## **Short Note**

## Importance of Social Relationships in a Group of Bottlenose Dolphins (*Tursiops truncatus*) During a Natural Disaster

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Bottlenose dolphins (*Tursiops truncatus*) are found in coastal waters throughout much of the world. Their abundance and proximity to coastlines has resulted in considerable scientific study of dolphin social structure, including mother-calf relationships and social development (e.g., Wells et al., 1980, 1987; Wells, 1991, 2003; Mann & Smuts, 1999; Connor et al., 2000b; Grellier et al., 2003; Gibson & Mann, 2008; Sargeant & Mann, 2009; Connor, 2010; Mann et al., 2012; Cantor & Whitehead, 2013). Numerous studies have revealed that bottlenose dolphin social life is quite complex and is best characterized as a fissionfusion society (Connor et al., 2000b; Marino, 2002; Cantor & Whitehead, 2013).

The longevity of most small odontocetes can exceed 50 y (O'Shea & Odell, 2008). Sexual maturity for female bottlenose dolphins ranges from 5 to 13 y, and the range is 8 to 13 y for males (Connor et al., 2000b). Dolphin mothers may nurse their young as long as 4 y, an extended period of dependency that allows individuals ample opportunity to acquire the skills and aptitude necessary for life in a complex social environment (Gibson & Mann, 2008). Calf survival depends on a strong bond between an adult female and her offspring, although the nature and strength of this bond varies across mother-calf dyads (Hill et al., 2007). Separation times increase as calves mature by traveling to varying but increasing distances from the mother to engage in numerous activities, including play and socializing (Mann & Smuts, 1999). Maturing calves become more independent, spending more time socializing with other individuals, particularly peers of the same general age (Mann & Smuts, 1999; Kuczaj et al., 2006).

Living in a fission-fusion society, individuals interact in often changing small groups, but they maintain relationships within the larger community (Connor et al., 2000b). Individuals join and leave groups on a fluid basis, with associations lasting minutes to years (Wells et al., 1987; Smolker et al., 1992). Upon weaning and the birth of another calf, bottlenose dolphin mothers typically depreciate association with their calves (Miles & Herzing, 2003); the calf establishes new bonds within the fluid social system (Gibson & Mann, 2008). Some male bottlenose dolphins preferentially associate with other males, forming complex social connections that can last for years (Wells, 1991; Smolker et al., 1992; Connor et al., 2000a; Möller et al., 2001; Lusseau, 2007). These hierarchical, multilevel male alliances are complex and can range from two to 14 dolphins, depending on the level (Connor, 2007, 2010; Gibson & Mann, 2008). Adult females also form stable associations and nursery groups with other females, often including matrilineal kin (Wells, 1991; Connor et al., 1992; Mann & Smuts, 1999; Mann et al., 2000; Gibson & Mann, 2008). Highly stable patterns of association exist-not only between mothers and calves, but also among female kin for some bottlenose dolphin groups (Wells et al., 1987; Mann & Smuts, 1999).

Bottlenose dolphins in captivity have exhibited a similar social structure as that described in the literature for wild dolphins (Dudzinski, 2010; Dudzinski et al., 2010, 2012, 2013). Although life in an oceanarium environment may differ from the wild with respect to distance ranged, complex social relationships are still observed among captive dolphins (e.g., Bruck, 2013; Yeater et al., 2013). As has been observed in the wild, captive bottlenose dolphins form social hierarchies (McBride & Hebb, 1948) and exhibit dominance relationships (Samuels & Gifford, 1997). Possibly related to the limited number of conspecifics with which to form strong associations, any individual change or loss in a captive group could have a severe impact on the group's social structure or relations (Waples & Gales, 2002). Captive facilities often find it necessary to add or remove an animal from a social group for management considerations (Burks et al., 2001). These animal movements could be considered similar to the fluidity of a fission-fusion society in the wild. Loss of a close associate, change in the dominance hierarchy, or introduction of a new individual are all likely to affect the social behavior of small groups more so than larger groups. However, most dolphinaria house small dolphin groups to provide optimal compatibility and breeding control. Just as young bottlenose dolphin males may form stable bonds with individuals in the wild (Connor et al., 2000a; Gibson & Mann, 2008), captive bottlenose dolphin males are placed in the most stable social structure available in the facility. In a captive environment, careful consideration is often given when forming or changing social groups to provide a healthy and stress-free social environment (Waples & Gales, 2002).

