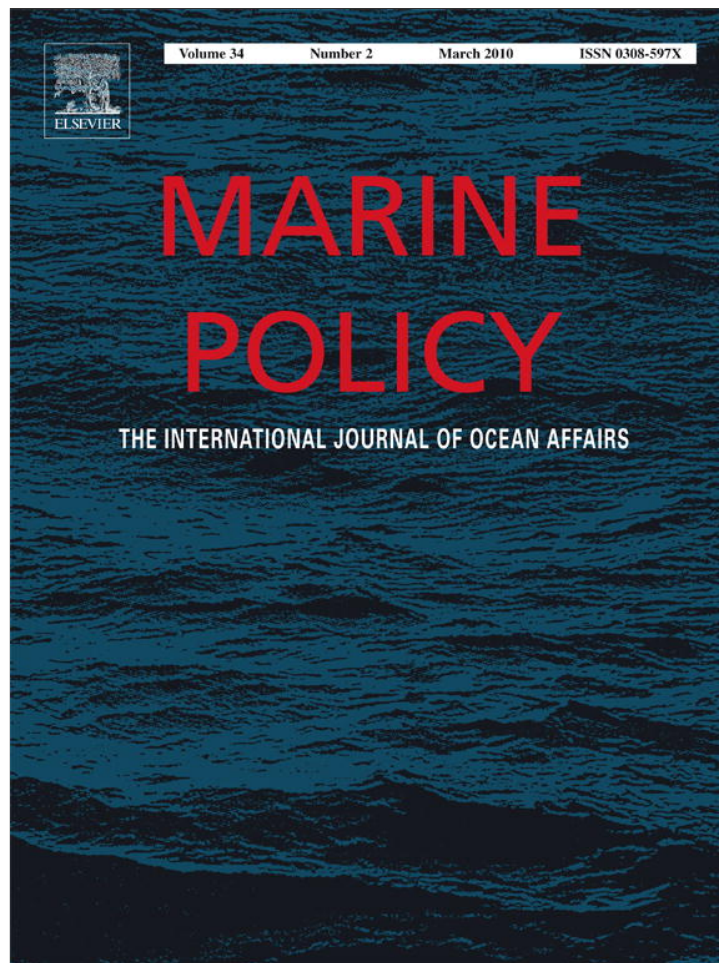


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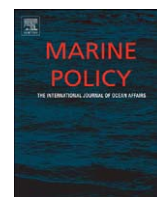


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Conflict of interest in research on anthropogenic noise and marine mammals: Does funding bias conclusions?

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ABSTRACT

The U.S. Navy, whose sonars kill marine mammals, provides approximately 50% of the funds for marine mammal research worldwide. We examined six reviews of research on the effects of anthropogenic sound on marine mammals, as well as the primary papers cited in the reviews. These reviews cite references showing noise has no effect on marine mammals at an increasing frequency as their funding moves from a conservation organization to independent to partial U.S. military sources. Primary papers are 2.3 times more likely to be cited in the reviews as concluding no effect of noise if the research was militarily-funded than if not. Thus, conflict of interest may have led to a misrepresentation of the effects of noise on marine mammals in both the primary and secondary literature, and thus misinform public policy decisions.

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1. Introduction

Conflict of interest has been defined as: “A set of conditions in which professional judgment concerning a primary interest (such as a patient’s welfare or the validity of research) tends to be unduly influenced by a secondary interest (such as financial gain)” [1]. By itself, the *perception* that scientists are under the influence of conflict of interest can undermine trust in science and thus reduce the value of their work for the betterment of society [2]. More serious is when conflict of interest *actually* affects the behaviour of the scientists. This can occur in several ways. Scientists may not be prepared to speak publicly about the adverse effects of the activities of their funding organizations, they may tailor their research goals so that the results are likely to favour the interests of the funding organizations, or they may wittingly or unwittingly interpret the results of the research so that they align with the stated or perceived interests of the funding organizations [2,3]. Additionally, the probability that they publish the results of the research may depend on how these results align with these interests these interest. There is considerable evidence that these repercussions of conflict of interest are occurring in some areas of science, such as pharmaceutical research [3].

