of the eight records herein, the molid was confirmed as killed (and the remaining one was suspected as killed), such a high success rate may be due, in part, to the application of such cautionary behaviour. Visser et al. (2023) found (in both non-predation and

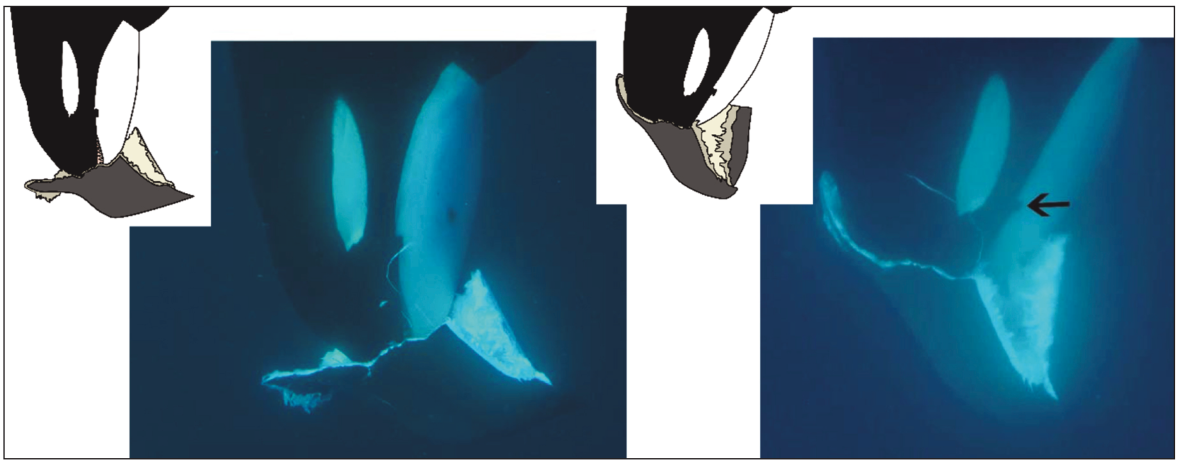


Figure 18 (left). Interaction #7. The molid was disarticulated by the orca into sections. Here, the orca placed its rostrum well into the body cavity of the molid, a feeding behaviour not previously documented for orca. Insert by LAF, photo by Ryan Sault. Figure 19 (right). Interaction #7. The same orca who is featured in Fig. 18, pushed its rostrum into the body cavity so it was inserted nearly to the mouth gape (indicated by the small protruding dark pigmentation, arrow). Insert by LAF, photo by Ryan Sault.

predation interactions) that the molids did not generally attempt to flee and that approximately 59% of interactions resulted in the death of the molid. They expressed the caveats that "*unobserved dive escape attempts may have occurred, or such attempts occur but were not recorded.*"

Given that imagery on social media platforms is typically edited and/or compressed, we found the original versions invaluable for ascertaining sequences of events and details of these wildlife interactions. As technology such as trail cameras (Connolly, 2007) and smartphones (Preece, 2017) continues to advance, and with it increased exposure of wildlife on social media platforms (which can exceed mainstream media e.g., Vins et al., 2022), they can provide opportunities for scientists to gather robust data in a range of diverse ways (Newman et al., 2012). And, although there are evident limitations to using social media to collate data in detail, when citizen scientists/interested members of the public document predation events, these resources can continue to make beneficial contributions towards our better understanding of wildlife behaviours and biodiversity. Importantly, no matter if such imagery/data is gathered/used for science or for entertainment, there needs to be appropriate considerations given as to how anyone interacts with/observes wildlife (Moorhouse et al., 2016; Carr & Broom, 2018) and how these encounters are portrayed on social media (Lenzi et al., 2020; Pagel et al., 2020). As such, we strongly encourage guidelines and laws which endorse responsible wildlife encounters/tourism and sensible representation of wildlife on social media platforms.

Understanding predation (and prey species selection) in predators can help inform conservation and management decisions (Lalas et al., 2007; Finke & Snyder, 2010), including for orca (Copello et al., 2021). For the latter, both predation techniques and prey type are key features typically assessed and utilized for field identification of various orca ecotypes (e.g., Ford et al., 1998; Matkin et al., 2007; Hanson & Walker, 2014; Copello et al., 2021). Although our sample size was small, the records of consumption of *Ma. lanceolatus* all occurred in the Pacific Ocean on the west coast of Central America. That, coupled with the novel behaviours described herein, may suggest an orca ecotype which has yet to be formally described.

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REFERENCES

Al Mabruk S.A.A., Abdulghani A., Nour M.O., Adel M., Crocetta F., Doumpas N., Kleitou P. & Tiralongo F., 2021. The role of social media in compensating for the lack of field studies: Five new fish species for Mediterranean Egypt. Journal of Fish Biology, 99: 673–678. https://doi.org/10.1111/jfb.14721.

Babu C., Silambarasan K., Anrose A. & Ramalingam L., 2019. A new record of a rare species *Masturus lanceolatus* (Point-tail sunfish) from Chennai coastal waters, India. Indian Journal of Geo Marine Sciences,. 48: 297–301.

Baptista M., Braga A.C., Rosa R. & Costa P.R., 2022. Does ocean sunfish *Mola* spp. (Tetraodontiformes: Molidae) represent a risk for tetrodotoxin poisoning in the Portuguese Coast? Marine Drugs. 20:e594, pp. 591–597. https://doi.org/10.3390/md20100594.

Baptista M., Figueiredo C., Lopes C., Costa P.R., Dutton J., Adams D.H., Rosa R. & Raimundo J., 2020. Chapter 11 Biotoxins, trace elements and microplastics in the ocean sunfishes (Molidae) In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfish: evolution, biology and conservation. CRC Press, Boca Raton, FL, USA, pp. 186–215.

Bemis K.E., Tyler J.C., Hilton E.J. & Bemis W.E., 2020. Chapter 4 Overview of the anatomy of ocean sunfishes (Molidae: Tetraodontiformes). In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfish: evolution, biology and conservation. CRC Press, Boca Raton, FL, USA, pp. 55–71.

Bergman J.N., Buxton R.T., Lin H.-Y., Lenda M., Attinello K., Hajdasz A.C., Rivest S.A., Tran Nguyen T., Cooke S.J. & Bennett J.R., 2022. Evaluating the benefits and risks of social media for wildlife conservation. FACETS, 7: 360–397. https://doi.org/10.1139/facets-2021-0112.

Best P.B., Meÿer M.A. & Lockyer C., 2010. Killer whales in South African waters - a review of their biology. African Journal of Marine Science, 32: 171–186. https://doi.org/10.2989/1814232X.2010.501544.

Caldera E., Whitney J.L., Nyegaard M., Ostalé-Valriberas E., Kubicek L. & Thys T.M., 2020. Chapter 3 Genetic Insights into the Taxonomy, Evolution and Development of the Ocean Sunfishes. In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfishes Evolution, Biology and Conservation. CRC Press, Boca Raton, FL, USA, pp. 37–54.

Carr N. & Broom D.M. (Eds.), 2018. Tourism and animal welfare. CABI, Wallingford, UK 190 pp.

Chanet B., Guintard C., Boisgard T., Fusellier M., Tavernier C., Betti E., Madec S., Richaudeau Y., Raphaël C., Dettaï A. & Lecointre G., 2012. Visceral anatomy of ocean sunfish (*Mola mola* (L., 1758), Molidae, Tetraodontiformes) and angler (*Lophius piscatorius* (L., 1758), Lophiidae, Lophiiformes) investigated by non-invasive imaging techniques. Comptes Rendus Biologies, 335: 744–752. https://doi.org/10.1016/j.crvi.2012.11.006

Cloutier T.L., Rasmussen G.S., Giordano A.J., Kaplin B.A. & Willey L., 2021. Digital conservation: using social media to investigate the scope of African painted dog den disturbance by humans. Human Dimensions of Wildlife, 26: 481–491. https://doi.org/10.1080/10871209.2020.1849873.

Connolly C., 2007. Wildlife-spotting robots. Sensor Review. https://doi.org/10.1108/02602280710821407.

Cooper Jr W.E., 2006. Dynamic risk assessment: prey rapidly adjust flight initiation distance to changes in predator approach speed. Ethology, 112: 858–864. https://doi.org/10.1111/j.1439-0310.2006.01240.x.

Copello J.M., Bellazzi G., Cazenave J. & Visser I.N., 2021. Chapter 1 Argentinean orca (*Orcinus orca*) as an umbrella species: Conservation & management benefits. In: Carvelho Mocellin V. (Ed.), Contributions to the global management and conservation of marine mammals. Editora Artemis, Curitiba, Brazil, pp. 1–27. https://doi.org/10.37572/EdArt_1003212861.

Cotton B.C., 1944. Killer whales in South Australia. The Australian Zoologist, 10: 293–294.

Couperus A.S., 1994. Killer whales (*Orcinus orca*) scavenging on discards of freezer trawlers north east of the Shetland islands. Aquatic Mammals, 20: 47–51. https://aquaticmammalsjournal.org/share/AquaticMammalsIssueArchives/1994/Aquatic_Mammals_20_1/20-01_Couperus.pdf.

Davenport J., Phillips N.D., Cotter E., Eagling L.E. & Houghton J.D.R., 2018. The locomotor system of the ocean sunfish *Mola mola* (L.): role of gelatinous exoskeleton, horizontal septum, muscles and tendons. Journal of Anatomy, 233: 347–357. https://doi.org/10.1111/joa.12842.

Dewhurst H.W., 1834. The natural history of the Order Cetacea, and the oceanic inhabitants of the Arctic regions. Dewhurst, London, 294 pp.

Dudley P., 1724. An essay upon the natural history of whales, with particular account of the ambergris found in the Sperma Ceti whale. In a letter to the Publisher, from the Honourable Paul Dudley Esq; F. R. S. Transactions of the Royal Society of London. 22(387): 256–269.

Dunn C. & Claridge D.E., 2014. Killer whale (*Orcinus orca*) occurrence and predation in the Bahamas. Journal of the Marine Biological Association of the United Kingdom, 94: 1305–1309. https://doi.org/10.1017/S0025315413000908.

Engelbrecht T.M., Kock A.A. & O'Riain M.J., 2019. Running scared: when predators become prey. Ecosphere, 10(1):e02531. https://doi.org/10.1002/ecs2.2531.

Eschricht D.F., 1866. On the species of the genus *Orca* inhabiting the northern seas. In: Flower W.H. (Ed.), Recent memoirs on the Cetacea. Ray Society, London, pp. 153–188.

