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Cetacean Mother-calf Behavior Observed from a Small Aircraft off Southern California

Mari A. Smultea[1,2*], Dagmar Fertl[3], Cathy E. Bacon[4], Meggie R. Moore[1], Vanessa R. James[1], & Bernd Würsig[2]

[1]Smultea Environmental Sciences, Preston, WA
[2]Marine Mammal Behavioral Ecology Group, Texas A&M University at Galveston, Galveston, TX
[3]Ziphius EcoServices, Magnolia, TX
[4]HDR, Inc., San Diego, CA

*Corresponding author (Email: mari@smulteasciences.com)

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Abstract - During early developmental stages, cetacean calves are dependent on their mothers for survival. Protection of young whales engaged in behaviors that are biologically important is critical for population recovery, so that appropriate management actions can be taken to minimize human disturbance. However, the occurrence and frequency of whale nursing and calves back-riding their mothers (both considered important to calf survival) have rarely been observed nor adequately quantified or defined. Therefore, it may not always be clear when disruption is occurring. We used extended behavioral observations, still photography, and video camera footage obtained during aircraft surveys in the Southern California Bight in 2008 – 2013 to characterize cetacean mother-calf interactions. Based on observations of four mother/calf pairs (two gray whale, *Eschrichtius robustus*, one fin whale, *Balaenoptera physalus*, and one blue whale, *B. musculus*) and one killer whale presumed mother/yearling pair (*Orcinus orca*), we describe bouts of nursing and calves riding on the backs of their presumed mothers, including activity duration, frequency, and relative body positioning. We conclude with specific definitions useful to wildlife conservation agencies authorizing and establishing restrictions to certain human activities when they might constitute behavioral disruptions.

Keywords – Gray whale, *Eschrichtius robustus*, Blue whale, *Balaenoptera musculus*, Fin whale, *Balaenoptera physalus*, Killer whale, *Orcinus orca*, Nursing, Back-riding, Calf

Protection of large whale species, particularly calves, from potential human disturbance is critically important for population recovery. During early developmental stages, cetacean calves like other mammalian young, are dependent on their mothers for survival including for food intake via nursing, protection from predators, and energy conservation (Whitehead & Mann, 2000). Baleen whale calves have a short and intense lactation period (e.g., 6-7 months for blue and fin whales, *Balaenoptera musculus* and *B. physalus*, respectively; Lockyer, 1981) resulting in a high daily caloric cost of lactation due to the compressed time to calf independence (Hayssen, 1993; Oftedal, 1997). For example, Oftedal (1997) reported that mean fat content of milk consumed by blue, fin, and gray whale (*Eschrichtius robustus*) calves ranged from 41 to 53%, with a corresponding estimated calf growth rate of 1.71 cm per day for the

gray whale (Best, 1982; Cartwright et al., 2016). Furthermore, many baleen whales seasonally migrate long distances between high-latitude summer feeding grounds and lower-latitude winter calving grounds where the mother fasts in tropical waters characterized by low biological productivity (Ford & Reeves, 2008). Although the impacts of disruptive anthropogenic activities on the reproductive success of individual whales are unknown (Clapham, 1999), interruption of nursing may reduce caloric intake of cetacean calves, which could be detrimental to calf survival. However, characteristics of wild cetacean mother-calf behaviors considered critical to survival (e.g., nursing), especially among baleen whales, are rarely documented. This is due to difficulties inherent in observing these animals that spend most of their life underwater, and often in hard-to-access oceanic areas. Further, it is difficult to obtain observations unbiased by the observer (e.g., a human diver) or observation platform (e.g., noise-producing vessels). An understanding of behavior that is biologically important to whale offspring survival is essential to conservation and recovery so that appropriate management action can be taken to minimize human disturbance. However, the occurrence, duration and frequency of whale nursing and calves back-riding their mothers, both considered important to calf survival, have rarely been observed and have not been adequately quantified or defined; therefore, it may not always be clear when disruption is occurring.

Apparent nursing by baleen whales has been observed from vessels, airplanes, and elevated shore stations, by human swimmers, and more recently using video footage obtained from small, overflying drones. The most detailed descriptions are for North Atlantic right (*Eubalaena glacialis*), South Atlantic right (*Eubalaena australis*), and bowhead (*Balaena mysticetus*) whales (Hain, Hampp, McKenney, Albert, & Kenney, 2013; Thomas & Taber, 1984; Würsig, Dorsey, Fraker, Payne, & Richardson, 1985). Brief and/or anecdotal descriptions of apparent nursing exist for humpback (*Megaptera novaeangliae*), gray, and Bryde's (*Balaenoptera edeni*) whales (e.g., Glockner-Ferrari & Ferrari, 1985; Reeves, Smith, Lund, Lebo, & Josephson, 2010; Steiner, Silva, Zereba, & Leal, 2007; Swartz, 1986; Sychenko, 2011; Williamson, 1961). Video recently obtained from drones documented blue whale mother-calf pairs in apparent nursing positions off southern California (Dana Point Whalewatching, 2016; Giradeau, 2015), Sri Lanka (Dykstra, 2013), and New Zealand (pygmy blue whale, *Balaenoptera musculus brevicauda*, Torres & Klinck, 2016).

