Humpback whales interfering when mammal-eating killer whales attack other species: Mobbing behavior and interspecific altruism?

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Abstract

Humpback whales (*Megaptera novaeangliae*) are known to interfere with attacking killer whales (*Orcinus orca*). To investigate why, we reviewed accounts of 115 interactions between them. Humpbacks initiated the majority of interactions (57% *vs*. 43%; *n*=72), although the killer whales were almost exclusively mammal-eating forms (MEKWs, 95%) *vs.* fish-eaters (5%; *n*=108). When MEKWs approached humpbacks (*n*=27), they attacked 85% of the time and targeted only calves. When humpbacks approached killer whales (*n*=41), 93% were MEKWs, and ≥87% of them were attacking or feeding on prey at the time. When humpbacks interacted with attacking MEKWs, 11% of the prey were humpbacks and 89% comprised 10 other species, including 3 cetaceans, 6 pinnipeds, and 1 teleost fish. Approaching humpbacks often harassed attacking MEKWs (≥55% of 56 interactions), regardless of the prey species, which we argue was mobbing behavior. Humpback mobbing sometimes allowed MEKW prey, including nonhumpbacks, to escape. We suggest that humpbacks initially responded to vocalizations of attacking MEKWs without knowing the prey species targeted. Although reciprocity or kin selection might explain communal defense of conspecific calves, there was no apparent benefit to humpbacks continuing to interfere when other species were being attacked. Interspecific altruism, even if unintentional, could not be ruled out.

Key Words: humpback whale, interspecific altruism, killer whale, *Megaptera novaeangliae*, mobbing behavior, *Orcinus orca*, predation

Introduction

Anecdotes have been passed down for centuries about dolphins at sea coming to the aid of distressed conspecifics, as well as other species, including humans (Caldwell and Caldwell 1966, Connor and Norris 1980, Whitehead and Rendell 2015). However, more recent observations, including popular accounts (*e.g.,* Dolphin 1987, D'Vincent *et al.* 1989, Pitman and Durban 2009) and videos posted on the internet (Appendix 1), suggest that a baleen whale - the humpback whale (*Megaptera novaeangliae*) – also approaches marine vertebrates in distress, most notably, when they are being attacked by killer whales (*Orcinus orca*). This seems particularly maladaptive for the humpbacks because they themselves are attacked by killer whales (Whitehead and Glass 1985, Jefferson *et al.* 1991, Reeves *et al.* 2006, Ford and Reeves 2008, Saulitis *et al.* 2015).

It is generally accepted that, due to their enormous size, large whales have no significant natural predators except, possibly, mammal-eating killer whales (MEKWs - *vs*. fish-eating forms; Jefferson *et al*. 1991, Reeves *et al.* 2006). The prevalence and overall ecological impact of MEKW predation on large whales, however, remains contentious and unresolved (*e.g*., Doak *et al.* 2006, Reeves *et al.* 2006, Springer *et al.* 2006, Trites *et al.* 2007).

Much of the uncertainty about killer whale predation on large whales is because attacks have been so rarely reported (Jefferson *et al.* 1991, Pitman *et al.* 2001, Springer *et*

70 *al.* 2008, Ferguson *et al.* 2010). Although some have argued that this lack of observations
71 is evidence that killer whales are *not* important predators of large whales (*e.g.*, Clapham
72 2001, Mizroch and Rice 2006), this 'absence of evidence' could also be a legacy of 20th
73 Century industrial whaling (Tønnessen and Johnsen 1982, Clapham *et al.* 2008, Rocha *et*
74 *al.* 2014), which means that most living humans have never experienced oceans that were
75 not already depleted of large whales. Within this "shifted baseline" (Pauly 1995) nearly
76 all large whale species are still in various stages of recovery, making it is impossible to
77 assess the historical impact of MEKW predation on their populations (Doak *et al.* 2006,
78 Kareiva *et al.* 2006, Springer *et al*. 2006, Pitman *et al.* 2015). Furthermore, by the time
79 commercial whaling ended, any populations of killer whales that might have previously
80 preyed upon large whales would almost certainly have either declined, become
81 extirpated, or been forced to switch to alternative prey (Springer *et al.* 2003, Branch and
82 Williams 2006, Doak *et al.* 2006; but see Wade *et al.* 2007 for an opposing view).
83 Consequently, MEKW populations around the world could also be in various stages of
84 recovery, albeit at a lagged and slower rate than large whales (Pitman *et al.* 2015). Only
85 if and when these species recover will we have a chance to view predator/prey
86 interactions as they once were (Kareiva *et al.* 2006).
87 For humpback whales, it is generally assumed that their most important non-
88 human predators are MEKWs (Jefferson *et al.* 1991, Paterson and Paterson 2001, Ford
89 and Reeves 2008). Until very recently, however, based on the relatively few documented
90 attacks (Chittleborough 1953, Whitehead and Glass 1985, Dolphin 1987, Jefferson *et al.*
91 1991, Flórez-González *et al*. 1994, Ford and Reeves 2008), MEKW predation on
92 humpbacks had been considered to be a rare (and almost never fatal) event and therefore

93 of limited ecological impact (Jonsgård 1968, Jefferson *et al.* 1991, Clapham 2001,
94 Mizroch and Rice 2006, Mehta *et al.* 2007, Ford and Reeves 2008).
95 There is, however, mounting evidence to suggest that killer whales may in fact
96 regularly attack humpbacks, and that calves and juveniles are the main targets
97 (Chittleborough 1953, Katona *et al.* 1980, Whitehead and Glass 1985, Jefferson *et al*.
98 1991, Paterson and Paterson 2001, Baird *et al.* 2006, Reeves *et al.* 2006, Ford and Reeves
99 2008, Saulitis *et al.* 2015). In three separate studies (Naessig and Lanyon 2004, Mehta *et*
100 *al.* 2007, Steiger *et al.* 2008), images from humpback whale photo-identification catalogs
101 compiled from various studies around the world were analyzed for MEKW tooth rake
102 marks on the flukes and used to infer the prevalence of killer whale attacks (keeping in
103 mind that marked whales represent only the survivors of such attacks – Clapham 2001).
104 Although the frequency of rake-mark occurrences in some populations ranged as high as
105 20%-40%, in the largest study (Mehta *et al*. 2007) less than 7% of whales acquired
106 additional rake marks after the first time they were photographed. Based on similar
107 findings, all three studies concluded that killer whales regularly attacked humpback
108 calves and juveniles but rarely adults (Naessig and Lanyon 2004, Mehta *et al.* 2007,
109 Steiger *et al.* 2008). Furthermore, these attacks could result in significant calf mortality.
110 When Gabriele *et al.* (2001) compared the number of individually-identified humpback
111 mothers with calves on their North Pacific breeding grounds, with those found later
112 *without* calves in the feeding areas, calf mortality during the first year of life was
113 estimated to be approximately 18% (15%-24%), although the specific causes or locations
114 of that mortality could not be identified.

In addition to overt predation, even just the threat of MEKW attack could significantly influence behavioral decisions made by large whales, with potential population-level consequences (Creel and Christianson 2008, Wirsing *et al.* 2008). For example, many baleen whale species undertake extensive seasonal migrations between high-latitude feeding grounds and often prey-deficient, low-latitude breeding areas, but there is no consensus as to why they make these energetically costly movements (Stevick *et al.* 2002, Stern 2009). Some authors have suggested that migration allows calves to be born in lower latitudes where there are fewer killer whales and a reduced risk of predation (Corkeron and Connor 1999, Connor and Corkeron 2001; see also Cartwright and Sullivan 2009). Others (*e.g.,* Clapham 2001, Rasmussen *et al.* 2007), however, are not convinced that the threat of killer whale attack could provide the impetus for what is (or at least was, prior to the advent of global industrial whaling) arguably the largest seasonal movement of animal biomass on Earth. Observations from Western Australia also indicate that migrating humpback cows with calves take longer, more inshore routes compared to nonbreeders, presumably to reduce the risk of MEKW attack (Pitman *et al.* 2015). This suggests that the threat of predation could be influencing not only *why*, but *how* humpbacks migrate.

Clearly, MEKW predation, even if rarely observed and targeting mainly calves and subadults, represents a threat to humpbacks that is persistent, widespread, and perhaps increasing (Houghton *et al.* 2015, Pitman *et al.* 2015; see also Discussion). As such, humpbacks could be expected to show some specific anti-predator behaviors, and indeed some have been suggested. Ford and Reeves (2008) summarized the defensive capabilities of baleen whales faced with killer whale attack, and they identified two

general categories of response. Balaenopterid rorquals (*Balaenoptera* spp.) use their high speed and hydrodynamic body shape to outrun killer whales and were classified as *flight* species. The generally more rotund and slower-swimming species - right whales (*Eubalaena* spp.), bowhead whale (*Balaena mysticetus*), gray whale (*Eschrichtius robustus*), and humpback whale - apparently rely on their bulk and powerful, oversized appendages (tail and flippers) to ward off attackers. This group was categorized as *fight* species. As part of their fight response, humpbacks have also been reported exhibiting group defense against killer whale attack (*e.g.,* Whitehead and Glass 1985, Dolphin 1987, D'Vincent *et al*. 1989), and humpback cow/calf pairs are sometimes accompanied by an escort that will also help defend the calf from attack (Chittleborough 1953, Pitman *et al.* 2015).

As is evident above, most reports describing humpback interactions with MEKWs have emphasized humpback defensive behaviors, but there is a growing body of evidence to suggest that humpback anti-predator behavior may have evolved beyond just basic defense, possibly including humpbacks deliberately interfering when MEKWs are attacking other humpbacks and even other species. To investigate the nature and scope of these interactions, we reviewed published and unpublished sources and compiled observations of 115 separate encounters between humpbacks and killer whales from around the world. From these, we identified two general categories of interactions, with each species responding either offensively or defensively, depending on which species approached the other. Herein, we describe these interactions and discuss the adaptive and ecological significance of these behaviors for both species.

Methods

We compiled published and unpublished observations of interactions between humpback whales and killer whales, recorded over a 62-yr period (1951-2012), by at least 54 different observers from around the world. Nearly all of the observations were made either opportunistically (usually by passengers or naturalists on whale-watching boats), or by researchers studying killer whales or humpbacks (mainly photo-identification studies). Because the observations were recorded by scientists, naturalists, and laymen alike, they vary widely in accuracy, detail, and interpretation. The accounts are presented largely in their entirety in Appendix 2 and summarized in Table 1. For transparency, we have kept the accounts largely unedited and indicated in brackets any editorial comments or changes made for clarity. Collectively, we believe that these narratives offer new insights into the nature and prevalence of humpback/killer whale interactions (Bates and Byrne 2007).

Killer whale communities, at least within the continental shelf zone of much of the North Pacific (Ford *et al.* 1998, Ford 2011) and in Antarctica (Pitman and Ensor 2003), comprise sympatric populations of mammal- and fish-eating prey specialists ('ecotypes'). Distinguishing among these ecotypes clearly has important implications for understanding their interactions with humpbacks. In the text and table, Bigg's killer whales (Ford 2011; often referred to as 'transient killer whales' or 'transients'), refers to a mammal-eating ecotype from the eastern and central North Pacific. 'Residents' and 'offshores' are fish-eating ecotypes from the same area. Similarly, in Antarctica, in addition to mammal-eating killer whale ecotypes (type A and large type B [B1]), there is

184 at least one fish-eating form (type C) from eastern Antarctica and another possible fish-
185 eater (small type B [B2]) found in Antarctic Peninsula waters (Pitman and Ensor 2003,
186 Durban *et al.* 2016). The killer whales listed in Table 1 were classified as mammal-eating
187 killer whales (MEKWs) if they were identified in the Appendix 2 accounts as
188 "transients;" if they were attacking a marine mammal at the time of the observation, or if
189 the encounter occurred in tropical or subtropical waters. Killer whales in lower latitudes
190 tend to have unspecialized diets that include marine mammals (Baird *et al.* 2006). Killer
191 whales were classified as fish-eating ecotypes if they were identified as such by
192 experienced observers or from photo-identification matches to known types. Killer
193 whales that could not be categorized were classified as 'ecotype unknown.'
194 From the accounts in Appendix 2, we classified interactions between humpbacks
195 and killer whales based on which species approached the other (*i.e.*, which species
196 initiated the interaction) or as 'unknown' if a determination could not be made (*i.e.*, the
197 interaction was already in progress when the observer arrived) or was unrecorded (Table
198 1). Based on our interpretation of the duration and intensity of the approaches and the
199 specific comments in the Appendix 2 accounts, we further categorized MEKW
200 approaches to humpbacks as either a 'test' (sometimes described in the narratives as a
201 brief harassment), an attack, or unknown. Tests usually lasted 5 min or less and often
202 were little more than a brief pass-by; attacks lasted more than 5 min and involved direct
203 contact with the targeted species.
204 When possible, humpbacks were also noted as being either with or without a calf.
205 If a calf was not specifically identified, humpbacks were recorded 'without calf,'
206 although small calves may have been overlooked and larger calves can be difficult to

distinguish from other adults. The sex of individual humpback whales was sometimes determined, either genetically (through the analysis of tissue biopsies or sloughed skin) or from photographs of the genital area. An animal was also inferred to be female if it was closely and consistently attended by a calf at some time.

The term 'escort' is usually used to indicate an adult male humpback that accompanies a female with a calf on the breeding grounds (Herman and Antinoja 1977, Tyack and Whitehead 1983, Clapham 2000). However, as is clear from the accounts in Appendix 2 and Pitman *et al*. (2015), cow/calf pairs are sometimes accompanied by another humpback also during migration and on the feeding grounds. Therefore, although deviating somewhat from current usage, for this paper we define 'escort' as any humpback that accompanies a humpback cow/calf pair anytime or anywhere, including on the breeding or feeding grounds, or during migration. 'Group size' for killer whales and humpbacks refers to the total number of individuals directly involved in an individual interaction and within one humpback body length (*ca.* 15 m) of other conspecifics at some time during the interaction.

'Bellowing' is the term we use for the very loud exhalations humpbacks make when they are excited (Whitehead and Glass 1985, Dolphin 1987). These sounds are variously referred to in Appendix 2 as "trumpeting," "trumpet blowing," "wheezing blows," "snorting," "exhaling loudly," *etc*. 'Mobbing behavior' is defined as one or more humpbacks approaching MEKWs and doing one or more of the following: charging or chasing after the MEKWs, bellowing, and/or slapping or slashing their flipper or tail. As an additional cue, when humpbacks were mobbing, MEKWs actively fled from them or

avoided them. Unless otherwise indicated, numbered references in the text (usually in parentheses) refer to the specific numbered events in Appendix 2 and Table 1.

Results

Appendix 2 (summarized in Table 1) provides details of 108 encounters between killer whales and humpback whales; six of these encounters (Appendix 2: #16, 39, 48, 49, 58, 87) included a further 1-2 interactions with additional groups of humpbacks, which were treated as separate events, giving a total of 115 interactions. Although these events were recorded at widely scattered locations around the world (Fig. 1), by far the majority was recorded in the eastern North Pacific Ocean including Monterey Bay, California (48 interactions; 42% of total) and Southeast Alaska (27 interactions; 23%).

Interactions between humpbacks and killer whales were usually agonistic and sometimes protracted, but which species behaved offensively, and which defensively, depended largely on the ecotype of the killer whales involved, and which species initially approached the other. Humpback whales interacted almost exclusively with mammal-eating killer whales (MEKWs) *vs*. fish-eating forms: of the 115 killer whale groups observed interacting with humpbacks, 108 (94%) were identified to type, and these included 95% MEKWs and 5% known or suspected fish-eaters (Table 1).

Overall, humpbacks approached MEKWs more often than MEKWs approached humpbacks: of 103 interactions, MEKWs approached humpbacks 27 times (26%), humpbacks approached MEKWs 38 times (37%), and the approaching species was unknown 38 times (37%). When the approaching species was known (n = 65),

252 humpbacks initiated 58% of these interactions and MEKWs 42%. Among the 43
253 humpback/killer whale interactions for which the approaching species was not known, 38
254 (88%) included groups of MEKWs and 5 (12%) involved unidentified killer whale types.
255 Below we describe the behavioral responses of humpbacks and killer whales
256 during their interactions based on which was the approaching species. We also provide
257 some quotes from Appendix 2 from people who observed these interactions.
258
259 *Killer Whales Approached Humpbacks*
260 Killer whale groups that approached humpbacks (n = 31) were almost exclusively
261 MEKWs (at least 27 groups; 87%). The remainder comprised fish-eaters (6%, n = 2) and
262 unidentified types (6%, n = 2; Table 1). Among the identified ecotypes, MEKWs
263 comprised 93% of the total. On the two occasions when fish-eaters approached
264 humpbacks, the interactions were relatively benign: 1) a group of 'resident' killer whales
265 apparently 'harassed' a lone adult male humpback for 5 min before leaving it (#6), and 2)
266 suspected fish-eaters in Antarctica (type B2; Pitman and Durban 2010, Durban *et al.*
267 2016) caused a group of humpbacks to become briefly agitated. Other humpbacks
268 converged on the site, but then the killer whales traveled with the humpbacks for a while
269 afterward without incident (#49).
270 When MEKWs approached humpbacks (n = 27), no other potential prey species
271 were observed, although it is possible that small prey, such as a pinniped, could have
272 been overlooked (see, for example, #87). Humpback calves were present during at least
273 17 (63%) of the approaches, and MEKWs attacked during at least 16 (94%) of those. In
274 at least 12 of the 16 (75%) attacks with a calf present, it was reported (or suspected) that

275 the calf was specifically targeted (#30, 33, 34, 36, 37, 39, 40, 42, 43, 45, 47, 48), and in
276 the other 4 cases, calves were likely targeted as well (#31, 35, 38, 41).
277 When MEKWs attacked humpbacks and no calf was reported, there was,
278 nonetheless, evidence that younger animals were in fact targeted in most and perhaps all
279 cases. On the 10 occasions when MEKWs approached humpbacks and a calf was not
280 reported, 7 resulted in attacks of which at least 6 (86%) appeared to target nonadults,
281 including two possible calves (#2, 16), two single juveniles (#14, 58), a possible juvenile
282 (#10), and a lone subadult (#21). The remaining attack was on an animal of unknown age
283 (#1). During the three MEKW approaches when no humpback calves were seen and no
284 attack was reported, MEKWs were described as "testing" or "harassing" (*i.e.*, possibly
285 attacking) humpbacks of unknown age on one occasion (#3), and on two other occasions
286 MEKWs approached single humpbacks that were identified as adults (#13, 28), engaged
287 them briefly, and then left.
288 Although interaction times were infrequently noted, when MEKWs approached
289 humpbacks the interaction lasted longer if the humpback was with a calf. Six interactions
290 with calves present lasted 20, 20, 26+, 45+, 150+, and 390+ min (#33, 40, 34, 47, 48, and
291 41, respectively). When MEKWs approached humpbacks and calves were definitely not
292 present, typically there was a brief bout of bellowing or surface-active behavior by the
293 humpback(s), and the MEKWs moved on (#13, 28; these two interactions lasted an
294 estimated 5 and 2 min, respectively).
295 Although MEKWs purportedly killed one humpback calf (#36) and possibly
296 another (#10; neither kill was confirmed), no adult humpbacks were reported killed or
297 seriously wounded during any of the interactions. Observers sometimes reported seeing

298 exposed flesh, minor bleeding, or bits of skin and blubber floating on the surface during
299 some of the attacks (#2, 3, 34, 47), but there was no evidence to suggest that any adult
300 humpbacks sustained life-threatening wounds.
301
302 *Humpbacks Approached Killer Whales*
303 The killer whales that humpbacks approached were almost exclusively mammal-eating
304 forms: among the groups identified to ecotype, 38 of the 41 (93%) were MEKWs; the
305 remaining 3 (7%) were known or suspected fish-eaters (Table 1).
306 Humpback approaches to fish-eating killer whales were relatively uneventful. In
307 Alaska, humpbacks followed a group of known fish-eaters for over 2 h without incident
308 (#15); in Antarctica, a lone humpback followed a group of suspected fish-eaters (#29).
309 Also in Antarctica, suspected fish-eaters caused a group of humpbacks to become
310 agitated, and several nearby humpbacks moved in among them, but nothing happened
311 and the humpbacks dispersed (#49b).
312 Although infrequently noted, the distance humpbacks traveled to approach
313 MEKWs was sometimes considerable. The six observer accounts that included estimated
314 travel distances included: 200 m, >300 m, “several hundred meters”, >1 mile (>1.6 km),
315 *ca*. 1.8 km, and 2 miles (3.2 km; #92, 96, 78, 4, 59 and 77, respectively). On another
316 occasion (#55), one humpback observed among a group of attacking MEKWs had been
317 photographed feeding 2.7 h earlier, 3.5 nmi (6.5 km) away; a second had been
318 photographed feeding 2.5 h earlier, 3.6 nmi (6.7 km) away, and a third humpback among
319 this group had been photographed feeding 6.1 h earlier, 4.1 nmi (7.6 km) away. During
320 each of these events, the MEKWs were attacking or feeding on prey when the

humpback(s) arrived. The killer whale prey included a harbor seal (*Phoca vitulina*), an ocean sunfish (*Mola mola*), a California sea lion (*Zalophus californianus*), a humpback (no calf reported), a Steller sea lion (*Eumetopias jubatus*), another California sea lion, and a gray whale calf, respectively.

When humpbacks approached MEKWs (n = 38), at least 87% were attacking or feeding on prey at the time, and at least 3 of the other 5 MEKW groups may also have been with prey. Two groups (#87, 99) were suspected of having prey, and in one event (#108) MEKWs were "playing, jumping," which they often do after a kill (Ford and Ellis 1999, Matkin *et al.* 1999; Table 1). When humpbacks approached attacking MEKWs, among the prey identified (n = 29) were at least 10 species of large marine vertebrates, including humpbacks (17%) and other species (83%), the latter including 4 cetaceans, at least 5 pinnipeds, and 1 teleost fish. During an additional 43 interactions between MEKWs and humpbacks when the approaching species was not known, at least 23 (56%) of the MEKW groups were reported attacking or feeding on 8 different prey species (including other humpbacks). Overall, humpbacks interacted with MEKWs that were attacking a total of 11 different prey species: other humpbacks (n = 6; 2 with calf, 4 without); gray whales (n = 5), common minke whale (*Balaenoptera acutorostrata*; n = 1), Dall's porpoise (*Phocoenoides dalli*; n = 1), Steller sea lions (n = 13), California sea lions (n = 14), Weddell seals (*Leptonychotes weddellii*; n = 1), crabeater seals (*Lobodon carcinophaga*; n = 1), harbor seals (n = 3), northern elephant seals (*Mirounga angustirostris*; n = 2), ocean sunfish (n = 2), and unidentified (but nonhumpback) prey (n = 7; Table 1, Fig. 2). In summary, when humpbacks interacted with attacking MEKWs (*i.e.*, humpbacks approached killer whales or the approaching species was unknown), and

344 the prey were identified (n = 56), 11% were humpbacks and 89% were species other than
345 humpbacks.
346 The sex of humpbacks that approached MEKWs was determined for 15
347 individuals from 9 events and included both males and females (one male was recorded
348 twice – see below). Among humpbacks that approached attacking MEKWs, the sex was
349 known for five individuals from three events: a single male and a single female
350 (apparently initially unassociated) responded to an attack on a Steller sea lion (#65); an
351 adult female with two adults of unknown sex approached MEKWs that were with a
352 Steller sea lion kill (#70), and an adult female with 2-6 adult humpbacks of unknown sex,
353 and an adult male with three other adult humpbacks of unknown sex approached
354 MEKWs that killed a gray whale calf (#55). The sex of an additional 10 humpbacks from
355 6 events where the approaching species was not known included 8 males and 2 females: 2
356 single males interacted with MEKWs attacking a Steller sea lion (#60) and a harbor seal
357 (#91); at least 2 of 4 humpbacks present at a Steller sea lion attack (#61) were males; 2
358 previously-unassociated males each responded to an attack on a Steller sea lion (#62); an
359 adult male and another adult of unknown sex interacted with MEKWs at a Steller sea lion
360 kill (#69); and one of a pair of humpbacks at a Weddell seal attack in Antarctica (#88)
361 was genetically identified as a male. In addition, on at least two occasions, cow/calf pairs
362 were among other humpbacks that approached during MEKW attacks on a Steller sea
363 lion (#59) and a California sea lion (#74), respectively. The single male in event #60 was
364 also photo-identified as one of the two males in event #62; both events involved MEKW
365 attacks on single Steller sea lions in Icy Strait, Alaska, one in September 1988 and one in
366 September 2003 - 15 years apart!

When humpback whales interacted with MEKWs, they generally showed the same behavioral responses regardless of whether they approached MEKWs, or MEKWs approached them (*i.e.*, the same behaviors were used offensively and defensively), and regardless of whether the MEKWs were harassing or attacking them, their calves, other humpbacks, or other species of marine animals (Table 1). The most commonly reported behaviors for humpbacks interacting with MEKWs, regardless of the approaching species (n = 103), included: slapping their flukes at the surface ("lob-tailing") or slashing them from side-to-side (37 interactions; 36%), bellowing (26%), pursuing behavior (21%), and flipper slapping (14%). When humpbacks pursued MEKWs (n = 22), regardless of the initially-approaching species, they were variously described as just following the killer whales (#52, 55, 57, 59, 66, 69, 88, 89, 91, 100, 102, 104, 107), chasing them (#2, 39, 50, 55, 86, 94, 96, 105), or charging at them (#19, 31, 55, 77). We categorized as 'mobbing behavior' (see Discussion) whenever humpbacks used any of these behaviors offensively (*i.e.*, whenever humpbacks approached attacking MEKWs, or when the approaching species was not known and humpbacks were interacting with MEKWs attacking a third species or another humpback). Based on these criteria, humpbacks exhibited mobbing behavior during at least 31 out of 56 ($\geq$55%) interactions with attacking killer whales.

Observers sometimes reported that approaching humpbacks appeared to affect the outcome of the attack, and were reportedly responsible for the escape of at least two humpbacks (#16, 39), two gray whales (#52, 53), probably a Weddell seal (#87), and an unrecorded number of sea lions (#53). When humpbacks approached MEKWs attacking humpbacks (n = 5; 2 with calves), 4 of the attacks were unsuccessful and the outcome of the other was unknown. Furthermore, the approaching humpbacks were described as

coming to the aid (#4) or defense (#58) of the attacked whales, and in two other cases (#16 and 39) they reportedly drove off the attackers. When humpbacks approached MEKWs that were attacking pinnipeds (n = 18), the prey was killed on at least 13 (72%) occasions. It was not always possible to determine exactly when the pinniped died, but on at least five of those occasions (#65, 73, 78, 86, 92) the prey was probably already dead when the humpback(s) arrived.

What follows are quotes from Appendix 2 by three different observers, which offer some insights into the behaviors of humpbacks that approached attacking MEKWs.

"We observed the harassment of a humpback whale by [about 15] killer whales once; during the attack, other humpback whales rapidly converged on the attackers and appeared to drive the killer whales away" (#16).

[After being attacked by a group of approximately 15 killer whales, a humpback cow/calf pair joined a trio of humpbacks] "and for the next few minutes we could see what clearly looked like the three Humpback whales chasing off the Orcas! The Orcas left the scene completely, all the time with the three Humpbacks behind them" (#39).

"[W]e had traveled quite a distance to observe a group of killer whales attacking a gray whale mother and calf pair and out of NOWHERE, a humpback whale came trumpeting in followed by another and then another until we had about 5 or more humpbacks in the immediate area. It was strange because during the entire journey with several observers on effort, not a single humpback whale had been observed. It seemed quite clear that the KW/gray whale interaction had attracted the humpbacks, though I cannot say whether it was motivated by curiosity, playfulness or an act of benevolence. The result however was that the gray whale cow/calf pair was able

to escape. [On other occasions] I also personally observed several sea lions surviving predation attempts as a result of humpback whales distracting killer whales" (#53).

Additional Biological Observations

The overall median number of MEKWs present during each individual interaction with humpbacks was 6 (n = 97; range 1-17), and the median was the same regardless of whether they approached humpbacks (n = 26; range 1-17), or humpbacks approached them (n = 33, range 2–16). The overall median group size for the total number of humpbacks present in each interaction was 2 (n = 92; range 1-16), also regardless of whether they approached MEKWs (n = 36; range 1–16), or MEKWs approached them (n = 23; range 1–3).

The duration of interactions between humpbacks and attacking MEKWs was variable but often protracted and ranged from 15-437+ min (Table 1). Using data only from sightings observed from start to finish, humpback/MEKW interactions lasted an average of 59 min (n = 10, range 15-124). Longer events, however, were rarely observed in their entirety, usually because observers arrived after the event was already in progress or departed before it was over. If we also include events where the approaching species was unknown, there were 13 partially-observed interactions that lasted 60 min or longer. The longest occurred during a gray whale calf kill where humpbacks were present for a minimum of 437 min (#55).

When lone humpback cow/calf pairs were attacked (n = 6), the mother was sometimes able to drive off the MEKWs by herself (# 35, 42, 45, 46; killer whale group

436 size during these attacks was 1, 7, 6, and 2, respectively). When humpback cow/calf pairs
437 were accompanied by an escort, the escort at times appeared to defend the calf as
438 vigorously as the mother, although even their combined efforts apparently were not
439 always successful (#36). Escorts were reported accompanying cow/calf pairs on the
440 feeding grounds (#33, and probably 58), on the breeding grounds (#34, 37, 43), and on
441 migration (#31, 36).

442 Attacking MEKWs often tried to separate the humpback calf from its mother
443 (#34, 43, 45, 47), and the humpbacks took specific countermeasures. A lone mother
444 raised her calf out of the water on her back and head (#46). Mothers and escorts
445 sometimes responded by flanking the calf (#33, 36, 43, and probably 58), and during one
446 attack, a mother and an escort flanked a calf and partly raised it out of the water with
447 their flippers (#33). If there were more than two adult humpbacks present, they
448 sometimes surrounded the calf or calves (#38, 44).

449 In addition to mothers and escorts protecting calves from attacking MEKWs,
450 other unassociated humpbacks in the area sometimes assisted in driving away the
451 attackers (#4, 16, 39, 48, 49). For example, "in a harassment observed in 1988 in
452 Chatham Strait [Alaska], humpbacks came from over a mile away to the aid of the
453 victim" (#4). In another, 15 MEKWs attacked the smaller of three humpback whales, and
454 an hour into the attack, three other humpbacks "rapidly converged on the attackers and
455 appeared to drive the killer whales away" (#16). In an encounter in Antarctica, a
456 humpback cow/calf pair under attack swam in among three adult humpbacks and the trio
457 apparently chased off the killer whales (#39). In another case, killer whales were

attacking a humpback calf, and 30 min later 13 humpbacks "swam up to the injured calf" and the killer whales left the area (#48).

