Aquatic Mammals 2020, *46*(5), 466-477, DOI 10.1578/AM.46.5.2020.466

Live Strandings of Bigg's Killer Whales (*Orcinus orca*) Along the West Coast of North America

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Abstract

Killer whales (*Orcinus orca*) are known to live strand in many regions around the world. Some populations regularly and repeatedly do so in pursuit of prey, but this behaviour is otherwise relatively rare. Off the west coast of North America, historical records of live-stranded killer whales indicate that most individuals perished, were euthanized, or were captured for aquariums where they subsequently died. Few details are available on which of the three culturally distinct killer whale ecotypes in this region have been involved in live-stranding events (LSEs) and on the survival of any individuals that were able to unstrand. In this article, we report details on four LSEs since 2002 and, together with previous records, show that all live-stranded killer whales documented in this region during the last four decades have been of the Bigg's ecotype. There was no predominant sex or age class involved in these events, but among the five individuals reported herein, all three adults stranded on sandy shores, whereas both juveniles stranded on rocky outcroppings while hunting harbour seals. Stranded individuals were kept cool and wet by human responders during three of the four LSEs, and efforts were twice made to move the animals off the shore. All individuals survived the LSEs, although one adult male was never seen again. The other four individuals rejoined their respective families soon after becoming unstranded and have been photo-identified with them on numerous occasions since. One adult female that was pregnant when stranded gave birth to a healthy calf several months later. These results indicate that (1) human responses to live-stranded killer whales are not always necessary, but when they are, they can help preserve their lives, family bonds, and culture; and (2) LSEs are a natural risk associated with the foraging ecology of the Bigg's killer whale ecotype.

Key Words: killer whale, *Orcinus orca*, response, survival, stranding, photo-identification, eastern North Pacific, North America

Introduction

As aquatic mammals, cetaceans carry out all life processes in marine, estuarine, or river environments. When they die, it is not uncommon for their bodies to wash up along the coast, but live cetaceans also occasionally strand. Circumstances motivating cetaceans to incidentally live strand are not always clear, but environmental factors (Evans et al., 2005; Vanselow et al., 2018), human disturbance (Balcomb & Claridge, 2001), social behaviour (Oremus et al., 2013), and compromised health (Alava et al., 2019) are all recognized causes.

Some cetaceans that hunt in neritic environments have learned how to safely live strand in pursuit of prey (Hoese, 1971; dos Santos & Lacerda, 1987; Guinet, 1991). Among them, killer whales (*Orcinus orca*) are well known for their use of a temporary stranding technique to catch pinnipeds that congregate on pebble beaches in shallow waters in Argentina (Lopez & Lopez, 1985) and the Crozet Islands (Guinet & Bouvier, 1994). However, killer whales have occasionally become accidentally stranded where they are known to chase prey in shallow water in other regions of Argentina (Goodall et al., 2007), as well as in New Zealand (Visser, 1999), Marion Island

(Condy et al., 1978), the Faeroe Islands (Bloch & Lockyer, 1988), and the Falkland Islands (Yates et al., 2007; Galimberti & Sanvito, 2016). Killer whales were also speculated to live strand in pursuit of prey in Alaska (Lowry et al., 1987; Frost et al., 1992) and Mexico (Guerrero-Ruiz et al., 2006), whereas no potential causative factors were suggested for some live strandings of this species along the Atlantic coast of North America (Backus, 1961; Goodman, 1984; Lien et al., 1988). On several occasions, people have helped live-stranded killer whales (Haug & Sandnes, 1982; Guinet, 1991; Visser & Fertl, 2000; Brownell et al., 2007; Yates et al., 2007; Visser, 2012; Galimberti & Sanvito, 2016) and other species of cetacean (Gales et al., 2012; Zhao et al., 2017) safely return to the sea. In cases where live-stranded cetaceans require veterinary care, rehabilitation efforts can also lead to successful returns to their natural environments (Antrim, 2001; Pulis et al., 2018).