The study of the effects of anthropogenic noise on marine life is a potential case of conflict of interest. Anthropogenic noise in the ocean increases decade by decade [4]. Sources include intentional

inputs of sound, such as seismic exploration for petroleum resources and the sonars used by naval and fishing vessels, as well as unintentional anthropogenic noise such as that from commercial shipping, offshore construction, and recreational boating [5–11]. Noise can affect marine organisms in a range of ways, including the masking of animals’ own vocalizations or other vital sounds (used for communication, navigation, foraging, or predator/hazard avoidance), disturbance, habitat displacement, deafness, and other kinds of temporary or permanent injury, including death [5–12]. A particular concern over the past few years has been the mass mortalities of whales, especially beaked whales (family Ziphiidae), following the use of mid-frequency naval sonars most commonly during U.S. Navy exercises [13]. These concerns have led to calls for increased research on the effects of undersea noise on marine mammals [8].

The U.S. Department of Defence, through agencies such as the Office of Naval Research, has funded much of this research, claiming to provide about 50% of the funding for world-wide marine mammal research,¹ with a particular emphasis on research into the effects of noise. However, in attempts to prevent its activities being affected by restrictions designed to reduce the effects of noise on marine mammals, the U.S. Navy has fought a number of lawsuits, pressured Congress to weaken relevant laws, and “may have been pressuring scientists to downplay links between sonar and damage to marine life” [14]. Clearly, it is in the

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¹ S. Tomaszkeski, Oceanographer of the U.S. Navy; presentation at the First Plenary Meeting of the Advisory Committee on Acoustic Impacts on Marine Mammals, 3–5 February 2004, Bethesda, Maryland. Available at http://www.mmc.gov/sound/plenary1/pdf/plenary%201_tomaszkeski2.pdf.

U.S. Navy's interest if research in this area demonstrates that the sounds of its sonars do not affect marine life.

Thus, serious concerns have been raised about the repercussions of this funding structure in research examining the effects of underwater noise on marine life, especially on marine mammals [14,15]: it appears that a conflict of interest exists. However, other organizations that fund marine mammal research, such as conservation groups, have political agendas, and thus studies that they fund may also possess conflict of interest [16].

The purpose of this project was to examine whether the conflict of interest in the funding of marine mammal noise research has manifested into biases within the literature. Within marine mammal noise literature, is there a correlation between a study's funding source and the perceived direction of its conclusions? We address this question both at the level of secondary review papers, and the primary literature cited within the reviews.

2. Material and methods

2.1. Selection of reviews

In recent years a number of reviews of research on the effects of noise on marine mammals have been published. Six were chosen for this project as representative of the range of styles and funding sources of these reviews:

- "Oceans of noise" [9].² The Whale and Dolphin Conservation Society (WDCS) considers itself the world's most active charity that focuses on the conservation of whales, dolphins and porpoises. WDCS believes that cetaceans represent "a group of animals that has evolved to use sound as a primary sense and which, if deprived of this sense, can be expected to perish" [9]. "Oceans of noise" is their second report on the issue of noise and its impact on the marine environment.
- "Impacts of Anthropogenic Noise" [5]. This review is published as a chapter in the book "Marine Mammal Research: Conservation beyond Crisis". The book was funded by the U.S. National Fish and Wildlife Foundation, on behalf of the U.S. Marine Mammal Commission, a government-funded organization, created to act as an independent overseer of the marine mammal conservation policies and programs that are carried out by U.S. federal regulatory agencies <<http://www.mmc.gov/about/>>.
- "Report of the Ad-hoc Group on the Impact of Sonar on Cetaceans and Fish" [10]. The International Council for the Exploration of the Seas (ICES) is an organization that promotes marine research in the North Atlantic. Funded by 20 countries that border the North Atlantic, it networks 1,600 marine scientists and their ideas. Information gathered is used to provide unbiased, apolitical advice to the public and to the sponsoring countries <<http://www.ices.dk/aboutus/aboutus.asp>>.
- "Marine Mammals and Low-Frequency Sound" [8]; "Ocean Noise and Marine Mammals" [7]; "Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Significant Effects" [6]. The U.S. National Research Council (NRC) provides the U.S. government with advice on scientific and technical matters. These are the most recent of the four NRC reports that examined information on the effects of noise on marine mammals. The production of these reports was initiated by the U.S. Navy's Office of Naval Research, and all were at least partially funded by groups affiliated with the U.S. Department of Defence, as well as other major noise producers. NRC used a different panel of participants for each report,

although there was sometimes some overlap between reports in panel members.