Overall, regardless of the approaching species, a minimum of 38 prey animals were reported killed during the humpback/killer whale interactions, including humpback whales (2 calves/juveniles; kill(s) likely but not confirmed), gray whales (2; including at least one calf), minke whale (1), Steller sea lions (10), California sea lions (10), Weddell seal (1), harbor seals (3), northern elephant seals (2), and unidentified prey (7). One, possibly two ocean sunfish were attacked and probably killed, also. When humpbacks interacted with MEKWs that were attacking other humpbacks (n = 17), the fate of the prey was recorded 7 times (41%) and there were no kills. These included 2 groups with calves and 5 without. The fate of the prey was unrecorded 10 times (59%). When humpbacks interacted with MEKWs that were attacking nonhumpback prey (n = 53), the fate of that prey was recorded 44 times (83%): of those 36 (82%) were killed, and at least 8 (18%) were seen (or suspected) to escape (#51, 52, 53, 57, 72, 79, 87, 89).

Observer Comments

Some observers were clearly puzzled about why humpbacks would approach attacking MEKWs, and a number of possible explanations were included in the accounts. For example, it was suggested that the humpbacks might have been merely curious (#53, 75, 89), and others suggested that the humpbacks were also trying to kill or injure the prey that the MEKWs were attacking, by swatting them with their flippers or flukes (#61, 64, 65, 91). Although humpbacks in some of the accounts reportedly struck killer whale prey with their flippers or flukes, including in one case when the prey was apparently already

dead (#65), it was unclear whether this contact was intentional, or at least in some cases, whether the purported contact actually occurred. For example, “three adult humpbacks participated [in a Steller sea lion kill] by lobtailing on or near the sea lion 15 times, making physical contact with it a minimum of 10 times” (#61). However, after a careful review of the video that this account was based on, RLP has concluded that the humpbacks remained in close proximity to the sea lion and were swatting only when the killer whales made close passes, and that there was no confirmed contact with the carcass[1].

The following is an example of observer confusion as to whether humpbacks were attempting to strike the prey with their appendages or were targeting the killer whales. “It definitely looked like the humpback was slashing, with its pectoral fins, at the [Steller] sea lion. We were astonished and thought at the time that the humpback was participating in the kill. I remember noticing that the pectoral fin slashes were "late", a few beats behind as the Steller swam on the surface alongside the humpback, with orcas following…It's quite possible that the humpback was actually slashing at the orcas following the sea lion. Perhaps the animal wasn't late with its slashes, it might have been right on time!” (#64).

Other observers specifically stated that the aggressive behavior of the humpbacks was in fact directed at the attacking killer whales and not their prey (#19, 58, 68, 77, 86). According to one: “I remembered thinking that humpbacks can be fearsome if necessary. The trumpeting noise and quick forceful movements, directly at the Orcas, was

[1] Based on this same video footage, some of the co-authors (VBD, CMG, DRM, and JLN) thought that the

impressive" (#19). Another wrote that the humpbacks were "swatting killer whales with their flukes!" (#77). Despite the numerous accounts of humpbacks slapping or slashing their appendages in the presence of attacking killer whales (n = 38; Table 1), there were no confirmed reports of humpbacks actually striking MEKWs, although it could have happened (*e.g.*, #55, 59). And finally, some observers interpreted the humpbacks' behavior as attempts to rescue, guard or protect the prey (#52, 53, 55, 60, 68, 88).

Discussion

It is clear from these results that killer whales and humpback whales regularly approached each other but for entirely different reasons. Killer whales that approached humpbacks were almost exclusively mammal-eating forms (*vs*. fish-eaters), and they appeared to be looking for calves or juveniles to attack (see also Pitman *et al.* 2015, Saulitis *et al.* 2015). When humpbacks approached killer whales, they were selective about the type of killer whale that they interacted with and the circumstances: 93% of the killer whale groups that they approached were MEKWs, and at least 84% (and perhaps 100%) of those were attacking or feeding on prey at the time (Fig. 2). Although the threat of injury to an approaching adult humpback was probably minimal (see below), these interactions did come at a cost to the humpbacks. In addition to disruption of their normal behaviors (*e.g.*, feeding, resting, socializing), they sometimes traveled distances >2 km to approach killer whales. They often responded vigorously and aggressively and sometimes for extended periods of time: interactions regularly lasted >1 h and up to almost 7 h. Particularly puzzling was the fact that when humpbacks approached attacking MEKWs,

525 and the species of prey was identified (n = 33), 85% of the time it was a species other
526 than a humpback whale, but the approaching humpbacks often continued their
527 interactions or harassment regardless of the prey species. Below, we discuss the adaptive
528 significance and implications of these interactions for both species, and we comment on
529 how and why humpbacks may be willing to confront MEKWs, even when they were
530 attacking species other than humpbacks.
531
532 *Survival of the Biggest*
533 Our review supports previous conclusions that healthy adult humpback whales, because
534 of their much larger size, sometimes combative nature, and robust appendages (see
535 below), are probably immune to killer whale predation (Whitehead and Glass 1985,
536 Jefferson *et al.*1991, Mehta *et al*. 2007, Ford and Reeves 2008, Steiger *et al.* 2008,
537 Pitman *et al.* 2015). Even lone humpbacks sometimes deliberately approached and
538 interacted with groups of 10 or more MEKWs that were attacking various prey species
539 (Table 1), and when MEKWs approached adult humpbacks without calves, the MEKWs
540 left almost immediately. This confirms that any putative absence of predation pressure on
541 humpback whales by MEKWs (Clapham 1996, 2001; Clapham and Mead 1999; Mehta *et*
542 *al.* 2007) pertains only to healthy adult humpbacks, which presumably allows them to
543 approach attacking MEKWs largely with impunity.
544 Although adult humpbacks may be safe from MEKW predation, subadults,
545 juveniles, and especially calves are vulnerable to attack, and this probably applies to all
546 species of large whales (Melnikov and Zagrebin 2005; Reeves *et al.* 2006; Ford and
547 Reeves 2008; Pitman *et al.* 2007, 2015; Barrett-Lennard *et al.* 2011). As Scammon

548 (1874) commented about killer whales, “it is but rarely these *carnivora* of the sea attack
549 the larger Cetaceans, but chiefly prey with great rapacity upon their young.”
550
551 *Armed Response*
552 The humpback whale is, to our knowledge, the only cetacean that deliberately approaches
553 attacking MEKWs and can drive them off, although southern right whales (*Eubalaena*
554 *australis*) may also group together to fend off MEKWs attacking other right whales
555 (Sironi *et al.* 2008). The adult humpback’s enormous body size certainly contributes to its
556 apparent invulnerability, but there are other, larger whale species that are not known to
557 deliberately approach MEKWs. We suggest that the evolution of the humpback’s massive
558 pectoral flippers may have given it an advantage over killer whales and perhaps altered
559 the balance of power in their interactions.
560 Humpback flippers (Fig. 3) can measure up to 5 m long, one third of their total
561 body length (Woodward *et al.* 2006), and can weigh over 1 ton (1,016 kg, Tomilin 1967).
562 Although they are by far the largest cetacean flippers, both relatively and absolutely, they
563 are quite flexible and maneuverable, and humpbacks can wield them adroitly (Edel and
564 Winn 1978). Furthermore, in addition to sheer impact power, each flipper has a knobby
565 leading edge often encrusted with large, sharp, sessile barnacles (*Coronula* spp.) that can
566 tear the flesh of their opponents (Pierroti *et al*. 1985, Ford and Reeves 2008). These
567 formidable appendages provide protection at the anterior end of the whale, and, when
568 used in concert with the flukes, afford humpbacks with fore and aft, offensive and
569 defensive weaponry - a capability that is unique among living baleen whales. When
570 humpbacks are agitated by killer whales, they appear to randomly flail their flippers and

571 flukes without specifically targeting individual attackers. Nevertheless, killer whales
572 appear to recognize the danger and normally remain 'at arm's-length' when interacting
573 with humpbacks (RLP pers. obs.)

574 Various other functions have been suggested for the humpback's over-sized
575 flippers, including prey herding, visual and acoustic signaling, temperature regulation,
576 'coital clasping' during mating, and increased swimming proficiency and
577 maneuverability (Edel and Winn 1978, Fish and Battle 1995, Woodward *et al.* 2006).
578 These massive flippers can be especially important during the breeding season, when
579 adult male humpbacks participate in aggressive contests for access to breeding females.
580 During these bouts, vying males engage in charging behavior, flipper- and tail-slapping,
581 and bellowing (Tyack and Whitehead 1983, Baker and Herman 1984, Glockner-Ferrari
582 and Ferrari 1985) – the same behaviors that both sexes use during aggressive interactions
583 with killer whales (Pitman *et al.* 2015, this study). Regardless of the initial evolutionary
584 impetus for enlarged flippers in humpback whales, or any additional functions they may
585 have acquired over time, it is clear that they currently have important survival value as
586 weaponry against killer whales and for calf protection, and they may also be a major
587 reason why humpbacks are able to confront and drive off MEKWs.

588

589 *Humpback Whale Anti-predator Behaviors*

590 Among the *fight* baleen whale species described by Ford and Reeves (2008; see
591 Introduction), mothers with calves will often seek refuge in their physical environment
592 when they are attacked. This includes gray whales and right whales moving into
593 shallower waters (Ford and Reeves 2008, Sironi *et al.* 2008, Barrett-Lennard *et al.* 2011),

and bowhead whales using sea ice as protection from killer whales (Nerini *et al.* 1984, Philo *et al*. 1993). Although humpback mothers and calves also retreat to shallow waters when threatened (Pitman *et al.* 2015) or around structures such as boats (#37) or oil platforms (#41), they appear to require less shelter overall, which Ford and Reeves (2008) suggested might be due to the proficiency of adult humpbacks in fending off attacking MEKWs.

In addition to mothers retreating to shallow waters, the *fight* species described by Ford and Reeves (2008) also share a number of other behavioral responses to attacking MEKWs. For example, southern right whales respond with tail- and flipper-slapping when attacked and have been reported to strike killer whales with their flukes (Ford and Reeves 2008, Sironi *et al.* 2008). Right whales also exhibit group defense with nearby whales coming in to help defend calves from attacking killer whales. There are also reports of right whales protecting a calf from attack by using their bodies to enclose the calf in a circle or 'rosette,' with their heads pointed in and tails out (Ford and Reeves 2008, Sironi *et al.* 2008).

Cooperative defense by humpbacks during killer whale attacks has, however, received relatively little attention. Clapham (2000) made no mention of it in his comprehensive review, but more recently Ford and Reeves (2008) listed several instances when humpback mothers and calves were attacked by MEKWs, and nearby humpback adults approached and acted aggressively toward the killer whales (Fig. 4; see also Whitehead and Glass 1985, Dolphin 1987, D'Vincent *et al.* 1989). According to Ford and Reeves (2008), the approaching humpbacks sometimes "displayed apparently defensive or protective behaviour" as they positioned themselves closely around the calves.

From the Appendix 2 accounts, we identified two separate humpback responses to MEKWs attacking other humpbacks: 1) when (apparently) unassociated humpbacks approached other humpbacks that were being attacked (*e.g*., Fig. 4), and 2) when one or more escorts traveling with a cow/calf pair responded aggressively toward attacking MEKWs. As examples of the former, on one occasion four adult humpbacks 'grouped tightly' around a calf, and the circling MEKWs left after 10 min (#44). On another occasion, humpbacks near Hawaii formed a rosette (heads in, tails out) around an unspecified number of calves to shield them from attacking MEKWs (#38). The latter and Acevedo-Guitiérrez (2009) are, to our knowledge, the only reports of rosette-formation by humpback whales.

Herman and Antinoja (1977) first used the term "escort" to describe a whale accompanying a mother/calf pair on the breeding grounds, and they suggested that escorts might have a protective role. Herman and Tavolga (1980) subsequently suggested that the escort might also be a male waiting for the female to come into estrus. Later work confirmed that escorts on breeding grounds are almost always males and the current consensus is that their main function is to mate with the escorted female if the opportunity arises (Clapham 2000). Although the protective role of escorts have been dismissed (*e.g.,* Darling 2001), there have been numerous recent observations from Ningaloo, Western Australia, of escorts accompanying cows with calves during migration to the breeding grounds and vigorously defending the calf when killer whales attack (Pitman *et al.* 2015, see also Chittleborough 1953). Combined with some of the Appendix 2 accounts (*e.g.*, #34, 36, 37, 43), these observations suggest that calf defense by humpback escorts is a temporally and spatially widespread anti-predator measure. Future

640 research that identifies the relatedness of humpback escorts to the mothers and calves that
641 they accompany, and the duration of their associations, will be important for further
642 understanding the social and anti-predator roles of the escort.
643
644 *The Other "Killer Whales"*
645 In addition to MEKWs, other species in the cetacean subfamily Globicephalinae (*i.e.*,
646 "blackfish"), including false killer whales (*Pseudorca crassidens*) and pilot whales
647 (*Globicephala* spp.), are also known or suspected predators of other cetaceans, including
648 calves of large whales, and humpbacks have at times shown similarly aggressive
649 responses toward them also.
650 False killer whales have been known to attack large whales, including sperm
651 whales (*Physeter macrocephalus*, Palacios and Mate 1996) and humpbacks (Dolphin
652 1987, Naessig and Lanyon 2004), and reportedly killed and ate a humpback calf in
653 Hawaii (Mazzuca *et al.* 1998). Hoyt (1983) reported "an apparently aggressive episode
654 between humpbacks and false killer whales" in Hawaii: "Snorkeling in the water,
655 [Graeme] Ellis was watching five false killers quietly share a fish when 'a humpback
656 came out of nowhere, charged into the middle of them and scattered them like bowling
657 pins.' The false killers were emitting high-pitched squeaks as they sped away."
658 Pilot whales have also been known to act threateningly toward large whales – this
659 includes short-finned pilot whales (*G. macrorhynchus*) interacting with sperm whales
660 (Weller *et al.* 1996) and long-finned pilot whales (*G. melas*) with humpbacks (Ciano and
661 Jørgensen 2000). In addition, Siebert (2009) describes an account of a pod of 40-50 short-
662 finned pilot whales attacking a pair of gray whales off Baja California, Mexico, and a

663 nearby humpback came in and drove off the attackers. Although it is unclear if this was
664 an actual predation attempt by the pilot whales or just harassment, the humpback
665 appeared to recognize them as a potential threat and showed the same aggressive
666 responses that some humpbacks have shown to attacking MEKWs.
667
668 *Where Do Attacks Occur?*
669 There have been a number of speculations about where (geographically) MEKWs attack
670 humpback whales, *i.e.*, where do the calves acquire their tooth rake marks. The three
671 areas considered are the feeding grounds, the breeding grounds, or along the migratory
672 corridors that link them, and all have been suggested as likely venues.
673 Clapham (2000) noted that although as many as 33% of the humpbacks in the
674 western North Atlantic had killer whale tooth rake marks on their flukes, during two
675 decades of humpback research in the Gulf of Maine there had been few killer whale
676 sightings and no reported attacks on humpbacks, and that during 16 seasons of field work
677 on the West Indies breeding grounds, no killer whales had ever been sighted (but see
678 #30). From this it was concluded that calves were probably attacked mainly while en
679 route to high-latitude feeding grounds during their first migration (Clapham 2000, 2001;
680 Mehta *et al.* 2007). McCordic *et al*. (2014) reported significant differences in tooth-rake
681 marks among populations of humpbacks sampled from five different feeding grounds in
682 the North Atlantic, and because nearly all North Atlantic humpbacks breed in the West
683 Indies, they concluded that attacks probably occurred either during migration or on the
684 feeding grounds. When Steiger *et al.* (2008) analyzed tooth rake marks on humpbacks in
685 the eastern North Pacific, they concluded that calves were attacked mainly on the

686 breeding grounds. More recently, Pitman *et al*. (2015) documented MEKWs attacking
687 humpback neonate calves during their northbound migration to breeding grounds off
688 northwestern Australia, and estimated that at least dozens were taken annually.
689 Assuming that humpback calves wean only after they are large enough to defend
690 themselves against killer whales, they are probably vulnerable to attack anytime and
691 anywhere that they still accompany their mother. Since calves normally stay with their
692 mothers for about 1 yr (one entire migratory cycle; Clapham and Mayo 1990), this
693 suggests that attacks could potentially occur anywhere within their migratory range, and
694 our records confirm this: humpback calves have been attacked on or near breeding
695 grounds in the West Indies (#30), Colombia (#34), Ecuador (#43), Hawaii (#10, 38),
696 Tonga (#37), South Africa (#35), and West Africa (#41); on the feeding grounds in
697 Alaska (#33, 40, 42, 46, 47), California (#44, 48), and Antarctica (#39), and during
698 migration off Australia (#31, 36, see also Pitman *et al.* 2015).
699 It is still not clear where the majority of these attacks occur because the feeding
700 and breeding grounds of humpbacks both offer advantages and disadvantages for both
701 predator and prey. On the high-latitude feeding grounds, MEKWs are much more
702 abundant (Forney and Wade 2006), but humpback calves there will have grown
703 considerably larger by the time they reach those areas and would be more challenging to
704 kill. By contrast, MEKWs are much less common on the low-latitude breeding grounds,
705 where humpback calves are much smaller and more vulnerable to predation. Perhaps, as
706 suggested by the disparate results and conclusions from the different rake-mark studies
707 cited above, important attack areas may vary with region.
708

Do Humpbacks Respond to Killer Whale Attack Vocalizations?

Another question concerns how humpbacks were able to detect attacking MEKWs that were sometimes over 1 km away. We propose that they were responding to acoustic cues - cues from the MEKWs and not their prey.

Unlike fish-eating killer whales, MEKWs in the North Pacific, and probably globally, are mostly silent when they hunt, presumably because their mammalian prey species all have acute hearing capabilities (Barrett-Lennard *et al.* 1996; Deecke *et al.* 2005, 2011; Riesch and Deecke 2011). For example, it has been shown that when gray whales, harbor seals, belugas (*Delphinapterus leucas*), and sperm whales are exposed to playback calls of MEKWs, they respond with various anti-predator behaviors (Cummings and Thompson 1971, Fish and Vania 1971, Deecke *et al.* 2002, Curé *et al.* 2013). Humpbacks in the eastern Atlantic also appear to avoid MEKW vocalizations (Curé *et al*. 2015).

Once MEKWs have detected potential prey, however, they often become vocally active, during and after attacks (Morton 1990, Guinet 1992, Goley and Straley 1994, Barrett-Lennard *et al.* 1996, Deecke *et al.* 2005, Ford *et al*. 2005, Deecke *et al.* 2011, Riesch and Deecke 2011). As Reeves *et al.* (2006) suggested, "active sound processing presumably becomes allowable, and perhaps functionally important, once contact with the prey has been established." The reason(s) for vocalizing in this context is not currently understood, but it could be important for coordinating attack behavior, or for calling in other killer whales - either to assist in the attack, to share in the kill, or for socializing (Deecke *et al.* 2005).

731 We suggest, therefore, that when humpback whales approached attacking
732 MEKWs, they were responding to the attackers' vocalizations. Four observations support
733 this notion: 1) MEKWs and fish-eating killer whales occur sympatrically in the NE
734 Pacific, and presumably elsewhere. They have type-specific vocalizations (Ford and
735 Fisher 1982, Riesch and Deecke 2011), which humpbacks should be able to distinguish
736 (Deecke *et al.* 2002); 2) humpbacks approached MEKWs (*vs*. fish-eaters) in the large
737 majority of cases (93%; $n = 41$), and when they did, at least 84% ($n = 32$) of the MEKW
738 groups were already attacking or feeding on various prey species; 3) although
739 infrequently reported in Appendix 2, the distances that some of the humpbacks traveled
740 when they approached killer whales were obviously well beyond the visual range of
741 humpbacks. For example, on four occasions humpbacks reportedly traveled 1.6 and 7.6
742 km before approaching MEKWs that were attacking a humpback whale, a gray whale, a
743 Steller sea lion, and a California sea lion (#4, 55, 59, 77, respectively); and 4) on two
744 occasions, observers with hydrophones specifically recorded MEKWs vocalizing at an
745 attack site before the humpbacks arrived (#90, 97).
746 As additional evidence that humpbacks can recognize and respond to MEKW
747 vocalizations, at least in a defensive way, Curé *et al.* (2015) showed that humpbacks in
748 the eastern Atlantic displayed strong negative reactions (*i.e*., immediate changes in
749 feeding behavior, diving patterns, avoidance behavior, *etc*.) in response to playbacks of
750 MEKW vocalizations (recorded in the North Pacific). We do not have any information on
751 how often humpbacks may actively avoid vocalizing MEKWs, and the Curé *et al.* (2015)
752 sample size ($n = 8$) may have been too small to record the full range of humpback
753 responses to their playbacks.

754 Little is known about nonsong vocalizations of humpback whales (Silber 1986,
755 Clapham 2000, Dunlop *et al.* 2008, Zoidis *et al.* 2008, Wild and Gabriele 2014),
756 including whether or not they have an alarm call; if they do, it would be difficult to
757 explain why they responded when other species were being attacked. Furthermore, it
758 seems unlikely that humpbacks would respond to acoustic signals from nonhumpback
759 prey. On at least three occasions (#58, 59, 66), however, observers with hydrophones
760 reported that humpbacks among attacking MEKWs made "a variety of sounds"
761 underwater and that they regularly bellowed when they interacted with killer whales
762 (Table 1; see also Whitehead and Glass 1985, Dolphin 1987). The purpose of the
763 bellowing is unknown - it may only indicate a heightened level of excitement, or it could
764 signal aggression. As mentioned previously, humpback males on the breeding grounds
765 often bellow loudly during aggressive, competitive interactions with other males (Tyack
766 and Whitehead 1983), but during interactions with killer whales and depending on how
767 far this sound carries through the water, bellowing or other vocalizations could also serve
768 as signals to summon or alert other humpbacks in the area. Therefore, we infer that
769 humpbacks were reacting to calls of attacking killer whales and not to the calls of their
770 prey, which meant that approaching humpbacks probably did not know which species of
771 prey was being attacked until they arrived at the scene.
772 Although we assume that approaching humpbacks were responding primarily to
773 MEKW vocalizations, once among the MEKWs, humpbacks showed various responses
774 depending on the circumstances and, possibly, the demeanor of the individual humpback.
775 If another humpback was being attacked, the approaching humpback(s) always acted
776 aggressively towards the MEKWs, sometimes driving them off. But when a species other

than a humpback was being attacked, the approaching humpback(s) showed a range of responses, including: moving away, staying on the periphery of the action as if curious, or aggressively confronting the attackers. This could be due to individual responses reflecting differences in, for example, sex, size, age, reproductive status, kinship, individual history with killer whales, or personality of the approaching humpback (*e.g.*, Briffa and Weiss 2010, Highfill and Kuczaj 2010). Another possibility, testable through play-back experiments, is that the variation in the humpback responses could also reflect changes in the vocal behavior of the killer whales: if humpbacks are attracted to attack vocalizations of killer whales, then if MEKWs stop vocalizing when humpbacks approach, it might prevent humpbacks from interfering.

Mobbing Behavior in Humpback Whales

When a potential prey species detects a predator, the prey can show a range of responses, and although most animals seek to avoid predators and retreat to avoid detection, individuals of some species will, under certain circumstances, deliberately approach and even confront their predators (see review by Caro 2005). The resulting interaction typically falls into one of two general categories. *Predator inspection* is when a prey species approaches a predator, but maintains a safe distance and avoids direct interaction - it merely observes and sometimes follows the predator. *Mobbing behavior* (also known as 'predator harassment') is when a prey species closely approaches, often harasses, and sometimes even attacks a predator, often while calling to alert or summon conspecifics (Curio 1978, Berger 1979, Dugatkin and Godin 1992). Whether the predator is inspected

799 from a distance or harassed at close range normally depends on the level of vulnerability
800 of the inspecting/mobbing animal or its brood (Berger 1979, Dugatkin and Godin 1992).
801 Predator inspection has been reported among a variety of fishes, birds, and
802 terrestrial mammals, the latter including mainly ungulates, squirrels and primates
803 (Owings and Coss 1977, Curio 1978, Pitcher *et al*. 1986, Loughry 1988, Tamura 1989,
804 FitzGibbon 1994, Caro 2005, Graw and Manser 2007). Although predator inspection can
805 be dangerous and occasionally even fatal for the inspector (Sordahl 1990, Dugatkin and
806 Godin 1992, FitzGibbon 1994), numerous overriding benefits have been proposed: it
807 exposes the presence and location of a predator to conspecifics and kin; it lets stalking
808 predators know that they have been detected, often causing them to move out of the area;
809 it allows potential prey to monitor predator movements, and it may also provide an
810 opportunity, especially for younger animals, to learn about predators (Curio 1978,
811 Dugatkin and Godin 1992, FitzGibbon 1994, Caro 2005, Graw and Manser 2007).
812 Mobbing behavior is also a widespread anti-predator response. Although
813 especially common among birds, it is also found among insects, fishes, and terrestrial
814 mammals (Curio 1978, Dugatkin and Godin 1992, Ostreiher 2003, Caro 2005). There
815 have also been numerous explanations proposed for this seemingly counterintuitive, and
816 sometimes dangerous (*e.g*., Denson 1979), anti-predator strategy, but the consensus is
817 that it serves many of the same functions suggested for predator inspection, *i.e*., to alert
818 stalking predators that they have been detected; to bring the predator to the attention of
819 kin and other conspecifics, and to summon in others to assist in the mobbing and driving
820 off the predator. The main difference between inspection and mobbing is in the level of
821 engagement. Mobbing involves harassment at close range, often with the mobbers

822 making bodily contact and sometimes even killing the predator (Caro 2005). The main
823 benefit of mobbing (*vs*. inspecting) is that it can be more effective in driving off potential
824 predators.

825 Although more difficult to observe in the marine environment, predator mobbing
826 has been reported for a variety of marine mammal species. Among pinnipeds, Galápagos
827 fur seals (*Arctocephalus galapagoensis*), Galápagos sea lions (*Zalophus wollebaeki*), and
828 Australian fur seals (*A. pusillus doriferus*) have been reported to mob sharks (Barlow
829 1972, Trillmich 1996, Kirkwood and Dickie 2005). Steller sea lions have been reported
830 "harassing" (possibly mobbing) killer whales on at least two separate occasions (Heise *et*
831 *al.* 2003), although the specific details (including ecotype of killer whales) were lacking.
832 Matkin *et al.* (2007) reported 6 accounts of groups of 3-50 Steller sea lions approaching
833 MEKWs and following them from distances of 50-100 m; in all but one case, the sea
834 lions outnumbered the MEKWs, and on each occasion the MEKWs swam away from the
835 sea lions.

836 Among cetaceans, mobbing behavior and possible predator inspection have
837 previously been reported only for odontocetes (toothed whales and dolphins). Dolphins
838 have been reported to mob sharks (Essapian 1953, Wood *et al.* 1970, review by Connor
839 2000) and possibly killer whales. For example, Saayman and Tayler (1979) described
840 how three Indo-Pacific humpback dolphins (*Sousa chinensis*; length of adults < 3 m) off
841 South Africa broke from a group of 10 others and pursued an unidentified 4-5 m shark.
842 The dolphins 'forced' the shark into two separate coves before driving it off to the open
843 ocean, after which the dolphins returned to their original group. Off Southern California,
844 14 adult bottlenose dolphins (*Tursiops truncatus*, 3-4 m) raced toward a white shark (<3

845 m). They rammed it, breached on it, and drove it toward the nearby beach before it
846 disappeared[2]. Long-finned pilot whales were reported as possibly mobbing killer whales
847 off Norway (Curé *et al.* 2012), and de Stephanis *et al.* (2015) described "mobbing-like"
848 behavior by long-finned pilot whales toward killer whales in the Strait of Gibraltar. In
849 New Zealand, small groups of dusky dolphins (*Lagenorhynchus obscurus*) were observed
850 to approach killer whales and briefly swim around them before departing moments later
851 at high speed (Srinivasan and Markowitz 2009) in what may have been an example of
852 predator inspection.

853 We suggest that at least some of the humpback responses to attacking MEKWs
854 were clear examples of mobbing behavior. When Curio (1978) described mobbing in
855 birds, he stated that they "assemble around a stationary or moving predator (potentially
856 dangerous animal), change locations frequently, perform (mostly) stereotyped wing
857 and/or tail movements and emit loud calls." This description is almost identical to several
858 of the Appendix 2 accounts that describe humpback whales fluke- and flipper-slapping,
859 charging behavior, and bellowing during their interactions with attacking MEKWs.
860 Although predator mobbing typically involves a smaller, more agile prey species
861 harassing a larger predator, there are also cases of larger species mobbing smaller
862 (usually pack-hunting) predators. For example, adult African elephants (*Loxodonta*
863 *africana*), due to their extreme size and aggressive communal defense, are normally safe
864 from predators, but their one important predator – the lion (*Panthera leo*) – can prey on
865 elephant calves (Joubert 2006). When elephant calves are threatened, herd members will
866 respond by mobbing (and sometimes killing) their considerably smaller attackers

[2]Eric Martin, Manhattan Beach Roundhouse Aquarium, P.O. Box 1, Manhattan Beach, CA 90266, pers. comm., Jan 2015.

867 (McComb *et al*. 2011). Also, although mobbing species usually detect their predators
868 visually, auditory cues from a predator are also known to elicit strong mobbing
869 responses, especially among taxa that rely heavily on acoustic signals, including birds
870 (McPherson and Brown 1981, Chandler and Rose 1988), and possibly, as we suggest
871 above, humpback whales.
872
873 *Altruism in Humpback Whales?*
874 Reports of mobbing behavior by cetaceans have been rare, and the 31 accounts presented
875 here are more than all previous reports, for all other cetacean species combined, and the
876 first for a baleen whale. Not only was this behavior far from rare, but it occurred in
877 widely scattered locations, across a wide range of years, and this raises some interesting
878 questions. Why, for example, would humpback whales deliberately interfere with
879 attacking killer whales, spending time and energy on a potentially injurious activity,
880 especially when the killer whales were attacking other humpbacks that may not be
881 related, or even more perplexingly, as in the majority of cases reported, when they were
882 attacking other *species* of prey? Mobbing presumably provides individual and/or
883 inclusive fitness benefits and would be expected to persist if these benefits outweigh the
884 costs. Below, we consider three possible drivers of mobbing behavior in humpbacks: kin
885 selection, reciprocity, and altruism, and we discuss their possible fitness benefits.
886 Kin selection occurs only among related individuals; for unrelated individuals,
887 reciprocity can occur if there is a stable social unit (Trivers 1971, Connor and Norris
888 1982). Many cetaceans live in stable social groups that include related individuals, which
889 could allow for either kin selection or reciprocity, and some odontocete species are

famously known for coming to the aid of threatened or injured conspecifics, as well as other species, including humans (Caldwell and Caldwell 1966, Connor and Norris 1982, Whitehead and Rendell 2015). A concise definition of altruism is: "a behavior that increases the recipient's fitness at the cost of the performers" (de Waal 2008). To date, purported altruism among cetaceans has been attributed almost exclusively to smaller odontocetes (Caldwell and Caldwell 1966, Connor and Norris 1982, Wang *et al.* 2013), but has also been reported for killer whales (Albert Prince of Monaco 1898, Mikhalev *et al.* 1981) and sperm whales (Pitman *et al.* 2001, Whitehead 2003). The few instances of possible altruistic behavior among baleen whales have mostly involved individuals responding to calves or other associates that had been harpooned by whalers or were otherwise injured (Caldwell and Caldwell 1966, Deakos *et al.* 2010).

