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Environmental Enrichment, Marine Mammals, and Animal Welfare: A Brief Review

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Abstract

Central to the growing concern for animal welfare is the need to enrich the lives of animals living in enclosed settings, including marine mammals whose lives in human care (i.e., captivity) have come under heavy scrutiny in recent years. This article is a brief review addressing environmental enrichment, its link to animal welfare, and its application to marine mammals. We define *environmental enrichment* and address the factors that call for it. Additionally, we highlight the role that research and zoos play in implementing enrichment. Finally, we address factors to take into consideration regarding environmental enrichment for marine mammals, including a review of different types of environmental enrichment.

Key Words: welfare, enrichment, zoos, marine mammals, stereotypy

Introduction

When addressing a Pork Industry representative who argued that all ethical questions can be answered scientifically, Rollin (2011) stated that "if we . . . were asking the question of *how* to raise swine in confinement, science could certainly answer that question for us. But that is not the question [we are] asking. What we are asking is, *ought* we raise swine in confinement? And to this question, science is not relevant" (pp. 105-106). Like Rollin, we believe that maintaining an animal's welfare should be a vital part of maintaining animals under human care, part of the daily responsibilities of farm workers, zookeepers, lab technicians, and pet owners. What we address in this article is *how* we maintain one aspect of animal welfare (via science). Central to the animal welfare conversation is the need to ensure that captive animals get the best care, both mentally and physically. Environmental enrichment, therefore, plays a vital role in animal welfare and can impact both the mental and physical conditions of many animal species. With marine mammals featured in numerous facilities globally, along with heavy media attention in recent years, it is important to highlight the role that enrichment plays in their welfare.

What Is Enrichment?

The official field of enrichment, although relatively new, has received considerable attention, including an increase in the number of environmental enrichment definitions in the literature (e.g., see Newberry, 1995; Shepherdson, 1998; Behavior and Husbandry Advisory Group [BHAG], 1999; Swaisgood & Shepherdson, 2005), with most definitions alluding to or referring to enrichment's role in animal welfare. For example, Shepherdson's (1998) widely cited definition states that enrichment is "an animal husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being" (p. 1). Another similar example is the Behavior and Husbandry Advisory Group's (BHAG) (1999) definition which mentions that providing behavioral choices for animals as well as eliciting species-typical behaviors are important for enhancing animal welfare.

Environmental Enrichment and Stereotypic Behaviors

With the advent of marine mammals in enclosed settings, environmental enrichment features prominently in reducing stress (Carlstead & Shepherdson, 2000), which can be the outcome of several sources. For example, one source results from animals not being able to express species-specific behaviors or behaviors found in the wild (e.g., the inability to express social behavior in socially isolated primates housed in enclosed settings; Harlow & Harlow, 1965), which, after prolonged periods, can lead to

reduced welfare (Hughes & Duncan, 1988; Friend, 1989; Goldblatt, 1993; Swaisgood & Shepherdson, 2006). Ross (2006) found that two polar bears (*Ursus maritimus*) housed at the Lincoln Park Zoo significantly decreased pacing and other stereotypical behavior (see below for definition) and significantly increased the amount of time engaged in social play after being given access to an off-exhibit den. Although the time spent in the den did not increase by much, the *choice* to access the den (rather than the amount of time spent in the den) likely created the changes in behavior. Therefore, the opportunity to express behavioral choice in their environment (similar to what would be found in a wild environment) led to a reduction of detrimental behavior and, in turn, negative welfare.

It is important to note, however, that it may not be necessary for animals in captive environments to express *all* of their species-specific behaviors. For example, there may not be a need to express antipredator behavior in a captive environment, unless a threat (regardless of whether it is real) is perceived (Young, 2003). Other sources of stress include lack of control over their environment and boredom (Wood-Gush & Vestergaard, 1989; Wemelsfelder, 1991; Goldblatt, 1993; Newberry, 1995; Swaisgood & Shepherdson, 2006). Oftentimes, these sources of stress can lead to stereotypies/stereotypic behaviors or behavioral patterns that are repetitive with little variation and seem to be functionless (Mason, 1991). Not all repetitive behaviors are indicators of an abnormal mental state (see below for a more detailed distinction). Stereotypic behaviors that most likely indicate stress or abnormal mental states include those resulting from frustration, attempts to cope with a suboptimal environment, or brain dysfunction (Mason et al., 2007; Mason & Rushen, 2008). Some common examples of stereotypic behavioral patterns are pacing (e.g., polar bears and big cats), fur or feather plucking (e.g., ocelot), and excessive licking (e.g., giraffes) (Hancocks, 1980; Carlstead, 1991; Ross, 2006; Mason et al., 2007).