The observations documented herein occurred by chance. Our goal is to describe the opportunistic behavior of eight bottlenose dolphins living in a captive environment when a natural disaster struck. These dolphins were abruptly shifted into the wild, outside their familiar surroundings, during Hurricane Katrina. The hurricane made landfall as a strong Category 3 storm (estimated wind speeds of 190 km/h) just west of Gulfport, Mississippi, on 29 August 2005 (Fritz et al., 2007; Schott et al., 2012). Gulfport was located in the dangerous northeast quadrant of the storm and received the highest storm surge (7.5 m) in U.S. recorded history for this area (Federal Emergency Management Agency [FEMA], 2006). The dolphins survived the storm without regular feeding sessions or the attention of the husbandry staff to which they had become accustomed. This social dolphin group seemed to respond to storm conditions by remaining together, providing indirect support to the importance of their social relationships.

The subjects were 14 bottlenose dolphins housed at MarineLife Oceanarium in Gulfport. Six dolphins were evacuated inland to local hotel swimming pools, while the remaining eight dolphins were housed in an above ground main pool for the storm. These eight individuals included five dolphins resident to the main pool and three additional dolphins moved from an in-ground bay pool during hurricane preparations. This main pool was approximately 8.25 m above sea level. Storm surge was estimated to be between 8 to 9 m (Fritz et al., 2007) with 1 to 3 m waves added to the surge. Thus, the combined surge and wave height yielded an overall water height of 9.9 to 11.7 m at the facility. This water level was high enough to dislodge the dolphins from the main pool into the Mississippi Sound in the Gulf of Mexico.

The dolphins housed in the main pool prior to storm preparations included two older, experienced mothers, "Jackie" and "Kelly," both 31 y old (definition consistent with Mann & Smuts, 1998); Kelly's offspring ("Noah," 6 y); Jackie's offspring ("Elijah," 4 y); and "Michelle," a younger, slightly less experienced mother with no offspring in that pool (Table 1). The other three dolphins added to this pool immediately prior to the storm included an adult female ("Jill," 40 y) and two other younger females ("Toni," 17 y, daughter to Jackie;

 Table 1. The dolphins residing at MarineLife Oceanarium when Hurricane Katrina struck the Gulf Coast in 2005; W/C born

 = wild/captive born.

Dolphin name	Age class	Sex	W/C born	Age (y)	Location prior to storm	Location during storm	Experienced mothers
Jackie	Adult	F	Wild	31*	Main pool	Main pool	Yes
Kelly	Adult	F	Wild	31*	Main pool	Main pool	Yes
Michelle	Adult	F	Wild	20*	Main pool	Main pool	Yes
Jill	Adult	F	Wild	40*	Bay pool	Main pool	Surrogate**
Tamara	Adult	F	Wild	21*	Bay pool	Main pool	No
Toni	Adult	F	Captive	17	Bay pool	Main pool	No
Noah	Juvenile	М	Captive	6	Main pool	Main pool	
Elijah	Juvenile	М	Captive	4	Main pool	Main pool	

\*The wild-caught dolphins' ages are calculated from their estimated date of birth as reflected in their health records.

\*\*Jill did not have any biological offspring, but she did "adopt" calves by nursing and swimming with abandoned calves that were uncared for by their biological mothers.

and "Tamara," 21 y-all nulliparous). Though she never had her own calf, Jill spent 15+ y with the two most experienced mothers (Jackie and Kelly). Indeed, Jill had been observed exhibiting allomaternal care (Tizzi et al., 1999). On two occasions, when first-time mothers abandoned their infants, Jill brought them to the surface to breathe and established a maternal swimming pattern until the mothers returned, swimming with Jill and the calf and staying with the calf once Jill left them alone. Jill also spontaneously lactated to nurse a calf of a female who became ill and unable to properly care for her offspring. Adoption and surrogacy behavior have been documented in several instances of orphaned bottlenose dolphin calves (Smolders, 1988; Kastelein et al., 1990; Ridgway et al., 1995). Of the eight dolphins housed together in the main pool during Hurricane Katrina, three were captive born, while the others had been at the facility for the majority of their lives (Table 1).