Along the Pacific coast of North America, three sympatric but genetically, morphologically, and behaviourally distinct killer whale ecotypes are recognized—(1) Bigg's (also known as transients), (2) residents, and (3) offshores (Ford, 2014). Bigg's killer whales primarily consume marine mammals, whereas residents and offshores mostly consume fish (Ford, 2014). Several distinct populations of each ecotype face a variety of anthropogenic threats from pollution to entanglement in fishing gear (Scheffer & Slipp, 1948; Bigg & Wolman, 1975; Matkin et al., 2008; Allen & Angliss, 2012) and are listed as Threatened or Endangered under the Species at Risk Act in Canada (Fisheries and Oceans Canada, 2016) or the Endangered Species Act in the United States (National Marine Fisheries Service [NMFS], 2008). Natural risks to individuals in some of these populations include diseases (Raverty et al., 2017), reduced prey availability (Ford et al., 2010), infanticide (Towers et al., 2018), and entrapment (Scheffer & Slipp, 1948; Dahlheim & Heyning, 1999). Due to constant tidal oscillations throughout the ranges of these killer whale populations, live stranding is also a natural risk in this region, but little is known about which ecotypes are most prone to becoming live stranded.

A few historical records of killer whales live stranded along the Pacific coast of North America exist, but details from most events are limited. Scheffer & Slipp (1948) reported that one killer whale live stranded on the bar in Willapa Bay, Washington, on an unknown date, and another one live stranded on the beach near Tacoma, Washington, in the spring of 1942. Additionally, Carl (1945) reported that one of two killer whales that went aground at an unknown date in Ucluelet, British Columbia, off the west coast of Vancouver Island was shot while still alive. He also reported a live-stranding event at Cherry Point on the east side of Vancouver Island on 28 September 1944 where several adult killer whales managed to free themselves, but one young female remained trapped in a depression between rocks and died. A mass stranding of 21 killer whales at Estevan Point on the west coast of Vancouver Island on 13 June 1945, some of which were alive when first found, was also reported by Carl (1945). These were later determined to be offshore killer whales (Ford et al., 2011). Bigg & Wolman (1975) reported individual female killer whales that were found disoriented in shallow water in August 1970 at Port Madison, Washington, and live stranded in March 1973 at Ocean City, Washington. These and another female killer whale found immobile in shallow water off the east side of Vancouver Island in 1977 (Jeune, 1979) were placed in aquariums and died a few years later. Another young female killer whale that live stranded in California in 1979 died from unknown causes a few days into rehabilitation efforts (Zagzebski et al., 2006). An adult male Bigg's killer whale that was presumably from the west coast transient (WCT) population live stranded on the west coast of Vancouver Island on 9 April 1976 and subsequently died (Ford & Ellis, 1999). There are also four accounts of Gulf of Alaska (GOA) Bigg's killer whales live stranded in Cook Inlet, Alaska (Shelden et al., 2003), in May 1991, August 1993, September 2000, and August 2002. Of the 13 whales reported stranded in these incidents in Alaska, only one adult male was confirmed to die as a result of the stranding.

Aside from population designation for some whales involved in the live-stranding events (LSEs) mentioned above, the life history of individuals that have live stranded has not been reported. Furthermore, no details on the survival of individuals that were temporarily live stranded have been published. In this article, we outline the details of unpublished LSEs of killer whales along the Pacific coast of North America. All four LSEs documented occurred since 2002 and involved only Bigg's killer whales belonging to the WCT population. We discuss the human responses to these LSEs; and as most animals in this population are regularly photo-identified (Towers et al., 2019), we provide information on the survival of the five individuals that stranded. Additionally, we propose that LSEs are an inherent natural threat to the WCT population of Bigg's killer whales due to their foraging ecology.

