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Authors
Dudzinski, Kathleen M
Hill, Heather M
Zaccaroni, Annalisa
et al.

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Distinguishing Personal Belief from Scientific Knowledge for the Betterment of Killer Whale Welfare – A Commentary

Kathleen M. Dudzinski[1], Heather M. Hill[2], Annalisa Zaccaroni[3], Radhika Makecha[4], Malin Lilley[5], Javier Almunia[6], Erin Frick[7], Todd Feucht[8], Grey Stafford[9], and Charles I. Abramson[10]

[1] Dolphin Communication Project, Port Saint Lucie, FL
[2] Psychology, St. Mary's University, San Antonio, TX
[3] Department of Veterinary Medical Sciences, University of Bologna, Italy
[4] Psychology/Animal Studies, Eastern Kentucky University, Richmond, KY
[5] Department of Science and Mathematics, Texas A&M University, San Antonio, TX
[6] Loro Parque Fundación, Puerto de la Cruz, Spain
[7] Animal Studies, Eckerd College, Petersburg, FL
[8] Oerca, Orlando, FL
[9] College of Science, Engineering, and Technology, Grand Canyon University, Phoenix, AZ
[10] Psychology, Oklahoma State University, Stillwater, OK

We contest publication of Marino et al. (2019) regarding captive killer whale (*Orcinus orca*) welfare because of misrepresentations of available data and the use of citations that do not support assertions. Marino et al. misrepresent stress response concepts and erroneously cite studies, which appear to support Marino et al.'s philosophical beliefs regarding the cetacean hypothalamic–pituitary–adrenal axis. To be clear, these misrepresentations are not differences of scientific opinion, as the authors' conclusions lack any scientific basis. More extensive review of Marino et al.'s citations reveal a dearth of empirical evidence to support their assertions. Further, Marino et al.'s approach to animal welfare is not consistent with conventional veterinary approaches to animal welfare, including their apparent opposition to the use of preventative and therapeutic veterinary interventions. While Marino et al. argue that killer whales' cognitive and spatial needs preclude management of this species under human care, misrepresentation of the citations used to support this opinion invalidates their arguments. Misleading interpretations of data relative to killer whales' cognitive and emotional needs, as well as specious and unsubstantiated comparisons with states experienced by humans with posttraumatic stress disorder and other conditions, represent a number of strategies used to misrepresent knowledge regarding killer whale welfare. These misrepresentations and fallacies are inconsistent with scientific ethical standards for credible, peer-reviewed journals (ICMJE, 2018) and are barriers to rigorous discourse and identification of strategies for optimizing killer whale welfare. Assertions in the paper amount to nothing more than a compilation of conclusory, philosophical statements. We would also like to mention that manuscripts such as Marino et al.'s do great damage to the fields of comparative psychology and to behavioral science as a whole.

Keywords: killer whales, *Orcinus orca*, behavior, welfare, stressors

Introduction

This paper contests Marino et al. (2019) regarding the welfare of killer whales[1] (*Orcinus orca*) under human care. The focus of this paper is the misrepresentation of available data and promotion of fallacies in Marino et al. These misrepresentations and fallacies are inconsistent with scientific ethical standards for credible, peer-reviewed journals (ICMJE, 2018; https://www.elsevier.com/authors/journal-authors/policies-and-ethics). These misrepresentations and fallacies are barriers to rigorous discourse and identification of

[1] Note that we will use the term "killer whale" because it is used in common convention, except where the term "orca" is used as part of a quote.

Please send correspondence to Kathleen M. Dudzinski, Dolphin Communication Project, Port Saint Lucie, FL 34985. Electronic mail may be sent to kathleen@dcpmail.org

strategies for optimizing killer whale welfare. Full consideration of the philosophical basis for Marino et al.'s beliefs and discussion of differences of opinion require separate forums.

Marino et al. (2019) is incorrectly presented as a balanced review. In fact, Marino et al. is more an editorial that presents selected information out of context in support of the beliefs stated in the title and text of the paper (Overall, 2018, 2019). Beliefs supported by credible data and the need to use data for the betterment of animal welfare are important points because science and medicine have advanced when minds have been open to understanding the difference between beliefs and whether or not there is evidence supporting these beliefs; beliefs are not equivalent to scientific knowledge (Overall, 2019). Beliefs and hypotheses are often wrong, even when based on reasonable principles (Evans, 2012).