Apparent nursing among mysticetes has been reported during rest or slow travel with the mother and calf partially exposed at the water surface, only the calf below the surface, or both animals below the surface. South Atlantic right whale and bowhead whale nursing "bouts" were typically separated by the calf breathing one to three times at the surface, subsequently submerging for more nursing, and ending with a deeper dive (Thomas & Taber, 1984; Würsig et al., 1985). Assumed nursing (i.e., "suckling") by North Atlantic right whales occurred when the calf's head maintained alignment with the mother's teats, followed by the calf surfacing and then nursing on the opposite side of the mother, alternately repeating this behavior (Hamilton & Cooper, 2010). In contrast to balaenids, apparent nursing by Eschrichtiidae and Balaenopteridae calves is anecdotally reported to occur below the surface during both rest and slow travel. Sychenko (2011) defined apparent nursing among western gray whales as the mother rolling and the calf diving under her to nurse. Apparent nursing by humpback whales occurred with the mother and calf in a horizontal position (Glockner, 1983); a vertical position (head up; Bauer, 1986); or occasionally at the surface with the mother's flukes extending into the air (e.g., Bauer, 1986; Morete, Freitas, Engel, Pace, & Clapham, 2003). Drone video showed different blue whale calves in an apparent nursing position with the mother resting at or near the surface and the calf below the surface with its rostrum oriented to the mother's teat area, usually with the calf dorsal side up but also ventral side up or on its side (Dana Point Whalewatching, 2016; Dykstra, 2013; Giradeau, 2015; National Geographic, 2016).

Study Objectives

The objective of our study was to conduct focal group and individual behavioral observations of cetaceans using video from an aircraft, focusing on pairs of mother-calf whales as a critical component of population conservation. We use results to provide definitions of vital mother-calf behavior useful to

develop conservation and management measures aimed at minimizing disturbance to these biologically significant behaviors. Focal species included the endangered blue and fin whales, and the gray and killer (*Orcinus orca*) whales.

Method

Aerial Survey Protocol

Aerial surveys for marine mammals were flown in the Southern California Bight two to four times per year (7 – 10 days per survey) from 2008 through 2013 (see Smultea, 2016 for detailed methodology). The survey area extended from the coastline to approximately 200 km offshore from San Diego north to near Los Angeles, California (centered around 32° 54' 19.6" N 118° 22' 49.8 W). Surveys were conducted at an altitude of 244 – 305 m and 100 knots ground speed, primarily from a high-wing, twin-engine Partenavia P68 and glass-nosed Observer (n = 17 surveys), with the remaining survey made from an Aero Commander aircraft. Observation effort occurred throughout each flight focused along systematic transect lines following conventional distance sampling protocol (Buckland, Rexstad, Marques, & Oedekoven, 2015). Two observers searched for marine mammals on each side of the aircraft through a bubble window while a recorder collected data on a laptop running customized data collection and mapping software, including Mysticetus™ (www.mysticetus.com). Sighting position information was calculated and plotted on a laptop map screen in real time by Mysticetus based on the horizontal bearing and declination angle to the sighting measured with a clinometer. Observer voices were recorded throughout each flight by taping a mini-microphone into a headphone earpiece connected to a portable voice recorder.

When a mother-calf whale pair was sighted, the plane circled the sighting at radial distance 0.5 – 1 km and a target altitude of 457 m to collect extended detailed behavioral observations (i.e., focal follow); flying a small aircraft in this manner has been shown to avoid potential disturbance of whales by flying outside Snell's air-to-water sound transmission cone (Richardson, Greene, Malme, & Thomson, 1995; Urick, 1972). All-occurrence focal individual and focal group sampling methods were used to record behavioral states (travel, mill, rest, unknown) and events following an ethogram (Altmann, 1974; Mann, 1999; Smultea, 2016). In addition, minimum and maximum distance between nearest neighbors as a measure of cohesion within a group (estimated in number of adult species body lengths [BL]) and magnetic orientation were recorded once per minute. A calf was defined as an animal less than three-quarters the body length of the closely accompanying adult (i.e., within one-half adult BL). A yearling was defined as an animal estimated to be approximately three-quarters the BL of the closely accompanying adult whale (Taber & Thomas, 1982). Photographs and video were taken to document species and behaviors through an open porthole window using a Canon EOS 40D or 60D or a Nikon D300 or D7000 DSLR camera with a 100 – 400 mm f/4.5-5.6 IS USM lens and a high-definition Sony Handycam HDR-XR550 or HDR-XR520 video camera.

