Title
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Journal Publication Trends Regarding Cetaceans Found in Both Wild and Captive Environments: What do we Study and Where do we Publish?

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Scientists conducting research on cetaceans have a variety of publication outlets. However, a formal assessment of those options has not been conducted. To better understand the trends in publications regarding dolphins and whales, we surveyed peer-reviewed articles from 9 different databases. Our survey produced 1,628 unique articles involving 16 cetaceans found both in the wild and in captivity. Each article was coded a variety of information: habitat, geographic location, genus, topic, research design, and journal type. The analyses indicated that 68% studies were conducted with wild populations and 29% were performed with captive populations. A quarter of the journals publishing research on dolphins or whales published almost 80% of all the articles selected for this study. Studies were conducted across many different geographic locations and topics. Other major findings elucidated relationships between various variables. As expected, specific topics were more likely associated with certain research designs, habitats, and journal types. One of the most important findings of this study is the limited publication of research conducted with captive cetaceans. While it is important to continue to examine animals in their natural environments, there is much to be learned from studies conducted with animals in captivity. As a group, we must become cognizant of the publication trends which currently describe our research progress as we integrate our knowledge from captivity and the wild.

Much of the extant knowledge of marine mammals is summarized in large compilations of encyclopedias or books dedicated to specific cetaceans, aspects of their life history, geographic distributions, anatomy and physiology, sensory systems and capabilities, or behavioral and cognitive abilities (e.g., Herman, 1980; Ridgway & Harrison, 1999; Schusterman, Thomas, & Wood, 1986; Thomas & Kastelein, 1990). These comprehensive summaries are instrumental in the integration of past knowledge and current findings. Many of the topics compiled in these comprehensive books include findings from research conducted in both the wild and captive settings. A simple review of this literature suggests that some research topics are better addressed with wild populations (e.g., life history parameters, distributions) while others are more appropriate for captive animals (e.g., sensory system capabilities, cognitive capacities).

It is critical that research continues to integrate information from both wild and captive populations. Each population provides unique contributions to our understanding of the pressures faced by marine mammals. Ten years ago, Mann and her colleagues compiled and published the most comprehensive review of the literature to date on several species of cetaceans in the book, Cetacean Societies (Mann, Connor, Tyack, & Whitehead, 2000). The editors of this book provided a wealth of information that integrated different aspects of the lives of four cetaceans. Interestingly, two of the cetaceans are found in both wild and captive settings (i.e., Tursiops truncatus, bottlenose dolphin, and Orcinus orca, killer...
whale) and two are found only in the wild (i.e., *Megaptera novaeangliae*, humpback whale, and *Physeter macrocephalus*, sperm whale). Authors of individual chapters compiled information regarding the history of captive research, aspects of life history, behavior, development, relationships, acoustics, and communication abilities of these four cetaceans. One of the particularly exciting components of this edited book was the integration of findings from observations in the wild and observations in captivity. This integration allowed readers to assess the findings of research conducted with wild and captive animals simultaneously. For example, this comprehensive review suggested that wild and captive bottlenose dolphins often exhibit very similar behaviors (e.g., play behaviors, association patterns, affiliative or aggressive interactions) and developmental milestones (e.g., echelon swim versus infant swim patterns, emergence of independence).

With approximately 35 different species of cetaceans in captivity (May, 1998), only a very small number have been studied and compared with their wild counterparts (e.g., *Tursiops*; *Orcinus*). In fact, since the publication of *Cetacean Societies* a decade ago, very few comprehensive reviews regarding the progress made in the knowledge of cetaceans have been published (e.g., Harley, 2008; Shaffer & Costa, 2006). Researchers must comb through and integrate a vast body of published peer-reviewed literature, article by article.

Comprehensive reviews on various topics involving wild and captive cetaceans would allow current researchers opportunities to better understand the areas in which progress has been made as well as identify areas in need of more research. For example, research has progressed in our understanding of the acoustic complexity of a variety of cetaceans, including humpback whales, sperm whales, and killer whales (Deecke, 2006). However, much of this research has been conducted in the wild. In comparison, many improvements have been made in the care of captive animals, resulting in better health and longevity (Wells, 2009). Research regarding the effects of humans on the behavior and physical health of cetaceans has also expanded and incorporated knowledge from research conducted in wild and captive settings (Nowacek, Thorne, Johnston, & Tyack, 2007; Thomas, 2009). Similarly, attempts to examine the cognitive abilities, the importance of play, social interactions, and individual differences of a variety of cetaceans continue to move forward (Harley, 2008; Highfill & Kuczaj, 2007; Kuczaj, Gory, & Xitco, 2009; Paulos, Dudzinski, & Kuczaj, 2008).

A recent report regarding animals in captivity, sponsored by the Humane Society of the United States and the World Society for the Protection of Animals, indicated that research involving captive cetaceans was lacking and had made little progress (Rose, Parsons, & Garinato, 2009). Specifically, the authors indicated that research from United States-based marine mammal facilities was minimal and had produced few significant contributions regarding our understanding of marine mammals. With incredulity, we initiated the current review of the available literature pertaining specifically to cetaceans. Our own experience suggested a different interpretation, and we wished to determine the accuracy of the conclusions drawn by Rose and her colleagues.
A variety of marine mammals have been housed in captive environments for approximately 150 years (Samuels & Tyack, 2000). Given the vast body of published literature on marine mammals from both captive and wild settings, we narrowed the focus of our review to include only journal articles that centered on cetaceans cared for by humans at some point during captivity’s documented history. Although this choice biased our understanding of publication trends regarding marine mammals, it allowed for a more comprehensive and interpretable picture of research conducted with one major branch of marine mammals. To better understand the type of research conducted with cetaceans found in both the wild and in captivity and published in journals, we examined the following questions:

1. How are articles on dolphins or whales distributed across a variety of databases?
2. Which journals published research involving dolphins or whales most frequently?
3. What dolphins or whales were represented most frequently?
4. What geographic locations were represented most frequently?
5. From which habitat (wild, captive, or both) were samples derived the most frequently?
6. What topics were represented most frequently?
7. What research designs were used most frequently?
8. Were the articles distributed across the journal types related to the habitat?
9. Were the topics examined related to the habitat from which the samples were derived?
10. Were the habitats related to the type of research design used within the studies?
11. Were the research designs related to the type of journal in which they were published?
12. Were the topics examined related to their research designs?