Thus, of the six reviews examined, one was funded by a conservation group [9], three partially by the U.S. Navy [6–8], and two by organizations with no apparent conflict-of-interest [5,10]. All were directly or indirectly intended to inform public policy on this issue.

This set comprises most of the reviews of the subject available in 2006/2007, when the initial readings were completed. The protocol that we employed meant that once the primary papers had been examined, we could not add new secondary reviews to the analysis (see below). Thus, while in hindsight we recognize that adding a second conservation-funded review (e.g. [17]) would have improved the balance of the study, and there have been some reviews published since the initial work [11,12], these cannot be incorporated without introducing potential biases as the reader is now familiar with the funding of many of the primary papers.

2.2. Evaluating citations

One of us (L. Wade), with no previous experience of the literature or individuals in marine mammal noise research, examined all citations in these reviews and scored them into two categories:

1. The citation was scored as an effect if the review stated that the cited paper: (a) recorded a change in behaviour (vocal or physical) in response to the noise, (b) recorded physiological effects of noise, or (c) stated that noise had a statistically, or biologically, significant effect changing the behaviour or physiology of the animal in question, even if it did not state the initial change as either (a) or (b). Citations to studies that documented the habituation of marine mammals to noise sources were scored as an "effect", as habituation includes an initial effect [18].
2. The citation was scored as no effect if the review stated that the original paper: (a) did not record a change in behaviour in response to the input of noise, (b) did not record any physiological effects of noise, or (c) found that any changes in behaviour or physiology observed were not statistically or biologically significant, even if it did not state initial lack of change as in either (a) or (b).

The citation was not scored if: (a) the citation did not refer specifically to the effects of noise on marine mammals, (b) did not have an explicit, unidirectional conclusion, or (c) referred to studies of temporary threshold shifts, as these are designed to produce a pre-determined physiological effect.

If Wade had any doubt about the scoring of a citation, it was scored again using the above criteria by two readers with no knowledge of the controversy. In all but two cases the two readers agreed in their scoring of these citations. Where they disagreed, Wade's original analysis was used to break the tie.

In the analysis of bias at the level of the review, for each review, each cited source was scored as "effect" if all scores of citations of that paper in that review were in category 1, "no effect" if all were in category 2, and "both" if there was at least one citation to the source scored in category 1 and one in category 2.

Analysis at the level of the primary paper was conducted by comparing and consolidating the scores that each cited source was given in each review. For example, if a primary paper was scored in category 1 in three reviews then it was categorized as "effect", if in category 1 in two reviews and category 2 in one

² One of us, Weiglart, was an editor of this review.

review then it was scored as “both”, and if in category 2 only then it was scored as “no effect”.

2.3. Determination of funding sources of primary literature

Following the scoring of the citations of primary literature in the reviews, we sought the funding sources of each cited primary paper. When the cited reference was to a journal article or chapter in an academic book, its acknowledgements section was examined to determine the funding source. If there was no acknowledgements section, funding sources were allocated using the declared affiliations of the authors if given. We carried out analyzes: (a) using funding sources determined from acknowledgements and affiliations; as well as (b) just using acknowledgements. We categorized funding sources (Table 1) as follows (using an internet search to determine the primary function of the funding organization if not obvious): (1) Conservation: the organization was independent of national governments and focussed on the conservation of species; (2) Military: the organization was affiliated with the U.S. Department of Defence (usually the U.S. Navy); (3) Oil and Gas: the organization was concerned with oil and gas exploration, shipping or commerce; (4) Other: organization that did not fall into categories 1–3, including government agencies unrelated to national defence.

There was no recorded funding by non-U.S. national defence agencies. The same primary paper could be funded by organizations from different funding source categories.

2.4. Statistical analysis

For each review, we calculated the proportion of cited references scored as “effect”, “no effect” or “both”. We tested the null hypothesis that the probabilities of placing a cited reference in these categories were the same for all reviews using likelihood-ratio *G*-tests.

The research described in primary papers was often funded by organizations from more than one source category. Thus an overall null hypothesis, such as that used in the analysis of the reviews, could not be tested. Instead, we made two-by-two contingency table analyses comparing primary papers funded or not funded by different categories of funding source versus “effect”/“no effect”, as well as versus “both”/not “both” (using only papers for which funding source was determined). From these contingency tables, the presence of interactions between funding source and direction of conclusions was tested using likelihood-ratio *G*-tests, with null hypotheses that the type of funding source and cited direction of conclusions were unrelated.