With a total of 600,000 birds and mammals in zoos worldwide (International Union of Directors of Zoological Gardens [IUDZG], 1993), it is estimated that at least 10,000 of them exhibit stereotypic behavioral patterns. Therefore, environmental enrichment is most often implemented in a zoo or laboratory setting to help reduce stereotypy that might lead to impacted welfare (Mason et al., 2007). As mentioned previously, these abnormal patterns of behavior can manifest for a number of reasons (Mason et al., 2007), including being unable to perform species-specific behaviors, lack of sensory stimulation, or lack of control in their environment (Swaisgood & Shepherdson, 2006). Continued stress resulting from these factors can affect particular regions in the brain. Additionally, insufficient rearing environments, such as barren environments or environments where social species are reared in isolation, can cause lasting damage to the central nervous system such as impaired brain development and the elicitation of abnormal behavioral patterns facilitated by stress and its impact on the brain (Mason et al., 2007). Both of these factors can consequently result in the development of stereotypic behaviors. Therefore, identifying factors that affect or cause stereotypic behavioral patterns is important for determining the type of environmental enrichment that can most effectively reduce negative welfare and reduce or entirely eliminate stereotypic behavior, although complete elimination is rare (Swaisgood & Shepherdson, 2006; Mason et al., 2007).

It also is important to note that not all repetitive behavior is a sign of stress or reduced welfare (Mason, 1991). For example, sharks and dolphins in aquariums are often seen swimming repetitive circles around a tank, which resembles stereotypic behavior. However, instead of being an abnormal/stereotypic behavior, this action may have resulted from a motivation to perform patrolling behavior (Young, 2003; Miller et al., 2011). Additionally, surface-directed behavior of dolphins, when their heads remain above water for a significant amount of time, may also resemble stereotypy but instead could result from dolphins' interest in complex environmental stimuli above the water's surface (Clark, 2013), including monitoring for the availability of prey (e.g., dusky dolphins [*Lagenorhynchus obscurus*]; Würsig & Würsig, 1980).

Given our preceding discussion, it is important to take the following into consideration when using enrichment to reduce negative welfare, including stereotypic behavior: opportunities to express species-specific behaviors, opportunities to exert control over their environment (including being given a variety of behavioral choices), the presentation of novel stimuli on a regular basis (to keep animals stimulated and interested), and a highly complex captive environment both socially and physically as much as is possible (Goldblatt, 1993; Newberry, 1995; Kuczaj et al., 1998; Carlstead & Shepherdson, 2000; Swaisgood & Shepherdson, 2006; Swaisgood, 2007; Hoy et al., 2010).

Personality and Enrichment

Many zoos and aquariums worldwide provide enrichment (e.g., as devices or environmental stimuli) to their animals. These devices/stimuli are usually meant to diversify the behavioral repertoires of the animals housed within a certain exhibit or laboratory. However, animal caretakers note that one type of enrichment often does not work for all individuals, even within a single species (Swaisgood & Shepherdson, 2005). While one solution would be

to broaden the enrichment technique to attract all animals, another solution could be to tailor particular enrichment techniques for specific animals based on their individual personalities. Animal personality refers to an individual animal's distinct and consistent behavioral traits, which remain stable over time and across situations. This area of research has blossomed over the past few decades; and many species, both in the wild and in captivity, have been studied (see Highfill & DeVere, 2016). Overall, examining individual differences enables animal caretakers to better understand and predict the behavior of animals (Vazire & Gosling, 2004).

The issue of tailoring enrichment to animal personality was addressed by Bacon et al. (2000), who examined the effect of enrichment items tailored for use by individual pandas (*Ailuropoda melanoleuca*). In their article, Bacon et al. explained that their two adult pandas had distinctly different personalities: Bai Yun was described as energetic and confident, yet easily bored, whereas Shi Shi was characterized as reserved and finding little interest in objects besides food. With these differences in mind, the researchers developed separate enrichment goals for each animal based on individual needs. For Bai Yun, they wanted to alleviate her boredom with a source of mental stimulation; they also wanted to elicit more natural behaviors in an effort to prevent the development of stereotypic behaviors. Their goals for Shi Shi were different in that they wanted to (1) increase his exploratory behavior by encouraging an interest in his surroundings and (2) specifically decrease his wandering and door-directed behaviors. Furthermore, Shi Shi was an older male, so they wanted to provide physical exercise to help with his muscle tone. For their study, Bacon et al. began by providing both pandas with the same types of enrichment (e.g., heavy scatter of food, frozen ice blocks with food, and bamboo puzzle feeders) and then modified them according to their specific needs. The pandas showed marked differences in their responses to the same enrichment items. For example, Shi Shi was not interested in frozen ice blocks with food; he would only briefly paw at the blocks and then leave the area. Bai Yun, on the other hand, would interact with the ice blocks for extended periods of time by biting, chewing, and manipulating the block to retrieve the food inside. She nearly doubled her normal foraging time, which helped alleviate her boredom. Based on their individual preferences, the researchers were able to modify the enrichment techniques that worked best for each panda. This study exemplifies the importance of considering individual animal personalities when developing realistic enrichment goals and techniques.

Keeping Enrichment Novel

In addition to personality, the novelty of enrichment to an animal is important. Just like children (and even adults), animals can habituate to enrichment items in their habitat and tire quickly of them. Therefore, it is important to vary enrichment on a regular basis, introducing novel items frequently, as well as keeping these objects available for different amounts of time to avoid boredom or possible habituation. To illustrate this approach, Kuczaj et al. (2002) found that when a novel object was left in the habitat of 12 different species (consisting of marine mammals and two different species of birds) over a 60-min period, these species habituated to the object over time, including a decrease in levels of play with the object. However, when varying the time intervals of exposure to a novel object (from 1 to 15 min), these species were more likely to continue to play with the object.