Method

Sample

We examined a sample of 1,628 unique peer-reviewed journal articles published between 1950 and December 2009. Although there are documented publications dating to 1875, we wanted to focus on articles that were contemporaneous with the current research standards for animal safety and welfare. Our sample was derived from a comprehensive, but not necessarily exhaustive, search of nine databases, using the terms “dolphin” or “whale” as our search terms in all text available for the nine search engines: Academic Search Complete, Agricola, Annual Reviews, Biological Abstracts, EbscoHost (E-Journals, TOPICSearch, and PsycArticles), JSTOR, PsychINFO, Psychology & Behavioral Sciences Collection, and Science & Technology Collection. These terms represented the greatest number of response hits as compared to “cetacean” only and even “marine mammal.” We believe that a similar review of pinnipeds alone would be extremely beneficial for the field. A review of other marine mammals not captured in the current review would also be productive.
recognize that some articles relevant to the current study may not be represented in the current sample. However, we believe the sample is representative of the research conducted and published.

**Procedure**

In order to manage the large number of potential sources, we used several exclusionary criteria during the search process. First, we excluded marine mammals that were not cetaceans (e.g., *Ursus maritimus*, polar bears, and *Enhydra lutris kenyoni*, sea otters) and whale or dolphin genera that were found only in the wild (e.g., *Balaenoptera* sp., all baleen whales and sperm whales). Thus, we included cetaceans that had been cared for by humans for some length of time (i.e., beyond animals held temporarily due to strandings or catch-and-release field studies). Second, we excluded all books, chapters, reviews, unpublished dissertations, and popular press references. Only peer-reviewed articles found within the above databases were selected for this study. Third, we excluded articles in which fossils or fossil records comprised the primary sample. Most of the studies excluded using this criterion focused on the paleontology and evolutionary history of cetaceans. While these studies are important, they did not appear to be directly related to the current care and well-being of animals in captivity. Finally, if a genus could not be indentified from the title, abstract, or full text, it was coded as “unidentified.”

Using the exclusionary criteria above, the search for articles, from which the current sample was derived, produced over 30,000 hits. Each abstract or article was individually reviewed to determine if it met the inclusion criteria (i.e., the word, dolphin or whale, present somewhere in the abstract or title, the species could be found both in the wild and in captivity, the subjects generally were alive, and the study was a peer-reviewed journal article). Approximately 325 articles were duplicated across different databases. Duplicate articles were excluded from the final sample. Once selected for the sample, each abstract or article was coded for the following information: habitat, geographic location, genus, topic, research design, and journal type. Due to the huge range of geographic location, topics, and journals, we collapsed each category into larger categories to facilitate our statistical analyses. See Table 1 for the final individual designations for each category.

Geographic location was originally designated by United States (U.S.) areas (Northeast, Southwest, etc.), European Union (E.U.), United Kingdom (U.K.), and single countries or locations (e.g., Caribbean, Gulf of Mexico). These areas were then grouped by ocean basin with the exception of the North Atlantic, which was divided into the Canadian North Atlantic, the U.S. North Atlantic and the European North Atlantic. If the specific area could not be determined, then it was coded as a separate category indicating that no location was stated. See Table 1 for a list of collapsed categories of geographic areas.

Each article was also coded for species. Initially, all genus species identifications were made for every species examined in a given study. Species that were not directly identified were placed in an unidentified category. The species categories were then collapsed by genus to facilitate the analyses. Sixteen genera were identified across journal articles (see Table 1).

After identifying over 41 topics across the 1,628 articles, we grouped the topics into 14 broad categories. While a finer level of analysis would be ideal, there were too many categories with less than five cases. This condition violated one of the assumptions for our statistical analyses. Thus, the more specific categories were collapsed and may be found in Table 1. See the appendix for the original categories used to create the broad categories analyzed.

Each study was also coded for the type of research design used to conduct the study. Studies were grouped into one of the following categories: observational, observational-biology, experimental-psychology, experimental-biology, and undetermined or miscellaneous. Observational studies were any studies performed in which no or very little manipulation of the subjects occurred. These studies included population and distribution studies and observational research studies of various behaviors. Observational-biology studies included studies that involved techniques requiring more manipulation or invasion to the animal, such as acquiring biological matter (e.g., lesions.

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2Different levels of access are available for various databases. Thus, if the current search was replicated at a different institution or facility with greater levels of access, a different sample would be produced.
stomach contents, genetic material) from stranded animals. Experimental-psychology studies involved any research in which aspects of the environment were manipulated or altered to investigate the effects on cognition or behavior. Experimental-biology studies involved any research in which manipulations occurred and affected the subjects, physiologically. These studies included studies on genetics, physiological studies, sensory system studies, and immunological studies. The categories are also listed in Table 1.