Finke D.L. & Snyder W.E., 2010. Conserving the benefits of predator biodiversity. Biological Conservation, 143: 2260–2269. https://doi.org/10.1016/j.biocon.2010.03.022.

Ford J.K.B., 2018. Killer whale *Orcinus orca*. In: Perrin W.F., Würsig B. & Thewissen J.G.M. (Eds.), Encyclopedia of marine mammals. 3rd ed. Academic Press, San Diego, pp. 669-676.

Ford J.K.B., Ellis G.M., Barrett-Lennard L.G., Morton A.B., Palm R.S. & Balcomb 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-Revue Canadienne de Zoologie, 76: 1456–1471. https://doi.org/10.1016/B978-0-12-804327-1.00010-8.

Fricke R., Eschmeyer W.N. & Van der Laan R., 2020. Eschmeyer's catalog of fishes. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.

Gaius P., 1669. Naturalis Historia. Chapter 5. The balæna and the orca. Vol. Book IX.

Gauldie R.W., 1992. 'Plywood' structure and mineralization in the scales of the ocean sunfishes, *Mola mola* and *M. ramsayi*. Tissue and Cell, 24: 263–266. https://doi.org/10.1016/0040-8166(92)90099-S.

Gemmell G.L., McInnes J.D., Heinrichs S.J. & de Silva Wijeyeratne G., 2015. Killer Whale (*Orcinus orca*) Predation on Whales in Sri Lankan Waters. Aquatic Mammals, 41: 265–271.

Gesner C., 1558. Historiae Animalium, 1156.

Gladstone W., 1988. Killer whale feeding observed underwater. Journal of Mammalogy, 69: 629–630. https://doi.org/10.2307/1381360.

Halstead B., 1996. The Dive Sites of Papua New Guinea - Comprehensive Coverage of diving and Snorkelling. New Holland (Publishers) Ltd, London, pp. 176.

Hanson B.M. & Walker W.A., 2014. Trans-Pacific consumption of cephalopods by North Pacific killer whales (*Orcinus orca*). Aquatic Mammals, 40: 274–284.

Harbison G.R. & Jannssen J., 1987. Encounters with a Swordfish (*Xiphias gladius*) and Sharptail Mola (*Masturus lanceolatus*) at depths Greater Than 600 Meters.: American Society of Ichthyologists and Herpetologists, 2: 11–513. https://doi.org/10.2307/1445796.

Hatfield B.B., Marks D., Tinker M.T., Nolan K. & Peirce J., 1998. Attacks on sea otters by killer whales. Marine Mammal Science, 14: 888–894. https://doi.org/10.1111/j.1748-7692.1998.tb00775.x.

Hausmann A., Toivonen T., Heikinheimo V., Tenkanen H., Slotow R. & Di Minin E., 2017. Social media reveal that charismatic species are not the main attractor of ecotourists to sub-Saharan protected areas. Scientific Reports, 7: 1–9. https://doi.org/10.1038/s41598-017-00858-6.

Heise K., Barrett-Lennard L.G., Saulitis E., Matkin C. & Bain D.E., 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals, 23: 325–334. https://www.zoology.ubc.ca/~consort/pdfs/heise2003.pdf.

Hocking D.P., Fitzgerald E.M., Salverson M. & Evans A.R., 2015. Prey capture and processing behaviors vary with prey size and shape in Australian and subantarctic fur seals. Marine Mammal Science, 32: 568–587. https://doi.org/10.1111/mms.12285.

Jefferson T.A., Stacey P.J. & Baird R.W., 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review, 21: 151–180. https://doi.org/10.1111/j.1365-2907.1991.tb00291.x.

Jonsgård A., 1968. A note on the attacking behaviour of the killer whale (*Orcinus orca*). Norsk Hvalfangst-Tidende, 57: 84–85.

Lalas C., Ratz H., McEwan K. & McConkey S.D., 2007. Predation by New Zealand sea lions (*Phocarctos hookeri*) as a threat to the viability of yellow-eyed penguins (*Megadyptes antipodes*) at Otago Peninsula, New Zealand. Biological Conservation, 135: 235–246. https://doi.org/10.1016/j.biocon.2006.10.024.

Lenzi C., Speiran S. & Grasso C., 2020. "Let Me Take a Selfie": Implications of social media for public perceptions of wild animals. Society & Animals, 1(aop): 1–20. https://doi.org/10.1163/15685306-bja10023.

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: 181–183. https://doi.org/10.2307/1380981.

Marino L., Rose N.A., Visser I.N., Rally H.D., Ferdowsian H.R. & Slootsky V., 2019. The harmful effects of captivity and chronic stress on the well-being of orcas (*Orcinus orca*). Journal of Veterinary Behavior, 35: 69–82. https://doi.org/10.1016/j.jveb.2019.05.005.

Matkin C.O., Barrett-Lennard L.G., Yurk H., Ellifrit D.K. & Trites A.W., 2007. Ecotypic variation and predatory behavior among killer whales (*Orcinus orca*) off the eastern Aleutian Islands, Alaska. Fishery Bulletin, 105: 74–87. https://fisherybulletin.nmfs.noaa.gov/sites/default/files/pdf-content/2007/1051/matkin.pdf.

Mehta A.V., Allen J.M., Constantine R., Garrigue C., Jann B., Jenner C., Marx M.K., Matkin C.O., Mattila D.K., Minton G., Mizroch S.A., Olavarría C., Robbins J., Russell K.C., Seton R.E., Steiger G.H., Víkingsson G.A., Wade P.R., Witteveen B.H. & Clapham P.J., 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.

Moorhouse T.P., D'Cruze N.C. & Macdonald D.W., 2016. Unethical use of wildlife in tourism: What's the problem, who is responsible, and what can be done? Journal of Sustainable Tourism: 25: 1–12. https://doi.org/10.1080/09669582.2016.1223087.

Newman G., Wiggins A., Crall A., Graham E., Newman S. & Crowston K., 2012. The future of citizen science: Emerging technologies and shifting paradigms. Frontiers in Ecology and the Environment, 10: 298–304. https://doi.org/10.1890/110294.

Nghiem L.T.P., Webb E.L. & Carrasco L.R., 2012. Saving Vietnam's wildlife through social media. Science, 338(6104): 192–193.
https://doi.org/10.1126/science.338.6104.192-b

Nyegaard M., Andrzejaczek S., Jenner C.S. & Jenner M.-N.M., 2019. Tiger shark predation on large ocean sunfishes (Family Molidae) - two Australian observations. Environmental Biology of Fishes, 96: 1–8.
http://doi.org/10.1007/s10641-019-00926-y.

Nyegaard M., Garcia-Barcelona S., Phillips N.D. & Sawai E. 2020. Chapter 12 Fisheries interactions, distribution modeling and conservation issues of the ocean sunfishes. In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfish: evolution, biology and conservation. CRC Press, Boca Raton, FL, USA, pp. 216–242.

Nyegaard M., Visser I.N. & Fletcher L.A., 2023. Ocean sunfish, genus *Mola* Kölreuter, 1766 (Pisces Molidae), exhibit surprising levels of agility during interactions with orca, *Orca orcinus* (Linnaeus, 1758) (Mammalia Delphinidae). Biodiversity Journal, 14: 3–17.
https://doi.org/10.31396/Biodiv.Jour.2023.14.1.3.17

Oftedal O.T., 1997. Lactation in whales and dolphins: Evidence of divergence between baleen- and toothed-species. Journal of Mammary Gland Biology and Neoplasia, 2: 205.
https://doi.org/10.1023/a:1026328203526.

Ortiz R.M., 2001. Osmoregulation in marine mammals. The Journal of Experimental Biology, 204: 1831–1844. https://doi.org/10.1242/jeb.204.11.1831.

Pagel C.D., Orams M.B. & Lück M., 2020. #BiteMe: Considering the potential influence of social media on in-water encounters with marine wildlife. Tourism in Marine Environments, 15: 1–22.
https://doi.org/10.3727/154427320X15754936027058.

Passadore C., Domingo A. & Secchi E.R., 2015. Depredation by killer whale (*Orcinus orca*) and false killer whale (*Pseudorca crassidens*) on the catch of the Uruguayan pelagic longline fishery in Southwestern Atlantic Ocean. ICES Journal of Marine Science, 72: 1653–1666.
https://doi.org/10.1093/icesjms/fsu251.

Pastore M.A., 2009. Necropsy of an ocean sunfish stranded along the Taranto coast (Apulian, south Italy). Marine Biodiversity Records. 2:e118, pp. 111–113. https://doi.org/10.1017/s1755267209001006.

Preece J., 2017. How two billion smartphone users can save species! Interactions, 24: 26–33.
https://doi.org/10.1145/3043702.

Rash R. & Lillywhite H.B., 2019. Drinking behaviors and water balance in marine vertebrates. Marine Biology, 166:e122, pp. 121–121.
https://doi.org/10.1007/s00227-019-3567-4.

Reidenberg J.S. & Laitman J.T., 2008. Cetacean prenatal development. In: Perrin W.F., Würsig B. & Thewissen J.G.M. (Eds.), Encyclopedia of marine mammals. Academic Press, San Diego, pp. 220–230.
https://doi.org/10.1016/B978-0-12-373553-9.00056-0.

Richard J. & Neuville H., 1936. Documents sur les cétacés et pinnipeds des croisieres du Prince Albert 1er de Monaco réunis par Jules Richard [Documents on cetaceans and pinnipeds from the campaigns of Prince Albert 1st of Monaco collected by Jules Richard. In; Results of scientific campaigns carried out on his yacht by Albert 1st Prince Sovereign of Monaco. Volume 94]. In: Richard J. (Ed.), Résultats des campagnes scientifiques accomplies sur son yacht par Albert 1er Prince Souverain de Monaco Fascicule XCIV. Gouvernement á Monaco, Monaco, 34–71.

Sardari P., Felfelian F., Mohammadi A., Nayeri D. & Davis E.O., 2022. Evidence on the role of social media in the illegal trade of Iranian wildlife. Conservation Science and Practice.e12725 (12721–12710).
https://doi.org/10.1111/csp2.12725.

Sawai E., Nyegaard M. & Yamamoto Y., 2020. Chapter 2. Phylogeny, taxonomy and size records of ocean sunfishes. In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfish: evolution, biology and conservation. CRC Press, Boca Raton, FL, USA, pp. 18–36.

Sawai E., Yamanoue Y., Nyegaard M. & Sakai Y., 2018. Redescription of the bump-head sunfish *Mola alexandrini* (Ranzani 1839), senior synonym of *Mola ramsayi* (Giglioli 1883), with designation of a neotype for *Mola mola* (Linnaeus 1758) (Tetraodontiformes: Molidae). Ichthyological Research, 65: 142–160.
https://doi.org/10.1007/s10228-017-0603-6.