As the storm intensity and wind speed began to slow, the facility's director of animal care returned and became aware that these eight dolphins were gone from the pool and were now somewhere in the Mississippi Sound. It was not possible to search for them until 12 d following storm landfall. (For a timeline of recapture events, see Table 2.) The first search for the dolphins was conducted by boat and helicopter with trainers very familiar with the individuals and their identification details. Within the first 30 min, the helicopter crew sighted a small group of dolphins just outside Gulfport Harbor. The rescue boat was directed to this group, and trainers used two blasts of their whistles to call the dolphins-two whistle blasts is a discriminative stimulus for their "recall" behavior.

Immediately, Michelle surfaced and stationed in front of the bow. Another dolphin oriented toward the boat, then another, until all eight dolphins were "stationed" at the boat. They were grouped together and at ~900 m from where their pool had been located before the storm. All eight dolphins were located during that initial search; and on subsequent days, they came as a group to the boat where they were fed, examined, and treated medically as best as possible. We believe it was possible that the three most experienced adult females (Jill, Kelly, and Jackie) kept the group together based on the following observations:

- Due to the spillage of shipping cargo containers containing chicken into the Sound, sharks were visually in abundance.
- The oldest and most physically fit females, Jill and Kelly, always came in following the group and remained stationed approximately 4 to 5 m behind the others as the others stationed and ate next to the boat. Mann & Barnett (1999) documented a bottlenose dolphin mother apparently defending her calf from a shark, which may be related to the grouping behavior that we observed with Jill and Kelly always stationing or milling about 4.6 m behind the others.
- There were numerous wild dolphins continuously in the immediate area. They could be seen all around, coming right up to but staying just outside the group. We never witnessed any animals ever make their way past Kelly and Jill into the group as feeding and training were taking place. This may be interpreted as a defensive or possible care-giving behavior by the experienced mothers. There have been other examples of epimeletic or care-giving behavior in dolphins, specifically in assisting sick or injured conspecifics or calves (e.g., Caldwell & Caldwell, 1966; Warren-Smith & Dunn, 2006; Howells et al., 2009).

Table 2	2. Timel	line of im	portant	events
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Date	Event			
29 Aug 2005	Hurricane Katrina made landfall in Gulfport, Mississippi, as a Category 3 storm.			
29 Aug 2005	The 14 dolphins housed at MarineLife Oceanarium during the storm were deemed missing, presumably in the Mississippi Sound.			
10 Sept 2005	Dolphins first sighted from boat and first training session in Mississippi Sound.			
15 Sept 2005	First attempt to collect dolphins from Mississippi Sound; Jackie and Jill beached on mats on the boar and were taken to the Holiday Inn pool.			
16 Sept 2005	Noah beached on mats on the boat and was taken to the Holiday Inn pool.			
17 Sept 2005	U.S. Navy personnel set up pools at the Navy Base in Gulfport. Three dolphins were moved from the Holiday Inn pool to the Navy Base. Kelly beached on mats and was transferred to the Navy pools.			
18 & 19 Sept 2005	Search continued for remaining dolphins, but they were not found.			
20 Sept 2005	Remaining four dolphins rescued (in order: Tamara, Michelle, Jill, and Elijah) and brought to the Navy pools.			

• When the trainers signaled the dolphins from the boat, they all approached from the same direction but appeared to have been dispersed and engaged in milling often within a ~100 m radius. However, the two young juveniles, Noah and Elijah, were found side-by-side each time they were observed. The observations of these two young males always together supports the idea that peer social bonding or alliance formation is important in young male dolphins (Connor et al., 2000b; Kuczaj et al., 2006; Yeater et al., 2013).

Rescue and re-collection of the dolphins was facilitated by operant conditioning. Two large floating mats were tied together and anchored to the sea bottom where trainers could feed and train the dolphins. Beaching on command was used to bring dolphins onto the mats, and they were then extracted one at a time onto the rescue boat. The dolphins were collected in a certain order to minimize the potential disruption of the group as a whole. Jackie and Toni were re-collected first because they were of most concern health-wise. Jackie was very thin and was having difficulty holding station due to the current. Toni had the most wounds on her body, possibly from roofing material falling into the main pool.

The first rescue attempt on 15 September 2005 was made several days after the initial sighting (see Table 2 for timeline). From the rescue boat, Jackie and Toni were loaded onto stretchers and transported by boat to inland hotel pools. The next day (16 September 2005), the plan was to collect Noah and Elijah. Noah was rescued first because of his compliance with trainers. Once Noah was collected and taken to the hotel pool, Elijah was alone without his peer. Unfortunately, Elijah did not cooperate with voluntary beaching behavior. Although the removal of Noah was a large change in the social grouping, we had predicted that Kelly and Jill (the experienced mothers) would likely be observed in close proximity to Elijah, especially with his mother Jackie also being gone. In the past, Kelly often swam with Elijah.