The core question posed by Marino et al.'s (2019) manuscript is whether there are data to support the belief that killer whales and other cetaceans differ from other species with high cognitive abilities to such a great extent that humans are unable to care for their needs. In this paper, we provide evidence that multiple misrepresentations and fallacies exist in Marino et al. Based on a thorough examination of the data presented by Marino et al., we conclude that there is currently no support for the posed belief that humans cannot meet killer whale needs.

Fallacies in Marino et al.'s (2019) Argument That Killer Whales Under Human Care Suffer from Chronic Stress

The central message of Marino et al. (2019) is that killer whales under human care suffer from chronic stress. There are two core issues that undermine Marino et al.'s central assertion. First, the authors focus on distress or maladaptive stress under the generic term "stress," while blurring the distinction between stressors and acute and chronic stress responses. This misrepresentation could be due to a misunderstanding of the concepts or an imprecise use of terminology. For example, Marino et al. refers to "maladaptive stressors" (p. 13), rather than recognizing that a maladaption can only occur in the stress response, and should therefore not be referred to as a type of stressor (Bautista & Burggren, 2019; Felder et al., 2018; Homberg et al., 2017; Parker et al., 2017). Whether this misrepresentation is due to a misunderstanding of the concepts, conscious omission, or other reasons is uncertain. Regardless, this misrepresentation evidences a misunderstanding of the established scientific understanding of the stress response, including references cited by Marino et al. (e.g., Lupien et al., 2009; Selye, 1976; see our Appendix). We also note that one of Marino et al.'s most frequently cited sources (McEwen and colleagues) considers "stress" to be an imprecise term (McEwae, 2000) and that McEwan's papers (see Appendix 1) clearly define the concepts that McEwan and colleagues present. Marino et al.'s blurring and misrepresentation of concepts confounds clear evaluation of their central assertion.

Second, a core misconception advanced by Marino et al. (2019) is that "orcas and other cetaceans…adhere to the classic HPA[2] model" (p. 13). In actuality, Marino et al. selectively interpret these references and fail to acknowledge that Marino et al.'s core references (*cf.* Atkinson et al., 2015; Atkinson & Dierauf, 2018) present information that is inconsistent with Marino et al.'s) statement. For instance, the title of Table 2 in Atkinson et al. (2015) is "Differences between marine and terrestrial species in their stress responses" (p. 471).

Other examples in Atkinson et al. (2015) that Marino et al. (2019) do not acknowledge include passages where Atkinson et al. (2015) stated that marine mammal "mediator activity … diverges from generalized terrestrial models," (abstract, p. 477), and where it is stated that "marine mammals seem to diverge from the terrestrial mammal norm in the complexity of regulatory systems that increase activity under perceived or physical stressors" (Atkinson et al., p. 477). Further undermining Marino et al.'s efforts to apply the "classic HPA model" to killer whales is in the conclusion of Atkinson's second paper, which states that "the stress response…. (is a) term (that) is too often applied indiscriminately as a convenient 'catchall' when efforts

[2] Hypothalamic–pituitary–adrenal axis

to reach some other diagnosis fall short" (Atkinson & Dierauf, 2018, p. 10).

This caution is repeated elsewhere among Marino et al.'s (2019) references, where it is stated that "a recent review (Atkinson et al., 2015) warned that terrestrial animal stress models might not always be applicable to marine mammals, and these authors presented evidence to suggest that neuroendocrine hormones may be regulated very differently in cetaceans" (Clegg & Butterworth, 2017, p. 196). Marino et al.'s assertions about the cetacean HPA also misused citations about acute stress in cetaceans (Fair et al., 2014; Thomson & Geraci, 1986) when discussing chronic stress, thereby conflating two very different concepts and misrepresenting the available empirical evidence. The remaining references cited by Marino et al. in support of their misstatement that cetaceans adhere to the classic HPA model (Houser et al., 2011; Levin, 2018; Romano et al., 2002) do not present data on chronic stress in cetaceans. Marino et al.'s citations do not support their statement regarding the cetacean HPA, and this misrepresentation of the citations is not consistent with scientific ethical standards.

The extensive mention of stress and publication title of Marino et al. (2019) are not accompanied by rigorous support for the authors' thesis. The use of the term "stress" in this paper reflects common use of the term as a negative affective state, although the origin of the term (in Marino et al.'s Selye [1976] reference) recognizes that all living beings are exposed to various stressors, some of which result in "good" (eustress) stress responses and some of which result in "bad" (distress) stress responses. Given Marino et al.'s discussion, we will interpret their use of the word stress as meaning distress unless otherwise stated in the text.