Similä T. & Ugarte F., 1993. Surface and underwater observations of cooperatively feeding killer whales in northern Norway. Canadian Journal of Zoology, 71: 1494–1499. https://doi.org/10.1139/z93-210.

Thys T.M., Hearn A.R., Weng K.C., Ryan J.P. & Peñaherrera-Palma C., 2017. Satellite tracking and site fidelity of short ocean sunfish, *Mola ramsayi*, in the Galapagos Islands. Journal of Marine Biology, Article ID 7097965: 1–10.
https://doi.org/10.1155/2017/7097965.

Towers J.R., Tixier P., Ross K.A., Bennett J., Arnould J.P.Y., Pitman R.L. & Durban J.W., 2018. Movements and dive behaviour of a toothfish-depredating killer and sperm whale. ICES Journal of Marine Science, 76: 1–14.
https://doi.org/10.1093/icesjms/fsy118.

Towner A.V., Watson R.G.A., Kock A.A., Papastamatiou Y.P., Sturup M., Enrico G., Baker K.C., Booth T., L D.M., Chivell W., Elwyn S., Kaschke T., Edwards

D.E. & Smale M.J., 2022. Fear at the top: killer whale predation drives white shark absence at South Africa's largest aggregation site. African Journal of Marine Science, 44: 139–152.
https://doi.org/10.2989/1814232X.2022.2066723.

van Opzeeland I.C., Corkeron P.J., Leyssen T., Similä T. & Van Parijs S., 2005. Acoustic behaviour of Norwegian killer whales, *Orcinus orca*, during carousel and seiner foraging on spring-spawning herring. Aquatic Mammals, 31: 110–119.
http://dx.doi.org/10.1578/AM.31.1.2005.110.

Vins M., Aldecoa M. & Hines H.N., 2022. Sharing wildlife conservation through 4 billion views on YouTube. Global Ecology and Conservation, 33:e01970 (01971–01978).
https://doi.org/10.1016/j.gecco.2021.e01970.

Visser I.N., 2005. First observations of feeding on thresher (*Alopias vulpinus*) and hammerhead (*Sphyrna zygaena*) sharks by killer whales (*Orcinus orca*) Specialising on elasmobranchs as prey. Aquatic Mammals, 31: 83–88.
http://dx.doi.org/10.1578/AM.31.1.2005.83.

Visser I.N. & Mäkeläinen P.H., 2000. Variation in eyepatch shape of killer whales (*Orcinus orca*) in New Zealand waters. Marine Mammal Science, 16: 459–469.
https://doi.org/10.1111/j.1748-7692.2000.tb00938.x.

Visser I.N., Nyegaard M. & Fletcher L.A., 2023. Orca, *Orcinus orca* (Linnaeus, 1758) (Mammalia Cetacea), interactions with ocean sunfishes (Family Molidae, genus *Mola* Kölreuter, 1766 and *Masturus* Gill, 1884): A global review. Biodiversity Journal, 14: 61–164.
https://doi.org/10.31396/Biodiv.Jour.2023.14.1.61.164

Visser I.N., Zaeschmar J., Haliday J., Abraham A., Ball P., Bradley R., Daly S., Hatwell T., Johnson T., Johnson W., Kay L., Maessen T., McKay V., Turner N., Umuroa B. & Pace D.S., 2010. First record of predation on false killer whales (*Pseudorca crassidens*) by killer whales (*Orcinus orca*). Aquatic Mammals, 36: 195.
https://doi.org/10.204.https://doi.org/10.1578/AM.36.2.2010.195.

Watanabe Y. & Davenport J., 2020. Chapter 5 Locomotory systems and biomechanics of the ocean sunfish. In: Thys T.M., Hays G.C. & Houghton J.D.R. (Eds.), The Ocean Sunfish: Evolution, biology and conservation. CRC Press Boca Raton, FL, USA, pp. 72–86.

Wellard R., Lightbody K., Fouda L., Blewitt M., Riggs D. & Erbe C., 2016. Killer whale (*Orcinus orca*) predation on beaked whales (*Mesoplodon* spp.) in the Bremer sub-basin, Western Australia. PLoS ONE, 1–15.
https://doi.org/10.1371/journal.pone.0166670.

Whitehead H.P. & Reeves R.R., 2005. Killer whales and whaling: the scavenging hypothesis. Biology Letters. 1: 415–418.
https://doi.org/10.1098/rsbl.2005.0348.

Willemen L., Cottam A.J., Drakou E.G. & Burgess N.D., 2015. Using social media to measure the contribution of red list species to the nature-based tourism potential of African protected areas. PLoS ONE, 10(6): e0129785 (0129781–0129714).
https://doi.org/10.1371/journal.pone.0129785.

Williams T.M., 2008. Swimming. In: Perrin W.F., Würsig B. & Thewissen J.G.M. (Eds.), Encylopedia of Marine Mammals. Academic Press, San Diego, pp. 1140–1147.

Links from Table 1

All links last accessed on 24 October 2022.

1. YouTube. Ecuador.
https://www.youtube.com/watch?v=IaCDfEoqoIQ
2. YouTube. Papua New Guinea.
https://www.youtube.com/watch?v=PrL8_SEvpNk
3. Facebook. Malaysia.
https://www.facebook.com/watch/?v=2137160263260581
4. Instagram. Costa Rica.
https://www.instagram.com/p/CMo-jD_gD_n/?hl=en
5. Instagram. South Africa.
https://www.instagram.com/p/CLC250wAjRv/?hl=en
6. Instagram. Mexico.
https://www.instagram.com/p/CTPaQ1CgDNM/?hl=en
7. Instagram. Mexico.
https://www.instagram.com/p/Cjd-mzwvRDn/?hl=en
8. Blog. Mexico.
https://www.creativecoin.xyz/hive-119888/@ina-van/orcas-in-baja-california-sur-mexico
9. Instagram. Mexico.
https://www.instagram.com/reel/Cg2D18HrXes/?igshid=YmMyMTA2M2Y=

Supplemental Material S-1. Additional details and images of orca-molid interactions.

Interaction numbers refer to Table 1 in the main body of text.

Figure S-1.1 Interaction #3. The same molid as Fig. 6, in the main text. A juvenile orca pushed against it. The dorsal and anal fin extremities have been bitten off (arrows). Also note the 'cloud' of fishes (potentially *Remora* sp.) surrounding the orca. Frame from video by Vito Mafei, Malaysia.

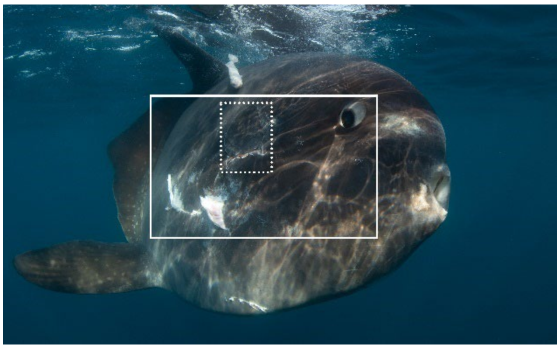

Figure S-1.2 Interaction #7. The injured *Masturus lanceolatus* (sharptail sunfish) from the front. The white boxes indicate the cropping zone for Fig. S-1.2 (solid lines) and Fig. S-1.3 (dotted line). Note the remora, likely *Remora albescens* (pers. comm. Chris Paulin) near the base of the molids dorsal fin. Photo by Ryan Sault.

Figure S-1.3 Interaction #7. The same molid as Fig. S-1.1, cropped in as per the solid-line box. Note the two remnants of the intestine (black arrows) protruding from the Y-shaped wounds. Photo by Ryan Sault.

Figure S-1.4 Interaction #7. The same molid as Figs. S-1.1 & S-1.2, cropped in as per the dotted line in S-1.1. The wound can be seen to wrap around the base of the pectoral fin (left arrow) and perhaps extend as far as the gill opening (right arrow). Photo Ryan Sault.

Figure S-1.5 Interaction #7. The molid, *Ma. lanceolatus* after the intestine was removed by the orca. It had part of the remaining intestine (presumably still attached to the internal cavity), at times protruding from its mouth (see Fig. S-4.10 for close-up detail from another image and Figs. S-4-10 for a sequence, showing the intestine as it moved with the water flow). Photo Ryan Sault.

Figure S-1.6 Interaction #7. Close-up showing the remains of the intestine visible in the mouth of the molid. Compare to the intestine remains protruding from the side of the molid in Fig. 11 in the main text. Photo Ryan Sault.

Figure S-1.7 Interaction #7. Sequence showing the intestine moving with the flow of water. Photos Ryan Sault.

Figure S-1.8 Interaction #7. Long parts of the intestine were carried by at least two orca (see F Figs. S-1.7-1.9 for identification details). Photo by Ryan Sault.

Figure S-1.9 Interaction #7. An orca carries a piece of intestine over the top of its rostrum (i.e., not in its mouth). Photo by Ryan Sault.

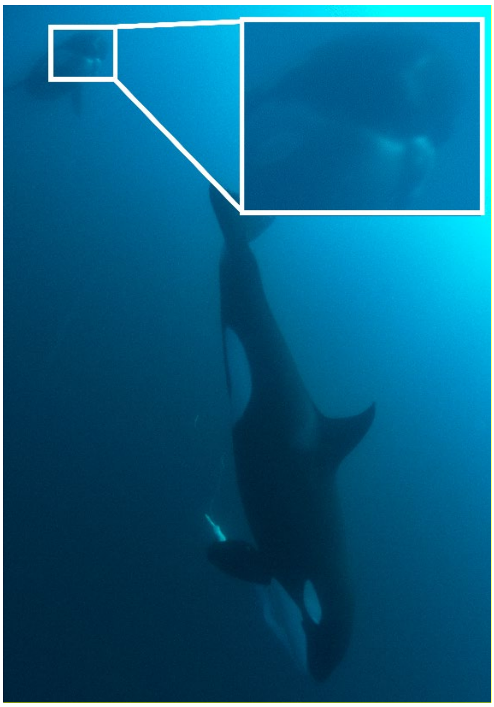

Figure S-1.10 Interaction #7. Two orca, each carrying the molids intestines at the same time. Photo by Ryan Sault.

Figure S-1.11 Interaction #7. One of the three orca for which the left eye-patch was photographed when carrying/consuming intestines. Note the 'hook' at the front [category '2', following Visser & Mäkeläinen (2000)]. Also, note the shape of the black pigmentation at the gape, which like the eye-patch shape, differs from the orca in Figs. S-1.8 & S-1.9. This orca was pregnant at the time of the interaction. Photo by Ryan Sault.