Methods

Historic accounts of LSEs of killer whales along the west coast of North America were compiled from published literature (see "Introduction"). Field notes and visual media, including photographs and videos, were obtained firsthand from observers of other LSEs of this species between southeastern Alaska and northern Washington. Killer whales involved in LSEs were individually identified from photographs and videos of their dorsal fins, saddle patches, and eye patches using the latest available Bigg's killer whale photo-identification catalogues (Black et al., 1997; Ford & Ellis, 1999; Ellis et al., 2008; Towers et al., 2012, 2019) and unpublished photographic data maintained by the Fisheries and Oceans Canada Cetacean Research Program.

Individuals were considered to have been involved in an LSE if confirmed alive while documented stranded. They were classified as juveniles if under the age of 10, subadults between the ages of 10 and 19, and adults if 20 years or older (Towers et al., 2019). The human responses to LSEs were classified as either passive (few to no actions were taken to keep the animal cool or wet), active (the animal was continually kept cool and wet until the tide came in), or interventive (in addition to keeping the animal cool and wet, efforts were made to move the animal off the shore).

Results

LSE Descriptions and Follow-up

LSE #1—LSE #1 occurred in inner Dungeness Bay, Washington, on 2 January 2002 (Figure 1; Table 1). It involved an adult male (CA188) that was found stranded on the east side of Dungeness Spit at 1100 h. Early in the afternoon, this whale's presumed mother (CA189) was found dead nearby in the shallows of outer Dungeness Bay. Reports from observers indicated that both killer whales were in the area, alive, and possibly accompanied by a juvenile the previous day.

Efforts to secure CA189 for necropsy and move CA188 into deeper water were immediately organized. With the rising tide on the afternoon of 2 January, a first attempt to tow CA188 was made using a harness rigged over his pectoral fins and under his belly. During these efforts, he slipped out of the harness and restranded in the same spot he had previously been. While grounded there for about 8 h on the overnight low tide, he was kept cool and wet with seawater poured over sheets and towels that were draped over his body (Figure 2). During high tide on 3 January, four attempts to move CA188 were made, but in each case he slipped out of the harness, headed west, and restranded in the shallows along the east side of the spit. He was heard vocalizing on several occasions, and his behaviour during the repeated towing attempts varied from unresponsive to resistant and agitated. Overnight, he was once again kept cool and wet while grounded for approximately 8 h during low tide.

In the final towing attempt on the morning of 4 January, a new harness was rigged, this time under CA188's pectoral fins and over his back, and a line with buoys attached was rigged around his caudal peduncle to reduce his mobility. A temporary VHF radio tracking tag was also attached to his body with suction cups (Figure 2). The whale was unresponsive during the tow through the narrows into the outer bay (Figure 2), but he was kept in an upright position by a responder who would counter-balance any uneven effect of the tow line by leaning to one side or the other from his position on CA188's back behind his dorsal fin. Once around Dungeness Spit, the gear was released, and the whale then exhibited a regular surfacing pattern while swimming west into Juan de Fuca Strait at a steady pace. This is the last time CA188 was ever seen, but the signal from his tag was picked up 2 d later to the southwest of Cape Flattery, Washington, indicating that he had continued west and exited Juan de Fuca Strait.

LSE #2—LSE #2 took place on 29 July 2011 near Genn Island, British Columbia, on a sandbar commonly used as a haulout by harbour seals (*Phoca vitulina*) (Figure 1; Table 1). It involved an adult female (T123) and her subadult son (T123A) (Figure 3). The pair was first observed by a floatplane pilot at approximately 1630 h and then responded to via vessel. Based on the height of the stranding above sea level and the tide cycles this day, it was speculated that the whales had become stranded at approximately 1300 h.

At approximately 1730 h, both killer whales were approached on foot. They initially reacted by lifting their flukes off the sand. One whale shuddered when water was poured on it, but due to the cool air temperature (less than 10°C) and constant precipitation, no further response was taken. However, T123A did respond to verbal interaction by vocalizing after every phrase spoken directly to him from close range. At approximately 2100 h, the incoming tide reached the whales. At around midnight, T123 unstranded, and T123A was free a few minutes later. They then swam away together after being stranded for approximately 11 h.