Although direct evidence for kin selection or reciprocity is generally lacking for humpbacks, they have several features that could promote the development of either, including some semblance of social structure as well as site fidelity. Humpbacks are usually characterized as occurring in small, unstable groups (Connor 2000, Clapham 2009), but some studies have found relatively stable associations on the feeding grounds that span different seasons (Weinrich 1991, Ramp *et al.* 2010) or even decades (Pierszalowski 2014), which could foster reciprocity. Maternally-mediated philopatry among humpbacks could also allow for either reciprocity or kin selection. As mentioned previously, humpback calves typically stay with their mothers for about 1 yr (occasionally 2; Clapham and Mayo 1990) - long enough for the calf to complete an entire migration circuit and learn their mother's feeding and breeding grounds (Weinrich 1998). After weaning, calves often exhibit maternally-directed site fidelity (Clapham

913 1996, Baker *et al.* 2013, Barendse *et al.* 2013), with annual rates of return to their
914 mother's feeding area up to 90% (Clapham 2000, Pierszalowski 2014). In addition, Baker
915 *et al*. (2013) reported evidence of strong natal fidelity by humpbacks to their breeding
916 grounds, although several feeding stocks sometimes mix within a single breeding area.
917 This consistent evidence for site fidelity on the feeding and breeding grounds (Darling
918 and Jurasz 1983; Baker *et al.* 1990, 2003; Weinrich 1991, 1998; Calambokidis *et al.*
919 2001; Weinrich *et al.* 2006; Witteveen *et al.* 2011) increases the likelihood that individual
920 humpbacks are more related to, or long-term associates with, neighboring conspecifics
921 than they are to individuals in the population at large, thus laying a foundation for either
922 kin selection or reciprocity.
923 More often though, humpbacks approached MEKWs that were attacking prey
924 species that were clearly not humpbacks (*e.g*., a gray whale calf with its mother, a seal
925 hauled out on an ice floe, a sunfish), and although the humpbacks faced little risk of
926 serious injury, they also gained no obvious benefits for their time and energy spent.
927 However, if the net effect for mobbing humpbacks was an increase in their individual or
928 inclusive fitness through kin selection or reciprocity, then this behavior could persist even
929 if it inadvertently benefitted other species sometimes. This would be an example of what
930 Norris and Dohl (1980) described as "'spillover' of an intraspecific pattern into the
931 domain of more distant [*i.e*., interspecific] relationships." We suggest that humpbacks
932 providing benefits to other potential prey species, even if unintentional, could be a focus
933 of future research into possible genetic or cultural drivers of interspecific altruism.
934
935 Acknowledgments

We received invaluable assistance in the field from D. Allan, D. Anderson, and K. Jeffs, as well as J. Poncet and D. Poncet of the *Golden Fleece*. Additional sightings information and field assistance were kindly provided by S. Anna, C. Bane, S. Benson, L. Beraha, A. Borker, E. Bowlby, J. Collins, K. Cummings, M. de Roos, M. Donoghue, D. Ellifrit, G. Ellis, T. Evans, N. Flores, J. K. B. Ford, R. Frank, B. Gisborne, M. Joergensen, S. Johnston, G. Joyce, J. Katakura, C. Matkin, J. Mayer, K. Newton, F. Nicklin, M. Nolan, R. Palm, E. Robinson, A. H. Romero, J. Scarff, F. Sharpe, A. Spear, K. Spencer, J. Straley, J. Totterdell, T. van Wyck, J. Williams, and H. Yurk. Important comments on earlier drafts of this paper were provided by L. T. Ballance, D. J. Boness, P. J. Clapham, J. Darling, S. Mesnick, B. Würsig and three anonymous reviewers. Genetic identifications were courtesy of K. Robertson, SWFSC, La Jolla, CA. T. J. Moore produced Fig. 1. Research by R. Pitman and J. Durban was supported by US NOAA Fisheries, the BBC Natural History Film Unit and a grant from National Geographic Society, and was conducted under ACA Permit No. 2009-013M#1, and MMPA No. 774-1714-08 issued to NOAA Fisheries, Southwest Fisheries Science Center.

Literature Cited

Acevedo-Guitiérrez, A. 2009. Group behavior. Pages 511-520 *in* W. F. Perrin, B. Würsig and J. G. M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. Academic Press, San Diego, CA.

959 Albert, Prince of Monaco. 1898. Some results of my researches on oceanography. Nature
960 58:200-204.
961
962 Baird, R. W., D. J. McSweeney, C. Bane, *et al*. 2006. Killer whales in Hawaiian waters:
963 information on population identity and feeding habits. Pacific Science 60:523–530.
964
965 Baker, C. S., and L. M. Herman. 1984. Aggressive behavior between humpback whales
966 (*Megaptera novaeangliae*) wintering in Hawaiian waters. Canadian Journal of Zoology
967 62:1922-1937.
968
969 Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis and S. J.
970 O'Brien. 1990. Influence of seasonal migration on geographic distribution of
971 mitochondrial DNA haplotypes in humpback whales. Nature 344:238–240.
972
973 Baker, C. S., D. Steel, J. Calambokidis, *et al.* 2013. Strong maternal fidelity and natal
974 philopatry shape genetic structure in North Pacific humpback whales. Marine Ecology
975 Progress Series 494: 291–306.
976
977 Barendse, J., P. B., I. Carvalho and C. Pomilla. 2013. Mother knows best: occurrence
978 and associations of resighted humpback whales suggest maternally derived fidelity to a
979 Southern Hemisphere coastal feeding ground. PLoS ONE 8(12):e81238.
980
981 Barlow, G. W. 1972. Galapagos sea lions are paternal. Evolution 28:476-478.

Barrett-Lennard, L. G., J. K. B. Ford and K. A. Heise. 1996. The mixed blessing of echolocation: differences in sonar use by fish-eating and mammal-eating killer whales. Animal Behaviour 51:553-565.

Barrett-Lennard, L. G., C. O. Matkin, J. W. Durban, E. L. Saulitis and D. Ellifrit. 2011. Predation on gray whales and prolonged feeding on submerged carcasses by transient killer whales at Unimak Island, Alaska. Marine Ecology Progress Series 421:229–241.

Bates, L. A., and R. W. Byrne. 2007. Creative or created: Using anecdotes to investigate animal cognition. Methods 42:12-21.

Berger, J. 1979. "Predator harassment" as a defensive strategy in ungulates. American Midland Naturalist 102:197-199.

Branch, T. A., and T. M. Williams. 2006. Legacy of industrial whaling: could killer whales be responsible for declines of sea lions, elephant seals, and minke whales in the Southern Hemisphere? Pages 262-278 *in* J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell, Jr., eds. Whales, whaling, and ocean ecosystems. University of California Press, Berkeley, CA.

Briffa, M., and A. Weiss. 2010. Animal personality. Current Biology 20:R912-914.

1005 Caldwell, M. C., and D. K. Caldwell. 1966. Epimeletic (care-giving) behavior in Cetacea.
1006 Pages 755-788 *in* K. S. Norris, ed. Whales, dolphins, and porpoises. University of
1007 California Press, Berkeley, CA.
1008
1009 Calambokidis, J., G. H. Steiger, J. M. Straley, *et al*. 2001. Movements and population
1010 structure of humpback whales in the North Pacific. Marine Mammal Science 17:769–
1011 794.
1012
1013 Caro, T.M. 2005. Antipredator defenses in birds and mammals. University of Chicago
1014 Press, Chicago, IL.
1015
1016 Cartwright, R., and M. Sullivan. 2009. Behavioral ontogeny in humpback whale
1017 (*Megaptera novaeangliae*) calves during their residence in Hawaiian waters. Marine
1018 Mammal Science 25:659-680.
1019
1020 Chandler, C. R., and R. K. Rose. 1988. Comparative analysis of the effects of visual and
1021 auditory stimuli on avian mobbing behavior. Journal of Field Ornithology 59:269-277.
1022
1023 Chittleborough, R. G. 1953. Aerial observations on the humpback whale, *Megaptera*
1024 *nodosa* (Bonnaterre), with notes on other species. Australian Journal of Marine and
1025 Freshwater Research 4:219-226.
1026

1027 Ciano, J. N., and R. Jøorgensen. 2000. Observations on an interaction between a
1028 humpback whale (*Megaptera novaeangliae*) and pilot whales (*Globicephala melas*).
1029 Marine Mammal Science 16:245-248.
1030
1031 Clapham, P. J. 1996. The social and reproductive biology of humpback whales: an
1032 ecological perspective. Mammal Review 26:27-49.
1033
1034 Clapham, P. J. 2000. The humpback whale: seasonal feeding and breeding in a baleen
1035 whale. Pages 173-196 *in* J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead, eds.
1036 Cetacean societies. University of Chicago Press, Chicago, IL.
1037
1038 Clapham, P. J. 2001. Why do baleen whales migrate? A response to Corkeron and
1039 Connor. Marine Mammal Science 17:432-436.
1040
1041 Clapham, P. J. 2009. Humpback whale *Megaptera novaeangliae*. Pages 582-585 *in* W. F.
1042 Perrin, B. Würsig and J. G. M. Thewissen, eds. Encyclopedia of marine mammals, 2nd
1043 edition. Academic Press, San Diego, CA.
1044
1045 Clapham, P. J., and C. A. Mayo. 1990. Reproduction of humpback whales, *Megaptera*
1046 *novaeangliae*, observed in the Gulf of Maine. Pages 171-175 *in* P. S. Hammond, S. A.
1047 Mizroch and G. P. Donovan, eds. Individual recognition of cetaceans: use of photo-
1048 identification and other techniques to estimate population parameters. Reports of the

1049 International Whaling Commission, special issue 12. International Whaling Commission,
1050 Cambridge, UK.
1051
1052 Clapham, P. J., and J. G. Mead. 1999. *Megaptera novaeangliae*. Mammalian Species
1053 604:1–9.
1054
1055 Clapham, P. J., A. Aguilar and L. T. Hatch. 2008. Determining spatial and temporal
1056 scales for management units: lessons from whaling. Marine Mammal Science 24:183–
1057 201.
1058
1059 Connor, R. C. 2000. Group living in whales and dolphins. Pages 199-218 *in* J. Mann, R.
1060 C. Connor, P. L. Tyack and H. Whitehead, eds. Cetacean societies. University of Chicago
1061 Press, Chicago, IL.
1062
1063 Connor, R. C., and P. J. Corkeron. 2001. Predation past and present: killer whales and
1064 baleen whale migration. Marine Mammal Science 17:436-439.
1065
1066 Connor, R. C., and K. S. Norris. 1982. Are dolphins reciprocal altruists? American
1067 Naturalist 119:358-374.
1068
1069 Corkeron, P. J., and R. C. Connor. 1999. Why do baleen whales migrate? Marine
1070 Mammal Science 15:1228-1245.
1071

1072 Creel, S., and D. Christianson. 2008. Relationships between direct predation and risk
1073 effects. Trends in Ecology and Evolution 23:194-201.
1074
1075 Cummings, W. C., and P. O. Thompson. 1971. Gray whales, *Eschrichtius robustus*, avoid
1076 the underwater sounds of killer whales, *Orcinus orca*. Fishery Bulletin 69:525-530.
1077
1078 Curé, C., R. Antunes, F. Samarra, A-C Alves, F. Visse, P. H. Kvadsheim and P. J. O.
1079 Miller. 2012. Pilot whales attracted to killer whale sounds: acoustically-mediated
1080 interspecific interactions in cetaceans. PLoS ONE 7(12): e52201.
1081
1082 Curé, C., R. Antunes, A-C. Alves, F. Visser, P. H. Kvadsheim and P. J. O. Miller. 2013.
1083 Responses of male sperm whales (*Physeter macrocephalus*) to killer whale sounds:
1084 implications for anti-predator strategies. Scientific Reports 3(1579):1-7.
1085
1086 Curé, C., L. D. Sivle, F. Visser, *et al.* 2015. Predator sound playbacks reveal strong
1087 avoidance responses in a fight strategist baleen whale. Marine Ecology Progress Series
1088 526:267-282.
1089
1090 Curio, E. 1978. The adaptive significance of avian mobbing. I. Teleonomic hypothesis
1091 and predictions. Zeitschrift für Tierpsychologie 48:175–183.
1092
1093 Darling, J. D. 2001. Characterization of behavior of humpback whales in Hawaiian
1094 waters. Report prepared for Hawaiian Islands Humpback Whale National Marine

1095 Sanctuary, Division of Aquatic Resources. Honolulu, HI. 55 pp.
1096
1097 Darling, J. D., and C. M. Jurasz. 1983. Migratory destinations of North Pacific humpback
1098 whales (*Megaptera novaeangliae*). Pages 359-368 *in* R. Payne, ed. Communication and
1099 behavior of whales. Westview Press, Boulder, CO.
1100
1101 Deakos, M. H., B. K. Branstetter, L. Mazzuca, D. Fertl and J. R. Mobley, Jr. 2010. Two
1102 unusual interactions between a bottlenose dolphin (*Tursiops truncatus*) and a humpback
1103 whale (*Megaptera novaeangliae*) in Hawaiian waters. Aquatic Mammals 36:121-128.
1104
1105 Deecke, V. B., P. J. B. Slater and J. K. B. Ford. 2002. Selective habituation shapes
1106 acoustic predator recognition in harbour seals. Nature 420:171–173.
1107
1108 Deecke, V. B., J. K. B. Ford and P. J. B. Slater. 2005. The vocal behaviour of mammal-
1109 eating killer whales: communicating with costly calls. Animal Behavior 69:395–405.
1110
1111 Deecke, V. B., M. Nykänen, A. D. Foote and V. M. Janik. 2011. Vocal behaviour and
1112 feeding ecology of killer whales *Orcinus orca* around Shetland, UK. Aquatic Biology
1113 13:79-88.
1114
1115 Denson, R. D. 1979. Owl predation on a mobbing crow. Wilson Bulletin 91:133.
1116

1117 De Stephanis, R., J. Gimenez, R. Esteban, P. Gauffier, S. Garcia-Tiscar, M-HS. Sinding
1118 and P. Verborgh. 2015. Mobbing-like behavior by pilot whales towards killer whales: a
1119 response to resource competition or perceived predation risk? Acta Ethologica 18:69-78.
1120
1121 De Waal, F. B. M. 2008. Putting the altruism back into altruism: the evolution of
1122 empathy. Annual Review of Psychology 59:279-300.
1123
1124 Doak, D. F., T. M. Williams and J. A. Estes. 2006. Great whales as prey using
1125 demography and bioenergetics to infer interactions in marine mammal communities.
1126 Pages 231-244 *in* J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L.
1127 Brownell, Jr., eds. Whales, whaling, and ocean ecosystems. University of California
1128 Press, Berkeley, CA.
1129
1130 Dolphin, W. F. 1987. Observations of humpback whale, *Megaptera novaeangliae* and
1131 killer whale, *Orcinus orca*, interactions in Alaska: comparison with terrestrial predator-
1132 prey relationships. Canadian Field-Naturalist 101:70-75.
1133
1134 Dugatkin, L. A., and J-G. J. Godin. 1992. Prey approaching predators: a cost-benefit
1135 perspective. Annales Zoologici Fennici 29:233-252.
1136
1137 Dunlop, R. A., D. H. Cato and M. J. Noad. 2008. Non-song acoustic communication in
1138 migrating humpback whales (*Megaptera novaeangliae*). Marine Mammal Science 24:
1139 613–629.

1140

1141 Durban, J. W., H. Fearnbach, D. G. Burrows, G. M. Ylitalo, and R. L. Pitman. 2016.
1142 Morphological and ecological evidence for two sympatric forms of Type B killer whale
1143 around the Antarctic Peninsula. Polar Biology DOI 10.1007/s00300-016-1942-x

1144

1145 D'Vincent, C., D. Haley and F. Sharpe. 1989. Voyaging with the whales. Boulton
1146 Publishing Services, Toronto, Canada.

1147

1148 Edel, R. K., and H. E. Winn. 1978. Observations on underwater locomotion and flipper
1149 movement of the humpback whale *Megaptera novaeangliae.* Marine Biology 48:279-
1150 287.

1151

1152 Essapian, F. S. 1953. The birth and growth of a porpoise. Natural History 62:392-399.

1153

1154 Ferguson, S. H., J. W. Higdon and E. G. Chmelnitsky. 2010. The rise of killer whales as a
1155 major Arctic predator. Pages 117-136 *in* S. H. Ferguson, L. L. Loseto and M. L. Mallory,
1156 eds. A little less Arctic: top predators in the world's largest northern inland sea, Hudson
1157 Bay. Springer Science, Dordrecht, Netherlands.

1158

1159 Fish, F. E., and J. M. Battle. 1995. Hydrodynamic design of the humpback whale flipper.
1160 Journal of Morphology 225:51-60.

1161

1162 Fish, J. F., and J. S. Vania. 1971. Killer whale, *Orcinus orca*, sounds repel white whales,
1163 *Delphinapterus leucas*. Fishery Bulletin, U. S. Fish and Wildlife Service 69:531-535.
1164
1165 FitzGibbon, C. D. 1994. The costs and benefits of predator inspection behavior in
1166 Thomson's gazelles. Behavioral Ecology and Sociobiology 34:139-148.
1167
1168 Flórez-González, L., J. J. Capella and H. C. Rosenbaum. 1994. Attack of killer whales
1169 (*Orcinus orca*) on humpback whales (*Megaptera novaeangliae*) on a South American
1170 Pacific breeding ground. Marine Mammal Science 10:218–222.
1171
1172 Ford, J. K. B. 2011. Killer whales of the Pacific Northwest coast: from pest to paragon.
1173 Pages 15-23 *in* R. L. Pitman, ed. Killer whale: the top, top predator. Whalewatcher
1174 (Journal of the American Cetacean Society) 40:1-67.
1175
1176 Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an
1177 indicator of stocks in British Columbia. Reports of the International Whaling
1178 Commission 32:671–679.
1179
1180 Ford, J. K. B., G. M. Ellis, L. Barrett-Lennard, A. B. Morton, R. Palm and K. C.
1181 Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales
1182 (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of
1183 Zoology 76:1456–1471.
1184

1185 Ford, J. K. B., and Ellis, G. M. 1999. Transients: mammal-hunting killer whales.
1186 University of British Columbia Press, Vancouver, Canada.
1187
1188 Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs and A. B. Morton.
1189 2005. Killer whale attacks on minke whales: prey capture and antipredator tactics. Marine
1190 Mammal Science 21:603─618.
1191
1192 Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies in baleen
1193 whales. Mammal Review 38:50-86.
1194
1195 Forney, K.A., and Wade, P. 2006. Worldwide distribution and abundance of killer
1196 whales. Pages 145-162 *in* J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L.
1197 Brownell, Jr., eds. Whales, whaling, and ocean ecosystems. University of California
1198 Press, Berkeley, CA.
1199
1200 Gabriele, C. M., J. M. Straley, S. A. Mizroch, *et al.* 2001. Estimating the mortality rate of
1201 humpback whale calves in the central North Pacific Ocean. Canadian Journal of Zoology
1202 79:589-600.
1203
1204 Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior,
1205 reproduction, and distribution of humpback whales, *Megaptera novaeangliae*, in Hawaii.
1206 Rept. No. MMC-83/06. National Technical Information Service, Springfield, VA.
1207

Goley, P.D., and J. M. Straley. 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.

Graw, B., and M. B. Manser 2007. The function of mobbing in cooperative meerkats. Animal Behaviour 74:507-517.

Guinet, C. 1992. Comportement de chasse des orques (*Orcinus orca*) autour des ˆıles Crozet. Canadian Journal of Zoology 70:1656–1667.

Heise, K., L. G. Barrett-Lennard, E. Saulitis, C. Matkin and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 29:325─334.

Herman, L. M., and R. C. Antinoja. 1977. Humpback whales in the Hawaiian breeding waters: population and pod characteristics. Scientific Reports of the Whales Research Institute, Tokyo 29:59-85.

Herman, L. M., and W. N. Tavolga. 1980. The communication systems of cetaceans. Pages 149-209 *in* L. M. Herman, ed. Cetacean behavior: mechanisms and functions. Wiley-Interscience, New York, NY.

1230 Highfill, L. E., and S. A. Kuczaj, II. 2010. How studies of wild and captive dolphins
1231 contribute to our understanding of individual differences and personality. International
1232 Journal of Comparative Psychology 23:269-277.
1233
1234 Houghton, J., R. W. Baird, C. K. Emmons and M. B. Hanson. 2015. Changes in the
1235 occurrence and behavior of mammal-eating killer whales in Southern British Columbia
1236 and Washington State, 1987–2010. Northwest Science 89:154-169.
1237
1238 Hoyt, E. 1983. Great winged whales. Equinox 10:25-47.
1239
1240 Jefferson, T., A., P. J. Stacey and R. W. Baird. 1991. A review of killer whale
1241 interactions with other marine mammals: predation to co-existence. Mammal Review
1242 21:151-180.
1243
1244 Jonsgård, Å. 1968. Another note on the attacking behavior of killer whale (*Orcinus orca*).
1245 Norsk Hvalfangst-Tidende 57:175–176.
1246
1247 Joubert, D. 2006. Hunting behaviour of lions (*Panthera leo*) on elephants (*Loxodonta*
1248 *africana*) in the Chobe National Park, Botswana. African Journal of Ecology 44:279–281.
1249
1250 Kareiva, P., C. Yuan-Farrell and C. O'Connor. 2006. Whales are big and it matters. Pages
1251 379-387 *in* J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell, Jr.,
1252 eds. Whales, whaling, and ocean ecosystems. University of California Press, Berkeley,

CA.

Katona, S. K., P. M. Harcourt, J. S. Perkins and S. D. Kraus. 1980. Humpback whales of the western North Atlantic Ocean: a catalog of identified individuals. College of the Atlantic, Bar Harbor, ME.

Kirkwood, R., and J. Dickie. 2005. Mobbing of a great white shark *(Carcharodon carcharias*) by adult male Australian fur seals (*Arctocephalus pusillus doriferus*). Marine Mammal Science 21:336-339.

Loughry, W. J. 1988. Population differences in how black-tailed prairie dogs deal with snakes. Behavioral Ecology and Sociobiology 22:61-67.

Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard and D. Matkin. 1999. Killer whales of southern Alaska. North Gulf Oceanic Society, Homer, AK.

Matkin, D., J. Straley and C. Gabriele. 2007. Killer whale feeding ecology and non-predatory interactions with other marine mammals. Pages 155-158 *in* J. F. Piatt and S. M. Gende, eds. Proceedings of the Fourth Glacier Bay Science Symposium, 2004. U.S. Geological Survey, Juneau, AK.

Mazzuca, L., S. Atkinson and E. Nitta. 1998. Death and entanglements of humpback whales, *Megaptera novaeangliae,* in the main Hawaiian Islands, 1972-1996. Pacific

Science 52:1-13.

McComb, K., G. Shannon, S. M. Durnat, K. Sayialel, R. Slotow, J. Poole and C. Moss. 2011. Leadership in elephants: the adaptive value of age. Proceedings of the Royal Society B 278:3270-3276.

McCordic, J. A., S. K. Todd and P. T. Stevick. 2014. Differential rates of killer whale attacks on humpback whales in the North Atlantic as determined by scarification. Journal of the Marine Biological Association of the United Kingdom 94:1311–1315.

McPherson, R. J., and R. D. Brown. 1981. Mobbing responses of some passerines to the calls and location of the Screech Owl. Raptor Research 15:23-30.

Mehta, A. V., J. M. Allen, R. Constantine, *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. V., and I. A. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. Marine Mammal Science 21:550-556.

Mikhalev, Y. A., M. V. Ivashin, V. P. Savusin and F. E. Zelenaya. 1981. The distribution and biology of killer whales in the Southern Hemisphere. Reports of the International Whaling Commission 31:551-566.

1299

1300 Mizroch, S.A., and D. W. Rice. 2006. Have North Pacific killer whales switched prey
1301 species in response to depletion of the great whale populations? Marine Ecology Progress
1302 Series 310:235–246.

1303

1304 Morton, A. 1990. A quantitative comparison of the behaviour of resident and transient
1305 forms of the killer whale off the central British Columbia coast. Reports of the
1306 International Whaling Commission (Special Issue 12):245–248.

1307

1308 Naessig, P. J., and J. M. Lanyon. 2004. Levels and probable origin of predatory scarring
1309 on humpback whales (*Megaptera novaeangliae*) in east Australian waters. Wildlife
1310 Research 31:163–170.

1311

1312 Nerini, M. K., H. W. Braham, W. M. Marquette and D. J. Rugh. 1984. Life history of the
1313 bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). Journal of Zoology, London
1314 204:443-468.

1315

1316 Norris, K. S., and T. P. Dohl. 1980. The structure and function of cetacean schools. Pages
1317 211-261 *in* L. M. Herman, ed. Cetacean behavior: mechanisms and functions. Wiley-
1318 Interscience, New York, NY.

1319

1320 Ostreiher, R. 2003. Is mobbing altruistic or selfish behavior? Animal Behaviour 66:145–
1321 149.

Owings, D. H., and R. G. Coss. 1977. Snake mobbing by California ground squirrels: adaptive variation and ontogeny. Behaviour 62:50-69.

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

Paterson, R. A., and P. Paterson. 2001. A presumed killer whale (*Orcinus orca*) attack on humpback whales (*Megaptera novaeangliae*) at Point Lookout, Queensland. Memoirs of the Queensland Museum 47:436.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10:430.

Philo, L. M., E. B. Shotts, Jr., and J. C. George. 1993. Morbidity and mortality. Pages 275-312 *in* J. J. Burns, J. J. Montague and C. J. Cowles, eds. The bowhead whale. The Society for Marine Mammalogy. Allen Press, Lawrence, KS.

Pierroti, R., C. A. Swatland and P. Ewald. 1985. “Brass knuckles” in the sea: the use of barnacles as weapons. Abstracts. 6th Biennial Conference on the Biology of Marine Mammals. Lawarence, KS.

1345 Pierszalowski, S. 2014. The influence of local fidelity and recruitment on population
1346 dynamics and specialized foraging in humpback whales in Glacier Bay and Icy Strait,
1347 Alaska. M.S. thesis, Oregon State University, Corvallis, OR. 151 pages.
1348
1349 Pitcher, T. J., D. Green and A. E. Magurran. 1986. Dicing with death: predator inspection
1350 behaviour in minnow shoals. Journal of Fish Biology 28:439-448.
1351
1352 Pitman, R. L., L. T. Ballance, S. L. Mesnick and S. J. Chivers. 2001. Killer whale
1353 predation on sperm whales: observations and implications. Marine Mammal Science
1354 17:494-507.
1355
1356 Pitman, R. L., and P. Ensor. 2003. Three different forms of killer whales in Antarctic
1357 waters. Journal of Cetacean Research and Management 5:131-139.
1358
1359 Pitman, R., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, J. K. B. Ford and L. T. Ballance.
1360 2007. Killer whales preying on a blue whale calf on the Costa Rica Dome: genetics,
1361 morphometrics, vocalizations and composition of the group. Journal of Cetacean
1362 Research and Management 9:151-58.
1363
1364 Pitman, R. L., and J. W. Durban. 2009. Save the seal! Natural History Magazine,
1365 November 2009:48.
1366
1367 Pitman, R. L., and J. W. Durban. 2010. Killer whale predation on penguins in Antarctica.

1368 Polar Biology 33:1589-1594.
1369
1370 Pitman, R. L., and J. W. Durban. 2012. Cooperative hunting behavior, prey selectivity
1371 and prey handling by pack ice killer whales (*Orcinus orca*), type B, in Antarctic
1372 Peninsula waters. Marine Mammal Science 28:16-36.
1373
1374 Pitman, R. L., J. A. Totterdell, H. Fearnbach, L. T. Ballance, J. W. Durban and H.
1375 Kemps. 2015. Whale killers: prevalence and ecological implications of killer whale
1376 predation on humpback whale calves off Western Australia. Marine Mammal Science
1377 31:629-657.
1378
1379 Ramp, C., W. Hagen, P. J. Palsbøll, M. Bérubé and R. Sears. 2010. Age-related multiyear
1380 associations in female humpback whales (*Megaptera novaeangliae*). Behavorial Ecology
1381 and Sociobiology 64:1563–1576.
1382
1383 Rasmussen, K., D. M. Palacios, J. Calambokidis, *et al*. 2007. Southern Hemisphere
1384 humpback whales wintering of Central America: insights from water temperature into the
1385 longest mammalian migration. Biology Letters 3:302-305.
1386
1387 Reeves, R. R., J. Berger and P. J. Clapham. 2006. Killer whales as predators of large
1388 baleen whales and sperm whales. Pages 174-187 *in* J.A. Estes, D.P. DeMaster, D.F.
1389 Doak, T.M. Williams and R.L. Brownell, Jr., eds. Whales, whaling, and ocean
1390 ecosystems. University of California Press, Berkeley, CA.

D. W. Rice. 1963. Progress report on biological studies of the larger cetaceans in the waters off California. Norsk Hvalfangst-Tidende 52:181–187.

Riesch, R., and V. B. Deecke. 2011. Whistle communication in mammal-eating killer whales (*Orcinus orca*): further evidence for acoustic divergence between ecotypes. Behavioral Ecology and Sociobiology 65:1377–1387.

Rocha, R. C., Jr., P. J. Clapham and Y. V. Ivashchenko. 2014. Emptying the oceans: a summary of industrial whaling catches in the 20th Century. Marine Fisheries Review 76:37-48.

Saayman, G. S., and C. K. Tayler. 1979. The socioecology of humpback dolphins. Pages 165-226 *in* H. E. Winn and B. L. Olla, eds. Behavior of marine mammals: current perspectives in research. Vol. 3, Cetaceans. Plenum Press, New York.

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

Scammon, C. M. 1874. The marine mammals of the northwestern coast of North America. Together with an account of the American Whale-Fishery. John H. Carmany, San Francisco, CA.

1414

1415 Siebert, C. 2009. Watching whales watching us. New York Times Magazine, 12 July:26-

1416 35, 44-45.

