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Evidence that sperm whale (*Physeter macrocephalus*) calves suckle through their mouth

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All mammals feed their young through lactation, and have evolved a secondary palate to allow for simultaneous nursing and breathing (Clutton-Brock 1991). While evolving a suite of secondary adaptations to a life in water, cetaceans have maintained nursing through the voluntary ejection of milk into the mouth of the calf, which dives beneath the mother to suckle (Fig. 1). So despite some changes in the volume per energy ratio of the ingested milk and shorter suckling times compared to other mammals due to limited breath-holding capabilities of young calves (Ridgway *et al.*



Figure 1. Porpoise calf suckling its mother by placing its mouth over the mammary slit (photograph by Fjord and Belt, Kerteminde, Denmark).

1995), it is generally believed that cetacean offspring ingest milk through their oral cavity in a way similar to terrestrial mammals (Clutton-Brock 1991). Despite the unusual head anatomy of the sperm whale, observations by both 19th century whalers and more recent, brief observations by snorkelers, suggest that the calf dives subsurface and rolls under the adult female's underbelly to get the nipple in the gape of the its jaw (Beale 1839, Best *et al.* 1984, Gordon 1987) in the same way as other cetaceans (Fig. 1) (Drinnan and Sadleir 1981, Eastcott and Dickinson 1987, Russell *et al.* 1997).

However, published photo-documented observations of the suckling behavior of sperm whale calves is lacking, and the hypertrophied nose of the sperm whale could therefore be envisioned to force sperm whale calves to suckle differently than other marine mammals. To alleviate this, Gero and Whitehead (2007) recently reported observations on sperm whale calves with the aim of developing a more complete ethogram of infant sperm whale behavior during suckling. They observed repeated peduncle diving bouts from several different calves along with direct observations of underwater interactions between a young calf and its mother. No observations of attempts by the calf to make oral contact with the nipple area of the mother were made. Instead, the calf was seen repeatedly to arch down without rolling onto its side and move its head under the belly of its mother and press its blowhole to the mother's genital area (Gero and Whitehead 2007).

Gero and Whitehead (2007) then carefully listed possible explanations for why they may have missed observing oral suckling of the calf, but concluded that current

assumptions about suckling behavior in sperm whales need to be reevaluated. They advanced the alternative hypothesis that sperm whale calves could suckle nasally through their single blowhole pressed against the nipple slit area of the mother. This implies that suckling by sperm whale calves is done in a completely different way than all other studied mammals. Gero and Whitehead (2007) speculated that the mother may actively eject milk into the left nasal passage *via* the calf's open blowhole. Subsequently, they proposed that the calf, upon returning to the surface, opens the blowhole by which the milk is emptied into the nasopharyngeal pouch, past a dilated palatopharyngeal sphincter, and into the buccal cavity and the esophagus. This elaborate process presents a provoking and intriguing hypothesis that is founded on the lack of observations of oral suckling, but with repeated observations of the calf with its nose against the nipple slit area of the mother.

However, crucial observations to test this hypothesis are, despite concerted effort by Gero and Whitehead (2007), missing. To uncover how sperm whale calves suckle, and test the nasal suckling hypothesis of Gero and Whitehead (2007) it seems relevant to address two questions: (1) can sperm whale calves suckle with their mouth? and (2) do they use their mouth for suckling in the wild? Here, we report observations of the suckling behavior of sperm whale calves. Two neonate calves were observed during rehabilitation attempts and two calves were filmed in the wild, interacting with nursing females.

One of us (SR) spent several hours in the water with two neonatal sperm whales during attempts at rehabilitation, sound recording, and hearing testing (Ridgway and Carder 2001). The first whale calf, dubbed Odie, was being fed with a special formula with a tube inserted into the mouth. The calf was observed wrapping its tongue around the tube and making sucking motions. Between feedings, this calf often approached and actively sucked a person's finger or even their entire hand. The suction was very strong with the whale's tongue in the usual U-shape and the hand pressed between the tongue and palate. This sucking behavior was very similar to that experienced with bovine calves or with neonatal bottlenose dolphins (*Tursiops truncatus*) (Ridgway *et al.* 1995). The second sperm whale calf was not being fed, however, the suckling reflex was obvious when a finger was inserted into the mouth. Thus sperm whale calves have a suckle reflex with their mouth as any other juvenile mammal and will readily ingest milk through the mouth.

