Title
Use of water as a tool by a beluga (Delphinapterus leucas)

Journal
International Journal of Comparative Psychology, 36(1)

ISSN
0889-3675

Authors
Tomonaga, Masaki
Mori, Tomoko
Nishimoto, Sayo
et al.

Publication Date
2023-06-15

INTERNATIONAL JOURNAL OF COMPARATIVE PSYCHOLOGY

2023, 36
Charles I. Abramson
Editor
Peer-reviewed

Use of Water as a Tool by a Beluga (*Delphinapterus leucas*)

Masaki Tomonaga [1,2], Tomoko Mori [3], Sayo Nishimoto [3], and Miho Itou [3]

[1] Japan Monkey Centre, Inuyama, Aichi, Japan

[2] University of Human Environments, Matsuyama, Ehime, Japan

[3] Port of Nagoya Public Aquarium, Nagoya, Aichi, Japan

Captive belugas (*Delphinapterus leucas*) often spit water as object play. One female beluga spit water at a ball to obtain it for play. We examined whether or not this behavior could be considered a tool-use behavior. When the ball was placed 10 cm from the poolside, the beluga poked the ball with her rostrum, while she often spit water at the ball at 50 cm. This water-spitting behavior became more predominant when the ball was placed at 30 cm or farther, corresponding to the maximum distance she could reach, suggesting her understanding of the cause-effect relationship. Next, the two balls were placed at 30 cm and 60 cm, and one was placed inside the rings, so it would not be easy to move it out by water-spitting. When the closer ball was placed in the ring, she tried to spit water at the ball farther away but without the ring, suggesting an understanding of efficiency in tool use. Furthermore, during this study, the beluga showed the behavior of throwing the ball obtained by spitting water at another one with her mouth. This generalization may be based on the causal understanding established through water-spitting.

Keywords: beluga, cetaceans, tool use, water-spitting

Belugas (*Delphinapterus leucas*) living in aquariums often spit water at the audience. This behavior is quite common and publicly well-known; so many photographs and video clips of beluga's water-spitting can be found on the Internet. At the Port of Nagoya Public Aquarium, we have frequently observed belugas showing this water-spitting behavior. Several tool-use behaviors have been reported in cetaceans (Mann & Patterson, 2013 for review). The most famous is the use of sponges by bottlenose dolphins for foraging (Krützen et al., 2005; Smolker et al., 1997). Other behaviors have also been reported as "tool use"(Mann & Patterson, 2013). Can this water-spitting behavior be considered tool use?

There are various definitions of tool-use behavior in nonhuman animals (Crain et al., 2013; St Amant & Horton, 2008). Still, the most comprehensive definition at present is "the external employment of an unattached or manipulable attached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself, when the user holds and directly manipulates the tool during or prior to use and is responsible for the proper and effective orientation of the tool" (Shumaker et al., 2011; p. 5). Tool-use behaviors that meet this definition have been observed in a wide variety of species, from insects to humans, using a variety of environmental objects (e.g., Crain et al., 2013; Shumaker et al., 2011; St Amant & Horton, 2008).

Please send correspondence to Masaki Tomonaga, University of Human Environments, Matsuyama, Ehime 790-0825, Japan. Email: masakitomonaga1964@gmail.com

Some cetaceans reportedly did not use unattached environmental objects but manipulable "amorphous materials (St Amant & Horton, 2008)" such as water, sand, and mud (see also air use by Asian elephants; Mizuno et al., 2016): for example, water-squirting foraging by Irrawaddy dolphins (Stacey & Hvenegaard, 2002), mud-ring feeding by bottlenose dolphins (Ramos et al., 2022), and bubble-net feeding by humpback whales (Smith, 1961). Also in captivity, many cetacean species show various behaviors using amorphous materials. Dolphins and belugas sometimes play by spraying water with their faces above the surface as in the case of our belugas. They also play by creating bubbles and bubble rings (Hill, 2009; Manitzas Hill et al., 2023). Most of these behaviors might be classified as object play or object manipulation rather than tool use since there is no object to be altered by these behaviors. In addition, this water-spitting may be a component of their feeding behaviors. Watts and Draper (1986) observed that the belugas of western Hudson Bay expel water after capturing capelin (cf. Kane & Marshall, 2009).

Some water-spitting behaviors are aimed at other objects. For example, unlike other dolphins, belugas expel water from their mouths in a coherent column (Marsh et al., 1989). They often spit water at people. Such aimed water-spitting is often considered a tool-using behavior in other animals. A well-known example is the foraging behavior of archerfish (Dill, 1977; Schuster et al., 2004; cf. Mann & Patterson, 2013). Archerfish spit small amounts of water towards insects, causing them to fall onto the water surface, where they can be eaten. Aimed water-spitting by belugas does not seem to have the same purpose of making other objects (or agents) alter as it does in archerfish. Instead, it can be considered as a social play using water.

In the present study, we explored tool-use aspects of water-spitting behavior in an adult female beluga, particularly in terms of causal understanding and tool efficiency (Limongelli et al., 1995; Yamamoto et al., 2013). In Tests 1 and 2, we observed how she responded differently to obtain a ball placed at various distances from the edge of the pool. In Test 3, we presented pairs of balls with different distances and obstacles and observed which ball she attempted to obtain using water-spitting to examine efficiency. In Test 4, we further examined the novel behavior that emerged during Test 3, which involved retrieving another ball using the ball obtained by water-spitting.

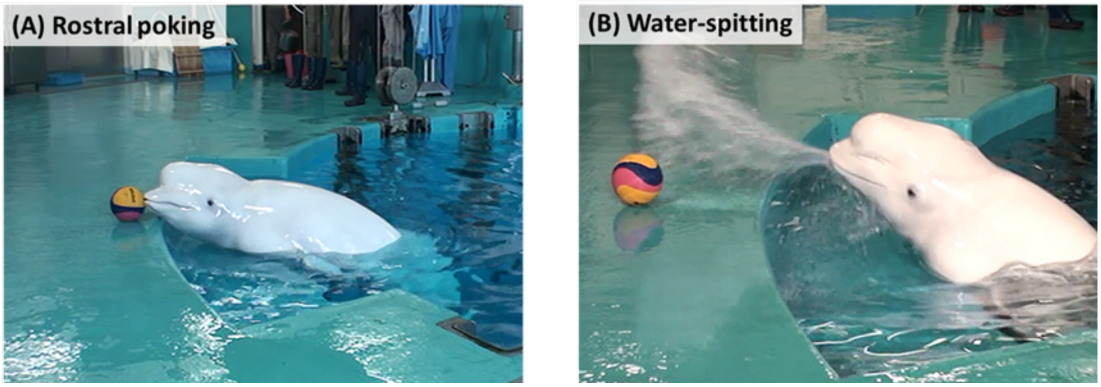
Method

Participant and Housing

Tanya, a female beluga, participated in this study (Figure 1). Tanya came to the Port of Nagoya Public Aquarium from Russia in 2001. Her estimated age at the time of this study was 18 years old. During public training, Tanya had been trained in water-spitting, ball-handling, and ball-throwing behaviors, reinforced with a piece of fish. She also often spit water at people and sometimes at other objects.