A survey of use of the word stress or stressors in Marino et al.'s (2019) text results in 79 mentions of stress and stressors over 19 pages of text, not including the title or headers, and 48 citations associated with these uses of stress and/or stressors (Appendix 1). Of these citations, only four present original data concerned with killer whales under human care, including two case reports of fungal infections in a single citation (Reidarson et al., 2018), a legal document developed by one of their co-authors regarding a single killer whale at a single facility (Visser, 2016), and a second unpublished, non-peer-reviewed self-citation of a killer whale at another facility (Visser & Lisker, 2016).

As addressed more fully later, these case reports and self-citations are insufficient to support this manuscript's assertions. While the data on other cetaceans could be relevant to killer whales, there are species differences, including Marino et al.'s (2019) failure to recognize that the smaller dolphin species and killer whales have different social structures ("open" and "closed", respectively) that limit cross-taxonomic inferences regarding responses to stressors (Simmonds, 2006). Therefore, Marino et al.'s (2019) merging of acute stress responses in bottlenose dolphins (*Tursiops truncatus*) (Fair et al., 2014; Thomson & Geraci, 1986) with speculation on chronic stress in killer whales represents a substantial conceptual deficiency and misrepresentation of the available data.

Similarly, associating chronic stress in cheetahs (*Acinonyx jubatus*) (Terio et al., 2004) with speculation on killer whales is a specious argument that has limited relevance when it is considered that findings in cheetahs do not appear to be generally applicable to even other Felidae species that are closer taxonomic relatives to the cheetah than are killer whales. (See also Simmonds (2006) for caution when directly comparing terrestrial and aquatic species.) A review of the references also reveals many misrepresentations and false statements in Marino et al.'s (2019) text, as listed in Appendix 1, and discussed later in this document. These concerns are not minimized by associating speculation on killer whale affective states, in the absence of corresponding and converging behavioral or functional brain data, with citations concerned with the experience of human prisoners of war and others experiencing depression (Aloni et al., 2018; Başoğlu, 2009; Lupien et al., 2009) or the biochemical and neuroanatomical changes in laboratory rodents that are completely immobilized or deprived of food and water (Bennur et al., 2007; Vyas et al., 2002). These misleading generalizations and false analogies are not consistent with the transparent expectations of peer-reviewed journals (ICMJE, 2018).

Marino et al.'s (2019) statements of causality based on correlational evidence also fail to meet expectations for transparency in peer-reviewed scientific literature. One example of many is the statement that "[t]he confinement of naturally wide-ranging mammals *causes* chronic stress (Dawkins, 1998) . . ." (p. 16). A second example is, "For example, Clubb and Mason (2003, 2007) found that natural home-range size predicted captive infant mortality and stereotypic pacing behavior in carnivores, and that captive environments *cause* the most stress to naturally wide-ranging species by preventing species-typical behavior" (p. 16). The cited studies are observational and therefore can only be used to establish correlation. Misuse of the word "cause" in these instances instead of "correlation" is a gross misrepresentation of the available data, minimally, especially without a full discussion of the limitations of these studies. This is a basic principle of the scientific method and it was misused in Marino et al.

Animal Welfare Assessment

Animal welfare can be assessed using principles that optimize the safety and well-being of animals within the context of existing and potential tradeoffs (Miller, Anthony, & Golab, 2018). The beliefs expressed by Marino et al. (2019) are inconsistent with the American Veterinary Medical Association's (AVMA, 2019) animal welfare principles, which include responsible use of animals for human purposes; making decisions about animal care, use, and welfare by balancing scientific knowledge and professional judgment; providing access to good health care; minimizing pain, fear, stress, and suffering; continuously evaluating current practices; focusing on conserving and managing the population ethically; treating animals with respect and dignity from beginning to end of life; and continually improving animal health and welfare through science, advocacy, and legislation (AVMA, 2019).

Rather than discussing approaches to optimize animal welfare, even to form a basis for comparison, Marino et al. (2019) chose to present what can be more accurately characterized as an opinion piece that optimized emotion and belief manipulation rather than an objective review of the data or analytical reasoning. This biased approach does not benefit the development of strategies for optimizing animal welfare. Publication of an opinion piece under the guise of scientific research and failure to acknowledge or discuss established veterinary professional animal welfare principles are not consistent with the important practice of distinguishing between belief and knowledge, doing good, advancing discourse on established principles, following the scientific process, or benefiting animal welfare.