On 17 September 2005, a team from the U.S. Navy Marine Mammal Program arrived to set up temporary pools with improved water filtration and security on the military base. Elijah continued to not cooperate and was not re-collected voluntarily. After much deliberation by Oceanarium staff and government agencies, it was determined that as many remaining dolphins as could be quickly recaptured must be removed from the Sound due to another tropical storm headed in our direction. Kelly was collected next, which led to what we perceived as a pronounced change in the social structure for the remaining dolphins because we knew from past experiences that Kelly was a leader. She would always be the one to lead the other animals in perceived dangerous situations. The remaining dolphins were Jill, Elijah, Michelle, and Tamara.

The next 2 d (18 and 19 September 2005), the dolphins were not where they had been for the previous 16 d. The exact reason for their move is unknown, but it could have been due to an increase in sharks in the area (due to increased food debris from the Dole plant) coupled with the change in their social group with the removal of the other four dolphins. On 20 September 2005, several boats went out to locate the missing dolphins. They were found in Biloxi, Mississippi, ~13 km away but only about 10 m offshore. It was a quiet area with no sign of sharks. Jill and Elijah were close together with Michelle following close by. Once sighted, Tamara was the only individual to station immediately on command, and she was rescued. As we worked with Tamara, Jill led Michelle and Elijah further out into the Sound. Once the last three dolphins were reacquired and the mats were set up, we stationed the dolphins and used a net to encompass the mats and dolphins. Michelle was first to beach and be collected. The trainers sent Jill from the station. hoping she would stay with Elijah to keep him from getting too close to the net. Jill's past behavioral experience demonstrated allomaternal care, so it was plausible that she might "care" for Elijah during this potentially stressful event. The likelihood of Elijah beaching voluntarily was becoming slim; therefore, Jill was collected next as boats were ready if Elijah hit the net. As soon as Jill was beaching on the mat, Elijah became entangled in the net. The awaiting crew of trainers worked diligently to remove him from the water. With only a few scratches, Elijah was in the boat with Jill on his way to the U.S. Naval Station.

These eight dolphins were put together into a new social grouping just hours before the weather forced them into the Mississippi Sound. They remained together in a group for a period of more than 17 d in the wild. These observations illustrate the importance of social relationships that were stable before, during, and after Hurricane Katrina. Even today, 11 y after the storm and after relocating to a facility in The Bahamas, trainers report that the dolphins from MarineLife Oceanarium that were displaced by Hurricane Katrina tend to remain in their own social groups, although they are currently housed with many other dolphins. Tedeschi & Calhoun (2004) describe one of the domains of post-traumatic growth for humans that involves forming closer relationships with others. Survivors of traumatic events often find support in one another. This is a possible explanation for why this group of dolphins stayed together in the wild, and maybe why they spend more time with each other even today. With the Gulf of Mexico available to them, these dolphins chose to remain within ~900 m of their prior residence. Though the water was visually populated with sharks, the only animal-related injury was from Elijah's curiosity with a stingray and a subsequent barb in his melon. Perhaps another driving force for staying together in a group was an anti-predatory response (Connor, 2000). The social group contained three long-term female associates, two mother-offspring pairs, and two juvenile peers, all of which represent strong social connections in a dolphin society (Mann & Smuts, 1999; Connor et al., 2000a). As the dolphins were re-collected one by one, they seemed to adapt to each change in their social structure and were observed to remain together. These social bonds were likely important to the survival of all of the dolphins in this non-captive setting for 17 d.

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## Literature Cited

- Bruck, J. (2013). Decades-long social memory in bottlenose dolphins. *Proceedings of the Royal Society of London B: Biological Sciences*, 280(1768). https://doi. org/10.1098/rspb.2013.1726
- Burks, K. D., Bloomsmith, M. A., Forthman, D. L., & Maple, T. L. (2001). Managing the socialization of an adult male gorilla (*Gorilla gorilla gorilla*) with a history of social deprivation. *Zoo Biology*, 20, 347-358. https:// doi.org/10.1002/zoo.1033
- Caldwell, M. C., & Caldwell, D. K. (1966). Epimeletic (care-giving) behavior in Cetacea. In K. S. Norris (Ed.), Whales, dolphins and porpoises (pp. 755-789). Los Angeles: University of California Press.
- Cantor, M., & Whitehead, H. (2013). The interplay between social networks and culture: Theoretically and among whales and dolphins. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 368(1618). https://doi.org/10.1098/rstb.2012.0340
- Connor, R. C. (2000). Group living in whales and dolphins. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead

(Eds.), Cetacean societies: Field studies of dolphins and whales (pp. 199-218). Chicago: University of Chicago Press.