Table 1
Categories of funding source.

Conservation	Other	U.S. military	Oil and Gas
American Cetacean Society	Alaska Department of Fish and Game	Acoustic Thermometry of Ocean Climate	American Petroleum Institute
Born Free Foundation	A.R.C.S. Foundation	Advanced Research Program Agency	AMOCO Production Co.
Chicago Zoological Society	Atlantic Canada Opportunities Agency	Defence Advanced Research Program Agency	Aran Energy Exploration Ltd.
Disney Wildlife Conservation Fund	B.B.N.	Department of Defence Legacy Program	Arctic Pilot Project
Earl and Ethyl B. Myers Oceanic Trust	Bioacoustic Research Program at Cornell University	Major Range Test Facility Base	BP Exploration
Earthwatch Institute	Canadian Coast Guard	Marine Acoustics Contracts	Canarctic Shipping Ltd.
Hubbs-Sea World Research Institute	Canadian Department of Fisheries and Oceans	Naval Air Systems Command	Chevron UK Limited
International Fund for Animal Welfare	Commonwealth Scholarship	Naval Submarine Medical Research Laboratory	Consolidex-Magnorth Ltd.
International Marine Mammal Association	Danish Research Foundation	Naval Undersea Research and Development Center	Dome Petroleum Ltd.
International Union for the Conservation of Nature	Don and Lee Hamilton	Navy Marine Mammal Program	Gulf Canada Resources Inc.
International Whaling Commission	Employment and Immigration (Canada)	North Pacific Acoustic Laboratory Project	Hibernia Management and Development Company Ltd.
Island Foundation	Environment Canada	Office of Naval Research	Repsol Exploration (UK) Ltd.
Laurel Foundation	Federal Aid to Wildlife Restoration funds	Program Executive Office-Undersea Warfare	
Natural Heritage Trust		Space and Naval Warfare Systems Center	
Northern Environmental Protection Branch of the Department of Indian Affairs and Northern Development (Canada)	Fisheries Innovation Program	Strategic Environmental Research and Development Program	
Whale and Dolphin Conservation Society (WDCS)	Harvey D. Oxenhorn Memoriam	U.S. Navy C.N.O.	

Table 1 (continued)

Conservation	Other	U.S. military	Oil and Gas
World Wildlife Fund	Henry Foundation Lerner-Gray Fund L.G.L. Ltd. Minerals Management Service (U.S.) National Geographic Society Natural Sciences and Engineering Research Council of Canada NODECO Ocean Science Venture Fund Olympic Coast National Marine Sanctuary Ship and Ocean Foundation of Japan Southwest Fisheries Science Center Steven E. Smathers needy-Graduate- Student Fund The Heart Institute University of California Research Expeditions University of Massachusetts, Boston U.S. Fish and Wildlife Service U.S. Geological Survey U.S. Marine Mammal Commission U.S. National Marine Fisheries Service U.S. National Oceanic and Atmospheric Administration U.S. National Oceanic Partnership Program U.S. National Marine Mammal Laboratory U.S. National Research Council U.S. National Science Foundation Woods Hole Oceanographic Institute World Health Organisation		

3. Results

3.1. Bias in reviews

The reviews differed significantly ($G=39.09$, $df=10$, $P<0.001$) in the rates at which they cited primary papers as concluding that noise does affect marine mammals, does not affect marine mammals, or both (Fig. 1). In the WDCS, conservation-funded, review almost all citations referred to an effect. When the WDCS review was removed, there was still a significant difference between reviews in the rates at which they cited primary papers as concluding that noise does affect marine mammals ($G=20.15$, $df=8$, $P=0.001$). Furthermore, the proportion of citations scored as “no effect” or “both” increased when moving from conservation-funded to independently-funded to partially military-funded reviews (Fig. 1).

3.2. Funding sources

For the 131 primary papers where funding source was determined through acknowledgements or affiliations, 18 (14%) were funded by conservation groups, 13 (10%) by oil and gas interests, 45 (34%) by the U.S. Department of Defence, and 88 (67%) by organizations not in these categories. Of the 86 cited primary papers where funding source was determined through acknowledgements alone, 14 (16%) were funded by conservation groups, 9 (10%) by oil and gas interests, 31 (36%) by the U.S. Department of Defence, and 58 (67%) by organizations not in these categories. These percentages do not sum to 100% because of multiple funding sources for many studies. Clearly military funding is very important to the field, but the U.S. military, which claims to provide about 50% of the funding for all marine mammal science with a particular emphasis on studies of noise, is not

obtaining a proportionate number of citations in the reviews or is not having its funding fully acknowledged.