The Face of Environmental Enrichment

In addition to concerns related to stereotypy and personality, the overall type of enrichment implemented at zoos and aquariums needs to be taken into consideration. Enclosed facilities typically take two approaches to environmental enrichment: (1) the naturalistic approach, which is aimed at reproducing a species' natural environment; and (2) the behavioral engineering approach, which uses enrichment that is targeted at satisfying appetitive needs, regardless of whether the enrichment looks natural (Yerkes, 1925; Tudge, 1992; Young, 2003). Not all practitioners (e.g., zookeepers, trainers, animal caregivers, etc.) are in agreement on the best approach, with many opposed to anything that looks non-naturalistic (although non-naturalistic enrichment may be used off exhibit) (Young, 2003; Kutska, 2009). For example, Hancocks (2007) states that, in some cases, non-naturalistic enrichment in zoo exhibits resembles trash piles consisting of colorful objects, plastic toys, and other synthetic material. Although he is of the belief that these objects may be enriching, he argues that this undermines the purpose of zoos, which is to demonstrate the relationship animals have with the natural habitat. This argument is based on the notion that zoos are proponents of environmental education, and the habitats, therefore, need to look as naturalistic as possible. Hancocks is aware of trying to balance the needs of the animals with environmental education and mentions with admiration Terry Maple, former president of the American Zoological Association and former director of Zoo Atlanta, who stated that the welfare of the animals should come as the top priority in zoos and aquariums.

Balancing the naturalistic presentation of animals for educational purposes with enrichment for animal welfare can, at times, be difficult. In our view, if non-naturalistic enrichment for a given animal seems to be the most effective enrichment for that animal, priority should be given to this type of enrichment on exhibit (in addition to whether it is provided off exhibit). Interestingly, the public is not particularly disturbed by seeing animals' "toys" in their enclosure. For example, zoo visitors reported a polar bear exhibit at the Central Park Zoo to be equally pleasurable regardless of whether naturalistic or non-naturalistic enrichment was on display (Kutska, 2009). Furthermore, seeing a chimpanzee (*Pan troglodytes*) with an iPad may increase the connection between visitors and this species, given that people can relate easily to animals who exhibit more human-like qualities (Bielick & Karns, 1998; Sickler et al., 2006; Harley et al., 2010; Maust-Mohl et al., 2012; Makecha & Ghosal, 2017). This example also highlights evolutionary continuity between chimpanzees and humans, and, therefore, serves an educational purpose. In such cases, zoos may work to counteract the potentially negative impact that non-naturalistic objects might have on the public's environmental education by educating them on the importance and purpose of this type of enrichment (e.g., using the appropriate signage, education programs, trainer and docent presentations, and other practices; see Sickler et al., 2006).

Research and Environmental Enrichment

Research is key in developing effective environmental enrichment. For example, one of the roles that environmental enrichment plays is to elicit species-specific behavior (Friend, 1989; Goldblatt, 1993; Hughes & Duncan, 1998; Swaisgood & Shepherdson, 2006). Therefore, understanding a species' behavior and cognitive abilities is important in developing appropriate enrichment. But one should exercise caution: comparing activity budgets of captive animals to those of wild counterparts seems a good idea, but these activity budgets will not necessarily match. For example, animals in enclosed settings do not need to spend as much time as their wild counterparts on the lookout for predators or in searching for food (Newberry, 1995; Young, 2003).

Data are scarce on how abnormal behaviors develop in animals, including in marine mammals (Clark, 2013). Understanding the source of these behaviors and their development would seem to be vital in developing enrichment that not only reduces/eliminates abnormal behaviors, but also treats the source and not the symptoms. Current methods of enrichment may make determining the causes of abnormal behavior difficult. Zoo personnel often use an *everything but the kitchen sink* approach. While this approach seems to be effective, it does not allow for determining which aspects of enrichment are successful. For example, to determine the effectiveness of a particular enrichment strategy, zoo personnel would have to forego the seemingly effective *everything but the kitchen sink* approach and focus on isolating each enrichment strategy separately. Short term, this would deny an animal access to a variety of enrichment that no doubt would be stimulating, but it would allow researchers to determine which strategy/strategies are more effective. In the long term, zoos would not have to waste resources with a widespread approach, but, instead, they would focus on the enrichment strategy/strategies that are best suited to an animal/species, making this more cost-effective. Perhaps zoos and researchers can reach a happy compromise wherein researchers can glean this information without an animal's welfare being compromised (Swaisgood & Shepherdson, 2006; Swaisgood, 2007).

In addition, researchers need to examine the long-term effects of enrichment—for example, stereotypy may diminish upon initial presentations of enriching stimuli but re-emerge (due to habituation) with subsequent presentation (Swaisgood & Shepherdson, 2006). Similarly, it is important to assess the impact that enrichment has on subsequent behavior because some intended enrichment could have a negative effect instead of the intended positive outcome(s) for which it was designed (Hoy et al., 2010). This was demonstrated when a group of Sumatran orangutans (*Pongo pygmaceus*) panicked after piñatas were placed in their enclosure (vs when the piñatas were given to a group of Bornean orangutans, who enjoyed destroying the piñatas), and it took staff 2 h to remove the piñatas from the enclosure (Hare et al., 2008).

