

## Lateralized behavior in a captive beluga whale (*Delphinapterus leucas*)

Lori Marino and Jennifer Stowe

*Department of Biology, Emory University, Atlanta, GA 30322, USA*

There have been few systematic studies of behavioral laterality in cetaceans. Lateralized behavior (i.e. a consistent preference or bias for one movement direction or one side of the body) exists in a number of nonhuman species (Springer & Deutsch, 1989; Bradshaw & Rogers, 1993; Hopkins & Morris, 1993, for reviews). In humans, population-level lateralized behavior (e.g. handedness) is associated with functional asymmetries in such complex processes as language (Springer & Deutsch, 1989). Such findings are important for understanding the evolution of the brain in general and for revealing underlying functional asymmetries in other species that are similar to those in humans.

Those studies on cetacean laterality that do exist point compellingly to the possibility that the level of behavioural asymmetry in some cetaceans is on a par with that in humans and other primates. Studies of gray (*Eschrichtius robustus*) and humpback whales (*Megaptera novaeangliae*) strongly suggest a population-level right-side bias in bottom-feeding (Kasuya & Rice, 1970; Clapham, Leimkuhler, Gray & Mattila, 1995) and flipper slaps (Clapham *et al.*, 1995, in gray whales). Also, numerous reports suggest that wild coastal bottlenose dolphins (*Tursiops truncatus*) exhibit a right-side-down bias when intentionally beaching themselves in order to feed on fish herded ashore (Hoese, 1971; Norris & Dohl, 1980; Rigley, Vandyke & Cram, 1981; Rigley, 1983; Caldwell & The Dolphin Project, 1993; Petricig, 1993; Silber & Fertl, 1995).

Assessments of behavioral laterality in captive odontocetes (i.e. *T. truncatus*, *Lagenorhynchus* sp., *Pseudorca crassidens*, *Orcinus orca*, and *Cephalorhynchus* sp.), though limited, are consistent with a right eye viewing preference under certain conditions (Ridgway, 1986) and a bias towards a counterclockwise swimming direction (Caldwell, Caldwell & Siebenaler, 1965; Ridgway, 1972, 1986) which would place the right eye in a position to access important visual information in the direction of the outer wall of the pool (Ridgway, 1986).

Sobel, Supin, and Myslobodsky (1994) reported consistent counterclockwise circling in captive bottlenose dolphins. However, our own observations (Marino & Stowe, 1997) of two healthy seven-year-old captive-born male bottlenose dolphins (*T. truncatus-aduncus*) revealed a predominance of clockwise swimming (as viewed from above). Both subjects swam in a clockwise direction during all 36 hours of recorded behavior across a ten-day period. Swimming direction did not differ when either subject swam with the other or alone. There was also a consistent 'clockwise' bias in the directionality of 'barrel roll' approaches. However, there was no evidence for a directional bias in circular head movements. No discernible tilt in either subjects' dorsal fin was ever evident, as has been reported for other captive bottlenose dolphins (Ridgway, 1986).

The present study is an assessment of the relationship between swimming direction and spinning and turning direction in a healthy thirteen-year-old male captive beluga whale (*Delphinapterus leucas*) across 10 two-hour observation sessions within a two-week period at the Aquarium for Wildlife Conservation in Brooklyn, New York. The subject was collected from Hudson Bay at the approximate age of three.

The subject does not have any known visual problems in either eye. Although formal vision tests have not been carried out, the subject often stopped at the observation window to view small novel items on the other side of the window and showed a shutting response in both eyes when it crossed the observation window and a sudden movement was made behind it. These observations can be interpreted as indicating good underwater visual acuity in our subject. Also, training personnel reported no visual problems in the past. Swimming direction was defined as the direction of the subject's circular forays around the pool, where a foray was defined as any type of swimming around the edge of the pool that covered at least one lap around the pool. It should be noted that this manner of swimming around the periphery of the pool was the

predominant way in which the subject swam around the pool. Spinning direction referred to the direction of the turn axis during a 'barrel-roll' (or corkscrew) maneuver. Turning direction referred to leftward or rightward lateral turns of the head and body that resulted in changes in direction either for a very short or longer period of time. The direction of swimming, turning, and spinning is defined as it appears when viewed from above.