1417

1418 Silber, G. 1986. The relationship of social vocalizations to surface behavior and

1419 aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian

1420 Journal of Zoology 72:805-811.

1421

1422 Sironi, M., J. C. Lopez, R. Bubas, A. Carribero, C. Garcia, G. Harris, E. Intrieri, M.

1423 Iniguez, and R. Payne. 2008. Predation by killer whales (*Orcinus orca*) on southern right

1424 whales (*Eubalaena australis*) off Patagonia, Argentina: Effects on behavior and habitat

1425 choice. Report to the Scientific Committee of the International Whaling Commission,

1426 SC/60/BRG29. 18 pages.

1427

1428 Sordahl, T. A. 1990. The risks of avian mobbing and distraction behavior: an anecdotal

1429 review. Wilson Bulletin 102:349-352.

1430

1431 Springer, A. M., J. A. Estes, G. B. van Vliet, *et al.* 2003. Sequential megafaunal collapse

1432 in the North Pacific Ocean: an ongoing legacy of industrial whaling? Proceedings of the

1433 National Academy of Sciences 100:12223-12228.

1434

1435 Springer, A. M., G. B. Van Vliet, J. F. Piatt and E. M. Danner. 2006. Whales and whaling

1436 in the North Pacific Ocean and Bering Sea: oceanographic insights and ecosystem

impacts. Pages 245-261 *in* J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell, Jr., eds. Whales, whaling, and ocean ecosystems. University of California Press, Berkeley, CA.

Springer, A. M., J. A. Estes, G. B. Van Vliet, T. M. Williams, D. F. Doak, E. M. Danner and B. Pfister. 2008. Mammal-eating killer whales, industrial whaling, and the sequential megafaunal collapse in the North Pacific Ocean: a reply to critics of Springer *et al.* 2003. Marine Mammal Science 24:414–442.

Srinivasan, M., and T. M. Markowitz. 2009. Predator threats and dusky dolphin survival strategies. Pages 133-150 *in* B. Würsig and M. Würsig, eds. The dusky dolphin: master acrobat off different shores. Academic Press, London, UK.

Steiger, G. H., J. Calambokidis, J. M. Straley, *et al.* 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure. Endangered Species Research 4:247–256.

Stern, S. J. 2009. Migration and movement patterns. Pages 726-730 *in* W. F. Perrin, B. Würsig and J. G. M. Thewissen, eds. Encyclopedia of marine mammals, 2nd edition. Academic Press, San Diego, CA.

1458 Stevick, P. T., B. J. McConnell and P. S. Hammond. 2002. Patterns of movement. Pages
1459 185-216 *in* A. R. Hoelzel, ed. Marine mammal biology: an evolutionary approach.
1460 Blackwell Publishing, Malden, MA.
1461
1462 Tamura, N. 1989. Snake-directed mobbing by the Formosan squirrel *Calliosciurus*
1463 *erythraeus thaiwensis*. Behavioral Ecology and Sociobiology 24:175-180.
1464
1465 Tomilin, A. G. 1967. Mammals of the USSR and adjacent countries, Vol. 9, Cetacea.
1466 Translated by Israel Program for Scientific Translation, V. G. Heptner, ed., Jerusalem,
1467 Israel.
1468
1469 Tønnessen, J. N., and A. O. Johnsen. 1982. The history of modern whaling. University of
1470 California Press, Berkeley, CA.
1471
1472 Trillmich, F. 1996. Parental investment in pinnipeds. Advances in the Study of Behaviour
1473 5:533-577.
1474
1475 Trites A. W., V. B. Deecke, E. J. Gregr, J. K. B. Ford and P. F. Olesiuk. 2007. Killer
1476 whales, whaling, and sequential megafaunal collapse in the North Pacific: a comparative
1477 analysis of the dynamics of marine mammals in Alaska and British Columbia following
1478 commercial whaling. Marine Mammal Science 23:751-765.
1479

1480 Trivers, R. L. 1971. The evolution of reciprocal altruism. Quarterly Review of Biology
1481 46:35–57.
1482
1483 Tyack, P. L., and H. Whitehead. 1983. Male competition in large groups of wintering
1484 humpback whales. Behavior 83:132-154.
1485
1486 Wade, P. R., V. N. Burkanov, M. E. Dahlheim, *et al.* 2007. Killer whales and marine
1487 mammal trends in the North Pacific – a re-examination of evidence for sequential
1488 megafauna collapse and the prey-switching hypothesis. Marine Mammal Science 23:766–
1489 802.
1490
1491 Wang, X., F. Wu, J. Mou and Q. Zhu. 2013. Indo-Pacific humpback dolphins (*Sousa*
1492 *chinensis*) assist a finless porpoise (*Neophocaena phocaenoides sunameri*) calf: evidence
1493 from Xiamen waters in China. Journal of Mammalogy 94:1123-1130.
1494
1495 Weinrich, M. T. 1991. Stable social associations among humpback whales (*Megaptera*
1496 *novaeangliae*) in the southern Gulf of Maine. Canadian Journal of Zoology 69:3012–
1497 3019.
1498
1499 Weinrich, M. T. 1998. Early experience in habitat choice by humpback whales
1500 (*Megaptera novaeangliae*). Journal of Mammalogy 79:163–170.
1501

Weinrich, M. T., H. Rosenbaum, C. S. Baker, A. L. Blackmer and H. Whitehead. 2006. The influence of maternal lineages on social affiliations among humpback whales (*Megaptera novaeangliae*) on their feeding grounds in the southern Gulf of Maine. Journal of Heredity 97:226-234.

Weller, D. W., B. Würsig, H. Whitehead, *et al.* 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. Marine Mammal Science 12:588-593.

Whitehead, H. 2003. Sperm whales: social evolution in the ocean. University of Chicago Press, Chicago, IL.

Whitehead, H., and C. Glass. 1985. Orcas (killer whales) attack humpback whales. Journal of Mammalogy 66:183-185.

Whitehead, H., and L. Rendell. 2015. The cultural lives of whales and dolphins. University of Chicago Press, Chicago, IL.

Wild, L. A., and C. M. Gabriele. 2014. Putative contact calls made by humpback whales (*Megaptera novaeangliae*) in Southeastern Alaska. Canadian Acoustics 42:23-31.

Wirsing A, M. R. Heithaus, A. Frid and L. M. Dill. 2008. Seascapes of fear: evaluating sublethal predator effects experienced and generated by marine mammals. Marine Mammal Science 24:1–15.

Witteveen, B. H., J. M. Straley, E. Chenoweth, *et al.* 2011. Using movements, genetics and trophic ecology to differentiate inshore from offshore aggregations of humpback whales in the Gulf of Alaska. Endangered Species Research 14:217-225.

Wood, F. G., D. K. Caldwell and M. C. Caldwell. 1970. Behavioral interactions between porpoises and sharks. Investigations on Cetacea 2:264-277.

Woodward, B. L., J. P. Winn and F. F. Fish. 2006. Morphological specializations of baleen whales associated with hydrodynamic performance and ecological niche. Journal of Morphology 267:1284-1294.

Zoidis, A. M., M. A. Smultea, A. S. Frankel, *et al.* 2008. Vocalizations produced by humpback whale (*Megaptera novaeangliae*) calves recorded in Hawaii. Journal of the Acoustical Society of America 123:1737-1746.

Table 1. Summarized observations of interactions between humpback whales and killer whales (see Appendix 2 for complete accounts). Individual events where killer whales initially approached humpbacks or other species, and then other humpbacks subsequently

approached those killer whales, are treated as separate events and are indicated by the same event numbers followed by ‘a’, ‘b’, and ‘c’.

Figure 1. Locations and numbers of recorded interactions between humpback and killer whales described in Appendix 2 and summarized in Table 1; the number in each circle is the number of interactions from the general area.

Figure 2. Examples of humpback whales interacting with mammal-eating killer whales attacking various prey species: A) large type B killer whales attacking a crabeater seal hauled out on an ice floe with an agitated (bellowing) humpback in the foreground; January 2009, Western Antarctic Peninsula, Appendix 2 account #89; photo by J. Durban; B) Bigg’s killer whales attacking a gray whale calf (gray whale mother on left; wounded calf in center) with a humpback whale in the background; May 2012, Monterey Bay, CA, #55; photo E. Robinson courtesy Monterey Bay Whale Watch; C) Bigg’s killer whales attacking a Steller sea lion with humpback in the immediate background; 21 Aug 2010, Vancouver Island, Canada, #67; photo by R. Frank; D) Bigg’s killer whales attacking a harbor seal (below trailing edge of killer whale dorsal fin; the seal has a transmitter mounted on its head) and a humpback in the background; June 2005, Glacier Bay, AK, #91; photo by M. de Roos.

Figure 3. A mother humpback whale and newborn calf photographed off Baja California, Mexico, Oct 2009. When necessary, the mother will use her massive pectoral flippers to

1567 defend her small calf from attacking predators, especially killer whales. Photo: M. Lynn,
1568 NOAA, Southwest Fisheries Science Center.
1569
1570 Figure 4. In the Aleutian Islands, Alaska, 17 Bigg's killer whales (in the background)
1571 attacked a large humpback calf accompanied by its mother and an escort in July 2003;
1572 three other adult humpbacks joined in and helped drive off the killer whales. (This record
1573 arrived too late to be included in Appendix 2). Photo: © Flip Nicklin/Minden Pictures.
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Table 1

Event No. (from Appendix)	Species interacting with killer whales	No. of killer whales	No. of humpback whales	Killer whales			Humpback whale behavior					Duration of interaction (mins)	Comments[d]
				Ecotype[a]	Behavior[b]	Prey killed?[c]	Pursued killer whales	Bellow	Flipper slap or slash	Fluke slap or slash	Travel distance(s)		
a) Killer whales approached humpbacks													
1	Humpback(s) without calf	3	1	MEKW	A	U							KW jumped on head and tail of HB
2	Humpback(s) without calf	10-12	3	MEKW	A	N	x	x		x			KW attacking HB on feeding grounds; attacked threesome may have included a calf
3	Humpback(s) without calf	17		MEKW	U	N				x			KWs attacking or perhaps testing scattered HB
6	Humpback(s) without calf	6	1	FEKW	T	N		x	x	x		5	Resident KWs (identified by G. Ellis) harass[?] lone adult male HB for 5 min
10	Humpback(s) without calf	5		MEKW	A	Y							KWs apparently killed and ate what appeared to be a juvenile HB (possibly a calf)
13	Humpback(s) without calf	6	1	MEKW	T	N				x		5	Transient KWs - one female 'tests' adult HB, then leaves
14	Humpback(s) without calf	3	1	MEKW	A	N				x			Juvenile HB wounded on wintering ground
16a	Humpback(s) without calf	15	3	MEKW	A	N						90	Transient KWs attacked 3 HB, smaller animal possibly a calf - see #16b
21	Humpback(s) without calf	4	1	MEKW	A	N						20	Unsuccessful attack by KW on a subadult HB
28	Humpback(s) without calf	10	1	MEKW	T	N		x	x	x		2	2 largeType B KWs from a group of 10 briefly harass an adult HB
58b	Humpback(s) without calf		1	MEKW	A	N							KWs attack juv HB from #58a (HB possibly a calf of #58c)
30	Humpback(s) with calf	5	2	MEKW	A	U							KWs attack HB calf (with mother) on breeding ground - outcome unknown
31	Humpback(s) with calf	4-5	3	MEKW	A	N	x			x			KWs attack 3 HBs (2 adults, 1 calf), an apparent HB escort drove off KWs
32	Humpback(s) with calf	6	2	UnE	U	N						12	KWs (ecotype unknown) spent 12 mins as close as 15 m to HB cow w calf - no responses
33	Humpback(s) with calf	2	3	MEKW	A	N						20	KWs targeted HB calf; 2 HB adults flanked calf, KWs left
34	Humpback(s) with calf	10	3	MEKW	A	U		x		x		26+	KWs attack 3 HBs (2 adults, 1 calf) - result of attack unknown
35	Humpback(s) with calf	1	2	MEKW	A	N				x			KW (1) attacks cow/calf HB - unsuccessful
36	Humpback(s) with calf	7	3	MEKW	A	Y							KWs attack 3 HBs (2 adults, 1 calf) - calf reportedly killed
37	Humpback(s) with calf	2	3	MEKW	A	N				x			KWs attack 3 HBs (2 adults, 1 calf) - unsuccessful
38	Humpback(s) with calf	5-6		MEKW	A	U							In response to KW attack, 13-16 HB form rosette with calves in the middle
39a	Humpback(s) with calf	15	2	MEKW	A	N				x			Large type B KWs attack HB cow/calf; other HBs chased off KWs - see #39b
40	Humpback(s) with calf	5	2	MEKW	A	N				x		20	Transient KWs harassed HB calf w cow, near a group of feeding HBs
41	Humpback(s) with calf	10	2	MEKW	A	U				x		390+	10 KWs harass cow/calf HB for over 6.5 hr next to oil platform - outcome unknown
42	Humpback(s) with calf	7	2	MEKW	A	N							Tranisent KWs apparently attack HB calf after a sea lion kill; displaced by cow HB
43	Humpback(s) with calf	2	3	MEKW	A	N				x			KWs attack HB calf with mother and companion on breeding ground - whalewatchers break it up
44	Humpback(s) with calf		5	UnE	T	N						10	4 adult HBs huddle to protect 1 calf; KWs depart after circling 10 min
45	Humpback(s) with calf	6	2	MEKW	A	N		x		x			KWs harass HB calf; cow apparently drives them off
46	Humpback(s) with calf	2	2	MEKW	T	N				x			KWs approach HB cow/calf; cow apparently drives them off
47	Humpback(s) with calf	7		MEKW	A	N						45+	3 adult HBs successfully defend a HB calf from attacking KWs
48a	Humpback(s) with calf	6	1	MEKW	A	U						150+	6 KWs attack apparent calf HB; 13 + 2 HBs join calf and KWs leave (see also #48b)
49a	Humpback(s) with calf	30-40	4	FEKW	U	N		x	x	x		45+	35 small type B Antarctic KWs (fish-eaters?) moved in among group of HBs - HBs initally agitated but no incidents (see #49b)
b) Humpbacks approached killer whales													
4	Humpback(s) without calf			MEKW	A	U					> 1 mile (1.6 km)		HBs come from 'over a mile away' to aid another HB attacked by KWs
15	Humpback(s) with calf	18	2	FEKW	U	N						60+	2 HBs follow 18 fish-eating KWs for at least 2 hrs without incident in AK
29	Humpback(s) with calf	50-70	2	FEKW	U	N							Single HB follows KW group (Antarctic small type B - fish-eaters?) - foraging together?
48b	Humpback(s) with calf	6	15	MEKW	A	N		x					6 transient KWs attack and injure HB calf (see #48a); 13 + 2 HB 'swam up to injured calf'; KWs leave
58c	Humpback(s) with calf		2	MEKW	A	N				x			2 adult HB come to defence of juv HB in #58b - possibly a calf of one of the adults
16b	Humpback(s) with calf	15	3	MEKW	A	N						30	Transient KWs attacking 3 HBs (#16a) joined by 3 other HBs and appeared to drive KW away
39b	Humpback(s) with calf	15	3	MEKW	A	N	x						3 adult HBs drove off large type B KWs that were attacking HB cow/calf pair - see #39a
49b	Humpback(s) with calf	35	6	FEKW	U	N							HBs w calves joined agitated group from #49a - group dispersed without incident while small type B KWs stayed among them
51	Gray whale	4	1	MEKW	A	N							KWs attack (test?) GW briefly; humpback swims close by; no interaction
52	Gray whale	5-6	1	MEKW	A	N	x		x	x		33+	Transient KWs attack GW calf w cow; HB appears to help calf escape
53	Gray whale		>5	MEKW	A	N		x					Transient KWs attack GW calf with ; 5 + HB come in to drive off KWs
55	Gray whale	11	16	MEKW	A	Y	x	x	x	x	3.5 mile (5.6 km); 3.6 mile (6.7 km);4.1 mile (7.6 km)	437+	Transient KWs kill gray whale calf; 2 HBs present, and at least 14 others join in and apparently interfere with attack and feeding by KWs
56	Minke whale	13	1	MEKW	A	Y				x			Transient KWs chase MW to boat; a demonstrative HB approaches but MW killed
57	Dall's porpoise	2	1	MEKW	A	N	x	x				8+	Transient KWs chase DP; HB follows bellowing
58a	Steller sea lion		1	MEKW	A	Y							Juv HB approaches KWs attacking SSL; SSL presumably killed (see #58b, c)
59	Steller sea lion	5-6	9	MEKW	A	U	x	x	x	x	1.8 km	105	KWs attacking SSL when HBs including a cow/calf pr intrude; 'excited' HBs stay 4+ h
65	Steller sea lion	4	2	MEKW	A	Y		x		x			Transient KWs kill SSL; 2 HBs (adult male + adult female) approach and tail slash
66	Steller sea lion	10	7	MEKW	A	Y	x	x				60	Transient KWs kill SSL; up to 7 HB move in close and follow KWs
67	Steller sea lion	10	1	MEKW	A	Y						39+	KWs attacking SSL 'approached' by HB - SSL 'very likley' killed
68	Steller sea lion	16	1	MEKW	A	Y			x	x			KWs attack and kill a SSL: HB makes a 'big fuss' in an apparent 'rescue attempt'
70	Steller sea lion	4	3	MEKW	A	Y		x		x			3 HBs joined 4 KWs that had just killed a SSL; HBs agitated
73	California sea lion	7	8	MEKW	A	Y						105+	Transient KWs kill CSL - "2 + 2 + 2 + 2" HBs "in area"
77	California sea lion	8	2	MEKW	A	U	x			x	2 miles (3.2 km)		Transient KWs attack CSLs; HB approach from 2+ miles, "swatting KW w/ their flukes"
78	California sea lion	pod	2	MEKW	A	Y		x			several hundred m		KWs kill CSL; 2 HBs approached kill site from 'several hundred meters', bellowing
80	California sea lion	7	2	MEKW	A	Y						15	Transient KWs taking CSLs; 2 HBs surface in the middle of the KWs
82	California sea lion	5-6	3	MEKW	A	U						82	Transient KWs kill CSL; 2 + 1 HBs approach and stay over an hour
86	California sea lion	8	7	MEKW	A	Y	x					29	Transient KWs carrying juv SL; 2 HB 'actually chasing' and 'harass' KW; 2 + 1 + 2 more HB arrive
87b	Weddell seal	10	2	MEKW	U	N		x	x	x			Large type B KWs; a pr of HB joins pr of HB from #87a during possible WS attack
89	Crabeater seal	10	2	MEKW	A	N	x	x					Large type B KWs attack CS on ice; pr of HBs from #87a appear to follow then interfere with attack
90	Harbor seal	5	1	MEKW	A	Y						44	Transient KWs attack and apparently kill an HS; single HB approaches then departs
92	Harbor seal	6	2	MEKW	A	Y					200 m		Transient KWs attacking a HS approached by 2 HBs
94	Northern elephant seal	5	1	MEKW	A	Y	x					58+	Transient KWs kill NES - HB shows up and chases KWs
96	Ocean sunfish	6-7	3	MEKW	A	U	x	x			>300 m	36+	Transient KWs attacking a sunfish are 'mobbed' by 3 HBs
97	Unidentified prey	8-12	2	MEKW	A	Y						26	Transient KWs vocalizing with unid kill; pr of HB approach and may have scattered KWs
99	Unidentified prey	6	1	MEKW	A	Y						74+	Transient KWs "killed something?" - "1 HB close by"
100	Unidentified prey	6	7	MEKW	A	Y	x					18+	Transient KWs 'killed something'; joined by up to 7 HB, several of which follow the KW
102	Unidentified prey	6	7	MEKW	A	Y	x						Transient KWs "killed something" - 2 + 3 + 2 HB join and follow KWs
104	No prey observed	5-6	2	MEKW	U	U		x				73	Transient KWs, possibly with prey, approached by 2 HB, which stayed with them over 1 h
105	No prey observed	11	11	MEKW	U	U	x					124	2 + 3 + 6 HBs following 5 + 6 KWs; HBs 'friendly' with boat
107	No prey observed	5	4	MEKW	U	U	x						"5 KWs followed by 4" HB
108	No prey observed	4	3	MEKW	U	U							HBs approach transient KWs that were 'playing, jumping'
c) Approaching whale(s) unknown													
5	Humpback(s) without calf	12-14	1	MEKW	U	U		x	x			45	Agitated HB surrounded by transient KWs; [KWs possibly after other prey?]
7	Humpback(s) without calf	3	1	MEKW	T	U							Transient KWs 'harass' 1 HB
8	Humpback(s) without calf	2	1	MEKW	U	N							Two KWs 'harassing' HB; possible test or attack
9	Humpback(s) without calf	4	1	MEKW	T	U							Transient KWs 'harass' 1 HB
11	Humpback(s) without calf	5	>1	MEKW	T	U							Transient KWs 'harass' HBs
12	Humpback(s) without calf	3	1	UnE	U	N							3 KWs passed within 25 m of 1 HB with no interaction
17	Humpback(s) without calf	4-5	1	MEKW	A	N		x	x	x			KWs attacked lone HB - attackers apparently repelled
18	Humpback(s) without calf	3-4	2	MEKW	U	U				x		60+	3-5 KWs circled pr of adult HBs for over 1 h; HB tail-slapping
19	Humpback(s) without calf	12	4	MEKW	U	N	x	x				30+	Group of HB charge at group of KWs and scatter them
20	Humpback(s) without calf	4-5	4	MEKW	U	U				x			4-5 KWs in immediate area of tight group of 4 tail-slapping HBs
22	Humpback(s) without calf	4-5	3	UnE	U	U		x					Agitated HBs (2 adult male and 1 unidentified) swim away from group of milling KW
23	Humpback(s) without calf	8	1	UnE	U	U			x	x			'Harassed' HB adult apparently repels KW with appendage slaps
24	Humpback(s) without calf	4	>1	MEKW	U	U							4 KWs "with HBs"
25	Humpback(s) without calf	3	3	MEKW	U	U							Transient KWs; no interaction recorded
26	Humpback(s) without calf	5	3	UnE	U	U							No specifc interaction recorded
27	Humpback(s) without calf	8	1	MEKW	U	U			x	x		180+	8 KWs spent over 3 hrs with agitated HB
50	Humpback(s) with calf	15	5	UnE	U	N	x					30+	HBs chasing KWs for 30 min; HB cow/calf broke off early
54	Gray whale	15	7	MEKW	A	Y							15 KWs at GW kill - "3 + 4 HBs" present
60	Steller sea lion	4	1	MEKW	A	Y						65+	KWs attacking SSL with a lone male HB acting 'protective' of SL
61	Steller sea lion	6	4	MEKW	A	Y		x	x	x		50	Transient KWs kill SSL; HBs demonstrative around carcass, touch it with flippers
62	Steller sea lion	4	2	MEKW	A	U		x		x			KWs attacking SSL; 2 adult male HBs converge, 'agitated' they stay close to SL
63	Steller sea lion	8	3	MEKW	A	Y						60+	Transient KWs kill SSL; 2-3 HB 'corralled' by adult male KW during kill
64	Steller sea lion	6	1	MEKW	A	U			x	x			Transient KWs attacking SSL; lone HB possibly slashing at KWs (or prey) with flippers and flukes
69	Steller sea lion	3	7	MEKW	A	Y	x	x	x	x	1/2 mile (0.8 km)	30+	Transient KWs kill SSL; agitated HBs closely follow and possibly 'harass' KWs
71	California sea lion	3	5	MEKW	A	Y						102+	Several HB 'near' as transient KWs attack CSLs; kill and eat one; no interactions noted
72	California sea lion	6	2	MEKW	U	N				x		40+	Transient KWs appear to be hunting CSLs; possible 'interference' by pair of HB
74	California sea lion	3	3	MEKW	A	Y							Transient KWs attack CSL; 3 HB (including cow/calf) 'interacted with' KW
75	California sea lion	3	2	MEKW	A	Y						109+	Transient KWs kill CSL; 2 HB "involved, curious?"
76	California sea lion	5	>1	MEKW	A	Y		x					Transient KWs kill CSL; HB "interfering" with KW and carcass
79	California sea lion	15	12	MEKW	A	N						69	Transient KWs chasing SLs; at least 5 HBs 'present'
81	California sea lion	6	4	MEKW	A	U						63+	Transient KWs chasing SLs; 4 HBs 'present'
83	California sea lion	6	4	MEKW	A	Y							Transient KWs kill CSL - "2 + 2 HB in area"
84	California sea lion	6	2	MEKW	A	Y						46+	Two HBs in among transient KWs for at least 46 min as they attack kill a CSL
85	California sea lion	12	3	MEKW	U	U						9+	Transient KWs with 3 HBs and CSLs present - no interactions recorded
87a	Weddell seal	10	2	MEKW	U	N		x	x	x			Large type B KWs; WS possibly seeking refuge among 2 + 2 HB - see #87b
88	Weddell seal	11	2	MEKW	A	Y	x	x	x	x	1/4 mile (0.4 km)		Large type B KWs attack WS; one of a pr of 'protective' HBs take seal up on its chest; 3 WESE kills
91	Harbor seal	4	1	MEKW	A	Y	x			x		60+	Transient KWs attack and presumably kill HS; adult male HB taking tail swipes at seal?
93	Northern elephant seal	10	2	MEKW	A	Y							HBs apparently turned toward hunting transient KWs - no interaction seen
95	Ocean sunfish	15	5-6	MEKW	A	U							Transient KWs apparently ate a sunfish; 'associated' with 5-6 HB
98	Unidentified prey	3		MEKW	A	Y							Transient KWs 'eating something', reportedly 'test' an HB
101	Unidentified prey	4-5	3	MEKW	A	Y		x					Transient KWs diving on prey slick; 3 HB swimming around perimeter
103	Unidentified prey	3	4	MEKW	A	Y						68+	Transient KWs 'killed something' and 4 HB have 'excited interaction' with them
106	No prey observed	5	2	MEKW	U	U	x						Two HBs chasing transient KWs briefly

[a] MEKW: mammal-eater, FEKW: fish-eater, UnE: undetermined ecotype

[b] A: Attack, T: Test, U: Unknown

[c] N: No, Y: Yes, U: Unknown

[d] KW: killer whale; HB: humpback whale

1577
Figure 1

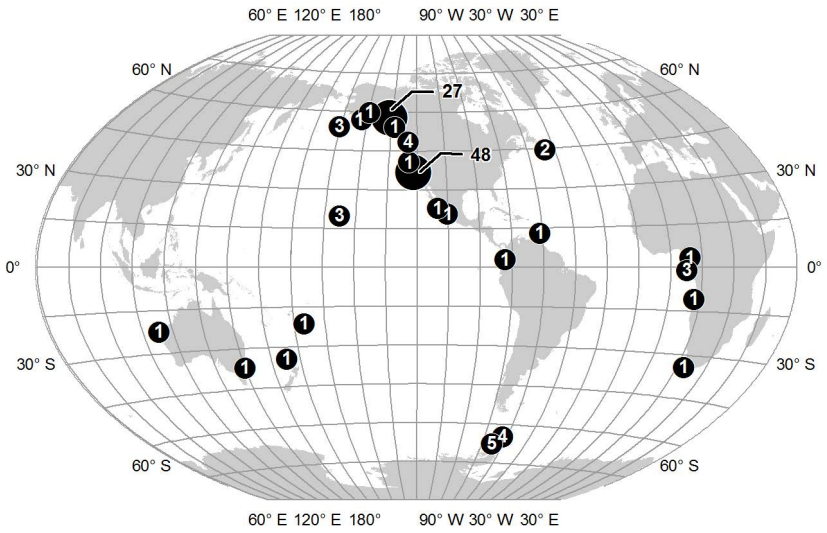
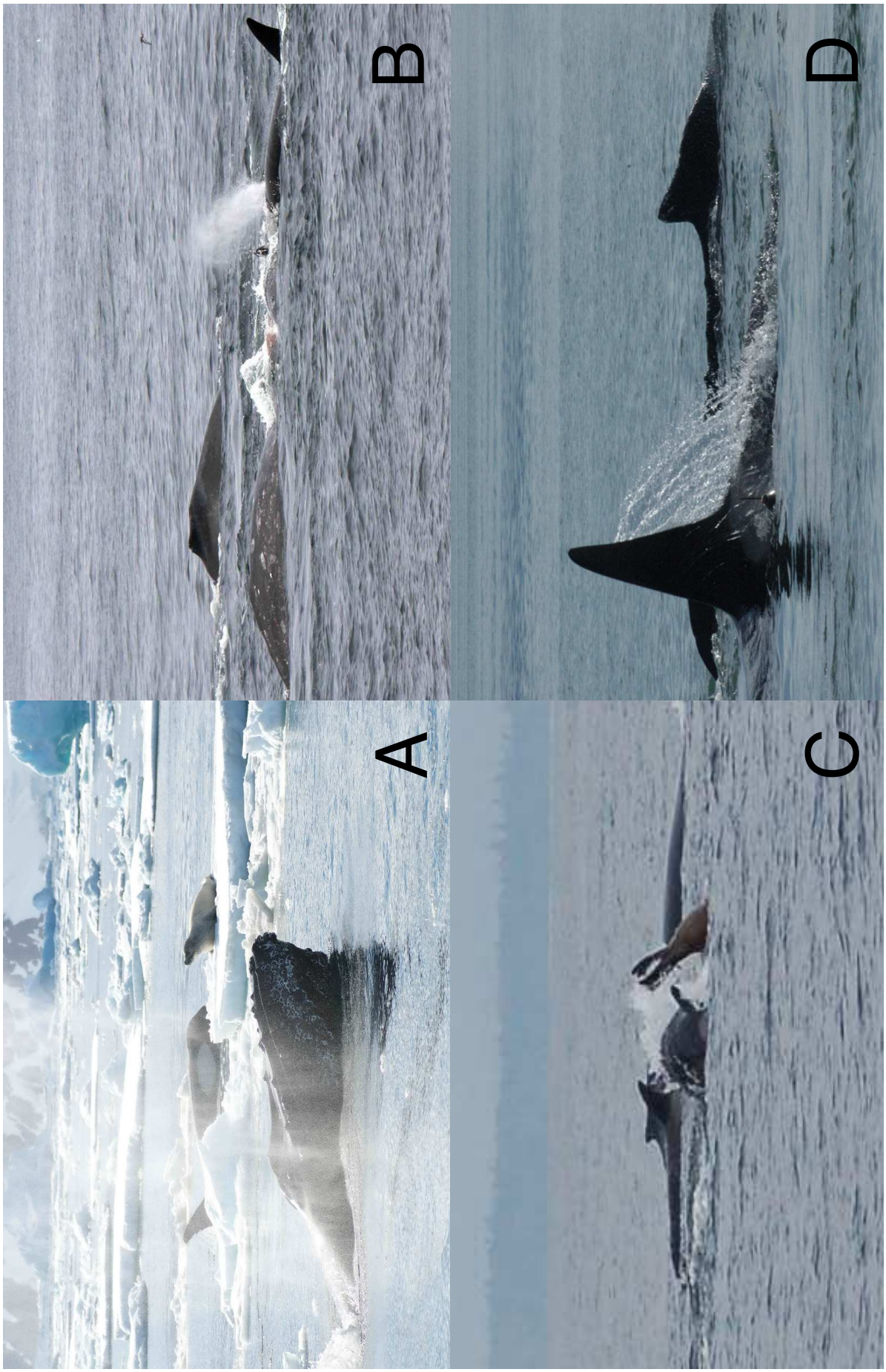


Figure 2

1578



1579 Figure 3

1580

1581 Figure 4

1582

1583 Appendix 1. Links to video footage of humpbacks interacting with killer whales attacking
1584 various species of prey; numbers in parentheses refer to event numbers in Appendix and
1585 in Table 1. All links accessed on 18 May 2016.
1586 https://www.youtube.com/watch?v=K1ZLTqn1WKg&feature=youtu.be (#61)
1587 https://www.youtube.com/watch?v=fgnj9QxFoh8&feature=youtu.be (#61)
1588 https://youtu.be/SFYAD5ECRXA (#61)
1589 http://www.youtube.com/watch?v=8Rwak1_YS7c (#101)
1590 https://www.youtube.com/watch?v=zQXOClAXh0M&feature=youtu.be (#94)
1591 https://www.youtube.com/watch?t=1&v=acU5dBF2nHo (#55)
1592 https://www.youtube.com/watch?v=-lw8_SAtX8o (#55)
1593 https://www.youtube.com/watch?v=SWIda-OUdg0 (#55)
1594 http://www.bbc.co.uk/programmes/p00s7tkj (#55)
1595 https://www.youtube.com/watch?v=O_LEa6o0XTo
1596 https://www.youtube.com/watch?v=-2XBwDNoQ9U
1597 https://www.youtube.com/watch?v=0OL73ChbRj8&app=desktop
1598 https://www.youtube.com/watch?v=yrKtxVHQQnE
1599
1600 Appendix 2: Accounts of humpbacks interacting with killer whales. We have tried to
1601 retain as much of the original wording of these accounts as possible; any subsequent
1602 rewording, clarification or comments are included in brackets. The Appendix is arranged
1603 chronologically by the species of prey targeted by killer whales and, for humpbacks,
1604 whether or not they were with calves. The event numbers correspond to numbers
1605 provided in the text and in Table 1; mammal-eating killer whales in the NE Pacific are

referred to as either “transients” or “Bigg’s” killer whales; for information on Antarctic killer whale types see Pitman (2011) and Durban *et al.* (2016).