Finally, our initial sample included 290 unique journals. Journals were collapsed into nine categories to better identify any trends in publications. The collapsed categories generally represented journals that shared similar topics or scopes of interest and may be found in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories</th>
</tr>
</thead>
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<tr>
<td>Habitat</td>
<td>Captivity, Wild, Both</td>
</tr>
<tr>
<td>Geographic Location</td>
<td>Arctic, North Atlantic Canada, North Atlantic U.S., North Atlantic Europe, Central Atlantic (Caribbean &amp; Gulf of Mexico), South Atlantic (Antarctic waters), North Pacific, South Pacific, Indian, Mediterranean</td>
</tr>
<tr>
<td>Genera</td>
<td><em>Cephalorhynchus, Delphinapterus, Delphinus, Feresa, Globicephalus, Grampus, Lagenodelphis, Lagenorhynchus, Neophocaena, Orcinus, Phocoena, Pseudorca, Sousa, Stenella, Steno, Tursiops, Unidentified</em></td>
</tr>
<tr>
<td>Topic</td>
<td>Behavior, Biology, Cognition, Conservation, Culture, Development, Echolocation &amp; Sound Detection, Human-Dolphin Interaction-Ecotourism, Human-Dolphin Interaction-Therapy, Maternity/Calf Mortality, Methodology, Noise &amp; Distribution, Social Structure, Sound Production</td>
</tr>
<tr>
<td>Journal Type</td>
<td>Animal/Ecology/Zoology, Biology/Chemistry/Sciences, Conservation/Environment, Human Interaction-Tourism &amp; Fisheries, Marine Sciences, Psychology, Sound/Acoustics, Therapy, Other (Technical/Foreign Journals)</td>
</tr>
<tr>
<td>Research Type</td>
<td>Observational, Observational-Biology, Experimental-Psychology, Experimental-Biology, Other-Methodology &amp; Technology</td>
</tr>
</tbody>
</table>

Results

*Article distribution across databases*

The results of a chi-square-goodness-of-fit test indicated that articles on cetaceans were distributed unequally across databases, $\chi^2 (8, N = 1628) = 1,242, p < 0.001$. Articles on cetaceans were found most frequently in the EbscoHost, Biological Abstracts, and PsycINFO databases (see Fig. 1).
Figure 1. Distribution of articles per database.

**Representation of journals**

Approximately a quarter (24.5%) of the journals identified in the current study published 78.5% of the selected journal articles. As seen in Table 2, the greatest number of publications on cetaceans was produced by *Aquatic Mammals* and *Marine Mammal Science*, which specialize in all aspects of marine mammals, and the *Journal of the Acoustical Society of America*, which specializes in the study of sound production and reception. The journals with the next most frequent publications regarding dolphins or whales dropped dramatically in their publication frequency as compared to these three prolific journals. Each of the remaining journals published only 2% or less of the identified articles.

**Representation of genera**

The results of a chi-square-goodness-of-fit test indicated that the cetaceans were not distributed equally, $\chi^2 (16, N = 1865) = 4,555.80, p < 0.001$. The most frequently researched animals were the genus, *Tursiops*, and the genus, *Orcinus*, along with a significant number of articles that did not have an identifiable species. See Table 3 for the distribution of genera.

**Representation of geographic location**

A chi-square-goodness-of-fit test indicated that the geographic locations were not equally distributed, $\chi^2 (11, N = 1677) = 797.21, p < 0.001$. The most frequent location was the North Atlantic Ocean around Canada, followed by the North Pacific Ocean, the North Atlantic Ocean around the United States, and the Indian Ocean. The Arctic Ocean had the fewest studies with less than 2% of the articles. See Table 4 for the distribution of geographic locations.
<table>
<thead>
<tr>
<th>Journal</th>
<th>f</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Aquatic Mammals</td>
<td>250</td>
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<tr>
<td>Marine Mammal Science</td>
<td>148</td>
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<td>Journal of the Acoustical Society of America</td>
<td>119</td>
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<td>Science</td>
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<tr>
<td>Journal of Mammalogy</td>
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<td>Animal Behaviour</td>
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<tr>
<td>Nature</td>
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<tr>
<td>Journal of Comparative Psychology</td>
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<tr>
<td>Canadian Journal of Zoology</td>
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</tr>
<tr>
<td>Environmental Science &amp; Technology</td>
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<tr>
<td>Biological Conservation</td>
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<tr>
<td>Annual Reviews</td>
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<tr>
<td>Science of the Total Environment</td>
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</tr>
<tr>
<td>International Journal of Comparative Psychology</td>
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<td>0.98</td>
</tr>
<tr>
<td>Behavioral Ecology and Sociobiology</td>
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<td>0.98</td>
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<tr>
<td>Anthrozoos</td>
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<tr>
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<td>Sensory Systems</td>
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<tr>
<td>Journal</td>
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<tr>
<td>------------------------------------------------------------------------</td>
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<tr>
<td><em>Environmental Toxicology &amp; Chemistry</em></td>
<td>9</td>
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</tr>
<tr>
<td>Ecology</td>
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<tr>
<td>Behaviour</td>
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</tr>
<tr>
<td>Animal Learning &amp; Behavior</td>
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<td>0.55</td>
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<tr>
<td>Journal of Animal Ecology</td>
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<tr>
<td>Behavioral &amp; Brain Sciences</td>
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<tr>
<td>Veterinary Immunology &amp; Immunopathology</td>
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<td>New Zealand Journal of Marine &amp; Freshwater Research</td>
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<td>Mammal Review</td>
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<td>Journal of Wildlife Diseases</td>
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<tr>
<td>Journal of Parasitology</td>
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</tr>
<tr>
<td>Jn of Comp Physiology B: Biochem, Systemic, &amp; Environ Physiology</td>
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Table 2 (cont.)