These two killer whales were next documented 38 d later off eastern Vancouver Island and on three other occasions in the same area later in 2011. At some point between encounters on 12 June and 3 November 2012, T123 gave birth to T123C. Between 2012 and the end of 2019, T123, T123A,

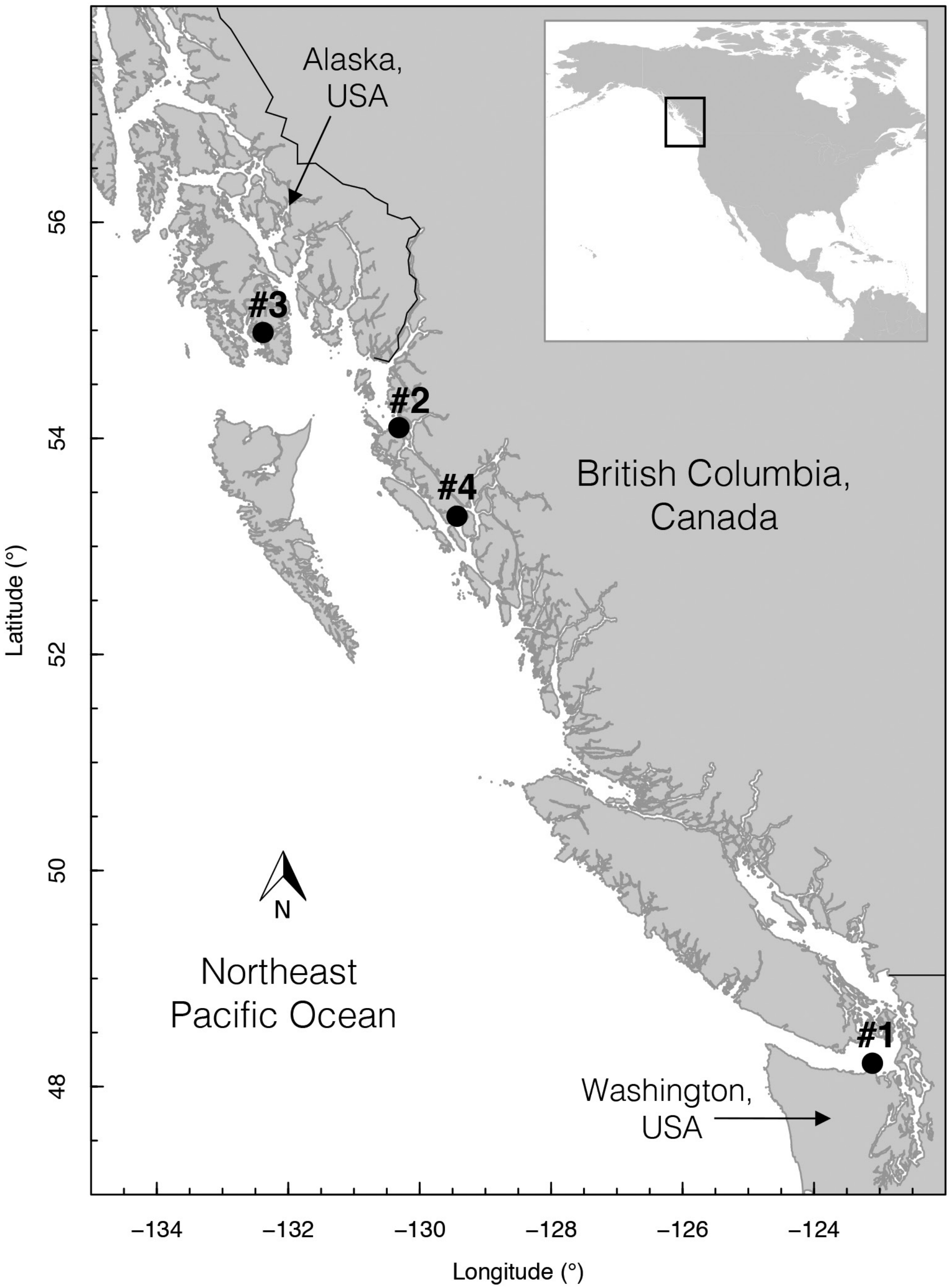

Figure 1. Black circles indicate the locations of each of the four live-stranding events (LSEs) of Bigg's killer whales (*Orcinus orca*) reported in the "Results."