3.3. Bias in primary papers

Funding source and direction of conclusions appear related at the level of the primary literature (Fig. 2). When author affiliations were used in the determination of funding sources, all types of funding source, except oil and gas for which sample sizes were small, affected the direction of conclusions (Table 2). Conservation-funded literature was always cited as showing an effect of noise, while military-funded literature was 2.34 times more likely than other literature to be cited concluding no effect (Fig. 2A). When author affiliations were not used, this ratio was reduced to 1.64 (Fig. 2B) and there was no statistically-significant bias in military-funded literature (Table 2). This indicates that much of the bias in military-funded literature was in work carried out at military institutions, rather than in studies funded by the military but carried out at universities and other institutions.

Militarily-funded studies were 3.44 times (3.10 times using just acknowledgements to determine funding source) more likely to be cited concluding both an effect and not an effect than those not funded by the U.S. Department of Defence (Table 2).

4. Discussion

4.1. Methodologies for analyzing the effects of conflict of interest

Although scoring from review papers could be considered a crude way of assessing the direction of the conclusions of primary research, the methodology adopted in this paper possesses several advantages. First, as the conclusions in primary papers are not

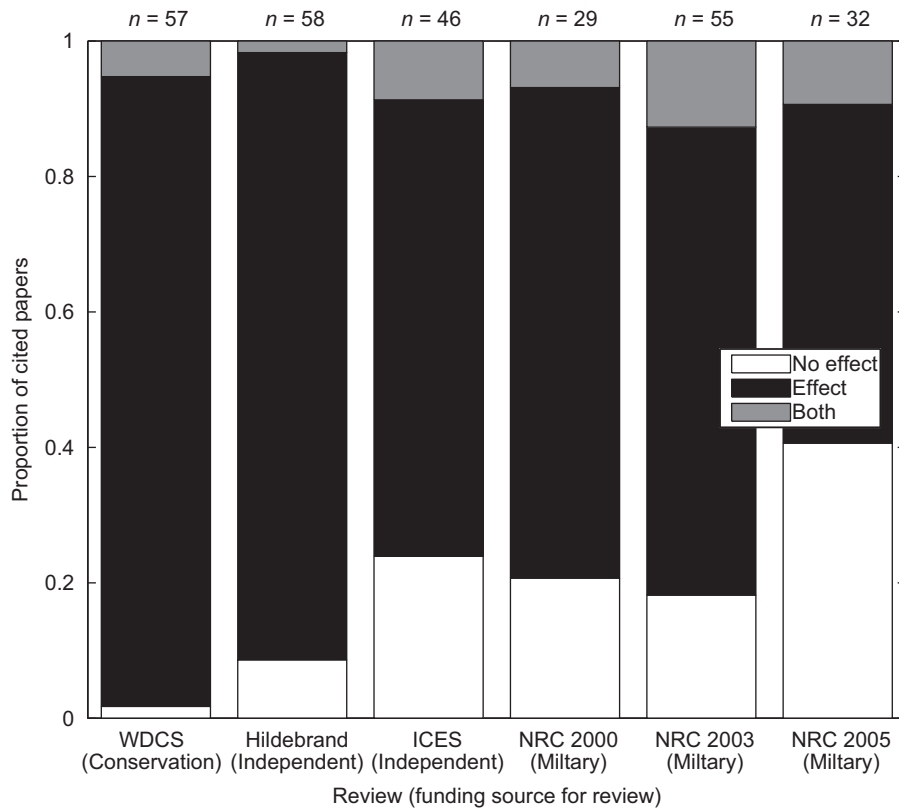


Fig. 1. The proportion of primary papers of each stance that were cited by each review.