Photographs and video were examined post-survey on a computer monitor to transcribe the frequency, duration, body orientation, distance between mother and calf, and laterality (i.e., mother's left or right side) of apparent nursing, back-riding events, and/or behavioral states. Distance between mother and calf were noted at 30 s intervals using instantaneous sampling methodology following the protocol of Taber and Thomas (1982). We defined back-riding as the calf touching or within one-quarter adult BL of the mother, positioned between the tail stock and the mother's head/rostrum. We defined apparent nursing as the mother and calf separated by less than one-quarter adult BL with the calf's head oriented towards the mother's teat area or peduncle for at least 5 s. We did not observe the presence of milk and thus could not confirm that milk was transferred to the calf during apparent nursing. Duration of apparent nursing (i.e., a "session") was defined as the elapsed time from when the calf began then moved out of an apparent nursing position (based on video transcription, field notes, and/or voice recordings). Periods (in elapsed time as displayed on the monitor screen) when the calf and/or mother dove out of sight of the

observer and/or video camera were also recorded. Whales were typically visible below the water surface to a depth of about 1 – 3 adult BL, depending on conditions (e.g., water clarity, cloud cover, Beaufort Sea State). Travel speed in kilometers per hour (km/hr) of mother-calf pairs was calculated based on the distance between the first and last GPS positions of each sighting divided by the focal follow duration (in hours).

Results

In 2008 – 2013, we conducted 87,735 km of observation effort during 18 aerial surveys totaling 97 flights in the Southern California Bight; at least one survey occurred during every month except December (see Smultea, 2016). Focal follows were conducted on 160 cetacean groups for periods of 5 – 60 min totaling 37.5 hr, 4.3 hr (11%) of which consisted of nine different mysticete whale mother-calf pairs. We observed apparent nursing and back-riding among four mysticete (two gray, one blue, and one fin whale) mother-calf pairs during observation periods of 19 – 54 min, all of which were documented with video except one gray whale mother-calf pair documented by field notes and voice recording only (Table 1). We also photographed apparent nursing by one adult/yearling killer whale pair. From our overhead aerial perspective, all observed apparent nursing occurred with the mother motionless or traveling slowly at the surface and the calf below the surface. Back-riding and apparent nursing by the calf was nearly evenly distributed laterally on both sides of the mother across whale species (Table 2).

Gray Whale: Nursing and Back-riding

On 15 February 2011, we conducted a focal follow on a lone gray whale mother-calf pair for 30 min as they traveled slowly southeast at a mean speed of 3.6 km/hr approximately 16 km from shore over a bottom depth of 580 m. The calf was estimated to be one-half the mother's BL based on video analysis. The pair was at or near the water surface and within view of the observers for 83% of the 30-min video recording. The pair was always observed within one-quarter mother BL of each other. One 15 s apparent nursing session was video-recorded (Table 1). The calf rode the mother's back 11 times with approximately equal frequency on the mother's left and right sides, of which 7 periods could be timed from start to finish (M = 12 s, SD = 9.8, n = 7; Table 1, Figure 1). Back-riding typically involved the following chronological behavioral sequence by the calf: (1) "lying" on one side of the mother's peduncle for several minutes as she swam slowly just below the water surface; (2) quickly (3 – 20 s duration) crossing over the mother's back; and (3) lying again on the other side of the mother's peduncle for several more minutes. Each time, the calf's travel appeared to be due to the mother's propulsion, with no calf fluke movement evident; however, the mother's flukes beat intermittently throughout the focal follow. The last observed behavior was the calf back-riding in a different manner, with its lower peduncle positioned near the mother's flukes, floating back and forth near the center of the mother's back as though propelled by the mother's fluke beats.

On 19 April 2011, a lone gray whale mother-calf pair slowly traveled northbound at a mean speed of 4.3 km/hr approximately 3 km from shore over a bottom depth of 30 m (Table 1). No video or photo was obtained for this focal follow. The calf was approximately one-half the mother's BL. The pair was at or near the water surface and within view of the observers for 85% of the 19.2 min focal follow. The whales were always observed within one-quarter to one mother BL of each another. Three apparent nursing sessions, each lasting 20 – 76 s, were seen, always while the mother was motionless at the water surface with both pectoral fins outstretched and the calf below the surface (Table 1). The calf back-rode the mother three times for periods of 60 – 90 s, rotating between the left (once) and right (twice) sides of the mother's peduncle area.

Figure 1. Gray whale calf at the water surface back-riding the rear left peduncle area of its mother as she swims below the water surface (mother has lighter body color) on 15 February 2011. Apparent nursing also was observed as the mother rested at the surface. Photograph by Bernd Würsig, NMFS permit 14451.

Blue Whale: Nursing and Back-Riding

On 24 May 2013, we conducted a 54 min focal follow on a lone blue whale mother-calf pair traveling slowly (approximately 3 – 4 km/hr) sub-surface 12 km from shore over a bottom depth of 290 m. The calf was estimated to be one-half the mother's BL. The whales were within view of observers for 71% of the 54 min focal follow, 39 min of which was captured on video; photographs were taken after the video ended. The pair was always observed within one-quarter to one mother BL of each another, except near the end of the focal follow when the calf moved 2 BL away as a small (< 10 m) outboard recreational boat approached to within 100 m, stopped for several minutes, then abruptly departed. We observed four apparent nursing sessions of 13 – 264 s duration each, three of which were recorded on video before the close approach by the small vessel (Table 1). The longest apparent nursing session of 264 s occurred after the small boat departed. Back-riding occurred four times with equal frequency on each side of the mother for periods of 8 – 94 s (Table 1).