Are Killer Whales Different?

The *Journal of Veterinary Behavior* (*JVB)* has published manuscripts on the behavior, welfare, and strategies for improving the welfare of species such as Atlantic salmon (*Salmo salar*) in aquaculture (King, 2009), working therapy dogs studied in outpatient hospital settings (Clark et al., 2019), pet gray parrots (*Psittacus erithacus*; Greenwell & Montrose, 2017), cheetahs (*Acinonyx jubatus*), tigers (*Panthera tigris*, Phillips et al., 2017), snakes (Warwick et al., 2019), and gorillas (*Gorilla gorilla gorilla*; Fuller & Allard, 2018) under different management systems. Thus, while the *JVB* publication of manuscripts about nondomestic animals is not unusual, opposition to human management of a species without clinical applications or research that improves animal welfare appears to be atypical. Philosophical opposition to any species under human care is a valid topic of discussion if explicitly and transparently addressed with rigor. In contrast, Marino et al. (2019) appear to be using a comparative approach to argue that killer whales are intrinsically unsuited to be held under human care. Thus, while Marino et al. propose that killer whales "possess the neurobiological foundations of complex psychology, emotion, and behavior," there is uncertainty as to how killer whales differ from other species discussed in the *JVB* manuscripts or whether Marino et al.'s underlying argument is that no species should be in human care.

Marino et al. (2019) used a selective comparative approach to argue that the neuroanatomy of killer whales enables them to have uniquely complex cognitive capabilities. The inaccuracies of Marino et al.'s assertions are highlighted by examining four points:

1. Marino et al. (2019) state that killer whale brains have been "described as being more corticalized than the human brain" (p. 3) without linking how corticalization results in compromised animal welfare when under human care. Marino et al.'s neuroanatomical specialness assertion also fails to acknowledge alternate hypotheses, such as was presented in the Wright et al. (2017) paper cited by Marino et al. The alternate hypothesis presented by Wright et al. proposed that delphinoid cetaceans (as a group) may have "divergent cerebral morphology … in response to the sensorimotor demands of the aquatic environment," (p. 417) rather than the "high-level cognitive and social functions" (p. 3) that Marino et al. present. Moreover, a broader comparative approach indicates that Marino et al.'s link between brain structure and function has limitations. This conclusion is based on species without comparable neocortical structure that are capable of cognitive tasks that are comparable and possibly superior to primates, such as corvids and psittacines (Emery, 2006), and species such as cephalopods that are capable of complex cognition in the absence of comparable brain structure (Mather & Dickel, 2017). We will not digress into how cognition is defined, but there are variable parameters for this term (Willemet, 2013).

2. Marino et al. (2019) stated that "recent work on orcas has shown that "limbic functions" are well integrated with other cortical functions" as an argument for the species' advanced emotional and cognitive capabilities (p. 4). This unsupported assertion assumes that killer whale cortical functions are fully inferred from neuroanatomy and does not consider differences between cetaceans and other species. Of more substantive concern is that Marino et al.'s (2019) three supporting citations (Marino et al., 2004; Morgane et al., 2005; Pessoa & Hof, 2015) consist of two citations that do not mention killer whales and a self-citation that was limited in scope to gross morphology (as recognized in Wright et al., 2017) and did not present data on killer whale's emotional and cognitive processes.

3. Marino et al. (2019) also use a self-citation to suggest that relative brain size is a predictor of cognitive capacity across species (Marino et al., 2004). However, Marino's assertion is oversimplified and not universally supported (Herculano-Houzel, 2011; Willemet, 2013).

4. Marino et al. (2019) links chronic stress to killer whale brain cell shrinkage. However, descriptions of CA3 neurons and steroid hormone receptors in the brains of cetaceans are not cited by Marino et al. and do not appear to be documented in peer-reviewed scientific literature. Thus, this line of reasoning is simply speculative and should have been represented as such rather than as fact.