Figure 1

Experimental Setting and the Participant Beluga, Tanya



Note: (A) Showing Rostral Poking to the Ball Placed 10 cm From the Pool's Edge in Test 1. (B) Water-spitting Toward the Ball at 50 cm in Test 1.

At that time, the aquarium housed five belugas as a group. There were four pools for belugas, and the group composition was changed based on systematic breeding. At the time of this study, Tanya stayed alone in the pool in the backyard hidden from the public. The pool was elliptical (9.5 m X 7.0 m, 5.0 m in depth) with a shallow area (3.5 m X 0.7 m, 0.3 m in depth). The outer floor sloped slightly toward the pool.

Stimuli

Rubber balls for water polo (Mikasa Corporation, Hiroshima, Japan, 20 cm in diameter, 300 g in weight) were used in this study (see Figure 1). This ball was used for public training and as an object for play during the rest of the day. An approximately 30 cm diameter ring made of a 2-cm thick PVC tube and a plastic hoop (1 m in diameter) were also used in Tests 3 and 4.

Procedure

Test 1

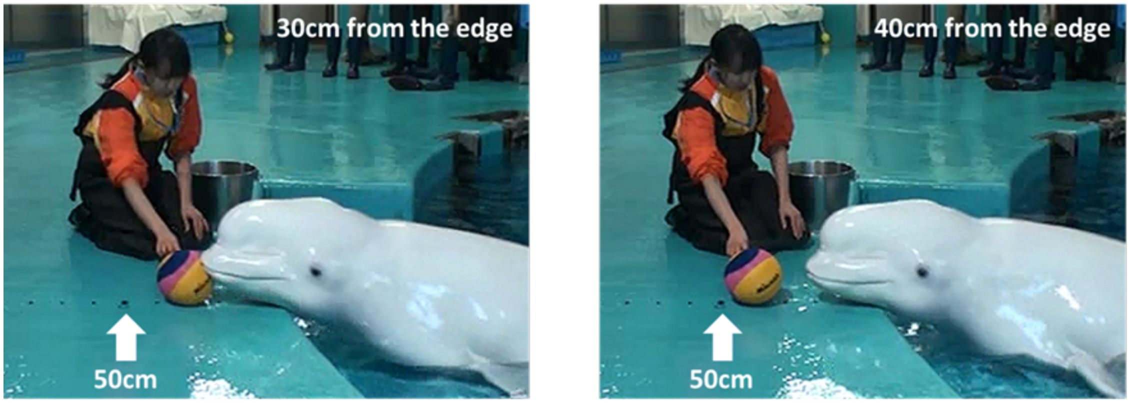
In the first test, we placed the ball 10 or 50 cm from the pool's edge and observed Tanya's behavior for 5 mins (see Figure 1). The trainer/caretaker put the ball in place and exited outdoors. These distances were initially set since Tanya could readily reach the ball using her rostrum, but she could not reach it by leaning over. To confirm these distances empirically, we conducted a supplementary test during Test 2 to measure the maximum reachable distance of her rostrum (described later). We recorded Tanya's behaviors with a video camera and later analyzed them. Sixteen trials were given per position, but if she did not obtain the ball within 5 mins, the trial was repeated later. Throughout this study, the position of the ball was randomly changed from trial to trial based on the computer-generated random sequences. Trials were conducted from once to seven times a day; the average number of daily trials was 2.7. The length of observation time, number of test trials, and the weekly testing schedule were determined in coordination with the trainer's work schedule.

Test 2

To investigate at which distance from the poolside the water-spitting behavior became dominant, we placed the ball on a 10 cm step ranging from 10 cm to 50 cm in each trial of Test 2. We repeated each position 16 times in random order as in Test 1. To confirm how far Tanya could readily reach the ball by her rostrum, we conducted a supplementary test during Test 2 to measure the maximum reachable distance of her rostrum (Figure 2).

Figure 2

Supplementary Test for the Maximum Distance That Tanya Could Reach.



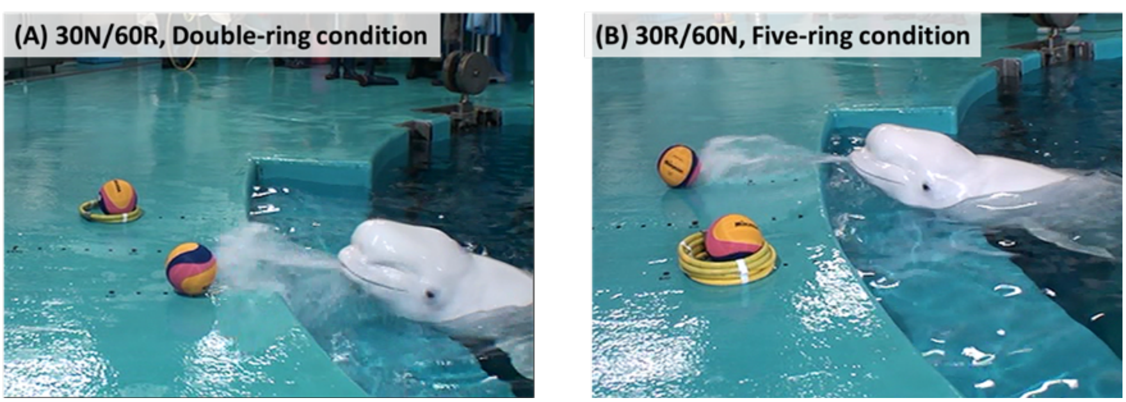
Note. Left: The Ball Was Set at 30 cm. Right: The Ball Was Set at 40 cm (She Could not Reach the Ball). White Arrow Indicates 50 cm From the Edge of the Pool.