Table 1
Summary of Whale Nursing and Back-Riding Behaviors Observed Among Mother-Calf Pairs in the Southern California Bight

					Apparent Nursing Session Duration (s)			Back-riding	
Species[a]	**Obs. Method**	**Date**	**Total Obs. Time (min)**	**Max. Space in Adult BL[a]**	**Mean (SD)**	**Range**	***n***	***n***	**Laterality (L / R)**
Gray whale	V & P	15 Feb 2011	30	0.25	15 (N/A)[b]	N/A	1	*11*	6 / 5
Gray whale	N	19 Apr 2011	16	1	42 (21)	20-76	3	*3*	1 / 2
Blue whale	V & P	24 May 2013	44	1	149 (132)	13-264	4	*4*	2 / 2
Fin whale	V & P	6 Jun 2009	50	1	90 (45)	30-138	3	*10*	5 / 5
Killer whale[c]	P	21 Nov 2009	40	--	--	--	--	--	--

Note. N = documented with notes and voice recording only; V & P = documented with video and photographs; BL = adult body length(s).
[a]Maximum estimated distance in adult BL observed between the presumed mother and calf.
[b]SD not applicable due to sample size of 1.
[c]Adult-yearling killer whale pair; all other sightings are mother-calf pair. Parameters for which no systematic data were collected are denoted with a dash.

Table 2
Reports of Apparent Nursing (N) or Back-Riding (B) by Cetacean Calves in Free-Ranging and Captive Environments

Species	Calf Behavior
Mysticetes	
North Atlantic right whale (*Eubalaena glacialis*)	N, B
South Atlantic right whale (*Eubalaena australis*)	N, B
Bowhead whale (*Balaena mysticetus*)	N, B
Blue whale (*Balaenoptera musculus*)	N
Pygmy blue whale (*Balaenoptera musculus brevicauda*)	N
Fin whale (*Balaenoptera physalus*)	N
Bryde's whale (*Balaenoptera edeni/brydei*)	N
Humpback whale (*Megaptera novaeangliae*)	N, B
Gray whale (*Eschrichtius robustus*)	N, B
Odontocetes	
Sperm whale (*Physeter macrocephalus*)	N, B
Beluga whale (*Delphinapterus leucas*)	N, B
Killer whale (*Orcinus orca*)	N
Short-finned pilot whale (*Globicephala macrorhynchus*)	N
False killer whale (*Pseudorca crassidens*)	N
Rough-toothed dolphin (*Steno bredanensis*)	N
Dusky dolphin (*Lagenorhynchus obscurus*)	N
Bottlenose dolphin (*Tursiops* spp.)	N
Hybrid: bottlenose and rough-toothed dolphin	N
Atlantic spotted dolphin (*Stenella frontalis*)	N
Spinner dolphin (*Stenella longirostris*)	N
Short-beaked common dolphin (*Delphinus delphis*)	N
Humpback dolphin (*Sousa plumbea*)	N
Commerson's dolphin (*Cephalorhynchus commersonii*)	N
Finless porpoise (*Neophocaena phocaenoides*)	N, B
Harbor porpoise (*Phocoena phocoena*)	N

Note. See Appendix A for a list of supporting references.