Humpback whale (*Megaptera novaeangliae*)

A. Humpbacks without calves:

1. Dec 1961; North Cape, New Zealand; Visser (1999). Three “orca seen to attack a humpback, orca ‘jumped’ onto head and tail of humpback”.

2. 4 July 1982; Grand Bank, Newfoundland; Whitehead and Glass (1985). “we saw 10 to 12 orcas attacking humpbacks...” “About 20-30 humpbacks, in groups of 2-4 animals were concentrated in an area of approximately 10 km^2.

“The orcas included three adult males (6-8 m in length), recognizable by their prominent dorsal fins, and 7-9 smaller (4-6 m in length) whales of unknown age or sex. Adult males generally milled about alone or, infrequently, in pairs, whereas groups of 2-3 smaller orcas remained together over periods of at least a few minutes.

“Typically, a single adult male, or 2-3 smaller animals, harassed a humpback at one time. The orcas rushed towards the humpback at about 11-15 km/h (Fig. 1). On four occasions we saw the humpback turn its belly toward the approaching orca, thrashing with its flukes. Fluke thrashing, turning, and rolling were common responses to orca attack. Directly after such an encounter, the orca retreated, frequently pursued for several meters by one or more of the humpbacks. Throughout our observations, the humpbacks generally moved slowly (less than 6 km/h).

"While being attacked by orcas, the humpbacks, made loud "wheezing" blows. These are rarely heard from humpbacks in normal circumstances.

"During the early part of the encounter, the orcas moved about among various groups of humpbacks, but after several hours they seemed to concentrate on one group of 3 animals. These 3 stayed in close association about 4 m apart. This is closer than the usual inter-animal distance of grouped humpbacks off Newfoundland…"

"The humpbacks were seen with open wounds: one on the dorsal fin, one on the caudal peduncle, and one on the lower jaw. Many lumps of stringy blubber (*ca*.1 kg), with small pieces of flesh attached, were seen floating in the water. These were the first such lumps that we had observed during 28 months of humpback research off Newfoundland, Greenland, and in the West Indies." [Humpback calves not specifically mentioned but may have been present, especially in group of 3.]

3. 25-26 June 1983; Grand Bank, Newfoundland; Whitehead and Glass (1985). "we observed about 17 orcas, including about 3 large males and 2 small calves, attacking humpbacks..." "The behaviour, groupings, speeds, and sounds of the orcas and the humpbacks were very similar to those of the previous sighting [#2]. However, there were differences between the observations of 25 June 1983 and 26 June 1983. On 25 June the groups of humpbacks were closely packed, with less than 100 m between adjacent groups. Vigorous attacks by the orcas were countered by violent fluke thrashes from the humpbacks. In contrast, on 26 June, the humpbacks were much more dispersed, with groups approximately 500 m apart. The orca attacks were less vigorous, and the humpbacks' defensive measures appeared almost leisurely. During the encounter no

lumps of blubber were sighted, and only one small flesh wound was seen on a humpback's fluke.

"During both encounters we had the definite impression that the orcas had no immediate intention of attempting to kill a humpback. The orcas may have been simply attempting to obtain mouthfuls of humpback flesh. Alternatively, they might have been testing the humpbacks to single out animals which, perhaps on account of disability, sickness, or age, could then be killed by a greater number of orcas acting cohesively."

4. 1988; Chatham Strait, AK; D'Vincent *et al*. (1989). "In every encounter we have observed between killer whales and humpbacks, either in playful harassment or determined effort, other humpbacks have come to the aid of the jeopardized animal [*i.e*., humpback], whether it be an adult or a juvenile. In a harassment observed in 1988 in Chatham Strait, humpbacks came from over a mile away to the aid of the victim. Such altruistic behavior is probably the humpbacks' best defense against the killer whale."

5. 24 June 1994; Chatham Strait, AK; J. Straley in Ford and Reeves (2008). "Adult humpback surrounded by killer whales reacted by splashing vigorously with flippers, shaking head, 'trumpet' blowing and exhaling underwater. Killer whales ended harassment after 45 min." J. Straley[3] reported: "12 [transient] killer whales reported 5 nm south of Yasha Island in Chatham Strait. Killer whales were circling in the area. 1545-1645 we approached and photographed the killer whales and one humpback whale dorsal fins. Humpback was not fluking. The killer whales surrounded a very agitated

[3]Jan Straley, University of Alaska Southeast, 1332 Seward Ave., Sitka, AK 99835 USA, pers. comm. 12 Jan 2010.

humpback whale. The humpback was shaking, exhaling underwater, moving quickly up and down in the water with the flippers creating breaking waves (white water), no vocalizations heard but it was very windy, SE 20K+, and choppy 3+foot seas. The killer whales were divided into two groups of 6-7 whales each with the groups alternating presumably attacking the humpback. When one group was not near the humpback the killer whales were off 1/4 nm breaching, charging around, doing head flips and showing flukes. The humpback disappeared and moved off while we were observing the killer whales. The groups were composed of a male, calf, 4-5 females or juveniles. Eventually 2 males separated from the others. We did not approach close to minimize our disturbance. Unknown if the killer whales actually made contact with the humpback, no blood or damage to the humpback on the dorsal surface was observed. There could possibly have been a calf or another humpback submerged that was the target of the attack but a second whale was never seen."

6. 3 July 1995; Point Carolus, Glacier Bay, AK; C. Gabriele; Glacier Bay National Park Annual Whale Report 1995. "4 humpbacks were feeding on shallow prey near Point Carolus when a group of approximately 20 killer whales (*Orcinus orca*) came into the area. Three of the humpbacks immediately disappeared from the area, and the fourth animal (male #118) remained. After the killer whales had milled in the area for about 5 minutes, a sub-group of approximately 6 killer whales surrounded whale #118 and appeared to 'harass' him. While he was surrounded, whale #118's respirations were wheezy and he repeatedly slashed his pectoral fins and tail from side to side. The killer whales stayed with the humpback for about 5 minutes, which remained on the surface

throughout the incident. The humpback then resumed feeding nearshore, and the killer whales eventually headed north into Glacier Bay. Identification photographs of the killer whales were taken, and later identified as resident-type AG pod, (Graeme Ellis, pers. comm.)."

7. 26 Aug 1995; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 3 transient killer whales "harassing a humpback whale."

8. 12 Jan 1998; West Hawaii, Hawaiian Islands; Baird *et al.* (2006). 2 killer whales 'harassing humpback whale".

9. 19 Nov 2000; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 4 transient killer whales "harassed 1 [humpback whale]."

10. 20 March 2001; Kaua'i, Hawaiian Islands; Baird *et al.* (2006). 5 killer whales "feeding on humpback whale". C. Bane[4] reported: 15 May 2011. "The day we saw the Orca killing and eating the humpback we never saw the Humpback except for the pieces that were being brought up and displayed (for lack of a better word). There was a lot of dorsal slaps by the biggest adult male right next to the boat as well as some charges/head slaps 10' from the boat before he'd dive under our boat. And, of course lots of blood. About 2-3 miles north were over 10 HBs that for lack of a better word seemed to be "climbing" over each other as to get out of the water. I had first saw the Orca, went over

[4] Chris Bane, 1601 Harmonys Place, Sooke, BC V9Z 0T1 Canada, pers. comm. 15 May 2011.

to the area, waited a few minutes, looked NE and saw a bunch of activity (spouts, splashes and bodies), so I headed up there and saw the mayhem. We didn't see any Orca so I headed back to the spot of the Orca sightings and that's when we started to see the Orca getting active on the surface (basically getting lots of breaths and going back down). The first thing we saw was what looked to be a tongue, around 8' long very pale red in the mouth of the largest male. Within 10 minutes of that we saw the blood come up then the male had a circular piece of belly meat in his mouth (around 6-8' in diameter). He showed it to us long enough to see the ventral pleats, layer of fat and muscle with what looked like tendons/arteries and such hanging off. After that we saw no more feeding, just the male getting aggressive when we would drift too close. It's kind of hard to say if it was a small adult or a large juvenile, but the pleats were rather too large to be a baby."

11. 29 May 2001; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 5 transient killer whales "harassed [humpback whales]."

12. 30 Aug 2001; Gabon, West Africa; Weir *et al*. (2001). 3 "Killer whales passed within 25 m of a single adult humpback without obvious direct interaction".

13. 8 July 2002; off Kodiak Island, AK; R. Pitman unpubl. notes. "While we were with [a group of 6 transient killer whales] an adult [humpback whale] showed up ahead of us; one of the females [killer whales] broke off and went over and tested the whale. There was some tail flailing by the [humpback] and the [killer whale] broke off. Seemed more

of an annoyance for the [humpback] than a real threat." [Total duration of event: 5 minutes]

14. 28 December 2002; Bahia de Banderas, Mexico; Ford and Reeves (2008). "Juvenile humpback attacked and wounded by [3] killer whales struck at predators with tail flukes on several occasions.

15. 21 July 2003; off Unalaska Island, Alaska; R. Pitman and J. Durban field notes. A pair of humpback whales followed a group of an estimated 18 fish-eating ('resident') killer whales around for at least 2 h; nothing happened.

16a-b. 30 July 2003; Akutan Island, Eastern Aleutians, Alaska; C. Matkin *et al*. (2007). "We observed the harassment of a humpback whale by [15] killer whales once; during the attack, other humpback whales rapidly converged on the attackers and appeared to drive the killer whales away." C. Matkin pers. comm. 26 Feb 2010: "There were originally three humpback whales with about 15 KWs that were attacking the smaller of the trio. Some bloody rake marks on humpback fluke. An hour into the attack three other HW joined. KWs aborted the attack about 30 minutes later." [We assume the humpbacks were a cow/calf pair with an escort].

17. 15 August 2003; Langara Island, British Columbia; Ford and Reeves (2008). "Single humpback rolled, thrashed tail flukes and flippers, and 'trumpeted' in response to attack." [4-5 killer whales involved]; no kill.

18. 3 Sept 2003; Gabon, West Africa; Weir *et al.* (2010). “a group of three to four killer whales circled a pair of adult humpback whales for over an hour. One humpback whale was seen to repeatedly tail-lob and tail swipe. The humpback pair always dived together, with the killer whales circling above and then diving to follow. No direct interactions were observed, but the pattern persisted until the observations ceased due to deteriorating sea conditions.

19. 3 May 2005; Monterey Bay, CA; K. Newton and S. Benson unpubl. notes. “I don't believe there were any pinnipeds in the mix. There were 4-5 humpbacks...one seemed smaller than the others, but I wouldn't say it was a calf. It appeared that the humpbacks were coalesced by the approaching Orcas. The humpbacks came out of the huddle and charged the Orca group. Humpback blows were forceful and created a loud trumpeting sound. After the humpbacks passed through the Orcas, they huddled-up again before aligning themselves for another pass (reminiscent of a bullfight). This sequence of events continued for a couple more passes. The Orcas became more scattered with each subsequent pass. I remembered thinking that humpbacks can be fearsome if necessary. The trumpeting noise and quick forceful movements, directly at the Orcas, was impressive.” [SB] “I remember the humpbacks and orcas charging back and forth at each other. I also do not recall any pinnipeds. I just looked through the few photos we have from the event and I didn't see any pinnipeds. We watched the event for about a half an hour (from 12:30 - 1pm) before departing to resume our line transect survey. The event

occurred May 3, 2005 in Monterey Bay (36.796N -122.021W). We recorded 4 humpbacks and 12 orcas (my notes indicate a best of 12, high 15, low 10)." [KN]

20. 13 Aug 2005; Gabon, West Africa; Weir *et al.* (2010). 4-5 killer whales; "No direct interaction observed. The four adult humpback whales maintained a tight group structure and exhibited tail-swiping, but it was unclear whether this was directed at the killer whales or whether one or both species was feeding on the numerous sardine (*Sardinella* sp.) shoals in the region.

21. 8 June 2006; Sitka Sound, AK; Ford and Reeves (2008). "Four killer whales attacked subadult humpback by swimming onto its back in apparent attempt to submerge it. Humpback reacted by rolling vigorously at the surface to dislodge killer whales. Killer whales left after 20 min."

22. 3 October 2007; Point Adolphus, Icy Strait, AK; C. Gabriele; Glacier Bay National Park Annual Whale Report 2007. "On October 3 we observed three humpback whales (adult male #186, adult male #1244 and an unidentified individual) wheeze blowing next to a group of four or five killer whales. Soon after, the humpback whales began to travel away while the killer whales began milling approximately 500 m away. We did not detect a killer whale predation event associated with this interaction and we do not know the significance of the behavior we observed."

23. 2 November 2007; Tenakee Inlet, AK; Ford and Reeves (2008). “Adult-sized humpback harassed by [8] killer whales responded by repeatedly slashing with tail flukes and pectoral flippers, often while lying with ventrum to the surface.”

24. 30 May 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 4 KWs “with MNs”.

25. 13 August 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. 3 transient killer whales (same group killed a California sea lion in same area day before; see #74, 75); “3 [humpbacks] present”.

26. 23 August 2008; Monterey Bay, CA; anonymous report to R. Ternullo. 5 killer whales with 3 humpback whales.

27.13 Sept 2008; Angola, West Africa; Weir *et al*. (2010). “No direct interaction observed. However, the [8] killer whales spent over 3 hours in direct proximity to a single adult humpback whale which was seen maneuvering tightly in various directions and exhibiting some longer dives with frequent belly-up rolls, headstands, tail-thrashing and flipper-slapping.”

28. 17 January 2009; Laubeuf Fjord east of Adelaide Is, West Antarctic Peninsula, Antarctica; R. Pitman and J. Durban unpubl. notes. “This evening we also saw a [humpback whale] swimming in the opposite direction to the [type B killer whales] and

the latter could not help themselves and had to harass the lone animal. It rolled on its side several times, swatted it tail, thrashed its flippers and bellowed loudly as one of the sprouters and the ragged female [from a group of 10] harassed it at close quarters. Perhaps it was to test for a possible predation attempt or maybe just some bad boys flexing their muscles." [the killer whales departed after approximately 2 min with the adult humpback unharmed].

29. 23 Jan 2012, Gerlache Strait, Antarctic Peninsula, Antarctica; R. Pitman field notes. "We pulled into a group of 50-70 small type B killer whales (possibly a fish-eating ecotype in Antarctica). "Right at the first there was a MENO [humpback whale] in among them and several ORCA [killer whale] were flanking it – it looked like it could have been an attack on the larger whale. But as we stayed with them it was clear that the ORCA weren't particularly interested in the MENO and that the MENO was actually trying to keep up with the ORCA that were traveling fairly fast. One of the ORCA would drop back to the MENO on occasion and swim alongside it – what that was about was not clear. Also, the MENO on a couple of occasions stopped and fluked up. So, just as we saw BABN [Antarctic minke whale] and fur seals swimming along with small type B ORCA, we have now seen MENO do the same thing. A fur seal was also seen among this group at one time – the person who first noticed the fur seal thought it was being attacked, much as people thought that the MENO was being attacked. My guess is that these are fish-eating ORCA and the camp followers are tagging along to see what opportunities might arise. Also, there was a large flock of [Southern Giant Petrels] sitting on the water in a tight bunch and it looked like there may have been some recent feeding

going on but no sign of what the food might have been. This group of ORORmight be after fish that shoals around the high spot here just off Useful Island".

B. Humpbacks with calves:

30. Undated (pre-1988); Lesser Antilles, Caribbean; Katona *et al.* (1988). "Bequia whalemen recounted an (undated) attack by a small group of (perhaps 5) orcas on a humpback calf accompanied by its mother. The killer whales breached repeatedly onto the calf, perhaps attempting to drown it."

31. October 1951; Exmouth Gulf, Western Australia; Chittleborough (1953). "Mr. J. Perkin observed in Exmouth Gulf four or five killer whales attacking a group of humpback whales consisting of two adults and a calf. One adult humpback (presumably the cow) kept the calf very close, while the other adult (possibly a bull) charged the killer whales, beating them off with its flukes. A very similar incident occurred off Point Cloates in the 1952 season. In neither case were the killer whales seen to be successful in their attacks."

32. 3 August 1983; Frederick Sound, AK; Dolphin (1987). "Between 1110 h and 1915 h on 3 Aug 1983, 15 Humpback Whales were dispersed over an area of 5.5 km^2. A cow (12-13 m in length) and an accompanying 7 m calf were apparently feeding near a steep ridge approximately 0.4 km from the nearest other humpback (a single 13 m adult which we had under observation). At 1415 a pod of six Killer Whales (two adult males, three females, and one subadult) fed briefly near the surface approximately 0.5 km from the

cow and calf and 0.8 km distant from us: splashing, rapid surface rushes, and "porpoising" behavior were seen. The Killer Whales changed direction by approximately 45 degrees and swam slowly as a unit toward the cow and calf humpbacks, reaching them at 1426 h. The pod of Killer Whales then dispersed. Individual Killer Whales often swam to within 15 m of the humpbacks. The humpback cow made no discernible attempt to move the calf or herself out of the area, nor were there any detectable changes in respiration or behavior patterns. The Killer Whales remained in the vicinity of the humpbacks for approximately 12 minutes. By 1440 h the pod had regrouped and was slowly traveling off. The cow and the calf humpback continued feeding in the area until at least 1510 h." [possibly fish-eating killer whales?]

33. Summer 1987; Chatham Strait, AK; D'Vincent *et al.* (1989). "Two killer whales suddenly appeared in the midst of a pod of humpbacks during a cooperative lunge feed. They targeted a calf for attack, but two adult humpbacks immediately sandwiched the calf between them, so forming a protective barrier. The calf was repeatedly raised partially out of the water by the flippers of the adults, who maintained this defensive formation for nearly 20 minutes until the killers departed. It appeared that the killers caught the humpbacks off guard, by using the humpbacks feeding vocalization to mask their approach. When banded together in large cooperative feeding groups such as this one, humpbacks appear to be more vulnerable to surprise attack. The loud feeding vocalizations and surface commotion of the cooperative groups can easily attract the attention of killer whales. When these animals move in to investigate a lunge feeding

pod, our observations suggest that the typical humpback response is to stop feeding at once and disperse."

34. 15 September 1991; off Gorgona Island, Colombia (Pacific); Flórez-González *et al.* (1994). "The group of killer whales comprised two adult males (8-9 m long), four calves (2-3 m long) and four females or immature males (6-7 m long)." "While following the killer whales, we also observed three humpback whales approximately 200 m in the distance, consisting of two adults (15-18 m in length), apparently a mother and escort, and a calf (approximately 6-7 m in length).

"At 1500 h the group of killer whales swam directly towards the humpbacks. The killer whale females and calves separated the humpback calf from the adults while the two mature male killer whales paralleled the course of the adult humpbacks, preventing them from coming near the calf.

"Periodically, the two male killer whales rapidly swam perpendicularly to and along the sides of the adult humpbacks, causing erratic movements in addition to forceful exhalations and snorting by the humpback whales." "Fourteen minutes after the attack had commenced (1514 h); we saw an open bite anterior to the dorsal fin on one of the adult humpbacks. White blubber was clearly visible, but the injury was not bleeding. The humpback whales did not appear to attempt evasive actions or to flee rapidly from the area…"

"As the male killer whales attacked the adult humpback whales, the group consisting of eight killer whale females (or immature males) and the calves surrounded the humpback calf, separating it from the adults by approximately 200 m. The killer

whales, notably the calves, swam quickly around the humpback calf which remained at the surface, shaking and slashing its tail flukes, only submerging for periods of less than one minute.

"The attack…was brief (only 26 min), and the mature male killer whales concentrated their attack on the adult humpback whales, who did not attempt to escape. The killer whale females and the calves were the main participants in attacking the humpback calf." [The whales were all lost in heavy seas and it was not known if the calf was killed].

35. 21 November 1991; False Bay, South Africa; Ford and Reeves (2008). "Single killer whale harassed humpback adult with calf. Presumed mother repeatedly struck sea surface with flukes, and killer whale left."

36. 16 November 1998; near Eden, New South Wales, Australia; Naessig and Lanyon (2004). "At 1030 hours, fishermen in the area reported observing this group of killer whales [7 individuals including 1 adult male, 1 juvenile male, 4 adult females and a calf] attacking a pod of humpback whales consisting of two adults and one calf. These witnesses stated that the killer whales attacked the tail of the calf. At one point, the calf was positioned between the two adult whales. The calf was then observed diving below the surface for an extended period, and resurfacing between the two adults. At one stage the calf dived, but was not seen again." [The calf was apparently killed - chunks of flesh and a section of its lower jaw were subsequently observed in the immediate area].

37. *Ca*. 2000; Fatamanga Island, Tonga; M. Donoghue[5]. "About 10 years ago, I witnessed an attempt by an adult male orca and one presumed mature female to take down a humpback calf accompanied by mother and escort in deep water off the island of Fatamanga, in the Vava'u group of islands, Kingdom of Tonga. I was at the wheel of a 40-foot sailboat under engine, and approached the interaction. When we got within about 70 metres, the adult male orca charged the boat, thought the better of making contact and gave us a very close examination before diving. The putative female also dove. We approached the humpbacks, who took up station about 30 metres off our port quarter. We intended to escort the group to shallower water with a coral backdrop, and we set off at about 4 knots. The calf remained at the surface and each adult took turns to submerge. After about 5 minutes, as I looked back at the whales, the adult on the surface nearest to the vessel changed direction towards the boat, and about 2 seconds later the head of the adult male orca exploded out of the water by the humpback. The orca attempted to grab the pectoral flipper, but missed. He slid down the body and clamped onto the humpback's tail fluke. For two or maybe three thrashings of the tail, the orca hung on, but there was so much power in the humpback's tail that it released its hold and we didn't see the orcas again. The humpbacks stuck with us for the best part of an hour until we separated. I have always assumed that the orca was intending to attack the calf from underneath, and that the adult put itself in harm's way."

[5] Mike Donoghue, Threatened and Migratory Species Adviser, SPREP, Apia, Samoa, pers. comm. 9 Aug 2010.

38. Ca 1998; 3 miles off the NE side of Lehua Rock, Hawaii; C. Bane[6]. 15 May 2011. “a group of orca (maybe 5-6…) that had a group of humpbacks surrounded .... There were a few babies/juveniles in the middle with some large whales with their heads pointed inward/tails out in a circle and on the outside of all this was a few males "patrolling". When we got close the orca dove and the larger whales were acting aggressive towards the boat, approaching the boat blowing bubbles near us, making some heavy breathing sounds from their blow-holes like when you put our lips together and let them flap as you exhale w/ tail and peduncle slaps.” “I'd have to guess there was probably 4-5 babies/juveniles on the inside 5-6 on the surface and the largest adults (don't know if they were male or female, didn't get that close) on the outside patrolling were 4-5. In retrospect I wish I had a camera (digitals just came out then) and I wish I would have hung around longer and taken notes.”

39a-b. 8 Feb 2003; Gerlache Strait, Antarctic Peninsula, Antarctica; M. Jørgensen[7]. “Loose groups of feeding Humpback whales were seen in the distance (approximately 9 individuals in all). The ship was turned to bring us closer, and already from a distance Orcas (dorsal fins) were seen in with the Humpbacks. We approached the scene, and soon found ourselves right before a mother and calf pair of Humpback whales together with approximately 15 Orcas. The other Humpbacks were scattered a little further away. My first impression/thought was, there must be really good feeding here, since the two species of whale are that close together, and with all the birds around too. Then I realized

[6] Chris Bane, 1601 Harmonys Place, Sooke, BC V9Z 0T1 Canada, pers. comm. 15 May 2011.

[7]Morten Jørgensen, Broagergade 1, 3.th., 1672 København V, DK - Denmark, pers. comm. 18 Apr 2003.

that something more was happening. The behaviour of the Humpbacks indicated stress and distress, the female was thrashing about in the water, throwing it's fluke and body back and forth, and both it and the calf were sounding irregularly, seemingly trying to stay only briefly at the surface. The Orcas were on all sides of the Humpbacks, regularly showing very close to the whales. On a couple of occasions it seemed that the female was trying to position herself between the Orcas and the calf. Whenever the Orcas were visible from the surface on one side of the pair, the mother seemed to try to get in between them and her calf. It was my very clear impression that the Orcas were after the calf. As the Humpback whales moved, quite rapidly, from the area (we turned the ship to follow), the Orcas were obviously following them, it looked like a classic chase scene. What then happened was quite interesting too: The mother and calf succeeded in swimming towards and up to a group of three adult Humpback whales. Very quickly, upon the pairs' getting practically in among these three whales, the scene reversed. The direction of the following pod of Orcas changed, they swerved approximately 90 degrees from what had been their following course, and for the next few minutes we could see what clearly looked like the three Humpback whales chasing off the Orcas! The Orcas left the scene completely, all the time with the three Humpbacks behind them, and soon after we turned the ship away and left as well.

"On a least two occasions we saw, floating on the surface, large chunks of skin and blubber. The giant petrels [*Macronectes* sp.] were feeding on this (tugging and pulling), and the storm-petrels [*Oceanicus oceanicus*] were dancing around them. There was no doubt in our minds that we were seeing pieces of skin and blubber that had been

2007 torn off the Humpbacks whale (probably the calf). The largest piece was perhaps 15 by 6
2008 inches, the other piece that I recall a bit smaller."
2009
2010 40. 24 July 2003; Pt. Augusta, Southeast AK; J. Collins[8]. *Ca.* "5 [killer whales] harassed
2011 humpback calf with cow. Cow/calf humpback stayed with feeding group of other
2012 humpbacks (just calf harassed)." "This group of transients put a humpback calf to a very
2013 strong test of strength/will. The calf was with mother humpback and cow/calf were
2014 'acting' like they were doing 'escort duty' to a pod of 6-7 Humpbacks who were actively
2015 bubble net feeding, while traveling south down Chatham Strait." "Killer Whales first
2016 approached humpbacks…Interaction was maybe 20 minutes… Definitely the humpbacks
2017 defended with tail slapping".
2018
2019 41. 21 Oct 2003; Cameroon, West Africa; Weir *et al.* (2010). "video footage provided by
2020 oil industry divers from a platform off Cameroon, showing a group of ten killer whales
2021 harassing a humpback whale and its young calf for over 6.5 hours. The humpbacks swam
2022 within metres of the platform in an apparent evasive attempt, and appeared to perceive
2023 the killer whales as a threat. The adult humpback was observed thrashing its tail through
2024 the water although whether this was directed at the boat containing the divers or at the
2025 killer whales was unclear. The outcome of the interaction is not known."
2026
2027 42. 20 June 2004; Saginaw Channel, near Juneau, AK; V. Deecke unpubl. notes.

[8] Jim Collins, Po Box 211609 Auke Bay AK 99821 USA, pers. comm. 12 Oct 2010.

2028 “transients T065A, T065A2, T086A, T101, T101A, T101B and T102 attacked and
2029 probably killed a Steller sea lion in Saginaw Channel (near the Barlow Pt. light buoy?) at
2030 approximately 11:00hrs. While still milling after the kill and exhibiting surface-active
2031 behaviour, members of the group apparently attacked a nearby humpback whale calf at
2032 around 12:30hrs. The attack apparently included chasing and breaching by the transients,
2033 but the killer whales backed off once the calf's mother approached.”
2034
2035 43. 18 Aug 2005; Tonsupa, Ecuador; J. Denkinger unpubl. notes. “at 10.34h [2 adult
2036 killer whales] swam very fast and straight to a humpback whale group of mother, calf and
2037 escort. [This group] with the calf in the center increased speed in a Northward direction.
2038 At 10.39h both orcas closed up to [the] Humpback group and while Orca male 1 breached
2039 on the calf and Orca 2 tried to push one of the adults away from the calf. Then they took
2040 turns in breaching on the calf and pushing the adults. The humpback whales tried to
2041 maintain the calf in their center and frequently tail-slapped until at 10.44h another
2042 whalewatching boat approached and divided the Orcas from the humpback whales. We
2043 tried to keep them off, but the captain wanted to save the humpback whale calf and
2044 succeeded. The orcas disappeared at 10.50h towards the coast in a south easterly
2045 direction.”
2046
2047 44. 30 August 2005; off Eureka, California; Ford and Reeves (2008). “Four adult
2048 humpbacks grouped tightly around single calf as killer whales circled closely for *ca.* 10
2049 min before departing.”
2050

45. 1 July 2006; Pleasant Island, Icy Strait, AK; S. Anna; Glacier Bay National Park Annual Whale Report 2006. "observers reported seeing a group of approximately 20 killer whales off southwest Pleasant Island and then approximately six adult females and immature killer whales began milling around a humpback whale cow/calf pair. The killer whales leaped over the calf and temporarily separated it from its mother. The mother slashed her flukes and produced wheeze blows when the killer whales were close and her entire body shook when she surfaced. Eventually, the killer whales appeared to lose interest and departed the area, at which time the observers believed that the humpback whale mother and calf reunited."