Test 3

The third test was conducted with a two ball situation. The balls were positioned at 30 cm and 60 cm, set approximately 1 m apart. One ball was also placed inside the rings (Figure 3). We prepared two test conditions with different combinations of distance and rings: with the ring set on the 60-cm side (30N/60R, Figure 6A; N means without rings, R means with rings) and with the ring set on the 30-cm side (30R/60N, Figure 6B). In the first half of the test, a double ring was used (4 cm high), but since Tanya readily put the ball out of the ring by water-spitting, we changed to a five-ring condition as an "impossible" condition (10 cm high). In addition to the test conditions, we also prepared two control conditions: one with the same distance but with or without rings (30N/30R) and one without rings but with different distances (30N/60N). These four trial types appeared in random order. As in the previous tests, the trainer/caretaker exited outdoors after setting the balls. Sixteen trials were conducted for each condition. The first eight trials for each test/control condition were conducted under the double-ring condition, and the second eight were conducted under the five-ring condition.

Figure 3

Two Ball Test



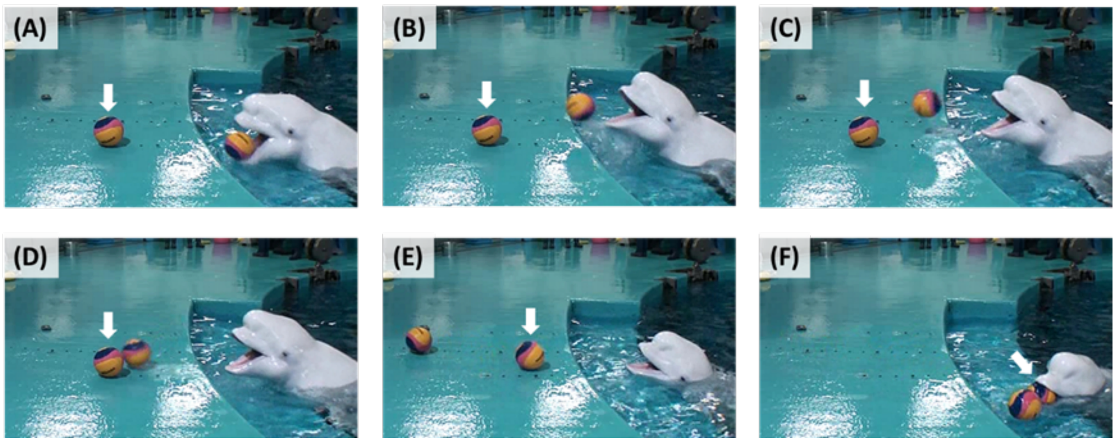
Note. (A) Tanya Spitting Water Toward the Ball at 30 cm During the 30N/60R Trials in the Double-ring Condition in Test 3. (B) Water-spitting Toward the Ball at 60 cm Without the Rings During the 30R/60N Trials in the Five-ring Condition in Test 3.

Test 4

During Test 3, Tanya began to try to obtain the remaining ball using the ball with her mouth (Figure 4). We also analyzed this behavior through video recordings. Furthermore, to observe this behavior in more detail, we conducted Test 4, the "object-use" test, after Test 3. We placed the ball at 30 cm from the pool's edge and a ball, ring, or hoop in the shallow end of the pool and observed Tanya's behavior for approximately five mins or until she obtained the second ball (Figure 5). In each trial, only one object was provided at a time, and each object was presented 12-14 times in random order.

Figure 4

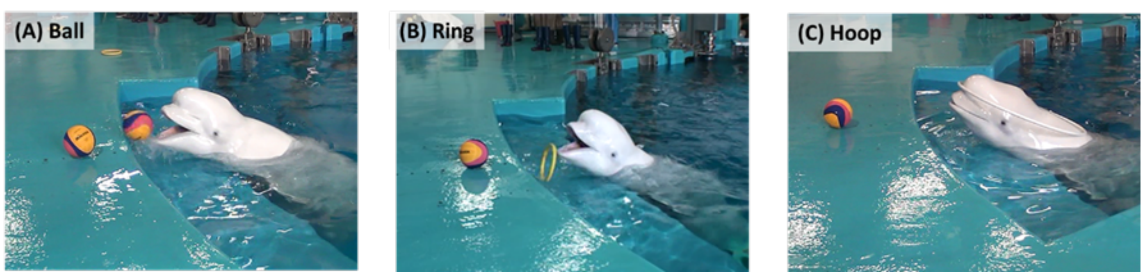
A Typical Sequence of Ball-throwing Behavior Observed During Test 3 [8th trial (30N/60N)].



Note. White Arrow Indicates the Second Ball.

Figure 5

Object-use Test (Test 4)



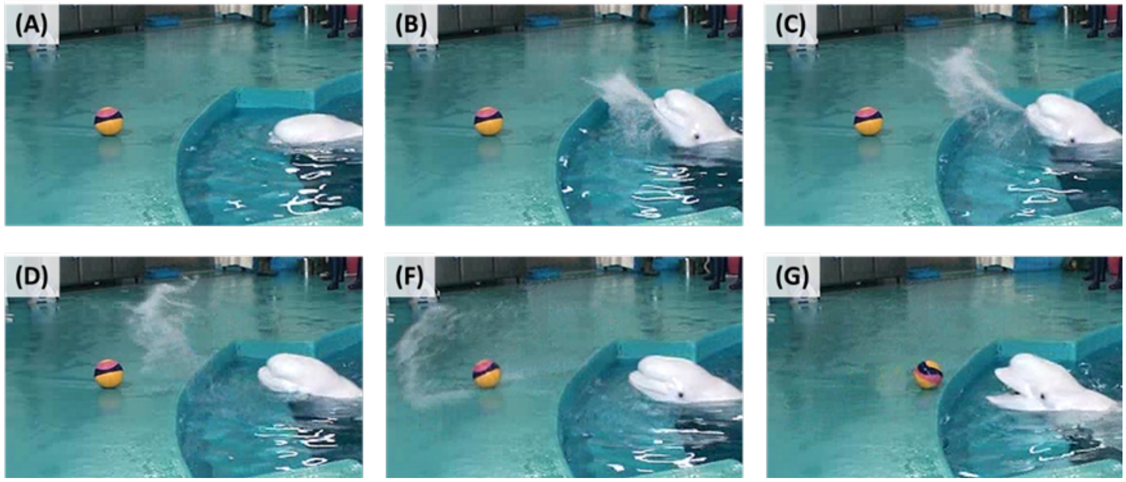
Note. (A) Tanya Throwing the Ball Toward Another Ball on the Floor in Test 4. (B) Tanya Trying to Throw the Ring in Test 4. (C) Tanya Hooking the Hoop on the Melon and Trying to Push it Toward the Poolside in Test 4.