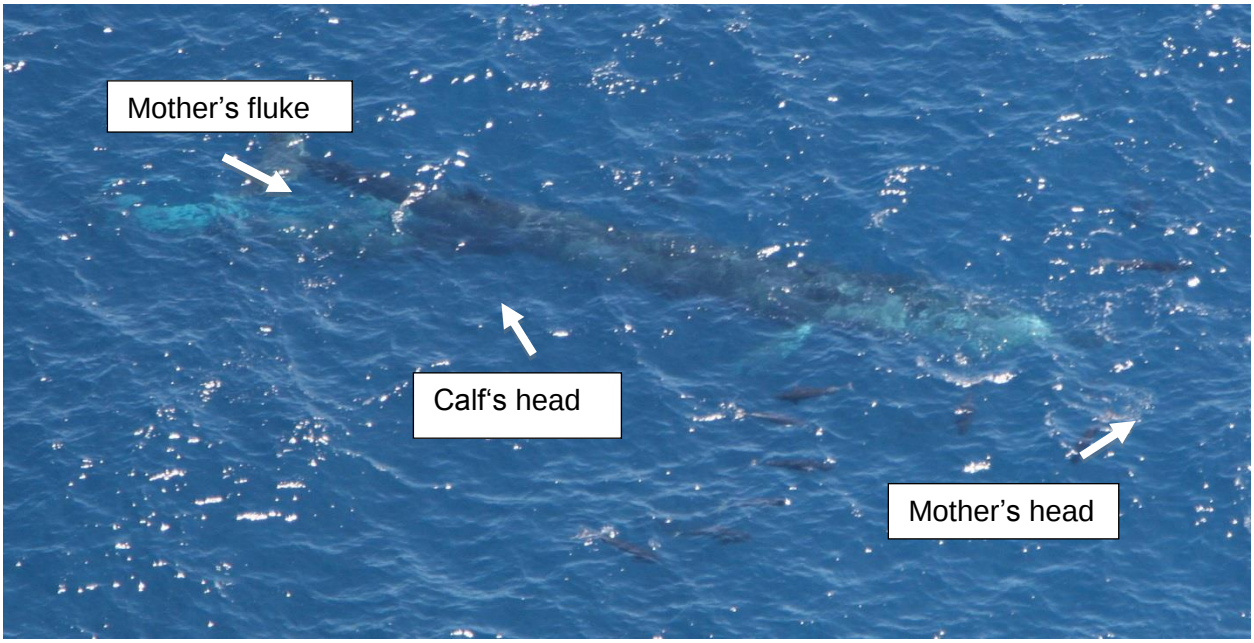


Figure 2. Apparent nursing by a fin whale calf (on upper left with white-colored ventral area visible below surface and head oriented toward the mother's teat area; mother's body is dark-colored to right) on 6 June 2009. Photograph by Lori Mazucca, NMFS permit 14451.

Figure 3. Same fin whale mother-calf pair as depicted in Figure 2, following and interacting with northern right whale dolphins on 6 June 2009. Photograph by Lori Mazucca, NMFS permit 14451.

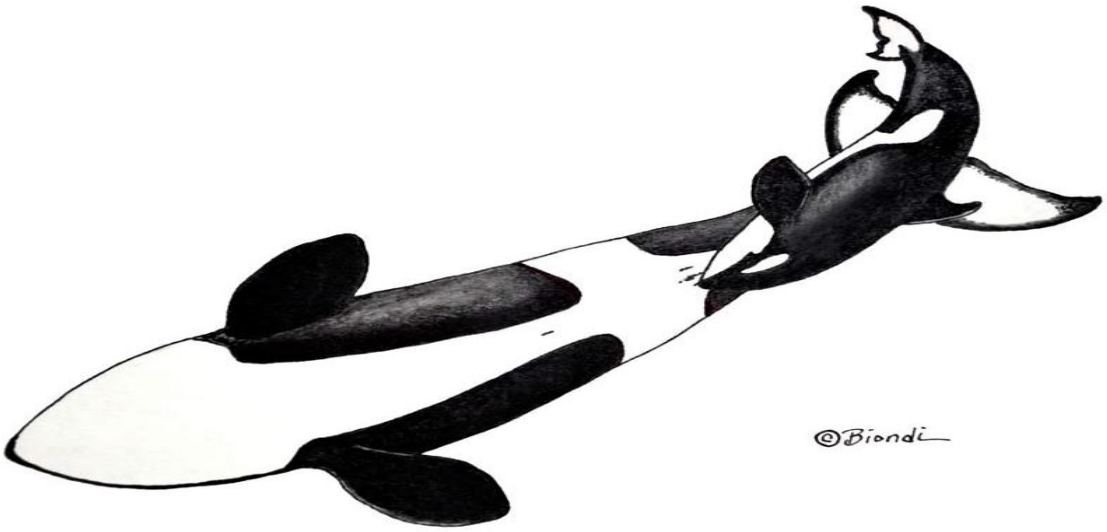
Fin Whale: Nursing and Back-Riding

On 6 June 2009, we conducted a 50 min focal follow on a fin whale mother-calf pair as they closely followed an estimated 1,000 northern right whale dolphins (*Lissodelphis borealis*) approximately 28 km from shore over a bottom depth of 785 m. The fin whale pair traveled southwest at a mean speed of 6.6 km/hr, always at the rear of the dolphin group. The calf was approximately two-thirds the mother's BL and always remained within one mother BL next to or ahead of her. The mother-calf pair was visible at or near the water surface for 84% of the 50 min video-recorded focal follow. Apparent nursing was observed and photographed when the calf swam below the mother's peduncle/teat area in a generally perpendicular position relative to the mother including with the calf ventral-side up (Figure 2). Apparent nursing occurred for periods of 31 – 138 s (Table 1), while the calf remained below the surface as intermittently visible on the video. The calf occasionally appeared to play with individual dolphins by moving towards the dolphins and initiating physical contact with its head (Figure 3). The calf rode the mother's back on 10 occasions (M = 21 s, SD = 13.8, n = 10), equally split between the left and right sides of the mother (Table 1).

Killer Whale: Nursing

On 21 November 2009, we circled a group of 55 killer whales (including three calves and a yearling) in three subgroups as they traveled slowly southeast at a mean speed of 10.4 km/hr approximately 28 km from shore over a bottom depth of about 785 m. These individuals were likely from the offshore killer whale ecotype based on group size, location, and "closed" saddle patches (K. Balcomb, Center for Whale Research, personal communication, 19 January 2013). Approximately 250 photographs were taken, three images which captured apparent nursing among the same adult female and a smaller apparent yearling in two different nursing positions. The first position involved the adult and yearling lying on their sides, parallel to each other. Flukes were oriented in the same direction, and the whales' ventral sides faced each other while the yearling's rostrum was positioned at the adult's peduncle area. The whales were underwater, but the yearling's posterior end was at the surface (Figure 4A). In the second position, the adult swam on her back with the yearling lying on top of her. Again, their bodies exhibited the same orientation, and the yearling's rostrum was positioned at the adult's teat area while the adult was completely submerged. The yearling was also submerged, except for the dorsal fin (Figure 4B). Each of the two nursing positions lasted about 4 – 5 min. Apparent nursing was based on the position of the yearling's mouth in proximity to the accompanying adult female's teats, the prolonged travel in this position, reports of similar nursing positions in captive killer whales (Asper, Young, & Walsh, 1988; Clark & Odell, 1999), the yearling's estimated age, and review of the photos by killer whale experts (K. Balcomb and D. Ellifrit, Center for Whale Research, personal communication, 19 and 22 January 2013, respectively).