A Brief History on Environmental Enrichment and Marine Mammals

Marine mammals have been kept in menageries and zoos for hundreds of years (Reeves & Mead, 1999). One of the earliest records is from 1760 when a Mediterranean monk seal (*Monachus monachus*) was brought into captivity (Maxwell, 1967). Historically, polar bears and pinnipeds were the first marine mammals to be kept in captivity. This can be attributed to the fact that they are amphibious, spending time on land and in the water, which made them easier to capture and maintain (Reeves & Mead, 1999). The first public oceanarium to house bottlenose dolphins (*Tursiops truncatus*) was Marine Studios (now Marineland) of Florida, which opened in

1938 (Reeves & Mead, 1999). The middle of the 20th century saw an explosion of oceanariums opening around the world.

Although marine mammals have been in captive settings for centuries, environmental enrichment for any species in human care was only formally introduced approximately 90 years ago by Yerkes (1925) when he designed play items for primates housed at his lab. His goal was to provide physical and behavioral stimulation to a relatively sterile environment. During the 1940s, Hediger (1950) was first to consider the psychological needs of animals housed at the Zurich Zoo. Hediger believed that zoo exhibits should be constructed in a way that the animals are encouraged to exhibit natural behaviors. Since these pioneering studies, many researchers and zookeepers around the world have recognized the need for environmental enrichment (for reviews, see Swaisgood & Shepherdson, 2005; Shyne, 2006).

While not everyone agrees whether marine mammals, especially cetaceans, should be kept under managed care, everyone does agree that these animals need to live enriched lives, with care taken to ensure an enriched social and physical environment (as for all species living under the care of humans). This view is reflected in the Animal Welfare Act's stipulation that marine mammals, many of which are social, be housed with at least one other conspecific (Kulpa-Eddy et al., 2005). Marine mammals provide an interesting case for environmental enrichment because of their aquatic environments. Terrestrial humans must think *outside their land-locked box* to provide these animals with the best kind of environment—socially and physically.

Marine Mammal Enrichment

Environmental enrichment can be categorized in a number of ways. In a recent meta-analysis of enrichment research, de Azevedo et al. (2007) reported five main types of enrichment discussed in the literature: (1) structural (e.g., adding furniture or toys), (2) food related (e.g., hiding food), (3) sensory (e.g., adding a new smell), (4) social (e.g., changing social groups), and (5) cognitive (e.g., puzzles). All of these types of enrichment have been used with marine mammals with varying degrees of success.

Structural Enrichment

One of the easiest methods for providing environmental enrichment to animals is to offer them objects that they can manipulate. One study examined the effects of structural environmental enrichment on the behavior of seven harbor seals (*Phoca vitulina*) and two grey seals (*Halichoerus grypus*) (Hunter et al., 2002). Behavioral observations of the seals were made with and without the presence of five enrichment devices: (1) a PVC sculpture, (2) a grass bed, (3) a bubble net, (4) a crate structure, and (5) a floating platform. Each seal was observed with each enrichment device separately. The results indicated that pattern swimming decreased and random swimming increased when enrichment items were present (Hunter et al., 2002). Also, the amount of time the seals spent exploring increased when enrichment items were in their pool. Specifically, the seals increased their activity the most when the bubble net was present, followed by the PVC sculpture and floating platform. Overall, structural enrichment benefited harbor and grey seals by reducing stereotypic behaviors and increasing activity levels. Thus, structural environmental enrichment can serve as a very beneficial, yet fairly simple enrichment option.

Certain types of structural enrichment may have some limitations. One study examined the introduction of 21 familiar objects to a group of bottlenose dolphins at a marine park (Delfour & Beyer, 2012). Their results revealed that the dolphins only interacted with about half of the objects. The authors concluded that introducing objects should not be the only type of enrichment offered to these animals. They also noticed differences in behavior toward the objects by individual dolphins, which supports the approach of developing individual enrichment profiles.

Food-Related Enrichment

Another common approach to environmental enrichment is providing animals with a wide variety of food items and feeding methods. The goal of this method is typically to encourage natural foraging behaviors. Grindrod & Cleaver (2001) examined the effects of a variety of enrichment interventions with the harbor seal. The enrichment technique that was the most impactful on the group was the "fish pull," which involved tying a (dead) fish to a fishing line and pulling it across the pool quickly. All of the seals in the group were interested in the fish action and, subsequently, would chase and compete for the item. Overall, providing food-related enrichment can serve as a simple and naturalistic method for increasing species-typical behaviors.

Sensory Enrichment

More recently, environmental enrichment has started to include more sensory-focused items such as odors, sounds, and tactile stimulation. For example, Samuelson et al. (2017) examined the effect of olfactory enrichment on the behavior of captive California sea lions (*Zalophus californianus*). Four sea lions were exposed to four natural odors (potting soil, sand, kelp, and sardine oil) and

four non-natural odors (orange, banana, vanilla extract, and cinnamon). Each scent was rubbed on the wall and tested individually. Overall, the olfactory enrichment significantly reduced pattern swimming and increased utilization of the habitat. In general, sensory enrichment techniques can serve as a creative, novel, and cost-effective way to enrich the environments of captive animals.