Table 1. An overview of identities, sex and age classes, and group sizes of individuals involved in each live-stranded event (LSE), along with details on shore type, response type, stranding duration, survival, and the number of resightings of each individual since becoming unstranded

LSE	Date (d/mo/y)	Sex	Age class	Age at stranding	Identity	Shore type	Group size	Response	Hours stranded	Survived	Resightings
#1	2/1/2002	Male	Adult	≥ 21	CA188	Sand	2	Interventive	~16-24	Initially	1*
#2	29/7/2011	Female	Adult	26	T123	Sand	2	Passive	~11	Yes	119
#2	29/7/2011	Male	Subadult	11	T123A	Sand	2	Passive	~11	Yes	119
#3	30/9/2013	Unknown	Juvenile	6	T068C1	Rock	3	Interventive	~4	Yes	13
#4	22/7/2015	Male	Juvenile	9	T069A2	Rock	5	Active	~8.5	Yes	25

*Not a sighting but a VHF detection from a suction cup tag the animal was carrying

Figure 2. Photo montage of LSE #1 showing wet blankets on CA188 (top left) to help keep him cool on the evening of 2 January 2002; responders signaling that the whale was harnessed and ready for towing on 4 January 2002 (top right; note suction cup deployed VHF radio tag at base of dorsal fin); and CA188 subsequently being towed through the narrows between inner and outer Dungeness Bay, Washington (bottom). (*Photos:* Kelley Balcomb-Bartok)

Figure 3. Photo of LSE #2 showing T123 (foreground) and T123A (background) live stranded on sandbar near Genn Island, British Columbia, on 29 July 2011 (*Photo:* Doug Davis)

and T123C were photo-identified on 115 occasions between Juan De Fuca Strait, Washington, and Squally Channel, British Columbia. All individuals appeared healthy in each encounter following the LSE.

LSE #3—LSE #3 occurred in Klakass Bay, Prince of Wales Island, Alaska, on 30 September 2013 (Figure 1; Table 1). At approximately 1400 h, three killer whales were observed from a vessel to be hunting harbour seals near a rocky reef when the larger of the two juveniles (T068C1) began thrashing its body vigorously in shallow water. It then stopped moving and, upon closer inspection, the whale was confirmed to be stuck, while several harbour seals were observed on the reef. Meanwhile, T068C1's younger sibling (T068C3) and mother (T068C) were swimming close to where it was on the rocks. The vocalizations and echolocation of the three whales could be heard from above the water. T068C was observed approaching T068C1 on several occasions (Figure 4) and then directing a considerable sized wave towards the animal with her tail. This apparent effort to wash her offspring off the rock was to no avail and soon ceased with the dropping tide.

At approximately 1600 h, when the killer whale's body was nearly completely exposed to the air, it was approached on land (Figure 4) and noticed to have incurred some superficial scrapes to the underside of its fluke. Its appendages were hot to the touch, so seawater was poured over its body. Although the air temperature was about 5°C, its body only noticeably cooled after over an hour of this. T068C1 breathed once every 2 to 4 min and vocalized regularly when not being touched. As the tide rose around T068C1, after 1800 h, the whale had difficulty lifting its blowhole above the surface to breathe due to its tail end being positioned higher on the rock than the head. Two oars were quickly acquired and placed between the pectoral fins and upper abdomen to leverage the whale into deeper water. During this effort, the whale began pumping its fluke and became free of the rock after about 4 h of being stranded. At first, T068C1 rolled upside down and became motionless for approximately 2 min. It then righted itself, took a breath, and joined the other two whales in the distance.