A)



B)

Figure 4. Two positions of a presumed mother killer whale nursing her yearling calf. **A)** Ventral-swimming calf nursing from ventral-swimming mother. **B)** Dorsal-swimming calf nursing from ventral swimming mother. Drawn from photographs taken off Southern California on 27 November 2009.

Discussion

Our observations of apparent nursing and back-riding behavior were characterized by definable parameters that may also be useful indices of potential human disturbance/threat. This information facilitates recognition of critical behavior in the wild relative to implementation of management regulations specifically aimed at protecting cetacean mother-calf pairs. Comparisons of our observations with other studies suggest several patterns for apparent nursing and back-riding among mysticetes and killer whales that contribute to further understanding of mother-calf behaviors: (1) mother-calf positions were similar among mysticete species with a few exceptions, and were similar for captive and free-ranging killer whales; (2) apparent nursing and back-riding always included the mother and calf remaining within one-half adult BL of one another; (3) back-riding occurred relatively frequently; (4) durations of apparent nursing were similar to the few mysticetes with available data; and (5) no preference for side of the mother (left or right) was evident among our small back-riding observation sample for mysticetes, in contrast to available data on killer whales and beluga whales.

Apparent Nursing

Our literature review revealed descriptions of nursing among at least 27 cetacean species or sub-species (Table 2). Duration of apparent nursing varies within and across mysticetes in the wild based on comparisons of our data with the few studies where data were systematically recorded. Among our gray, blue, and fin whale sightings, apparent nursing duration ranged from 13 to 264 s (Table 1). The longest gray whale apparent nursing duration was 76 s (M = 45 s, SD = 0.5, n = 3). The blue whale mother-calf pair had the two longest apparent nursing durations of 260 and 264 s (M = 149 s, SD = 2.2, n = 4), followed by the fin whale mother-calf pair at 138 s (M = 90 s, SD = 0.9, n = 3). In comparison, six nursing submergences (measured as time from submergence to apparent nursing position to surfacing) for a bowhead whale calf previously separated from its mother for at least 71 min ranged from 10 to 27 s (M = 15.8, SD = 6.37; Würsig et al., 1985). Apparent nursing submergences of South Atlantic right whale calves less than one-year-old ranged from < 90 s as newborns to typically 90 – 120 s for yearlings (Thomas & Taber, 1984). South Atlantic right whale infants also appeared to nurse at the mother's teat area for shorter periods (M = 2.7 s, SD = 3.6, n = 21) than yearlings (M = 6.8 s, SD = 11.3, n = 3) (Thomas & Taber, 1984).

Our observations of a female killer whale swimming on her back with a yearling swimming above her and bumping her teat area during apparent nursing is similar to published accounts of observations of nursing among captive and free-ranging killer whales (Asper et al., 1988; Clark & Odell, 1999; Condy, Van Aarde, & Bester, 1978), and unpublished video-documented observations (i.e., drone flight video [Press, 2015]). Based on the size/age of the yearling in our observations, it is also possible that the mother rolled onto her back to terminate the nursing session, as similarly suggested occasionally for South Atlantic right whales (Payne, 1995; Payne & Dorsey, 1983; Sironi, 2004; Thomas & Taber, 1984). Comparable behavior was observed among both captive and free-ranging killer whales in which, nursing occurred when the calf swam on its side at about a 45-degree angle with its mouth placed on either teat (Asper et al., 1988; Clark & Odell, 1999).

Back-riding by Calves

We observed a calf riding the presumed mother's back near the peduncle area among blue, fin, and gray whales. Back-riding behavior by calves previously was reported for an additional five cetacean species (Table 2 herein) (Hain, et al., 2013; Morete, Bisi, & Rosso, 2007; Pilleri & Chen, 1979; Thomas & Taber, 1984; Würsig, Koski, & Richardson, 1999). The diversity of cetacean species that display back-riding by calves supports the hypothesis that its adaptive benefits include locomotion energy savings for the calf via "drafting," particularly for young, less-agile calves, and during migration (e.g., Caron, 1987;

Noren, 2008; Swartz, 1986; Taber & Thomas, 1982; Würsig et al., 1999). Back-riding also appears to serve adaptive significance during the critical first few months of a calf's life by facilitating physical contact and close proximity to the mother for protection while the calf is in its early, vulnerable developmental stages (Krasnova, Bel'kovich, & Chernetsky, 2006). As documented among many mammals (e.g., Trivers, 1974), proximity of cetacean mothers and young calves and duration traveling near the mother decreases with increasing calf age, corresponding to larger size and increased calf dexterity (e.g., Cartwright, 2005; Krasnova et al., 2006; Mann & Smuts, 1999; Thomas & Taber, 1984). Although we found no laterality preference for back-riding among the four mysticete mother-calf pairs we observed, beluga and killer whale calves preferred the right side of their mothers while swimming, a bias attributed to right-hemispheric advantage resulting in left eye social preference, as described in other vertebrates and cetaceans (e.g., Karenina, Giljov, Ivkovich, Burdin, & Malashichev, 2013; Krasnova et al., 2006).