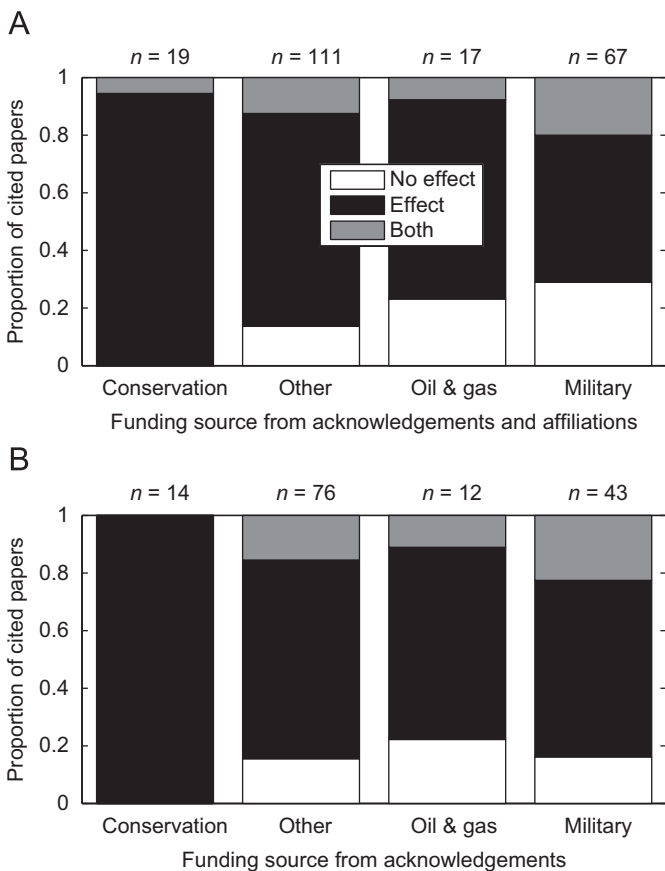


Fig. 2. Cited direction of the conclusions of primary papers funded by different sources using (A) acknowledgements and affiliations, or (B) acknowledgements alone to determine funding sources.

Table 2

Results of G-tests for interactions between funding source (whether or not there was funding from a particular type of source) and cited conclusion of primary paper (“effect” versus “no effect”; and both “effect” and “non effect” versus either “effect” or “no effect” but not both). One degree of freedom for all tests.

Funding	“Effect”/“no effect”	“Both” (effect and no effect)/not “both”
<i>Funding sources determined using acknowledgements and affiliations:</i>		
Conservation funding/no conservation	G=9.34 (P=0.002)	G=0.67 (P=0.414)
“Other” funding/no “other”	G=5.52 (P=0.019)	G=0.99 (P=0.321)
Oil and gas funding/no oil and gas	G=0.06 (P=0.809)	G=0.15 (P=0.701)
Military funding/no military	G=5.50 (P=0.019)	G=5.87 (P=0.015)
<i>Funding sources determined using acknowledgements alone:</i>		
Conservation funding/no conservation	G=6.48 (P=0.011)	G=4.21 (P=0.040)
“Other” funding/no “other”	G=0.01 (P=0.927)	G=1.30 (P=0.255)
Oil and gas funding/no oil and gas	G=0.22 (P=0.638)	G=0.03 (P=0.871)
Military funding/no military	G=0.11 (P=0.743)	G=3.98 (P=0.046)

expressed in any standard manner, and may present arguments on both sides of a scientific issue with different strengths, reducing these conclusions directly to a binary “for/against” score after reading the primary paper is often difficult and may be considered arbitrary. Second, with this system of scoring from citations in review papers, the scorer cannot be influenced by attributes revealed during the examination of primary papers such as the

affiliations of the authors, the name of the journal, or details of the methodology. Furthermore, examination of the reviews provided an account of how the conclusions of the primary literature are being presented to non-specialists and the scientifically literate public, with the intention of informing public policy. Reviews are designed to present non-specialists and the public with an accessible account of the primary literature, and therefore act as interpreters of the conclusions of the primary literature. Thus, the scores of the direction of the results of the primary papers cited within a review are representative of the conclusions that were presented to the public, regardless of what the conclusions of the primary papers actually were. Additionally, we could examine factors potentially influencing the direction of the presentation of the results of primary research within the reviews, such as the funding source of the review. Most importantly, our methodology avoided introducing bias at the level of the scoring of primary papers cited by reviews. The scorer of the citations in the review papers was unfamiliar with the names and affiliations of scientists in the field, and completed the scoring before any primary papers were examined for their funding sources. Thus the scorer had no information as to which citation might or might not refer to research funded by a particular source type.