T068C1 was next documented 65 d later off the west coast of Vancouver Island. Between this date and the end of 2019, T068C1 appeared healthy on 12 occasions when photo-identified with kin between Juan De Fuca Strait, British Columbia, and Glacier Bay, Alaska.

Figure 4. Photo montage of LSE #3 on 30 September 2013 showing T068C checking on T068C1 while responders watched from shore on Prince of Wales Island, Alaska (top left and right); and efforts to keep T068C1 cool and wet while waiting for the tide to rise (bottom left and right) (Screengrabs from video by Jason Vonick, Nick Segal, and John Oakes)

LSE #4—LSE #4 took place near Union Pass, British Columbia, on 22 July 2015 (Figure 1; Table 1). It involved a single juvenile male (T069A2) that stranded on the rocks off the south side of the Edwards Islets at approximately 0800 h. Prior to the stranding, T069A2, his mother (T069A), younger sibling (T069A3), aunt (T069D), and cousin (T069D1) were observed circling the rocks where several dozen harbour seals were hauled out. A burst of splashes was observed on the far side of an islet and, upon closer inspection, T069A2 was found submerged but stationary between the islet and a dried boulder. He remained still while the other four killer whales continued hunting around the islets. However, as the dropping tide began to expose T069A2's body, the other whales ceased hunting and lingered nearby facing him (Figure 5).

By 1000 h, T069A2 was fully exposed on the rocks. The weather was partly cloudy and cool, but the killer whale was also occasionally exposed to periods of full sun. To mitigate overheating, responders approached the whale on foot from the other side of the islet and poured seawater over bedsheets, pillowcases, and sarongs that they draped over him (Figure 5). T069A2's breathing was intermittent (once every 2 to 3 min), and he occasionally vocalized. By approximately 1130 h, the other whales in the group were no longer visible nearby, but efforts to keep T069A2 cool and wet continued until around 1530 h. As the rising tide then enveloped T069A2, an increase in vocalization rate was detected on a hydrophone. After being stranded for about 8.5 h, the whale unstranded at 1630 h, vocalized once more, and surfaced southeast of the islets. Further observations of this whale and his kin were not made on this day.

T069A2, his mother, and younger sibling were next documented 29 d later in Barkley Sound, British Columbia, and on two other occasions later in 2015—both along the west coast of Vancouver Island. T069A2 is a very slender killer whale but was observed behaving normally with kin on 22 occasions between 2016 and the end of 2019 from Haida Gwaii to southwest Vancouver Island.

Discussion

Live strandings of killer whales along the west coast of North America are relatively rare. Only a few cases have ever been reported, and all

Figure 5. Photo montage of LSE #4 on 22 July 2015 showing T069A, T069D, and T069A3 facing T069A2 live stranded on the rocks off the Edwards Islets, British Columbia (top); T069A2 as the tide was receding (bottom left); and efforts to keep T069A2 cool and wet using sheets and a hand pump connected to a long hose (bottom right). (*Photos:* top and bottom right, Janie Wray; bottom left, Nicole Robinson)

eight known LSEs that occurred over the last four decades have been of the Bigg's ecotype. Among these cases, four involved Bigg's killer whales from the GOA population and occurred in Cook Inlet, Alaska, between 1991 and 2002 (Shelden et al., 2003), whereas the four cases reported herein only involved individuals from the WCT population and occurred between northern Washington and southeastern Alaska from 2002 to 2015. It is likely that some LSEs along the west coast of North America have gone unnoticed or unreported, but the increased occurrence through the 2000s of LSEs involving WCT Bigg's killer whales may be explained by two corresponding factors. First, LSEs of WCT Bigg's killer whales may be more likely to occur because this population has exhibited remarkable growth since the 1990s (Ford et al., 2013; Towers et al., 2019), likely due to increased abundance of several species of preferred prey (Shields et al., 2018). Second, any LSEs that do occur from central California to southeastern Alaska may be more likely to be detected because whale-watching activity and research effort has been increasing since the 1970s and is currently relatively widespread within this region (O'Connor et al., 2009; Towers, 2017).