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<tr>
<th>Journal</th>
<th>f</th>
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<tbody>
<tr>
<td>Aquatic Toxicology</td>
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</tr>
<tr>
<td>American Journal of Veterinary Research</td>
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</tr>
<tr>
<td>A.N.A.E. Approche Neuropsychologique des Apprentissages chez l'Enfant</td>
<td>5</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**Note:** Journals publishing 5 or more cetacean articles are **bolded** and presented in descending order. Journals with 10 or more cetacean articles are *italicized* and presented in descending order. Finally, journals are alphabetized within each number category.

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Table 3

The representation of genus categories across articles.

<table>
<thead>
<tr>
<th>Genus</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalorhynchus</td>
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<td>1.3</td>
</tr>
<tr>
<td>Delphinapterus</td>
<td>104</td>
<td>5.6</td>
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<td>Delphinus</td>
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<td>Feresa</td>
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<td>Tursiops</td>
<td>743</td>
<td>39.8</td>
</tr>
<tr>
<td>Unidentified</td>
<td>253</td>
<td>13.6</td>
</tr>
</tbody>
</table>

- 422 -
Table 4

Distribution of geographic location across articles.

<table>
<thead>
<tr>
<th>Area</th>
<th>( f )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>31</td>
<td>1.8</td>
</tr>
<tr>
<td>North Atlantic- Canada</td>
<td>318</td>
<td>19.0</td>
</tr>
<tr>
<td>North Atlantic- U.S.</td>
<td>235</td>
<td>14.0</td>
</tr>
<tr>
<td>North Atlantic- Europe</td>
<td>199</td>
<td>11.9</td>
</tr>
<tr>
<td>Central Atlantic</td>
<td>55</td>
<td>5.6</td>
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<tr>
<td>South Atlantic</td>
<td>83</td>
<td>4.9</td>
</tr>
<tr>
<td>North Pacific</td>
<td>265</td>
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</tr>
<tr>
<td>South Pacific</td>
<td>107</td>
<td>6.4</td>
</tr>
<tr>
<td>Indian</td>
<td>212</td>
<td>12.6</td>
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<tr>
<td>Mediterranean</td>
<td>94</td>
<td>5.6</td>
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<td>General</td>
<td>54</td>
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</tr>
<tr>
<td>None stated</td>
<td>24</td>
<td>1.4</td>
</tr>
</tbody>
</table>

**Representation of habitat**

A chi-square-goodness-of-fit test indicated that the habitats (wild, captive, or both) were not equally represented across the sample, \( \chi^2 (2, N = 1628) = 1,062.42, p < 0.001 \). Wild habitats were most frequently studied as opposed to captive habitats. A very small number of the articles included samples from both habitats. See Figure 2 for the percentage breakdown of each habitat.

![Figure 2. Distribution of articles per habitat.](image-url)
**Representation of topics**

A chi-square-goodness-of-fit test indicated that the topics were not equally represented, $\chi^2 (13, N = 1631) = 2034.00, p < 0.001$. As Table 5 demonstrates, biology comprised the most frequently published topic, followed by behavior, and the effects of anthropogenic noise on cetaceans and cetacean distribution. The topics with the fewest articles included culture, human-dolphin interactions involving therapy, and development. See Table 5 for the results regarding the 14 broad topics.

<table>
<thead>
<tr>
<th>Topic</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropogenic Noise &amp; Distribution</td>
<td>144</td>
<td>8.8</td>
</tr>
<tr>
<td>Behavior</td>
<td>243</td>
<td>14.9</td>
</tr>
<tr>
<td>Biology</td>
<td>533</td>
<td>32.7</td>
</tr>
<tr>
<td>Calf Mortality &amp; Maternity</td>
<td>33</td>
<td>2.0</td>
</tr>
<tr>
<td>Cognition</td>
<td>82</td>
<td>5.0</td>
</tr>
<tr>
<td>Conservation, Ecology, &amp; Environment</td>
<td>52</td>
<td>3.2</td>
</tr>
<tr>
<td>Culture</td>
<td>11</td>
<td>0.7</td>
</tr>
<tr>
<td>Echolocation, Sound Detection</td>
<td>113</td>
<td>6.9</td>
</tr>
<tr>
<td>Development</td>
<td>26</td>
<td>1.6</td>
</tr>
<tr>
<td>Human-dolphin: Interaction</td>
<td>96</td>
<td>5.9</td>
</tr>
<tr>
<td>Human-dolphin: Therapy</td>
<td>24</td>
<td>1.5</td>
</tr>
<tr>
<td>Methodology</td>
<td>88</td>
<td>5.4</td>
</tr>
<tr>
<td>Sound Production</td>
<td>139</td>
<td>8.5</td>
</tr>
<tr>
<td>Social Structure</td>
<td>47</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**Representation of research design**

A chi-square-goodness-of-fit test indicated that the research designs were not equally utilized, $\chi^2 (4, N = 1627) = 830.75, p < 0.001$. The most frequent research design used was observational in nature, followed by studies using an observation-biology based design. See Figure 3 for the percentage breakdown of research designs across articles.