In total, Marino et al.'s (2019) assertion that killer whales have unique capabilities based on neuroanatomy represent inaccurate presentations of peer-reviewed, published literature. Similarly, other citations used by Marino et al. concerned with biochemical mechanisms and neuroanatomy did not establish a relationship between the citations' findings and killer whales, or how killer whales might be suffering from chronic distress and be uniquely unsuited to thrive under human care. Rather, the use of citations obscured the discourse by providing misleading information about concerns that deserve to be soberly considered, and failed to provide any direct empirical support or acknowledge information that is inconsistent with Marino et al.'s beliefs. As indicated above for other topics, these misrepresentations and fallacies are inconsistent with scientific ethical standards for credible, peer-reviewed journals (ICMJE, 2018).

Are Killer Whales' Physical Needs Met Under Human Care?

A basic question for all animals under human care is whether their physical needs are met. One way that this can be considered is by examining health issues on a population-level and individual-animal basis. However, Marino et al.'s (2019) section on causes of illness and death suffers from the fallacious, implicit assertion that the existence of disease represents poor husbandry and poor welfare. In fact, as clinicians generally understand for all species, including humans, disease occurs in living organisms. The infectious diseases listed by Marino et al. are not restricted to killer whales; moreover, Marino et al. neglected to acknowledge that bacterial, viral, and fungal infectious diseases also occur in free-ranging killer whales (Goldman et al., 2011; LaMere et al., 2009; Raverty et al., 2017).

The impact of infectious and noninfectious disease on individuals and populations is the key consideration for placing the occurrence of disease for killer whales in context. For instance, while Marino et al. (2019) associates gastric ulceration with *Helicobacter pylori* infections using a 1994 citation concerned with humans (Nomura et al., 1994), this assertion ignores research over the last quarter century that indicates that *Helicobacter* spp. can be a commensal organism in humans (Li & Perez-Perez, 2018) and other species (Terio et al., 2005; Yasuda et al., 2015) and that both captive and wild healthy cetaceans harbor *Helicobacter* spp. (Goldman et al., 2011). Thus, in contrast to Marino et al.'s assertion, the presence of *Helicobacter* spp. in cetaceans and other species is not a valid indicator of disease, "prolonged stress" (Marino et al., p. 8), or compromised animal welfare; Marino et al.'s assertion should not be accepted by a legitimate peer-reviewed medical journal such as *JVB*.

The *JVB's* acceptance of summaries of diseases in killer whales without context and as a proxy for chronic stress is puzzling. Similarly, the *JVB's* implicit acceptance that veterinary care of killer whales is a source or consequence of maladaptive stress is unfortunate for a veterinary journal. The detailed descriptions of veterinary (including dental) treatments and discussion of the potential for adverse effects from therapy appear to suggest that provision of veterinary care for killer whales is problematic.

As free-ranging killer whales also have dental, infectious, and noninfectious disease, rigorous data are needed to establish that the conditions listed by Marino et al. (2019) represent untenable consequences or causes of chronic stress in killer whales under human care. Marino et al. also failed to note that killer whales in human care voluntarily cooperate with their medical care, which is a strategy that reduces distress in killer whales and other marine mammals and improves the number of viable options for providing quality veterinary care (Brando et al., 2018; Lacave, 2018).

Given that animals under human care deserve to receive management and veterinary care that optimize their welfare, there is a need for the *JVB* to clarify why killer whales are not deserving of veterinary services, as seems to be put forth by Marino et al. (2019). We also note that veterinary care of captive killer whales is the basis for provision of veterinary services to free-ranging killer whales with medical concerns, such as well-publicized interventions proposed and enacted for Southern Resident killer whales (Gaydos et al., 2019; Shore, 2018). As anthropogenic stressors increase in extent and magnitude, this veterinary medical expertise will likely become more critical for free-ranging killer whales. This approach is similar to what has been recognized for terrestrial wildlife that are inhabiting increasingly restricted "natural" areas (Deem, 2007).

Nutrition is another key component of meeting the physical needs of killer whales under human care. Marino et al.'s (2019) use of the word "dead" when referring to fish and squid fed to killer whales under human care seems to suggest that conventional feeding practices are flawed. If this is Marino et al.'s intent, it fails to acknowledge the feeding of restaurant-quality fish, assessment, and quality control of fish nutritional quality, regulatory oversight, and other strategies used to address the nutritional needs of killer whales and other marine mammals under human care (Brando et al, 2018; Crissey & Spencer, 1998; Rosen & Worthy, 2018). Of relevance to animal welfare is that freezing fish also kills parasites that could infest killer whales, in contrast to parasite transmission that occurs with consuming live prey in wild marine mammal populations (Rosen & Worthy, 2018). Feeding live fish to killer whales under human care is an alternate strategy, although this presents animal welfare concerns for the fish and illustrates the tradeoffs and biases that are inherent in assessing and optimizing animal welfare for all species (Miller, Anthony, & Golab, 2018). This is yet another example of an opinion set forth by Marino et al. without any discussion of established principles and current practices.