A total of five animals were involved in the LSEs reported herein, and each individual had been photo-identified prior to the LSE (Black et al., 1997; Towers et al., 2012). All individuals survived the LSEs, but subsequent detection rates varied. The adult male from LSE #1 was only detected on one occasion after the incident when a signal from his tag was received 2 d later at least 70 nmi from where the stranding occurred. Although this killer whale initially survived being stranded for more than 16 h over a 3-d period, we believe he died soon after, especially considering the mortality rate of adult male killer whales increases once their mothers die (Foster et al., 2012), and this individual live stranded in association with a dead female presumed to be his mother. The four other individuals documented in LSEs were observed on multiple occasions since and are considered to be alive at present. One of them, the female stranded for approximately 11 h during LSE #2, gave birth following the LSE. Considering the gestation period of 17.5 mo for killer whales (Robeck et al., 2015), the dates of encounters with this whale and her new offspring indicate that she was anywhere from 2.5 to 7 mo pregnant at the time of the LSE. At least two other killer whales have given birth at intervals of approximately 6 and 8 y after stranding (Visser, 2012); however, LSE #2 is the first instance we know of where subsequent documentation of offspring has indicated that the individual was pregnant while stranded.

Consistent with previous reports (Carl, 1945; Shelden et al., 2003), there was no predominant age or sex class represented in LSEs as both adult male and female killer whales, as well as juveniles of unknown sexes, were documented live stranded. However, both juveniles were found on rocky outcroppings, and all subadults and adults were found on sandbars. It is not known if this is simply an artefact of the small sample size or if it is possible that juvenile WCT Bigg's killer whales are less aware of the risks associated with close proximity to rocky coastlines than adults. For example, adult WCT Bigg's and other mammal-eating killer whales usually pursue and kill prey in open water, but when prey seek refuge near or on rocky shores, attacks are often abandoned (Condy et al., 1978; Goodall et al., 2007; Ford et al., 2013). This is likely due to the potential for live stranding or bodily harm that would occur when trying to maneuver at high speed to catch prey near the shoreline. Like killer whales in other regions (Lopez & Lopez, 1985; Frost et al., 1992; Visser, 1999), it is likely that WCT Bigg's killer whales may be more willing to chase prey in shallow water over pebbly, sandy, or muddy substrates due to the limited negative effect that contact with a smooth surface may have on their bodies. However, such shorelines are not common throughout the range of the WCT Bigg's killer whale population. It is therefore possible that they do not have much experience in navigating these shorelines or with the effects of tides in this habitat. This may be especially true for individuals of the putative outer-coast subpopulation that do not often travel in coastal waters (see Ford et al., 2013) and may explain why LSE #1 occurred as the individual involved belonged to that subpopulation. Juvenile killer whales often hunt with adults; however, due to their smaller size, they may be able to avoid becoming stranded in relatively flat environments where adults strand. Although the presence of juveniles was not documented in any of the LSEs of adults reported in this study, it is worthy of note that a juvenile offspring (T123B) of the female documented in LSE #2 was last observed during the final encounter with this group before the LSE occurred. It is not clear if the LSE led to its disappearance or if it is unrelated.

In the two LSEs involving juveniles, the individuals were documented with their respective matrilineal groups in all following encounters. In the case of LSE #3, the mother and younger sibling of the stranded juvenile did not leave the scene of the LSE until the whale was free of the shore about 4 h later; and although the behaviour of the whales was not noted following LSE #4, the kin of the stranded individual remained nearby for at least several hours. This behaviour is not surprising considering most maternally related Bigg's killer whales are known to exhibit strong social bonds that, in some cases, last throughout their lives (Baird & Whitehead, 2000).