Behavior Coding

We analyzed the video recording for each trial from when the trainer left until the beluga obtained the ball (or until the time limit). We mainly coded two behaviors. The first was "rostral poking," in which the beluga moved her body out of the water and touched or tried to touch the ball with her rostrum (Figure 1A, see Video 1). The second was "water-spitting," in which she spit water at the ball (Figure 1B, see Video 2). Figure 6 also shows a typical sequence of water-spitting. In Test 3, we also recorded which ball she had tried to obtain. Although the amount and force of water spit by the beluga were critical for analyzing this behavior, we could not measure them quantitatively. The behavior of throwing and attempting to throw an object using her mouth at the ball (i.e., toward the poolside) was also recorded as aimed-throwing (see Figure 4 and Video 4). We did not record the behavior of throwing a ball or ring into the air and catching it herself as aimed-throwing. For hoops, we defined aimed-throwing as attempting to localize the hoop toward the poolside by hooking it onto the melon since Tanya did not manipulate it with her mouth (see Figure 5C).

Figure 6

A Typical Sequence of the Water-spitting by Tanya (2nd 50-cm trial in Test 1).



The authors of the aquarium staff (T.M., S.N., and M.I.) performed data coding. The first author (M.T.) also coded the number of occurrences of each behavior in 25% of the total data to check for reliability. The interrater reliability was 92.2%.

Results

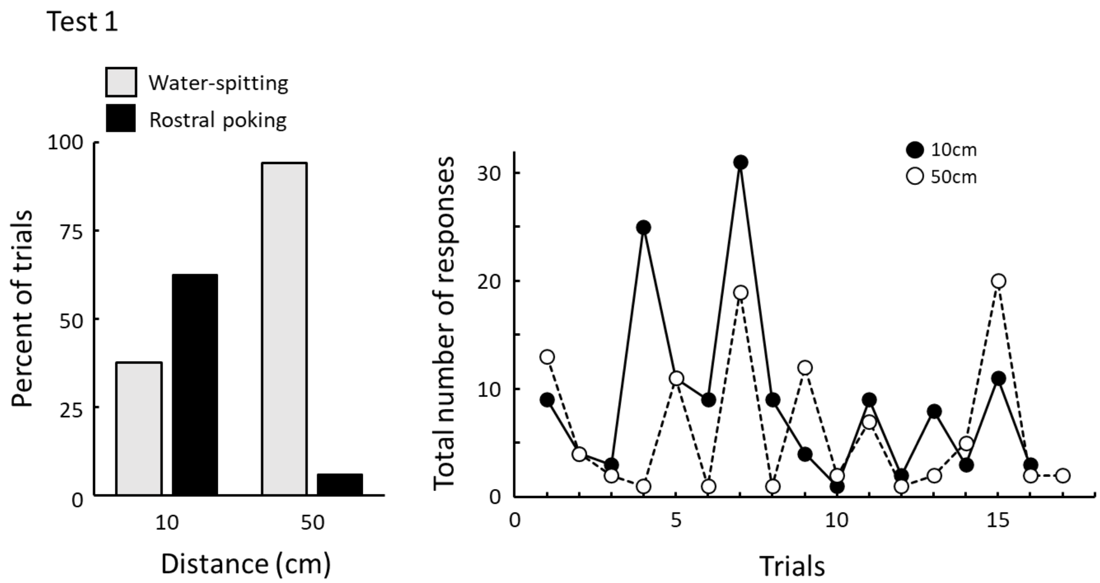
The raw data for each test is shown in the Supplementary File.

Test 1

Test 1 started with a 10-cm trial, and Tanya showed water-spitting at the ball after two attempts of rostral poking (49 s after the start of the trial, see Video 1). In the second 10-cm trial, the first response was water-spitting, but she could not get the ball. She finally obtained the ball by rostral poking. In the first 50-cm trial, the first attempt with rostral poking was followed by an immediate switch to water-spitting (see Video 2). Tanya then played with the ball she had acquired. This object-play behavior was consistently observed throughout the study. In the second trial, the water-spitting behavior was observed from the first response (see Figure 6). Tanya failed to obtain the ball only once (at 50 cm) out of the 32 trials. In that trial, the ball rolled away due to a large amount of water spit ("over-blow" error), although we could not measure the amount of water nor the force of spitting quantitatively. The left panel of Figure 7 shows the relative frequency of the first responses for each condition: water-spitting was more frequent when the ball was placed at 50 cm ($\chi^2(1) = 9.478$, $p = .002$, $\varphi = 0.536$).

Figure 7

Results of Test 1.



Note: Left: Relative Frequency of First Responses for Each Condition. Right: The Total Number of Responses for Each Distance as a Function of Trials.

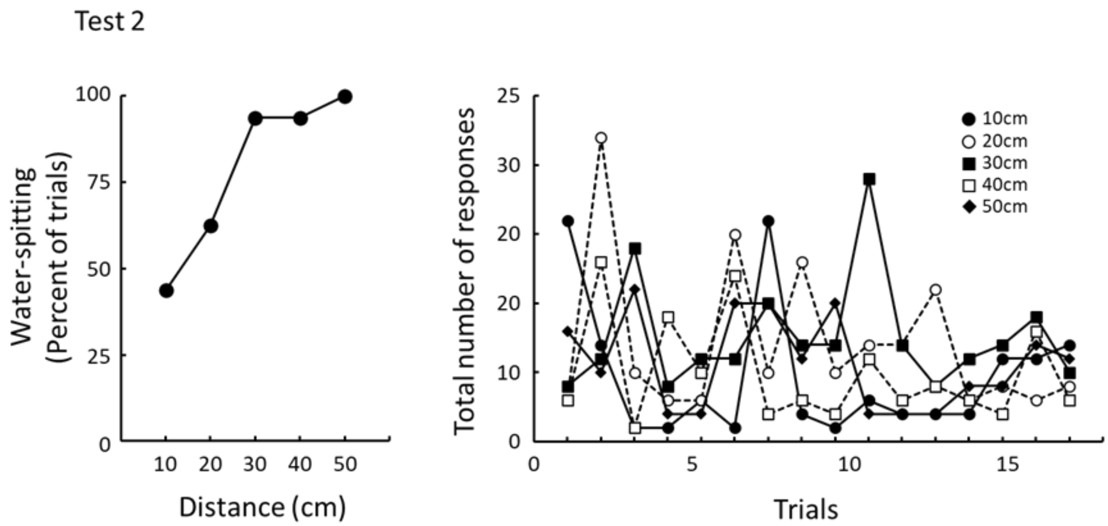
To examine how Tanya's behavior changed throughout Test 1, the frequency of responses across trials was analyzed using a generalized linear model (GLM). The objective variable was the number of responses (Poisson distribution), with the response type (poking vs. water-spitting), the distance of the ball from the edge (10 cm vs. 50 cm), and the trial as fixed effects. We selected the model with the smallest AIC among all possible models. In addition, each parameter estimate was evaluated based on Wald's test statistic. As a result, the selected model included all the fixed effects and the interaction between the response type and the distance and between the distance and the trial. The right panel of Figure 7 shows the total number of responses (poking + water-spitting) for each distance as a function of trials. The total number of responses decreased over trials when the ball was set at 10 cm (β = -0.052, p = .005, 95% confidence interval (CI) [-0.089, -0.016]), while no such trend was observed when the ball was set at 50 cm (β = -0.013, p = .511, 95% CI [-0.052, 0.026]).