The beluga spent 79% of his time swimming in a clockwise direction and 14.7% of his time swimming in a counterclockwise direction. The remainder of the time was spent feeding, stationing, and moving at random. These percentages were consistent across all sessions within the two-week period. Thus, these findings are consistent with the predominant clockwise direction found in bottlenose dolphins in our previous study.

A Chi-square ( $\chi^2$ ) analysis of rightward and leftward spins of the beluga demonstrated a significant overall preference for leftward spins,  $\chi^2(1)=6.92$ ,  $P<0.01$ . There was a significant overall preference for rightward turns,  $\chi^2(1)=7.70$ ,  $P<0.01$ , but there was a significant interaction between swimming direction and turning and spinning. Specifically, a two-way  $\chi^2$  analysis of the relationship between swimming direction and spinning direction revealed there was a marked preference for leftward spins when swimming clockwise,  $\chi^2(1)=9.47$ ,  $P<0.01$ . (The frequency of spins during counterclockwise swimming was too low for a preference to be determined by statistical analysis, but the frequency of rightward spins during counterclockwise swimming was greater than the frequency of leftward spins.) The phi coefficient for this analysis was 0.38 indicating that 14.5% of the variance was accounted for by the relationship between swimming direction and spinning direction.

A two-way  $\chi^2$  analysis of turning and swimming direction revealed there was a marked preference for leftward turns when swimming clockwise, as viewed from above, and a preference for rightward turns when swimming counterclockwise,  $\chi^2(1)=47.55$ ,  $P<0.01$ . The phi coefficient for this analysis was 0.55 indicating that 30.25% of the variance was accounted for by the relationship between swimming direction and turning. Therefore, our results revealed a clear relationship between swimming direction and spinning and turning direction, at least within the two-week period of observation.

Our observations of a predominant clockwise swimming direction in our subject are generally inconsistent with most of the published observations. The present findings are consistent, however, with our own observations of another captive odontocete, *T. truncatus* (Marino & Stowe, 1997). Nevertheless, in the present study, we observed that

swimming direction typically reversed when a novel stimulus or situation was encountered, e.g. the appearance of an unfamiliar person at the beluga's underwater window. This finding is somewhat consistent with reports that newly captured dolphins swim in a counterclockwise direction before habituating to their new environment (Townsend, 1914; Caldwell *et al.*, 1965). After habituation to the novel circumstances, however, our beluga subject always resumed a clockwise swimming direction. Finally, although the effects of a mild clockwise water current in the tank in which our subject was maintained are largely unknown, two studies of captive dolphins strongly suggest that water current does not have an effect on an established swimming direction (Ridgway, 1972; Marino & Stowe, 1997).

The results of the present study provide evidence for a consistent clockwise swimming direction in a captive beluga whale. Furthermore, this study shows that there is a significant relationship between overall swimming direction and the direction of spins and turns. Finally, these results support the findings of other studies which have suggested that a novel situation or stimulus is associated with a temporary change in swimming direction.

Overall, the present findings add to the growing evidence for behavioral laterality in cetaceans, and although not directly applicable, are tentatively consistent with evidence for neuroanatomical asymmetry in other cetacean species (Morgane & Jacobs, 1972; Ridgway & Brownson, 1979, 1984). Future studies should be conducted with larger sample sizes and longitudinal assessments of individual subjects in order to gain a better understanding of the consistency, extent, and strength of behavioral laterality in cetacean species. Furthermore, comparative studies of both captive and free-ranging dolphins are important for determining whether there are any reliable behavioral differences between captive and free-ranging animals of the same species.

#### Acknowledgements

We would like to thank the administration and training personnel of the Aquarium for Wildlife Preservation, as well as Diana Reiss, Sari Vernon, and Laurie Pels.