Poor health did not seem to be a factor leading at least four of the five killer whales to strand considering they survived these events. In fact, in each of these cases, whales were observed hunting nearby prior to stranding or stranded in an area where prey were known to haul out. Given that these LSEs were infrequent and potentially deadly, we believe that they and other previously reported strandings of this ecotype (Ford & Ellis, 1999; Shelden et al., 2003) were accidental outcomes resulting from the intent to capture prey, which is somewhat different to learned stranding behaviours described as intentional in other regions by Lopez & Lopez (1985) and Guinet (1991), and proposed for this area by McInnes et al. (2020). Either way, such incidents appear to be a natural risk associated with the foraging ecology of this ecotype and, although Bigg's killer whales typically avoid unnecessary contact with the shoreline (Ford et al., 2013), sympatric resident killer whales often spend considerable time in shallow water rubbing their bodies on the smooth pebbles of particular beaches (Ford, 2014). This appears to be highly social behaviour not related to foraging. Despite how common this beach-rubbing behaviour is for northern resident killer whales, no associated accidental strandings have been documented. This may be because unlike the mammalian prey of Bigg's killer whales that often hide in the shallows when being pursued (Ford et al., 2013), the fish prey of resident killer whales typically dive deep when being chased (Wright et al., 2017).

Killer whales and other cetaceans that have been found stranded alive, but otherwise healthy, have in several cases been successfully rescued after spending many hours on shore (Visser & Fertl, 2000; Gales et al., 2012; Visser, 2012). In situations where capture and rehabilitation were required, such efforts have ensured that some cetaceans could return to their natural habitats (Antrim, 2001; Pulis et al., 2018), and in one case helped a juvenile killer whale found alone and emaciated in Washington successfully reunite with her family in British Columbia (Francis & Hewlett, 2007). However, many live-stranded cetaceans show very low survival rates following rehabilitation (Zagzebski et al., 2006). Only four killer whales that live stranded or were found alone in shallow water along the west coast of North America in the 1970s were captured and rehabilitated, but all subsequently died (Bigg & Wolman, 1975; Jeune, 1979; Zagzebski et al., 2006). In all other cases reported along the west coast of North America, the animals either died, were euthanized on shore, or found their way back into the water. The fate of those that returned to their environment remains unknown. However, all five whales documented in the four LSEs presented herein were found to initially survive. This may be in part due to the human responses to three of these events. Today, four of the previously stranded individuals are currently alive, and at least one has successfully reproduced. Visser (2012) has also documented reproduction and longevity of killer whales that have survived LSEs in New Zealand and suggests that rehabilitation in captive facilities is not typically necessary. Instead, efforts to keep healthy live-stranded killer whales cool, moist, and calm until they can be aided into the water or move into the water under their own power with the assistance of a rising tide appear to often be successful.

Acknowledgments

We thank Robyn Angliss, Liam Antrim, Larry Baker, Ed Bowlby, Mary Sue Brancato, John Calambokidis, Marilyn Dahlheim, Doug Davis, Archie Dundas, Dave Ellifrit, Emily Ezell, George Fisher, Jeff Foster, Brad Hanson, Colleen Irvine, Steve Jeffries, Dyanna Lambourn, Hermann Mueter, Brent Norberg, John Oakes, Rich Osborne, Andy Palmer, Mack Peterson, Marven Robinson, Nicole Robinson, Kevin Ryan, Greg Schorr, Jennifer Schorr, Pete Schroeder, Nick Segal, Sam Watson, and Janie Wray for their efforts during live-stranding events, and Marcie Callewaert, Dave Ellifrit, John Forde, Brian Gisborne, Jackie Hildering, Mark Malleson, Christie McMillan, Kathy Peavey, Neil Pilgrim, James Pilkington, Lauren Portner, Tasli Shaw, Jennifer Steven, Gary Sutton, and Wendy Szaniszlo for photo-identifying whales that had been live stranded during encounters following the LSEs. We also thank the Git Ga'at First Nation for permission to conduct research in their territory; Dave Bain, Lance Barrett-Lennard, and Graeme Ellis for helpful discussions during the preparation of the manuscript; and John Ford, Josh McInnes, Ingrid Visser, and two anonymous individuals for reviewing the manuscript.

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