46. 22 July 2006; Point Adolphus, Icy Strait, AK; J. Williams; Glacier Bay National Park Annual Whale Report 2006. "two male killer whales were seen traveling rapidly approximately 200 meters from Point Adolphus and then approached what appeared to be a humpback whale cow/calf pair. Shore-based observers reported that the "adult humpback began tail lobbing quiet violently for two to three minutes. Shortly after this, it appeared that the humpback was holding the calf out of the water with her head/back for about 30 seconds. The [killer whales] were visible one more time then vanished. The humpback and calf traveled west…and appeared to be swimming and diving normally."

47. 20 July 2007; off Seward, AK; T. Evans[9]. "At first we were just looking at the Humpback Whales before we realized that the killer whales were attacking something. The captain of the boat was very accommodating and allowed us to observe the whales

[9] Thomas Evans, U.S. Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Rd., Anchorage, Alaska 99503 USA, pers. comm. 12 November 2009.

for about an hour. With whales (both species) diving repeatedly and staying under water for varying amount of time, it was difficult to tell what exactly was going on at first. It became evident that there was a calf with the 3 adult humpbacks, two of which looked big and another one almost as big as the other two. There were 7 killer whales in the pod and they took turns diving under the water and seemed intent on taking the calf. The calf would appear periodically on the surface usually with one adult close by. I didn't see any injuries - torn flukes, lacerations in the side, blood from the blow hole, or any other behavioral signs that would indicate obvious signs of injury. The calf, estimated to be 18-20 ft (not quite half of the adult whales), was obviously stressed and had to have longer bouts on the surface before diving again as the attack went on but after about 45 minutes the killer whale pod swam away and the calf seemed ok although there could have been some internal injuries that would manifest themselves later. I know the killer whales often go for the tongue but I am not sure if that is a method of kill or what they eat after they mortally injure other whale species that they prey upon. As we watched this event unfold it was interesting that at first it seemed like there were only 5 killer whales 2 smaller males and 3 females (which were diving repeatedly) for the first 15 minutes or so. Then suddenly a large male surfaced along with another large female. My guess is that these two were harassing the calf or trying to distract the adult humpbacks while the other ones attempted to separate the calf from the adults. I assume the killer whales would either drown and/or mortally injure the calf by tearing up the flippers or flukes or ramming it causing internal damage. The tag team attack by the killer whales seemed somewhat organized and initially I thought they would get the calf as there were more of them and eventually they would wear down the calf and/or the adults. Initially the attack

started further offshore (approx. 0.5 miles) and it seemed to me that it was fortunate for the humpbacks to have ended up at or found the cliff so they only had to defend 3 sides. The humpbacks didn't do any tail slapping or jumps but would surface just long enough to get air and dive again. We didn't see any attacks on the surface thus assume most of the attack was occurring underwater. The killer whales (except for the two that seemed to stay under longer) seemed to come to the surface more frequently to get air than the humpback whales although this was variable during the struggle although it was not possible to tell if the humpbacks got air each time they surfaced (the killer whales did seem to get air each time they surfaced). As far as I could tell there were no injuries to any of the killer whales. There was some fresh blood on the right pectoral fin of one of the adult humpbacks. Without being able to see what was going on under water, a lot of this is my interpretation based on what we could see from the activities on the surface. There were some vocalizations by the calf when it surfaced which sounded like it was in stress (literally fighting for its life) but I didn't take any notes and cannot remember enough to describe the sounds." Also – "I once watched 3 humpback whales defend a calf from a pod of killer whales. The humpbacks backed themselves (or at least that is where they ended up) next to a cliff in Resurrection Bay (Seward, Alaska) and successfully saved the calf. The killer whales gave up after trying for about 45 minutes."

48a-b. 23 Aug 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. 1019 - 6 KWs "attacking MN calf?"; 10:49 – "13 MN swam up to injured calf"; 11:10 – "attack on MN resume, trumpet blows, no sign of blubber or oil"; 1230 – "KW move W, MN stay and

mill"; 12:33 – "2 more MN"; 1244 – "KW make 5+ min dives"; 1249 – "KW spyhop/mill, end?".

49a-b. 28 Feb 2010; Southern Bransfield Strait, Antarctic Peninsula, Antarctica; R. Pitman field notes. "The MENO [humpbacks] were blowing hard and kicking up a bit of a fuss and then we saw some [30-40] ORCA [killer whales] among them – these were small Type B killer whales, including some we saw last week further south. The ORCA were swimming right in among the MENO and seemed to be checking them out – there were some fairly small calves among the MENO. The MENO were bellowing, raising their flukes and flippers in the air and charging around a bit. While we were there for the first 45 min or so, other MENO came into the area [total 10]. The ORCA didn't seem too interested and moved on – the MENO followed along after them but seemed to lose interest and most of the group went their own ways. We continued to stay with the ORCA as they appeared to be foraging among and staying with the MENO – the MENO seemed less concerned all the time. The ORCA, mainly females and calves, seemed to stay with individual MENO and were diving and turning as they dove right among them – they seemed to be foraging and it looked like maybe there were fish associated with the MENO that the ORCA were after. The guess here is that the MENO panicked when the first saw the ORCA and sent out an alarm call that lots of other MENO heard and responded to – mobbing. Once they figured out either these were not the bad ORCA, or at least these were not attacking ORCA, the MENO dispersed and went their separate ways. Must be some kind of fish around here that these guys are after." [small type B killer whales are suspected fish-eaters; Pitman (2011)]

50. 14 Aug 2010; Frederick Sound, AK; J. Katakura unpubl. notes. "When I found the blow and approached the group, humpbacks had already run after the orcas. Humpbacks were 5 individuals including 1 calf. 3 adults were running after the orca considerably positively. Their movement was like mating of the breeding area. 1 adult and 1 calf were swim after their, and have parted somewhere at once [a cow/calf pair were also chasing the killer whales but they departed almost immediately]. Orcas were about 15 individuals including 2 or 3 calves and 4 or 5 males. They hardened like the group, escaped from the humpbacks, and were swimming fast. Both of them surfacing senses were about 3 minutes. Humpbacks chased orcas about 30 minutes. After the chase, humpbacks group and orcas group had parted. The orcas and the humpbacks have surfaced sideward soon about my boat many times. But I was not able to take a lot of photographs because I was scary. And unfortunately, I did not have a video camera. Do you believe this story? I think only that the humpbacks were angry because orcas approached their calf."

Gray whale (*Eschrichtius robustus*)

51. 8 June 2001; Icy Strait, AK; anonymous report to D. Matkin. "4 [killer whales] attack gray whale briefly. Single humpback swam by close, kept going – no interaction."

52. 22 April 2008; Monterey Bay, CA; M. Srinivasan, R. Ternullo, and N. Black unpubl. notes 2 Nov 2009. "At 1611 hours, we started recording behavior and location information at 10-minute intervals. We also took photographs of all animals involved in the activity for later identification.

"We observed approximately 5 killer whales, including an adult male seen earlier in the morning. The killer whales were within 10-15 meters of the gray whale mother/calf pair. The gray whale calf had already sustained attack marks and appeared bruised. Two adult humpback whales were also spotted in the vicinity (~ 100 meters) of the killer whales. Around 1626 hours, a humpback whale was spotted within 10 meters of the gray whale calf with a male killer whale (CA20) surfacing directly in front of the calf, appearing to block its movement. Occasionally, the humpback whale would raise its tail flukes near the killer whale. During this time period, the mother gray whale was nearby (~ 15 m) but not beside the calf. The humpback whale was closest to the gray whale calf at this time.

"At 1635 hours, we observed only the humpback whale surfacing with the gray whale calf (side by side). The humpback whale engaged in lob-tailing and occasionally raised its pectoral flippers or flukes near the killer whales. However, at 1636 hours only killer whales were observed, surfacing frequently at the same location. At 1637 hours, the gray whale calf surfaced alone followed by a 2-3 killer whales (~ 25 meters away), in turn followed by the humpback whale (~25 meters). The calf was alone and was surfacing roughly in 12-15 sec intervals. The killer whales followed the calf closely and engaged in repeated dives with short surface intervals of 2-3 minutes apart.

"At 1642 hours, we observed the mother gray whale and calf surface next to each other; the pair had been separated for 10 minutes, last seen side by side at about 1632 hours. The calf appeared injured with one pectoral flipper bleeding. The killer whales made repeated dives of less than a minute and surfaced directly in front of or beside the gray whales. During this period both mother and calf appeared motionless at the surface

and were positioned on their sides touching each other. The calf was jolted from below by the killer whales at least 3 or 4 times causing it to buckle and rise above the water surface. One killer whale leapt and fell directly over on top the gray whale calf. The male killer whale CA20 was not observed near the gray whales during these actual attacks on the calf. The three adult female killer whales were most involved and worked as a team. There was also no sign of the humpback whale and was last seen at 1640 hours.

"Around 1644 hours, at a depth of 10-15 meters, the gray whales managed to get away from the killer whales and then suddenly dove. After which, we did not detect the gray whales again. We observed no surface blows or behavior to indicate gray whale presence. The humpback whale was also not visible at the surface.

"After the failed attack, the killer whales took off at high speed in the opposite direction, heading west. Perhaps depth was a factor in their decision to give up further attack. Notably, all animals were first observed at a depth of 60 meters. Throughout the attack phase, the gray whales continued to move into the shallows, assuming a straight track towards shallower waters. It is also interesting to note the smaller group size of the attacking killer whales, which could have limited their ability to hunt effectively and quickly?

"As we followed the killer whale pod, we observed a second group of killer whales ahead of our group. Both groups were porpoising and heading west. At 1722, we lost track of both groups of killer whales.

"…humpback whale roles in such predation events may have protective or disruptive functions. Thus, they may either directly harass/confront killer whales

(disruptive) or block killer whale access by staying close to the gray whale calf (protective). The latter maneuver was the preferred option for the humpback whale in the April 22nd interaction described above. However, it will require sustained surface and underwater observations combined with species-specific data to explain the precise nature of this unique multi-species interaction."

53. [undated]; Monterey Bay, CA; L. Beraha[10]. "it did appear to me on various occasions that the humpbacks were coming to the rescue of both sea lions and gray whales. As described in your paper [Pitman and Durban 2009], at first we thought perhaps the killer whales were harassing the humpbacks when we observed increased activity at the surface. However it soon became apparent that the humpbacks were not intimidated by the KW but appeared to be pursuing them. It was also quite uncanny the way one day we had traveled quite a distance to observe a group of killer whales attacking a gray whale mother and calf pair and out of NOWHERE, a humpback whale came trumpeting in followed by another and then another until we had about 5 or more humpbacks in the immediate area. It was strange because during the entire journey with several observers on effort, not a single humpback whale had been observed. It seemed quite clear that the KW/gray whale interaction had attracted the humpbacks, though I cannot say whether it was motivated by curiosity, playfulness or an act of benevolence. The result however was that the gray whale cow/calf pair was able to escape. I also personally observed several sea lions surviving predation attempts as a result of humpbacks whales distracting killer

[10] Lori Beraha, P.O. Box 1554, Santa Cruz, CA 95061 USA, pers. comm. 4 Nov 2009.

whales." [A number of these events are probably described elsewhere in this Appendix but this offers a different observer's point of view.]

54. 3 May 2009; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 10:44 – 15 KWs and "3 + 4 MN"; 11:37 – "confirm ER [gray whale] kill"; 15:41 – "MN move off W".

55. 3 May 2012; Monterey Bay, CA; A. Schulman-Janiger and N. Black unpubl. notes. [When they arrived at 12:35, on the Pt. Sur Clipper, 10 Bigg's killer whales were attacking a gray whale cow/calf pair and 2 humpbacks were initially present. Humpback whale photo-identification images taken during this nearly 7-h encounter indicated that at least 16 different humpbacks were involved; we had encountered three of them earlier, feeding at different locations.] "The gray whale calf was rolling and bleeding; its mother was holding calf up. We saw the gray whale calf take at least 6 breaths within one minute; killer whales were jumping on top of it. We saw the killer whale calf dive right where the gray whale cow/calf pair went down – followed by one humpback whale, which dove in this same location. There was a second humpback whale very close to this action. We heard the humpback whales trumpet blow. (Note: Trumpet blows often occurred throughout this encounter, although the frequency dropped off with time. They occurred much more often than noted specifically here).
1238: The mother gray whale milled around for about seven minutes, making a few dives in the vicinity of her missing calf. A humpback whale surfaced right next to her. A

few killer whales briefly escorted her toward our boat. The gray whale calf disappeared underwater; we did not see it again.

1245: The gray whale mom escaped, swimming under our boat and off towards the shore. There were also two highly agitated humpback whales that had been present during the attack, surfacing as close as one body length from the killer whales. (They may have been trying to intervene in the attack). They were trumpet blowing and thrashing their flukes. A few black-footed albatross circled over the scene.

1248: The two humpbacks followed or chased the killer whales. Within 10 minutes after the kill, three more humpbacks came into the area, joining with the original two; two additional humpbacks later joined them.

1300: A slick appeared on the water. The gray whale calf was dead, but the humpbacks continued to remain in the area where the calf was last seen.

[1300 onward: The killer whales came together as a pod and circled the area where the humpbacks were. They broke up into subgroups. Occasionally they approached the humpbacks - spyhopping and breaching a few times. More often, humpbacks approached the killer whales.]

1306: A SMALL SEA LION lay motionless in the water nearby; it did NOT approach the slick.

1307: One humpback whale did a headstand

1313: Humpbacks thrashed their tails; more humpbacks followed the killer whales.

1316: Humpbacks huddled in a tight group of seven, facing killer whales

1323: A humpback slashed its long pectoral flipper through the water

1324: A humpback whale-fluked and partially rolled (next to another fluking humpback); its fluke matched that of a surface feeding humpback we had encountered this morning (at 1056). This humpback had been at its feeding area 2 hours 28 minutes earlier, 3.6 nautical miles from our current location

1325: The humpbacks followed the killer whales.

1330: A humpback rolled onto its side; one killer whale was VERY close to the humpback, and the humpback's flipper may have made minor contact with the killer whale.

1331: A humpback approached the male killer whale - raising its flukes high up next to at least 3 killer whales.

1332: A humpback whale came up directly behind three killer whales, fluked high, and then tail slashed toward the killer whales. The humpback whale's fluke matched that of a surface feeding humpback that we had encountered earlier this morning (at 1052). This humpback was the last one that we had photographed before turning around to search for killer whales; we received the call about this attack just over an hour later. We were then about 6 miles away from the attack scene; it took us 30 minutes to arrive at the scene. This humpback had been at its feeding area 2 hours 40 minutes earlier - 3.5 nautical miles from our current location – and had left its feeding site and moved to the gray whale attack site.

1338: A humpback turned on its side, thrashing – then turned upside-down. This humpback was missing its left pectoral flipper, and was confirmed through photo-id and biopsy to be a male.

1345: Noticeably more black-footed albatross have moved into the area, along with some gulls.

1346: The male killer whale passed about 25 meters from three humpbacks; the humpbacks rolled onto their sides.

1349: The male and female killer whale passed the humpbacks; one humpback rolled onto its side,

1350: The killer whales moved together in a tight group – including the killer whale cow/calf pair.

1351: The humpbacks moved away from killer whales.

1352: The killer whales surfaced near three humpbacks; the furthest humpback rolled on its side and tail-slashed, the middle humpback logged as it faced the passing killer whales, while the third humpback surfaced WITH the male killer whale – no more than a few meters away from him. As the killer whales milled, the humpbacks turned, tail-slashed, and produced trumpet-blows.

1353: One humpback rolled onto its side, and released a MASSIVE DEFECATION; then it turned upside-down as a killer whale passed perhaps 10 meters away.

1355: The killer whale cow/calf pair surfaced nearby. Other killer whales surfaced near us, as the humpbacks logged outside of the killer whales – facing the opposite direction.

1358: Three humpbacks surfaced together.

1400: Eight killer whales – including the calf – surfaced very close to us. – in the slick. They passed very close to the humpbacks – going in the opposite direction. As the large male killer whale passed them, one humpback tail-thrashed. Humpbacks continued to

fluke and tail-thrash as the killer whales moved away. One humpback rolled onto its side, then turned upside-down. One humpback tilted its chin up.

1402: One humpback fluked near the killer whales and the gray whale calf carcass; this was the same humpback that we had photographed earlier at its feeding site [1332]. This humpback's distinctive fluke bore many healed killer whale tooth scars, acquired during a previous encounter. The single-flippered humpback is seen again.

1411: Killer whales turned and passed by again; four humpbacks huddled close together, rolling, tail-slashing, and trumpet-blowing.

1422: An albatross sat on the slick. One humpback spyhopped; all four humpbacks stayed tight together.

1440: One killer whale did a headstand in the slick (likely feeding on the gray whale calf carcass). Six other killer whales stayed in a tight group – including the calf – at the edge of the slick. The killer whale calf was tucked into the middle of the chorus line. A male and female killer whale traveled together, separated a bit from the main group.

1455: The killer whale subgroup passed close by, followed by humpback whales, including a large, flop-finned female [had been photographed with a calf on previous occasions].

1459: Two humpback whales surfaced and closely approached the male and female killer whales' right sides at a 90 degree angle (the most common humpback whale approach angle), submerging just feet away.

1500: Many birds were circling over the growing slick. Phalaropes gathered (krill-eaters). Killer whales milled in different directions.

1502: Two humpbacks approached the killer whaless' left sides (at 90 degree angle).

1506: The killer whales milled in subgroups – one on the edge of the slick, and one in the slick. The humpbacks stayed tight together between the subgroups. More birds flew in and settled on the slick, while others flew over the slick.

1507: One killer whale breached twice. The slick has grown MUCH larger.

1508: The killer whale calf sub-pod passed close by us, diving into main slick; the humpbacks surfaced and dove in the same area. The killer whales surfaced again and dove in the same area. The male killer whale surfaced and dove. One humpback raised its chin; others arched, tail-slashed, and released trumpet-blows. Sooty shearwaters flew close to the water, inspecting it.

1513: The male and female killer whale pair surfaced very close to us.

1516: One humpback raised its flukes especially high. The humpbacks and killer whales surfaced together – heading in opposite directions – less than 7 meters apart. When the humpbacks surfaced again, they were facing the same direction as the killer whales.

1519: The killer whales milled around the gray whale calf kill. THE HUMPBACKS PRODUCED MANY TRUMPET BLOWS. ABOUT SEVEN HUMPBACKS WERE NOW PRESENT. One humpback appeared to consistently guard the gray whale calf carcass – trumpeting and tail-slashing as one killer whale repeatedly approached it and fed on it. The slick is now over 200 meters across. (Blubber is NOT visible).

1522: The killer whales surfaced near the Sea Wolf II; ~10 albatross sat in the large slick, which has grown to more than 200 meters across; others flew above it. Humpbacks logged at the surface, facing the opposite direction as the killer whales.

1523: There were still about 10 albatross in this area, sitting on the slick or flying fly. A few small sea lions may have been spotted nearby. The killer whale(s) had torn a few pieces of flesh off of the gray whale carcass.

1528-15:40: **A young female killer whale repeatedly dove into the slick, obviously feeding - tearing pieces off of the gray whale calf's carcass. A juvenile killer whale stayed by her side, appearing to also feed. Other killer whales came into the slick (including the killer whale calf), but most of the active feeding appeared to be from these two killer whales.

1538: Three humpbacks approached the killer whales within 30 meters (from a 90 degree angle) then followed them at about 10 meters.

1540: One killer whale turned on its side as it dove; a humpback whale charged up high out of the water at that location, releasing an underwater blow and trumpet blow as it spyhopped/lunged.

1541: Two humpbacks dove, rolled, and closely followed the milling killer whales. Other humpbacks were still in sight near the slick area. Scraps of tissue from the gray whale calf carcass floated up onto the water's surface in the slick above the feeding killer whales. MANY albatross and gulls landed in the slick and picked up scraps of flesh

1545: Two humpback whales logged at the surface as the killer whales moved away.

1553: Two humpbacks suddenly did surface lunge-feeding once - right in front of us. (This was the ONLY time we saw any of the humpbacks in the gray whale calf kill area stop to feed on the very abundant surface krill; there were an estimated 100+ surface feeding humpback whales within five miles of our location).

1559: There were MANY circling birds. One killer whale did a headstand on the gray whale calf's carcass: a large quantity of blood appeared in the water

1600: The killer whales tore loose a HUGE section of the gray whale calf's grooved throat area; it floated on the water's surface. Seven albatross landed and fed on this flesh, squabbling noisily. The killer whale tore a smaller piece off; it floated up to the surface, and five albatross landed on the water and fed on it – joined by killer whales that took this throat section away. 3 humpbacks in area. The slick from the carcass now covers ½ mile of water.

1608: A second slick formed about ¼ mile away. Birds flew over to that spot and stated to circle over it. We spotted an eleventh killer whale, a male not yet seen today: CA217, AKA "CHOPFIN", "STUMPY", "STUBBY".

1615: The slick is still about ½ mile diameter. Three humpbacks milled over the area of the gray whale calf carcass. Our boat was about ¼ mile from the slick. Some birds are flying away from slick.

1617: Some of the killer whales pulled pull more pieces of the gray whale calf's throat to surface, away from the humpbacks. Pieces of the calf's throat floated at the water's surface. (The birds in the area did not fly near the humpbacks).

1624: A humpback whale fluked nearby; its fluke matched that of a surface feeding humpback that we had encountered earlier this morning (at 1017). This humpback had been at its feeding area 6 hours 7 minutes earlier - 4.1 nautical miles from our current location.

1625: The killer whales split into 2 groups, separated by about 1/4 mile: ~6 killer whales were in the first slick (CA45s, CA46s, CA113s); ~5 killer whales in 2nd slick (CA216s, CA217-CHOPFIN).

The humpbacks tail-slashed in the first slick – directed toward the killer whales. The humpbacks exhaled underwater, and followed the male killer whale. The humpbacks were scattered over ½ mile – even further; birds fed in the slick area.

1626: The killer whales dove at the edge of the slick; the blood from the gray whale calf's carcass was visible in front of one killer whale as many birds circled overhead.

1627: Two humpbacks surfaced – trumpet-blowing and tail slashing – right behind the killer whales and the calf's carcass; the humpbacks moved from right to left, perpendicular to the killer whales. The humpback closest to the carcass directed its tail-slashes toward that feeding killer whale – just a meter away.

1632: The gray whale calf carcass surfaced. Three humpbacks were still mixing in with the killer whales. ~10 black-footed albatross and 60 gulls were in the area of the carcass. The killer whales were still in 2 groups: CA45s/CA46s/CA113s - with 3 humpbacks; CA217-Chopfin-CA216s (1/4 mile away).

1642: One killer whale did a headstand on the gray whale calf's carcass. Scraps of tissue surfaced; the albatross fought over them (squawking and lunging).

1649: The same killer whale did another headstand on the gray whale calf's carcass. An extremely grooved section from the gray whale calf's throat came up to the surface, torn loose by the killer whale.

1650 – 1653: The same killer whale did another headstand on carcass: a smaller grooved section from the gray whale calf's throat came up to the surface, torn loose by the killer

whale. The same killer whale did another headstand on the gray whale calf's carcass: she comes up holding a piece of flesh in her mouth. Albatross landed and fed – MANY birds were in this area.

1655: The humpbacks followed the male killer whale closely. The killer whales dove into the slick, feeding. The humpbacks also dove into the slick, near where killer whales submerged (seeming to follow them).

1701: Many birds were sitting on the water. Several humpbacks tail-slashed.

1703: Albatross fed on a floating piece of blubber; the killer whales surfaced, came over to that piece of blubber and also fed.

1713: A humpback laid on its side, as a killer whale surfaced quickly behind (and about 10 meters beyond) its fluke; birds circled over the killer whale. Two humpback whales surfaced and approached a group of killer whales – including Chopfin.

1715: Albatross ate scraps of the gray whale calf's carcass that were floating on the water. Two pairs of humpbacks produced trumpet-blows and tail-slashed, as more scraps of flesh surfaced around them. One humpback turned on its side as flesh scraps continued to surface around it; birds dove right next to it – picking up the scraps.

1718: The humpbacks tail-slashed right next to the killer whales that had just dove underwater in the carcass area.

1721: The killer whales combined into one larger group, feeding in the slick and milling.

1733: The killer whales followed the humpbacks; then the humpbacks followed the killer whales.

1742: The male killer whale Chopfin surfaced ½ mile away from the rest of the killer whales; (we haven't noted his presence for nearly 30 minutes).

1746: Chopfin surfaced by himself; 4-5 other killer whales followed ~100 meters behind him.

1750: Phalaropes were everywhere here, as were heavy patches of surface krill.

1754: Chopfin and the CA216s approached very close to our boat.

1756: Chopfin CLOSE approached our boat by himself; the other killer whales were in 2 groups, ¼ mile away.

1800: A killer whale spyhopped twice and breached once; they may have stopped feeding on the carcass. (Humpbacks possibly interfered with the killer whales feeding).

1805: The larger male killer whale surfaced VERY close to our boat. A sprouter male killer whale close approached the left side of a diving humpback.

1810: The killer whales milled and dove in the slick, with albatross sitting nearby.

1812: A humpback dove into the slick where the killer whales had been feeding.

1816: Chopfin surfaced ¼ mile away from the first sub-pod. (in a slick with no birds present), which was ¼ mile from the other sub-pod of killer whales Humpbacks followed them out. Killer whales were spread over 1/2 mile (three groups of killer whales). Chopfin stopped milling. The killer whales were moving slower now, with few birds over them.

1821: The killer whales were diving longer and spreading out.

1826: Three or four humpbacks surfaced close to us (including the flop-finned female), with the killer whales surfacing further away.

1830: Three to four humpbacks surfaced together.

1831: Most of the killer whales – including the cow/calf pair - surfaced very close to our boat.

1834: Chopfin closely approached our boat.

1837: One killer whale breached twice nearby.

1841: One humpback rolled onto its side.

1842: At least two humpbacks dove right where killer whales had just submerged.

1843: A killer whale and two humpback whales surfaced simultaneously in the same area; the killer whale headed slightly away. One surfacing humpback rolled onto its side after the killer whale submerged.

1845: One killer whale turned onto its side and did a tail-slash!

1848: The larger male killer whale lobtailed and raised his flukes high. The killer whales headed southwest in two groups, 200 meters apart.

1853: The cow/calf killer whales surfaced nearby, right on the edge of the slick.

1856: A humpback whale surfaced and logged, facing three surfacing killer whales that were within 7 meters of it; as the killer whales submerged, the humpback tail-slashed.

1858: A male killer whale did a prolonged headstand nearby.

1859: The same male killer whale dove. A nearby humpback rolled onto its side, then turned upside-down. Two or three other humpbacks surfaced on their sides; all humpbacks rolled tightly together.

1902: The killer whales milled. Two humpbacks followed the killer whales, moving back and forth.

1904: The cow/calf killer whale pair surfaced next to a humpback that was on its side; the humpback did a tail-slash as the cow/calf pair dove right next to it; Another humpback raised its fluke toward a killer whale (that was accompanying the cow/calf pair), and slashed it toward a fourth diving killer whale in that subgroup that was

departing. An albatross sat on the water right next to the humpbacks. Birds dove into the surrounding water.

1906: One humpback lay on the surface near the killer whales, as another humpback fluked right next to it; the fluke waved about and nearly touched the humpback that was at the surface. (The gray whale calf carcass possibly surfaced right between the two humpbacks, abutted against the humpback that was logging at the surface). An albatross sat on the water right next to the humpbacks; a few killer whales circled the humpbacks on the edge of the slick, a short distance away.

1911: The killer whales milled with the humpbacks. Three humpbacks rolled onto their sides in the slick, and tail-slashed near the killer whales – loudly trumpet-blowing. An albatross sat on the slick.

1914: One humpback lay on its side near the killer whales, raising a half-fluke up toward the killer whales. When we left, at 1914, the killer whales were still feeding and socializing; most of the humpbacks were further off but still hanging around, still trumpet blowing - although not as often as before. One humpback was still diving in the area of the gray whale calf carcass as we left.

SUMMARY (1300 onward): The killer whales came together as a pod and circled the area where the humpbacks were. Both species broke up into sub-groups. Occasionally the killer whales approached the humpbacks - spyhopping and breaching a few times. Nearly always, it was the humpbacks that approached the killer whales and followed (and even possibly chased) them. Most of the tail-slashing shown by humpbacks seemed directed to either the killer whale who was actively feeding on the gray whale carcass, or to the larger male; in both types of situations, the humpback whale was especially close to the

killer whale – and often released very loud trumpet-blows. The seven humpbacks initially stayed in a tight group, later sometimes breaking up into subgroups, then returned to tight formation. Sometimes they approached the killer whales, trumpeting and tail-slashing, flipper waving, spyhopping; they often closely followed the killer whales. They repeatedly dove into the slick area where the calf was last seen. Occasionally they surfaced within a few feet of a killer whale. The closest encounters involved a humpback that turned on its side or back; one humpback raised its head up toward a surfacing male killer whale – keeping it up for some time. A few more humpbacks came in toward the end of our encounter." [A BBC film crew was on board and photographed much of this incident.]. J. Mayer[11], captain of SeaWolf, reported: "At 12:00pm I spotted an area of splashing and disturbance in the water. Upon further examination it was clear that there were many animals thrashing about within close range of each other. There was Transient Killer Whales, two Humpback Whales, and cow and calf Gray Whales. The Killer Whales were clearly attacking the Gray Whale calf as the cow tried to fend away the Killer Whales. Within very close distance of the attack was the two Humpback Whales they appeared to follow the attack as the attack was moving about. Often the Humpback Whales would charge up next to the Killer Whales and 'trumpet blow', 'Tail Slash', or rollover on their side. It seemed clear that the behavior of the Humpback Whales was unsettled and aggravated perhaps even aggressive toward the Killer Whale attack. It could easily be interpreted that the Humpback Whales may have been acting instinctively toward the Killer Whales as to protect the Gray Whale calf or disrupting the attack. The

[11] John Mayer, 605 Williams Ave., Seaside, CA 93955 USA, pers. comm. 3 May 2012.