Test 2

The left panel of Figure 8 shows the relative frequency of water-spitting in the first response for each distance in Test 2. There was an increasing trend in the relative frequency of trials where the first response was water spitting as a function of distance (logistic regression: β = 0.160, p = .001, 95% CI [0.063, 0.258]). Interestingly, the relative frequency of water-spitting increased considerably at a distance of 30 cm. In a supplementary test conducted during Test 2, we found the maximum distance Tanya could reach the ball with rostral poking to be 30 cm (see Figure 2).

Figure 8

Results of Test 2.



Note. Left: Relative Frequency of Water-spitting in the First Response as a Function of Distance of the Ball. Right: The Total Number of Responses for Each Distance as a Function of Trials.

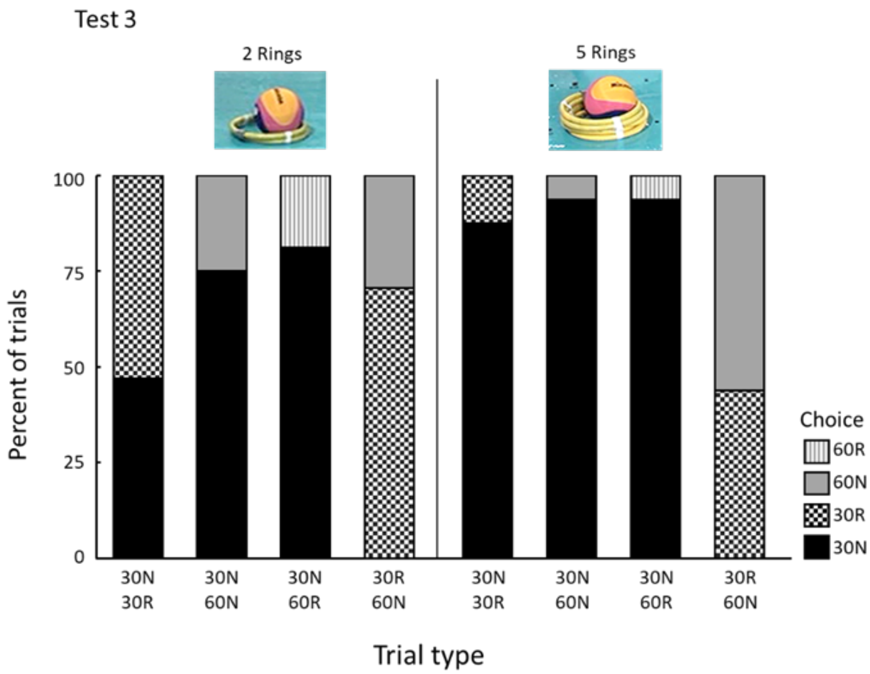
The right panel of Figure 8 shows the total number of responses for each distance across trials. We conducted a similar analysis to Test 1 using a GLM, and a model including all of the fixed effects and the interaction between the response type and the distance. A significant decrease in the total number of responses across trials was found (β = -0.030, p = .002, 95% CI [-0.050, -0.011]).

Test 3

The results of Test 3, conducted with two balls in place, are shown in Figure 9, separately for the double- and five-ring conditions. The two left bars in each ring condition are for the control condition, and the two right bars are for the test conditions. In the double-ring condition, water-spitting was observed when the ball was placed closer, irrespective of the presence of the rings. Especially in the 30R/60N condition, where the closer ball was inside the ring, 70.6% of the first responses were made toward the closer ball inside the ring, and finally, in 58.8% of the trials, she obtained the ball on the 30R side. In contrast, in the five-ring condition, where it was impossible to get the ball out of the ring by water-spitting, Tanya showed water-spitting at the ball on the 60N side as the first response in 56.3% of the 30R/60N trials (see also Figure 3B and Video 3). The frequency of the first responses varied significantly between the test conditions and between the ring conditions (Cochran-Mantel-Haenszel test, χ^2 (1) = 5.749, p = .017, 95% CI [1.405, 15.892]). Over-blow errors were also frequently observed during Test 3. In particular, a significant increasing trend was observed between the double- and five-ring conditions (4.5% vs. 27.5%; χ^2 (1) = 6.937, p = .008, φ = 0.230).

Figure 9

Results of Test 3: Relative Frequency of First Responses for Trial Type.



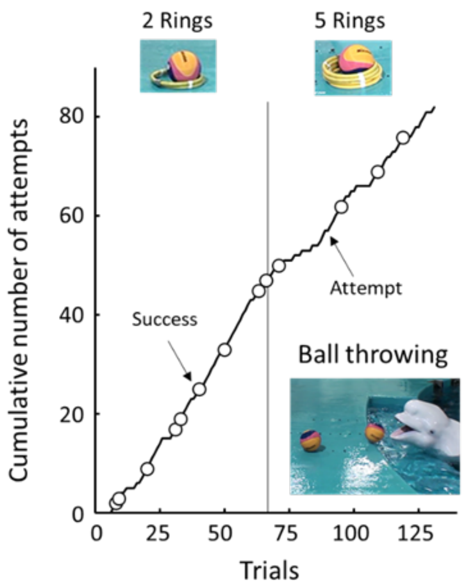
Note. The Horizontal Axis Indicates Pairs of Ball Conditions for Each Trial Type. R Indicates the Ball with Rings, and N Indicates the Ball Without Rings. Numbers Indicate the Distance of the Ball. The Patterns in the Bar Graphs Indicate the Ball Chosen by Tanya. Left: The Double-ring Condition. Right: The Five-ring Condition.