Social Enrichment

It is rarely possible for captive animals to live in social groups similar to the ones they would maintain in the wild. However, for the well-being of captive animals, it is important to understand the species' natural social groupings and, when possible, house the animals accordingly. For example, Yeater et al. (2013) examined the effects of merging two small groups of three rough-toothed dolphins (*Steno bredanensis*) together to form a group of six. The integration of the two groups was seen as a success and provided the opportunity for new social partnerships to form. Furthermore, the larger social group did not appear to change the already established interaction patterns previously present in the trios. Most notable was the formation of a new social dyad between the two juvenile males, which previously had been housed separately. Male–male alliances have been observed in wild dolphin populations, so the integration of the two groups potentially allowed for a more natural social dynamic for the two young males (e.g., Connor et al., 1992, 2000). Thus, Yeater et al. (2013) and similar studies suggest that placing animals in acceptable social groups in captivity can provide environmental enrichment.

Cognitive Enrichment

To date, cognitive enrichment has only been provided to a few animal species, yet it produced one of the highest success rates when compared to other types of enrichment (de Azevedo et al., 2007). Clark et al. (2013) presented an underwater maze device (UMD) to dolphins at Six Flags Discovery Kingdom. For this UMD, the dolphins had to navigate a rubber ball through a maze constructed of PVC. Interestingly, none of the female dolphins (all housed separately from the male group) even approached the UMD; however, the male dolphins approached the UMD during the first introduction. Ultimately, two of the six male dolphins successfully solved the UMD. While the UMD did not seem to decrease repetitive swimming patterns, the males spent more of their time under water when the UMD was in the pool.

Cognitive enrichment in the form of training also seems to be promising. Kastelein & Wiepkema (1998) reported that stereotypic swimming in a Steller sea lion (*Eumetopias jubatus*) who received 60 min of training per day was reduced from 7.2 to 0.5%. Similarly, dolphins trained to whistle at a specific frequency to receive a food reward (via a dispenser) did so even in the absence of a food reward (Mackay, 1981). These studies provide compelling evidence that cognitive enrichment can stimulate individuals of different species by providing both novelty and challenge.

Environmental Enrichment and Marine Mammal Re-Release

Special consideration needs to be given to planning environmental enrichment for animals that are being re-released back into the wild. This is especially important for marine mammals which are often rescued after stranding. For example, it seems reasonable that creating a captive environment that resembles an animal's wild environment and, more specifically, its release site, is important for successful re-introduction (Newberry, 1995). Part of modifying the captive environment includes designing the appropriate environmental enrichment to elicit important behaviors needed in the wild (e.g., foraging behavior, predator avoidance, etc.). Although animals that are rescued and subsequently released do not need to fine-tune their survival skills, an environment that does resemble their wild environment (e.g., feeding opportunities that resemble the wild) is important to maintain behaviors needed in the wild. For example, Cincinnati Zoo and Botanical Gardens, which is a partner with the U.S. Fish and Wildlife Service's Manatee Rescue, Rehabilitation, and Release Program, uses different feeding methods with their manatees deemed for re-release vs the manatees that will remain with the zoo. BamBam, one of their manatees that was recently released back in the wild, was used to feeding on the bottom. The zoo's veterinarian wanted to feed BamBam sweet potatoes, which float (it can be dangerous for manatees to feed at the surface because of boats, etc.), so BamBam's trainers developed a feeding log where "sweet potato fries" could be inserted and the log would not float (Garrett, 2016; Figure 1). Additionally, certain toys cannot be used with manatees deemed for re-release—for example, red balls cannot be used because they resemble the red buoys that are present where boat traffic passes (L. Garrett, pers. comm., 8 August 2016).