Figure S-1.12 Interaction #7. The second orca. Note the 'hook & bump' at the front [category '4' following Visser & Mäkeläinen (2000)]. Also, note the small black marks along the lower edge of the eye-patch, which will remain throughout the duration of the animals' life (Visser, unpublished data). Photo by Ryan Sault.

Figure S-1.13 Interaction #7. The third orca. Note the 'multiple hook' at the front [category '5' following Visser & Mäkeläinen (2000)]. Photo by Ryan Sault.

Figure S-1.14 Interaction #5. The same Cape fur seal ((*Arctocephalus p. pusillus*) as in Figs. 11 & 12 in the main text (and see Fig. S-1.15), surfaced with molid intestines and began flicking these about. Photo by Dani Abras.

Figure S-1.15 Interaction #5. The Cape fur seal as Fig. S-1.14, continued flicking the intestines and then consumed them in what we believe to be the first record of consumption of a *M. mola* for this species of pinniped. Photo by Dani Abras.

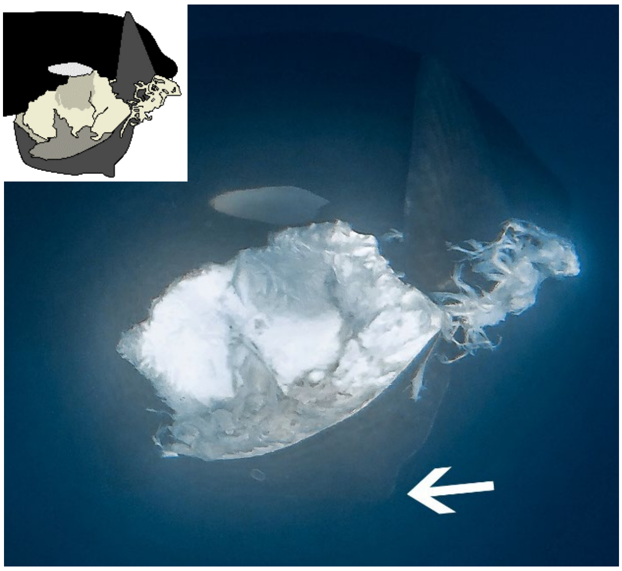

Figure S-1.16 Interaction #7. Typically, the molid was disarticulated, resulting in large pieces. In this case, the remains included either the dorsal or anal fin (see insert for orientation) as well as part of the clavus of the molid (arrow). Insert by LAF, photo by Giacomo Rossi.

Figure S-1.17 Interaction #8. A juvenile orca as it removes its rostrum from the body cavity of the same molid in Fig. 14 in the main text. Frame from video by Evans Baudin.

ACKNOWLEDGEMENTS

Please see the main body of text for the full acknowledgements. We express again here our thanks to the photographers/ videographers whose work and data features in this supplemental material; Dani Abras, Evans Baudin, Giacomo Rossi and Ryan Sault.

REFERENCES

Visser I.N. & Mäkeläinen P.H. 2000. Variation in eye-patch shape of killer whales (*Orcinus orca*) in New Zealand waters. Marine Mammal Science. 16(2):459-469. doi:https://doi.org/10.1111/j.1748-7692.2000.tb00938.x.

Table 1. Predation on various taxa similarities to molid predation

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Alava et al. (2013)	No	No	No	No		*Balaenoptera edeni* , Bryde's whales
Anderson & Prince(1985)	No	No	No	Yes		*Dugong dugon* , Dugong
Anderson (1995)	No	No	No	No		*Dugong dugon,* Dugong
Archibald & James (2018)	No	No	No	No		*Dermochelys coriacea* , Leatherback sea turtle
Arnbom et al. (1987)	No	No	No	No		*Physeter Macrocephalus,* Sperm whale
Berzin & Vladimirov (1982)	No	No	No	No		N/A
Best et al. (1984)	Yes	No	No	No	Targeting p59	*Physeter Macrocephalus,* Sperm whale
Best et al. (2010)	Yes	No	No	No	Targeting p180	*Delphinus Delphis, Common dolphin*
Best et al. (2014)	No	No	No	No		N/A
Bolaños-Jiménezet al. (2014	No	No	No	No		N/A
Caldwell & Caldwell (1969)	No	No	No	No		*Dermochelys coriacea,* Leatherback sea turtle
Capella et al. (2014)	No	No	No	No		*Otariidae spp.*
Chittleborough (1953)	No	No	No	No		*Megaptera novaeangliae,* Humpback whale
Constantine et al. (1998)	No	No	No	No		*Lagenorhynchus obscurus* , Dusky dolphin
Corkeron & Connor (1999)	No	No	No	No		Baleen Whales
Coscarella et al. (2015)	No	No	No	Yes		*Lagenorhynchus obscurus,* Dusky dolphin
Cosentino (2015)	No	No	No	No		*Phocoena phocoena* , Harbour porpoise
Cotton (1944)	No	No	No	No		*Balaenoptera musculus* , Blue whale
Court (1975)	No	No	No	No		N/A

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Alava et al. (2013)	No	p197 "the killer whales bit and ripped off part of the Bryde's whale's mouth and rostrum (Figure 1D-H), presumably targeting the tongue."
Anderson & Prince(1985)	No	p554 "Investigating, the fishermen found pieces of flesh and blubber and segments of intestine containing seagrass floating in the water."
Anderson (1995)	No	p.209 "One individual, seen but not photographed, had a deeply scarred area perhaps 30 cm in diameter that might have been the result of attack by a large shark or by a killer whale"
Archibald & James (2018)	No	p153 "Fig. 3. Injuries indicative of predatory origin from shark or killer whale interaction... (A) rake marks [on the head]"
Arnbom et al. (1987)	No	~~
Berzin & Vladimirov (1982)	No	~~
Best et al. (1984)	p59 "Fig. 7. Killer whale damage to sperm whale calf that stranded at Silverstroom Beach, Cape Town, April 1981. ... (c) Right **flipper**, tooth scars present, (d) Left **flipper** truncated."	~~
Best et al. (2010)	p180."Illustrations of the damage inflicted have already been documented (Best et al. 1984), but included removal of the terminal half of the lower jaw and tip of the left fluke, truncation of the left **flipper**, and tooth rakes on the head, both **flippers**, and tail flukes."	p181 "The heart and most of the diaphragm appeared to have been removed, leaving the lungs, liver and the digestive tract virtually intact." p 181 See Figure 14 showing a dolphin carcass stripped down, with the intestines still attached (i.e., not consumed).
Best et al. (2014)	No	~~
Bolaños-Jiménezet al. (2014	No	~~
Caldwell & Caldwell (1969)	No	p636 "The remains ... consisted of parts of the typical rigid carapace unique to leatherbacks.
Capella et al. (2014)	No	p5 "Killer whales killed otariids by ramming or knocking the seals with the head or the side of the body, pushing the prey out of the water with the head or throwing it from the mouth, or pulling it underwater while held in the mouth or pushing it down with the body."
Chittleborough (1953)	No	~~
Constantine et al. (1998)	No	~~
Corkeron & Connor (1999)	No	~~
Coscarella et al. (2015)	No	p185 "The dolphin was severely injured, and its intestines were popping out of a bleeding cut on its belly."
Cosentino (2015)	No	~~
Cotton (1944)	No	~~
Court (1975)	No	~~

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Cummings et al. (1972)	No	No	No	No		*Eschrichtius robustus,* Gray whale
Cummings & Thompson (1971)	No	No	No	No		*Eschrichtius robustus,* Gray whale
de Oliveira Santos & Netto (2005)	No	No	No	No		*Pontoporia blainvillei* , Franciscana dolphin
de Stephanis et al. (2008)	No	No	No	No		N/A
Deecke et al. (2005)	No	No	No	No		N/A
Dudley (1724)	No	No	No	No		*Physeter macrocephalus* , "Sperma Ceti" whale
Dunn & Claridge (2014)	No	No	No	No		N/A
Elwen & Leeney (2011)	No	No	No	No		*Dermochelys coriacea,* Leatherback sea turtle
Engelbrecht et al. (2019)	Yes	No	No	Yes	Targeting p3	*Notorynchus cepedianus* , Broadnose sevengill shark
Ferguson et al. (2010)	Yes	No	No	Yes	Targeting p127	*Balaena mysticetus,* Bowhead whale
Ford (2019)	No	No	No	No		N/A
Ford et al. (2005)	No	No	No	Yes		*Acutorostrata* sp.
Gemmell et al. (2015)	Yes	No	No	Yes	Targeting p268	*Balaenoptera musculus,* Blue whale
Goley & Straley (1994)	No	No	No	No		*Eschrichtius robustus,* Gray whale
Goodall, et al. (2007)	No	No	No	No		N/A
Grandi et al. (2012)	Yes	No	No	No	Targeting p1073-5	*Otaria flavescens,* South american sea lion
Guinet (1991)	No	No	No	No		*Mirounga leonina,* Southern elephant seal

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Cummings et al. (1972)	No	p9 "The killer whales 'hammered' away at the head region until the right whale opened its mouth. The killer whales then started tearing away at the tongue."
Cummings & Thompson (1971)	No	~~
de Oliveira Santos & Netto (2005)	No	~~
de Stephanis et al. (2008)	No	~~
Deecke et al. (2005)	No	~~
Dudley (1724)	No	~~
Dunn & Claridge (2014)	No	~~
Elwen & Leeney (2011)	No	~~
Engelbrecht et al. (2019)	p127 "Upon examining the external abrasions and bruising on the carcass, we found evidence of bite marks on the **pectoral fins** with bruising of the underlying tissue"	p3 "all of the carcasses were intact with the exception of a large tear across the pectoral girdle (Fig. 2A), exposing the body cavity of the shark. In each case, the liver had been removed, while the other organs such as the heart, stomach, and reproductive organs were all still intact."
Ferguson et al. (2010)	p127 "six interviewees reported that killer whales will bite the bowhead's **flippers** (see Westdal 2009 for similar information from other communities)."	p131 "In many instances dead whales have open wounds on their abdomen with parts of the viscera extruding, although the organs are often uneaten (Hancock 1965; Silber et al. 1990)."
Ford (2019)	No	~~
Ford et al. (2005)	No	p608 "On 30 July a minke carcass, presumably that of the animal killed three days earlier, was observed near the site of the kill, floating with stomach and intestines protruding from a hole in its ventral side.¨ p612 "only the skin, tongue and a small portion of the minke whale's blubber and other flesh were taken from the carcass"
Gemmell et al. (2015)	p268. "Both **pectoral fins** were severely lacerated , with the right **missing a large portion of the tip**" p268. "They will often target and bite down on vulnerable appendages such as pectoral **flippers**, dorsal fin and flukes shown to slow the whales down"..	p268. "The flesh of the abdominal region appeared to be torn, with what appeared to be the penis (or perhaps entrails) extending from the base of the wound"
Goley & Straley (1994)	No	~~
Goodall, et al. (2007)	No (but see additional comments column)	Mentions pectoral targeting from Melnikov & Zagrebin (2005), which we have as an original source
Grandi et al. (2012)	p1075 "While the adult male killer whale stayed below the sea lion, the other AF/SAM killer whale rushed from one side of the sea lion and tried to catch the **flippers**, but failed, then immediately swerved and caught the posterior third of the sea lion body in one bite" p1074 "tried to bite the posterior **flippers** of the sea lion unsuccessfully"	
Guinet (1991)	No	~~