Human-related activities involving underwater noise in the marine environment (e.g., seismic airguns, oil drilling, naval sonar, vessel traffic, pile driving, tourism) under some circumstances and received sound levels disturb and interrupt feeding, socializing, resting and diving patterns of cetaceans (e.g., Lundquist, Gemmell, & Würsig, 2012; Melcón et al., 2012; Richardson et al., 1995; Southall et al., 2007), including mother and calf humpback whales (Lebrón, 2012; Morete et al., 2007). Anthropogenic disturbance of nursing by cetacean calves has not been demonstrated. However, Morete et al. (2007) noted the absence of back-riding and less rest and fewer active behavioral events (e.g., rolling) by humpback whale calves within 100 m of vessels. In response to close (< 10 m) boat approaches, killer whale mothers shifted calf position from their right to their left side; the authors suggested that this response improved sensory information flow from the calf to the mother's left eye, resulting in right brain hemisphere advantage in visual acuity/responsiveness to a potential threat (Karenina et al., 2013). Calf laterality in mysticetes may also provide a quantitative measure of disturbance, though we did not find any lateral bias in our small sample size. Interruption of nursing and back-riding is of special concern given the endangered or threatened status of many large whale species, especially relative to the high-energy needs of fast-growing mysticete calves (e.g., Lebrón, 2012; Lockyer, 1981; Oftedal, 1997). Cumulative such disruptions could risk calf survival. To minimize and avoid such disturbance, a standardized definition of encompassing critical behavior is needed to ascertain and minimize such impacts.

Our small sample sizes reflect the difficulties inherent in observing whale mother-calf behavior in the wild. We describe herein how back-riding and apparent nursing occur when mother-calf whale pairs are in close proximity. Although we did not observe milk in the water, we believe that nursing likely occurs during this time. We thus recommend that mother-calf pairs not be disturbed when within one-half adult BL of each other. As such periods represent time that could be spent nursing or in other key behaviors including supported rest, protection of this behavior directly influences the potential survival of young in large cetaceans. Recent progress in the use of drones equipped with video cameras over clear waters (e.g., Durban, Fearnbach, Barrett-Lennard, Perryman, & Leroi, 2015), and at distances unlikely to disturb whales and dolphins, should provide further details on important cetacean mother-calf behavioral interactions, though ascertaining the exchange of milk may still be problematic. Notwithstanding, we provide rare descriptions and summary statistics for apparent nursing and back-riding in the wild by calves for the endangered blue and fin whale, and the gray and killer whale. Apparent nursing and back-riding as defined herein are biologically important behaviors that should not be interrupted by anthropogenic activities. Since accounts of nursing and back-riding behavior by free-ranging cetaceans are limited, our descriptions provide an important contribution of available information to identify and define mother-calf interactions biologically important to survival.

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Appendix A

Table A1
Reports of Apparent Nursing (N) or Back-Riding (B) By Cetacean Calves in Free-Ranging and Captive Environments