**Representation of habitat across journal types**

A chi-square-test-of-independence indicated that the journals and habitats were related, $\chi^2 (16, N = 1300) = 267.50, p < 0.001$, Cramer’s $V = 0.29$. As seen in Table 6, the animal, ecology, and zoology journals published articles investigating wild populations significantly more than captive populations. In contrast, the
marine science journals published articles almost exclusively from wild populations. As might be expected, psychology journals and the sound and echolocation journals published significantly more articles examining data from captive populations. See Table 6 for additional information.

![Pie chart showing distribution of articles per research design]

**Table 6**

<table>
<thead>
<tr>
<th>Journal Group</th>
<th>Wild</th>
<th></th>
<th>Captive</th>
<th></th>
<th>Both</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
</tr>
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<td>Biology/Sciences</td>
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<td>133</td>
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<td>Animals, Ecology, Zoology</td>
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<td>2</td>
<td>4.3</td>
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<td>5.5</td>
<td>80</td>
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<td>6</td>
<td>12.8</td>
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<tr>
<td>Marine Science</td>
<td>398</td>
<td>35.9</td>
<td>67</td>
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<td>14</td>
<td>29.8</td>
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<tr>
<td>Conservation</td>
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<td>0.6</td>
<td>0</td>
<td>0</td>
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<td>Therapy</td>
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<td>0.1</td>
<td>8</td>
<td>1.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Human-Dolphin Interactions</td>
<td>19</td>
<td>1.7</td>
<td>3</td>
<td>0.6</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Other</td>
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<td>1.2</td>
<td>20</td>
<td>4.3</td>
<td>3</td>
<td>6.4</td>
</tr>
<tr>
<td>Total</td>
<td>1,109</td>
<td>100</td>
<td>468</td>
<td>100</td>
<td>47</td>
<td>100</td>
</tr>
</tbody>
</table>

**Note:** Percentages above 10% and their frequencies are **bolded** to help identify trends. The highest percentage is also *italicized.*
Representation of article topic across habitat

A chi-square-test-of-independence indicated that the topics were related to the habitats from which the samples were taken, $\chi^2 (26, N = 1,624) = 456.10, p < 0.001$, Cramer’s $V = 0.38$. As might be expected, research on the effects of anthropogenic noise on cetaceans and cetacean distributions was performed more often in the wild while research on cognition and echolocation or sound detection was conducted most often in captivity. See Table 7 for specific information.

Table 7

<table>
<thead>
<tr>
<th>Topic</th>
<th>Wild</th>
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<th>Captive</th>
<th></th>
<th>Both</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f$</td>
<td>%</td>
<td>$f$</td>
<td>%</td>
<td>$f$</td>
<td>%</td>
</tr>
<tr>
<td>Anthropogenic Noise &amp; Distribution</td>
<td>140</td>
<td>12.6</td>
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<td>0.2</td>
<td>1</td>
<td>2.1</td>
</tr>
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<td>Behavior</td>
<td>199</td>
<td>17.9</td>
<td>42</td>
<td>9.0</td>
<td>2</td>
<td>4.3</td>
</tr>
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<td>363</td>
<td>32.7</td>
<td>149</td>
<td>31.8</td>
<td>20</td>
<td>42.6</td>
</tr>
<tr>
<td>Calf Mortality &amp; Maternity</td>
<td>12</td>
<td>1.1</td>
<td>20</td>
<td>4.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cognition</td>
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<td>0.7</td>
<td>73</td>
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<td>1</td>
<td>4.3</td>
</tr>
<tr>
<td>Conservation, Ecology, &amp; Environment</td>
<td>46</td>
<td>4.1</td>
<td>4</td>
<td>0.9</td>
<td>2</td>
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<td>0.2</td>
<td>0</td>
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</tr>
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<td>16.7</td>
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<td>12.8</td>
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<tr>
<td>Development</td>
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<td>1.2</td>
<td>12</td>
<td>2.6</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Human-dolphin Interaction</td>
<td>82</td>
<td>7.4</td>
<td>11</td>
<td>2.4</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>Human-dolphin: Therapy</td>
<td>1</td>
<td>0.1</td>
<td>23</td>
<td>4.9</td>
<td>0</td>
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<td>Methodology</td>
<td>70</td>
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<td>5</td>
<td>10.6</td>
</tr>
<tr>
<td>Sound Production</td>
<td>92</td>
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<td>8.1</td>
<td>8</td>
<td>17.0</td>
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<tr>
<td>Social Structure</td>
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<td>4.0</td>
<td>3</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1,109</td>
<td>100</td>
<td>468</td>
<td>100</td>
<td>47</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Percentages above 10% and their frequencies are **bolded** to help identify trends. The highest percentage is also *italicized*.

Representation of research design across habitats

As indicated by a chi-square-test-of-independence, the two variables were related, $\chi^2 (8, N = 1626) = 366.40, p < 0.001$, Cramer’s $V = 0.34$. As expected and seen in Table 8, wild research was more often observational whereas captive research was more experimental in nature.
Table 8

Distribution of articles across research type and habitat.

<table>
<thead>
<tr>
<th>Research Type</th>
<th>Habitat</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild</td>
<td>%</td>
<td>Captive</td>
<td>%</td>
</tr>
<tr>
<td>Observational</td>
<td>579</td>
<td>52.1</td>
<td>100</td>
<td>21.4</td>
</tr>
<tr>
<td>Observational-Biology</td>
<td>359</td>
<td>32.3</td>
<td>117</td>
<td>25.0</td>
</tr>
<tr>
<td>Experimental-Psychology</td>
<td>27</td>
<td>2.4</td>
<td>120</td>
<td>25.6</td>
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<tr>
<td>Experimental-Biology</td>
<td>82</td>
<td>7.4</td>
<td>121</td>
<td>25.9</td>
</tr>
<tr>
<td>Other</td>
<td>64</td>
<td>5.8</td>
<td>10</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td>1,111</td>
<td>100</td>
<td>468</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Percentages above 10% and their frequencies are **bolded** to help identify trends. The highest percentage is also *italicized*. Research type was equally divided across the major categories so the highest percentage was not noted.