An underlying concern for meeting killer whale physical needs is Marino et al.'s (2019) thesis that killer whales under human care have insufficient space and that this causes chronic stress. For instance, on page 16 of Marino et al., there is a section devoted to "The Stress of Confinement" and "the negative impacts of enclosure size (as) related to the natural history of a species." This section cites Morgan and Tromborg's (2007) dolphin studies as support for this assertion. However, besides limitations regarding extrapolations from smaller dolphins to killer whales (as indicated above) and contrary to Marino et al.'s assertion, Morgan and

Tromborg (2007) state that some species "do not always prefer the largest available living spaces," (p. 278) and cite Shyan et al. (2002) when stating that "dolphins given a choice between three pool sizes choose to spend most of their time in moderate-sized areas, rather than the largest area available" (p. 278). Misrepresentation of Morgan and Tromborg's publication is not consistent with scientific ethics and confounds serious consideration of Marino et al.'s discussion of enclosure size.

Are Killer Whales' Cognitive and Emotional Needs Met?

As described above, the discussion of killer whale cognitive and emotional needs suffers from the overinterpretation of available evidence, speculation when data are not available, and distortions of the current knowledge. Drawing conclusions about the potential function of various brain regions based on comparative neuroanatomical evidence represents an overgeneralization and is misleading to readers less familiar with this literature. Currently, there is no behavioral or functional imaging validation of Marino et al.'s (2019) proposed functions associated with cetacean neuroanatomy. Thus, it is speculative for Marino et al. to state that "the expansion of these areas in cetaceans is arguably associated with high-level cognitive and social functions such as attention, prediction, social awareness and empathy. . ." (p. 3).

Moreover, as previously indicated, Marino et al.'s (2019) assertions are misleading by failing to acknowledge a competing hypothesis that cetacean paralimbic cortex anatomy is an adaptation for meeting the sensorimotor demands of the aquatic environment (Wright et al., 2017). Furthermore, Marino et al.'s incomplete discussion of self-awareness as the basis for killer whales having unique cognitive qualities does not acknowledge that contingency checking is found in many species that never pass the mark test (Anderson & Gallup, 2015; Clary & Kelly, 2016). In fact, there is evidence that a fish species (cleaner wrasse, *Labroides dimidiatus*) shows both contingency checking and passes the mark test (Kohda et al., 2019), in contrast to Marino et al.'s suggestion that self-recognition is a special cognitive ability of killer whales.

In addition, Marino et al.'s (2019) use of words that are anthropomorphic, such as referring to offspring as "children" (p. 7), is inconsistent with presenting an objective scientific discussion. Unfortunately, failure to acknowledge strong evidence that counters Marino et al.'s beliefs, in combination with terminology that is not consistent with scientific expectations, precludes rigorous discussion of killer whale cognition and affective states. Moreover, to objectively evaluate the welfare concerns of killer whales in human care, a balanced discussion requires acknowledgement of current best practices to manage cetaceans in compatible social groups, an understanding of how human interactions serve to address cetacean's social needs, and a knowledge of various management practices to provide cetaceans with mental stimulation. While omission and use of terms intended to evoke emotion may be used to sway public opinion, the use of this persuasive technique is inconsistent with scientific ethical standards for credible, peer-reviewed journals (ICMJE, 2018).

Strategies Used to Misrepresent Knowledge Regarding Killer Whale Welfare

The three general categories of information presented in Marino et al. (2019) are: A) general information about the *General Adaptation Syndrome*, B) selective interpretations of cetacean characteristics, and C) hypothesized equivalence between killer whales and the biological and behavioral mechanisms of humans, rodents, carnivores, and other species without providing compelling links to killer whale affective states. These three categories of information represent a series of statements of why things *may* be, which are substituted for arguments as to how things *are*. The length of Marino et al.'s text, numerous references, and the variety of topics presented does not change the fact that their statement is an unsupported hypothesis based on erroneous assertions.