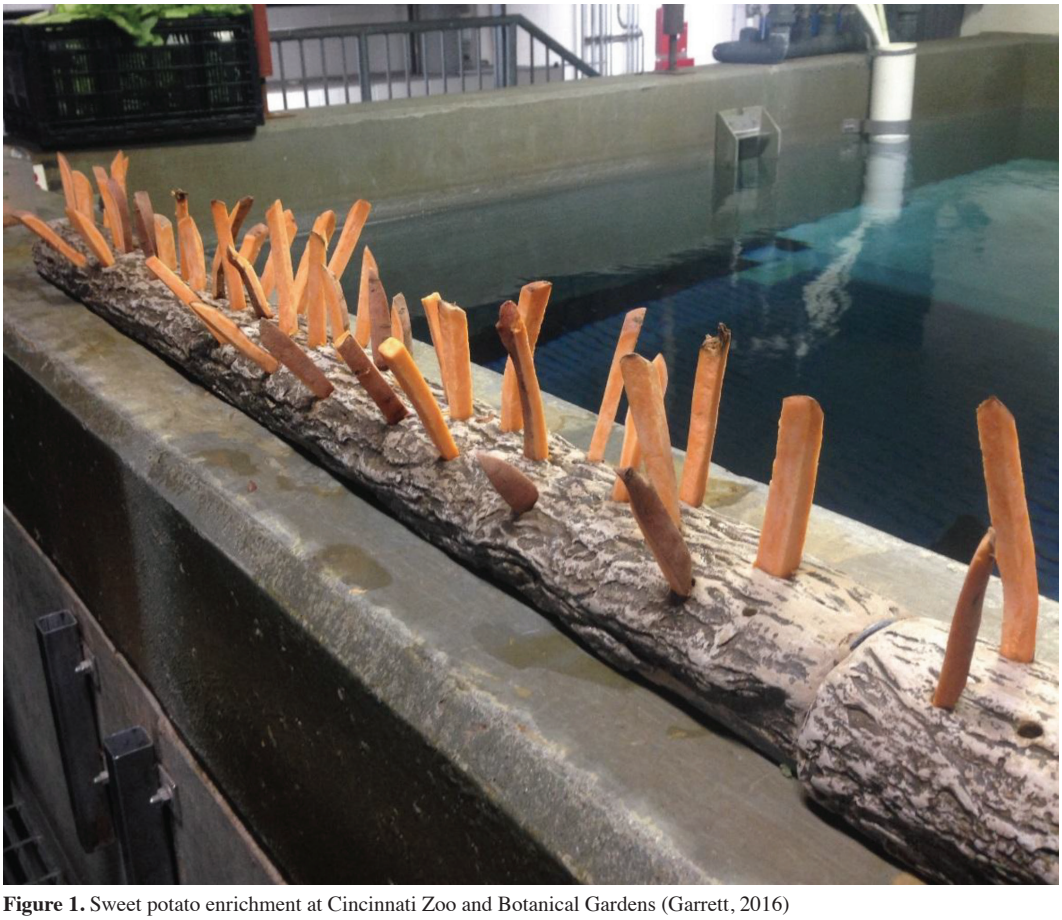

Figure 1. Sweet potato enrichment at Cincinnati Zoo and Botanical Gardens (Garrett, 2016)

Conclusions

It is clear that research on enrichment, environmental and social, is vital, and zoos are an appropriate and accessible venue in which to assess enrichment in animals (Robinson, 1998). Additionally, given the evidence presented in this article, enrichment is undisputedly effective for elevating animal welfare. Shyne's (2006) meta-analysis of environmental enrichment research solidifies this evidence. Their analysis, which included 54 studies, yielded 63 effect sizes. Ninety percent of the 63 effect sizes went in the predicted direction, which indicated that animals produced less stereotypic behavior when exposed to environmental enrichment than in the baseline condition. Shyne's results strongly support the notion that environmental enrichment has a positive influence on managing the behavioral patterns of captive zoo animals.

The field of environmental enrichment is considered relatively new, but it is also integral to maintaining positive animal welfare. Research in this area must continue, including assessing potential individual effects of different types of enrichment while taking personality and individual preferences into consideration. Additionally, adding to the scarce data on visitor perceptions of enrichment will allow us to fully and more effectively use zoos and aquariums as a powerful educational tool. This is especially important to facilities that house marine mammals and to those that have come under heavy scrutiny within the past decade. Swaisgood (2007) summarized the need for enrichment nicely when he stated,

> *I opine that enrichment is the key concept for those interested in maintaining wild animals in captivity, a fundamental need on par with food and water. The gold standard is to understand how we should provision captive animals with an appropriate environment that prevents the development of welfare problems in the first place. (p. 143)*

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Literature Cited

Bacon, K., Ripsky, D., Hawk, K., & Battershill, R. (2000). Giant panda personalities: Enrichment for the individual. *The Shape of Enrichment*, *9*(1), 1-4.

Behavior and Husbandry Advisory Group (BHAG). (1999). *Behavior and Husbandry Advisory Group, a scientific advisory group of the American Zoo and Aquarium Association Workshop at Disney's Animal Kingdom*. Orlando, FL: BHAG.

Bielick, S., & Karns, D. (1998). *Still thinking about thinking: A 1997 follow-up study of visitors to the Think Tank exhibition at the National Zoological Park*. Washington, DC: Smithsonian Institution, Institutional Studies Office.

Carlstead, K. (1991). Husbandry of the Fennec fox *Fennecus zerda*: Environmental conditions influencing stereotypic behaviour. *International Zoo Yearbook*, *30*, 202-207. https://doi.org/10.1111/j.1748-1090.1991.tb03487.x

Carlstead, K., & Shepherdson, D. (2000). Alleviating stress in zoo animals with environmental enrichment. In G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress* (pp. 337-354). New York: CABI. https://doi.org/10.1079/9780851993591.0337

Clark, F. E. (2013). Marine mammal cognition and captive care: A proposal for cognitive enrichment in zoos and aquariums. *Journal of Zoo and Aquarium Research*, *1*(1), 1-6.

Clark, F. E., Davies, S. L., Madigan, A. W., Warner, A. J., & Kuczaj II, S. A. (2013). Cognitive enrichment for bottlenose dolphins (*Tursiops truncatus*): Evaluation of a novel underwater maze device. *Zoo Biology*, *32*(6), 608-619. https://doi.org/10.1002/zoo.21096

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*, *89*(3), 987-990. https://doi.org/10.1073/pnas.89.3.987

Connor, R. C., Wells, R. S., Mann, J., & Read, A. J. (2000). The bottlenose dolphin. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies: Field studies of dolphins and whales* (pp. 91-126). Chicago: The University of Chicago Press.

de Azevedo, C. S., Cipresete, C. F., & Young, R. J. (2007). Environmental enrichment: A GAP analysis. *Applied Animal Behaviour Science*, *102*(3), 329-343. https://doi.org/10.1016/j.applanim.2006.05.034

Delfour, F., & Beyer, H. (2012). Assessing the effectiveness of environmental enrichment on bottlenose dolphins (*Tursiops truncatus*). *Zoo Biology*, *31*(2), 137-150. https://doi.org/10.1002/zoo.20383

Friend, T. (1989). Recognizing behavioral needs. *Applied Animal Behavior Science*, *22*, 151-158. https://doi.org/10.1016/0168-1591(89)90051-8

Garrett, L. (2016, October 28). Rehabilitating BamBam the orphan manatee. *Cincinnati Zoo Blog*. Retrieved from http://blog.cincinnatizoo.org/2016/10/28/rehabilitating-bambam-the-orphan-manatee

Goldblatt, A. (1993). Behavioural needs of captive marine mammals. *Aquatic Mammals, 19*(3), 149-157.