Our method of using citations in review papers to score the conclusions of research might be applicable in other areas of conflict-of-interest research. It should be particularly useful when straight “for”/“against” scores are hard to abstract from the primary literature. For this method to be applicable, there must exist: funding of primary research by organizations with different perceived interests in its outcome; reviews of the primary literature in the field, preferably several; and a binary (“yes”/“no”) question which many citations in the reviews appear to answer and so can be assigned, and which the different types of funding source would appear to have different preferred answers.

4.2. Bias in marine mammal noise research

The reviews clearly differ in how they present the results of marine mammal noise research, with the conservation-funded review providing a more negative image of the effects of noise on marine mammals than the independently-funded reviews, and especially than the partially military-funded reviews (Fig. 1). These differences were due both to the reviews citing different sets of primary papers, to some extent those whose results bolstered the interests of the funding source, and to differences in interpretation of the same paper. For instance, consider the “Quick look—Playback of low frequency sound to grey whales migrating past the central California coast—January 1998” [19]. Scores of this paper were “effect” by Hildebrand [5], “both” by ICES [10] and NRC [7,8], and “no effect” by NRC [6]. Evidently, the reviews differ in which conclusions, or how the conclusions, of a particular paper are presented.

The influence of funding source over the direction of results was also clear at the level of the primary paper. In fact, the trend in the conclusions of the primary papers by funding source (Fig. 2) parallels closely that shown in the distribution of “effect”, “no effect” or “both” scores of the different reviews (Fig. 1). Review studies and primary literature funded by conservation groups consistently found effects of noise on marine mammals. However, there were rather few such primary studies (20% of sample). In the primary papers and NRC reviews which were partially funded by the U.S. Department of Defence, “no effect” or “both” conclusions were much more prevalent.

4.3. Funding by conservation groups

Reasons for one-sided results in literature funded by conservation groups are perhaps more transparent than those of militarily-

funded literature. Conservation groups are generally mandated to publicize activities that are potentially damaging to species or to the environment, and usually do not involve themselves with human activities that are neutral. For instance, one of WDCS's two objectives is to “raise awareness of cetaceans and educate people about the need to address the continuing threats to their welfare and survival” (<<http://www.wdcs.org/dan/publishing.nsf/allweb/1226C6FCEE998C7280256A030060083C>>).

This could be used as a justification for the largely one-way conclusions of primary literature that were presented by the WDCS-funded review (Fig. 1) as they could be said to represent a conservation group raising public awareness of credible scientific studies that raise valid concerns for the welfare of their study species.

Perhaps the same rationale can help account for the fact that all conservation-funded primary papers were presented as concluding that noise does affect marine mammals (Fig. 2). Conservation groups do not fund research unless they have previously identified a potentially damaging effect. Results at the level of the primary paper may also be attributed to the way conservation groups understand the burden of proof necessary for management: they are generally more precautionary [20]. This precautionary role and practice of conservation groups is quite transparent and should not be problematic unless threats are “hyped” where there are none. However, the funding of primary research by conservation groups may be considered a conflict of interest [16]. This conflict of interest must be considered dangerous if some of the bias indicated in Fig. 2 results from scientists funded by conservation groups orienting their goals, methods, analysis or interpretation towards the perceived interests of the conservation community that funded them.

Thus, the funding of primary studies of noise research by conservation groups can be considered a problem. However, both the level of support and number of cited papers is much smaller than it is for noise polluters (U.S. military and oil and gas interests) and the argument can be made that their role as a preventative authority is necessary.

4.4. Funding by the U.S. Department of Defence

The NRC reviews partially funded by the U.S. Department of Defence were generally biased against effects of noise on marine mammals when compared to the independently (and conservation) funded reviews (Fig. 1). This is disturbing as NRC reviews are specifically commissioned to inform U.S. government policy.

At the level of the primary paper, the conclusions of marine mammal noise research funded by the U.S. Department of Defence also appears to be affiliated with the interests of the funding source, having a greater probability of being cited as showing “no effect” compared with research not funded by military interests (Table 1, Fig. 2). However, when author affiliations were not used to determine the funding source of primary papers, this difference was reduced (Fig. 2), and not statistically significant (Table 1). This indicates that much of the bias in military-funded literature was in work carried out at military institutions, rather than in studies funded by the U.S. Department of Defence but carried out at universities, or in other non-military institutions.