Humpback Whales were relentless in keeping close proximity to the attack the entire time it lasted."

Minke whale (*Balaenoptera acutorostrata*)

56. 27 July 1996; near Glacier Bay, AK; Andy Spear and D. Matkin; Ford *et al.* (2005). "a group of 13 transient killer whales in close high-speed pursuit of an adult-sized minke whale. As the transients and minke drew near to the boat, the minke slowed and approached closely alongside the boat as if it was attempting to hide from the attacking whales. At this point, the transients caught up to the minke, and the adult male T63 began ramming it repeatedly from beneath. Individual transients positioned themselves in front of the minke to block its forward path and prevent it from diving. On two occasions, a humpback whale approached to within 50 m of the scene of the attack. Each time, T63 left the minke and rammed the side of the humpback several times. The humpback responded by rolling over and thrashing its tail flukes towards the killer whale, which then returned to the minke attack." D. Matkin: "the minke died and sank to the bottom. The killer whales stayed in the area for a couple hours afterwards, diving and feeding on the carcass. The minke bloated and surfaced belly-up three days later."

Dall's porpoise (*Phocoenoides dalli*)

57. 14 Sept 2008; Monterey Bay, CA; anonymous report to R. Ternullo. 2 transient killer whales "chasing murres [*Uria* sp.] and auklets [*Ptychoramphus aleutica*]; 2 PD [Dall's porpoise] flee 0.5 km ahead; [KW] chasing PD [for 8 min]; escape; 1 MN [humpback] follows...trumpet blowing."

Steller sea lion (*Eumetopias jubatus*)

58a-c. August 1983; Frederick Sound, AK; D'Vincent *et al.* (1989). "A juvenile humpback swam directly through an area where killers were attacking a bull Steller sea lion. The sea lion was badly wounded, with large bleeding gashes from the killer whale's teeth. The killers appeared to be more interested in tormenting the sea lion than in actually eating it, for they were tossing the 1200-pound bull around as if it were a ball, and only occasionally taking a chunk out of it. At this point, a juvenile humpback appeared, and foolishly approached close enough to distract the killers from the sea lion. Immediately they closed in on the humpback, charging toward it with tremendous speed, veering off, then charging in once again. Next, two adult humpbacks [cow and escort?] swam in to join the juvenile; they flanked it on both sides and defended it by slashing their flukes at the killer whales. The humpbacks also rolled over, so that their stomachs were above the water, perhaps to protect that delicate region from attack. They also lifted their flukes and chins out of the water simultaneously, possibly because the flukes, tongue and lips are reputably favored by the killer whales. This is a posture which we have also seen assumed by other humpbacks when in the presence of killer whales. Throughout the attack, we had a hydrophone in the water and recorded some humpback vocalizations and a great many killer whale sounds. One noteworthy sound was a very loud crash that we heard repeatedly. We believe that this occurred when a killer whale made contact with a humpback underwater, but we were unable to determine this conclusively. Eventually the killer whales divided up so that the bulls patrolled around the attack, while the females and young moved in to strike. When striking, a killer would

leap into the air and come down on the whale, thrashing its tail violently, much as a shark does when tearing flesh. We did not at any time see blood or wounds on the humpbacks, yet there is no question that the killers repeatedly made contact." [The "juvenile" humpback described here may have been the calf of one of the adults]

59. 13 August 1983; Frederick Sound, AK; Dolphin (1987). [What follows are two accounts independently written by witnesses to the same event but on different boats.] "at 1225 h a pod of six Killer Whales (three adult females, one subadult male, one unsexed juvenile, and one calf) were observed harassing a single medium-sized Steller Sea Lion (*Eumatopias jubatus*), charging the animal singly or in groups of twos and threes. The sea lion was, on a number of occasions, struck by the tail of a Killer whale with force sufficient to throw it several meters across the water surface (see Figure 1). We were initially attracted to the scene by splashing visible at a distance greater than 3.5 km.

"At 1445 h a pair of 13-14 m Humpback Whales were observed approaching from approximately 1.8 km, and were within 50 m of the Killer Whales and sea lion at 1455 h. The humpbacks moved directly into the midst of the commotion where they then separated. The humpbacks were obviously very excited, as were the Killer Whales, all swimming rapidly at the surface on their sides, striking the flippers against the water surface, lobtailing, and lashing their flukes horizontally. Respiration rates of the humpbacks were significantly increased over the usual pattern and loud in-air vocalizations ("wheezes" and "trumpets") were emitted from their blowholes. Frequently the Humpback and Killer whales were in close proximity if not in actual physical contact.

"They were joined at 1526 by a small (10-11 m) single Humpback Whale; two additional singles and a pair joined within the next 40 minutes. At 1619 h (1 h 24 min after joining with the Killer Whales) three of the humpbacks moved off and apparently began to feed at a depth of 40-60 m, based on Sonar and ventil[at]ion patterns. Three other humpbacks moved off individually shortly thereafter. At approximately 1630 h a cow and calf humpback joined the Killer Whales, remaining in their midst for 1 h 45 min, until 1745 h. During this period there were three humpbacks with the Killer Whales: the cow and calf, and a small single who joined at 1526 and remained during the entire observation. The sea lion was no longer visible.

"We stayed with two of the three humpbacks which had left at 1619 h for 2 h and 09 min, until 1928 h, always within sight of the Killer Whales who continued to produce occasional bursts of activity and associated splashing. At 1930 h we reapproached the Killer Whales; there were now five Humpback Whales within 0.1 km with still no sign of the sea lion. At no time was there any indication of feeding by a humpback in the immediate vicinity of the Killer Whales. We left the area at 1945 h.

B. Mathews unpubl. notes, 13 Aug 1983: "At 15:17 we arrived in the area just off Gambier Island where "Hval Fisken" had reported that killer whales were 'working over' a sea lion. There were 5 orca in the group – 4 adults plus one calf. From the dorsals and composition of the pod it was obvious that this was the same pod that we'd observed circling Round Rock on July 30. 'Hval Fisken' …was still in the area. Three humpbacks… had joined the group by the time we arrived. What we observed follows: (also my 'impressions' about the incident). 15:17: A juvenile male Steller sea lion was floating and bobbing with its hind flippers up and limp. At first it appeared to be dead,

but later we did see movements which indicated that it was still alive, or at least responding in a manner which indicated that it was not yet physiologically dead. It seemed to stay inverted too long without breathing to be alive, but since I didn't record every apparent breath (deduced from head raising movement …) no quantification of this subjective perception is possible. Dan [McSweeney] dropped the hydrophone to record the sounds at 15:19. We could hear the sounds even through his headphones as he indicated that multitude of sounds were being produced. Mainly there were sounds from the killer whales, but the humpbacks were definitely producing a variety of sounds as the animals surfaced and dove around the sea lion. Some of the recorded noises may have come from the HBs or KWs.

"The killer whales were leaping over and into the bobbing sea lion. Several times two of the KWs would race up to the SL and breach into the body one after the other. Full head over fluke breaches were seen. During these aerial displays there was no indication that the O. orca were grasping or attempting to bite at the Steller's SL. In between some of the aerial bouts the sea lion would either disappear, or appear to be dragged along from below. When it did disappear, it would reappear in a different location. – Dan noted this movement which must have been caused by the killer whales dragging the animal beneath the surface. Most of the breaching was by the adults (or juv), although the KW calf was right in there with them.

"When we arrived at 15:17 we could see the 3 humpbacks surfacing in close, +parallel formation and about 50 ft from the seal lion. By this time the entrails were extruding from the inguinal region of the sea lion. A 4th HB came and joined the group at 15:42 [whale #4]. This whale …was one we'd identified earlier… [and] must have

moved about 3-4 miles between 14:58 and 15:42. [#4] came in close to the sea lion and killer whales and at 15:42 rolled over so that we could see its ventral surface. It was approximately 80-100 ft from the sea lion. The killer whales were surfacing close by. The HB rolled rather slowly on its side again and did not appear to have any forward or lateral motion. At 15:48 it repeated this slow roll, again close to (*ca*. 50 ft) the sea lion. After this 2nd roll it arched its head up and held it out of the water for almost a ½ minute. The throat pleats did not appear to be extended, but I can't say for sure whether they were or weren't. In any event, the movement did not resemble the vertical or angled forward closes of the mouth that I've seen when whales surface creating a bubble net (BN) or during other episodes where feeding is likely. Mainly the motions were slower and then held longer than similar feeding activities. After raising its rostrum in this manner, [#4] did a slow shallow sink/dive, without tipping flukes (they were parallel to the water surface so the underside was never shown).

"During the time that [#4] was rolling and finally sank, the killer whales were spread out with 3 appearing close to, or surfacing rapidly and crashing into the sea lion. Around 16:04 2 humpbacks not including [#4] surfaced together in tight formation and were heading back toward the sea lion. At 16:09 one of the killer whales…breached 2 times in a row – this time not onto the sea lion but about 25 ft from it. Then two other killer whales (possibly including the original breacher) breached in near synchrony… Soon after, all 5 KWs surfaced near one another. The breaches seemed to be in response to the approaching HBs since all previous aerial displays were directed onto or close to the sea lion.

16:10 – a different HB fluking, heading toward the area.

16:11 -…the humpbacks have gone down again and are again oriented toward the sea lion.

16:13 - … HB surfaced. At 16:16 HB [#4] rolled slowly over onto its side – similar to the rolling earlier, but this time only onto it side. The left [pectoral flipper] was visible and remained limp and motionless – unlike the active rolling and [pectoral fin] slapping that we often see in other contexts. At 16:30 the same whales surfaced near and directly toward the sea lion. On the next surfacing it was right over the spot where the sea lion was and it rolled slowly on its side, again with the [pectoral fin] draped at the surface. It appeared that the whale's [pectoral fin] was carried over the sea lion in a very slow movement. Because the sea lion disappeared from sight it is impossible to say where it was when the humpback passed over. The impression that I had though, was that there was either contact or close contact. The HB then continued on in the same direction and the sea lion did not return to the surface in the same spot. Instead it was a few minutes later that Dan noticed that the killer whales were at the surface about 100 ft from the previous location of the SL and that the sea lion was now with them.

"At 16:36 the KWs were still making close passes and leaps near or onto the sea lion. Once again, the sea lion's head came to the surface as [before]. Perhaps the animal's head was pushed up from below by one of the killer whales – making it appear that the sea lion had lifted its head. Because the sea lion had been bobbing upside down and abused for such a long time (at least 4 hours – "Hval Fisken' had arrived at 12:45 and the harassment had already begun), I find it hard to believe that it could still have been alive at this time.

16:39 – blows from another HB from the south heard.

16:43 – Killer whales still passing close, but fewer aerial displays.

16:43 – HB surfaces near S. lion again (I believe this was whale [#4] still – there were 2 others in the area also). At 16:47 2 new HBs surfaced heading away from the SL and just after they dove Dan noted that the KWs were echolocating – apparently in response to the diving whales. As it turned out, this was a cow and calf. We weren't absolutely sure, but from the dorsal sketches, it looked like [a pair] that we'd just seen east of this area about 3-4 miles and about 2 hours earlier. The cow and calf first surfaced quite close to the killer whales and we could not detect any response other than the increased echolocating that Dan had noted upon their arrival. That is, the killer whales did not move toward the cow and calf from what we could tell on the surface. The calf surfaced alone shortly after 16:47. At 16:48 the cow surfaced heading now toward the killer whales and sea lion, and about 180° from her first surfacing. On the next surfacing the calf (alone again at the surface) was also re-oriented toward the KW/SL group. At 16:55 the cow and calf surfaced together and still moving toward the killer whales. The calf surfaced at 16:57 alone. By 17:02 both cow and calf surfaced together heading NE – away from the KW/SL area…The cow and calf continued off away from the commotion after being in the area just 15 minutes.

"Around 17:30 we left the area to I.D. humpbacks…At 18:30 we returned to the scene where we found the killer whales and 2 humpbacks, but no sign of the sea lion or remains. Dan listened for sounds and recorded intermittently…The humpbacks and killer whales surfaced close together. At first I didn't see the calf in any of the three surfacings. It did appear on the 4th surfacing which was very close to our boat. The killer whales had come closer to our boat, moving away from the humpbacks. At 18:39 they circled the

boat (more or less) and at 18:40 on the HBs surfaced with a killer whale just 10-15 ft away from it. The HB did a moderate tail lash as it arched and lunged forward. At the distance I couldn't tell for sure but the lash did seem to be directed toward the area where the KW had most recently surfaced.

18:42 – Blows from a different humpback to the east. The whale closest to us and with the killer whales now surfaced on its side rapidly and was turning to the right. It seemed that the humpback was now following, or at least surfacing behind, the killer whales for 3 or 4 surfacings as they all headed south. Two new, or rejoining humpbacks surfaced near the group at 18:59 – blowing forcefully."

60. 12 September 1988; Point Adolphus, Icy Strait, AK; J. Straley[12]. [text in parenthesis was added by JS at a later date for clarification]. "As I approached Pt. Adolphus at ~0930 I observed breaching and 'commotion' off the Pt. I found 4 killer whales (a male KW and 3 females/ juveniles), 1 wounded (Steller) sea lion and MD (humpback whale - #157 nicknamed MD, a male, who is typically solitary) in the tide rip. The sea lion was still alive waving a flipper but floating with visible wounds (I remember seeing intestines extruding from the body). I did not get close to the sea lion, because all whales were circling with the smaller killer whale breaching and tail slashing on top of the sea lion. All whales including MD were circling and appeared to guard the sea lion. I left to observe other (humpback groups) and returned ~30 min later. Same activity but (whales were) further east (drifted with current). MD seemed even more 'protective' of sea lion, mixing right in (with the killer whales). Maybe schooling fish were under the sea lion

[12] Jan Straley, University of Alaska Southeast, 1332 Seward Ave., Sitka, AK 99835 USA, pers. comm. 12 Jan 2010.

but all whales seemed to have the sea lion as their object of attention. I departed at 1035 (to approach other groups of whales in the area and the humpback and killer whales were still drifting east)".

61. 29 August 1999, Icy Strait, AK; D. Matkin *et al.* (2007). "The longest close interaction of humpback and killer whales in Icy Strait occurred during a [Steller] sea lion kill by six transients. For 50 minutes, three [later determined from video to be 4] adult humpbacks participated by lobtailing on or near the sea lion 15 times, making physical contact with it a minimum of 10 times. The transients did not attack the humpbacks, and the humpbacks left the area together." Also, D. Matkin[13]: "It is fascinating, as it was one of the cases when the humpbacks lobtailed slowly on the dying [Steller] sea lion, and one humpback actually reach over and touched it with its pectoral flipper. They did this at times that the killer whales had temporarily moved off a ways. When the killer whales returned and vigorously lobtailed repeatedly on the sea lion, the humpbacks exhaled loudly and slashed their flukes from side-to-side as they [the killer whales] moved away." [Humpbacks later identified as "adult male #221 (age unknown), adult male #352 (born 1984; age 15) and two unidentified humpback whales presumed to be adults based on body size" – CMG. [This account is from video footage taken by C. Kellogg from a commercial whalewatching boat. A subsequent review of the footage by CMG and JN found only a single incidence of a humpback making contact with the sea lion with its fluke. Another review by RLP and JWD found no convincing evidence that the

[13] Craig Matkin, North Gulf Oceanic Society, 3430 Main Street, Suite B1, Homer, AK 99603 USA, pers. comm. 26 Feb 2010.

humpbacks made contact with the sea lion, but were in fact directing their tail slaps at the killer whales; see main text]

62. 22 September 2003; Icy Strait, AK; C. Gabriele; Glacier Bay National Park Annual Whale Report 2003. "we observed two adult male humpbacks (#157 and #118) interact closely with a group of four killer whales (*Orcinus orca*) that were attacking a Steller sea lion (*Eumetopias jubatus*) in Icy Strait. The killer whales hit, leapt over and generally harassed the sea lion while it remained passive and stationary at the surface. The two humpbacks, which had been separate just prior to the start of the killer whale attack, joined together and stayed very close to the sea lion, especially when the killer whales were charging at or leaping over the sea lion. The humpbacks appeared agitated – wheeze-blowing, laterally swishing their tails and rolling on their sides near the sea lion – and stayed at the surface most of the time. Due to daylight limitations we had to leave before this multi-species interaction ended."

63. 27 May 2004; off Olympic Peninsula, Washington; E. Bowlby[14]. "During one of our NOAA Ship *McArthur II* surveys in OCNMS we encountered a pod of [*ca.* 8] transients toying with an adult Steller sea lion. We stopped to film it (an hour of video), in which the young orcas were apparently given the freedom to make periodic rushes at the obviously stressed and partially immobilized sea lion. But during this hour, the adult orcas, especially one bull, kept [*ca.* 3] humpback whales corralled in a larger perimeter while the sea lion was being harassed. After the sea lion was eaten and just before the

[14] Ed Bowlby, 133 Fencebird Lane, Sequim, WA 98382 USA, pers. comm. 2 Nov 2009

ship had to resume our survey trackline, the orcas began to attack the whales. I wish we had the time to linger to see the conclusion but we had to leave."

64. 6 July 2006; Frederick Sound, AK; T. van Wyck[15]. "I witnessed a humpback interacting with a pod of 6 transients attacking a stellar sea lion. I was very curious about what was going on, as I had never seen this behavior (but witnessed several transient kills with humpbacks nearby in the area) off of southwestern Vancouver Island. In Frederick Sound, Alaska, though, the humpback was slapping the water with its pectoral fin right by the sea lion, and lobtailing quite a bit as well. When we arrived on scene, I thought at first the orcas were attacking the humpback, but the sea lion managed to get away and shelter under our boat.

"By that time the humpback left the area, and the 6 transients were left circling our vessel, with the Stellar sheltering between the two zodiacs towed at the stern of the vessel. It was quite an unusual situation!

"When we arrived in 2006 on the 70 foot sailing yacht in Frederick Sound, the humpbacks, stellar and orcas where already mixed up. As experienced whale watchers, the captain and I thought that the orcas were harassing or attacking the lone humpback. Transient kills are of course fascinating and riveting and a good example of "nature, red in tooth and claw", so we stood about 150 m off, and got ready for an amazing experience. However, as we began to look closer, we noticed the humpback thrashing around (as I said before, pectoral fin slapping and slashing, and tail lobbing).

"It definitely looked like the humpback was slashing, with its pectoral fins, at the

[15] Thomas van Wyck, Box 1115, 601 Gibson St, Tofino BC, 0R 2Z0 Canada, pers. comm. 4 Nov 2009.

sea lion. We were astonished and thought at the time that the humpback was participating in the kill. I remember noticing that the pectoral fin slashes were "late", a few beats behind as the Stellar swam on the surface alongside the humpback, with orcas following.

"It's quite possible that the humpback was actually slashing at the orcas following the sea lion. Perhaps the animal wasn't late with its slashes, it might have been right on time!

"I can't say much more definitive than that, I wish I had some pictures but as the mate, I was running the deck at the time. But I have a clear memory of at least 3 humpback pectoral fin slashes, I remember the sea lion getting "air" at least once from an attack coming up below the surface and the sea lion porpoising towards the two trailing dinghies and parking itself right there. I can also say that I don't recall any vocalizations in the air, and missed the hydrophone because the action was pretty fast and furious."

65. 31 August 2007; Point Adolphus, Icy Strait, AK; D. Matkin and J. Neilson; Glacier Bay National Park Annual Whale Report 2007. "On August 31 we observed a group of four transient killer whales attacking a Steller sea lion (*Eumetopias jubatus*) near Point Adolphus in Icy Strait. Several hours later, near the end of the kill, two humpback whales approached the kill site wheeze blowing and tail slashing at the remains of the dead sea lion. Based on dorsal fin photographs taken by killer whale researcher Dena Matkin, we identified the humpback whales as adult male #166 and whale #1907 (age class and sex unknown)." [#1907 was later identified as an adult female based on 2008 sighting with calf].

66. 14 Oct 2008; Swiftsure Bank, off Southern Vancouver Island, British Columbia; B. Gisborne and V. B. Deecke unpubl. notes 20 Dec. 2009. “We encountered this group [of 10 transient killer whales] as they were attacking a large juvenile or adult female Steller sea lion. It is not sure how long the attack had been going on, but the sea lion was still alive for the first 45 min of the encounter. At some point during the encounter, a second sea lion joined the one being attacked resting close next to it for about 10 min. There had been several humpbacks in the general area when we first encountered the whales. Several humpbacks approached the killer whales closely at about 11:00 hrs and between 4 and 7 humpbacks remained around the killer whales until the killer whales moved away at about 12:00 hrs, long after the Steller sea lion was dead. Killer whales and humpbacks were often within a body length of each other and in general it was the humpbacks following the movements of the killer whales rather than vice versa. We did not observe any physical contact between humpbacks and killer whales or between humpbacks and the prey in this encounter. The humpbacks trumpeted frequently. We recorded underwater sound from 10:59 to 11:30. There was almost constant vocal behaviour from humpbacks and killer whales with vocalizations from both species often overlapping. There were also many prey handling sounds presumably generated by the killer whales breaking up the sea lion carcass.”

67. 21 Aug 2010; west coast of Vancouver Island, British Columbia, Canada; Rod Palm pers. comm. 10 Bigg’s killer whales attacking a Steller sea lion were approached by a single humpback; interaction lasted at least 39 min; sea lion “very likely” killed.

68. 11 Aug 2011; Clayoquot Sound, British Columbia, Canada; R. Palm pers. comm. "Randy Frank (whale watch driver/interpreter) was watching Ted's gang (T041 [Bigg's killer whales]) in the company of two other gangs (16 animals in all) in the process of making a sea lion kill when in comes a Humpy trying to position itself between the [Steller sea] lion and the Killer Whales. He was making a big fuss with tail and pectoral thrashing. Sad, for the lion, this apparent rescue attempt was unsuccessful as the Killer Whales eventually enjoyed their meal. This behaviour has been observed on many occasions throughout the Pacific Northwest and is very curious in that Humpys are, on occasion, targets for the Kawkawin [killer whales]."

69. 31 August 2012; Icy Strait, AK; C. Gabriele and R. Gordon unpubl. notes. "Interpretation Ranger Rebecca Gordon and I were on the Sand Lance in Icy Strait, doing a humpback whale photo-ID survey. Viewing conditions were good, with flat seas and sunshine. We had spent an hour with a widely dispersed pod of resident-type killer whales and were just beginning to approach the numerous humpbacks about ¾ mile offshore, west of Point Adolphus. Around 10:50 AM, while we were photographing two single humpbacks, one of them, adult male #117, was wheezing for no apparent reason as he swam West. Rebecca noticed a sea lion leaping, and some killer whales (KWs) about ½ mile further West of us, in the opposite direction from where the resident KWs had been. At 11:06 we approached them and found a mother, calf and adult KW circling and diving in one area (*i.e.* typical postkill milling behavior) and two agitated adult humpback whales (HWs #1306 and #2315, both adults of unknown sex) wheezing and closely following the KWs. The KW group included transient-type KW #T086A and others.

No sea lion was sighted, but we presume that it had been killed and was being eaten by the KWs underwater.

"The KWs were diving for 2 to 4 minutes, closely followed by the HWs, who dove and surfaced with the KWs. The KWs would surface for about 1 minute, seeming to travel in a West to East line at the surface, then dive. While at the surface, the HWs would wheeze and roll at the surface, doing pectoral fin extensions and tail swishes. We did not see the HWs come into physical contact with the KWs at the surface. The KWs exhibited no signs of visible distress and did not hasten to leave the area. Subjectively, it looked like the HWs were harassing the KWs but not successfully driving them away. However, there was a net westward movement of the group over the 30 minute encounter. It is not clear whether this is explained by tidal currents or if the KWs were purposely moving. The TIDES program predicts that there was a 3.2 knot flood tidal current, which would seem to have pushed a passively drifting group East rather than West, so perhaps the movement is best explained by active swimming.

"At 11:30, we found and photographed a floating glob of blubber and muscle with short hairs mixed in that was being scavenged by gulls, which are consistent with a sea lion kill. The killer whales were about 250 m away at the time, and we were alerted by black-legged kittiwakes and glaucous-winged gulls (GWGU) that were looking for scraps. After we photographed the sample (later sent to NOAA Southwest Fisheries Science Center to confirm species), we collected a small sample and put it back in the water. Not long afterward, a juvenile GWGU landed near it, vocalized and then gulped down the impressively large glob in one mouthful (photos) and flew away. At 1135 we left the group to continue our work with the humpbacks.

"While we were with the KWs, there were many nearby HWs within ½ mile of the scene, and none were observed to join. However, at 12:04 when the KWs were about ½ mile West of us, we were approaching a group of 4 HWs (Pod 4a = #1088-female, #1474-male, #1244-male, #1904-unknown and #351-male) for photography when the two HWs that had been with the KWs (#2315 and #1306) were suddenly with the group. There was a lot of wheezing and interaction among the humpbacks. We tried to stay with the group (Pod 4B containing all 5 whales) assuming they would maintain their previous behavior pattern (milling and feeding) but on their next surfacing, the entire group had sprinted West to where it appeared the larger group had resumed harassing the KWs. Wheezing could be heard and commotion was seen at the sea surface from a distance. We did not re-approach the KWs to confirm this impression we had from a distance. Subjectively, it appeared that the pair of HWs who were initially with the KWs came and rounded up extra help and rejoined the KWs.

"We continued to photograph HWs in the area, and found many of these individuals in a large shoal of whales East of Point Adolphus by 13:00. We had left the area where the KWs were last seen, so we did not have any further sightings of them." [humpback #1306 was later genetically identified as a male; the prey sample was genetically identified as Steller sea lion].

70. 10 Oct 2012; Icy Strait, AK; C. Gabriele unpubl. notes. "I was on the National Park Service research vessel *Sand Lance* in Icy Strait, southeastern Alaska doing a humpback whale photo-ID survey in good viewing conditions with flat seas and partly cloudy skies.

There were probably 30-50 humpbacks (HW) within 2 miles of the Sand Lance as I sat about 500 m from the nearest whales and made audio recordings to see if I could pick up a singer, from 13:25-13:54. There were many HW vocalizations heard, but no killer whale (KW) vocalizations. While I was drifting to record, several humpbacks that had been in a few large groups to the west of me paraded eastward by the Sand Lance one or two at a time starting at 13:35. This is not that unusual, as HWs do relocate as tidal conditions and prey availability (apparently) change, but it is possible that the HWs were moving because of the KWs. At 13:45, still drifting, I saw four killer whales also traveling east right toward and under the boat. I heard no KW vocalizations or echolocation clicks although the KWs came directly toward the hydrophone and bumped or vocalized on it as they swam by (elapsed time 5:20 on the recording). At 13:59, after I finished recording, I got underway and approached the KWs for photo-ID (transient #T124A1, a medium-sized calf and two other adult sized animals); they were traveling eastward at about 4 knots with 6 minute dive times and had no visible interaction with the many HWs feeding in the area. The KWs passed within 100 m of several HWs with no sign of interaction.

"At 15:00, I resumed approaching HWs because there were several to the east of me that I had not yet photographed. At 15:19, I approached a group of three HWs (Pod 16: 58.29108 N, 135.77777 W) that I had seen east of Point Adolphus for the past hour. When I approached them, they immediately began wheezing, and I was unsure if it was a sign of disturbance from my approach. However, on their next surfacing they joined the KWs, which had slowed greatly and were loitering in the area. I did not see any marine mammals nearby. There was a lot of wheezing from the HWs although I had seen no sign

that the KWs had made a kill (I was more than 200 m from the KWs and no longer watching them since 14:34). The KWs breached a few times and tail slapped.

"At 15:28, I began to record with the hydrophone, but the recorder stopped recording 2 seconds later (!) so there were no recordings until 15:35 when I repositioned the boat because the combined group continued to travel southeastward. Many KW vocalizations were evident, and the HW wheezing was audible. There may be a few quiet HW growls, squeaks and clucks on the recording. No distant HW sounds were heard – the background ambient was quiet.

"At 15:45, I stopped underwater sound recording to approach the HWs for ID and got dorsal fin and partial fluke photos of #1813 (age and sex unknown; first sighted 2004, described as small to medium in size in 2004-2006), #2316 (age and sex unknown; first sighted 2009 and described as small in size) and #1832 (adult female). The HWs stayed close together and close to the KWs while all were at the surface. The HWs did many peduncle lifts, lateral tail swishes, tail throws and tail extensions near or at the KWs, but no physical contact was observed. All whales dove underwater for approximately 3 minute dive times. The KWs seemed to head toward the HWs at the surface (or maybe the HWs were directly over the unseen submerged carcass and the KWs were simply coming back toward it to keep feeding).

"At 15:50, the presence of Glaucous-winged gulls alerted me to prey remains in the water near the boat. I collected a small fragment of blubber from the water (later sent to NOAA Southwest Fisheries Science Center to determine species), and the gulls quickly ate the other scraps (see photos). The sample was blubber only, and smelled like other cetacean samples I have observed, so likely came from a harbor porpoise. I saw no

sign that the (presumed) porpoise was alive during any part of the interaction between the KWs and the HWs.

"At 16:02, I concluded my observation and left the area to return back to Bartlett Cove due to the late hour. At last observation, the HW and KW whales were continuing to interact and travel southeastward." [Prey sample was genetically identified as Steller sea lion.]

California sea lion (*Zalophus californianus*)

71. 17 Nov 2000; Monterey Bay, CA; A. Schulman-Janiger unpubl. notes. Sighting from 1300-1442 (102 min); "5 [humpbacks] (3 + 2) near [3 transient] KW (NO REACTION); 3 [humpbacks], lots of [California sea lions] VERY close; [KW] breached on [sea lions]: hundreds flee, porpoising… *ca.* 30 [sea lions] headed directly toward KW, who breached on some of them. These appeared to be juvenile [sea lions]; these [killer whales] killed and ate at least one [sea lion]. NO REACTION from the nearby [humpbacks]. "

72. 15 August 2006; Monterey Bay, CA; A. Schulman-Janiger unpubl. notes. Sighting from 1125-1205; "As we were approaching the [killer] whales, I saw a pair of surface-active humpbacks very close to them; at 1123, one humpback whale breached one time, and the other did at least one tail slash." "We arrived at the sighting at 1125, and saw that the [6 transient] killer whales were with porpoising [California] sea lions, VERY close to these two humpbacks. I did not see any active behaviors from these humpback whales once we arrived - just slow surfacing. There did not appear to be a sea lion kill." "At 1132-1134 [the killer whales] milled and closely passed another pair of 2 [humpbacks] in

the area. At 1137 they passed another pair of [humpbacks] ; at 1142 they CLOSELY passed 2 thermoregulating [California sea lions]. At 1145 the [KWs] split up (4+2) (3 + 3)". The KW pair stayed very close to us, while the subpod of 4 (a matriarch and her 3 juveniles) headed over to the nearby whalewatch boat and one group "very closely approached [humpbacks]; NO REACTIONS from several groups of [humpbacks], including a pair and a single whale (2 + 1: slow surfacing, swimming, slow fluking – no trumpet blows). At the same time, *ca.* 50 sea lions went porpoising past us: a few sea lions approached our boat and stopped, pressed against the boat…seemingly 'trying to hide' against our boat. At 1149 our [KW] pair closely passed one sea lion, at 1152 closely passed 8 more sea lions. At 1158 the group of four [KWS] approached us again, at 1159 they passed 2 single humpbacks – including one that was VERY close to the killer whales – NO REACTION. At 1200 one of our earlier humpback pairs (from 1137) fluked near the killer whales – NO REACTION. WE DID NOT OBSERVE ANY SEA LION KILLS. passed 50 [sea lions], 2 + 1 [humpbacks]; pass 1 [sea lion], pass 8 [sea lions]; passed 1 + 1 [humpbacks]; 1 humpback – very close to killer whales – NO REACTION; end of sighting". A. Schulman-Janiger: "There VERY LIKELY WAS INTERFERENCE on the part of the humpback whales in this sighting. There were 2 humpback whales with the killer whales and the sea lions – there was a lot of splashing and thrashing before we arrived at this sighting, and we witnessed some of that surface activity by the humpbacks."