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Guinet & Jouventin (1990)	No	No	No	No		*Mirounga leonina,* Southern elephant seal
Hatfield et al. (1998)	No	No	No	No		*Enhydra lutris,* Sea otter
Heide-Jørgensen (1988)	No	No	No	No		*Monodon monoceros,* Narwhal; *Odobenus rosmarus,* Walrus; *Delphinapterus leucas,* White whale; *Balaenoptera physalus,* Fin whale; *Megaptera novaeangliae,* Humpback whale; *Balaenoptera acutorostrata,* Common minke whale; *Globicephala melaena,* Pilot whale; *Pagophilus groenlandicus,* Harp seal; *Cystophora cristata,* Hooded seal; *Balaena mysticetus,* Bowhead whale
Heise et al. (2003)	Yes	No	No	No	Targeting p327	*Phoca vitulina,* Harbour seal
Heithaus et al. (2008)	No	No	No	No		*Chelonioidea* sp.; *Dermochelys coriacea,* Leatherback sea turtle; *Lepidochelys olivacea,* Olive ridley sea turtle; *Chelonia mydas,* Green sea turtle.
Hückstädt & Antezana (2004)	No	No	No	No		*Otaria flavescens,* Southern sea lion
Jefferson et al. (1991)	Yes	No	No	Yes	Targeting p160	N/A
Jonsgård (1968)	Yes	No	No	Yes	Targeting p84	*Hyperoodon ampullatus,* Bottlenosed whale; *Balaenoptera acutorostrata,* Minke whale
Jourdain et al. (2017)	No	No	No	Yes		*Phoca vitulina,* Harbor seal; *Halichoerus grypus,* Grey seal
Karenina et al. (2015)	No	No	No	No		N/A
Katona et al. (1988)	Yes	No	No	No	Targeting p212	*Balaenoptera physalus,* Fin whale; *Megaptera novaeangliae,* Humpback whale; *Balaenoptera acutorostrata,* Minke whale; *Balaenoptera borealis,* Sei whale
Ljungblad & Moore (1983)	No	No	No	No		*Eschrichtius robustus*, Gray whale
López & López (1985)	No	No	No	No		*Mirounga leonina*, Southern elephant seal; *Otaria flavescens*, Southern sea lion
Lowry et al. (1987)	No	No	No	No		*Acutorostrata* sp.
Lusseau et al. (2004)	No	No	No	No		*Tursiops truncatus*, Atlantic bottlenose dolphin
Maniscalco et al. (2007)	No	No	No	No		*Eumetopias jubatus*, Stellar sea lion
Matkin et al. (2007)	No	No	No	No		N/A

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Guinet & Jouventin (1990)	No	~~
Hatfield et al. (1998)	No	~~
Heide-Jørgensen (1988)	No	~~
Heise et al. (2003)	p327 "Stomach Contents: harbour seal claws (8 hind, 6 fore)" p327 "Stomach Contents: Regurgitated 1 harbour seal **flipper** "	~~
Heithaus et al. (2008)	No	~~
Hückstädt & Antezana (2004)	No	~~
Jefferson et al. (1991)	p160 "This cooperation often takes the form of some Killer Whales biting the flukes and **flippers** of large whales presumably to slow or stop their movement"	p160 "The following day, the whalers returned to the refloated carcass, and claimed their prize, complete except for the less commercially valuable tongue and lips."
Jonsgård (1968)	p84 "Three killer whales attacked it at the same time biting at the **flippers** and tail flukes"	p84 "adult minke whale with a body length 27'8" and apparently in good health was actually attacked and fed upon, although only the skin and tongue were eaten"
Jourdain et al. (2017)	No	p6 Figure 3. Photo B "confirms effective prey consumption" -their insert photo shows intestine was left
Karenina et al. (2015)	No	~~
Katona et al. (1988)	p212 "One indication of the intensity of killer whale predation on baleen whales is the frequency of bites or toothmarks on their bodies. In cetaceans taken during Antarctic whaling, for example, parallel scars 3.0 to 3.8cm apart, probably caused by killer whales, occurred most frequently on the **flipper**, flukes and, in the case of the fin whale, on the keel of caudal peduncle and dorsal fin (Schevchenko 1975). Such scars occured on 65.4% of sperm whales (*Physeter macrocephalus*), 53.4% of fin whales, 24.4% of sei whales (*Balaenoptera borealis*) and 6.4% minke whales examined"	~~
Ljungblad & Moore (1983)	No	~~
López & López (1985)	No	~~
Lowry et al. (1987)	No	~~
Lusseau et al. (2004)	No	~~
Maniscalco et al. (2007)	No	~~
Matkin et al. (2007)	No	~~

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Mehta et al. (2007)	Yes	No	No	No	Targeting p301	*Balaenoptera musculus* , Blue whale
Melnikov & Zagrebin. (2005)	Yes		No	No	Targeting p552	*Eschrichtius robustus* , Gray whale
Melnikov et al. (2007)	No	No	No	No		N/A
Merlen (1999)	No	No	No	No		N/A
Morisaka & Conner (2007)	No	No	No	No		N/A
Nishiwaki & Handa (1958)	No	No	No	No		N/A
Notarbartolo-di-Sciara (1987)	No	No	No	No		*Ziphius cavirostris* , Cuvier's beaked whale
Ott & Danilewicz (1998)	Yes	No	No	No	targeting p607	*Pontoporia blainvillei,* Franciscana dolphin
Oviedo et al. (2008)	No	No	No	No		*Dermochelys coriacea* , Leatherback sea turtle
Pachecoet al. (2019)	No	No	No	No		*Megaptera novaeangliae* , Humpback whale
Palacios & Mate (1996)	No	No	No	No		N/A
Pitman et al. (2017)	Yes	No	No	No	Target Supplemental Material p7, 9, 11	*Megaptera novaeangliae* , Humpback whale
Pitman & Durban (2010)	Yes	No	No	Yes	Target p1591, 1592	*Pygoscelis papua,* Gentoo penguin*;* *Pygoscelis antarcticus,* Chinstrap penguin
Pitman (2007)	No	No	No	No		*Balaenoptera musculus* , Blue whale
Pyle et al. (1999)	No	No	No	No		*Carcharodon carcharias,* White shark
Randall & Randall (1990)	No	No	No	No		*Spheniscus demersus* , Jackass penguin
Reyes & García-Borboroglu (2004)	No	No	No	No		*Notorynchus cepedianus,* Sevengill shark
Rice (1968)	No	No	No	No		N/A

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Mehta et al. (2007)	p301 "Off southeastern Australia, the only blue whale showing evidence of a killer whale attack had the tip of its left **pectoral fin** bitten off"	p 302 "The rake mark frequency on ventral tail flukes was considerably higher than that on other body regions."
Melnikov & Zagrebin. (2005)	p552 "Juveniles and adult female killer whales initiated the attack by seizing a gray whale by its tail fluke and **pectoral fins**, thus forcing it to stop. They seemed to impair the gray whale's breathing by swimming on top of its blowhole, biting the whale in the area of its pectoral fins, and tearing at the vulnerable submandibular sac and the jaw." "Subsequently the two smaller whales attacked the gray whale on either side in the mandibular region and **the pectorals**"	p554 "Only occasionally, in addition to the tongue and submandibular sac, did killer whales bite into the whale's subcutaneous fat from the lower surface of its body." [i.e., doesn't specifically say that they didn't eat the intestine, but is precise about what they did eat]
Melnikov et al. (2007)	No	~~
Merlen (1999)	No	~~
Morisaka & Conner (2007)	No	~~
Nishiwaki & Handa (1958)	No	~~
Notarbartolo-di-Sciara (1987)	No	~~
Ott & Danilewicz (1998)	p607 "On that occasion, the killer whale regurgitated a material that was identified as being remains of the **flippers**, the dorsal fin and the partially digested integument of an unidentified small odontocete. A recent review of that suggests that the materials regurgitated could also belong to a large teleost or elasmobranch"	~~
Oviedo et al. (2008)	No	~~
Pachecoet al. (2019)	No	~~
Palacios & Mate (1996)	No	p583 "The tooth mark scars on the flukes of humpback whales, sperm whales, and other cetaceans have most frequently been attributed to killer whales (*Orcinus orca*)"
Pitman et al. (2017)	Supplemental Material p7 Record "37.... The orca attempted to grab the **pectoral flipper**" ; p9 Record "47...There was some fresh blood on the right **pectoral fin** of one of the adult humpbacks, p11 Record "52... The calf appeared injured with one **pectoral flipper** bleeding."	~~
Pitman & Durban (2010)	p1591 "The head, entire **pectoral girdle (including flippers)** and the axial body were missing." ; p1591 "We examined the remains left behind; they consisted of the entire lower half of the body with the entrails, legs and tail intact—the head, **pectoral girdle and flippers** were all missing."; p1592 "Only the **pectoral girdle, including** the sternum, breast muscles and **both flippers**, was missing."	p1591 "We examined the remains left behind; they consisted of the entire lower half of the body with the entrails, legs and tail intact"
Pitman (2007)	No	~~
Pyle et al. (1999)	No	p564 "This killer whale continued to carry the shark until 1223, when it dropped it to feed on a large section of the liver that had separated from the rest of the carcass."
Randall & Randall (1990)	No	~~
Reyes & García-Borboroglu (2004)	No	p337 "The rest of the carcasses showed killer whale bite marks on the back part of their bodies, and part of the belly area, including the liver, was bitten off."
Rice (1968)	No	~~