Aimed Ball Throwing

During Test 3, aimed throwing of the ball was emergently observed: Tanya held the first ball in her mouth after obtaining it and threw it toward another ball on the poolside (see Figure 4). This behavior was first observed on the seventh trial, but she failed to get another ball. On the following eighth trial, Tanya tried again and obtained the ball. Overall, ball-throwing was observed in 82 trials, of which she obtained the ball in 13 trials (Figure 10). Ball-throwing occurred more frequently in the double-ring condition than in the five-ring condition (71.2% vs. 53.8%, χ^2 (1) = 4.218, p = .040, φ = 0.179), while there was no difference in success rates between conditions (19.1% vs. 11.4%, χ^2 (1) = 0.411, p = .522, φ = 0.071).

Figure 10

The Cumulative Number of Trials in Which Tanya Attempted to Throw the Ball Toward Another Ball on the Floor.



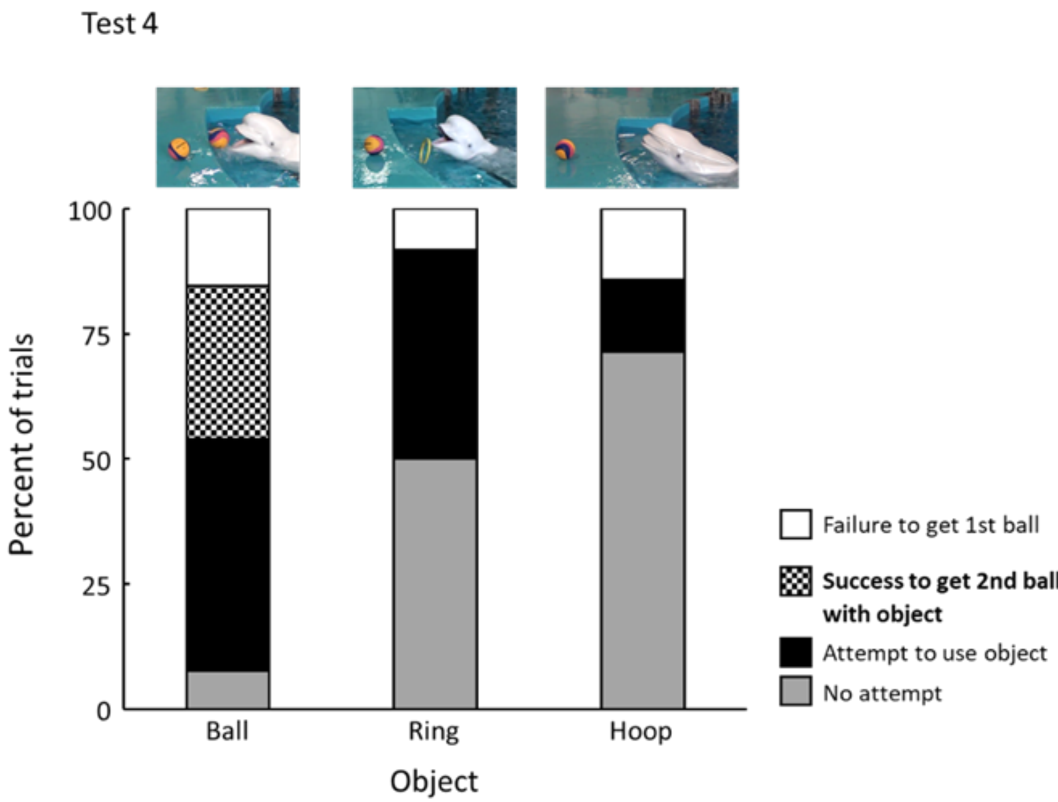
Note. Circles Show Successful Trials.

Test 4

In Test 4, the object-use test, conducted after Test 3, Tanya showed aimed-throwing on 76.9% of trials (10/13) for the ball condition, 41.7% (5/12) for the ring condition, and 14.3% (2/14) for the hoop condition (Figure 11; χ^2 (2) = 12.788, p = .002, Cramer's V = 0.613). However, she could obtain the ball only in the ball condition (4/10) but not in the ring and hoop conditions (see Videos 4 and 5).

Figure 11

Results of Test 4: Relative Frequency of Tanya's Responses for Each Object Condition.



Discussion

In the present study, we observed a beluga's water-spitting behavior as a tool. When the ball was placed at a position out of reach of her rostrum, she spit water at the ball in a very early phase of the testing, even though no special positive reinforcement training with food rewards was provided during the testing. When the ball was placed closer, she showed the rostral poking more frequently. This rostral poking behavior has been reported in belugas at another facility (Ham et al., 2023). However, they did not show water-spitting to retrieve the ball. Water-spitting was only observed in a play context (Ham et al., 2023).

The experience of moving the ball by rostral poking might have led the beluga to understand that the ball moved when an external physical force was applied to it. Water-spitting might also be based on this cause-effect understanding. In Test 2, the water-spitting behavior was predominantly observed when the ball was placed farther than 30 cm away. This distance of 30 cm corresponded to the maximum distance Tanya's rostrum could reach when she leaned out from the pool's edge.

The predominance of water-spitting from a distance that maximized the cost of rostral poking suggests that she may have a "body image" of herself and that more efficient water-spitting may have been chosen when the ball was placed farther away. In other words, our results suggest that Tanya's water-spitting behavior may be based on her understanding of tool use, such as "the ball will move if water is spit on it" and "water-spitting is more effective when her rostrum is out of reach." However, even when the ball was nearer than 30 cm, there was still no difference in frequency between rostral poking and water-spitting (Tests 1 and 2), suggesting that the water-spitting in this context may also share a property of "play behavior" (cf. Ham et al., 2023; Hill, 2009; Manitzas Hill et al., 2023).

In Test 3, over-blow errors became more frequent in the 5-ring condition. These results indicate that Tanya spit more water more intensely to get out the ball inside the ring, suggesting a flexible adjustment of water-spitting behavior. In addition, the first response to the farther ball without the rings in the 30R/60N trials increased in the 5-ring condition, suggesting that Tanya's choice was based on efficiency.