Grindrod, J. A. E., & Cleaver, J. A. (2001). Environmental enrichment reduces the performance of stereotypic circling behaviour in captive common seals (*Phoca vitulina*). *Animal Welfare*, *10*(1), 53-63.

Hancocks, D. (1980). Bringing nature into the zoo: Inexpensive solutions for zoo environments. *International Journal for the Study of Animal Welfare Problems*, *1*, 170-177.

Hancocks, D. (2007). Zoo animals as entertainment exhibitions. In R. Malamud (Ed.), *A cultural history of animals in the modern age* (pp. 95-118). New York: Berg. https://doi.org/10.5040/9781350049543-ch-004

Hare, V. J., Rich, B., & Worley, K. E. (2007, August). Enrichment gone wrong! *Proceedings of the Eighth International Conference on Environmental Enrichment*, Vienna.

Harley, H. H., Fellner, W., & Stamper, M. A. (2010). Cognitive research with dolphins (*Tursiops truncatus*) at Disney's The Seas: A program for enrichment, science, education, and conservation. *International Journal of Comparative Psychology*, *23*, 331-343.

Harlow, H. F., & Harlow, M. K. (1965). The affectional systems. In A. M. Schrier, H. F. Harlow, & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 2, pp. 287-334). New York: Academic Press. https://doi.org/10.1016/B978-1-4832-2821-1.50008-2

Hediger, H. (1950). *Wild animals in captivity*. London: Butterworths Scientific Publications.

Highfill, L., & DeVere, A. (2016). Animal personality. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 1-7). Cham, Switzerland: Springer International Publishing AG. https://doi.org/10.1007/978-3-319-28099-8_1201-1

Hoy, J. M., Murray, P. J., & Tribe, A. (2010). Thirty years later: Enrichment practices for captive mammals. *Zoo Biology*, *29*(3), 303-316. https://doi.org/10.1002/zoo.20254

Hughes, B. O., & Duncan, I. J. H. (1988). The notion of ethological "need," models of motivation and animal welfare. *Animal Behavior Science*, *36*, 1696-1707. https://doi.org/10.1016/S0003-3472(88)80110-6

Hunter, S. A., Bay, M. S., Martin, M. L., & Hatfield, J. S. (2002). Behavioral effects of environmental enrichment on harbor seals (*Phoca vitulina concolor*) and gray seals (*Halichoerus grypus*). *Zoo Biology*, *21*(4), 375-387. https://doi.org/10.1002/zoo.10042

International Union of Directors of Zoological Gardens (IUDZG)—The World Zoo Organization and The Captive Breeding Specialist Group of IUCN/SSC. (1993). *The World Zoo conservation strategy: The role*

of the zoos and aquaria of the world in global conservation. Brookfield, IL: Chicago Zoological Society.

Kastelein, R. A., & Wiepkema, P. R. (1988). The significance of training for the behaviour of Steller sea lions (*Eumetopias jubata*) in human care. *Aquatic Mammals*, *14*, 39-41.

Kuczaj II, S. A., Lacinak, C. T., & Turner, T. N. (1998). Environmental enrichment for marine mammals at Sea World. In D. J. Shepherdson & J. D. Mellen (Eds.), *Second nature: Environmental enrichment for captive animals* (pp. 314-328). Washington, DC: Smithsonian Institution Press.

Kulpa-Eddy, J. A., Taylor, S., & Adams, K. M. (2005). USDA perspective on environmental enrichment for animals. *Institute for Laboratory Animal Research Journal*, *46*(2), 83-94. https://doi.org/10.1093/ilar.46.2.83

Kutska, D. (2009). Variation in visitor perceptions of a polar bear enclosure based on the presence of natural vs. un-natural enrichment items. *Zoo Biology*, *28*(4), 292-306. https://doi.org/10.1002/zoo.20226

Mackay, R. S. (1981). Dolphin interaction with acoustically controlled systems: Aspects of frequency control, learning, and non-food rewards. *Cetology*, *41*, 1-12.

Makecha, R. N., & Ghosal, R. (2017). Elephant conservation: Reviewing the need and potential impact of cognition-based education. *International Journal of Comparative Psychology*, *30*, 1-6.

Mason, G. (1991). Stereotypies and suffering. *Behavioural Processes*,*25*,103-115.https://doi.org/10.1016/0376-6357(91)90013-P

Mason, G., & Rushen, J. (2008). *Stereotypic animal behaviour: Fundamentals and applications to welfare*. New York: CABI.