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Sarti et al. (1994)	No	No	No	No		*Dermochelys coriacea* , Leatherback sea turtle
Saulitis et al. (2015)	No	No	No	Yes		*Megaptera novaeangliae* , Humpback whale
Saulitis, et al. (2000)	No	No	No	No		N/A
Shelden, et al. (2003)	Yes	No	No	No	Targeting p536	*Delphinapterus leucas* , Beluga whale
Shpak & Shulezhko. (2013)	No	No	No	No		N/A
Silber et al. (1990)	No	No	No	No		*Balaenoptera edeni* , Bryde's whale
Similä & Ugarte (1993)	No	No	No	No		*Clupea Harengus* , Herring
Sironi et al. (2008)	Yes	No	No	No	Targeting, p7, 11	*Eubalaena australis* , Southern right whale
Song (2018)	No	No	No	No		N/A
Straneck et al. (1983)	No	No	No	No		*Tachyeres* sp.
Sucunza et al. (2022)	No	No	No	No		*Physeter macrocephalus* , Sperm whale
Thomas & Taber (1984)	Yes	No	No	No	Targeting p50	*Eubalaena australis* , Southern right whale
Tixier et al. (2016)	No	No	No	No		*Dissostichus eleginoides* , Patagonian toothfish
Towneret al. (2022)	Yes	No	No	No	Targeting p8	*Carcharodon carcharias* , Great white shark
van den Hoff & Morrice (2008)	No	No	No	No		N/A
Visser (2000)	No	No	No	No		*Galeorhinus galeus* , School shark; *Hyperoglyphe antarchia* , Bluenose warehou
Visser (2005)	No	No	No	No		*Alopias vulpinus,* Thresher shark; *Sphyrna zygaena,* Smooth hammerhead shark
Visser et al. (2010)	No	No	No	No		*Pseudorca Crassidens* , False killer whale

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Sarti et al. (1994)	No	~~
Saulitis et al. (2015)	No	p343 Table 2, no intestine consumption
Saulitis, et al. (2000)	No	~~
Shelden, et al. (2003)	p536 Table 1. "One adult male was seen in about 10 ft of water towing a live, thrashing beluga to deeper water accompanied by a beluga calf. No blood was seen, but the beluga was held by its **right pectoral**"	~~
Shpak & Shulezhko. (2013)	No	~~
Silber et al. (1990)	No	p1605 "We observed that the killer whales attacked areas clear of the tail of the Bryde's whale, a potential source of injury to the predator. Similarly, other authors reported attacks that focused on body parts clear of the tail flukes, including the tongue (Andrews 19 14; Scammon 1874), underside (Morejohn 1968), and areas about the head, dorsum, and flanks (Tarpy 1979; Arnbom et al. 1987)."
Similä & Ugarte (1993)	No	~~
Sironi et al. (2008)	p7 "Case D. ... Pieces of **pectoral fins**, tail flukes and skin were missing.", "Case E. ...The orcas encircled the whale, and the juveniles in the group attacked it on its flanks, **pectoral fins** and jaw, ...", "Case F. ... Three adult male orcas seized a solitary adult right whale **by its pectoral flippers** apparently to prevent it from moving toward shallower water... Bites were seen on the pectoral fins,", p11 "Attack behavior and body parts preferred. When we observed bites during the attacks, orcas aimed at the lower jaw, flanks and **pectoral fins** of right whales."	~~
Song (2018)	No	~~
Straneck et al. (1983)	No	~~
Sucunza et al. (2022)	No	~~
Thomas & Taber (1984)	p 50 "We saw young calves with parallel scars on their **flipper** or fluke tips that may have been from killer whale bites (see Wursig & Wursig, 1979 for a description of similar scars on *Tursiops truncatus*), and we witnessed killer whale attacks on adult right whales."	~~
Tixier et al. (2016)	No	~~
Towneret al. (2022)	p8 "A pair of easily identifiable killer whales were potentially responsible for predating on at least five white sharks in Gansbaai. The shark carcasses revealed a single large tear across the **pectoral girdle**, and the liver—and in some cases other internal organs—was missing, and rake marks were present on the fins."	~~
van den Hoff & Morrice (2008)	No	~~
Visser (2000)	No	~~
Visser (2005)	No	~~
Visser et al. (2010)	No	~~

SOURCE	TARGET PECTORAL FINS [y/n]	CONSUMES INTESTINES [y/n]	INSERTS ROSTUM INTO BODY CAVITY [y/n]	Specifically states that they did NOT consume the intestines [y/n]	page number(s)Target, Consumes, Inserts, KEY BEHAVIOUR (green columns)	TAXA INVOLVED; (n/a = no species listed)
Visser et al (2023)	No	No	No	Yes		*Cheloniidae* sp.
Voisin,(1976)	No	No	No	No		*Mirounga leonina,* Southern elephant seal
Weir et al. (2010)	No	No	No	No		*Megaptera novaeangliae,* Humpback whale; *Physeter macrocephalus,* Sperm whale; *Mola mola,* Ocean sunfish
Wellard et al. (2016)	No	No	No	No		*Mesoplodon spp,* Beaked whales; *Mesoplodon layardii,* Strap-toothed whale
Weller (2008)	Yes	No	No	No	Targeting p928	*Otaria flavescens,* Southern sea lion; *Mirounga leonina,* Southern elephant seal
Wenzel & Sears, R. (1988)	No	No	No	No		*Balaenoptera acutorostrata,* Minke whale
Williams et al. (1990)	No	No	No	No		*Spheniscus demersus,* Jackass penguin; *Phalacrocorax capensis,* Cape cormorant; *Phalacrocorax neglectus,* Bank cormorant
Wright et al. (2016)	No	No	No	No		*Oncorhynchus spp,* Pacific salmon; *Oncorhynchus tshawytscha,* Chinook salmon
Wursig & Wursig (1979)	No	No	No	No		*Tursiops truncatus* , Bottlenose dolphin
Yates et al. (2007)	No	No	No	No		*Mirounga leonina,* Southern elephant seal
Young et al (2020)	Yes	No	No	No		*Balaena mysticetus,* Bowhead whale

SOURCE	KEY BEHAVIOUR (green columns) QUOTE FROM SOURCE (including page number) (no = no relevant quote)	ADDITIONAL INFORMATION / OUR NOTES
Visser et al (2023)	No	Supplemental Material S-4 "Figure S-4.3 The remains of an unidentified hard-shelled turtle predated on by orca. Note that nearly all of the tissue was eaten by the orca, but that the ntestines are left behind."
Voisin,(1976)	No	~~
Weir et al. (2010)	No	~~
Wellard et al. (2016)	No	~~
Weller (2008)	p 927-928 "Once a seal or sea lion has been captured from the beach or nearshore area, they are usually held in the mouth of a killer whale by one of the **flippers** or taken crossways in the mouth and vigorously shaken."	~~
Wenzel & Sears, R. (1988)	No	~~
Williams et al. (1990)	No	~~
Wright et al. (2016)	No	~~
Wursig & Wursig (1979)	No	~~
Yates et al. (2007)	No	~~
Young et al (2020)	p58 "Similar, but smaller and more superficial lesions were apparent on **both flippers** and the distal limit of the **right flipper** was truncated with a curvilinear margin consistent with a killer whale attack"	~~

Supplemental Material S-2. Table 2. Orca prey species, number of publications describing predation on prey species and indication of targeting of the prey's pectoral fin by orca.

Running total of species	**Species** (by taxa & alphabetically by Latin name)	**# of publications** (regardless of targeting or not)	**Pectoral fin targeted**	**# of species targeted** (by taxa)
1	*Balaena mysticetus,* Bowhead whale	3	Yes	1
2	*Balaenoptera acutorostrata,* minke whale	4	Yes	2
3	*Balaenoptera borealis*, Sei whale	1	Yes	3
4	*Balaenoptera edeni,* Bryde's whale	2	No	
5	*Balaenoptera musculus*, Blue whale	4	Yes	4
6	*Balaenoptera physalus,* Fin whale	2	Yes	5
7	*Delphinus delphis,* Common dolphin	1	Yes	6
8	*Delphinapterus leucas,* Beluga whale	2	Yes	7
9	*Eschrichtius robustus,* Gray whale	5	Yes	8
10	*Eubalaena australis*, Southern right whale	2	Yes	9
11	*Globicephala melaena,* Pilot whale	1	No	
12	*Hyperoodon ampullatus,* Bottlenosed whale	1	Yes	10
13	*Lagenorhynchus obscurus,* Dusky dolphin	2	No	
14	*Megaptera novaeangliae,* Humpback whale	7	Yes	11
15	*Mesoplodon layardii*, Strap-toothed whale	1	No	
16	*Monodon monoceros,* Narwhal	1	No	
17	*Phocoena phocoena*, Harbor porpoise	1	No	
18	*Physeter macrocephalus,* Sperm whale	5	Yes	12
19	*Pontoporia blainvillei,* Franciscana dolphin	2	Yes	13
20	*Pseudorca crassidens*, False killer whale	1	No	
21	*Tursiops truncatus*, Bottlenose dolphin	2	No	
22	*Ziphius cavirostris*, Cuvier's beaked whale	1	No	
23	*Cystophora cristata,* Hooded seal	1	No	
24	*Halichoerus grypus,* Grey seal	1	No	
25	*Eumetopias jubatus*, Stellar sea lion	1	No	
26	*Mirounga leonina,* Southern elephant seal	6	Yes	1
27	*Odobenus rosmarus,* Walrus	1	No	
28	*Otaria flavescens*, Southern sea lion	4	Yes	2
29	*Pagophilus groenlandicus,* Harp seal	1	No	
30	*Phoca vitulina,* Harbor seal	2	Yes	3
31	*Dugong dugon*, Dugong	2	No	
32	*Enhydra lutris,* Sea otter	1	No	
33	*Phalacrocorax capensis*, Cape cormorant	1	No	
34	*Phalacrocorax neglectus,* Bank cormorant	1	No	
35	*Pygoscelis antarcticus*, Chinstrap penguin	1	Yes	1
36	*Pygoscelis papua,* Gentoo penguin	1	Yes	2
37	*Spheniscus demersus*, Jackass penguin	2	No	
38	*Alopias vulpinus,* Thresher shark	1	No	
39	*Carcharodon carcharias,* Great white shark	2	Yes	1
40	*Galeorhinus galeus*, School shark	1	No	
41	*Notorynchus cepedianus*, Broadnose sevengill shark	1	Yes	2
42	*Sphyrna zygaena*, Smooth hammerhead shark	1	No	
43	*Chelonia mydas*, Green sea turtle	1	No	
44	*Dermochelys coriacea,* Leatherback sea turtle	6	No	
45	*Lepidochelys olivacea,* Olive ridley sea turtle	1	No	
46	*Clupea Harengus,* Herring	1	No	
47	*Dissostichus eleginoides,* Patagonian toothfish	1	No	
48	*Hyperoglyphe antarchia*, Bluenose warehou	1	No	
49	*Mola mola*, Ocean sunfish	1	Yes (Visser et al. 2023)	1
50	*Oncorhynchus tshawytscha*, Chinook salmon	1	No	

+ two species in this study (*Mola alexandrini* & *Masturus lanceolatus*), where pectoral fin targeting was described for the first time, for both species.