- Connor, R. C. (2007). Dolphin social intelligence: Complex alliance relationships in bottlenose dolphins and a consideration of selective environments for extreme brain size evolution in mammals. *Philosophical Transactions* of the Royal Society B: Biological Sciences, 362(1480), 587-602. https://doi.org/10.1098/rstb.2006.1997
- Connor, R. C. (2010). Cooperation beyond the dyad: On simple models and a complex society. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1553), 2687-2697. https://doi.org/10.1098/ rstb.2010.0150
- Connor, R. C., Read, A. J., & Wrangham, R. (2000a). Male reproductive strategies and social bonds. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies: Field studies of dolphins and whales* (pp. 247-269). Chicago: University of Chicago Press.
- Connor, R. C., Smolker, R. A., & Richards, A. F. (1992). Two levels of alliance formation among male bottlenose dolphins (*Tursiops* sp.). *Proceedings of the National Academy of Sciences of the United States of America*, 89, 987-990. https://doi.org/10.1073/pnas.89.3.987
- Connor, R. C., Wells, R. S., Mann, J., & Read, A. J. (2000b). The bottlenose dolphin: Social relationships in a fission-fusion society. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies: Field studies of dolphins and whales* (pp. 91-126). Chicago: University of Chicago Press.
- Dudzinski, K. M. (2010). Overlap between information gained from complementary and comparative studies of captive and wild dolphins. *International Journal of Comparative Psychology*, 23, 566-586.
- Dudzinski, K. M., Danaher-Garcia, N., & Gregg, J. D. (2013). Pectoral fin contact between dolphin dyads at Zoo Duisburg, with comparison to other dolphin study populations. *Aquatic Mammals*, 39(4), 335-343. https:// doi.org/10.1578/AM.39.4.2013.335
- Dudzinski, K. M., Gregg, J. D., Paulos, R. D., Kuczaj II, S. A. (2010). A comparison of pectoral fin contact behaviour for three distinct dolphin populations. *Behavioural Processes*, 84, 559-567. https://doi.org/10.1016/j.beproc. 2010.02.013
- Dudzinski, K. M., Gregg, J. D., Melillo-Sweeting, K., Levengood, A., Seay, B., & Kuczaj II, S. A. (2012). Tactile contact exchanges between dolphins: Self-rubbing versus inter-individual contact in three species from three geographies. *International Journal of Comparative Psychology* (Special Symposium Issue 25), 21-43.
- Federal Emergency Management Agency (FEMA). (2006, May). Observations on the behavior of storm surge, waves and flooding on the Mississippi coast, Hurricane Katrina, 2005: A protocol study (Report No. FEMA-DR-1604-MS – Jackson – AFO). Retrieved from www.fema. gov/media-library-data/20130726-1713-25045-0591/ observations\_on\_the\_behavior\_of\_storm\_surge\_ waves\_and\_flooding\_on\_the\_mississippi\_coast.pdf