These biases could arise from correlations between the funding source of a study and its goals, scope, methods, or probability of publication [2,3]. Scientists funded by the military, and especially those directly employed by the U.S. Department of Defence, may have different research goals or methods from those not so funded. Alternatively or additionally, they may also interpret the results of the research or choose to publish in ways so that their

publications align with the stated or perceived interests of the funding organizations [2,3].

U.S. military funded studies were more likely to be cited showing both an effect and not an effect of noise than others (Table 2, Fig. 2). There are several possible causes for this. These include:

- Studies funded by the U.S. Department of Defence may have been larger, containing more results, and therefore more likely to find results directed both ways. There is an indication of this in our database with militarily-funded studies being cited a mean of 2.67 times in all the reviews combined, as compared to 2.39 for conservation-funded studies, 2.62 for oil and gas funded studies and 2.34 for studies with “other” funding. However, these differences are too small to fully account for the comparatively large number of citations showing both an effect and no effect in the militarily-funded studies. There were no statistically significant differences between the number of citations in all the reviews combined between primary papers funded and not funded by any of the categories of funding source (Mann-Whitney U tests, $P > 0.26$ in all cases).
- U.S. military-funded scientists could be more conscientious, cautious, or circumspect, considering their results from a wider range of perspectives than other scientists working in this area.
- Publishing ambiguous results could be in the best interest of militarily-funded scientists. It might be considered unwise to conclude overtly that noise is damaging to marine mammals and so compromise the U.S. Department of Defence’s financial investment or military goals. However, for scientists to receive substantial funds to research the effects of noise on marine mammals, there needs to be a debate over the influence that noise has on marine mammals. For this reason, it would, perhaps, be unwise to state unilaterally that noise does not have any damaging effect on marine mammals.

The fact that the U.S. Department of Defence’s involvement in marine mammal noise research is often through funding agencies that do not indicate a military connection in their name (such as “Advanced Research Program Agency” and “Strategic Environmental Research and Development Program”; Table 1), while the involvement of conservation groups is blatant, adds to the perception that the U.S. Department of Defence is exercising control over the field of marine mammal noise research and producing biased results [21].

4.5. Funding by oil and gas interests

Oil and gas companies, particularly through their seismic operations, are major noise producers, relying on the use of noise to generate profits. Thus, a conflict of interest exists for the studies of marine mammals and noise that they fund. While the sample sizes are small because oil and gas funds relatively little research directly, the results shown in Fig. 2 suggest similar biases, and reasons for these biases, as found in militarily funded studies.

4.6. “Other” funding

The “other” funding category, which we have considered previously as a control treatment, contains mainly non-military, often U.S., government agencies such as the Minerals Management Service and the National Marine Fisheries Service (Table 1). It is frequently perceived, and likely often true, that these agencies are biased towards the interests of powerful organizations that they regulate such as the oil and gas industry

and U.S. Navy.³ Thus studies funded by these agencies could possess similar biases to those funded directly by the U.S. Department of Defence. Although the effects seem to be smaller (Fig. 2), if present such biases could account for the major contrast between science funded by conservation groups and all others.

5. Conclusions

In both primary and secondary literature there is a divide between the conclusions presented by conservation groups and the scientists that they fund and those presented by studies funded by oil and gas companies and the U.S. Department of Defence. In all three cases, the conclusions of the research favour the interests of the sponsor. Connections to such blatant political agendas incur public distrust in the publications of research from both funding sources, and undermine attempts to produce rational and effective public policy [14]. Structural changes to the funding of marine mammal research, allowing the science to operate outside all political agendas, would be beneficial to everyone involved [8,15].

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³ See results of a survey of U.S. government employees by the Union of Concerned Scientists at: http://www.ucsusa.org/scientific_integrity/interference/survey-political-interference-at-noaa-fisheries.html.

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Glossary

Conflict of interest: A set of conditions in which professional judgment concerning a primary interest tends to be unduly influenced by a secondary interest.

Marine mammals: Mammals of the orders CETACEA (whales, dolphins and porpoises) and SIRENIA (manatees and dugongs) and of the families Otariidae (fur seals and sea-lions), Obenidae (walrus) and Phocidae (seals) within the order CARNIVORA.

Sonar: A sonar emits a specially-designed sound, and listens for its echo from potential targets, giving information on the position and characteristics of the targets.