During this study, the number of responses to obtain a ball in Tests 1 and 2 tended to decrease across the trials. These results suggest that the efficiency of Tanya's water-spitting behavior improved during this study. From the video recordings, the way she spit water, the direction, speed, amount, and coherence of the water (cf. Marsh et al., 1989) might have changed throughout the study. The over-blow errors mentioned above also suggest changes in efficiency. Unfortunately, it was somewhat difficult to measure these parameters of water-spitting quantitatively from the video recordings. In the future, objective measurements of these parameters will be needed to study changes in the efficiency of water-spitting.

During Test 3, Tanya began to throw the first ball with her mouth toward the remaining ball on the floor. This ball-throwing behavior had been reinforced during public training. Therefore, this behavior was a kind of application of the existing behavioral repertoire to the new situation based on the causal understanding described above. Interestingly, the success rate of ball-throwing was 19.1% of attempts during the double-ring condition, which seemed lower than water-spitting. Tanya did not choose ball-throwing based on efficiency but as play behavior. This account might be supported by the fact that in the ring condition of Test 4, Tanya tried to throw the ring toward the ball and never succeeded.

In addition, poking the ball with the ring in her mouth was never observed in Test 4. It is well known that New Caledonian crows use twigs to forage for insects that are out of reach of their beaks (Hunt, 1996). Tanya never showed such generalizations toward using objects as "extensions" of the body, suggesting a lack of understanding of the functional properties of objects in her tool-use behavior (Gruber et al., 2019; Sabbatini et al., 2012). This limitation may have originated from the difference in body structure between cetaceans and other animals and is also critically important in discussing the cognitive foundations and physical constraints behind tool-use behaviors. Future comparative studies on various animal species adapted to diverse environments with different body structures will be necessary to address this issue.

Finally, we discuss the limitations of this study. First, our findings were limited to a captive individual. It is critical to ask whether the water-spitting behavior we found in captivity is also observed in the wild. As mentioned earlier, water-spitting behavior is considered one of the components of beluga's foraging behavior (Kane & Marshall, 2009; Watts & Draper, 1986). It is very difficult, however, to observe the behaviors of cetaceans underwater (especially near the seafloor) in the wild. This difficulty might be the primary reason why there have been few reports of tool use in cetaceans (cf. Mann & Patterson, 2013) and why those reports are mainly limited to the behaviors near the water surface (e.g., Stacey & Hvenegaard, 2002) or observations from the water surface and land (e.g., Mann et al., 2008; Smolker et al., 1997). From this point of view, detailed observations and experiments in captivity are necessary for studying tool-use behavior and its underlying cognitive functions in cetaceans.

Second, we discussed our results based on "cognitive" accounts such as causal understanding and body image. However, another account is also possible; such as “associationist” or operant conditioning-based. As mentioned in the Methods section, Tanya’s water-spitting behavior has been explicitly reinforced during the public training sessions, although this is included in the beluga’s behavioral repertoire. In addition, Tanya had spit water at humans and objects in daily observations before the current study. Since no detailed records were kept, the acquisition process of this behavior remains unclear. Since Tanya had used the ball obtained by water-spitting for object play, it is highly likely that the ball and subsequent object play further reinforced her water-spitting during the study period. It may also be that because specific testing conditions had been repeatedly presented for a certain period, object configurations had played the role of discriminative stimulus for specific responses. For example, the distance of the ball from the edge of the pool might have differentially controlled occurrences of reaching and water-spitting responses in Tests 1 and 2. Furthermore, we might not be able to rule out the possibility that the distance of the ball and the presence or absence of the ring were combined discriminative cues that controlled Tanya's behavior in Test 3. In fact, the total number of responses on each trial in Test 2 decreased over the testing, suggesting that learning may have occurred. In addition, we also discussed the unsuccessful use of objects other than the ball as a tool in Test 4 in relation to body image. But it may simply be that aimed throwing behavior was not generalized to those objects. Thus, it may be difficult to rule out associationist or operant account from the present study alone. To address this issue, it would be necessary to test how the water-spitting behavior observed in this study would be generalized to novel contexts in the future (cf. Limongelli et al., 1995).

Third, the most critical weakness of our study is that it is based on observations of only one individual. Although the other belugas in our aquarium also showed water-spitting behavior, we could not systematically test their behaviors due to the constraints on breeding management and the other programs in the aquarium. However, we need to increase the number of individuals to verify the generality of the tool-use aspects of the water-spitting behavior.

As described in the introduction, the water-spitting behaviors by belugas in captivity are commonly observed. Nevertheless, to conduct a systematic study such as ours, each aquarium could not avoid limitations like ours, such as the number of individuals, breeding management, etc. To overcome such situations, multi-facility collaborative research programs based on the standard research protocols will become important in the future. In the primate cognition domain, such collaborative efforts called *ManyPrimates* have already started and are beginning to show outcomes (ManyPrimates, 2019a,b). Such efforts are also needed in behavioral and cognitive research with cetaceans and should be promoted in the near future.

Acknowledgments

The authors thank Mr. M. Soichi, H. Nitto, M. Kurita, and the Port of Nagoya Public Aquarium staff for their generous support of the present study. We especially thank Mr. K. Kanda for his kind support of the present study and the preparation of the manuscript.

Funding

This study was financially supported by JSPS-MEXT Grants-in-Aid for Scientific Research (23220006 and 15H05709).

Ethics statements

The experimental procedure for the beluga was approved by the Port of Nagoya Public Aquarium and adhered to the *Ethical Guidelines for the Conduct of Research on Animals by Zoos and Aquariums* issued by the World Association of Zoos and Aquariums, the *Code of Ethics* issued by the Japanese Association of Zoos and Aquariums, *Guidelines for Animal Experiments* issued by the Japanese Society for Animal Psychology, and the Japanese *Act on Welfare and Management of Animals*.

Author Contributions

M.T. conceived and designed the present study; M.T., T.M, S.N, and M.I. performed the experiments, analyzed the data, and discussed the results. M.T. wrote the paper, and all authors commented on the manuscript.

Data accessibility

All the data used for this study are available in the supplementary materials.