**Representation of research design across journal type**

A chi-square-test-of-independence indicated that research design and journal type were related, $\chi^2 (32, N = 1624) = 334.20, p < 0.001$, Cramer’s $V = 0.23$. As summarized in Table 9, sound and acoustic journals were more likely to publish articles using experimental designs involving clear manipulations while psychology journals were more likely to publish articles using experimental research designs with some manipulation. Biology and science journals were more likely to publish studies that used observational designs involving some invasive techniques as compared to marine science journals, which published more observational research.

**Representation of article topic across research designs**

A chi-square-test-of-independence suggested that the topics were not equally distributed across the designs, $\chi^2 (52, N = 1624) = 2,233.00, p < 0.001$, Cramer’s $V = 0.59$. As expected, research on behavior, the effect of anthropogenic noise on cetaceans, sound production, and social structures incorporated observational research designs more often than expected by chance alone. In contrast, research on biology incorporated more invasive observational and experimental designs. Research on echolocation and sound detection also tended to use experimental designs involving more manipulation. Finally, research on cognition and human-dolphin interactions involving therapy incorporated more experimental-psychology based designs than expected by chance alone. See Table 10 for these trends and others.
Table 9  
Distribution of articles across journal and research type.

<table>
<thead>
<tr>
<th>Journal</th>
<th>Observational</th>
<th>Observational- Biology</th>
<th>Experimental- Psychology</th>
<th>Experimental- Biology</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( f )</td>
<td>( % )</td>
<td>( f )</td>
<td>( % )</td>
<td>( f )</td>
</tr>
<tr>
<td>Biology/ Sciences</td>
<td>133</td>
<td>29.1</td>
<td>209</td>
<td>45.7</td>
<td>28</td>
</tr>
<tr>
<td>Psychology</td>
<td>101</td>
<td>50.0</td>
<td>20</td>
<td>9.9</td>
<td>49</td>
</tr>
<tr>
<td>Animals, Ecology, Zoology</td>
<td>112</td>
<td>57.4</td>
<td>43</td>
<td>22.1</td>
<td>19</td>
</tr>
<tr>
<td>Acoustics</td>
<td>38</td>
<td>25.9</td>
<td>37</td>
<td>25.2</td>
<td>15</td>
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<tr>
<td>Marine Science</td>
<td>253</td>
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<td>Conservation</td>
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<td>Therapy</td>
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<td>0</td>
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<tr>
<td>Human-Dolphin</td>
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<td>Other</td>
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</tbody>
</table>

Note: Row percentages add to 100%. Percentages above 10% and their frequencies are **bolded** to help identify trends. The highest percentage is also *italicized*. Note that observational research is generally performed and published most frequently across the different journal categories.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Observational</th>
<th>Observational Biology</th>
<th>Experimental Psychology</th>
<th>Experimental Biology</th>
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<td><em>f</em></td>
<td>%</td>
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</tr>
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<td>Anthropogenic Noise &amp; Distribution</td>
<td>131</td>
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<td>18.3</td>
<td>5</td>
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<td>57</td>
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<td>34</td>
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<td>Culture</td>
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<td>0</td>
<td>0</td>
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<td>Social Structure</td>
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**Note:** Row percentages add to 100%. Percentages above 10% and their frequencies are **bolded** to help identify trends. The highest percentage is also *italicized*. Note that observational research is generally performed for most research topics. Some notable exceptions are research in cognition, echolocation, and human-dolphin therapy programs, which tended to incorporate experimental paradigms.
Discussion

The purpose of the current study was to explore the publication trends for research involving dolphin and whale species that may be found in captive and wild conditions. An extensive, although not exhaustive, search for relevant literature was conducted using nine research databases. Despite limitations of specific databases regarding their level of access to published articles, the search produced a representative sample of 1,628 unique articles from 290 journals. Three journals in particular dominated the publication record: Aquatic Mammals (18.5% of identified articles), Marine Mammal Science (MMS, 9% of identified articles), and Journal of the Acoustical Society of America (JASA, about 7% of identified articles). Aquatic Mammals, as the oldest publication dedicated to marine mammals, has published almost twice as many articles as MMS or JASA and eight times as many articles as Science, Journal of Mammalogy, Animal Behavior, Journal of Experimental Biology, Nature, and Journal of Comparative Psychology, the next most frequent journals.

Roughly 20% of all whale and dolphin species were represented in the sample collected with 16 different genera identified (Leatherwood, Randall, & Foster, 1983). The most frequently cited genus was *Tursiops* (bottlenose dolphins), which accounted for 42.9% of all the articles identified. Considering *Tursiops* has a world-wide distribution with abundant populations and is one of the most frequently occurring genera in captivity, this finding is not surprising (Leatherwood et al., 1983; Mann et al., 2000; May, 1998). Again, with a broad geographic range and widespread presence in captivity, the next most frequent genus was *Orcinus* (killer whales, 9.9%). Interestingly, despite the common presence of these two genera in captivity, most of the published literature included data collected from wild populations (*Tursiops* – 23.5% and *Orcinus* – 8.5%). Thus, captive research with *Tursiops* represented 18.1% of all articles and captive research with *Orcinus*, only 1.2% of all articles. In contrast, the two least represented genera, *Feresa* (pygmy killer whale, 0.3%) and *Lagenodelphis* (Fraser’s dolphin, 0.4%), are cetaceans which have relatively limited geographic ranges, numbers, captive presence, and thus available information. Clearly, there is a need to increase our knowledge of animals that are not easily observable in the wild. However, there is also a large need to conduct research with captive populations, such as killer whales, so that we may better understand their cognitive and social needs when in the care of humans.