- Fritz, H., Blount, C., Sokoloski, R., Singleton, J., Fuggle, A., McAdoo, B., . . . Tate, B. (2007). Hurricane Katrina storm surge distribution and field observations on the Mississippi Barrier Islands. *Estuarine, Coastal and Shelf Science*, 74, 12-20. https://doi.org/10.1016/j. ecss.2007.03.015
- Gero, S., Bejder, L., Whitehead, H., Mann, J., & Connor, R. C. (2005). Behaviorally specific preferred associations in bottlenose dolphins, *Tursiops* spp. *Canadian Journal* of Zoology, 83(2), 1566-1573. https://doi.org/10.1139/ z05-155
- Gibson, Q. A., & Mann, J. (2008). The size, composition and function of wild bottlenose dolphin (*Tursiops* sp.) mother-calf groups in Shark Bay, Australia. *Animal Behaviour*, 76, 389-405. https://doi.org/10.1016/j.an behav.2008.01.022
- Grellier, K., Hammond, P., Wilson, B., Sanders-Reed, C., & Thompson, P. (2003). Use of photo-identification data to quantify mother-calf association patterns in bottlenose dolphins. *Canadian Journal of Zoology*, 81, 1421-1427. https://doi.org/10.1139/z03-132
- Gubbins, C., McGowan, B., Lynn, S., Hooper, S., & Reiss, D. (1999). Mother-infant spatial relations in captive bottlenose dolphins, *Tursiops truncatus*. *Marine Mammal Science*, 15, 751-765. https://doi. org/10.1111/j.1748-7692.1999.tb00841.x
- Hill, H., Greer, T., Solangi, M., & Kuczaj II, S. A. (2007). All mothers are not the same: Maternal styles in bottlenose dolphins (*Tursiops truncatus*). *International Journal of Comparative Psychology*, 20, 35-54.
- Howells, E. M., Reif, J. S., Bechdel, S. E., Murdoch, M. E., Bossart, G. D., McCulloch, S. D., & Mazzoil, M. S. (2009). A novel case of non-offspring adoption in a free-ranging Atlantic bottlenose dolphin (*Tursiops truncatus*) inhabiting the Indian River Lagoon, Florida. *Aquatic Mammals*, 35(1), 43-47. https://doi. org/10.1578/AM. 35.1.2009.43
- Kastelein, R., Dokter, T., & Zwart, P. (1990). The suckling behavior of a bottlenose dolphin calf (*Tursiops truncatus*) by a foster mother, and information on transverse birth bands. *Aquatic Mammals*, 16(3), 134-138.
- Kuczaj II, S. A., Makecha, R., Trone, M., Paulos, R., & Ramos, J. (2006). Role of peers in cultural innovation and cultural transmission: Evidence from the play of dolphin calves. *International Journal of Comparative Psychology*, 19, 223-240.
- Lusseau, D. (2007). Why are male social relationships complex in the Doubtful Sound bottlenose dolphin population? *PLOS ONE*, 2(4), e348. https://doi.org/10.1371/ journal.pone.0000348
- Mann, J., & Barnett, H. (1999). Lethal tiger shark (Galeocerdo cuvieri) attack on bottlenose dolphin (Tursiops sp.) calf: Defense and reactions by the mother. Marine Mammal Science, 15, 568-575. https://doi. org/10.1111/j.1748-7692.1999.tb00823.x
- Mann, J., & Smuts, B. (1999). Behavioral development in wild bottlenose dolphin newborns

(Tursiops sp.). Behaviour, 136, 529-566. https://doi. org/10.1163/156853999501469

- Mann, J., Connor, R. C., Barre, L. M., & Heithaus, M. R. (2000). Female reproductive success in bottlenose dolphins (*Tursiops* sp.): Life history, habitat, provisioning, and group-size effects. *Behavioral Ecology*, 11, 210-219. https://doi.org/10.1093/beheco/11.2.210
- Mann, J., Stanton, M., Patterson, E., Bienenstock, E., & Singh, L. (2012). Social networks reveal cultural behavior in tool-using dolphins. *Nature*, *3*, 980. https://doi. org/10.1038/ncomms1983
- Marino, L. (2002). Convergence of complex cognitive abilities in cetaceans and primates. *Brain, Behavior and Evolution*, 59, 21-32. https://doi.org/10.1159/000063731
- McBride, A., & Hebb, D. (1948). Behavior of the captive bottle-nose dolphin, *Tursiops truncatus. Journal of Comparative and Physiological Psychology*, 41, 111-123. https://doi.org/10.1037/h0057927
- Miles, J., & Herzing, D. (2003). Underwater analysis of the behavioural development of free-ranging Atlantic spotted dolphin (*Stenella frontalis*) calves (birth to 4 years of age). *Aquatic Mammals*, 29(3), 363-377.
- Möller, L. M., Beheregaray, L. B., Harcourt, R. G., & Krützen, M. (2001). Alliance membership and kinship in wild male bottlenose dolphins (*Tursiops aduncus*) of southeastern Australia. *Proceedings of the Royal Society* of London B: Biological Sciences, 268, 1941-1947. https://doi.org/10.1098/rspb.2001.1756
- O'Shea, T., & Odell, D. (2008). Large-scale marine ecosystem change and the conservation of marine mammals. *Journal of Mammalogy*, 89, 529-533. https://doi. org/10.1644/07-MAMM-S-416R.1
- Parsons, G., & Hoffmayer, E. (2007). Identification and characterization of shark nursery grounds along the Mississippi and Alabama gulf coasts. *American Fisheries Society Symposium*, 50, 301-316.
- Reid, K., Mann, J., Weiner, J., & Hecker, N. (1995). Infant development in two aquarium bottlenose dolphins. *Zoo Biology*, 14, 135-147. https://doi.org/10.1002/zoo. 1430140207
- Ridgway, S., Kammolick, T., Reddy, M., Curry, C., & Tarpley, R. (1995). Orphan-induced lactation in *Tursiops* and analysis of collected milk. *Marine Mammal Science*, *11*, 172-182. https://doi.org/10.1111/j.1748-7692.1995. tb00516.x
- Samuels, A., & Gifford, T. (1997). A quantitative assessment of dominance relations among bottlenose dolphins. *Marine Mammal Science*, 13, 70-99. https://doi. org/10.1111/j.1748-7692.1997.tb00613.x
- Sargeant, B. L., & Mann, J. M. (2009). Developmental evidence for foraging traditions in wild bottlenose dolphins. *Animal Behaviour*, 78, 715-721. https://doi. org/10.1016/j.anbeav.2009.05.037
- Schott, T., Landsea, C., Hafele, G., Lorens, J., Taylor, A., Thurm, H., . . . Zaleski, W. (2012). *The Saffir-Simpson hurricane wind scale*. Retrieved from www.nhc.noaa. gov/pdf/sshws.pdf