S- 2 Table 1 REFERENCE LIST

Alava, J.J., Smith, K.J., O'Hern, J., Alarcón, D., Merlen, G., and Denkinger, J. (2013). Observations of killer whale (*Orcinus orca*) attacks on Bryde's whales (*Balaenoptera edeni*) in the Galápagos Islands. Aquatic Mammals 39(2), 196-201.

Anderson, P.K., and Prince, R.I.T. (1985). Predation on dugongs: attacks by killer whales. Journal of Mammalogy 66(3), 554-555.

Anderson, P.K. (1995). Scarring and photoidentification of dugongs (*Dugong dugon*) in Shark Bay, Western Australia. Aquatic Mammals 21(3), 205-211.

Archibald, D.W., and James, M., C (2018). Prevalence of visible injuries to leatherback sea turtles *Dermochelys coriacea* in the Northwest Atlantic. Endangered Species Research 37, 149-163

Arnbom, T., Papastavrou, V., Weilgart, L.S., and Whitehead, H. (1987). Sperm whales react to an attack by killer whales. Journal of Mammalogy 68, 450-453.

Berzin, A.A., and Vladimirov, V.L. (1982). Novyi vid kosatki izvod Antarktiki (A new species of killer whale from Antarctic waters). Priroda (Nature) 71(6), 31.

Best PB, Canham PAS, MaCleod N. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report of the International Whaling Commission (Special Issue 6): 51–79.

Best, P.B., Meÿer, M.A., and Lockyer, C. (2010). Killer whales in South African waters — a review of their biology. African Journal of Marine Science 32(2), 171-186.

Best, P.B., Meÿer, M.A., Thornton, M., Kotze, P.G.H., Seakamela, M., Hofmeyr, G.J.G., et al. (2014). Confirmation of the occurrence of a second killer whale morphotype in South African waters. African Journal of Marine Science 36(2), 215-224.

Bolaños-Jiménez, J., Mignucci-Giannoni, A.A., Blumenthal, J., Bogomolni, A.L., Henríquez, A., Iniguez, M., et al. (2014). Distribution, feeding habits and morphology of killer whales *Orcinus orca* in the Caribbean Sea. Mammal Review, 1-13

Caldwell, D.K., and Caldwell, M.C. (1969). Addition of the leatherback sea turtle to the known prey of the killer whale, *Orcinus orca*. Journal of Mammalogy 50, 636.

Capella, J.J., Abramson, J.Z., Vilina, Y.A., and Gibbons, J. (2014). Observations of killer whales (*Orcinus orca*) in the fjords of Chilean Patagonia. Polar Biology 37, 1533–1539.

Chittleborough, R.G. (1953). Aerial observations on the humpback whale, *Megaptera nodosa* (Bonnaterre), with notes on other species. Australian Journal of Marine and Freshwater Research 4(2), 219-226 + 212 plates.

Constantine, R., Visser, I., Buurman, D., Buurman, R., and McFadden, B. (1998). Killer whale (Orcinus orca) predation on dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. Marine Mammal Science 14(2), 324-330.

Corkeron, P.J., and Connor, R.C. (1999). Why do baleen whales migrate? Marine Mammal Science 15, 1228-1245.

Coscarella, M.A., Bellazzi, G., Gaffet, M.L., Berzano, M., and Degrati, M. (2015). Technique used by killer whales (*Orcinus orca*) when hunting for dolphins in Patagonia, Argentina. Aquatic Mammals 41(2).

Cosentino, A.M. (2015). First record of Norwegian killer whales attacking and feeding on a harbour porpoise. Marine Biodiversity Records 8, 1-8.

Cotton, B.C. (1944). Killer whales in South Australia. The Australian Zoologist 10(3), 293-294.

Court, D.J. (1975). Killer whales and Risso's dolphin at Kawerua. Tane 21, 61-64.

Cummings, W., Fish, J.F., and Thompson, P.O. (1972). Sound production and other behavior of southern right whales, *Eubalaena [sic] glacialis*. Transactions of the San Diego Society of Natural History 17(1), 1-13.

Cummings, W.C., and Thompson, P.O. (1971). Gray whales ,*Eschrichtius robustus*, avoid the underwater sounds of killer whales, Orcinus orca. Fishery Bulletin 69(3), 525–530.

de Oliveira Santos, M.C., and Netto, D.F. (2005). Killer whale (Orcinus orca) predation on a Franciscana dolphin (*Pontoporia blainvillei*) in Brazilian waters. Latin American Journal of Aquatic Mammals 4(1), 69-72.

de Stephanis, R., Cornulier, T., Verborgh, P., Sierra, J.S., Pérez Gimeno, N., and Guinet, C. (2008). Summer spatial distribution of cetaceans in the Strait of Gibraltar in relation to the oceanographic context. Marine Ecology Progress Series 353, 275-288.

Deecke, V.B., Ford, J.K.B., and Slater, P.J.B. (2005). The vocal behaviour of mammal-eating killer whales: Communicating with costly calls. Animal Behavior 69, 395-405.

Dudley, P. (1724). An essay upon the natural history of whales, with particular account of the ambergris found in the Sperma Ceti whale. In a letter to the Publisher, from the Honourable Paul Dudley Esq; F. R. S. Transactions of the Royal Society of London 22(387), 256-269.

Dunn, C., and Claridge, D.E. (2014). Killer whale (*Orcinus orca*) occurrence and predation in the Bahamas. Journal of the Marine Biological Association of the United Kingdom 94(6), 1305-1309.

Elwen, S.H., and Leeney, R.H. (2011). Interactions between leatherback turtles and killer whales in Namibian waters, including possible predation. South African Journal of Wildlife Research 41(2), 205-209.

Engelbrecht, T.M., Kock, A.A., and O'Riain, M.J. (2019). Running scared: when predators become prey. Ecosphere 10(1), e02531.

Ferguson, S.H., Higdon, J.W., and Chmelnitsky, E.G. (2010). "The rise of killer whales as a major Arctic predator. In; A little less Arctic: Top predators in the world's largest northern inland sea, Hudson Bay. Springer), 288.

Ford, J.K.B. (2019). "Killer Whales: Behavior, social organization, and ecology of the oceans' apex predators," in Ethology and Behavioral Ecology of Odontocetes, ed. B. Würsig. (Switzerland: Springer), 239-259.

Ford, J.K.B., Ellis, G.M., Matkin, D.R., Balcomb, K.C., Briggs, D., and Morton, A.B. (2005). Killer whale attacks on minke whales: Prey capture and antipredator tactics. Marine Mammal Science 21(4), 603-618.

Gemmell, G.L., McInnes, J.D., Heinrichs, S.J., and de Silva Wijeyeratne, G. (2015). Killer Whale (*Orcinus orca*) Predation on Whales in Sri Lankan Waters. Aquatic Mammals 41(3), 265-271.

Goley, P.D., and Straley, J.M. (1994). Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Canadian Journal of Zoology 72, 1528-1530.

Goodall, R.N.P., Boy, C.C., and Schiavini, A.C.M. (2007). Historical and modern records of cetaceans self-stranding to escape from killer whales. International Whaling Commission, 1-26.

Grandi, M.F., Loizaga de Castro, R., and Crespo, E.A. (2012). Killer whales attack on South American sea lion associated with a fishing vessel: predator and prey tactics. Latin American Journal of Aquatic Research 40(4), 1072-1076.

Guinet, C. (1991). Intentional stranding apprenticeship and social play in killer whales (*Orcinus orca*). Canadian Journal of Zoology 69, 2712-2716.

Guinet, C., and Jouventin, P. (1990). La vie sociale des 'baleines tueuses'. La Recherche 21, 508-510.

Hatfield, B.B., Marks, D., Tinker, M.T., Nolan, K., and Peirce, J. (1998). Attacks on sea otters by killer whales. Marine Mammal Science 14(4), 888-894.

Heide-Jørgensen, M.-P. (1988). Occurrence and hunting of killer whales in Greenland. Rit Fiskideildar 11(North Atlantic killer whales), 115-135.

Heise, K., Barrett-Lennard, L.G., Saulitis, E., Matkin, C., and Bain, D.E. (2003). Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 23(3), 325-334.

Heithaus, M.R., Wirsing, A.J., Thomson, J.A., and Burkholder, D.A. (2008). A review of lethal and non-lethal effects of predators on adult marine turtles. Journal of Experimental Marine Biology and Ecology 356, 43-51.

Hückstädt, L.A., and Antezana, T. (2004). Behaviour of Southern sea lions in presence of killer whales during fishing operations in Central Chile. Scientia Marina 68(2), 295-298.

Jefferson, T.A., Stacey, P.J., and Baird, R.W. (1991). A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21(4), 151-180.

Jonsgård, A. (1968). A note on the attacking behaviour of the killer whale (Orcinus orca). Norsk Hvalfangst-Tidende 57(4), 84-85.

Jourdain, E., vongraven, D., Bisther, A., and Karoliussen, R. (2017). First longitudinal study of seal-feeding killer whales (*Orcinus orca*) in Norwegian coastal waters. PLoS ONE 12(6), e0180099.

Karenina, K.A., Giljova, A.N., Ivkovich, T.V., and Malashichev, Y.B. (2015). Evidence for the perceptual origin of right-sided feeding biases in cetaceans. Animal Cognition 19(1), 239-243.

Katona, S.K., Beard, J.A., Girton, P.E., and Wenzel, F. (1988). Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. Rit Fiskideildar 11(North Atlantic killer whales), 205-224.

Ljungblad, D.K., and Moore, S.E. (1983). Killer whales (*Orcinus orca*) chasing gray whales (*Eschrichtius robustus*) in the northern Bering Sea. Arctic 36(4), 361-364.

López, J.C., and 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.

Lowry, L.F., Nelson, R.R., and Frost, K.J. (1987). Observations of killer whales, *Orcinus orca*, in western Alaska: sightings, strandings, and predation on other marine mammals. The Canadian Field-Naturalist 101, 6-12.

Lusseau, D., Williams, R., Wilson, B., Grellier, K., Barton, T.R., Hammond, P.S., et al. (2004). Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic bottlenose dolphins. Ecology Letters (7), 1068-.

Maniscalco, J.M., Matkin, C.O., Maldini, D., Calkins, D.G., and Atkinson, S. (2007). Assessing killer whale predation on steller sea lions from field observations in Kenai Fjords, Alaska. Marine Mammal Science 23(2), 306-321.