The errors presented in Marino et al. (2019), as documented above and in Appendix 1, represent a number of recognizable misrepresentations of killer whale affective states that are based on what appear to be philosophical beliefs. Given the publicity that killer whales and other cetaceans receive and the impact of misrepresentations on the welfare of cetaceans under human care and in the wild, we will briefly summarize (in Table 1) some of the types of fallacies that Marino et al. used to support their assertions misrepresented as

scientific discourse. While full discussion of such strategies in societal discourse is beyond the scope of this document, there is a need to highlight such strategies when they sully scientific communications. Disagreements and debate of ideas are a part of accepted scientific discourse, but the failure (intentionally or unintentionally) to adhere to ethical norms is not acceptable (ICMJE, 2018).

Table 1 lists a variety of misrepresentations that Marino et al. (2019) used to distract readers from the core points that the authors presented with the effect of minimizing rigorous analysis. These misrepresentations are not comprehensive and are not mutually exclusive, such as the example of omission of a quarter of a century of data on *Helicobacter* spp. also having the effect of evoking emotional concern about gastric ulceration.

Table 1

A Partial List of Misrepresentations Evident in Marino et al. (2019) with Selected Examples

Type of Misrepresentation	Selected Examples [Page Number in Marino et al. (2019) in Brackets]
Fabrication	• Marino et al. stated that "regularly prescribed prophylactic antibiotics prior to even minor repair work in the stadium adjoining her tank" (p. 17) occurred for a single killer whale at a single facility, based on an unpublished self-citation (Visser, 2016). The Visser (2016) self-citation had a single mention of a whale stadium repair, and no antibiotics appear to be listed in the document. (See Appendix 1 for more information.)
Distortion	• Marino et al. stated that cetaceans "adhere to the classic HPA model" (p. 13) while the cited references state otherwise (for a full discussion, see the above section: *Fallacies in Marino et al.'s argument that orca under human care suffer from chronic stress*). • Marino et al. misused a citation on use of novel objects for environmental enrichment (Sambrook & Buchanan-Smith, 1997) to support a statement that "one of the greatest stressors in the lives of captive animals is their inability to control most aspects of their surroundings and lives" (p. 17). Sambrook and Buchanan-Smith (1997) did not use the word stressor, and "stress" is only included in Sambrook and Buchanan-Smith's list of citations. • Marino et al. state that "The expansion of these areas in cetaceans is arguably associated with high-level cognitive and social functions such as attention, prediction, social awareness and empathy" (p. 3). Neither citation used supports this statement. One of the citations used (Allman et al., 2005) is concerned with autism in humans. The second paper (Hof et al., 2005) is a self-citation, in which the words "attention," "prediction," "social awareness," or "empathy" do not appear with an electronic search of the text.
Omission	• Marino et al. state that "Gastric ulceration is often caused by prolonged stress, as well as being associated with the bacterium *Helicobacter pylori* (Nomura et al., 1994)" (p. 8). However, Marino et al. failed to cite the extensive number of *Helicobacter*-related publications subsequent to Nomura et al. (1994) indicating that the organism is generally a commensal (nonpathogenic) and that it is also found in healthy free-ranging cetaceans (for more information see above section: *Are killer whales' physical needs met under human care?*).
Cherry picking[1]	• Marino et al.'s section on self-awareness (p. 5) does not acknowledge that contingency checking is found in many species that never pass the mark test (Anderson & Gallup, 2015; Clary & Kelly, 2016), and that a