#### References

- Bradshaw, J. & Rogers, L. (1993) The evolution of lateral asymmetries, language, tool use, and intellect. Academic Press: San Diego.
- Caldwell, M. C., Caldwell, D. K. & Siebenaler, J. B. (1965) Observations on captive and wild Atlantic bottlenosed dolphins, *Tursiops truncatus*, in the

- Northeastern Gulf of Mexico. *Los Angeles County Museum Contributions in Science* **91**, 1–10.
- Caldwell, M. & The Dolphin Project (1993) Observations of mudding by Georgia bottlenose dolphins, 10th Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.
- Clapham, P. J., Leimkuhler, E., Gray, B. K. & Mattila, D. K. (1995) Do humpback whales exhibit lateralized behaviour? *Animal Behaviour* **50**, 73–82.
- Hoese, H. D. (1971) Dolphin feeding out of water in a salt marsh. *Journal of Mammalogy* **52**, 222–223.
- Hopkins, W. D. & Morris, R. D. (1993) Handedness in great apes. A review of findings. *International Journal of Primatology* **14**, 1–25.
- Kasuya, T. & Rice, D. W. (1970) Notes on baleen plates and on arrangement of parasitic barnacles of gray whale. *Scientific Report of the Whales Research Institute* **22**, 39–43.
- Marino, L. & Stowe, J. (1997) Lateralized behavior in two captive bottlenose dolphins (*Tursiops truncatus*). *Zoo Biology* **16**, 173–177.
- Morgane, P. J. & Jacobs, M. S. (1972) Comparative anatomy of the cetacean nervous system. In: R. J. Harrison (ed.) *Functional anatomy of marine mammals: volume 1*. pp. 118–244. Academic Press: London.
- Norris, K. S. & Dohl, T. P. (1980) The structure and functions of cetacean schools. In: L. M. Herman (ed.) *Cetacean behavior: mechanisms and functions*. pp. 211–261. John Wiley & Sons: NY.
- Petricig, R. O. (1993) Diet patterns of 'strand feeding' behavior by bottlenose dolphins in South Carolina salt marshes, 10th Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.
- Ridgway, S. H. (1972) *Mammals of the sea: biology and medicine*. Thomas: Springfield, IL.
- Ridgway, S. H. (1986) Physiological observations on the dolphin brain. In: R. Schusterman, J. A. Thomas & F. G. Wood (eds) *Dolphin cognition and behavior: a cognitive approach*. pp. 31–60. Lawrence Erlbaum: Hillsdale, NJ.
- Ridgway, S. H. & Brownson, R. H. (1979) Brain size and symmetry in three dolphin genera. *Anatomical Record* **193**, 664.
- Ridgway, S. H. & Brownson, R. H. (1984) Relative brain sizes and cortical surface areas in odontocetes. *Acta zoologica fennica* **172**, 149–152.
- Rigley, L. (1983) Dolphins feeding in a South Carolina salt marsh. *Whalewatcher* **Summer**, 305.
- Rigley, L., Vandyke, V. G., Cram, P. & Rigley, I. (1981) Shallow water behavior of the Atlantic bottlenose dolphin (*Tursiops truncatus*). *Proceedings of the Pennsylvania Academy of Sciences* **55**, 157–159.
- Silber, G. K. & Fertl, D. (1995) Intentional beaching by bottlenose dolphins (*Tursiops truncatus*) in the Colorado River Delta, Mexico. *Aquatic Mammals* **21**, 183–186.
- Sobel, N., Supin, A. Ya. & Myslobodsky, M. S. (1994) Rotational swimming tendencies in the dolphin (*Tursiops truncatus*). *Behavioural Brain Research* **65**, 41–45.
- Springer, S. P. & Deutsch, G. (1989) *Left brain, right brain*. W. H. Freeman & Co.: NY.
- Townsend, C. H. (1914) The porpoise in captivity. *Zoologica* **1**, 289–299.