The sample of articles collected indicated that research from around the world is somewhat equally represented. The North Atlantic-Canada (19.0%), North Pacific (15.9%), North Atlantic-United States (14%), Indian (12.6%), and North Atlantic-Europe (11.9%) oceans were the most frequently represented geographic locations across the articles. The Arctic Ocean was the least represented geographic location, accounting for only 1.8% of the articles examined.

As expected, the majority of the published research was conducted with wild populations (68.4%). A mere 3% of the identified articles examined both wild and captive populations. Although research with captive populations is not
published, or perhaps not conducted, as frequently as research with wild populations, it is nowhere as sparse as suggested by Rose and her colleagues (2009), who concluded that research with captive populations was extremely rare (about 5%). This estimate was derived by Rose and her colleagues by examining the abstracts of research presented at the 16th Biennial Conference for the Biology of Marine Mammals in South Africa during 2007, one of the major international conferences for marine mammals. In direct contrast, our findings indicated that 28.6% of our sample incorporated captive populations. Clearly, additional research involving captive populations is needed, but it is not as meager as implicated by the most current report on the case against captivity.³

The 1,628 articles represented over 40 different topics. As summarized in the appendix, these individual topics were grouped into 14 broad topics. Biology, representing many different aspects of physiology and genetics, comprised the most abundant topic, accounting for a third of the sample. Behavior followed with 15% of the sample. Sound production, particularly sounds used for communication purposes, and the production and reception of echolocation were the next two most frequent categories, accounting for about 15% of the sample when combined. The least represented topic in our sample involved studies examining various aspects of culture across various cetaceans, with less than 1% of the articles dedicated to this topic. This result is intriguing as it is one of the few topics that represents a single category of research. Perhaps, this result should be viewed optimistically as it may indicate a more liberal perspective on the complex behaviors and traditions shared by some non-human species (see Rendell & Whitehead, 2001 for a relatively recent review of this topic).

Surprisingly, less than 4% of the articles investigated topics involving mother-calf interactions and behaviors and only 5% of the articles involved studies pursuing cognitive research. Considering we specifically selected genera that could be found in both wild and captive settings, it is interesting that few studies have examined some of the most important components of an animal’s life – development and offspring care and cognitive abilities. The paucity of available publications may be due to a lack in the research itself or in an inability to publish such studies in the peer-reviewed arena. Many of these studies involve relatively small sample sizes examined over long periods of time, and traditionally studies involving small sample sizes can be difficult to publish. Additional research, such as the sample size found across publications, is needed to better understand the reasons behind these less researched areas.

As indicated earlier, the results demonstrated that observational studies were the most abundant type of designs published in our sample, accounting for 43% of the articles. Observational studies involving slightly more invasive or hands-on techniques comprised 30% of the sample. In contrast, studies employing more experimental manipulations or research designs accounted for approximately

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³A brief review of the abstracts from the 17th Biennial Conference for the Biology of Marine Mammals in Canada also indicated that 5% of the presented research was conducted solely in captivity.
22.5% of the articles. This trend is not surprising given the prevalence of the topics described above and the difficulties of conducting experimental studies.

Several clear relationships emerged suggesting that the type of research conducted depended on the habitat and that certain categories of journals published specific types of research with regard to habitat and research design. First, most observational studies were conducted in the wild with almost twice as many studies incorporating purely observational techniques (83%) or observational techniques with some invasion or manipulation (74%) as compared to experimental paradigms. In contrast, more experimental designs were conducted in captivity (78.4% - psychology and 56.8% - biological). Interestingly, an equal number of articles existed across the four major research designs for research conducted in captivity whereas the articles involving wild populations clearly emphasized observational forms of research with a limited number of experimental forms of research. This trend is not surprising, given the difficulties of conducting well-constructed experimental studies in the field. However, experimental studies are possible in the field and should be attempted more often (e.g., playback studies).

A second trend indicated that some categories of journals were more likely to publish research conducted in specific habitats. Specifically, journals publishing research on the marine sciences, conservation, and animals, their ecology, and zoology were more likely to publish research conducted in the wild than in captivity. In fact, these three categories of journals published only 108 articles (about 7%) in which the samples were drawn from captive populations only. In comparison, the journals emphasizing the marine sciences, conservation, and animals, their ecology and zoology published five times as many articles (38.5%) involving wild populations. If researchers are interested in publishing research conducted in captivity, then the best opportunities for publication can be found in psychology, acoustic, and miscellaneous journals. In fact, 7% of all the articles involving captive populations were published by psychology journals. Journals publishing acoustic research also published research performed in captivity more often than other journals (i.e., about 5% of all the articles). These trends are not unexpected given the research scopes of each of the journals included in these categories and fit well with the relationship between these journal categories and type of research design used.

As described earlier, observational designs were the most frequent type of design observed across articles. However, the journal categories differed in their representation of the two types of observational research. That is, the topics of marine sciences (15.6% of the articles), animals, ecology, and zoology (about 7% of the articles), psychology (about 6% of the articles), and human-dolphin interactions (about 1% of the articles) most often involved the use of strict observational techniques. The biology/sciences (about 13% of the articles) and conservation (about 2% of the articles) categories of journals most often published observational studies in which more manipulation or invasion occurred. Similarly, experimental studies were most often published by psychology-based (about 3% of
the articles) and acoustic-based (about 3% of the articles) journals, as would be expected.