- Smolders, J. (1988). Adoption behaviour in the bottlenose dolphin. Aquatic Mammals, 14(2), 78-81.
- Smolker, R. A., Richards, A. F., Connor, R. C., & Pepper, J. W. (1992). Sex differences in patterns of association among Indian Ocean bottlenose dolphins. *Behaviour*, *123*, 38-69. https://doi.org/10.1163/156853992X00101
- Tedeschi, R., & Calhoun, L. (2004). Posttraumatic growth: Conceptual foundations and empirical evidence. *Psychological Inquiry*, 15, 1-18. https://doi.org/10.1207/ s15327965pli1501\_01
- Tizzi, R., Trombetti, C., & Pace, D. S. (1999). Alloparental care in *Tursiops truncatus*: A case report. *European Research on Cetaceans*, 12, 182-190.
- Waples, K. A., & Gales, N. J. (2002). Evaluating and minimizing social stress in the care of captive bottlenose dolphins (*Tursiops aduncus*). Zoo Biology, 21, 5-26. https:// doi.org/10.1002/zoo.10004
- Warren-Smith, A., & Dunn, W. (2006). Epimeletic behavior toward a seriously injured juvenile dolphin (*Tursiops* sp.) in Port Phillip, Victoria, Australia. *Aquatic Mammals*, 32(2), 357-362. https://doi.org/10.1578/AM. 32.2.2006.357
- Wells, R. S. (1991). The role of long-term study in understanding the social structure of a bottlenose dolphin community. In K. Pryor & K. S. Norris (Eds.), *Dolphin* societies: Discoveries and puzzles (pp. 199-225). Los Angeles: University of California Press.
- Wells, R. S. (2003). Dolphin social complexity: Lessons from long-term study and life history. In F. B. M. de Waal & P. L. Tyack (Eds.), *Animal social complexity: Intelligence, culture, and individualized societies* (1st ed., pp. 32-56). Cambridge, MA: Harvard University Press. https://doi. org/10.4159/harvard.9780674419131.c4
- Wells, R. S., Irvine, A. B., & Scott, M. D. (1980). The social ecology of inshore odontocetes. In L. M. Herman (Ed.), *Cetacean behavior: Mechanisms and functions* (pp. 263-317). New York: John Wiley & Sons.
- Wells, R. S., Scott, M. D., & Irvine, A. B. (1987). The social structure of free-ranging bottlenose dolphins. In H. G. Genoway (Ed.), *Current mammalogy*, Vol. 1 (pp. 247-305). New York: Plenum Press. https://doi. org/10.1007/978-1-4757-9909-5\_7
- Yeater, D., Miller, L., Caffery, K., & Kuczaj II, S. A. (2013). Effects of an increase in group size on the social behavior of a group of rough-toothed dolphins (*Steno bredanensis*). Aquatic Mammals, 39(4), 344-355. https://doi. org/10.1578/AM.39.4.2013.344