Species	**Source**
North Atlantic Right Whale (*Eubalaena glacialis*)	Foley et al., 2011 (B); Hain et al., 2013 (N,B); Hamilton & Cooper, 2010 (N)
South Atlantic right whale *Eubalaena australis*	Best et al., 2015 (N); Patenaude, 2000 (B); Santillian et al., 2004 (N); Thomas & Taber, 1984 (B); Van Waerebeek et al., 1998 (N);;
Bowhead whale *Balaena mysticetus*	Boertmann & Nielsen, 2010 (N); Carroll & Smithhisler, 1980 (N,B); Richardson et al., 1990 (N,B); Würsig & Clark, 1993 (N,B); Würsig et al., 1983, 1984, 1985, 1986, 1999 (N,B)
Blue whale *Balaenoptera musculus*	Dana Point Whalewatching, 2016; Dykstra, 2013 (N); Giradeau, 2015 (N); National Geographic, 2016 (N); Torres & Klinck, 2016 (N)
Fin whale *Balaenoptera physalus*	Edds & MacFarlane, 1987 (N)
Bryde's whale *Balaenoptera edeni/brydei*	Notarbartolo di Sciara, 1983 (N); Steiner et al., 2007 (N)
Humpback whale *Megaptera novaeangliae*	Bauer, 1986 (N); Cartwright, 2005 (N,B); Cartwright & Sullivan, 2009 (N); Deakos et al., 2010 (B); Clapham & Mayo, 1987 (N); Edel & Winn, 1978 (B); Ferreira et al., 2014 (B); Glockner & Venus, 1983 (N); Glockner-Ferrari & Ferrari, 1984, 1985 (N,B); Lefèvre et al., 1999 (N); Morete et al., 2003 (N); Scammon, 1874 (N); Uwagbae & Van Waerebeek, 2010 (N) Van Waerebeek et al., 2001 (N)
Gray whale *Eschrichtius robustus*	Busch, 1998 (N); Reeves et al., 2010 (B); Swartz, 1986 (B); Sychenko, 2011 (N)
Sperm whale *Physeter macrocephalus*	Bennett, 1840 (N); Berzin, 1972 (N); Best et al., 1984 (N); Bullen, 1889 (N); Dudley, 1725 (N,B); Gero & Whitehead, 2007 (N); Gordon, 1987, 1991 (N); Johnson et al., 2010 (N); Whitehead, 2003 (N)
Beluga whale *Delphinapterus leucas*	Béland et al., 1990 (B); Campbell, 2011 (N); Caron, 1987 (N,B); Chapskii, 1941 (as cited in Norris & Dohl, 1980) (B); Drinnan & Sadlier, 1981 (N); Hewlett, 1978 (N); Krasnova et al., 2006 (N,B); Leung et al., 2010 (N); Russell et al., 1997 (N); Sergeant & Brodie, 1975 (B); Tomilin, 1967 (B)
Killer whale *Orcinus orca*	Asper et al., 1988 (N); Clark & Odell, 1999a (N); Condy et al., 1978 (N); Haenel, 1986 (N); Jacobsen, 1986 (N); Press, 2015 (N); Visser, 2000 (N)
Pilot whale *Globicephala* sp.	Starrett & Starrett, 1955 (N)
Short-finned pilot whale *Globicephala macrorhynchus*	Hofmann et al., 2004 (N)
False killer whale *Pseudorca crassidens*	Clark & Odell, 1999b (N)

Table A1 (cont.)

Rough-toothed dolphin *Steno bredanensis*	Kuczaj & Yeater, 2007 (N)
Dusky dolphin *Lagenorhynchus obscurus*	Deutsch, 2008 (N); Markowitz, 2012 (N)
Bottlenose dolphin (*Tursiops truncatus* and *T. aduncus*)	Amundin, 1999 (N); Barlowe et al., 2001 (N); Caldwell & Caldwell, 1972 (N); Chirighin, 1987 (N); Clugston, 1974 (N); Cockcroft & Ross, 1990 (N); Essapian, 1953 (N); Dohl et al., 1974 (N); Dudok van Heel & Meyer, 1974 (N); Eastcott & Dickinson, 1987 (N); Fellner, 2000 (N); Gubbins et al., 1999 (N); Gurevich, 1977 (N); Jacobsen et al., 2003 (N); Kastelein et al., 1990 (N); Mann & Smuts, 1999 (N); Mann et al., 2000 (N); McBride & Kritzler, 1951 (N); Mello et al., 2005 (N); Morisaka et al., 2005, 2010 (N); Peddemors et al., 1992 (N); Rakhmawati, 2013 (N); Reid et al., 1995 (N); Ridgway et al., 1995 (N); Sakai et al., 2016 (N); Schroeder, 1990 (N); Stensland & Berggren, 2007 (N); Tavolga & Essapian, 1957 (N); von Streit et al., 2011, 2013 (N); Wells, 1991 (N)
Hybrid: bottlenose and rough-toothed dolphin	Dohl et al., 1974 (N); Norris & Dohl, 1980 (N)
Atlantic spotted dolphin *Stenella frontalis*	Dudzinski, 1996 (N); Miles & Herzing, 2003 (N)
Spinner dolphin *Stenella longirostris*	Johnson & Norris, 1994 (N); Norris & Dohl, 1980 (N); Silva Jr. et al., 2005 (N)
Short-beaked common dolphin *Delphinus delphis*	Schaffar-Delaney, 2004 (N)
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	ZooBorns, 2012 (N)
Humpback dolphin *Sousa plumbea*	Saayman & Tayler, 1979 (N)
Commerson's dolphin *Cephalorhynchus commersonii*	Joseph et al., 1987 (N); Kastelein et al., 1993 (N); Sakai et al., 2013 (N)
Finless porpoise *Neophocaena phocaenoides*	Chen et al., 1979 (B); Kasuya, 1999 (B); Liu et al., 1986 (B); Pilleri & Chen, 1979 (B); Wei et al., 2002 (B); Xian et al., 2010 (N, B): Xian et al., 2012 (N)
Harbor porpoise *Phocoena phocoena*	Camphuysen & Krop, 2011 (N); Johnson et al., 2010 (N)

Note. Previously published records were reviewed and some did not meet criteria for inclusion. For example, a source that stated that suckling or nursing was observed without any detailed behavioral description (e.g., angle of the calf relative to the mother) was excluded. For example, Williamson (1961) states that suckling was observed, but no details were provided to confirm that interpretation, and this publication was considered suspect and is not presented in the table. Video documenting nursing (as defined herein) is included in this table.

Appendix A References

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