Mason, G., Clubb, R., Latham, N., & Vickery, S. (2007). Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Applied Animal Behavior Science*, *102*, 163-188. https://doi.org/10.1016/j.applanim.2006.05.041

Maust-Mohl, M., Fraser, J., & Morrison, R. (2012). Wild minds: What people think about animal thinking. *Anthroozoos*, *25*, 133-147. https://doi.org/10.2752/175303712X13316289505224

Maxwell, G. (1967). *Seals of the world*. Boston, MA: Houghton Mifflin.

Miller, S. J., Mellen, J., Greer, T., & Kuczaj II, S. A. (2011). The effects of education programmes on Atlantic bottlenose dolphin (*Tursiops truncatus*) behaviour. *Animal Welfare*, *20*, 159-172.

Newberry, R. C. (1995). Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science*, *44*(2-4), 229-243. https://doi.org/10.1016/0168-1591(95)00616-Z

Reeves, R. R., & Mead, J. G. (1999). Marine mammals in captivity. In J. R. Twiss, Jr. & R. R. Reeves (Eds.), *Conservation and management of marine mammals* (pp. 412-436). Washington, DC: Smithsonian Institution Press.

Robinson, M. H. (1998). Enriching the lives of zoo animals and their welfare: Where research can be fundamental. *Animal Welfare*, *7*, 151-175.

Rodger, S. (1995). Individual education plans revisited: A review of the literature. *International Journal of Disability, Development and Education*, *42*(3), 221-239. https://doi.org/10.1080/0156655950420305

Rollin, B. E. (2011). Animal rights as a mainstream phenomenon. *Animals*, *1*, 102-115. https://doi.org/10.3390/ani1010102

Ross, S. R. (2006). Issues of choice and control in the behaviour of a pair of captive polar bears (*Ursus maritimus*). *Behavioural Processes*, *73*, 117-120. https://doi.org/10.1016/j.beproc.2006.04.003

Samuelson, M. M., Lauderdale, L. K., Pulis, K., Solangi, M., Hoffland, T., & Lyn, H. (2017). Olfactory enrichment in California sea lions (*Zalophus californianus*): An effective tool for captive welfare? *Journal of Applied Animal Welfare Science*, *20*(1), 75-85. https://doi.org/10.1080/10888705.2016.1246362

Shepherdson, D. J. (1998). Tracing the path of environmental enrichment in zoos. In D. J. Shepherdson & J. D. Mellen (Eds.), *Second nature: Environmental enrichment for captive animals* (pp. 1-14). Washington, DC: Smithsonian Institution Press.

Shepherdson, D. J. (2003). Environmental enrichment: Past, present and future. *International Zoo Yearbook*, *38*(1), 118-124. https://doi.org/10.1111/j.1748-1090.2003.tb02071.x

Shyne, A. (2006). Meta-analytic review of the effects of enrichment on stereotypic behavior in zoo mammals. *Zoo Biology*, *25*, 317-337. https://doi.org/10.1002/zoo.20091

Sickler, J., Fraser, J., Gruber, S., Boyle, P., Reiss, D., & Webler, T. (2006). *Thinking about dolphins thinking: Understanding the impact of social narratives on public acceptance of cognitive science research* (WCS Working Paper No. 27). New York: Wildlife Conservation Society.

Swaisgood, R. R. (2007). Current status and future directions of applied behavioral research for animal welfare and conservation. *Applied Animal Behaviour Science*, *102*(3), 139-162. https://doi.org/10.1016/j.applanim.2006.05.027

Swaisgood, R. R., & Shepherdson, D. J. (2005). Scientific approaches to enrichment and stereotypies in zoo animals: What's been done and where should we go next? *Zoo Biology*, *24*, 499-518. https://doi.org/10.1002/zoo.20066

Swaisgood, R. R., & Shepherdson, D. J. (2006). Environmental enrichment as a strategy for mitigating stereotypies in zoo animals: A literature review and meta-analysis. In G. Mason & J. Rushen (Eds.), *Stereotypic animal behaviour: Fundamentals and applications to welfare* (pp. 256-285). New York: CABI. https://doi.org/10.1079/9780851990040.0256

Tudge, C. (1992). *Last animals at the zoo: How mass extinction can be stopped*. Washington, DC: Island Press.

Vazire, S., & Goslong, S. D. (2004). Personality and temperament: A comparative perspective. In M. Bekoff & J. Goodall (Eds.), *Encyclopedia of animal behavior* (pp. 818-822). Westport, CT: Greenwood Press.

Wemelsfelder, F. (1991). Animal boredom: Do animals miss being alert and active. In S. M. Rutter (Ed.), *Applied animal behaviour: Past, present and future* (pp. 120-123). Potters Bar, UK: Universities Federation for Animal Welfare.

Wood-Gush, D. G., & Vestergaard, K. (1989). Exploratory behavior and the welfare of intensively kept animals. *Journal of Agricultural and Environmental Ethics*, *2*(2), 161-169. https://doi.org/10.1007/BF01826929

Würsig, B., & Würsig, M. (1980). Behavior and ecology of the dusky dolphin, *Lagenorhynchus obscurus*, in the South Atlantic. *U.S. Fisheries Bulletin*, *77*, 871-890.

Yeater, D. B., Miller, L. E., Caffery, K. A., & 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

Yerkes, R. M. (1925). *Almost human*. New York: Century.

Young, R. J. (2003). *Environmental enrichment for captive animals*. Hoboken, NJ: Blackwell Publishing. https://doi.org/10.1002/9780470751046