It is thus clear that neonate sperm whales can suckle and ingest milk orally as demonstrated by the animals in rehabilitation, but will a nursing neonate calf behave the same way when ingesting milk in the wild? Video footage taken on two occasions along the Hellenic Trench (Greece, Mediterranean Sea) strongly indicates that they do (Fig. 2, 3). While onboard the R/V *Nereis*, of the Pelagos Cetacean Research Institute, a social unit of 13 sperm whales was observed over several days in the Ionian Sea (19–23 July 2007). Among its members was a neonate, estimated to be 24–48 h old, with umbilical cord still attached. On 23 July two of us (CJ, GJ) observed and recorded underwater suckling attempts by the calf while the group was socializing near the surface. Video was recorded on a Sony HVR-Z1U HDV camera (Sony, Japan), in 1080i mode at 25 frames per second (1,440 × 1,080 pixels interlaced expanded to 1,920 × 1,080 pixels). The camera was housed in an underwater video

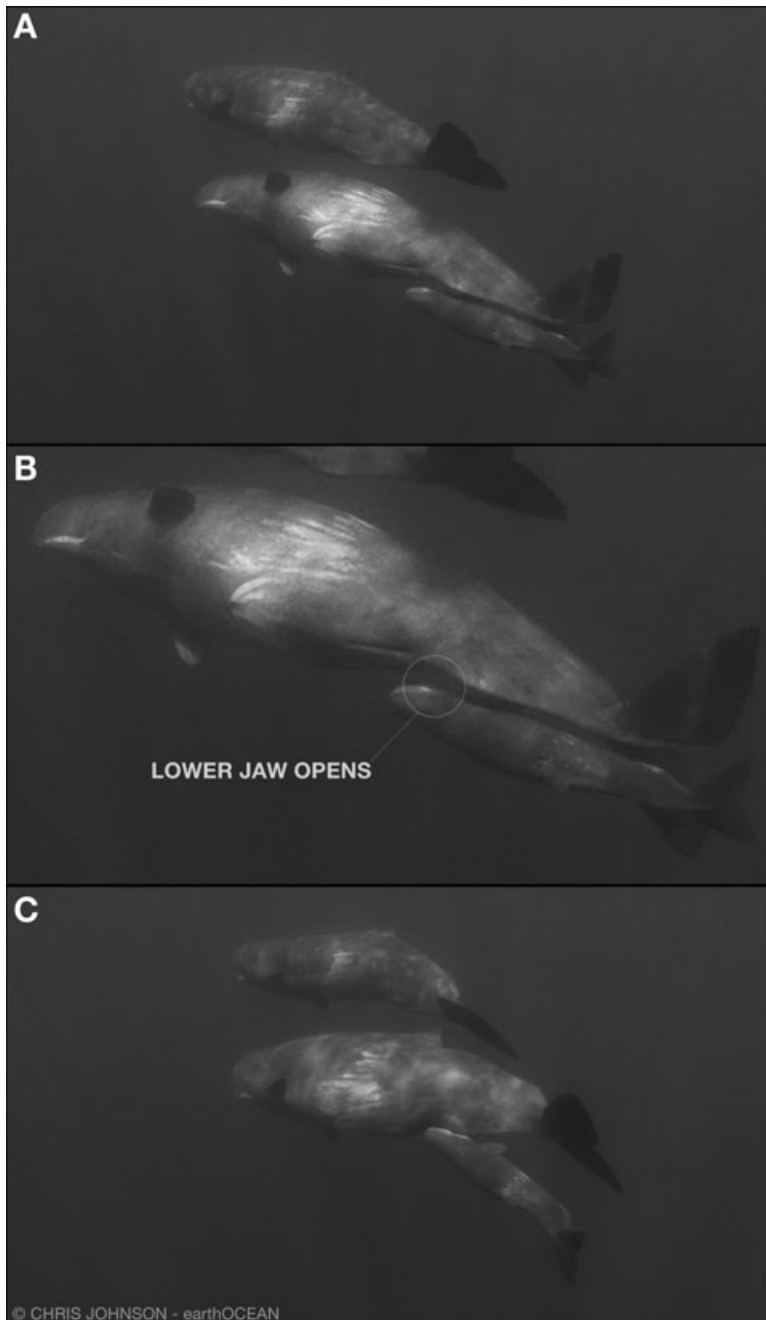


Figure 2. Orientation of oral contact with mammary inferred to be sperm whale suckling. (A) Neonate sperm whale calf approaches the mammary slit of an adult female. (B) When close to the right mammary slit, it opens its mouths and hangs on for a few seconds (C).