When the findings associated with journal type and habitat and the findings associated with journal type and research design are examined together, a dilemma for researchers conducting studies with captive populations emerges. First, studies conducted with captive populations are published or conducted half as often as studies conducted with their wild counterparts. Second, journals are more likely to publish experimental research than observational research from captive populations, presumably due to the greater confidence in the research findings under controlled contexts. These two findings may be best explained by the limited opportunities researchers face when conducting research in a captive setting. Research in captivity involves overcoming many competing demands (e.g., availability of animals, training time, and monetary support) and working within the goals of the facility (e.g., education, animal interaction, and entertainment). These limitations pose major obstacles for researchers interested in captive populations and make experimental paradigms very challenging. Given the difficulty of completing an experimental study, an observational research approach seems more plausible and efficient. Unfortunately, the ecological validity of a single study conducted with a population of animals at a particular facility is often questioned.

While many facilities have attempted to provide opportunities to conduct research, only a handful of researchers have successfully created research programs centered on a captive population. What characteristics make these research programs successful? Anecdotal evidence suggests that these captive populations had some animals that were dedicated for research purposes, but a formal assessment is necessary.

As one would expect, some topics were pursued more often with wild populations while other topics were pursued more often with captive populations. For example, the effects of anthropogenic noise on dolphins and whales, the behavior of dolphins or whales, interactions between humans and dolphins, social structure, methodology, and conservation were researched primarily in the wild and represented more than a third of the sample. For research conducted in captivity, the most frequently researched topics included cognition, echolocation production and reception, the use of dolphins as a form of therapy for humans, calf survival and maternal care, and development. These topics accounted for only an eighth of the sample. Perhaps the most interesting finding of this analysis was that research on the production of sounds used for communication was equally represented across the wild and captive habitats and, in fact, had significantly more studies conducted in both habitats within the same study than any other topic. As this type of research is often attempting to determine the function of various sounds within specific contexts, conducting research in both field and controlled settings is extremely important in cross-validating conclusions (Harley, 2008; Mann et al., 2000).

Finally, the analyses corroborated the expectation that certain topics are examined more often with specific research designs. The topics with the greatest
representation of observational techniques were behavior (12% of the articles), the effect of anthropogenic noise on cetaceans and cetacean distributions (8% of the articles), sound production (6% of the articles), and social structure (2.5% of the articles). Cetacean biology research most frequently involved observational techniques requiring more manipulation and invasion, which constituted almost a quarter of the entire sample. Experimental studies using more psychology-based research designs most often included research on cognition (3.5% of the articles) and the use of dolphins as therapy for humans (1% of the articles). Experimental studies from a biological perspective included echolocation (3.6% of the articles) and biological research (7.6% of the articles). While these findings are not surprising, researchers should be aware of the different types of research designs utilized for various topics. Certainly, some topics are better suited for observational research and some topics require more invasive manipulations to fully understand them. However, more progress may be possible if a mixed methods approach was utilized more often. To be successful, cooperation between researchers, facilities, and the federal government is a necessity.

In summary, we explored the trends in the publication of marine mammal research, with an emphasis on dolphin and whale species that can be found in both wild and captive settings. The overall findings suggested that a large number of peer-reviewed articles have been published on a variety of topics in a number of different journals. Marine mammal researchers have a variety of journals to which to submit their research. However, many of these journals publish research conducted in the wild more often than research conducted in captivity. Whether this trend is due to a journal preference for more ecologically valid research, the lack of opportunity to conduct research at captive facilities, the availability of financial resources for different research questions, or simply the preference of researchers themselves, additional research is necessary. It is important to continue to examine animals in their natural environments. However, there is much to be learned from studies conducted with animals in captivity and more efforts should be made by researchers, facilities, and funding agencies alike.

Despite the apparent interest in cetaceans, there are clearly preferences in the pursuit of topics. Unfortunately, some very important topics have been grossly under-represented (e.g., cognition, development, calf survival, social structure, and conservation) while other topics are well-represented (e.g., biological features, behavior, sounds production, echolocation). Again, it is not clear if these trends simply reflect the current interests of scientists or the current sources of funding, but more attention should be focused on the under-represented topics. We experienced the first extinction of an extant cetacean during our lifetime, the baiji, or Yangtze river dolphin (*Lipotes vexillifer*) (see Turvey, 2008 for a review). While this event may not have been preventable, ultimately, perhaps an awareness of the paucity of research in certain arenas will spur individuals within the scientific community to shift their interests (Smith, 2009).

As a group, we must become cognizant of the publication trends which currently describe our research progress so that we may better integrate our knowledge from captivity and the wild. Researchers should consider all
publication sources, such as book chapters, reviews, popular press articles, or unpublished theses and dissertations when developing their studies. We also suggest that those individuals involved in the peer-review process for journals be open-minded to the advantages of both large and small sample studies investigating topics that are less represented. Future studies investigating publication trends should examine the variation in sample sizes and their relation to the journals publishing the studies, the research design used, the population examined, and the topic pursued. While our sample may not contain every study ever published on a dolphin or whale species found in captivity and the wild, we believe that it was representative and provides the field with an accurate description of the current state of peer-reviewed published research. We hope that others may find this review helpful in identifying areas of future research as well as areas that could be improved within the publication process.

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Note: Bolded references represent citations used to support the premise and findings of the paper. References in regular font include those that were used in the sample from which the statistics were calculated.

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