References

Dill, L. M. (1977). Refraction and the spitting behavior of the archerfish (*Toxotes chatareus*). *Behavioral Ecology and Sociobiology*, *2*(2), 169–184. https://doi.org/10.1007/BF00361900

Crain, B. J., Giray, T., & Abramson, C. I. (2013). A Tool for every job: Assessing the need for a universal definition of tool use. *International Journal of Comparative Psychology*, *26*(4), 281–303. https://doi.org/10.46867/ijcp.2013.26.04.03

Gruber, T., Frick, A., Hirata, S., Adachi, I., & Biro, D. (2019). Spontaneous categorization of tools based on observation in children and chimpanzees. *Scientific Reports*, *9*(1), 1–12. https://doi.org/10.1038/s41598-019-54345-1

Ham, J. R., Lilley, M. K., Miller, M. R., Leca, J-B., Pellis, S. M., & Manitzas Hill, H. M. (2023). Self-handicapping in object play: How belugas (*Delphinapterus leucas*) make play difficult, *International Journal of Play*, *12*(1), 67–80. https://doi.org/10.1080/21594937.2022.2152535

Hill, H. M. (2009). The behavioral development of two beluga calves during the first year of life. *International Journal of Comparative Psychology*, *22*(4), 234–253. https://escholarship.org/uc/item/2rs0c1nq

Hunt, G. R. (1996). Manufacture and use of hook-tools by New Caledonian crows. *Nature*, *379*(6562), 1–3. https://doi.org/10.1038/379249a0

Kane, E. A., & Marshall, C. D. (2009). Comparative feeding kinematics and performance of odontocetes: Belugas, Pacific white-sided dolphins and long-finned pilot whales. *Journal of Experimental Biology*, *212*(24), 3939–3950. https://doi.org/10.1242/jeb.034686

Krützen, M., Mann, J., Heithaus, M. R., Connor, R. C., Bejder, L., & Sherwin, W. B. (2005). Cultural transmission of tool use in bottlenose dolphins. *Proceedings of the National Academy of Sciences*, *102*(25), 8939–8943. https://doi.org/10.1073/pnas.0500232102

Limongelli, L., Boysen, S. T., & Visalberghi, E. (1995). Comprehension of cause–effect relations in a tool-using task by chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology*, *109(1)*, 18–26. https://doi.org/10.1037/0735-7036.109.1.18

Mann, J., & Patterson, E. M. (2013). Tool use by aquatic animals. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1630), 1–11. https://doi.org/10.1098/rstb.2012.0424

Mann, J., Sargeant, B. L., Watson-Capps, J. J., Gibson, Q. A., Heithaus, M. R., Connor, R. C., & Patterson, E. (2008). Why do dolphins carry sponges? *PLOS ONE*, *3*(12), 1–7. https://doi.org/10.1371/journal.pone.0003868

ManyPrimates (2019a). Establishing an infrastructure for collaboration in primate cognition research. *PLOS ONE*, *14*(10), 1–19. https://doi.org/10.1371/journal.pone.0223675

ManyPrimates (2019b). Collaborative open science as a way to reproducibility and new insights in primate cognition research. *Japanese Psychological Review*, *62*(3), 205–220. https://doi.org/10.24602/sjpr.62.3_205

Marsh, H., Lloze, R., Heinsohn, G. E., & Kasuya T. (1989). Irrawaddy dolphin- *Orcaella brevirostris* (Gray, 1866). In S.H. Ridgway & S.R. Harrison (Eds.) *Handbook of marine mammals Vol. 4: River dolphins and the larger toothed whales* (pp. 101-118), Academic Press.

Manitzas Hill, H. M., Ortiz, N., Kolodziej, K., & Ham, J. R. (2023). Social games that belugas (*Delphinapterus leucas*) play, *International Journal of Play*, *12*(1), 81–100., https://doi.org/10.1080/21594937.2022.2152536

Mizuno, K., Irie, N., Hiraiwa-Hasegawa, M., & Kutsukake, N. (2016). Asian elephants acquire inaccessible food by blowing. *Animal Cognition*, *19*(1), 215–222. https://doi.org/10.1007/s10071-015-0929-2

Ramos, E. A., Santoya, L., Verde, J., Walker, Z., Castelblanco ‐ Martínez, N., Kiszka, J. J., & Rieucau, G. (2022). Lords of the Rings: Mud ring feeding by bottlenose dolphins in a Caribbean estuary revealed from sea, air, and space. *Marine Mammal Science*, *38*(1), 364–373. https://doi.org/10.1111/mms.12854

Sabbatini, G., Truppa, V., Hribar, A., Gambetta, B., Call, J., & Visalberghi, E. (2012). Understanding the functional properties of tools: Chimpanzees (*Pan troglodytes*) and capuchin monkeys (*Cebus apella*) attend to tool features differently. *Animal Cognition*, *15*(4), 577–590. https://doi.org/10.1007/s10071-012-0486-x

Schuster, S., Rossel, S., Schmidtmann, A., Jäger, I., & Poralla, J. (2004). Archer fish learn to compensate for complex optical distortions to determine the absolute size of their aerial prey. *Current Biology*, *14*(17), 1565–1568. https://doi.org/10.1016/j.cub.2004.08.050

Shumaker, R. W., Walkup, K. R., & Beck, B. B. (2011). *Animal tool behavior: The use and manufacture of tools by animals*. JHU Press.

Smith, K. A. (1961). Air-curtain fishing for Maine sardines. *Commercial Fisheries Review*, *23*(3), 1–14.

Smolker, R., Richards, A., Connor, R., Mann, J., & Berggren, P. (1997). Sponge carrying by dolphins (Delphinidae, *Tursiops* sp.): A foraging specialization involving tool use? *Ethology*, *103*(6), 454–465. https://doi.org/10.1111/j.1439-0310.1997.tb00160.x

St Amant, R., & Horton, T. E. (2008). Revisiting the definition of animal tool use. *Animal Behaviour*, *75*(4), 1199–1208. https://doi.org/10.1016/j.anbehav.2007.09.028

Stacey, P. J., & Hvenegaard, G. T. (2002). Habitat use and behaviour of Irrawaddy dolphins (*Orcaella brevirostris*) in the Mekong River of Laos. *Aquatic Mammals, 28*(1), 1–13. https://doi.org/10.7939/r3-ppqm-er09

Watts, P. D., & Draper, B. A. (1986). Note on the behavior of beluga whales feeding on capelin. *Arctic and Alpine Research*, *18*(4), 439. https://doi.org/10.2307/1551093

Yamamoto, S., Humle, T., & Tanaka, M. (2013). Basis for cumulative cultural evolution in chimpanzees: Social learning of a more efficient tool-use technique. *PLOS ONE*, *8*(1), 1–5. https://doi.org/10.1371/journal.pone.0055768

Financial conflict of interest: No stated conflicts.
Conflict of interest: No stated conflicts.

Submitted: *February 23rd, 2023*
Resubmitted: *April 12th, 2023*
Accepted: *April 20th, 2023*