73. 14 May 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 09:52 – 7 KWs "attack adult CSL"; 10:11 – "CSL dead"; 10:30 – "6 more KW 2km NW"; 10:44 – "2 + 2 + 2 MN in area"; 11:37 – "2 + 6 MN".

74. 12 August 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 3 "transients: predation on [California] sea lion: humpbacks (3 – including [a cow with a calf]) interacted with KW." [see #25,75]

75. 12 August 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. Sighting from 1018-1207 h; 3 transient killer whales "kill [California sea lion], not much pounding [with flukes]; 2 [humpbacks] involved, curious?" [same killer whale group as #74, but different event; see also #25]

76. 13 August 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. 5 transient killer whales "killed [California] sea lion; humpbacks trumpeting, interfering with [killer whales] and [sea lion] carcass."

77. 13 Sept 2008; Monterey Bay, CA; S. Johnston[16]. 8 transient killer whales "charged 3 young CA sea lions; 2 humpbacks came fr/2 miles away, surfaced in middle, swatting KW w/ their flukes!" Also: "Watched 6 transients in Monterey Bay have some odd interactions with 3 young California Sea Lions and 2 huge Humpback Whales! The sea lions seemed to be watching the Orcas swimming in some very relaxed synchronized

[16] Steve Johnston, 940 Peach Ct., Hollister, CA 95023 USA, pers. comm. Sept 2008.

exercises that would make Olympic athletes jealous. They didn't appear injured or concerned, just curious. After we had watched for over a half hour, however, things changed. The Orcas began to charge the sea lions and bat them around, but not bite them; it appeared that they might be teaching the young one in the group how hunting worked. There was no blood, and the sea lions showed no external wounds when they swam close. After nearly another half hour two humpbacks that had been a couple miles away suddenly appeared right in the middle of things! They seemed to be actually swimming right at the Orcas and occasionally trying to swat them with their tails. Periodically they would dive and be down for 3-5 minutes, then come back up right in the middle of things again."

78. 9 October 2008; Monterey Bay, CA; J. Scarff[17]. "a couple of humpbacks came from several hundred meters away to where a pod of orcas has apparently just killed a California sea lion. The sea lion was underwater, so I never saw the carcass. The humpbacks were blowing hard, almost trumpeting, and dove at exactly the spot where the orcas had dived. The orcas and humpbacks alternated surfacing and diving at the same spot, with the humpbacks continuing to spout very loudly. The humpbacks and orcas were never at the surface at the same time. After 4-5 minutes, the humpbacks disengaged, came over to our whale-watching boat, and hung around as friendly whales for another 5+ minutes before heading off. While they were around our boat they seemed much more relaxed and blowing much quieter."

[17] Jim Scarff, 1807 Martin L. King Jr Way #D, Berkeley, CA 94709 USA, pers. comm. 5 Nov 2009.

79. 11 Oct 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. Observed for 69 min; 5 transient killer whales and "3 + 2 [humpback whales] present; lots of [California sea lions] in area;" second group of 10 killer whales moves in; "+ 2 + 3 + 2 [humpbacks];" [killer whales] "chase [sea lion], escapes."

80. 18 Oct 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. 7 transient killer whales and "2 [humpbacks] present; kill multiple [California sea lions] all day?" K. Cummings[18]: "Today we encountered around six transients about three miles west of Moss Landing hunting sea lions. If I took this picture a second earlier you would be able to see the sea lion in the whale's mouth! We watched the pod hunt and kill one, possibly two sea lions when we saw two humpbacks approaching from the other side of our boat. Once the humpbacks got close, they dove under our boat and reappeared in the middle of all the killer whales. They hung around for about 15 minutes until they trailed off." P. Stap unpubl. notes: 11:02 [4 transient killer whales, 2 females and 2 calves, killed a California sea lion]; 12:07 [group starts porpoising, traveling at 6.5-6.7 kts]; 13:01 [joined by another killer whale]; 13:21 "Had lost them but they were behind us. There is blood in the water and birds are swarming above. Three or four sea lions in the area. Calves are showing flukes - grayish orange in color. 50 plus birds. Two adults are tail slapping off about 100 yards from other orcas." 13:41 "Breach". 13:42 "Brought kill to the surface in its mouth-spy hop; at this point 2 others approximately 1000 yards away" 13:45 "Saw blood; They went under the boat." 13:53 "Saw it in the calve's mouth just below the surface. Blood slick on surface. Two humpbacks approximately 500 yards."

[18] Kate Cummings, 367 Archer Street, Monterey, CA 93940 USA, pers. comm. 18 Oct 2008

14:10 “Humpbacks nearing; orca surfaces with kill on head.” 14:12 “Humpbacks came up right next to the orcas approximately 50 yards (Boat in neutral)”. [time not recorded] “Engine off. Humpbacks within 10 feet of 3 orca group (close group).” 14:27 “there are now 3 [additional humpbacks] 600-700 yards northwest”. 14:32 [another killer whale has joined]; 14:43 [killer whale] “Tossed something in air with fluke”; 14:57 “Humpback surfaced right next to us (50 yards) approximately 200 sea lions jumping.” 15:21 [killer whale] “Tail slaps/surfaces right of us; humpbacks [present]”; 15:38 “Small group [of killer whales] surfaced near us; spy hop; playing? Splashing”; 15:41 [7 killer whales now present]. 16:00 “Sea lion tried to use the boat as shield from killer whales. They circled. A sea lion bumped the underside of the boat. We moved.” 16:12 “Humpback surfaced directly behind killer whale breach.” 16:16 “Engine off. Humpbacks within 10 yards of us; sea lions in area.” 16:26 “Killer whales went under boat and circled; sea lions in area.” [time not recorded] “Double humpback breach.” 16:34 [2 humpbacks] “North of boat approximately 1 mile away (port); 2 more approximately 200 yards away at 120° (east of us).” 16:46 “Two humpbacks to the right; 3 killer whales in front; 2 killer whales in back”; 16:49 “The group of 3 [killer whales] that we've been following picked up speed.” 17:05 [killer whales] “Milling; then held up and came up to the boat”; 17:22 [same group, swimming at] “Approximately 2 mph; at 17:25 then held up again”; 17:26 [Killer whales] “Spy hop up to pect fin 3 times (1/2 way out of water)”; 17:28 [humpback(s)] “Came up behind us. Could be same as S#4 but no pics so gave it a separate sighting number. Does not have number of animals in sighting on log.” 17:33 [killer whale] “Porpoised on port side.” 17:34 [killer whales] “Picked up speed, heading in same direction; 400 yards from boat.” [boat returned to dock after this].

81. 20 Oct 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. Observed for 63 min; 6 transient killer whales with "2 [humpback whales]; [KW] chasing [California sea lions] and common murres [*Uria aalge*]; KW intensely social; 4 [humpbacks] present."

82. 21 Oct 2008; Monterey Bay, CA; P. Stap unpubl. notes. 15:35 "A Sea lion was 30 yds from boat and headed right towards us. Sea lion is bleeding and tried to jump on the boat. He succeeded on landing on the gunnel on the port side. Martijn grabbed the net and I jumped behind the helm. Martijn pushed the sea lion back in water and when it was clear of the prop on boat I moved slowly away from Sea lion as killer whales were starting to circle around the boat in a wide circle. Called [NMFS agent] Joe Cordaro immediately after the incident to report the incident and asked him if there was a better way to handle the situation but he said no since we felt in danger with the large bull sea lion." 16:02 "Put boat in neutral; [2 humpbacks] came within 50 yards of boat between us and Killer Whales." 16:02 [5-6 transient killer whales present]; 16:16 "Humpbacks went right toward killer whales so we could not move in neutral." 16:17 "Humpbacks went to the other side of killer whales." 16:37 [pair of humpbacks] "Went to killer whales"; 16:38 [3 humpbacks] "are with Orcas." 17:14 [killer whales] "Threw sea lion." 17:24 "Killer Whales on a 90° heading" [traveling 4-5 kts; last seen 18:06].

83. 22 Oct 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 10:37 – 6 KW "2 + 2 MN in area"; 11:16 – KW "attack adult male CSL"; 12:20 – "kill CSL."

84. 22 Oct 2008; Monterey Bay, CA; P. Stap unpubl. notes. 17:26 “2 humpbacks with killer whales; killer whales attacking sea lion.” 17:45 [Killer whales] “Bite into sea lion; 100 birds.” 18:03 “odor very strong from sea lion.” 18:12 “2 [humpbacks] came up to boat; birds picking up scraps; 100+ birds” [killer whales travel slowly NW but humpbacks do not follow].

85. 29 Oct 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. Observed for 9 min; 12 transient killer whales with “3 [humpbacks] present; pass 50 [California sea lions].”

86. 26 Nov 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. Observed for 29 min; 8 transient killer whales “carrying juv [California sea lion]?; attract 2 [humpbacks]; [humpbacks] actually chasing KW; [humpbacks] get friendly with boat; [humpbacks] harass KW; 2 + 1 + 2 [humpbacks] arrive.”

Weddell seal (*Leptonychotes weddellii*)

87a-b. 15 Jan 2009; Laubeuf Fjord, east of Adelaide Is, West Antarctic Peninsula, Antarctica; Pitman and Durban (2009) and unpubl. notes. We located a group of 10 type B killer whales comprised of one adult male, two sub-adult males, four adult females, one juvenile, and two calves. When we initially approached the group, they appeared to be harassing a pair of adult-sized humpback whales that they had surrounded. The humpbacks were bellowing and thrashing the surface with their flukes and pectoral

flippers. Two of the killer whales, including the adult male, were close in among the humpbacks but they were not acting aggressive from what we could see. This impression was reinforced by the fact that most of the other killer whales were straying off away from the humpbacks and spyhopping [*i.e*., lifting their heads out of the water], looking for seals on the ice floes. After approximately 30 min of this interaction between the killer whales and the humpbacks, another pair of humpbacks came in and joined the first pair. After more bellowing and splashing by both pairs of humpbacks, the killer whales seemed to lose interest and moved on. At the time, this did not appear to be a serious attack, and we inferred that perhaps the killer whale were just harassing or testing the humpbacks. Later on, however, we viewed some video footage of the encounter taken by a BBC cameraman on board the vessel, and we saw for the first time that there was a Weddell seal in among the humpbacks. We concluded that the seal may have sought refuge there and the humpbacks just agitated by the incidental attention they were getting from the killer whales. Based on what we saw the seal escaped unharmed.

88. 24 Jan 2009; Laubeuf Fjord east of Adelaide Is., West Antarctic Peninsula, Antarctica; Pitman and Durban (2009) and unpubl. notes. "we came upon a group of 11 [killer whales] (1 adult male, 6 adult females, 4 juveniles) attacking a Weddell seal on an ice floe. There was a pair of humpbacks present when we first arrived [one was determined to be a male from a biopsy sample]; from photographs we were able to determine that the humpbacks were not the same as [in events #87 and #89]." "We saw 4 attacks and three kills - all Weddell seals. The one that got away probably benefitted from our presence. Perhaps the most amazing thing was a pair of humpbacks that were present

right from the start. In the first kill they came in right among the killer whales and at one point the killer whales broke up a small bergy bit that the seal was on. When it headed out into open water, it went straight toward the [humpbacks]. One of the [humpbacks] rolled over onto its back and the seal was [swept up] onto its chest. In the video footage, the humpback [quite clearly] uses its flipper to nudge the seal onto its chest. My guess is it [was] trying to protect the seal from the predatory actions of the killer whales… The seal spent a few seconds on the chest (I think it was probably freaked out by the humpbacks attentions - if that's what they were) and then swam over to another bergy bit (the seal was eventually killed and eaten). During the next couple hours of killer whales taking Weddell seals the humpbacks stayed right with us and the killer whales. They were often [bellowing] and clearly agitated although the killer whales were not paying much attention to them. During the second and third kills, the [humpbacks] were with the third [seal] before it was killed but broke off to go over and join the [killer whales] feeding on the second seal - perhaps they heard vocalizing associated with the feeding. They were [approximately] a quarter mile away and went over to [bellow] and be around where the feeding was going on. As things picked up at the kill number 3 site, they broke off and went over there. They repeatedly circled back among the attacking killer whales although the seal was in among the ice the whole time and the humpbacks could never have seen it or heard it."

Crabeater seal (*Lobodon carcinophaga*)

89. 15 Jan 2009; Laubeuf Fjord east of Adelaide Is, West Antarctic Peninsula, Antarctica; Pitman and Durban (2009) and unpubl. notes. After the type B killer whale group from a

previous encounter (#87) moved away from the area, they fanned out and began hunting [*i.e*., spyhopping around ice floes looking for hauled out seals; Pitman and Durban 2012]. Two of the humpbacks from that previous encounter followed them for a mile or so, but then appeared to fall behind. Shortly afterward, the killer whales detected a crabeater seal on a large ice floe. The swam in unison and created a wave that broke up the floe into smaller bits but when they went in to take a closer look at the seal the same pair of humpbacks moved in and started swimming around the floe between the killer whales and the seal. The humpbacks began spyhopping, lunging aggressively and bellowing loudly; they were "right in there with the [killer whales] and seemed to be curious more than anything else but also seemed to be getting in the way and maybe irritating the [killer whales]". Although the humpbacks appeared agitated, they had moved in among the killer whales of their own volition. After several minutes of rather spirited interaction, the killer whales and then the humpbacks all swam away leaving the crabeater unharmed on the small floe. Our speculation at the time was that the humpbacks were 'mobbing' the killer whales much the way small birds do larger birds of prey. [We subsequently determined that the killer whales were not interested in taking crabeater seals and only wanted Weddell seals – Pitman and Durban 2012].

Harbor seal (*Phoca vitulina*)

90. 7 July 2000; East of Point Gustavus, Icy Strait, AK; Harald Yurk and V. Deecke unpubl notes. "at 13:56 hrs, we encountered a group of 14 killer whales travelling south in Sitakaday Narrows." "We followed the animals south to Pt. Carolus and then east to Pt. Gustavus. At approximately 16:15 hrs, the animals split into two subgroups off Pt.

Gustavus and we remained with the trailing subgroup (presumed to be T063, T065, T065A, T065A1, and T065B). At approximately 16:24 the animals started milling on the Gustavus Flats just east of Pt. Gustavus and became vocal. At approximately 16:45 hrs we first noticed a humpback whale approaching the killer whales as they surfaced repeatedly over the same spot. The humpback whale stayed within 50 to 100 m of the transients, often remaining upside down with the tail flukes visible above the surface for several minutes. Shortly after 16:58 hrs, one killer whale tossed a harbour seal through the air. The killer whales remained at the same spot until 17:08 hrs, when they resumed travelling southeast in Icy Strait. We lost track of the humpback about 15 min after it was first seen."

91. 27 June 2005; North Marble Island, Glacier Bay, AK; V. Deecke and M. de Roos; Glacier Bay National Park Annual Whale Report 2005; photos on file at Glacier Bay National Park. "observed adult [humpback] whale #1795 follow and remain in close proximity to four transient killer whales while the killer whales attacked a harbor seal for over one hour near North Marble Island. They observed several tail swipes from whale #1795 and it appeared that some of them were directed at the seal." [Whale #1795 has subsequently been genetically identified as a male. An acoustic recording made at the time of the observation recorded "distinctive bone-crunching noises" and the seal was presumed to have been killed]

92. 22 Oct 2008; Monterey Bay, CA; P. Stap unpubl. notes. 15:28 - 6 transient KWs "Just attacked another sea lion or harbor seal - it was still alive." 15:48 "Harbor seal still in

orca's mouth." 16:15 "2 humpbacks 500-600 yards." 16:17 "2 humpbacks 200 yards; coming in; 2 orcas separated from humpbacks." 16:34 "Killer whales bearing 160° [traveling slowly]; went in opposite direction of humpbacks." N. Black and R. Ternullo unpubl. notes: 15:45 – 6 KW "toss PV about 30 ft in air"; 15:57 – "feed"; 1619 – "mill, feed"; 16:25 – "2 MN swim toward KW"; 16:28 – "MN move away"; 16:32 "MN back"; 16:36 – "MN move away".

Northern elephant seal (*Mirounga angustirostris*)

93. 14 May 2008; Monterey Bay, CA; P. Stap unpubl. notes. 10:50 2 humpbacks seen; 11:07 "Orcas … are tail slapping, breaching. There are 8 orcas plus 2 males separate from group of 8." 11:39 "As orcas went by, the [humpbacks] changed their direction 180 degrees toward area orcas went by". 12:29 "Orcas have possibly a harbor seal… Then an orca did a tail slap next to seal and seal was gone from surface." 12:38 "5 gulls and 3 albatross eating pieces of something at surface." [boat stayed with killer whales until 15:41 and the humpbacks apparently weren't seen again; prey later identified from photos as northern elephant seal].

94. 4 June 2009; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes; L. Beraha video. 11:07 – 5 KWs "catch MA juv"; 11:19 – "MN shows up, friendly"; 11:28 – 2 California sea lions show up, "MN chases KW"; 11:55 "MA killed, MN moves off NW"; 12:05 – "MN returns". [video link in Appendix 1 shows humpback apparently chasing killer whales].

Ocean sunfish (*Mola mola*)

95. 24 Oct 1999; Monterey Bay, CA; D. Shearwater unpubl. notes. 15 transient killer whales "associated with 5-6 [humpback whales] and 2 [Pacific white-sided dolphins *Lagenorhychus obliquidens*]. Ate a *Mola* [*mola*]?"

96. 27 September 2009; Monterey Bay, CA, D. Shearwater unpubl. notes and A. Borker[19]. "From the get-go, the orcas were tail-lobbing and splashing quite a bit, thrashing all around. … Finally, as they approached our vessel, we were able to see that they appeared to be trying to kill an ocean sunfish, (*Mola mola*)! I've seen an adult male orca kill a Blue Shark, but never a Sunfish. The spyhopping, breaching and tail lobbing continued. Once, they went after a common murre … Then suddenly, some humpback whales appeared at our 10 o'clock. The orcas were at the 2 o'clock. Unbelievably, the three humpback whales made their way, keeping their ranks extremely close to each other, toward the orcas! It was hard to believe what we were seeing. I have seen orcas killing and chasing large baleen whales. But, this was the other way around! The humpbacks were chasing and bearing down on the killer whales! It was as if the humpbacks were acting like passerines that mob an owl. They seemed quite intent on their pursuit of the killer whales and came incredibly close to them. At least one of the humpbacks was making a racket with its blowing. …Alas, as they approached, the entire scene was engulfed in fog." D. Shearwater unpubl. notes: "I've been wanting to ask you about this interaction of killer whales apparently killing an ocean sunfish, and then, these humpback whales coming in, and practically running down the orcas!... It was as if the

[19] Abraham Borker, UCSC Center for Ocean Health, 100 Shaffer Road, Santa Cruz, CA 95060 USA, pers. comm. 30 Nov 2009

humpbacks "mobbed" the orcas! Prior to the arrival of the hump[back]s, the orcas did a lot of displays-- breaching, spyhopping, swimming belly up, *etc.* It was positively spectacular. When we first approached the orcas, their behavior reminded me of every time I've ever seen them on a kill, or having just recently killed an animal. In this case, it was the mola." [DS estimated 5-6 killer whales] Also, A. Borker[9]: "we spotted about 6-7 orcas and when we approached found them to be biting and presumably killing a sunfish. They dragged it through the water, but then lost interest. The orcas pod was rolling and breaching around the boat. At one point an orca made a pass at a common murre at the surface." "We then spotted two humpbacks about 300 m away and closing in on our location. They were on the opposite side of our vessel (65'). I think the captain had us slowly moving alongside the orcas, and the humpbacks came behind the boat, and then behind the orcas." "The humpbacks stayed very close together, and at the surface swam towards the orca pod. Myself and others, qualitatively (and perhaps biased) thought that the frequent blows were very loud and raspy." "As far as I could tell the Humpbacks never got closer than ~30 meters from the orcas, the orcas did seem to be pushed forward or "chased" off by the two humpbacks." "Fog rolled in and we left after ~45 minutes observing the orca pod." "We first spotted the orcas at 10:44 am, first observed the humpbacks ~11 am and left the scene at 11:36 am. I've attached a photo of the three humpbacks." [Length of the sunfish was estimated to be 1-1.5 m – A. Borker[9]; killer whales identified as Bigg's from photos by J. Durban]

Unidentified Prey

97. 3 May 2005; Monterey Bay, CA; P. Stap unpubl. notes. 10:52 “Hydrophone in [the water] and Oo’s [8-12 transient killer whales] really vocalizing/echolocating. Oo's just milling then moving a little more West.” 11:22 “Oo's still milling & vocalizing.” 11:31 “Slick now at surface & can smell blubber scent. 8 gulls & 2 albatross. Oo's were milling but now slowly moving to West.” 11:50 “There are 2 Mn's [humpbacks].” 11:55 “Mn's went down - Oo's scattered.” 12:05 “Both Mn's came right at Oo's.” 12:10 “Mn's coming toward us, rolling at surface, raised pec[toral fin] with 4 to 5 Oo's about 200 yds SW of [the boat]. 12:13 “Mn's now heading toward Oo's.” 12:15 “2 Mn's now turning south & both fluked & Oo's heading West.” 12:16 “Oo's about 250 yds apart from Mn's. [Killer whale] CA137 usually stayed out 100 yds but came in once by Mn's. There was usually only 4 to 5 Oo's but once 6 Oo's by Mn's. Oo's on 317 degree heading & Mn's 88 degree heading.” [end of encounter]. 14:07 “Captain on [a whalewatch boat] said after we left Oo's there was 5 Mn's together with Oo's circling Mn's.”

98. 3 June 2006; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 3 transient killer whales “eating something, test [humpback whale(s)].”

99. 25 May 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 11:06 - 6 KWs “killed something?”; 11:20 – “1 MN close by, killed something?”; 12:20 –“end”.

100. 10 Sept 2008, Monterey Bay, CA; R. Ternullo unpubl. notes. Observed 18 min.; 6 transient killer whales “killed something, 2 [humpbacks] join; 3 [humpbacks] join, leave, then follow [killer whales], 2 more [humpbacks] join.”

101. 12 Sept 2008; Monterey Bay, CA; K. Cummings[20]. [4-5 transient killer whales] "interacting with several [3 in video] humpback whales" and "a lot of trumpet blowing." [a short video segment of this encounter in Appendix 1 shows 3 humpbacks milling close by and the killer are circling and diving in a large slick area – apparently a kill had taken place].

102. 9 Oct 2008; Monterey Bay, CA; R. Ternullo unpubl. notes. 10:10 – 6 KW "killed something, 2 MN join"; 10:18 – "3 MN join, leave, then follow KW, 2 more MN join"; 10:45 – "end".

103. 11 Nov 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. Observed for 68 min; 3 transient killer whales "killed something; pester[ed] 3 [California sea lions]; 4 [humpbacks have] excited interaction with [killer whales]; [later, the killer whales] pass 2 [California sea lions]." P. Stap unpubl. notes: 09:55 [3 transient] "killer whales killed something." 10:01 "50-60 gulls in area; picked up flinging prey." 10:14 "70 birds in area; [whalewatch boat] in area and 1 killer whale moved off to the east." 10:17 [1 humpback in area]; 10:26 "Engine off; male killer whale harassing humpbacks, humpbacks trumpeting; killer whales moved to west." 10:46 "Sea lion in area; engine off; humpbacks have been mugging boat." 12:32 "humpbacks engaged boat; engine off." 12:40 "Lost killer whales as they moved off when humpbacks came within 100 yds of boat so turned engine off." [killer whales were found again and finally lost at 13:21].

[20] Kate Cummings, 367 Archer Street, Monterey, CA 93940 USA, pers. comm. 18 Oct 2008

No Prey Observed

104. 1 May 2008; Monterey Bay, CA; P. Stap unpubl. notes. 09:33 “When first arrived we shut off engines. [5-6 transient] Orca's came next to boat. One Orca blew bubbles under the boat starting from the stern to the bow.” 09:42 “down time approx. 5 minutes.” 09:48 “Orca's came next to boat - engines still off.” 10:00 “We were with the orca's and the engines were off. We were concentrating on the orca's which were on our port side when 2 Mn's [humpbacks] surface about 75 to 100 yds on our starboard side. Never saw them coming so do not know their behavior. The orcas went down when the Mn's surfaced. Then orca's spy hopped, one raised tail fluke in air.” 10:11 “One Orca in picture just after Mn Dorsal. Could not see which Orca blew bubbles that came to surface & did a bubble bursts heading towards Mn's.” 10:18 “3 Orca's that had been together were harassing the Mn's. One Mn did a couple trumpet blows. Mn's & Orca's were about 200 yds apart and then they all headed toward each other.” 10:32 “Mn's & Oo's about 200 yds apart but now Mn's heading toward the Oo's. Turned engines back on.” 10:45 “2-3 Orca's were north of this position by 200 yds and were tail slapping. The Mn's came up about 150 yds east of this position with 1 Orca just west of them by approx 25 yds and Mn's were heading toward it.” 1048 “The 2 Mn's & the 1 Orca are together by 10:48. One Orca came up after the Mn's went down. Mn's are not fluking.” 10:51 “2 Orca's went under the boat toward the 2 Mn's that are 200 yds east of this position. Then the orca's including a small Orca were close to Mn's. Mn's are not fluking. One Mn did fluke earlier but they are just rounding out to go down.” 11:06 “Orca's all together now with Mn's 200 yds NE of our position.” 11:13 “Mn's came to the Orca's.” 11:22 “3 Orca's (1 with a calf) in this

position & Mn's 250 yds south of this position & at least 1 Orca 100 yds north of this position." [killer whales and humpbacks not seen together after this]

105. 23 May 2008; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 10:17 - 5 KWs "with 2 MN following, then get friendly with the boat"; 10:42 – "3 more MN"; 10:46 – "6 more MN"; 11:11 – "MN still follow"; 11:29 – MN get friendly with other boats"; 11:39 – 6 more KWs present; 12:21 – "end". [Bigg's KWs; no potential prey identified]

106. 31 Oct 2008; Monterey Bay, CA; P. Stap unpubl. notes. 14:18 [5 transient killer whales milling and] "2 humpbacks in the area 100 yards north"; 14:25 "2 humpbacks chasing behind us chasing killer whales"; [boat followed killer whales until 15:24; no further interactions seen].

107. 19 Aug 2009; Monterey Bay, CA; N. Black and R. Ternullo unpubl. notes. 5 KWs "followed by 4 MN". [Bigg's KWs; no prey identified]

108. 27 Sept 2009; Monterey Bay, CA; S. Johnston[21]. 4 Bigg's killer whales observed "playing, jumping; 3 humpback whales showed up, came to KW: 2 MNs surfaced w/2 KWs right in front of their heads."

Appendix Literature Cited

[21] Steve Johnston, 940 Peach Ct., Hollister, CA 95023 USA, pers. comm. Sept 2009.

Baird, R. W., D. J. McSweeney, C. Bane, *et al.* 2006. Killer whales in Hawaiian waters: information on population identity and feeding habits. Pacific Science 60:523-530.

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 4:219-226.

Dolphin, W. F. 1987. Observations of humpback whale, *Megaptera novaeangliae* and killer whale, *Orcinus orca*, interactions in Alaska: Comparison with terrestrial predator-prey relationships. Canadian Field-Naturalist 101:70-75.

Durban, J. W., H. Fearnbach, D. G. Burrows, G. M. Ylitalo, and R. L. Pitman. 2016. Morphological and ecological evidence for two sympatric forms of Type B killer whale around the Antarctic Peninsula. Polar Biology DOI 10.1007/s00300-016-1942-x

D'Vincent, C., D. Haley and F. Sharpe. 1989. Voyaging with the whales. Boulton Publishing Services, Toronto.

Florez-Gonzalez, L., J. J. Capella and H. C. Rosenbaum. 1994. Attack of killer whales (*Orcinus orca*) on humpback whales (*Megaptera novaeangliae*) on a South American Pacific breeding ground. Marine Mammal Science 10:218–222.

Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies in baleen whales. Mammal Review 38:50-86.

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

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

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

Matkin, D., J. Straley and C. Gabriele. 2007. Killer whale feeding ecology and nonpredatory interactions with other marine mammals. Pages 155-158 *in* J. F. Piatt and S. M. Gende, eds. Proceedings of the Fourth Glacier Bay Science Symposium, 2004. U.S. Geological Survey, Juneau, AK.

Naessig, P. J., and J. M. Lanyon. 2004. Levels and probable origin of predatory scarring on humpback whales (*Megaptera novaeangliae*) in east Australian waters. Wildlife Research 31:163–170.

Pitman, R. L., and J. W. Durban. 2009. Save the seal! Natural History Magazine November 2009:48.

Pitman, R. L. 2011. Antarctic killer whales: top of the food chain at the bottom of the world. Pages 39-45 *in* R. L. Pitman, ed. Killer whale: the top, top predator. Whalewatcher (Journal of the American Cetacean Society) 40:1-67.

Pitman, R. L., and J. W. Durban. 2012. Cooperative hunting behavior, prey selectivity and prey handling by pack ice killer whales (*Orcinus orca*), type B, in Antarctic Peninsula waters. Marine Mammal Science 28:16-36.

Visser, I. N. 1999. A summary of interactions between orca (*Orcinus orca*) and other cetaceans in New Zealand waters. New Zealand Natural Sciences 24:101-112.

Weir, C. R., T. Collins, I. Carvalho and H. C. Rosenbaum. 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 90:1601–1612.

Whitehead, H., and C. Glass. 1985. Orcas (killer whales) attack humpback whales. Journal of Mammalogy 66:183-185.