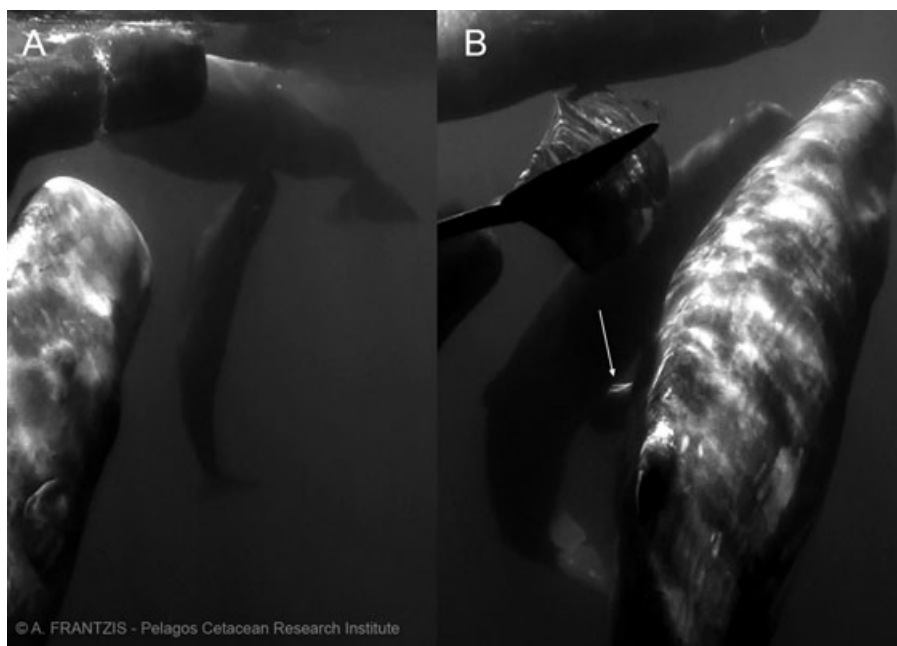


Figure 3. Calf approaches nursing female (A), and opens its mouth around the mammary slit (B). Forty-five seconds separate the two frames. Arrow points to gape of calf.

housing (Phenom VHFZX106, Ampibico, Montreal, Canada) with a Phenom 94° wide-angle lens.

The neonate was observed and filmed in an oral suckling position on two separate occasions with the same nursing female. On both occasions the nursing female rolled on her side with her belly facing the observers. The calf approached from behind and rolled laterally to its left, its blowhole outermost and facing away from the female as it positioned itself close to the nursing female's genital area (Fig. 2). For 2–3 s before the female and calf separated, the neonate's jaw opened momentarily, but was mostly obscured by the head of the calf. The position and behavior are consistent with that observed in other suckling cetaceans (Ridgway *et al.* 1995) (Fig. 1), suggesting that the calf was suckling, or at least attempting to suckle through its mouth (Fig. 2). The same sequence of movements was observed moments later. Footage is available for viewing at <http://earthocean.tv/sperm-whale-calf-nursing/>.

A second observation of a suckling attempt by a calf (approximately 5.5-m long) was made by one of us (AF) while with another socializing unit on 3 August 2008. This time the video was recorded on SONY SRV-12 HDV camera (Sony, Japan) in 1080i mode at 25 frames per second (1,920 × 1,080 pixels). Although another whale mostly obscured the view of the suckling calf, it was clearly observed to open its mouth under the female's genital area (Fig. 3). This nursing female was positioned perpendicular to the water surface with its head pointing up, and the calf was parallel to the water surface facing upside down (Fig. 3).

In combination, these *in situ* observations strongly suggest that sperm whale calves interacting with their mothers or escorting females do suckle with their mouths as also reported by Beale (1839), Best *et al.* (1984), and Gordon (1987). We thus find that the most parsimonious explanation for the observations at hand is that all sperm whale calves suckle with their mouth. We also observed the contact between the calf forehead (both left and right) and the nipple area of the mother seen by Gero and Whitehead (2007) on several occasions. We argue that this behavior is not suckling, but a mammary bump (Miles and Herzing 2003), as also proposed by Gero and Whitehead (2007), likely akin to the milk releasing mechanical stimulation that many infant mammals engage in (Lent 1974). This, then begs the question of why Gero and Whitehead (2007) never observed mouth suckling despite careful observations. Gero and Whitehead (2007) point out themselves that successful suckling may have failed due to the presence of the research vessel and the underwater snorkelers. If that scenario is correct, it may be envisioned that: (1) the calf is hiding beneath the mother or (2) that it was repeatedly “head butting,” but the mother did not release milk perhaps due to the presence of the research vessel.

If the mechanism proposed by Gero and Whitehead (2007) is indeed correct for older calves, the nasal suckling hypothesis can be tested by observing the behavior of a calf when it returns to the surface after a peduncle dive. They proposed that the calf needs to return to the surface after each filling of the left nasal passage to open the blowhole and let the milk run to the esophagus. If that inference is correct, the calf should not exhale immediately after returning to the surface, but first open the blowhole to move the milk and then subsequently exhale. So, if a calf returning to the surface after a nursing dive exhales immediately when the blow hole opens, the nasal suckling hypothesis is falsified in our view.

We conclude from observations of three neonate calves and one older calf that the most parsimonious explanation for the observations at hand is that sperm whales suckle through their mouths, like other mammals, and not *via* their nasal complex as proposed by Gero and Whitehead (2007). Despite the specialized anatomy of the sperm whale nose, it has thus not likely evolved as an organ that also offers an alternate way of suckling, but rather as a complex generator of sound (Norris and Harvey 1972, Madsen *et al.* 2002, Wahlberg *et al.* 2005), even in neonates (Madsen *et al.* 2003), to be used for echolocation (Møhl *et al.* 2003) and communication (Weilgart and Whitehead 1997).

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