	fish species (cleaner wrasse, *Labroides dimidiatus*) shows both contingency checking and passes the mark test (Kohda et al., 2019).
Misleading vividness[2]	• Use of terms such as "commercial trade" (p. 2), "concrete tanks" (pp. 1-3, 10, 14-19), and "tricks" (rather than trained behaviors for husbandry or enrichment purposes) (p. 18), "dead fish" (p. 11), and dental pulps that are "necrotic, infected, or hyperplastic" (p. 11), are intended to evoke negative emotional connotations. • Referring to killer whale offspring as children (p. 7) invokes a human-based association instead of remaining objective. This contrasts with previous *JVB* publications, in which production swine are housed in "individual crates" (Oelke et al., 2018), Atlantic salmon (*Salmo salar*) in "transport systems" for aquaculture (King, 2009), and working therapy dogs studied in outpatient hospital settings (Clark et al., 2019). Similarly, nondomestic animals kept as pets or for exhibition were housed in cages (pet gray parrots, *Psittacus erithacus*; Greenwell & Montrose, 2017), cheetahs (*Acinonyx jubatus*) and tigers (*Panthera tigris*) were kept in enclosures (Phillips et al., 2017), snakes in enclosures or viveria (Warwick et al., 2019), gorillas (*Gorilla gorilla gorilla*) in indoor habitats (Fuller & Allard, 2018), and dolphins (*Tursiops truncatus*) housed in open and closed facilities (Ugaz et al., 2013).
Snow job[3]	• Extensive discussion of encephalization, cerebral expansion, limbic system, sensory regulation, self-awareness, emotion, and other information (pp. 2-6) that does not specifically address the question of whether killer whale experience chronic distress that compromises their welfare. • Linking of killer whale welfare and killer whale attacks on humans (pp. 10, 33, 34) when they are distinct issues.
Draw your own conclusion/jumping to conclusions fallacy[4]	• Marino et al.'s extensive list of medical and dental diseases (pp. 8-11) with descriptions of treatments that may be intended to evoke negative connotations. This contrasts with the context and consideration of how medical and dental care is viewed for humans and other species, as well as for untreated disease in free-ranging killer whale.
Red herring fallacies[5]	Four types of red herring fallacies are listed below.
• Appeal to emotion	• Reference to the negative emotional experiences of post-traumatic stress disorder (p. 16), learned helplessness (p. 18), and other psychological concerns of humans without documentation on the affective states of killer whales is misleading and lacks valid reasoning.
• Appeal to consequences[6]	• Mention of rare killer whale attacks on caretakers (p. 10) rather than acknowledgement of human-killer whale bonds or link to animal welfare consequences.
• Appeal to nature[7]	• Marino et al. argued that killer whales must be suffering from maladaptive stress responses (p. 13) due to the absence of opportunities for extensive travel, rather than considering the elements of why killer whale travel (e.g., to forage) and how relevant animal needs could be addressed under human care.
• Association fallacy[8]	• Correlating Carnivora and killer whale behavior (p. 16) because both consume other animals, rather than accounting for different environmental and other factors.

Note. [1]Selection of individual cases or data that support a position while ignoring a larger body of evidence that contradicts the position

[2]Vividly detailed descriptions that are intended to convince that a problem exists while appealing to emotion

[3]Overhelming readers with large quantities of true but marginally relevant information that looks impressive but is not fully understood
[4]Where readers are provided "shocking evidence" and encouraged to make their own conclusions without the expectation that readers will take the time to reason through the argument
[5]A strategy of distracting readers from a concept by presenting a different argument that is easier to address. There are different types of red herrings, such as those identified.
[6]Use of positive or negative outcomes in support of an assertion that distracts from the main point
[7]Judgement is based solely on whether something is considered natural or unnatural
[8]Arguing that shared characteristics imply general similarities

Conclusion

We document an extensive number of misrepresentations that undermine Marino et al.'s (2019) beliefs regarding killer whale welfare under human care. These misrepresentations are not differences of scientific opinion and instead represent misleading talking points in support of what appear to be philosophical beliefs that are not explicitly discussed. Marino et al.'s use of these illusory approaches undermines the credibility of every one of their points regarding killer whale needs, animal welfare, and affective states. Their biased representations are also obstacles to objective consideration of how to best care for killer whales. In addition, this approach does not contribute to the development of strategies for improving animal welfare or advancing established principles. Importantly, failure to use objective and candid assessments of available data markedly contrasts with the scientific ethical standards expected of credible, peer-reviewed journals (ICMJE, 2018). These deviations from scientific norms are characteristic of common, nonscientific literature that is available to the general public rather than a rigorous contribution to the scientific peer-reviewed literature.

We would also like to mention that manuscripts such as Marino et al.'s (2019) do great damage to the fields of comparative psychology and to behavioral science as a whole. Recently, an international effort attempted to replicate some of the more well-known findings in social and cognitive psychology and could only replicate 30% and 50%, respectively (Open Science Collaboration, 2015). This problem of replication of previous studies is illustrative of what we consider a serious and growing issue in not only the behavioral sciences but of science more generally with respect to the acceptance and publication of sloppy work with subjective interpretation that leads to faulty science. The usage of the Marino et al. publication can impair the sharing of dependable research and create misinformation in the field of killer whales in human care.

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