Matkin, C.O., Barrett-Lennard, L.G., Yurk, H., Ellifrit, D.K., and Trites, A.W. (2007). Ecotypic variation and predatory behavior among killer whales (*Orcinus orca*) off the eastern Aleutian Islands, Alaska. Fishery Bulletin 105, 74-87.

Mehta, A.V., Allen, J.M., Constantine, R., Garrigue, C., Jann, B., Jenner, C., et al. (2007). Baleen whales are not important as prey for killer whales *Orcinus orca* in high-latitude regions. Marine Ecology Progress Series 348, 297-307.

Melnikov, V., and Zagrebin, I. (2005). Killer whale predation in coastal waters of the Chukotka Peninsula. Marine Mammal Science 21(3), 550-556.

Melnikov, V.V., Zagrebin, I.A., Zelensky, G.M., and Ainana, L.I. (2007). Killer whales (*Orcinus orca*) in waters adjacent to the Chukotka Peninsula, Russia Journal of Cetacean Research and Management 9(1), 53-63.

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

Morisaka, T., and Conner, R.C. (2007). Predation by killer whales (*Orcinus orca*) and the evolution of whistle loss and narrow-band high frequency clicks in odontocetes. European Society for Evolutionary Biology.

Nishiwaki, M., and Handa, C. (1958). Killer whales caught in the coastal waters off Japan for recent 10 years. Scientific Reports of the Whales Research Institute 13, 85-96.

Notarbartolo-di-Sciara, G. (1987). Killer whale, *Orcinus orca*, in the Mediterranean sea. Marine Mammal Science 3(4), 256-360.

Ott, P.H., and Danilewicz, D. (1998). Presence of franciscana dolphins (*Pontoporia blainvillei*), in the stomach of a killer whale (*Orcinus orca*), stranded in southern Brazil. Mammalia 62(4), 605-609.

Oviedo, L., Esteves, M.A., Alfe, E., Acevedo, R., and Bolaños-Jiménez, J. (2008). Interaction between killer whales (*Orcinus orca*) and a leatherback turtle (*Dermochelys coriacea*) off the north-eastern coast of Venezuela. JMBA2 - Biodiversity Records e51, 1-2.

Pacheco, A.S., Castro, C., Carnero-Hauman, R., Villagra, D., Pinilla, S., Denkinger, J., et al. (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.

Palacios, D.M., and Mate, B.R. (1996). Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Gálàpagos Islands. Marine Mammal Science 12(4), 582-587.

Pitman, R.L., Deecke, V.B., Gabriele, C.M., Srinivasan, M., Black, N., Denkinger, J., et al. (2017). Humpback whales interfering when mammal-eating killer whales attack other species: Mobbing behavior and interspecific altruism? Marine Mammal Science 33(1), 7-58.

Pitman, R.L., and Durban, J.W. (2010). Killer whale predation on penguins in Antarctica. Polar Biology 33, 1589-1594.

Pitman, R.L., Fearnbach, H., LeDuc, R., Gilpatrick, J.W.J., Ford, J.K.B., and Ballance, L.T. (2007). Killer whales preying on a blue whale calf on the Costa Rica dome: genetics, morphometrics, vocalisations and composition of the group. Journal of Cetacean Research and Management 9(2), 151-157.

Pyle, P., Schramm, M.J., Keiper, C., and Anderson, S.D. (1999). Predation on a white shark (*Carcharodon carcharias*) by a killer whale (Orcinus orca) and a possible case of competitive displacement. Marine Mammal Science 15(2), 563-568.

Randall, R.M., and Randall, B.M. (1990). Cetaceans as predators of jackass penguins *Spheniscus demersus*: Deductions based on behaviour. Marine Ornithology 18, 1-12.

Reyes, L.M., and García-Borboroglu, P. (2004). Killer whale (*Orcinus orca*) predation on sharks in Patagonia, Argentina: a first report. Aquatic Mammals 30(3), 376-379.

Rice, D.W. (1968). Stomach contents and feeding behavior of killer whales in the eastern North Pacific. Norsk Hvalfangst-Tidende 57, 35-38.

Sarti, M.L., Flores, O.L., and Aguayo, A.L. (1994). Evidence of predation of killer whale (*Orcinus orca*) on a leatherback sea turtle (*Dermochelys coriacea*) in Michoacan, Mexico. Revista de Investigaciones Ciencias 2(Esp. Somenna 2), 23-26.

Saulitis, E., Holmes, L.A., Matkin, C.O., Wynne, K., Ellifrit, D., and St-Amand, C. (2015). Bigg's killer whale (*Orcinus orca*) predation on subadult humpback whales (*Megaptera novaeangliae*) in Lower Cook Inlet and Kodiak, Alaska. Aquatic Mammals 41(3), 341-344.

Saulitis, E., Matkin, C., Barrett-Lennard, L., Heise, K., and Ellis, G. (2000). Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Marine Mammal Science 16(1), 94-109.

Shelden, K.E.W., Rugh, D., Mahoney, B.A., and Dahlheim, M.E. (2003). Killer whale predation on belugas in Cook Inlet, Alaska: Implications for a depleted population. Marine Mammal Science 19(3), 529-544.

Shpak, O.V., and Shulezhko, T. (2013). "Observations and photoidentification of an unusual group of mammal-eating killer whales (*Orcinus orca*) in the Western Sea of Okhotsk (Наблюдения и фотоидентификация необычной группы плотоядных косаток (*Orcinus orca*) в западной части Охотского моря)".).

Silber, G. K., Newcomer, M. W., & Perez Cortes, M. H. (1990). Killer whales (*Orcinus orca*) attack and kill a Bryde's whale (*Balaenoptera edeni*). Canadian Journal of Zoology, 68(7), 1603-1606.

Similä, T., and Ugarte, F. (1993). Surface and underwater observations of cooperatively feeding killer whales in northern Norway. Canadian Journal of Zoology 71, 1494-1499.

Sironi, M., López, J.C., Bubas, R., Carribero, A., García, C., Harris, G., et al. (2008). Predation by killer whales (*Orcinus orca*) on southern right whales (*Eubalaena australis*) off Patagonia, Argentina: effects on behavior and habitat choice Journal of Cetacean Research and Management, 1-18.

Song, Y. (2018). Feeding habits of different killer whale (*Orcinus orca*) ecotypes and populations. Bachelor of Science BSc, Wuhan University.

Straneck, R., Livezey, B.C., and Humphrey, P.S. (1983). Predation on steamer-ducks by killer whale. Condor 85, 255-256.

Sucunza, F., Andriolo, A., Dalla Rosa, L., Castro, F. R., Danilewicz, & Zerbini, A. N. (2022). Sperm whale, *Physeter macrocephalus*, harassment by killer whales, *Orcinus orca*, in the western South Atlantic Ocean. Latin American Journal of Aquatic Mammals, 17(2)

Thomas, P.O., and Taber, S.M. (1984). Mother-infant interaction and behavioral development in southern right whales, *Eubalaena australis*. Behaviour 88, 42-60.

Tixier, P., Gasco, N., Duhamel, G., and 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(3), 983-100.

Towner, A.V., Watson, R.G.A., Kock, A.A., Papastamatiou, Y.P., Sturup, M., Enrico, G., et al. (2022). Fear at the top: killer whale predation drives white shark absence at South Africa's largest aggregation site. African Journal of Marine Science 44(2), 139-152.

van den Hoff, J., and Morrice, M.G. (2008). Sleeper shark (*Somniosus antarcticus*) and other bite wounds observed on southern elephant seals (*Mirounga leonina*) at Macquarie Island. Marine Mammal Science 24(1), 239-247.

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

Visser, I.N. (2005). First observations of feeding on thresher (*Alopias vulpinus*) and hammerhead (*Sphyrna zygaena*) sharks by killer whales (*Orcinus orca*) which specialise on elasmobranchs as prey. Aquatic Mammals 31(1), 83-88.

Visser, I.N., Zaeschmar, J., Haliday, J., Abraham, A., Ball, P., Bradley, R., et al. (2010). First record of predation on false killer whales (*Pseudorca crassidens*) by killer whales (*Orcinus orca*). Aquatic Mammals 36(2), 195-204.

Visser, I.N., Nyegaard, M., and Fletcher, L. (2022). Orca (*Orcinus orca*) interactions with ocean sunfishes (Family Molidae, genus Mola and Masturus): A global review Biodiversity Journal.

Voisin, J.F. (1976). On the behaviour of the killer whale, *Orcinus orca* (L.). Norwegian Journal of Zoology 24, 69-71.

Weir, C.R., Collins, T., Carvalho, I., and Rosenbaum, H.C. (2010). Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa. Journal of the Marine Biological Association of the United Kingdom 90(8), 1601-1611.

Wellard, R., Lightbody, K., Fouda, L., Blewitt, M., Riggs, D., and Erbe, C. (2016). Killer whale (*Orcinus orca*) predation on beaked whales (*Mesoplodon* spp.) in the Bremer sub-basin, Western Australia. PLoS ONE, 1-15.

Weller, D.W. (2008). "Predation on marine mammals," in Encyclopedia of marine mammals, eds. W.F. Perrin, B. Würsig & J.G.M. Thewissen. (San Diego, CA: Academic Press), 923-932.

Wenzel, F., and Sears, R. (1988). A note on killer whales in the Gulf of St. Lawrence, including an account of an attack on a Minke whale. Rit Fiskideildar 11. North Atlantic killer whales, 202-204.

Williams, A.J., Dyer, B.M., Randall, R.M., and Komen, J. (1990). Killer whales *Orcinus orca* and seabirds: "play", predation and association. Marine Ornithology 18, 37-41.

Wright, B., Ford, J.K.B., Ellis, G.M., and Stredulinsky, E. (2016). Kin-directed food sharing promotes lifetime natal philopatry of both sexes in a population of fish-eating killer whales, *Orcinus orca*. Animal Behavior 115, 81-95.

Wursig, B. & Wursig, M. (1979). Behavior and ecology of the bottlenose dolphin, *Tursiops truncatus*, in the south atlantic. - Fish. Bull. 77, p. 399-412.

Yates, O., Black, A.D., and Palavecino, P. (2007). Site fidelity and behavior of killer whales (*Orcinus orca*) at Sea Lion Island in the Southwest Atlantic. Latin American Journal of Aquatic Mammals 6(1), 89-95.

Young, B. G. Fortune, S. M. E., Koski, W. R., Raverty, S. A., Kilabuk, R. and Ferguson, S. H. (2020). Evidence of killer whale predation on a yearling bowhead whale in Cumberland Sound, Nunavut. Arctic Science. 6(1): 53-61.